PHYSICS

UNIQUE GUIDE FOR PLUS TWO

NEW QUESTION PATTERN

- One Mark Book Ex. Q & A
- One Mark Additional Q & A
- Two Mark Book Ex. Q & A
- Two Mark Additional Q & A
- Simplified Three Mark Answer
- Simplified Five Mark Answer
- Frequently Asked Problems

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CONTENTS

QUESTION PATTERN:

Part	Mark	Total	Remark
I [Choose]	15 x 1	15	More Creative Qn
II [2Mark]	[9] 6 x 2	12	One Compulsory Qn
III [3 Mark]	[9] 6 x 3	18	One Compulsory Qn
IV [5 Mark]	[10] 5x 5	25	Either OR Choice
		70	

Highlights:

1. No Blue Print.
2. More than two Problems may be asked in Part I & II.
3. Problems can be asked in Part III also.
4. More number of creative Questions will come in part I.
5. Reasoning and creative question will come in part II.
6. Minimum pass Mark 35/100 [15 Mark in Theory & 20 Mark in Internal]

INTERNAL (30)	EXTERNAL (70)
Internal Test -4 Mark	Choose – 15 Mark
Assignment -2 Mark	2 Mark Qn - 12 Mark
Attendance -2 Mark	3 Mark Qn - 18 Mark
Co curricular activities - 2 mark	5 Mark Qn - 25 Mark
Record Note - 5 Mark Practical Exam - 15 Mark	

Take short term PAIN for long term GAIN.

1. ELECTROSTATICS

Important Note:

The following are sample questions only. Any questions can be asked from the text / syllabus. There is no category for 2 mark, 3 mark and 5 mark. Any question can be asked in any part.

Short Answer Questions Book Ex:

1. *Define electric field at a point. Give its unit and obtain an expression for the electric field at a point due to a point charge*
2. *Write the properties of lines of forces.* **[M'07,O'07,M'08,M'10,M'15,O'11,J'12,M'13,M'15,M'18,J'17]**
3. *Derive an expression for the torque acting on the electric dipole whenplaced in a uniform field.* **[O'12,O'14,J'16]**
4. *Define electric potential at a point. Is it a scalar or a vector quantity? Obtain an expression for electric potential due to a point charge.* **[M'09,O'16]**
5. *What is electrostatic potential energy of a system of two point charges? Deduce an expression for it.* **[O'09]**
6. *Prove that the energy stored in a parallel plate capacitor is $q^2/2c$ (or) ½ $CV.^2$* **[M'12,O'15]**
7. *What is dielectric? Explain the effect of introducing a dielectric slabbetween the plates of parallel plate capacitor.* **[J'13]**
8. *Explain the principle of capacitor.* **[J'14]**
9. *Deduce an expression for thecapacitance of the parallel plate capacitor.* **[J'10,J'15,M'17]**

Other Important Questions:

10. *Derive an expression for the electric potential energy of an electric dipoleplaced in a uniform electric field.* **[O'10]**
11. *Deduce an expression for the equivalent capacitance of capacitors connected in series.* **[M'14]**
12. *Explain the basic properties of electric charges.*

Long Answer Questions: Book Ex:

1. *Derive an expression for electric field due to an electric dipole at a point on its axial line.* **[M'06, J'06, M'09, J'10, O'10, M'11,J'14,M'16,M'18]**
2. *Derive an expression for electric field due to an electric dipole at a point along the equatorial line.* **[M'07, J'09,O'13,J'15,O'18]**
3. *Derive an expression for electric potential due to an electric dipole. Discuss special cases.* **[O'06, M'08, J'08, M'10,O'11,M'13,M'15,J'17]**
4. *State Gauss's law. Applying this, calculate electric field due to* **[J'11 ,M'12,J'13]**
   (i) an infinitely long straight charge with uniform charge density
   (ii) an infinite plane sheet of charge of q.

5. Deduce an expression for the equivalent capacitance of capacitors connected in series and parallel. **[J'07, O'07]**
6. State the principle and explain the construction and working of Van de Graaff generator. **[O'08, O'09,O'12,M'14,O'15,M'17]**
7. Explain the principle of capacitor. Deduce an expression for the capacitance of the parallel plate capacitor. **[J'12,O'14]**
8. State Gauss's law. Applying this, calculate electric field due to uniformly charged spherical shell (i) At a point outside the shell(ii) At a point on the surface(iii) At a point inside the shell.
9. Deduce an expression for the capacitance of the parallel plate capacitor with dielectric medium between the plates. Write the application of the capacitors. **[J'16]**

2. CURRENT ELECTRICITY

Short and Long Answer Questions **Book Ex:**

1. Establish a relation between drift velocity and current. **[M'06,O'14,J'16,O'18]**
2. Give the applications of superconductors. **[O'08, M'09, J'11, O'12, M'13, J'14,O'14,M'16,M'18]**
3. Explain the effective resistance of a series network and **parallel** network. **[O'06,O'15]**
4. Explain the determination of the internal resistance of a cell using voltmeter. **[J'08, O'09,J'11, J'13,J'15]**
5. State and explain Kirchoff's laws for electrical networks. **[J'07,O'16]**
6. Describe an experiment to find unknown resistance and temperature coefficient of resistance using metre bridge?
7. Explain the principle of a potentiometer. **[O'07,J'14,J'15,J'16]**
8. How can emf of two cells be compared using potentiometer? **[M'07, O'10, O'11, M'12, M'14,M'17]**
9. State and verify Faraday's first laws of electrolysis. **[J'08,O'09,M'16]**
10. State and verify Faraday's second law of electrolysis. **[J'06,M'08,M'11,O'13O'16]**
11. Explain the reactions at the electrodes of

(i) Daniel cell **[O'08,J'09,J'10,M'11,M'14,M'18,O'18]** (ii) Leclanche cell **[J'07,O'12,O'13,J'17]**

12. Explain the action of the lead acid accumulator. **[O'15]**
13. Obtain the condition for bridge balance in Wheatstone bridge. **[M'06, J'06, O'06, M'08, J'09, M'10, M'15,M'17]**
14. Discuss the variation of resistance with temperature with an expression and graph. **[J'12]**

3.EFFECTS OF ELECTRIC CURRENT

Short Answer Questions **Book Ex:**

1. Applying Amperes circuital law, find the magnetic induction due to a straight solenoid.
2. Explain how you will convert a galvanometer into an ammeter. **[M'08,J'12,O'13]**
3. Explain how you will convert a galvanometer into a voltmeter. **[M'10,J'11,M'12]**

Other Important Question:

4. What are the special features of magnetic Lorentz force? **[M'11, J'07,M'16]**
5. State and explain Biot-Savart law. **[J'09,O'18]**

6. *Explain in detail the principle, construction of a tangent galvanometer.* **[O'08]**
7. *Write a note on Thomson effect*
8. *Explain Thermopile.*
9. *Obtain an expression for the magnetic moment of a circular current carrying loop.*

Long Answer Questions: Book Ex:

1. *State Joule's law. Explain Joule's calorimeter experiment to verify Joule's laws of heating.* **[J'07,J'12,O'18]**
2. *Obtain an expression for the magnetic induction at a point due to an infinitely long straight conductor carrying current.* **[M'06, J'06, O'09, M'10,O'13,O'14,M'17]**
3. *Deduce the relation for the magnetic induction at a point along the axis of a circular coil carrying current.* **[O'07,M'08,M'12]**
4. *Explain in detail the principle, construction and theory of a tangent galvanometer.* **[J'08]**
5. *Deduce an expression for the force on a current carrying conductor placed in a magnetic field. Find the magnitude of the force.* **[O'08,M'09,J'11,O'12,O'16,M'18,J'17]**
6. *Explain in detail the principle, construction and the theory of moving coil galvanometer.*

Other Important Questions:

7. *Obtain an expression for the force between two long parallel current carrying conductors. Hence define Ampere.* **[M'11,J'16]**
8. *Define Ampere's Circuital law. Applying it find the magnetic induction due to a long solenoid carrying current.* **[O'06,J'09]**
9. *Explain in detail the principle, construction, working and limitation of a cyclotron with neat diagram.* **[M'07,O'10,O'11,J'13,J'15,M'16]**
10. *Discuss the motion of the charged particle in a magnetic field.* **[J'10,M'13,J'14,O'15]**

4. ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT

Short Answer Questions Book Ex:

1. *Mention the difference between a step up and step down transformer.*
2. *Obtain an expression for the rms value of a.c.*
3. *State Lenz's law and illustrate through an experiment. Explain how it is in accordance with the law of conservation of energy.*
4. *Obtain an expression for the self–inductance of a long solenoid.* **[M'14,J'16,M'17]**
5. *Explain how an emf can be induced by changing the area enclosed by the coil.* **[O'07, J'07, O'08, M'09, O'12,J'13,J'15,O'15]**
6. *Explain the mutual induction between two long solenoids. Obtain an expression for the mutual inductance.* **[J'08,M'12,O'16,M'18]**
7. *Derive an expression for the average power in an ac circuit.*

Other Important Questions:

8. *Obtain an expression for the current in an ac circuit containing a pure* ***inductance****. Find the phase relationship between voltage and current.* **[M'06,M'08]**
9. *Explain varies power losses in a transformer. How are they minimized?*

[J'06,O'06, O'09, J'10, O'10, M'11,M'13,O'14,M'15]

10. Give the application of eddy current. **[M'07,M'10,J'14,J'17,O'18]**
11. Derive an expression for energy associated with an inductor. **[O'13]**
12. What are the inferences of Faraday's electromagnetic induction experiment?
13. Explain series resonance in RLC circuit.
14. Obtain an expression for the current flowing in a circuit containing **resistance** only to which alternating emf is applied. Find the phase relationship between voltage and current. **[O'11, J'12,M'16]**

Long Answer Questions: Book Ex:

1. Discuss with theory the method of inducing emf in a coil by changing its orientation with respect to the direction of the magnetic field. **[J'08,O'09,M'10,J'10,O'11,M'13,O'14,M'15,J'17]**
2. What are eddy currents? Give their applications. How are they minimised? **[M'09]**
3. Obtain an expression for the current in an ac circuit containing a pure **inductance**. Find the phase relationship between voltage and current. **[O'08,O'16]**
4. Obtain an expression for the current flowing in the circuit containing **capacitance** only to which an alternating emf is applied. Find the phase relationship between the current and voltage. **[O'06,O'18]**
5. Describe the principle, construction and working of a single – phase a.c generator. **[M'07,O'07,M'08,J'07,O'10,M'11,J'11,J'12,J'13,M'14,M'16,M'18]**
6. Explain the principle of transformer. Discuss its construction and working. **[M'06,M'12,O'13]**
7. Explain how power can be transmitted efficiently to long distance.
8. Describe the principle, construction and working of a choke coil.
9. Describe the principle, construction and working of three–phase a.c generator.
10. A source of alternating emf is connected to a series combination of a resistor R an inductor L and a capacitor C. Obtain with the help of a vector diagram and impedance diagram, an expression for
    (i) the effective voltage (ii) the impedance (iii) the phase relationship between the current and the voltage. **[J'06,J'09,O'12,J'14,J'15,O'15,J'16,M'17]**

5. ELECTROMAGNETIC WAVES AND WAVE OPTICS

Short Answer Questions Book Ex:

1. Distinguish between Fresnel and Fraunhofer diffraction.
2. Bring out the differences between ordinary and extra ordinary light.
3. Write a note on Nicol prism. .... **[O'09,O'11]**
4. State and explain Brewster's law. **[J'06 0'06, J'07, J'08, M'09,J'10,O'12,M'13,M'15,M'17]**
5. Write a note on Polaroid.

Other Important Questions:

6. Explain the working of pile of plates. .... **[M'06,J'09]**
7. What are the characteristics of electromagnetic waves?
8. Distinguish between interference and diffraction. .... **[O'10]**

9. What is Polaroid? Give theUses of Polaroid. **[J'16]**
10. Explain double refraction.
11. Obtain an expression for the radius of the n^{th} dark ring in Newton's ring experiment. **[J'11,M'12,M'18]**

Long Answer Questions: Book Ex:

1. Explain emission and absorption spectra. **[J'09,M'10,M'12J'12,O'12,J'13,M'15,M'18]**
2. Explain the Raman scattering of light. **[M'07,O'07,M'08,J'11,M'13,O'14,O'15,M'16,J'16,J'17,O'18]**
3. On the basis of wave theory, explain total internal reflection. **[M'06,J'06,O'13,O'16]**
4. Derive an expression for bandwidth of interference fringes in Young's double slit experiment. **[O'06,J'07,M'09,J'10,O'10,M'11,O'11,J'14,M'14,M'17]**
5. Discuss the theory of interference in thin transparent film due to reflected light and obtain condition for the intensity to be maximum and minimum. **[J'08,O'09]**
6. Discuss the theory of plane transmission grating.
7. What are Newton's rings? Describe its construction and theory.

Other Important Questions:

8. State Huygen's principle. On the basis of wave theory prove the laws of reflection. **[O'08,J'15]**
9. Explain refraction on the basis of wave theory.
10. State Huygen's principle. On the basis of wave theory prove the laws of refraction.

6. ATOMIC PHYSICS

Short Answer Questions Book Ex:

1. Write the properties of cathode rays. **[O'08,J'09,O'14,M'17]**
2. Write the properties of canal rays. **[M'14,M'16,O'18]**
3. Explain the results of Rutherford α–particle scattering experiment.
4. What are the drawbacks of Rutherford atom model?
5. State the postulates of Bohr atom model.
6. Prove that the energy of an electron for hydrogen atom in nth orbit is, $E_n = \frac{-me^4}{8\varepsilon_o^2 n^2 h^2}$ **[O'07]**
7. Explain the spectral series of hydrogen atom. **[M'06,M'10,J'10,M'12,M'13,J'14J'16,O'16,M'18]**
8. What are the drawbacks of Sommerfeld atom model?
9. Write the properties of X –rays? **[J'06,M'11,O'13,M'15,J'17]**
10. State and obtain Bragg's law. **[J'08,O'09,O'11,J'15]**
11. Explain how a Bragg's spectrometer can be used to determine the wavelength of X–rays.
12. Explain the origin of characteristic x-rays. **[M'09,J'11,J'12,O'12]**
13. Obtain the expression for the radius of the n^{th} orbit of an electron based on Bohr's theory. **[J'13]**

Other Important Questions:

14. Describe Laue experiment. What are the facts established by it. **[O'06,O'15]**
15. Give the application of X-ray.
16. Give the application of laser.
17. Explain the origin of Continuous X–rayspectra.

Long Answer Questions: Book Ex:

1. Describe the J.J. Thomson method for determining the specific charge of electron. **[O'09, M'10, J'10,O'10, O'11, J'12, O'13,O'14, M'16,O'16]**
2. Describe Millikan's oil drop experiment to determine the charge of an electron. **[O'08,J'08]**
3. State the postulates of Bohr atom model. Obtain the expression for the radius of the nth orbit of an electron based on Bohr's theory. **[M'06, M'08, J'09, M'12,M'14,O'15,M'18]**
4. With the help of energy level diagram, explain the working of He−Ne laser. **[J'06, M'11, J'13, J'15, J'17]**
5. Explain the working of Ruby laser with neat sketch. **[O'06, O'07 ,M'09, J'11 O'12, M'13, M'15,M'17]**

Other Important Questions:

6. Derive Bragg's law. Explain how a Bragg's spectrometer can be used to determine the wavelength of X-rays. Write any five properties of X-ray. **[M'07,J'07,J'14]**
7. Explain Sommerfeld atom model.
8. Explain the method of producing X ray using Coolidge tube.
9. State the postulates of Bohr atom model. Prove that the energy of an electron for hydrogen atom in nth orbit is $E_n = \frac{-me^4}{8\varepsilon_o^2 n^2 h^2}$ **[O'18]**

7. DUAL NATURE OF RADIATION AND MATTER AND RELATIVITY

Short and Long Answer Questions Book Ex:

1. What is photo electric effect? State the laws of photoelectric emission. **[M'07, M'09, M'11, O'11,J'15, M'16]**
2. Obtain Einstein's photo electric equation. **[M'06,J'06,O'09,M'10,J'10,O'12,J'14,M'14,M'18]**
3. What are the applications of photo-cells? **['06,J'07,M'08,J'08,J'09,M'12,J'13,O'16,M'17]**
4. Derive an expression for de Broglie wavelength of matter waves. **[O'06,M'07,M'09,J'10,O'10,J'11,J'12,M'13,M'15,M'17]**
5. Derive Einstein's mass energy equivalence. **[J'07]**
6. Explain time dilation. **[J'06,J'08,O'13,M'16]**
7. Explain length contraction.{ Lorentz – Fitzgerald contraction} **[M'06, M'08, M'10,O'10,O'11,J'13, M'15,O'15,J'17]**
8. Discuss the concept of space, time and mass.
9. Explain the variation of photoelectric current with applied voltage.

Other Important Questions:

10. Explain the construction and working of a photo emissive [electric] cell with diagram. **[O'08,O'13,O'18]**
11. Explain the wave mechanical concept of atom. **[O'07]**
12. Explain Hallwachs experimental set-up to study the photo electric effect.
13. List the uses and limitations of electron microscope. **[M'13,J'16]**
14. Derive an expression for de Broglie wavelength of electron. **[O'14,O'18]**

8. NUCLEAR PHYSICS

Short Answer Questions Book Ex:

1. *Explain the variation of binding energy with mass number by a graph and discuss its features.* **[J'10,O'16]**
2. *Explain the different characteristics of nuclear forces.*
3. *Explain the Soddy–Fajan's radioactive displacement law.* **[M'11]**
4. *Explain how liquid drop model of the nucleus can account for nuclear fission.*
5. *Explain how carbon–nitrogen cycle can account for the production of stellar energy*. **[O'14]**

Other Important Questions:

6. *Explain the latitude effect of cosmic rays.* **[O'07,J'09,J'17]**
7. Explain how a cosmic ray shower is formed? **[M'07,J'12]**
8. Write a note on biological hazards of nuclear radiations. **[O'08]**
9. Write the **properties of α**,β and **γ**-rays. **[O'10,J'15,O'15]**
10. Explain chain reaction.
11. *Explain how the intensity of the cosmic rays changes with altitude.*
12. *Explain the principle and working of an atom bomb.* **[J'14]**
13. *Derive the relationship between half life period and mean life period.*
14. *Explain the application of radio isotope in various fields.*
15. Write the properties of neutron. **[J'13]**

Long Answer Questions: Book Ex:

1. *Obtain an expression to deduce the amount of the radioactive substance present at any moment.* [Rutherford *and Soddy law [or]*Prove that $N = N_0 e^{-\lambda t}$ *[Or]* Radioactive disintegration *law]. Obtain the relation between half life period and decay constant.* **[O'08, O'09, O'11,M'12,J'12, J'15, J'17]**
2. *Explain the construction and working of a Geiger–Muller Counter.* **[M'07, O'07, J'09, M'11, M'13, J'14,O'15,M'17]**
3. *What are cosmic rays? Explain the latitude effect of cosmic rays. Explain how the intensity of the cosmic rays changes with altitude.* **[M'08,M'10,J'13,M'15]**
4. *What is a nuclear reactor?Explain the function of i)moderator ii) control rods iii) neutron reflector. Give the uses of nuclear reactor.* **[M'06,J'16,O'16]**
5. *Discuss the principle and action of a Bainbridge mass spectrometer to determine the isotopic masses.* **[O'06,J'06,J'07,J'08,M'09,J'10,O'10,J'11,O'12,M'14,O'13,M'16,M'18,O'18]**
6. *Describe the discovery of neutron .Mention* the properties of neutron. **[O'14]**

9. SEMICONDUCTOR DEVICES AND THEIR APPLICATIONS

Short Answer Questions Book Ex:

1. *Explain the working of bridge rectifier.* **[J'06]**
2. *Explain the working of a half wave diode rectifier.* **[M'09,J'11,M'12,M'13,O'13,M'16,O'18]**

3. *Deduce the relation between α and β of a transistor.* **[J'07,M'14,J'16,M'18]**
4. *Explain with necessary circuit how Zener diode can be used as a voltage regulator.* **[J'15]**
5. *Describe the working of a transistor amplifier.*
6. *State and prove DeMorgan's theorems.* **[M'06,O'06,O'09,M'10,O'10,O'11,J'13,J'14,M'17]**
7. *Explain how operational amplifier is used as a summer.*
8. *Explain how multimeter is used as ohm meter.* **[M'11,O'15]**
9. *Describe the action of an operational amplifier as difference amplifier*

Other Important Questions:

10. *With the circuit diagram explain voltage divider biasing of a transistor.* **[M'07,J'09]**
11. *Explain the function of a transistor as a switch.* **[O'07,O'14,M'15]**
12. *Explain the circuit symbol and pin out configuration of an operational amplifier* **[O'08, O'16]**
13. *Draw the frequency response curve of single stage amplifier and discuss the results .* **[M'08]**
14. *What is an AND gate? Explain the function of AND gate using electrical circuit using diodes.* **[J'08]**
15. *What is OR gate? Explain the function of OR gate using electrical circuit using diodes.*
16. *Explain the formation of P-type semiconductor.*
17. *Explain the formation of N-type semiconductor.*
18. *Describe the action of Zener diode as voltage regulator.* **[O'12,J'17]**

Long Answer Questions: Book Ex:

1. *What is rectification? Explain the working of bridge rectifier.* **[M'06, J'07, M'10, J'10,O'11,J'12, M'14 J'16,M'18]**
2. *Explain an experiment to determine the characteristics of a transistorin CE configuration. Explain how the transistor parameters can be evaluated.* **[O'12,O'18]**
3. *What is meant by feed back? Derive an expression for voltage gain of an amplifier with negative feedback.* **[M'09,J'13,M'15,M'17]**
4. *Sketch the circuit of Colpitt's oscillator. Explain its working.* **[J'06, O'06, M'08, J'09, J'11, [M'12, J'14, O'15, J'17]**
5. *Describe an operational amplifier. Explain its action as (i) inverting amplifier and (ii) non inverting amplifier.* **[O'13,O'09,M'16]**
6. *Explain how operational amplifier is used as a summer.* **[M'07,J'12,J'15]**
7. *Describe the action of an operational amplifier as difference amplifie.r* **[O'07]**

Other Important Questions:

8. *Explain with a neat circuit diagram the working of a single stage CE amplifier.Draw the frequency response curve and discuss the results.* **[J'08,O'08,M'11,M'13,O'16]**
9. *Describe the CRO. Explain its parts.*
10. *Explain the construction and working of a multimeter.*
11. *Explain the outputcharacteristics of an NPN transistor in common emitterconfiguration with the help of neat circuit diagram.* **[O'10]**
12. *Explain the input characteristics of an NPN transistor in common emitterconfiguration with the help of neat circuit diagram.* **[O'14]**

10.COMMUNICATION SYSTEMS

Short Answer Questions Book Ex:

1. Explain the ground wave propagation.
2. Explain the wave propagation in ionosphere.
3. Explain amplitude modulation.
4. Explain frequency modulation.
5. Explain the function of an AM radio transmitter with the help of the block diagram. **[O'07,O'10, M'14,O'15,O'18]**
6. What is an optical fiber? Mention theadvantages of fiber optic communication system? **[J'07,M'08,O'11,M'16]**

Other Important Questions:

7. Mention the principle of RADAR and write its applications. **[M'07,M'10,M'13,M'18]**
8. What are the advantages and disadvantages of digital communication? **[M'06,J'06,J'08,J'09,J'12,O'18]**
9. Explain the space wave propagation of radio waves. **[O'06]**
10. Explain the function of FM transmitter with neat block diagram. **[O'08, O'09,J'10, J'11,O'12, J'14, J'16]**
11. With the help of block diagram, explain the operation of an FM super heterodyne receiver. **[M'09,M'15,J'17]**
12. Write a note on i) Modem ii) Fax
13. Explain the types of wire and cable used in data communications.
14. Mention the principle of radar and write its application. **[M'12]**
15. What are the merits and demerits of satellite communications? **[J'13,O'13,J'15]**
16. Draw the block diagram of RADAR system.
17. What are the advantages and disadvantages of frequency modulation? **[O'16]**

Long Answer Questions: Book Ex:

1. Explain the principle and function of RADAR with neat block diagram. **[O'07, O'11,O'12 ,M'15,M'17]**
2. Explain the function of a Vidicon camera tube. **[J'09,M'14]**
3. With the help of block diagram, explain the functions of various units in the monochrome television transmission. **[J'08,O'08,O'09,J'15,M'16]**
4. With the help of block diagram, explain the functional block diagram of a monochrome TV receiver. **[M'06,M'07,M'10,J'11,J'13,O'14]**

Other Important Questions:

5. Make an analysis of Amplitude Modulated wave with the help of frequency spectrum. **[J'06, O'06, M'08, M'09, J'10, O'10, J'12,M'13,J'14,J'16,J'17]**
6. With the help of block diagram, explain the operation of a super heterodyne AM receiver. **[J'07, M'11, M'12, O'13,O'16,M'18]**

Category: 3 Mark*

Year	Unit: 1	Unit: 3	Unit: 8	Unit: 5	Unit: 2,7	Other
March'06	1.13 (S)	3.30 (Ex)	8.10 (S)/ 8.7(S)	---	---	---
June'06	1.59 (Ex)	3.35 (Ex)	8.49(E)/8.55(E)	---	---	---
Oct'06	1.59 (Ex)	3.5 (S)	8.53 (E)/8.9 (S)	---	---	---
March'07	---	3.16 (S)	---	---	2.12 (S)/2.33(E)	6.5* (S)
June'07	1.9 (S)/1.54(E)	---	O. S1*	---	---	6.8 (S)
Oct'07	--	3.4 (S)	---	5.3 (S) /5.43 (E)	7.9 (S)	---
March'08	---	---	8.5 (S)/8.53 (E)	5.7 (S)	---	6.4 (S)
June'08	1.49 (E)	3.18 (S)	8.9 (S) /8.55(E)	---	---	---
Oct'08	1.55 (E)	--	---	5.42(E)*/5.3(S)*	7.8 (S)	---
March'09	--	3.16 S/3.30E	8.2 (S)	---	2.2 (S)	---
June'09	1.16 (S)	--	---	---	7.38 (E) /7.40(E)	4.5 (S)
Oct'09	---	3.13 (S) / 3.35 (E)	8.55 (E)	---	7.2 (S)	---
March'10	---	--	8.54 (E)	5.7 (S) /5.47 (E)	2.33 (E)	
June'10	---	3.13 (S)	---	---	2.10 (S) /2.30(E)	9.2 (S)
Oct'10	-----	3.39 E	---	----	2.44(E)/ 2.11 (S)	6.45 E
March'11	---	---	---	5.42 (E)/5.4 (S)	7.42(E)	10.1(S)
June'11	1.10(S)/1.59(E)	---	8.55 (E)	---	7.9 (S)	---
Oct'11	---	3.36 E.	8.51 E/8.10 S	---	2.33 E.	---
March'12	---	---	8.53 E.	---	2.10 S 7.9S/7.38 E	---
June'12	---	---	---	5.7 (S)	7.2 S, 2.9 S/2.44 E	---
Oct'12	---	3.17(S)	8.6 (S) /8.49(E)	---	7.5(S)	---
March'13	---	3.13(S) 3.35(E)	8.5(S)	----	7.2(S)	---
June'13	------	3.16(S)	-----	5.8 (S) /5.48 (E)	2.8 (S)	---
Oct'13	1.16(s)	-----	8.7(s)/8.56(E)	5.3(s)	-----	----
March'14	------	3.6(s)	8.55(E)/8.10(s)	5.47(E)	----	----
June'14	-----	3.15(S)	---	5.5(S)	7.9(S)/7.34(Ex)	----
Oct'14	-----	3.7(S)	---	5.1(S)/5.43(E)	7.8(S)	----
March'15	-----	3.16(S)	8.2(S)	---	2.11(S)/2.33(E)	---
June'15	----	3.30 (E)	-----	5.7(S)/5.43(E)	7.8(s)	----
Oct'15		3.11(S)/3.35(E)		5.47 (E)	7.4(S)	
March'16	1.16(s)/1.48(E)		8.51 (E)	5.1(S)		
June'16		3.39 (E)	8.10 (S)/8.50(E)		7.8(S)	
Oct'16		3.13 (S)		5.41(E)	7.2(s) /7.40(E)	
March'17		3.10 S /3.30E	8.55(E)			10.1 (S)
June'17		3.6 S /3.36 E		5.48 (E)	7.2(s)	
Oct'17	1.16(s)		8.5 (S)/8.49(E)	5.40 E		
March'18		3.5 S	8.5 (S)/8.49(E)		7.9S)	

Category: 2 Mark

YEAR	Unit: 2	Unit: 4	Unit: 5	Unit: 6	Unit: 9	Other Units:
March'06	O.S1 D	4.4(S)	5.8(S)	6.49(Ex)	O.S2	---
June'06	2.32(Ex)	4.2(S)	5.2(S)	6.9(S)	9.3(S)	---
Oct'06	2.10(S)	4.2(S)*	5.45(Ex)	6.7(S)	O.S3	---
March'07	2.38 (Ex)	4.2 choose	5.5 (S)	---	9.52 (Ex)	8.58 (Ex)
June'07	2.5 (S)	---	5.5 (S)	6.50 (Ex)	9.9 (S)*	7.5 (S)
Oct'07	2.5 (S)	---	5.45 (Ex)	---	9.5(S)	8.47 (Ex)
March'08	2.5 (S)	4.2 (S)	5.6 (S)	----	9.2 (S)	1.59(Ex)
June'08	2.9 (S)	4.7 (S)	5.45 (Ex)	---	9.8 (S)	---
Oct'08	---	O.S4	---	6.9 (S)	O.S5	1.15 (S) model 7.32 Ex Model
March'09	2.6 (S)	4.4 (S)	5.8 (S)	6.9 (S)	9.56 (Ex)	---
June'09	2.5 (S)	4.5 (S)	5.45 (Ex)	---	9.60 (Ex)	8.57 (Ex)
Oct'09	2.34 (Ex)	---	5.49 (Ex)	6.7 (S)	9.3 (S)	8.58 (Ex)
March'10	2.1 (S)	4.6Choose	---	6.52 (Ex)	9.3 (S)	8.52 (Ex)
June'10	2.38 (Ex)	4.2 (S)	---	6.9 (S)	9.50 (Ex)	8.58 (Ex)
Oct'10	2.5 (S)	4.2 (S)	5.4 (S)	6.9 (S)	9.3 (S)	----
March'11	O.S6D	4.2(S)	5.2(S)	6.9 (S)	----	O.S7Ln.8
June'11	2.1(S)	----	5.45(Ex)	O.S8	9.57(Ex)	7.6(ii) (S)
Oct'11	2.5 (S)	4.6(S)	5.5(S)	----	9.52(Ex)	O.S9 Ln.8
March'12	----	4.6 (S)	O.S10	6.1 (S)	9.8 (S)	1.7 (S)
June'12	2.12*	----	5.4 (S)	6.9 (S)	----	8.52* (Ex) 3.4 (S)
Oct'12	2.5(S)	----	5.49(Ex)	----	9.4(S),9.50(Ex)	8.52(Ex)
March'13	2.32(Ex)	4.3(i) (S)	5.40(Ex)	6.50(Ex)	9.50(Ex)	----
June'13	------	4.6(S)	------	6.52(Ex)	O.S11	1.15(S)*model, 8.47 (Ex)
Oct'13	2.5(s)	4.7(s)	---	6.49(E)	---	3.12(s),In.9*
March'14	2.3(s)	4.1(s)	---	6.45(E)	9.4*(s)	1.7(s)
June'14	2.43(Ex)	P.153*	---	---	9.51(Ex),9.3(s)	8.60(Ex)
Oct'14	M'11	4.55(E)	5.2(S)	6.49(E)	---	8.57(E)
March'15	---	4.5(S)	5.4(S)	6.7(S)	9.8c(S)	1.8(S)
June'15	2.5(s)	4.4 (S)	5.8 (S)	---	9.50 model	8.57(E)
Oct'15	2.39(E)	4.7 (S)		6.49(E)	9.50(Ex)	1.12(S)
March'16	2.13 (s)	4.2 (S)		6.3 (S) model	9.3 (S)	3.29(E)
June'16	2.38(E)		5.49 (E)	6.9 (S)	9.60(E)	1.59(E)
Oct'16	2.38(E)	Case(i)Pg140		6.12 O/W	9.55 (E)	1.11(S)
March'17	2.31 (E)	4.5 (S)	5.8 (S)	6.7(S)	OS 12	
June'17	2.3(s)	4.2 MCQ	6.48 E	8.58 (Ex)	9.52(Ex)	
Oct'17	2.32 (E)	4.6(S)		8.48 E	9.50(Ex), 9.57 E	
March'18	2.5(s)	4.2(S)	5.4(S)	6.9 (S)	9.4 S	

S-Solved, **Ex** – Exercise, **O.S**- Outside Problem, **D**- Diagram,*-twisted/indirect/inside the book.

1. ELECTROSTATICS

1. A glass rod rubbed with silk acquires a charge of +8 x 10^{-12} C. The number of electrons it has gained or lost

(a) 5 x 10^{-7} gained (b) 5 x 10^{7} lost (c) 2 x 10^{-8} lost (d) -8 x 10^{-12} lost

2. The electrostatic force between two point charges kept at a distance d apart, in a medium ε_r = 6, is 0.3 N .The force between them at the same separation in vacuum is

(a) 20 N (b) 0.5 N (c) 1.8 N (d) 2 N

3. Electric field intensity is 400 Vm^{-1} at a distance of 2 m from a point charge. It will be 100 Vm^{-1} at a distance?

(a) 50 cm (b) 4 cm (c) 4 m (d) 1.5 m

4. Two point charges +4q and +q are placed 30 cm apart. At what point on the line joining them the *electric field* is zero?

(a) 15 cm from the charge q (b) 7.5 cm from the charge q

(c) 20 cm from the charge 4q (d) 5 cm from the charge q

5. A dipole is placed in a *uniform* electric field with its axis parallel to the field. It experiences

(a) only a net force (b) only a torque (c) both net force and torque

(d) neither a net force nor a torque

6. If a point lies at a distance x from the midpoint of the dipole, the electric potential at the point is proportional to

(a) $1 / x^2$ (b) $1 / x^3$ (c) $1 / x^4$ (d) $1 / x^{3/2}$

7. Four charges +q, +q ,-q, and –q respectively are placed at the corners A, B , C and D of a square of side a .The electric potential at the center O of the square is

(a) $\frac{1}{4\pi \varepsilon_o} \frac{q}{a}$ (b) $\frac{1}{4\pi \varepsilon_o} \frac{2q}{a}$ (c) $\frac{1}{4\pi \varepsilon_o} \frac{4q}{a}$ (d) Zero

8. Electric potential energy (U) of *two point charge* is

(a) $\frac{q_1q_2}{4\pi \varepsilon_o r^2}$ (b) $\frac{q_1q_2}{4\pi \varepsilon_o r}$ (c) pE cos θ (d) pE sin θ

9. The work done in moving 500 μC charge between two points in equipotential surface is

(a) zero (b) finite potential (c) finite negative (d) infinite

10. Which of the following quantities is scalar?

(a) dipole moment (b) electric force (c) electric field (d) electric potential

11. The unit of *permittivity* is

(a) $C^2 N^{-1} m^{-2}$ (b) $N m^2 C^{-2}$ (c) $H m^{-1}$ (d) $N C^{-2} m^{-2}$

1	2	3	4	5	6	7	8	9	10	11
b	c	c	c	d	a	d	b	a	d	a

12. The number of electric lines of force originating from a charge of 1 C is

(a) 1.129×10^{11} (b) 1.6×10^{-19} (c) 6.25×10^{18} (d) 8.85×10^{12}

13. The electric field *outside* the plates of two oppositely charged plane sheets of charge density σ is

(a) $\frac{+\sigma}{2\varepsilon_0}$ (b) $\frac{-\sigma}{2\varepsilon_0}$ (c) $\frac{\sigma}{\varepsilon_0}$ (d) zero

14. The capacitance of a parallel plate capacitor increases from 5μF to 60 μF when a dielectric is filled between the plates. The dielectric constant of a dielectric is

(a) 65 (b) 55 (c) 12 (d) 10

15. A hollow metal ball carrying an electric charge produces no electric field at points

(a) outside the sphere (b) on its surface

(c) inside the sphere (d) at a distance more than twice

2. CURRENT ELECTRICITY

1. A Charge of 60 C passes through an electric lamp in 2 minutes. Then the current in the lamp is

(a) 30 A (b) 1 A (c) 0.5 A (d) 5 A

2. The material through which the electric charge can flow easily is

(a) quartz (b) mica (c) germanium (d) copper

3. The current flowing through the conductor is proportional to

(a) drift velocity (b) 1/ area of cross section

(c) 1 / no of electron (d) square of area of cross section

4. A toaster operating at 240 V has a resistance of 120 Ω . The power is

(a) 400 W (b) 2 W (c) 480 W (d) 240 W

5. If the length of a copper wire has a certain resistance R, then on doubling the length its specific resistance

(a) will be doubled (b) will become 1/ 4 th

(c) will become 4 times (d) will remain the same

6. When two 2 Ω resistances are in parallel, the effective resistance is

(a) 2 Ω (b) 4 Ω (c) 1 Ω (d) 0.5 Ω

7. In the case of insulators, as the temperature decreases, resistivity

(a) decreases (b) increases (c) remains constant (d) becomes zero

12	13	14	15	1	2	3	4	5	6	7
a	d	c	c	c	d	a	c	d	c	b

8. If the resistance of the coil is 2 Ω at 0 ° and α = 0.004 / °C, then its resistance at 100 °C is

(a) 1.4 Ω (b) 0 Ω (c) 4 Ω (d) 2.8 Ω

9. According to Faraday's law of electrolysis, when a current is passed, the mass of the ions deposited at the cathode is <u>independent</u> of

(a) current (b) charge (c) time (d) resistance

10. When n resistors of equal resistances (R) are connected in <u>series</u>, the effective resistance is

(a) n/ R (b) R/n (c) 1/ nR (d) nR

3. EFFECTS OF ELECTRIC CURRENT

1. Joule's law of heating is

(a) $H = I^2t / R$ (b) $H = V^2 Rt$ (c) VIt (d) IR^2t

2. Nichrome wire is used as a heating element because it has

(a) low specific resistance (b) low melting point
(c) high specific resistance (d) high conductivity

3. Peltier coefficient at a junction of a thermocouple <u>depends</u> on

(a) the current in the thermocouple (b) the time for which current flows
(c) the temperature of the junction (d) the charge that passes through the thermocouple

4. In a thermocouple the temperature of the cold junction is 20° C, the neutral temperature is 270 °C. The temperature inversion is

(a) 520 °C (b) 540 °C (c) 500 °C (d) 510 °C

5. Which of the following equations represents Biot-savart law?

(a) $dB = \mu_0 Idl / 4\pi r^2$ (b). $\vec{dB} = \mu_0 Idl \sin\theta / 4\pi r^2$

(c) $\vec{dB} = \dfrac{\mu_0 I\vec{dl} \times \vec{r}}{4\pi r^2}$ (d). $\vec{dB} = \dfrac{\mu_0 I\vec{dl} \times \vec{r}}{4\pi r^3}$

6. Magnetic induction due to an infinitely long straight conductor placed in a medium of permeability μ is

(a) $\mu_0 I / 4\pi a$ (b) $\mu_0 I / 2\pi a$ (c) $\mu I / 4\pi a$ (d) $\mu I / 2\pi a$

8	9	10	1	2	3	4	5	6
d	d	d	c	c	c	a	d	d

7. In a Tangent Galvanometer , for a steady current , the deflection produced is 30°. The plane of the coil is rotated through 90° . Now for the same current , the deflection will be

(a) 30° (b) 60 ° (c) 90° (d) 0°

8. The period of revolution of a charged particle inside a cyclotron does not depend on

(a) the magnetic induction (b) the charge of the particle

(c) the velocity of the particle (d) the mass of the particle

9. The torque on the rectangular coil placed in a uniform magnetic field is large, when

(a) the number of turns is large (b) the number of turns is less

(c) the area is small (d) the plane of the coil is perpendicular to the field

10. Phosphor –Bronze wire is used for suspension in a moving coil galvanometer, because it has

(a) high conductivity (b) high resistivity

(c) large couple per unit twist (d) small couple per unit twist

11. Of the following devices which has small resistance?

(a) moving coil galvanometer (b) ammeter of range 0 – 1 A

(c) ammeter of range 0 – 10 A (d) volt meter

12. A galvanometer or resistance G Ω is shunted with S Ω . The effective resistance of the combination is R_a . Then which of the following statement is true?

(a) G is less than S (b) R_a is less than both G and S

(c) S is less than R_a but greater than G (d) S is less than both G and R_a

13. An ideal voltmeter has

(a) zero resistance (b) finite resistance less than G but greater than zero

(c) resistance greater than G but less than infinity (d) infinite resistance

4. ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT

1. Electromagnetic induction is not used in

(a) transformer (b) room heater (c) AC generator (d) choke coil

2. A coil of area of cross section 0.5 m^2 with 10 turns is in a plane which is perpendicular to an uniform magnetic field of 0.2 Wb/m^2. The flux through the coil is

(a) 100 Wb (b) 10 Wb (c) 1 Wb (d) Zero

7	8	9	10	11	12	13	1	2
d	c	a	d	c	b	d	b	c

3. Lenz's law is in accordance with the law of

(a) conservation of charges (b) conservation of flux

(c) conservation of momentum (d) conservation of energy

4. The self inductance of a straight conductor is

(a) zero (b) infinity (c) very large (d) very small

5. The unit of henry can also be written as

(a) $Vs\,A^{-1}$ (b) $Wb\,A^{-1}$ (c) $\Omega\,s$ (d) all

6. An emf of 12 V is induced when the current in the coil changes at the rate of 40 A s^{-1} . The co efficient of self induction of the coil is

(a) 0.3 H (b) 0.003 H (c) 30 H (d) 4.8 H

7. A DC of 5 A produces the same heating effect of an AC of

(a) 50 A rms current (b) 5 A peak current (c) 5 A rms current (d) none of these

8. Transformer works on

(a) AC only (b) DC only (c) both AC and DC (d) Ac more effectively than DC

9. The part of the Ac generator that passes the current from the coil to the external circuit is

(a) field magnet (b) split rings (c) slip rings (d) brushes

10. In an AC circuit the applied emf $e = E_0 \sin(\omega t + \pi / 2)$ leads the current $I = I_0 \sin(\omega t - \pi/2)$ by

(a) $\pi / 2$ (b) $\pi / 4$ (c) π (d) 0

11. Which of the following <u>cannot</u> be stepped up in a transformer?

(a) input current (b) input voltage (c) input power (d) all

12. The power loss is less in transmission lines when

(a) voltage is less but current is more (b) both voltage and current are more

(c) voltage is more but current is less (d) both voltage and current are less

13. Which of the following devices <u>does not allow</u> d.c to pass through?

(a) resistor (b) capacitor (c) inductor (d) all of the above

14. In an Ac circuit

(a) the average value of current is zero

(b) the average value of square root of current is zero

(c) the average power dissipation is zero

(d) the rms current is √ 2 times of peak value

3	4	5	6	7	8	9	10	11	12	13	14
d	a	d	a	c	a	d	c	c	c	b	a

5. ELECTROMAGNETIC WAVES AND WAVE OPTICS

1. **In an electromagnetic wave**
   (a) power is equally transferred along the electric and magnetic fields
   (b) power is transmitted in a direction perpendicular to both the fields
   (c) power is transmitted along the electric fields
   (d) power is transmitted along the magnetic fields
2. **Electromagnetic waves are**
   (a) transverse (b) longitudinal (c) may be longitudinal or transverse
   (d) neither longitudinal nor transverse
3. **Refractive index of glass is 1.5. Time taken for light to pass through a glass plate of thickness 10 cm is**
   (a) 2×10^{-8} s (b) 2×10^{-10} s (c) 5×10^{-8} s (d) 5×10^{-10} s
4. **In an electromagnetic wave the phase difference between electric field $\vec{E}$ and magnetic field $\vec{B}$ is**
   (a) $\pi / 4$ (b) $\pi / 2$ (c) π (d) zero
5. **Atomic spectrum should be**
   (a) pure line spectrum (b) emission band spectrum
   (c) absorption line spectrum (d) absorption band spectrum
6. **When a drop of water is introduced between the glass plate and plano convex lens in Newton's ring system , the ring system**
   (a) contracts (b) expands (c) remains same (d) first expands, then contracts
7. **A beam of monochromatic light enters from vacuum into a medium of refractive index μ. The ratio of wavelengths of the incident and refracted waves are**
   (a) $\mu : 1$ (b) $1 : \mu$ (c) $\mu^2 : 1$ (d) $1 : \mu^2$
8. **If the wavelength of the light is reduced to one fourth , then the amount of scattering is**
   (a) increased by 16 times (b) decreased by 16 times
   (c) increased by 256 times (d) decreased by 256 times
9. **In Newton's ring experiment the radii of the m^{th} and $(m+4)^{th}$ dark rings are respectively $\sqrt{5}$ mm and $\sqrt{7}$ mm . What is the value of m?**
   (a) 2 (b) 4 (c) 8 (d) 10
10. **The path difference between two monochromatic light waves of wavelength 4000 A° is 2×10^{-7} m. The phase difference between them is**
    (a) π (b) 2π (c) $3\pi / 2$ (d) $\pi / 2$

1	2	3	4	5	6	7	8	9	10
b	a	d	d	a	a	a	c	d	a

11. In Young's experiment, the third bright band for wavelength of light 6000 A° coincides with the fourth bright band for another source in the same arrangement. The wavelengths of the another source is

(a) 4500 A° (b) 6000 A° (c) 5000 A° (d) 4000 A°

12. A light of wavelength 6000 A° is incident normally on a grating 0.005 m wide with 2500 lines. Then the maxim order is

(a) 3 (b) 2 (c) 1 (d) 4

13. A diffraction pattern is obtained using a beam of red light. What happens if the red light is replaced by blue light?

(a) band disappear (b) no change

(c) diffraction pattern become narrower and crowed together

(d) diffraction pattern become broader and farther apart

14. The refractive index of the medium, for the polarizing angle 60° is

(a) 1.732 (or) $\sqrt{3}$ (b) 1.414 (c) 1.5 (d) 1.468

6. ATOMIC PHYSICS

1. Cathode rays are

(a) a stream of electron (b) a stream of positive ions

(c) a stream of uncharged ions (d) the same as canal rays

2. A narrow electron beam undeviated through an electric field E= 3 x 10^4 V/m and an overlapping magnetic field B= 2 x 10^{-3} wb/m². The electron motion, electric field and magnetic field are mutually perpendicular to each other. The speed of electron is

(a) 60 ms^{-1} (b) 10.3 x 10^7 ms^{-1} (c) 1.5 x 10^7 ms^{-1} (d) 0.67 x 10^{-7} ms^{-1}

3. According to Bohr's postulates, which of the following quantities take discrete values?

(a) kinetic energy (b) potential energy (c)angular momentum (d) momentum

4. The ratio of the radii of the first three Bohr orbit is,

(a) 1 : 1/2 : 1 /3 (b) 1 : 2 : 3 (c) 1 : 4 : 9 (d) 1 : 8 : 27

5. The first excitation potential energy or the minimum energy required to excite the atom from ground state of hydrogen atom is,

(a) 13.6 eV (b) 10.2 eV (c) 3.4 eV (d) 1.89 eV

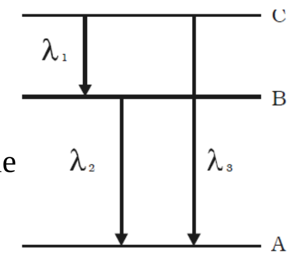
6. According to Rutherford atom model , the spectral lines emitted by an atom is ,

(a) line spectrum (b) continuous spectrum

(c) continuous absorption spectrum (d) band spectrum

11	12	13	14	1	2	3	4	5	6
a	a	c	a	a	c	c	c	b	b

7. Energy levels A,B,C of a certain atom correspond to increasing value of energy (i.e.,) $E_A < E_B < E_C$. If λ_1 , λ_2, λ_3 are the wavelengths of radiations corresponding to the transitions C to B, B to A and C to A respectively , which of the following statement is correct?



(a) $\lambda_3 = \lambda_1 + \lambda_2$ (c) $\lambda_1 = \lambda_2 + \lambda_3$

(b) $\lambda_3 = \lambda_1 \lambda_2 / (\lambda_1 + \lambda_2)$ (d) $\lambda^2_3 = \lambda^2_1 + \lambda^2_2$

8. The elliptical orbit of electron in the atom were proposed by

(a) J.J . Thomson (b) Bohr (c) Sommerfeld (d) de Broglie

9. X-ray is

(a) phenomenon of conversion of kinetic energy into radiation.

(b) conservation of momentum (c) conservation of energy in to mass

(d) principle of conservation of charge

10. In an X-ray tube , the intensity of the emitted X-ray beam is <u>increased</u> by

(a) increasing the filament current (b) decreasing the filament current

(c) increasing the target potential (d) decreasing the target potential

11. The energy of a photon of characteristic X-ray from a Coolidge tube comes from

(a) the kinetic energy of the free electrons of the target

(b) the kinetic energy of the ions of the target

(c) kinetic energy of the striking electron (d) an atomic transition in the target.

12. A Coolidge tube operates at 24800 V. The <u>maximum frequency</u> of X-radiation emitted from Coolidge tube is

(a) 6×10^{18} Hz (b) 3×10^{18} Hz (c) 6×10^{8} Hz (d) 3×10^{8} Hz

13. In hydrogen atom which of the following transitions produce a spectral line of <u>maximum</u> wavelength?[minimum frequency]

(a) $2 \rightarrow 1$ (b) $4 \rightarrow 1$ (c) $6 \rightarrow 5$ (d) $5 \rightarrow 2$

14. In hydrogen atom which of the following transitions produce a spectral line of <u>maximum</u> frequency?[minimum wavelength]

(a) $2 \rightarrow 1$ (b) $6 \rightarrow 2$ (c) $4 \rightarrow 3$ (d) $5 \rightarrow 2$

15. After pumping processor in laser,

(a) the number of atom in the *ground state is greater than* the number of atom in the excited state

(b) the number of atom in the *excited state is greater than* the number of atom in the ground state

(c) the number of atom in the ground state is equal to the number of atom in the excited state (d) no atoms are available in the excited state

16. The chromium ions doped in the ruby rod

(a) absorbs red light (b) absorbs green light

(c) absorbs blue light (d) emits green light

7	8	9	10	11	12	13	14	15	16
b	c	a	a	d	a	c	a	b	b

7. DUAL NATURE OF RADIATION AND MATTER AND RELATIVITY

1. A photon of energy υ is incident on a metal surface of threshold frequency υ_0. The kinetic energy of the emitted photoelectron is

(a) $h(\upsilon - \upsilon_0)$ (b) $h\upsilon$ (c) $h\upsilon_0$ (d) $h(\upsilon + \upsilon_0)$

2. The work function of photoelectric material is 3.3 eV. The threshold frequency will be equal to

(a) 8×10^{14} Hz (b) 8×10^{10} Hz (c) 5×10^{20} Hz (d) 4×10^{14} Hz

3. The stopping potential of a metal surface is <u>independent</u> of

(a) frequency of incident radiation (b) intensity of incident radiation

(c) the nature of the metal surface (d) velocity of the electron emitted

4. At the threshold frequency, the velocity of the electron is

(a) zero (b) maximum (c) minimum (d) infinite

5. The photoelectric effect can be explained on the basis of

(a) corpuscular theory of light (b) wave theory of light

(c) electromagnetic theory of light (d) quantum theory of light

6. The wavelength of matter wave is <u>independent</u> of

(a) mass (b) velocity (c) momentum (d) charge

7. If the kinetic energy of the moving particle is E, then the de Broglie wavelength is

(a) $\lambda = h / \sqrt{2mE}$ (b) $\lambda = \sqrt{2mE} / h$ (c) $\lambda = h\sqrt{2mE}$ (d) $\lambda = h / E\sqrt{2m}$

8. The momentum of the electron having wavelength 2A° is

(a) 3.3×10^{24} Kg m s^{-1} (b) 6.6×10^{24} Kg m s^{-1}

(c) 3.3×10^{-24} Kg m s^{-1} (d) 6.6×10^{-24} Kg m s^{-1}

9. According to relativity, the length of a rod in motion

(a) is same as its rest length (b) is more than its rest length

(c) is less than its rest length (d) may be more or less than or equal to rest length depending on the speed of the rod

10. If 1 Kg of a substance is fully converted in to energy, then the energy produced is

(a) 9×10^{16} J (b) 9×10^{24} J (c) 1 J (d) 3×10^{8} J

1	2	3	4	5	6	7	8	9	10
a	a	b	a	d	d	a	c	c	a

8. NUCLEAR PHYSICS

1. The nuclear radius of $_4Be^8$ nucleus is

(a) 1.3×10^{-15} m (b) 2.6×10^{-15} m (c) 1.3×10^{-13} (d) 2.6×10^{-13} m

2. The nuclei $_{13}Al^{27}$ and $_{14}Si^{28}$ are examples of

(a) isotopes (b) isobars (c) isotones (d) isomers

3. The mass defect of certain nucleus is found to be 0.03amu. Its binding energy is

(a) 27.93 eV (b) 27.93 KeV (c) 27.93 MeV (d) 27.93 GeV

4. Nuclear fission can be explained by

(a) shell model (b) quark model (c) liquid drop model (d) Bohr atom model

5. The nucleons in a nucleus are attracted by

(a) gravitational force (b) nuclear force (c)electrostatic force (d) magnetic force

6. The ionization power is maximum for

(a) neutrons (b) α- particle (c) γ- rays (d) β-particle

7. The half life period of certain radioactive element with disintegration constant 0.0693 per day is

(a) 10 days (b) 14 days (c) 140 days (d) 1.4 days

8. The radio isotope used in agriculture is

(a) $_{15}P^{31}$ (b) $_{15}P^{32}$ (c) $_{11}Na^{23}$ (d) $_{11}Na^{24}$

9. The average energy released per fission is

(a) 200 eV (b) 200 MeV (c)200 meV (d) 200 GeV

10. The explosion of atom bomb is based on the principle of

(a) uncontrolled fission reaction (b) controlled fission reaction
(c) fusion reaction (d) thermonuclear reaction

11. Anemia can be diagnosed by

(a) $_{15}P^{31}$ (b) $_{15}P^{32}$ (c) $_{26}Fe^{59}$ (d) $_{11}Na^{24}$

12. In the nuclear reaction $_{80}Hg^{198} + X \rightarrow {}_{79}Au^{198} + {}_1H^1$. X –stands for

(a) proton (b) electron (c) neutron (d) deutron

13. In β- decay*

(a) atomic number decreases by one (b) mass number decreases by one
(c) proton number remains the same (d) neutron number decreases by one

14. Isotopes have *

(a) same mass number but different atomic number
(b) same proton number and neutron number
(c) same proton number but different neutron number
(d) same neutron number but different proton number

* Ref book for more answer

1	2	3	4	5	6	7	8	9	10	11	12	13	14
b	c	c	c	b	b	a	b	b	a	c	c	d	c

15. The time taken for half the radioactive element to reduce to 1/e times is

(a) half life (b) mean life (c) half life / 2 (d) twice the mean life

16. The half life period of Na^{13} is 10.1 minutes. Its life time is

(a) 5.05 minutes (b) 20.2 minutes (c) 10.1/0.6931 minutes (d) infinity

17. Positive rays of the same element produce two different traces in a Bainbridge mass spectrometer. The positive ions have

(a) same mass with different velocity (b) same mass with same velocity
(c) different mass with same velocity (d) different mass with different velocity

18. The binding energy of $_{26}Fe^{56}$ nucleus is

(a) 8.8 MeV (b) 88 MeV (c) 493 MeV (d) 41.3 MeV

19. The ratio of nuclear density to the density of mercury is about

(a) 1.3×10^{10} (b) 1.3 (c) 1.3×10^{13} (d) 1.3×10^{4}

9. SEMICONDUCTOR DEVICES AND THEIR APPLICATIONS

1. The electron in the atom of an element which determine its chemical and electrical properties are called

(a) valence electrons (b) revolving electrons
(c) excess electrons (d) active electrons

2. In an N- type semiconductor, there are

(a) immobile negative ions (b) no minority carriers
(c) immobile positive ions (d) holes as majority carriers

3. The reverse saturation current in a PN junction diode is only due to

(a) majority carriers (b) minority carriers (c) acceptor ions (d) donor ions

4. In the forward bias characteristic curve , a diode appears as

(a) a high resistance (b) a capacitor (c) an OFF switch (d) an ON switch

5. Avalanche breakdown is primarily dependent on the phenomenon of

(a) collision (b) ionisation (c) doping (d) recombination

6. The colour of light emitted by a LED depends on

(a) its reverse bias (b) the amount of forward current
(c) its forward bias (d) type of semiconductor material

7. The emitter base junction of a given transistor is forward biased and its collector -base junction is reverse biased . If the base current increased , then its

(a) V_{CE} will increase (b) I_C will decrease (c) I_C will increase (d) V_{CC} will increase

15	16	17	18	19	1	2	3	4	5	6	7
b	d	c	c	c	a	c	b	d	a	d	c

8. Improper biasing of a transistor circuit produces

(a) heavy loading of emitter current (b)distortion in the output signal

(c) excessive heat at collector terminal (d) faulty location of load line

9. An oscillator is

(a) an amplifier with feedback (b) a converter of ac to dc

(c) nothing but an amplifier (d) an amplifier without feed back

10. In a Colpitt's oscillator circuit

(a) a capacitive feedback is used (b) tapped coil is used

(c) no tuned LC circuit is used (d) no capacitor is used

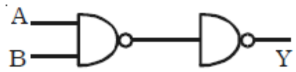
11. Since the input impedance of an ideal operational amplifier is infinite,

(a) its input current is zero (b) Its output resistance is high

(c) its output voltage becomes independent of load resistance

(d) it becomes a current controlled device

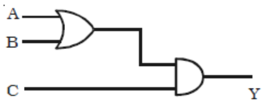
12. The following arrangement performs the logic function of



(a) AND (b) OR (c) NAND (d) EX OR

13. If the output (Y) of the following circuit is 1 , the inputs A,B,C must be

(a) 0 1 0 (b) 1 0 0 (c) 1 0 1 (d) 1 1 0



14. According to the laws of Boolean algebra , the expression (A+AB) is equal to

(a) A (b) AB (c) $\bar{B}$ (d) $\bar{A}$

15. The Boolean expression $\overline{ABC}$ can be simplified by

(a) $AB + \bar{C}$ (b) $\bar{A} . \bar{B} . \bar{C}$ (c) AB + BC +CA (d) $\bar{A} + \bar{B} + \bar{C}$

10. COMMUNICATION SYSTEMS

1. High frequency waves follow

(a) the ground wave propagation (b) the line of sight direction

(c) ionospheric propagation (d) the curvature of the earth

2. The main purpose of modulation is to

(a) combine two waves of different frequencies

(b) acquire wave shaping of the carrier wave (d) produce side band

(c) transmit low frequency information over long distance efficiently

8	9	10	11	12	13	14	15	1	2
b	a	a	a	a	c	a	d	c	c

3. In amplitude modulation

a) the amplitude of the carrier wave varies in accordance with the amplitude of the modulating signal
b) amplitude of the carrier wave remains constant
c) the amplitude of the carrier wave varies in accordance with the frequency of the modulating signal
d) modulating frequency lies in the audio range

4. In amplitude modulation, the band width is

(a) equal to signal frequency (b) twice the signal frequency
(c) thrice the signal frequency (d) four times the signal frequency

5. In phase modulation

(a) only the phase of the carrier wave varies
(b) only the frequency of the carrier wave varies
(c) both the phase and the frequency of the carrier wave varies
(d) there is no change in the frequency and phase of the carrier wave

6. The RF channel in a radio transmitter produces

(a) audio signals (b) high frequency carrier waves
(c) both audio signal and high frequency carrier waves (d) low frequency carrier waves

7. The purpose of dividing each frame into two fields so as to transmit 50 views of the picture per second is

a) to avoid flicker in the picture
b) the fact that handling of high frequency is easier
c) that 50 Hz is the power line frequency in India
d) to avoid unwanted noise in the signals

8. Printed documents to be transmitted by fax are converted into electrical signals by the process of

(a) reflection (b) scanning (c) modulation (d) light variation

3	4	5	6	7	8
a	b	c	b	a	b

1. ELECTROSTATICS

S.No.	Quantity	Formula	Unit	Scalar/ Vector
01.	Charge	$q = ne$	Coulomb	Scalar
02.	Electric Potential	$V = \frac{q}{4\pi\varepsilon_o r}$	Volt	Scalar
03.	Coulomb's law	$F = \frac{1}{4\pi\varepsilon_o r^2} q_1 q_2$	newton (N)	Vector
04.	Electric field due to point charge	$E = \frac{F}{q} = \frac{q}{4\pi\varepsilon_o r^2}$	$N\ C^{-1}$	Vector
05.	Torque	$\tau = pE \sin\theta$ $\vec{\tau} = \vec{p} \times \vec{E}$	N m	Vector
06.	Relation between Electric field and Potential	$E = -\frac{dv}{dx}$	$V\ m^{-1}$	Vector
07.	Electric Flux- Gauss law	$\phi = \frac{q}{\varepsilon_o}$	$N\ m^2 C^{-1}$	Scalar
08.	Electric field due to infinitely long straight charged wire [direction :+Ve -> outward - Ve -> inwards]	$E = \frac{\lambda}{2\pi\varepsilon_o r}$	$N\ C^{-1}$	Vector
09.	Electric field due to infinitely charged plane sheet	$E = \frac{\sigma}{2\varepsilon_o}$	$N\ C^{-1}$	Vector
10.	Electric field due to two parallel charged sheet i) Point between the plates ii) Point outside the sheet	$\frac{\sigma}{\varepsilon_o}$ Zero	$N\ C^{-1}$	Vector
11.	Electric field due to uniformly charged spherical shell i) Outside the shell E = ii) At a point on the surface E = iii) Inside the shell E =	$\frac{1}{4\pi\varepsilon_o}\frac{q}{r^2}$ $\frac{1}{4\pi\varepsilon_o}\frac{q}{R^2}$ zero	$N\ C^{-1}$	Vector
12.	Linear charge density	$\lambda = \frac{q}{\ell}$	$C\ m^{-1}$	Scalar
13.	Surface charge density	$\sigma = \frac{q}{A}$	$C\ m^{-2}$	Scalar
14.	Capacitance of capacitor	$C = \frac{q}{V}$	Farad	Scalar
15.	Capacitance of a parallel plate capacitor i) air ii) medium	$C = \frac{\varepsilon_o A}{d}$ $C = \frac{\varepsilon A}{d} = \frac{\varepsilon_r \varepsilon_o A}{d}$	Farad Farad	Scalar

16.	Electric field at any point in the air between i)the plates ii) Dielectric slab.	$E = \frac{\sigma}{\varepsilon_o}$ $E = \frac{\sigma}{\varepsilon_o \varepsilon_r}$	$N C^{-1}$ $N C^{-1}$	Vector
17.	Capacitors in series	$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$	Farad	-
18.	Capacitors in parallel	$C_p = C_1 + C_2 + C_3$	Farad	-
19.	Molecular Polarisability	$\alpha = \frac{p}{E}$	$C^2 m N^{-1}$	-
20.	Energy stored in a capacitor	$\frac{1}{2} CV^2$ or $\frac{q^2}{2C}$	Joule	--
21	Electric dipole moment	$p = 2qd$	C m [Mar'07,J,16]	vector
22	Electric potential energy (of dipole) [Mar'07]	$U = -pE\cos\theta$	Joule.	-
23.	Electric potential energy of two point charges [M '09,J'10]	$W = Vq_2 = \frac{q_1 q_2}{4\pi\varepsilon_0 r}$	Joule.	-
24.	Electric field intensity	$E = F/q$	$N C^{-1}$ [Or] Vm^{-1} [O'06,M'09]	vector
25.	Electric Flux	$d\Phi = \vec{E}.\vec{ds} = E\, ds \cos\theta$	$N\ m^2 C^{-1}$ [J'09]	scalar

Govt. Exam Questions:

01. The number of lines of force originating from a charge of 1 micro Coulomb [μ C] is <u>1.129 x 10^5</u> (Or) <u>1.13 x 10^5</u> . ($N = q/\varepsilon_0 = 1x\,10^{-6}/8.85x\,10^{-12}$) [O'07]

02. The law that governs the force between the electric charges is <u>Coulomb's law.</u> [O'07]

03. Which of the following is not a dielectric (Insulator)? [J'07]

a) ebonite b) mica c) oil <u>d) gold</u>

04. The direction of electric field at a point on the equatorial line due to an electric dipole is <u>parallel to the axis of the dipole and opposite to the direction of the dipole moment</u>. J'07

05. The torque (τ) experienced by an electric dipole placed in a uniform electric field (E) at an angle θ with the field is <u>pE sinθ .</u> [J'09]

06. When a point charge of 6 μC is moved between two points in an electric field , the work done is 1.8 x 10^{-5} J. The potential difference between the two point is <u>3 V.</u>

<u>Hint:</u> $W = V.q \ \therefore \ V = W/q = 1.8 \times 10^{-5}/6 \times 10^{-6} = 3\ V$ [O'09]

07. The intensity of the electric field at a point is equal to --- **[O'10]**

a) *the force experienced by a charge q*

b) the work done in bringing unit positive charge from infinity to that point

c) the positive gradient of the potential **d) the negative gradient of the potential**

Hint: $E = \frac{-dV}{dx}$

08. The capacitance of capacitor is **[O'10]**

a) directly proportional to the charge q given to it

b) inversely proportional to its potential v

c) directly proportional to the charge q given to it , inversely proportional to its potential v

d) independent of both the charge q and potential v

Hint : C = $\epsilon_0 A/d$

09. Example for conductors: Metals, human body, Earth **[O'08]**

Example for insulators: Glass, mica, ebonite, plastic.

10. Law of quantization of electric charges q = n e. **[O'08]**

11 $\varepsilon_0 = \frac{1}{4\pi \times 9 \times 10^9} = \frac{1}{36\pi \times 10^9} = \frac{10^{-9}}{36\pi}\ C^2N^{-1}m^{-2}$ {O'08}

12. Lightning arrester uses the principle of corona discharge [or] action of points. **[O'06]**

13. The negative gradient of potential is Electric field (intensity). **[J'09]**

14. The electric field intensity at a distance r due to infinitely long straight charged wire is directly proportional to ----. **[J'10]**

Hint: $E = \frac{\lambda}{2\pi\varepsilon_0 r}$

a) r **b) 1/r** c) r^2 d) $1/r^2$

15. The unit of number of electric lines of force passing through a given area is-----

Hint: [Unit of flux] **[Mar'11]**

a) no unit b) $N\,C^{-1}$ **c) $N\,m^2\,C^{-1}$** d) N m

16. A dielectric medium is placed in an electric field E_0. The field induced inside a medium acts opposite to E_0. **[J'11]**

17. If "n" capacitors each of capacitance C are connected in series the effective capacitance will be $\frac{C}{n}$. [Note: If parallel: **nC**] **O'11**

18. A non polar (Or) polar **dielectric is placed in an electric field E. Its induced dipole moment acts in the direction of E.** **O'11**

19. The electric field intensity at a short distance r from uniformly charged infinite plane sheet of charge is--------- **J'12**

a) proportional to r b) proportional to 1/r c) proportional to $1/r^2$

d) *independent of r*

Hint: $E = \frac{\sigma}{2\varepsilon_o}$

20. When the charge given to the capacitor is doubled, its capacitance does not change. **M'12 , S'15**

21. Electric field intensity at a distance r from an infinitely long uniformly charged straight wire is directly proportional to ----- **O'12**

Hint: $E = \frac{\lambda}{2\pi\varepsilon_o r}$

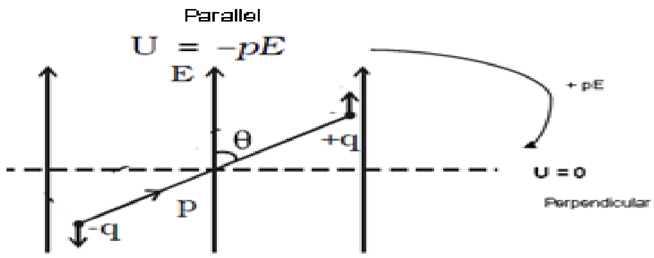
a) r **b) r^{-1}** c) r^2 d) r^{-2}

22. Two point charges +q and –q are placed at a point A and B respectively separated by a small distance. The electric field intensity at the midpoint O of AB **M'13**

a) is zero **b) acts along AB** c) acts along BA d) acts perpendicular to AB

Hint: Electric field intensity at a point, in an electric field is defined as the force experienced by a unit positive charge kept at that point. Here at O ,+q is there .

23. An electric dipole of dipole moment 'p' is kept parallel to an electric field intensity 'E'. The work done in rotating the dipole through an angle of 90^0 is :



a) Zero b) -pE ***c) pE*** d)2pE

24. Van de Graaff generator works on the principle of **J'14**

a) electromagnetic induction and action of points

b) electrostatic induction and action of points

c) electrostatic induction only

d) action of points only

25. What must be the distance between two equal and opposite point charges (say +q and –q) for the electrostatic force between them to have a magnitude of 16 N? **M'14**

a) $4\sqrt{kq}$ metre **b) $\frac{q}{4}\sqrt{k}$ metre** c) 4 kq metre d) $\frac{4k}{q}$ metre

26. The repulsive force between two like charges of 1 coulomb each separated by a distance of 1m in vacuum is equal to **O'13**

a) 9×10^9 N b) 10^9 N c) 9×10^{-9} N d) 9 N

27. Two point charges $+q_1$ and $+ q_2$ are placed in air at a distance of 2 m apart. One of the charges is moved towards the other through a distance of 1 m. The work done is: **[J'15]**

a. $\frac{q_1 q_2}{4\pi\varepsilon_0}$ b. $\frac{2q_1 q_2}{4\pi\varepsilon_0}$ **c.** $\frac{q_1 q_2}{8\pi\varepsilon_0}$ d. $\frac{q_1 q_2}{16\pi\varepsilon_0}$

28. The nature of the electrostatic force and nuclear force between a proton and a neutron inside a nucleus are respectively: **M'15**

a) repulsive and attractive **b) zero and attractive**
c) repulsive and repulsive d) attractive and attractive

29. Point charges +q, +q, -q and –q are placed at the corners A, B, C and D respectively of a square. O is the point of intersection of the diagonals AC and BD. The resultant electric field intensity at the point O: **M'15**

a. acts in a direction parallel to AB b. **acts in a direction parallel to BC**
c. acts in a direction parallel to CD d. is zero

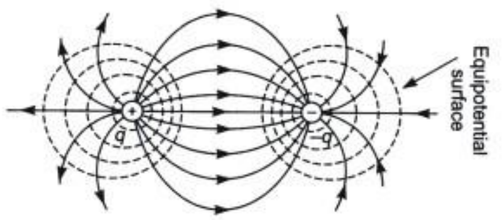
30. The equipotential surface of an electric dipole is: **M'16**

a) a sphere whose centre coincides with the centre of the electric dipole

b) a plane surface inclined at an 45° with the axis of the electric dipole

c) a plane surface passing through the centre of the electric dipole and perpendicular to the axis of the electric dipole

d) any plane surface passing through the axis of the electric dipole



Equipotential surfaces due to electric dipole

31. A and B are two hollow metal spheres of radii 50 cm and 1 m carrying charges 0.6 μ C and 1 μ C respectively. They are connected externally by a connecting wire. Now the charge flows from: **M'16**

a) A to B till the charges become equal

b) A to B till the potential become equal

c) B to A till the charges become equal

d) B to A till the potential become equal

32. When a dielectric slab is introduced between the plates of a charged parallel plate capacitor, its : **M'16**

a) potential increases **b) electric field decreases** c) charge increases

d) capacitance decreases

Frequently Asked Questions:

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \ \ N\,m^2 C^{-2}$$

$$\frac{F}{F_m} = \frac{\varepsilon}{\varepsilon_0} = \varepsilon_r$$

$F \rightarrow$ Force between two charged bodies in air

$F_m \rightarrow$ Force between two charged bodies in medium.

$\varepsilon \rightarrow$ Permittivity of medium

$\varepsilon_r \rightarrow$ Relative permittivity or dielectric constant [no unit]

{ ε_r =80 for water}

01. Torque $\vec{\tau} = \vec{p} \times \vec{E}$ = p E Sin θ

A dipole is placed in ----	Force F = qE	Torque τ = pE sinθ	Result
i) uniform field at an angle θ	+qE-qE = 0	τ = pE sinθ	Only torque , force is zero
ii) Non-Uniform field at an angle θ	F = qE	τ = pE sinθ	Both net force and torque [M'08,O'08]
iii) Uniform field with its axis parallel to the field (θ= 0)	Zero	Zero	Neither a net force nor a torque

02. Torque on a dipole in a uniform electric field is maximum when the angle between P and E is equal to 90°. (i.e when the dipole is aligned perpendicular to the field).

$\vec{\tau} = \vec{p} \times \vec{E}$ = pE sinθ [if θ = 90, sin 90 = 1] [J'06, O'09]

03. An electric dipole of moment $\vec{p}$ is placed in a uniform electric field of intensity $\vec{E}$ at an angle θ with respect to the field. The direction of torque is Perpendicular to the plane containing $\vec{p}$ and $\vec{E}$. [Mar'10]

04. The dipole has minimum potential energy when it is aligned parallel to the field.

[θ= 0 ; U= - PE Cos (o) = - PE] [Note:Maximum PE ; θ= 90 ,U = 0] [J'08]

05. Permittivity of free space ε_0 = $8.854 \times 10^{-12}\ C^2 N^{-1} m^{-2}$

06. Classification of negative and positive charges was termed by Benjamin Franklin.

07. Gauss's law $\Phi = q / \varepsilon_0$; Φ → total flux ; q → Net Charge

08. The resultant electric field between two charged (equal, opposite) plates, when the point P is ----

(i) In between two plates = σ / ε_0 (ii) Out side the plate = Zero

09. The electric field due to uniformly charged thin shell is Zero at all points *inside the shell.*

10. A Capacitor is a device for storing electric charges. The Capacitance depends on geometry{ size and shape} of the conductors and nature of the medium.

11. Examples for dielectric: Ebonite, mica and oil.

12. The non polar molecules *do not have permanent dipole moment.* Ex: O_2 , N_2, H_2 .

13. The polar molecules *have permanent dipole moment.* Ex: N_2O, H_2O , Hcl, NH_3 .

14. Energy stored in a capacitor $U = \frac{1}{2}\frac{q^2}{C} = \frac{1}{2}CV^2$

15. $\sigma \propto 1 / r$. Charge density is inversely proportional to *radius of curvature.*

16. Change of potential with distance is potential gradient.

17. Dielectric constant $K = \frac{C^1}{C} = \frac{\text{Capacitance of dielectric filled Capacitor}}{\text{Capacitance of air filled capacitor.}}$ [no unit]

18. Force between two point charges depends on the nature of the medium.

19. Relative permittivity[Dielectric constant] [ε_r]of vacuum or(air) = 1 [M'12]

20. For any dielectric medium Relative permittivity $\varepsilon_r > 1$. Eg: $\varepsilon_r = 80$ for water.

21. Unit of relative permittivity[Dielectric constant]: no unit . [J'12]

22. If the medium between two charges is replaced by air, then the force between them increases.{ie if a dielectric medium is placed in between two charges force between them decreases ; $F_M = F/ \varepsilon_r$ }

23. When air medium in capacitor is replaced by a medium of dielectric constant ε_r, the capacitance increases ε_r times. [$C' = C \varepsilon_r$]

24. The capacitance of a capacitor when a dielectric slap is introduced *increases.*

25. Electric line of force was introduced by Michael Faraday.

26. Examples for permanent electric dipoles: H_2O, CO_2, ammonia, Chloroform.

27. The number of electrical lines of force produces by a unit charge in vacuum is---

a) $1/ \varepsilon_o$ b) $10^{12} / 8.854$ c) $36\pi \times 10^9$ *d) All of there.*

28. In a parallel plate capacitor the radius of the circular plates and the distance between the plates are doubled, then the capacitance increases two times.

Note: $C = \frac{\varepsilon_o A}{d} = \frac{\varepsilon_o \pi r^2}{d} = \frac{\varepsilon_o \pi (2r)^2}{2d} = \frac{2 \varepsilon_o A}{d}$

29. The electrostatic force between two point charges kept at a distance of d apart in air is F. The force between them at the same separation in a medium of dielectric constant ε_r is F/ε_r [Note: $F/F_m = \varepsilon_r$]

30. Charge of an electron e = 1.6 X 10^{-19} C .

31. Gauss's law relates the flux through any closed surface and the net charge enclosed within the surface.

Other Important Questions:

1. A device not working with the principle of electrostatic induction is micro wave oven.
2. The microwave generated in a microwave oven produce *a non uniform oscillating electric field.*
3. In a series connection *charge* on each capacitor remains constant.
4. In a parallel connection *voltage across* each capacitor remains constant.
5. Practical units of capacitors are µF , pF [1 pF = 10^{-12} F ; 1 µF = 10^{-6} F]
6. A body cannot have a charge of 2.4 X 10^{-19} C, because q = + ne, n is an Integer.
7. The dipole moment of polar molecule is -----.

   a) Zero b) *Permanent* c) Varying c) Constant

8. In case of uniform electric field, equipotential surfaces are parallel planes with the surface perpendicular to the lines of force, Incase of point charge It is concentric circles.
9. Unit of electric flux : N m^2 C^{-1} (OR) V m (OR) A m Ω
10. The unit equivalent to the unit of capacitance (farad)is

    a) $S\Omega^{1}$ b) Wb m^{-1} c) Am^{-1} d) H m^{-1}

11. Normally the charge of the substance is

    a) having any value b) a constant c) in an integer

    d) *an integral multiple of the charge of an* electron

12. The unit equivalent to the unit V/m is ------ [Electric field]

    a) N/ C b) $NA^{-1}S^{-1}$ c) J/Cm *d) all of there*.

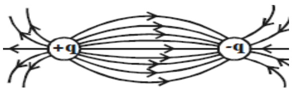
13. The electric field at any point in the air between

    i) The metal plates $E = \frac{\sigma}{\varepsilon_o}$ ii) Dielectric slab $E = \frac{\sigma}{\varepsilon_r \varepsilon_o}$

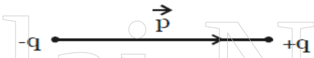
14. Electric lines of force do not pass through a closed conductor. Inside a charged closed conductor electric field is zero.
15. The magnitudes of the induced dipole moment p is directly proportional to the external electric field E.

    $p \propto E$ (or) $p = \alpha E$ or $\alpha = p/E$, α = molecular polarisability.

16. **An electric dipole of moment p is placed in a uniform electric field of intensity E at an angle θ with respect to the field. The direction of dipole is in the direction of electric field.**
17. **The direction of electric field in a equipotential surface is normal to the surface.**
18. **The charges in Electrostatic fields are same to masses in gravitational field. They possess potential energy.**
19. **If glass rod rubbed with a silk, glass acquires *positive charge*, silk acquires negative charge.** [i.e *glass rod lost electrons*]
20. **If an ebonite rod rubbed with fur, it becomes *negatively* charged.** [Ebonite rod gain electrons.]
21. **Properties of attraction and repulsion between charges are used in**
    (i) Electrostatic painting (ii) Powder coating
    (iii) ink-jet printing (iv) Photostat copying [Xerox]



22. **Electric dipole's direction : +q to –q**
23. **Electric dipole moment's direction : -q to +q**



24. **SI unit of electric charge is**
    i) coulomb ii) ampere second iii) $\frac{\text{volt second}}{\text{ohm}}$ iv) all of these

29. If the distance between two charges is doubled the electro static fore between the charges will be. [F= K. $\frac{q_1q_2}{r^2}$]

Ans: Four times less.

30. The force between two charges in a medium of dielectric constant D and in the air is 1 : D

31. The force between two charges in a medium of dielectric constant D and in the air is F. If the charges and the distances between these are doubled, then the force between them is

a) F. b) 2F c) F/4 d) 4F

32. The accumulation of charges in a charged conductor is maximum at

a) a point where the curvature is maximum b) sharp points

c) a point where the radius is minimum **d) all the above**

33. The capacitance of a parallel plate capacitor is C. If the charge on the capacitor is doubled, then the capacitance will be

a) C b) 2C c) C/2 d) C^2

34. Radius of the conductor 'r' and its charge density σ is related as $\sigma \propto \frac{1}{r}$

35. In micro wave oven, the water molecules are excited by

a) force **b) oscillating torque** c) torque d) oscillating force

36. In parallel plate capacitor, the electric field at any point between the plates does not depend on charge on the plates. [Note: $E = \sigma / \varepsilon_0$]

37. Gauss's law tells us that the flux of E through a closed surface S depend only on the value of net charge inside the surface and not on the location of the charges.

Frequently Asked Problems:

1. A capacitor of capacitance 6μF is connected to a 100 V battery. The energy stored in a capacitor is …….. {M'08}

Solution: $U = \frac{1}{2} CV^2 = \frac{1}{2} \times 6 \times 10^{-6} \times 100 \times 100 = 3 \times 10^{-2}\ J = 0.03\ J$

2. The equivalent capacitance of two capacitors in series is 1.5μF. The capacitance of one of them is 4 μF. The value of capacitance of the other is --------. {O'07, O'09}

Solution: $C = \frac{C_1C_2}{C_1 + C_2} = \frac{4C_2}{(4+C_2)} = 1.5 \Rightarrow 4C_2 = 1.5\,(4+C_2)$

$4C_2 = 6+1.5C_2$

$4C_2 - 1.5C_2 = 6$

$2.5C_2 = 6$

$C_2 = 6 / 2.5 \quad \therefore \boxed{C_2 = 2.4\ \mu F}$

3. The work done in moving 4 μc charge from one point to another in an electric field is 0.012 J . The potential difference between them is... {M'06}

Solution: Work done $W = V.q_2$; $V = \frac{W}{q_2} = \frac{0.012}{4 \times 10^{-6}} = 3000\ V = 3\ KV$

$= 3 \times 10^3\ V$

4. Three capacitors of capacitance 1 μF , 2 μF , 3 μF are connected in series . The effective capacitance of the capacitor is ------ {M'10}

Solution:

$1/C = 1/C_1 + 1/C_2 + 1/C_3$

$\frac{1}{C} = \frac{1}{1} + \frac{1}{2} + \frac{1}{3} = \frac{6+3+2}{6} = \frac{11}{6} \qquad \therefore C = \frac{6}{11}\ \mu F$

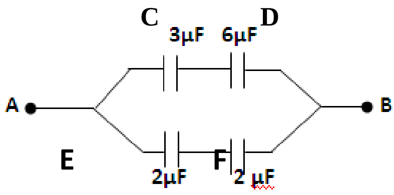
5. Potential energy of two equal negative point charges of magnitude 2μC placed 1 m apart in air is ____________. {J'06}

Solution:

Electric P. E = $\frac{q_1q_2}{4\pi\varepsilon_o r} = \frac{2 \times 10^{-6} \times 2 \times 10^{-6} \times 9 \times 10^9}{1} = 0.036\ J = \boxed{36 \times 10^{-3}\ J}$

$= 3.6 \times 10^{-2}\ J$

6. In the given circuit, the effective capacitance between A and B will be …… {J'07}



Solution:

C_1 => C, D are series $\dfrac{C_1 C_2}{C_1+C_2} = \dfrac{3 \times 6}{3+6} = \dfrac{18}{9} = 2\ \mu F$

C_2 => E, F are series $\dfrac{C_1 C_2}{C_1+C_2} = \dfrac{2 \times 2}{2+2} = \dfrac{4}{4} = 1\ \mu F$

Both are parallel $C = C_1 + C_2 = 2 + 1 = \boxed{3\ \mu F}$

7. The magnitude of the force acting on a charge of 2×10^{-10} C placed in a uniform electric field of 10 Vm^{-1} is $\underline{2 \times 10^{-9}\ N}$ [Hint: E= F/q] { Mar ' 09 }

8. The intensity of electric field that produces a force of 10^{-5} N on a charge of 5 μC is –
Solution: $E = F/q = 10^{-5}/5 \times 10^{-6} = 2\ N\ C^{-1}$ [M'11]

9. The capacitance of a parallel plate capacitor increases from 5 μ F to 50 μ F when a dielectric is filled between the plates. The *permittivity* of the dielectric is------- [J'09]
Solution:

$\varepsilon_r = \dfrac{C'}{C} = \dfrac{50}{5} = 10$ but $\dfrac{\varepsilon}{\varepsilon_0} = \varepsilon_r$; $\varepsilon = \varepsilon_r \varepsilon_0 = 10 \times 8.854 \times 10^{-12}$

$\varepsilon = 8.854 \times 10^{-11}\ C^2 N^{-1} m^{-2}$

10. The ratio of electric potential at points 10 cm and 20 cm from the centre of an electric dipole along its axial line is ......(Hint: $v = P\cos\theta / 4\pi\varepsilon_o r^2$) [July 2010]
a) 1:2 b) 2:1 c) 1:4 d) 4:1
Solution: $v = \dfrac{p}{4\pi\varepsilon_o r^2}$; $V_1 : V_2 = \dfrac{p}{4\pi\varepsilon_o (10)^2} \times \dfrac{4\pi\varepsilon_o (20)^2}{p} = \dfrac{400}{100} = 4:1$

11. Two capacitances 0.5 μ F and 0.75 μ F are connected in parallel. Calculate the effective capacitance of the capacitor. S'15
Solution: $C_p = C_1 + C_2 = 0.5 + 0.75 = 1.25\ \mu F$

11. The number of lines of force that radiate outwards from one coulomb charge is...
Solution: $N = \dfrac{q}{\varepsilon_o} = \dfrac{1}{8.854 \times 10^{-12}} = 1.129 \times 10^{11}$

12. The potential at a point due to a charge 4×10^{-7}C located at 0.09 m away is----.
Solution:

$V = \dfrac{q}{4\pi\varepsilon_o r} = \dfrac{4 \times 10^{-7} \times 9 \times 10^{9}}{0.09} = 4 \times 10^{4}\ V$

13. 5 μF capacitor is charged by a battery of 1000 V potential, then the energy stored in the capacitor is __________.
Solution: $\frac{1}{2} Cv^2 = \frac{1}{2} \times 5 \times 10^{-6} \times 10^{6} = 2.5$ J.

14. If a capacitor of capacitance 55 pF is charged to 1.6 V , then the number of electrons on its negative plate is ....

Solution: $q = ne$; $n = \frac{q}{e}$ [to find q → $C = q / V$, $q = CV$]

$$n = \frac{CV}{e} = \frac{55 \times 10^{-12} \times 1.6}{1.6 \times 10^{-19}} = 55 \times 10^{7}$$

15. Two charges 10^{-6}C and 10^{-7}C repel each other with a force of 400 N. The distance between the charges is 1.5 mm.

Solution: $F = \frac{q_1 q_2}{4\pi\varepsilon_o r^2}$ ∴ $r^2 = \frac{q_1 q_2}{F 4\pi\varepsilon_o} = \frac{10^{-6} \times 10^{-7} \times 9 \times 10^{9}}{400} = 2.25 \times 10^{-6}$ ∴ $r = 1.5 \times 10^{-3}$ m

16. The potential difference between two parallel plate is 100 V, the electric field between them is 10^4 V/m. Then the distance between the plates is 1 cm.

Solution: $E = -\frac{dv}{dx}$; $dv = \frac{dx}{E}$ => $\frac{100}{10^4} = 10^{-2}$m = 1 cm

17. The work done in moving a charge of 2μC between two points having different potential of 110 V and 220 V is 2.2 x 10^{-4} J.

Solution: $W = (V_B - V_A) q_2 = (220 - 110) \times 2 \times 10^{-6} = 2.2 \times 10^{-4}$ J

18. Two charges +4 C and +1C are separated by a distance 3 m. To keep these charges in equilibrium, a third charge is to be placed at 2m from the charge 4C.

Solution: [Ref 1.5 Solved problem]

$$\frac{4}{X^2} = \frac{1}{(3-X)^2} \qquad \boxed{X = 2}$$

19. If the distance between two protons in uranium atom is 9 x 10^{-15} m the mutual electric potential energy is 2.56 x 10^{-14} J.

Solution:

$$U = \frac{q_1 q_2}{4\pi \varepsilon_o r} = \frac{1.6 \times 10^{-19} \times 1.6 \times 10^{-19} \times 9 \times 10^{9}}{9 \times 10^{-15}} = 2.56 \times 10^{-14} \text{ J}$$

20. If the moment of an electric dipole is 1.2 x 10^{-9} Cm, and the distance between the charges is 3mm, then the charge of the dipole is 0.4 μC

Solution:

$p = 2qd$ $$q = \frac{p}{2d} = \frac{1.2 \times 10^{-9}}{3 \times 10^{-3}} = 0.4\ \mu C = \boxed{0.4 \times 10^{-6} \text{ C}}$$

21. The total flux over a closed surface enclosing a charge q is 36 π x 10^9 q .

Solution: $\phi = \frac{q}{\varepsilon_0}$ w.k.t $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}$; $\frac{1}{\varepsilon_0} = 36\pi \times 10^{9}$

22. The number of lines of forces emerging from a charge 8.854 μC is 10^6 .

Solution: $n = q/\varepsilon_0 = 8.854 \times 10^{-6} / 8.854 \times 10^{-12} = 10^6$.

23. The electric flux around a charge 17.7 X 10^{-15} C with in a closed surface in air is ---

Solution: $\phi = \frac{q}{\varepsilon_o} = \frac{17.7 \times 10^{-15}}{8.85 \times 10^{-12}} = 2 \times 10^{-3}\ N\ m^2 C^{-1}$

24. 6 μC charge is given to a thin infinite plate of area 3 cm^2. Find its charge density.

Solution:

$\sigma = \frac{q}{A} = \frac{6 \times 10^{-6}}{3 \times 10^{-4}} = 2 \times 10^{-2}\ C\ m^{-2}$

25. The force between two charges is 5N. If they are placed in a medium of relative permittivity 5, then the force will be ___________

a) 25 N b) 5N **c) 1 N** d) 10N

Solution: $F = 5N$, $\varepsilon_r = 5$ $F_m = \frac{F}{\varepsilon_r} = \frac{5}{5} = 1\ N$

26. The force experienced between two point charges placed in medium of relative permittivity ε_r = 4 is 0.8 N. What is the force when they are placed in vacuum?

Solution: $\frac{F}{F_m} = \varepsilon_r$ $F = \varepsilon_r F_m = 0.8 \times 4 =$ **3.2 N.**

27. The work done to move a charge of 0.2 μC from one point do another point is 8 mJ. Then the potential difference between the point in __________.

Solution: $W = Vq$, $V = \frac{W}{q} = \frac{8 \times 10^{-3}}{0.2 \times 10^{-6}} = 4 \times 10^4\ V$

28. The potential due to a charge of 6 μC at a point distance 3m is__________.

Solution: $V = \frac{q}{4\pi \varepsilon_o r} = \frac{9 \times 10^9 \times 6 \times 10^{-6}}{3} = 18\ KV$

29. The intensity of the electric field that produces a force of 20 N on a charge of 4C is

Solution: $E = \frac{F}{q} = \frac{20}{4} = 5\ NC^{-1}$

30. The work done in moving a charge of 2 X 10^{-9} C from a point of potential 3000 V to another point is 5 X 10^{-5}J . What is the potential at that point?

Solution: $(V_B - V_A)\ q = W$

$(V - 3000)\ 2 \times 10^{-9} = 5 \times 10^{-5}$

$\boxed{\therefore V = 28000\ V}$

31. Two capacitors of capacitance 2 μF each are connected in series. Then the effective capacitance will be 1 μF.

Solution: $C_s = C_1C_2 / C_1+C_2 = 4/4 = 1$

Other Important problems

01. A parallel plate capacitor connected to 12 V source is charged to 21 μC. If the capacitor is filled with an oil of dielectric constant 3, then the charge stored is 63 μC.

Solution: $\varepsilon_r = C' / C\ \therefore C' = \varepsilon_r C = \varepsilon_r .q / V$

$$C' = 3 \times \frac{21\times10^{-6}}{12} = \frac{21 \times 10^{-6}}{4}$$

but $q = C'V = \frac{21 \times 10^{-6} \times 12}{4}$ q $\boxed{= 63\ \mu C}$

02. The electric potential at a distance 12cm from a point charge 6 nC is------

a) 72 b) 500 V **c) 450 V** d) 200 V

Solution:

$$V = \frac{1}{4\pi\varepsilon_o}\frac{q}{r} = \frac{9 \times 10^{9} \times 6 \times 10^{-9}}{12 \times 10^{-2}} = 450\ V$$

03. The electric flux inside the hallow metallic sphere of radius 5 cm is 8 x 10^3 Nm^2c^{-1}. Find the amount of charge within the sphere.

Solution: $\phi = \frac{q}{\varepsilon_o}$ => $q = \phi\, \varepsilon_o$

$= 8 \times 10^{3} \times 8.854 \times 10^{-12}$

$= 70.8 \times 10^{-9}$ C (or) 70.8 n C

04. The numbers of electric lines of force produced by 5 μC of charge in vacuum is :

Solution: $N = \frac{q}{\varepsilon_o} = 36\pi \times 10^{9} \times 5 \times 10^{-6}$

$= 180 \times 3.14 \times 10^{3}$

$= 565 \times 10^{3}$

$N = 5.65 \times 10^{6}$

$$\left[\begin{array}{l} \frac{1}{4\pi\varepsilon_o} = 9 \times 10^{9} \\ \frac{1}{\varepsilon_o} = 36 \times 10^{9}\,\pi \end{array}\right]$$

05. The electric field at a point from an infinite sheet of charge having charge density 1.77 X 10^{-8} Cm^{-2} in ________.

Solution: $E = \frac{\sigma}{2\varepsilon_o} = \frac{17.7 \times 10^{-8}}{2 \times 8.85 \times 10^{-12}} = 10^{4}\ V\,m^{-1}$

06. The work done in bringing charges 12 μC and 18 μC at a distance of 6m is _____

Solution: $U = \frac{q_1q_2}{4n\,\varepsilon_o r} = \frac{9\times 10^{9} \times 12 \times 10^{-6} \times 18 \times 10^{-6}}{6}$ $\therefore U = 0.324\ J$

07. The plates of parallel plate capacitor are separated by a distance of 1 mm. If the capacitance is 8.854 μF, then the area of the plate is--------

a) 10^{-3} m^2 b) 10 m^2 c) 10^3 m^2 d) 10^2 m^3

Solution: $C = \frac{\varepsilon_o A}{d}$ $\therefore A = \frac{Cd}{\varepsilon_o} = \frac{8.854 \times 10^{-6} \times 10^{-3}}{8.854 \times 10^{-12}}$ $\therefore$ $A = 10^{3}\ m^2$

08. Equivalent Capacitance of two capacitors when connected in parallel is 8 μF and when connected in series is 15/8 μF .Then the values of the two capacitors are----

Solution: $C1 + C2 = 8$

$$\frac{C1\,C2}{C1+C2} = \frac{15}{8} \quad \therefore \quad C1C2 = \frac{15}{8}(C1+C2) \qquad = \frac{15}{8} \times 8 = 15$$

$C1+C2 = 8$; $C1C2 = 15$ $\quad \therefore C1 = 5\ \mu F$, $C2 = 3\mu F$.

09. Two capacitors of capacitance 200 pF and 600 pF are connected in parallel and then charged to a potential of 120V. Then the value of the total charge on the capacitor is __________.

Solution:

Total capacitance = 200 pF + 600 pF = 800 PF

$$C = \frac{q}{v} \quad \therefore q = CV \quad = 800 \times 10^{-12} \times 120$$

$$= 96 \times 10^{-9} C \quad = 96\ nC.$$

10. If two identical point charges separated by 3m experience a force of 10N, then the value of each charge is __________

Solution: $q_1 = q_2 = q$

$$F = \frac{q_1 q_2}{4\pi\varepsilon_o r^2} = \frac{q2}{4\pi\varepsilon_o r^2} = \frac{9 \times 10^9 \times q^2}{9} = 10N$$

$$q^2 = \frac{10}{10^9} = 10^{-8} \qquad q = 10^{-4}\ C$$

11. A parallel plate capacitor consists of two circular plates of radius 3cm separated by a dielectric material of thickness 0.5mm and dielectric constant 4. Then the capacitance of the capacitor is __________

Solution:

$$C = \frac{\varepsilon_r \varepsilon_o A}{d} = \frac{4 \times 8.85 \times 10^{-12} \times 3.14 \times (3 \times 10^{-2})^2}{0.5 \times 10^{-3}}$$

$$C = 200 \times 10^{-12}\ F \quad \therefore \quad C = 200\ pF.$$

12. The charge of a $_7N^{14}$ Nucleus is _______

Solution: $q = ne = 7 \times 1.6 \times 10^{-19} = 11.2 \times 10^{-19}$ C.

13. Two capacitors of capacitance 5 μF are in series. The effective capacitance is <u>5/2 μF</u> .

Solution: $Cs = \frac{C_1 C_2}{C_1 + C_2} = \frac{25}{10} = 5/2$

14. A 20 C charge moved through 2cm, the amount of work done is 2J,Then the potential difference between the two points is_________.

Solution: $W = qv \quad V = \frac{W}{q} = \frac{2}{20} = 0.1$ V.

15. The amount of work done to charge a capacitor of capacitance 100 μF to a value of 8×10^{-18} C is---------

Solution: $\frac{1}{2}CV^2 = \frac{q^2}{2C}$ $\left[C = \frac{q}{V}, \quad V = \frac{q}{C} \right]$

$$\frac{q^2}{2C} = \frac{(8 \times 10^{-18})^2}{2 \times 100 \times 10^{-6}} = 32 \times 10^{-32} J$$

16. The potential difference which accelerates an electron to 6.4×10^{-18} J energy is—

Solution: $W = Vq \therefore V = W/q = \frac{6.4 \times 10^{-18}}{1.6 \times 10^{-19}} = 40$ V

17. If the distance between two protons in uranium atom is 9×10^{-15} m, then the mutual electric potential energy between them is 2.56×10^{-14} J.

Solution: $U = \frac{q_1 q_2}{4\pi\varepsilon_o r} = \frac{1.6 \times 10^{-19} \times 1.6 \times 10^{-19} \times 9 \times 10^{9}}{9 \times 10^{-15}} = 2.56 \times 10^{-14}$ J

18. The distance between the two point charge is reduced to half and each charge is doubled, then the force will be increases 16 times

Solution: $F = \frac{q_1 q_2}{4\pi\varepsilon_o r^2} = \frac{2q_1\, 2q_2}{4\pi\varepsilon_o (r/2)^2} = \frac{16\, q_1 q_2}{4\pi\varepsilon_o r^2} = 16$ F

19. An electric dipole with dipole moment 4×10^{-9} C m is kept at 30^0 with the direction of uniform electric field of magnitude 5×10^4 NC^{-1}. The magnitude of the torque in the dipole is 10^{-4} N m

Solution: $\tau = pE \sin\theta = 4 \times 10^{-9} \times 5 \times 10^4 \sin 30 = 10^{-4}$ N m

20. When two point charges +6 C and -5 C experiences a force of 2.7×10^{11} N, the distance between them is 1 m

Solution: $F = \frac{q_1 q_2}{4\pi\varepsilon_o r^2} \therefore r^2 = \frac{q_1 q_2}{4\pi\varepsilon_o F} = \frac{6 \times 5 \times 9 \times 10^9}{2.7 \times 10^{11}} = 1$ $r^2 \boxed{= 1, \quad r = 1}$

21. Two identical metal spheres have charges +15 μC and +25 μC are separated by a distance. If the spheres are first brought into contact and then separated to the original distance, then the ratio of the new force between them to the previous force is 16:15

Solution: 15+25 = 40/2 = 20 ∴ 20 x 20 : 15 x 25 = 400 : 375 = 16 :15

22. Three capacitors 2 μF , 5 μF and 3 μF are in parallel in across with 5 V power supply. The charges on each of them respectively are 10 μC, 25 μC , 15 μC.

Solution:

$C_p = C_1 + C_2 + C_3$ =2+5+3 =10 μF ; C = Q/V ;Q = CV 10 x 5 =50 μF

$q_1 = C_1V$ = 2 μF x 5 = 10 μC ; $q_2 = C_2V$ = 5 μF x 5 = 25 μC ; $q_3 = C_3V$ = 3 μF x 5 = 15 μC

2. CURRENT ELECTRICITY

S.No	Quantity	Formula	Unit
1.	Current	$i = dq/dt$ $I = q/t$	Ampere
2.	Drift velocity	$V_d = \frac{eE\tau}{m} = \mu E$	m s^{-1}
	acceleration	$a = eE/m$	m s^{-2}
3.	Mobility	$\mu = \frac{e\tau}{m}$	$m^2 V^{-1} s^{-1}$
4.	Current density	$J = \frac{I}{A}$ (or) nev_d	Am^{-2}
5.	Resistance	$R = \frac{mL}{nAe^2\tau}$	Ohm (Ω)
6.	Conductance	$C = 1/R$	mho (or) Ω^{-1}
7.	Specific Resistance (electrical resistivity)	$\rho = \frac{RA}{L}$	Ω m (or) ohm m
8.	Electrical conductivity	$\sigma = \frac{1}{\rho}$	$\Omega^{-1} m^{-1}$ (Or)mho m^{-1} {J'07}
9.	Electro Chemical equivalent	$Z = m/q$	Kg C^{-1}
10.	Temp. Co.efficient of resistance.	$\alpha = \frac{R_t - R_o}{R_o t}$	Per °C(or) °C^{-1}
11. 12.	Resistance in Series Resistance in Parallel	$R_s = R_1+R_2+R_3+...$ $\frac{1}{Rp} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$	ohm
13.	Electric field	$E = F/q$	NC^{-1} or Vm^{-1}
14.	Ohm's law	$I \alpha V$	
15	Internal resistance of a cell	$r = \frac{(E-V)}{V} R$	Ohm
16	Power	$P = VI = I^2R$	Watt
17.	Electric Energy	Power X time	Joule
18	Temperature Co-efficient of resistance (for difference temperature	$\alpha = \frac{R_2 - R_1}{R_1t_2 - R_2t_1}$	Per°C (or) /°C

Govt. Exam Questions :

1. Mercury has zero resistance at ***4.2 K***. { -268.8 ^{0}C} **[J'09]**
2. The colour of carbon resistor is orange, orange, red. What is the value of resistance?

   Ans: 33 x 10^2 = 3300 Ω = 3.3 K Ω

   ii) Red, Red, black = 22 x 10^0 = 22 Ω **[J'06]**
3. If the diameter of wire is doubled, its resistance will become **M'12**

   a) *half* b) double c) four times d) **one- forth**.[Decreases four times]
4. The electrical resistivity of thin copper wire and a thick copper rod are respectively $\rho_1\Omega$m and $\rho_2\Omega$m. Then : **M'13**

   a) $\rho_1 > \rho_2$ b) $\rho_2 > \rho_1$ **c)** $\rho_1 = \rho_2$ d) $\rho_2 / \rho_1 = \infty$
5. When 'n' resistors of equal resistance (R) are connected in series and in parallel respectively, then the ratio of their effective resistance is **M'14**

   a) 1 : n^2 **b)** n^2 : 1 c) n : 1 d) 1 : n
6. A graph is drawn taking potential difference across the ends of a conductor along X-axis and current through the conductor along the Y-axis. The slope of the straight line gives: **M'15**

   a. resistance **b. conductance** c. resistivity d. conductivity
7. 1 Wh (watt hour) is equal to : **M'16**

   a) 36 x 10^5 J b) 36 x 10^4 J **c) 3600 J** d) 3600 Js^{-1}

Frequently Asked Questions:

Materials	Resistivity	Examples
Conductors	10^{-6} to 10^{-8} Ωm	Silver, Al, Cu, Fe, Tungsten, Nichrome,manganin,constantan
Insulators	10^8 to 10^{14} Ωm	Glass, mica, amber, quartz, Teflon,wood,bakelite
Semi Conductor	10^{-2} to 10^4 Ωm	Germanium, silicon

1. The reciprocal of resistance is conductance. Its unit is mho or (Ω^{-1}).
2. Resistivity of metals increase with increase in temperature.
3. Insulators and Semi conductors have *negative* temperature coefficient of resistance i.e their resistance *decreases with increase in temperature.*
4. Metals have positive temperature coefficient of resistance i.e their resistance *increases with increase in temperature.*
5. A material with negative temperature co-efficient is called thermistor.
6. Kirchoff's first law (current law) is a consequence of conservation of charges.
7. Kirchoff's second law (voltage law) is a consequence of conservation of energy.
8. 1 K Wh = One unit of electric energy = 1000 Wh = 1000 x 3600 = 36 x 10^5 J = 3.6 x 10^6J
9. Unit of electro chemical equivalent is kgC^{-1}.
10. Temperature Co- efficient of manganin is *low and positive.*

11. **The transition temperature of mercury**

    a) 4.2 °C *b) -268.8°C* (4.2 K) c) -277°K d) (a) & (c)

12. **The phenomenon of Super conductivity was first observed by**

    a) Kammerlingh *Onnes[1911]* b) Bardeen c) Cooper d) Einstein.

13. **In a carbon resistor the third coloured ring indicates powers of 10 to be multiplied.**
14. **Resistivity of a conductor depends on the nature of the conductor.(** It is a *constant* for a particular material.)
15. **The relation ship between current and drift velocity is $I = nAV_de$**
16. **Relation between current density and drift velocity is $J= nV_de$**

Other Important Questions:

1. The external energy necessary to drive the free electrons in a definite direction is called electromotive force.{ emf}
2. The drift velocity of electrons is proportional to the electric field intensity. It is in the order of 0.1 cm s^{-1} = 0.1 x 10^{-2} ms^{-1} = 1 x 10^{-3} ms^{-1} = 1 mm
3. The temperature co-efficient is *low for alloys*.
4. A freshly prepared cell has *low internal resistance*. Due to ageing the internal resistance of a cell increases.
5. Kirchoff's Laws can be used in complicated circuits.[Ohm's law for simple circuit]
6. In Kirchoff's second law, the current in clockwise direction is taken as positive and the current in anti clockwise direction is taken as *negative.*
7. Electric power = $\frac{\text{Work done}}{\text{Time}} = \frac{VIt}{t} = VI = I^2R$ [V=IR] : Unit: watt
8. Electric energy: Capacity to do work. It is measured by watt hour (OR) kilowatt hour.(KWh)
9. The electrode towards which positive ions travel is *cathode.*
10. The electrode towards which negative ions travel is *anode.*
11. Lead-Acid Accumulator: Emf = 2.2V, As the cell is discharged by drawing current from it, the emf falls to about 2 volts, specific gravity of electrolyte is 1.28.
12. Force experienced by a free electron in an electric field E is *F = Ee*
13. At the transition temperature, electrical resistivity equal to zero and electrical *conductivity is equal to infinity.* The magnetic flux lines are excluded from the material.
14. The core of carbon resistor is made up of ceramic.
15. An instrument used to measure electric power consumed is *watt meter.*

Colour code for resistors:

Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Grey	White
0	1	2	3	4	5	6	7	8	9

16. **Tolerance:**

Silver	Gold	Red	Brown	no colour
10%	5%	2%	1%	20%

17. The passage of an electric current through a liquid causes chemical changes and this process is called electrolysis.
18. The plates through which current enters and leaves an electrolyte are known as electrodes. Liquids are called electrolytes.
19. The cells from which electrical energy in derived by irreversible chemical actions are called Primary cells.
   i) Eg. Daniel cell, Leclanche cell, dry cell.
   ii) These cells cannot be recharged electrically.
20. Chemical equivalent $= \dfrac{\text{Relative atomic mass.}}{\text{Valency}}$

$$= \frac{\text{mass of the atom}}{1/12 \text{ of the mass of } C^{12} \text{ atom } \times \text{ Valency}}$$

21. Ohm's law holds good only when a steady current flows through a conductor.
22. If E is the strength of the electric field, e is the charge of electron and m is the mass of electron, the acceleration produced is given by

   a) $\frac{em}{E}$ b) $\frac{Em}{e}$ ***c)*** $\frac{eE}{m}$ d) $\frac{m}{eE}$.
23. The first electrochemical battery is produced by

   a) Luige Galvani b) Lucia c) ***Alessandro Volta*** d) Daniel.
24. The direction of conventional current is the direction

   a) of motion of electrons b) of random motion of electron

   c)opposite to the motion of electrons d)opposite to the motion of positive charges
25. In the phenomenon of electrolysis

   a) Positive ions move towards cathode b) Negative ions move towards anode

   c) Positive ions move towards anode and negative ions move towards cathode

   d) ***Both (a) and (b) are correct.***
26. In primary cells, the metal used as negative electrode is

   a) Cu ***b) Zn*** c) Pb d) Ag.
27. Metre bridge consists of a wire of high

   a) temperature coefficient and low specific resistance

   b) temperature coefficient and high resistance

   c) specific resistance and high temperature coefficient.

   d) specific resistance and low temperature coefficient.
28. The resistivity of super conductor is

   a) Zero b) infinity c) moderate d) very low.

29. **The first theoretical explanation of superconductivity was given by <u>Bardeen, Cooper and Schrieffer</u> in 1957 and it is called the <u>BCS theory</u>.**
30. **Free electrons are very closely attached to the <u>nuclei.</u>**
31. **The resistance of a conductor of unit length having unit area of cross section is <u>resistivity or specific resistance</u> [$\rho = RA/L$].** Unit: ohm meter.

32. **The positive ions which are mostly formed from the metals or hydrogen are called <u>cations.</u>**
33. **When one coulomb charge is passed through the electrolyte, the mass of the substance liberated is called <u>electrochemical equivalent.</u>**
34. **In secondary cells the process of reproducing active materials is called <u>charging.</u>**
35. **While on charging and discharging the value of specific gravity of the electrolyte of secondary cell should be <u>1.28 and 1.12</u>**
36. **The current drawn from a battery is maximum when the internal resistance is <u>minimum.</u>**
37. **The thermodynamic internal energy of the material is sufficient to liberate the <u>outer *electrons*</u> from individual atoms.**
41. **The cells from which the <u>electrical energy</u> is derived by <u>irreversible</u> chemical reactions are called <u>primary cells</u>.**

CELL	ELECTRODES	ELECTROLYTES	EMF	CURRENT
Voltaic cell	Cu [+] , Zn [-]	Dilute sulphuric acid.	1.08 V	--
Daniel cell	Cu[+] , Zn [-]	Dil. H_2So_4 Cu So_4	1.08 V	--
Leclanche cell	Carbon Rod[+], Zinc Rod[-]	Ammonium Chloride Solution	1.5 V	0.25 A
Lead – Acid accumulator	Spongy lead(Pb) [-] lead oxide(PbO_2) [+]	Dilute sulphuric acid	2.2 V	--

+ Anode , - Cathode

<u>Cathode</u>: i) The positively charged terminal of a voltic cell or storage battery that supplies current.

ii) A negatively charged electrode that is the source of electron entering an electrical device.

<u>Anode:</u> i) The negatively charged terminal of a voltic cell or storage battery that supplies current.

ii) A positively charged electrode that is the source of electron entering an electrical device.

Frequently Asked Problems

01. Resistance of a metal wire of length 10 cm is 2 Ω. If the wire is stretched uniformly to 50 cm, the resistance is 50 Ω . {M'06}

Solution: Volume of wire, Before Stretching is equal to After Stretching , specific resistance is *constant* .

$\pi r_1^2 h_1 = \pi r_2^2 h_2$	$\rho = \frac{\pi r^2 x}{l}$	$r_2^2 R_2 = 10 r_1^2$
$10 r_1^2 = 50 r_2^2$	$\frac{\pi r_1^2 R_1}{l_1} = \frac{\pi r_2^2 R_2}{l_2}$	$R_2 = \frac{10 \times 5 r_2^2}{r_2^2}$
$r_1^2 = 5 r_2^2$	$\frac{2 r_1^2}{10} = \frac{R_2 r_2^2}{50}$	$R_2 = 50\ \Omega$
{Volume constant}		$R' = n^2R = 5^2 \times 2 = 50\ \Omega$
{Specific resisitance constant}		

02. Length of the wire with resistance R is stretched for 3 times of its original length, now the resistance becomes 9R [Ref. previous question]

03. A cell of emf 2.2 V sends a current of 0.2 A through a resistance of 10 Ω.The internal resistance of the cell is---1 Ω J'12

04. The resistance of a wire of 1 m length, and 0.034 mm² area of cross section having specific resistance 1.7×10^{-8} Ωm is = 0.5 Ω .

Solution: $\rho = \frac{\pi r^2 R}{l} = \frac{AR}{l}$; $R = \frac{\rho l}{A} = \frac{1.7 \times 10^{-8} \times 1}{0.034 \times 10^{-6}} = \boxed{0.5\ \Omega}$

05. A wire of resistance 0.1 Ω having a length of 30 m has a specific resistance of 2.7×10^{-8} Ω m. The area of cross section of the wire is ----

Solution: $\rho = \frac{\pi r^2 R}{l} = \frac{AR}{l}$ ∴ $A = \frac{\rho l}{R} = \frac{2.7 \times 10^{-8} \times 30}{0.1} = 8.1 \times 10^{-6}\ m^2$

06. The number of electrons flowing per second through a conductor when a current of 3.2 A flows through it is---------- .

Solution: $I = q/t = \frac{ne}{t}$; $n = \frac{It}{e} = \frac{3.2 \times 1}{1.6 \times 10^{-19}} = \boxed{2 \times 10^{19}\ A}$

07. A 1.15 KW, 230 V water heater can draw a current of _________.

Solution: $P = VI$; $I = P/V = \frac{1.15 \times 10^3}{230} = \boxed{5\ A}$

08. When two equal resistances connected in series and parallel then the ratio of their effective values is a) 1 : 1 b) 1 : 4 *c) 4 : 1* d) 1: 2

09. A current of 0.3 A from a cell of emf 1.5 V is passed through a resistance of 4Ω . The internal resistance of the cell is 1 Ω

Solution: $r = \left(\frac{E - V}{V}\right) R$ [but $V = IR = 0.3 \times 4 = 1.2$]

$= \left(\frac{1.5 - 1.2}{1.2}\right) 4$ $r = 1\ \Omega$

10. A 750 W power iron box is used for 4 hours. If the cost per unit is 75 paise the total expense is Rs 2.25 .

Solution: Energy = power x time = 750 x 4 = 3000 W = 3 unit

Total Amount = 3 x 0.75 = $\boxed{\text{Rs } 2.25}$

11. An incandescent lamp is operated at 240 V and the current is 0.5 A, then the resistance of the lamp is 480 Ω.

Solution: V = IR ∴ R = V/I = $\frac{240}{0.5}$ = $\boxed{480\ \Omega}$

12. If two resistors of resistance 200 Ωand 0.1KΩ are connected in series then the effective resistance of the system is -----------.

a) 200. 1 Ω b) *300 Ω* c) 201 K Ω d) 2.1 KΩ.

Solution: 200 + 0.1 x 10^3 = 200 + 100 = 300Ω

13. The current drawn by 1.5 KW, 220V water heater is _________

Solution: P= VI I = $\frac{P}{V}$ = $\frac{1.5 \times 10^3}{220}$ = $\frac{1500}{220}$ = 6.82 A.

14. An electrical instrument of resistance 30 Ω is operated at 240V.The power is __

Solution: P = VI = $\frac{V^2}{R}$ = $\frac{240 \times 240}{30}$ = 1920W = 1.92KW

15. A cell having 1.5V emf is connected with a resistor of 1000Ω. What is its power?

a) 2.25 mW b) 1.5 W c) 225 W d) 150 mW.

Solution: P = $\frac{V^2}{R}$ = $\frac{1.5 \times 1.5}{1000}$ = 2.25 x 10^{-3} W = 2.25 mW

16. A charge of 60 C passes through an electric appliance in one minute through a wire of cross section area 1 mm^2 . Then the current density is ------------

a) *10^6 Am^{-2}* b) 10^{-6} Am^{-2} c) 1 Am^{-2} d) 10^3 Am^{-2}

Solution: J = $\frac{I}{A}$ = $\frac{q/t}{A}$ = $\frac{60/60}{1 \times 10^{-6}}$ ∴ J = 10^6 A m^{-2} {t = 1 min = 60s}

17. The number of electrons flowing per second through a conductor, when a current of 3.2A flows through it is-----

a) 2 X 10^{19} b) 3 X 10^{18} c) 6.25 X 10^{18} d) 6.25 X 10^{19}

Solution:. q = It ; ne = It ; n = It /e = $\frac{3.2 \times 1}{1.6 \times 10^{-19}}$ ∴ n = 2 X 10^{19}

18. A power of 11000 W is transmitted at 220 V . The current through the line is --- [M'08]

Solution: P= VI ∴ I = P/V = 11000/220 = 50 A

19. Find the resistance of a carbon resistor which has only Brown , black,and red rings on one side continuously .

Solution: $10 \times 10^2 = 1000\ \Omega$ (or) $1\ K\Omega \pm 20\%$

20. A water heater is marked 1500 W , 220 V.The resistance offered by the heater is 32.26 Ω.

Solution: $P = VI = V^2/R$; $R = V^2/P$ => $220 \times 220 / 1500 = 32.26\ \Omega$

Other Important problems

01. If a charge of 1 C passes through an electrical equipment in 10 s , then the current flowing through it is -----

Solution: $I = q/t = 1/10 = 0.1A$

02. The marking at the bottom of a tape recorder are as follows. 9V, 450 mA. The net resistance of the tape recorder is ----

Solution: $R = V/I = 9/450 \times 10^{-3} = 9000/450 = 20\ \Omega$

03. An electrical instrument of resistance 30 Ω is operated at 240 V. the power is ------

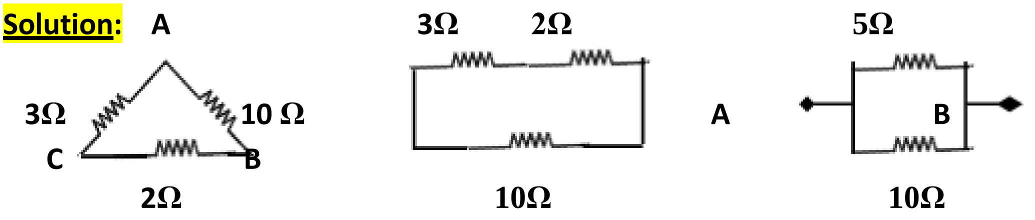
Solution: $P = VI = V^2/R = \frac{240 \times 240}{30} = 1920\ W = 1.92\ KW$

04. The resistance of the conductor of 10 m long and 0.1 mm² area is 1.7 Ω . The specific resistance of the material of the conductor is ---

Solution: $\rho = \frac{RA}{L} = \frac{1.7 \times 0.1 \times 10^{-6}}{10} = 1.7 \times 10^{-8}\ \Omega m$

05. Three resistances of values 10 Ω , 2 Ω and 3 Ω are connected to form the sides of a triangle AB,BC and CA respectively. The effective resistance between A and B is –

Solution:



$$R_p = \frac{R_1R_2}{R1+R2} = \frac{5 \times 10}{5+10} = \frac{50}{15} = 3.33\ \Omega$$

06. In a meter bridge with a standard resistance of 5 Ω in the right gap, the ratio of balancing lengths is 3:2. The value of the other resistance is ---

Solution: $P = Q\frac{L_1}{L_2} = 5 \times 3/2 = 15/2\ \Omega = 7.5\ \Omega$

07. The balancing lengths of two cells are 250 cm and 750 cm respectively, in a potentiometer experiment. If the emf of the first cell is 2V , the emf of the second cell is----

Solution: $E_1 / E_2 = L_1/L_2 \Rightarrow 2/E_2 = 250/750 \therefore E_2 = 6V$

08. A copper wire of 10^{-6} m^2 area of cross section carries a current of 1 A. The current density is----

Solution: $J = I/A = 1/10^{-6} = 1 \times 10^{6}\ A/m^2$

09. The value of a carbon resistor with the colour code of yellow, violet and orange is --.

Solution: $47 \times 10^3\ \Omega = 47\ K\Omega$

10. A cell has a potential difference of 6V in an open circuit, but it falls to 4V when a current of 2A is drawn from it. Then the internal resistance of the cell is ---

Solution:

$$r = \left(\frac{E - V}{V}\right) R = \left(\frac{6 - 4}{4}\right) 2 = \frac{4}{4} = 1\ \Omega$$

11. A cell of emf 9V and internal resistance 1Ω is connected to an external resistance of 8 Ω. The potential difference across the cell is ---

Solution: $r = \frac{E - V}{V} R$; $1 = \left(\frac{9 - V}{V}\right) 8 \Rightarrow V = 72 - 8V :: 9V = 72 \therefore V = 8\ V$

12.The ratio of diameter of two copper wires of length 2m and 8m having equal resistance is 1:2

Solution:

$$\frac{\pi r_1^2 x}{l_1} = \frac{\pi r_2^2 x}{l_2} \Rightarrow \frac{r_1^2}{2} = \frac{r_2^2}{8} \qquad \frac{r_1^2}{r_2^2} = \frac{2}{8} = \frac{1}{4}$$

$$\frac{D_1^2}{D_2^2} = \frac{1}{4} \qquad \frac{D_1}{D_2} = \frac{1}{2} \qquad \boxed{1 : 2}$$

13. An electric iron of resistance 80 Ω is operated at 200 V for two hours. The Electric energy consumed is 1 KWh.

Solution:

$$\text{Energy} = \text{power} \times \text{time} = VI.t$$

$$= V\frac{V}{R}.t = \frac{200 \times 200 \times 2}{80}$$

$$= [V^2/R]\,t = 1{,}000\ Wh = 1\ KWh$$

14. The current flowing through a conductor when 1.875×10^{19} electrons crossing a point in one second is ---.

a) 1.6×10^{9} A b) 6.25×10^{18} A c) 1 A d) 3 A

Solution: $I = \frac{q}{t} = \frac{ne}{t} = \frac{1.875 \times 10^{19} \times 1.6 \times 10^{-19}}{1} \therefore \quad I = 3A$

15. How many 100W bulbs may be safely used on 220 V with 5 A fuse?

a) 22 b) 11 c) 10 d) 20

Solution: P = VI = 220 x 5 = 1100 W ; 11 bulbs x 100 W = 1100W

16. When 1.6 A current is flowing through a conductor in one minute, then the number of electrons moving in it is-------------

a) 60×10^{19} b) 3×10^{20} c) 6.25×10^{18} d) 1.6×10^{-19}

Solution: $I = \frac{q}{t} \Rightarrow q = It$

$q = ne \Rightarrow ne = It$

$n = \frac{It}{e} = \frac{1.6 \times 60}{1.6 \times 10^{-19}}$

$\boxed{n = 60 \times 10^{19}}$

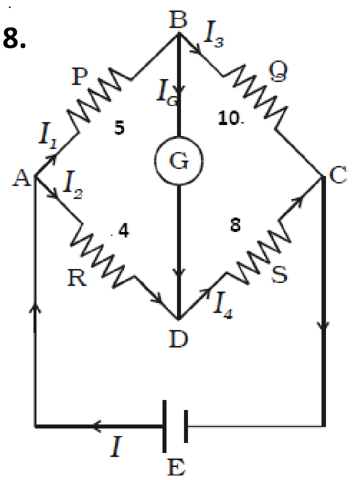
17. The average time between two successive collision of an electron is 3.64×10^{-8} s . Its mobility is ------.

Solution:

$\mu = \frac{e\tau}{m} = \frac{1.6 \times 10^{-19} \times 3.64 \times 10^{-8}}{9.11 \times 10^{-31}} = 6.4 \times 10^{3}\ m^2 V^{-1} s^{-1}$

18. In wheat stone's bridge, under bridge balance condition, the four resistances of the four arms in cyclic* order are

a) 5, 10, 4, 8 b) 5, 10, 8 , 4 c) 5, 8, 10, 4 d) 5, 4, 10, 8.



3. EFFECTS OF ELECTRIC CURRENT

S.No	Quantity	Formula	Unit
01.	Joule's law [Amount of heat produced]	$H = VIt = I^2Rt = \frac{V^2t}{R}$	Joule
02.	Neutral temperature	$\theta n = \frac{\theta c + \theta i}{2}$	°C
03.	Peltier Co-efficient	$\pi = \frac{H}{It}$	Volt (or) JC^{-1}
04.	Biot – Savart law	$dB = \frac{\mu_o}{4\pi} \frac{I.dl \sin\theta}{r^2}$	Tesla (or) Weber m^{-2}
05.	Magnetic induction (B) due to infinitely long straight conductor Carrying current	$B = \frac{\mu_o I}{2\pi a}$ $B = \frac{\mu I}{2\pi a}$ (for medium μ) [J'11]	Tesla (or) Weber m^{-2}
06.	B along the axis of a circular coil carrying current i) At the center of the coil x=0	$B = \frac{\mu_o n I a^2}{2(a^2 + x^2)^{3/2}}$ $B = \frac{\mu_o n I}{2a}$	Tesla (or) Weber m^{-2}
07.	Current in T.G Reduction factor	$I = K \tan\theta$ $K = \frac{2aBh}{\mu_o n}$	Ampere Ampere[M'06]
08.	Magnetic induction due to long Solenoid Carrying current i) With medium	$B = \mu_o n I$ $B = \mu n I = \mu_o \mu_r n I$	Tesla Tesla
09.	Magnetic Lorentz force	$\vec{F} = q\,(\vec{V} \times \vec{B})$ [J'06] $F = Bqv \sin\theta$	Newton
10.	Force on a current carrying conductor in a magnetic field	$\vec{F} = I\vec{l} \times \vec{B}$ $F = BIL \sin\theta$	Newton
11.	Force between two long parallel current carrying conductors.	$F = \frac{\mu_o I_1 I_2 L}{2\pi a}$	Newton
12.	Torque experienced by a current loop in a uniform magnetic field	$\tau = nBIA \sin\theta$	Nm
13.	Current in moving coil galvanometer	$I = \frac{C}{nBA}\theta$	ampere
14.	Current sensitivity	$\frac{\theta}{I} = \frac{nBA}{C}$	Radian/ampere
15.	Voltage sensitivity	$\frac{\theta}{V} = \frac{\theta}{IG} = \frac{nBA}{CG}$	Radian/volt
16.	G → A Shunt Resistance(low R ,II^{el})	$S = G \frac{Ig}{I - Ig}$	Ohm

17.	G → V ; Shunt Resistance (High, series)	$R = \frac{V}{Ig} - G$	Ohm
18.	Magnetic moment of current loop	M = IA	Am^2
19.	Gyro magnetic Ratio 8.8×10^{10} C Kg^{-1}	$\frac{\mu}{L} = \frac{e}{2m}$	CKg^{-1}
20.	Bohr magnetron 9.27×10^{-24} Am^2	$\frac{eh}{4\pi m}$	Am^2
21.	Thermo emf of thermocouple	$V = \alpha\theta + \frac{1}{2}\beta\theta^2$	volt

Biot – Savart law

In vector form, $\overrightarrow{dB} = \frac{\mu_o}{4\pi}\frac{I\overrightarrow{dl} \times \vec{r}}{r^3}$ or $\overrightarrow{dB} = \frac{\mu_o}{4\pi}\frac{I\overrightarrow{dl} \times \hat{r}}{r^2}$

$\mu o = 4\pi \times 10^{-7}$ henry/metre. For air $\mu r = 1$.

Govt. Exam Questions:

01. Fuse wire: Lead[Pb] – 37%, Tin[Sn] – 63 % . [M'08]

It has *high resistance* and low melting point. O'11

02. Lorentz force : $\vec{F} = q(\vec{V} \times \vec{B}) = BqV \sin\theta$ [J'09]

In the presence of electric field, $\vec{F} = q\,[(\vec{V} \times \vec{B}) + \vec{E}]$

03. G $\xrightarrow[\text{Parallel}]{\text{Low Resistance}}$ A   G $\xrightarrow[\text{Series}]{\text{High Resistance}}$ V [M'06]

04. Thermopile works on the principle of [O'07]

a) Peltier effect b) Thomson effect c) Seebeck effect d) Magnetic effect

05. In which of the following pairs of metals of a thermo couple the emf is maximum?

a) Fe – Cu b) Cu – Zn c) Pt – Ag d) Sb – Bi [J'07]

06. When the number of turns in a Galvanometer is doubled, the current sensitivity [O'10,S'15]

a) remains constant b) decreases twice c) increases twice d) increases four times

07. Peltier effect is the *converse of Seebeck effect*. [M'07]

08. Thermopile is used to measure *the intensity of thermal radiation*. [O'08]

09. For a given thermo couple the neutral temperature is *constant*. [J'10]

10. In the experiment to verify Joule's law when the current passed through the circuit is doubled keeping resistance (R) and time of passage of current(t) constant, temperature of the liquid [O'12]

a) increases twice b) increases four times

c) increases sixteen times d) decreases four times

Hint: $H = I^2Rt$

11. Consider a circular coil of radius 10cm in an air medium. If 5A current passes through it, what would be the magnetic induction at its centre? **M'14**

a) $\pi \times 10^{-5}$ T b) $\pi \times 10^{5}$ T c) $\pi \times 10^{-15}$ T d) $\pi \times 10^{-6}$ T

12. A proton and an α particle are projected with the same velocity normal to a uniform magnetic field. The ratio of the magnetic Lorentz force experienced by the proton and the α particle is: **[J'15]**

a. 1 : 1 **b. 1 : 2** c. 2 : 1 d. 1 : 0

13. The scattering of sun light by gas molecules in the earth's atmosphere is : **O'14**

a) Raman effect b) α – scattering c) Tyndal scattering d) **Rayleigh scattering**

14. In Joule's Calorimeter experiment, when a current of 1 ampere is passed through a coil for a known interval of time 't', the temperature of water increases from 30⁰C to 33⁰C. When a current of 2 A is passed through the same coil placed in the same quantity of water and for the same time, the temperature of water increases from 30⁰C to: **M'15**

a. 33^0C b. 36^0C c. 39^0C **d. 42^0C**

Hint: $\frac{I_1^2 Rt}{I_2^2 Rt} = \frac{wd\theta_1}{wd\theta_2} = \frac{1}{4} = \frac{3}{d\theta_2}$

15. A wire of length 1 m is made into a circular loop and it carries a current of 3.14 A . The magnetic dipole moment of the current loop (in Am^2) is: **M'16**

a) 1 b) 0.5 **c) 0.25** d) 0.314

Frequently Asked Questions:

1. **Melting point of tungsten is 3380⁰C.**
2. **Nichrome: alloy of nickel and chromium. It is used as a heating element.**
3. **Joules heating effect is undesirable in dynamo and transformer.**
4. **Relationship between θn , θi , θc is** $\theta n = \frac{\theta i + \theta c}{2}$
5. **Peltier co-efficient** $\pi = \frac{H}{It}$ **; Unit : Volt**
6. **Positive Thomson effect [Ex]: : Ag, Au, Cd, Sb, Sn, Zn, Cu**
   Negative Thomson effect [Ex]: : Fe, Bi, Co, Hg, Ni, Pt
   Zero Thomson effect [Ex:] : Lead
7. **Unit of Thomson co-efficient is volt per ºC.**
8. **Unit of Magnetic induction : Telsa (or) Weber m^{-2}** Magnetic Flux: **Weber**
9. **Reduction factor of T.G is** $K = \frac{2aBh}{\mu_o n}$ **,** ***UNIT : Ampere***
10. **Direction of magnetic induction around a straight conductor carrying current is determined by *Maxwell's Right hand cork screw rule.***
11. **Direction of magnetic field due to solenoid is given by *Right hand palm rule.***

12. T.G is used to measure current. It works on the principle of Tangent law.

13. Magnetic field outside the solenoid is Zero.

14. The magnetic polarity of current carrying solenoid is given by *end rule.*

15. Ideal ammeter has *zero resistance*. Ideal voltmeter has infinite resistance.

16. Which of the following statement is wrong?

The neutral temperature of thermocouple-------

a)constant of given couple b) depends on the temperature of cold junction

c) $\theta_n = \frac{\theta_i + \theta_c}{2}$ **d) The temperature at which thermo emf is maximum.**

17. Magnetic induction at the centre of a circular coil of radius 'a' is $B = \frac{\mu_o n I a^2}{2(a^2 + x^2)^{3/2}}$

When x = 0 $B = \frac{\mu_o n I}{2a}$

18. Suspended coil galvanometer can measure current in the order of 10^{-8} **A.**

19. Two parallel wires carrying same current in opposite direction will experience *repulsive force.*

Two parallel wires carrying same current in same direction will experience *attractive force.*

20. Work done by Lorentz force is always zero.

21. Thomson effect is zero for lead. So that it is used for the purpose of drawing thermo electric diagrams.

22. Electric filament lamp is working on the basis of

a) *Joule's heating effect* b) Peltier effect c) Thomson effect d) Seebeck effect

23. The neutral temperature of a thermocouple depends on

a) Temperature of cold junction **b) Temperature of hot junction**

c) *The metals which make the thermocouple* **d) None of these.**

24. The torque experienced by a current loop is maximum ,when the coil *is parallel to the magnetic field* and zero when the coil is perpendicular to the magnetic field.

25. The coil in a moving coil galvanometer is suspended by a Phosphor-bronze wire.

26. Biot – Savart law expressed in an alternative way is called Ampere's circuital law.

27. In a thermo pile the deflection of the galvanometer is proportional to ---------of the radiation

a)intensity b)frequency c)velocity d)energy

28. If a current carrying conductor is placed parallel to the magnetic field then the force acting on the conductor is zero.[Note: F=B$I\ell$sinθ; Perpendicular –maximum]

29. For small temperature difference the graph showing the variation of thermo emf with temperature of hot junction is a <u>straight line</u>. [Note: For large difference in temperature, the graph is a parabola.]

Other Important Questions:

1. Galvanometer is used to detect the direction of flow *<u>of current.</u>*
2. Nichrome wire is used as heating element, because it has
   i) high specific resistance ii) high melting point iii) not easily oxidized
3. If the radius of the coil and the number of turns is doubled the magnetic field at the centre of the coil *<u>remains same.</u>*
4. To increase the range of an ammeter shunt resistance should be <u>smaller.</u>
5. When an electron is <u>revolving</u> around the nucleus, magnetic dipole moment is due to *<u>orbital magnetic moment.</u>*
6. When an electron is <u>rotating</u> around the nucleus, magnetic dipole moment is due to its <u>spin</u>.
7. In an unequally heated conductor , when current is flowing from a region of lower temperature to a region of higher temperature <u>Heat energy absored;positive Thomson effect</u> { Note: high temp→low temp ; Heat energy evolved;NegativeThomson effect]
8. <u>Angular frequency</u> and period of rotation of a charged particle in a magnetic field is *<u>independent of velocity and radius of the particle</u>*. Hint: $\boxed{\omega = \frac{Bq}{m}}$ $\boxed{T = \frac{2\pi m}{Bq}}$
9. Galvanometer constant $k = \frac{C}{nBA}$.
10. In a tangent galvanometer, the plane of the coil should be adjusted to be in -----
    a) geographic meridian **b) magnetic meridian**
    c) any direction d) parallel to east-west direction.
11. The rule used to find the direction of magnetic lines of force around a conductor carrying current is
    a) Right hand palm rule ***b) Maxwell's right hand screw rule***
    c) Ampere's swimming rule d) Fleming's right hand rule.
12. Which of the following is wrong, according to joule's law of heating effect?
    a) $H \propto I^2$, for a given R b) $H \propto R$, for given I
    c) $H \propto V$, for a given R d) $H \propto 1/R$ for a given V

13. Magnetic needle of the tangent galvanometer is kept small because, the magnetic field at the centre of the coil is uniform over a very small area.

14. Each section of the coil of wire of a T.G has -----no.of turns

Ans: 2,5 & 50

15. For a solenoid whose length is very large compared to its radius , the magnetic field at points outside the solenoid is Zero.

16. In a T.G experiment , the deflection has to be adjusted to be between 30^0 and 60^0 .The tangent galvanometer is most sensitive at a deflection of 45^0.

17. Period of circular motion of the charged particle in a uniform magnetic field is $T = \frac{2\pi m}{Bq}$

18. Cyclotron cannot accelerate an electron. [also photon & neutron]

19. Cyclotron is used to accelerate protons, deutrons and α - particles.[Positive charged particles only]

20. If a current carrying loop is placed in a magnetic field by its plane perpendicular to the field ;it will not rotate.

21. In case of a moving coil galvanometer the deflection is directly proportional to the current flowing through the coil.

22. Moving coil galvanometer works on the principle that a current carrying coil placed in a magnetic field experiences a torque.

23. Current sensitivity of a galvanometer is defined as deflection produced for unit current

24. When the number of turns (n)in a galvanometer is doubled, current sensitivity is doubled .But voltage sensitivity remains unchanged.[since resistance will be doubled]

Note: When voltage sensitivity increases current sensitivity may or may not change.

25. Expression for orbital magnetic moment of an electron is $\frac{el}{2m}$ [or] $\frac{neh}{4\pi m}$ **Unit:** Am^2

26. Which of the following is not a thermo emf effect?

a) Peltier effect b) Thomson effect **c) joule effect** d) Seeback effect.

27. The thermo emf of a thermocouple is of the order of

a) 10^{-2} V b) 10^3 V c) 10^2 V **d) 10^{-3}V. (1mV)**

28. Tangent galvanometer is most sensitive if

a) $B > B_h$ b) $B < B_h$ c) $b < B_h$ **d) $B = B_h$**

29. Solenoid is commonly used to obtain:

a) Strong magnetic field **b) uniform magnetic field**

c) decreasing magnetic field d) increasing magnetic field.

30. Filament of a electric bulb is usually enclosed in a glass bulb containing _____

a) inert gas at high pressure **b) inert gas at low pressure**

c) ideal gas at high pressure d) ideal gas at low pressure

31. Heating element of an electric heater should be made with a material which should have __________

a) High specific resistance and high melting point

b) High specific resistance and low melting point

c) Low specific resistance and low melting point

d) Low specific resistance and high melting point.

32. Position of the metal in the thermoelectric series depends on _________

a) temperature b) nature of the metal

c) magnitude of thermo emf d) atomic number of metal

33. For a given thermocouple, the temperature of inversion __________

a) is constant **b) depends upon the temperature of the cold junction**

c) is independent of temperature of cold junction

d) depends on the neutral temperature.

34. Galvanometer of resistance G Ω is shunted with S Ω .The effective resistance of the combination is R_a. Then, which of the following statements is wrong?

a)G >S b) $R_a < S < G$ c)$R_a < S$ d) $R_a > S > G$

Note: $R_a = GS/(G+S)$; To convert G→A ; low R in parallel. Let G=6Ω,S=2Ω ∴ R_a = 1.5Ω

35. Ampere's hypothesis: A simple current loop behaves like a bar magnet.

Direction of	Rule
1. Magnetic field due to circular closed loop(solenoid**)**	**1. Right hand palm rule**
2. Magnetic field around a straight conductor carrying current.	***2. Maxwells's right hand cork screw rule***
3. The magnetic polarity of the current carrying solenoid.	**3. *End rule***
4. Force on a current carrying conductor placed in a magnetic field.	**4. *Fleming left hand rule* [M'13**

Frequently Asked Problems

01. In a thermo couple the temperature of cold junction is 20 °C , the inversion temperature is 600 °C , then the neutral temperature is ---- **[O'06]**

Solution: $\theta n = \frac{\theta i + \theta c}{2} = \frac{600 + 20}{2} = 310\ ^\circ C$

02. In a thermocouple, the temperature of the cold junction is -30°C, the neutral temperature is 270°C. The temperature of inversion is ***O'11***

Solution: $\theta i = 2\,\theta n - \theta c = 2 \times 270 - (-30) = 570\ ^\circ C$

03. In a tangent galvanometer a current of 1 A produces a deflection of 30 ° . The current required to produce a deflection of 60 ° is--- **[O'06]**

Solution: $\frac{I_1}{I_2} = \frac{\tan \theta_1}{\tan \theta_2}$; $\frac{\tan 30}{\tan 60} = \frac{1/\sqrt{3}}{\sqrt{3}}$; $\frac{1}{I_2} = \frac{1}{3}$ $\therefore I_2 = 3\ A$

(Or) $I = K \tan \theta = \sqrt{3}\tan 60^\circ = \sqrt{3}\sqrt{3} = 3\ A$; $[K = I/\tan\theta = 3/\tan 30^\circ = 1/(1/\sqrt{3}) = \sqrt{3}]$

04. Which of the following produce large heating effect? **M'12**

a) 1A current through 2Ω resistor for 3 second

b) 1A current through 3Ω resistor for 2 second

c) 2A current through 1Ω resistor for 2 second

d) 3A current through 1Ω resistor for 1 second

Ans: d **Hint: $H = I^2Rt$**

05. In a thermo couple $\theta_c = 20^\circ C$, $\theta_i = 400^\circ C$, Find θ_n.

Solution: $\theta n = \frac{\theta i + \theta c}{2}$; $\theta_n = \frac{400 + 20}{2} = \boxed{210\ ^\circ C}$

06. A wire of length 50 cm carrying a current 2A placed in a magnetic induction of 10 T, if makes an angle of 60° to the *normal* to the field, the force of the wire is

Solution: $F = BIl \sin\theta \Rightarrow 50 \times 10^{-2} \times 2 \times 10 \times \sin 30 = 5\ N$

07. Two wires of equal length are first connected in series and then is parallel with a voltage source the ratio of heat developed in two cases is *1 : 4.*

Solution: $H = V^2t/R$ $\therefore$ $V^2 t/2R : 2V^2 t/R = 1:4$ $[R_s = 2R \ ;\ R_p = R/2]$

08. The amount of heat dissipated per second in a wire of resistance 5Ω through which a current of 5A flows______.

Solution: $H = I^2 Rt = 5^2 \times 5 \times 1 = 125\ J$

09. In a thermocouple, the temperature of cold junction is 20°C, while the neutral temperature is 300°C. Its temperature of inversion is __________

a) 580 °C b) 850°C c) 508°C d) 805°C

Solution: $\theta_i = 2\theta_n - \theta_c$ => 2 (300) – 20 = 580 °C

10. If a current of $\sqrt{3}$ A produces a deflection of 45° in a tangent galvanometer, then the current required to produce a deflection of 60° is

a) 1. 732A b) 1/3A c) 3A d) 5A

Solution: I = K tan θ

$\frac{I_1}{I_2} = \frac{\tan\theta_1}{\tan\theta_2}$; $\frac{\sqrt{3}}{I_2} = \frac{\tan 45}{\tan 60}$; $\frac{\sqrt{3}}{I_2} = \frac{1}{\sqrt{3}}$ ∴ I_2 = 3 A

11. Find the heat energy produced in a resistance of 5 Ω when 2A current flows through it to 3 minutes .

Solution: $H = I^2 Rt$ = 2 x 2 x 5 x 3 x 60 = 3600 J

12. The resistance of the filament of a 60W, 240V electric bulb is

a) 4 k Ω b) 960Ω c) 250 Ω d) 1440 Ω

Solution: P= VI = V^2/R ; R = V^2/P = 240 x 240 / 60 = 960 Ω

13. A conductor of length 50cm is placed perpendicular in a uniform magnetic field. When 5A current flows through it, the force acting on the conductor is 5 X 10^{-3} N, then find the value of magnetic field.

a) 10 X 10^{-3} T b) 4 X 10^{-3} T c) 2 X 10^{-3} T d) 6 X 10^{-3} T

Solution: F = Bil sinθ , θ = 90 ; $B = \frac{F}{Il} = \frac{5 \times 10^{-3}}{5 \times 50 \times 10^{-2}} = 2 \times 10^{-3}$ T

14. The magnetic field of induction at the center of circular coil of radius 5cm carrying current 2A is --------

a) 10 пX 10^{-7} T b) 30 лX 10^{-6} T c) 8п X 10^{-6} T d) 16п X 10^{-6} T

Solution: $B = \frac{\mu_0 I}{2a} = \frac{4\pi \times 10^{-7} \times 2}{2 \times 5 \times 10^{-2}} = 8\pi \times 10^{-6}$ T = 25.12 X 10^{-6} T

15. A wire of length 1.5 m is placed perpendicular to a magnetic field of induction 4.5 T. Find the force acting on it when a current of 6A flows through it.

a) 36 N b) 18N c) 40.5 N d) 20 N.

Solution: F = Bil sinθ = 4.5 x 6 x 1.5 x sin 90° = 40.5 N

Other Important problems:

01. Current is flowing through a conductor of resistance 10 Ω . Indicate in which of the following cases, maximum heat will be generated? **Hint:** H α I^2Rt

a) 5A passing for 2 minutes [25 x 10 x 120 = 30000 J] b) 4A passing for 3 minutes [16 x 10 x 180 = 28800]

c) 3A passing for 6 minutes [9 x 10 x 720 = 32400 J] d) 2A passing for 5 minutes [4 x 10 x 600 = 24000 J]

02. A current of $\sqrt{3}$ A produces a deflection of 45° in a tangent galvanometer having 50 turns and radius 10 cm. The reduction factor of the tangent galvanometer is ---

Solution: $K = \frac{I}{\tan\theta} = \frac{\sqrt{3}}{\tan 45} = \frac{\sqrt{3}}{1} = \sqrt{3} = 1.732$ A

03. If the reduction factor of a T.G is 0.9A, then the current that produces a deflection of 30° is ----

Solution: $I = K \tan\theta \Rightarrow 0.9 \times \tan 30 = 0.9 \times 0.577 = 519.6 \times 10^{-3} \approx 520$ mA

04. A proton enters into a uniform magnetic field of induction 2.5 T with a velocity of 2.5×10^6 m s^{-1} by making an angle of 30° with the direction of the field. Lorentz force on the proton is ---

Solution: $F = Bqv \sin\theta = 2.5 \times 1.6 \times 10^{-19} \times 2.5 \times 10^6 \times \sin 30 = 5 \times 10^{-13}$ N

05. An electron is moving with a velocity of 3×10^6 m/s perpendicular to the magnetic field of 0.5 T, then the force experienced by an electron is –

Solution: $F = Bqv \sin\theta = 0.5 \times 1.6 \times 10^{-19} \times 3 \times 10^6 \times \sin 90 = 2.4 \times 10^{-13}$ N

06. If the heating element of the electric toaster has resistance of 22Ω and is connected to an voltage source of 110 V , the amount of heat generated in 1 minute in ----

Solution: $H = \frac{V^2 t}{R} = \frac{110 \times 110 \times 60}{22} = 33000$ J = 33 KJ

07. A current of 2A flows through 5 turns coil of a tangent galvanometer having a radius of 12.5 cm. If the deflection of the needle at the centre is 45° , the horizontal component of earth field at that point is –

Solution: $B_H = \frac{\mu_o n I}{2a \tan\theta} = \frac{4\pi \times 10^{-7} \times 5 \times 2}{2 \times 12.5 \times 10^{-2} \times 1} = 16\pi \times 10^{-6}$ T $= 5.24 \times 10^{-6}$ T

08. The resistance of the filament of a 110 W , 220 V electric bulb is –

Solution: $P = VI = V^2/R \therefore R = V^2/P = 220 \times 220 / 110 = 440\ \Omega$

09. An inductor offers an resistance of 628 Ω for an a.c current of frequency 50 Hz, then its self inductance value is 2H.

Solution: $X_L = L\omega = L2\pi\nu \therefore L = X_L / 2\pi\nu = 628/2 \times 3.14 \times 50$ 628/314 = 2H

10. The magnetic field at a point at a distance 10cm from the straight long conductor carrying current 4 A is [Note: If I =10 A ,B= 2×10^{-5} T)

a) 40 T b) 2.5×10^{-5} T <u>c) 8×10^{-6} T</u> d) $2\pi \times 10^{-3}$ T

Solution: $B = \dfrac{\mu_o I}{2\pi a} = \dfrac{4\pi \times 10^{-7} \times 4}{2\pi \times 10 \times 10^{-2}} = 8 \times 10^{-6}\ T$

11. The resistance to be connected with the Galvanometer to convert it into voltmeter of range 5 V with current 50m A and Galvanometer resistance 20Ω is

a) 80Ω in parallel <u>*b) 80Ω in series*</u> c) 800Ω in parallel d) 800Ω in series

Solution: $R = \dfrac{V}{I_g} - G = \dfrac{5}{50 \times 10^{-3}} - 20 = \dfrac{5}{5 \times 10^{-2}} - 20 = 100 - 20$ $\boxed{R = 80\Omega \text{ in series}}$

4. ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT

S.NO	QUANTITY	FORMULA	UNIT
1.	Magnetic Flux	$\Phi = \vec{B}.\vec{A}\ \cos\theta$	Wb[weber]
2.	Self Inductance	$L = -e / \frac{dI}{dt}$	Henry
3.	Self induction of long Solenoid	$L = \frac{\mu N^2 A}{l}$	Henry
4.	Energy stored in an inductor	$W = \frac{1}{2} L I_o^2$	Joule
5.	Mutual inductance	$M = -e_s / \frac{dIp}{dt}$	Henry
6.	Mutual induction of two long Solenoid	$M = \mu o\, N_1 N_2 A / l$	Henry
7.	RMS value of AC	$Irms = \frac{Io}{\sqrt{2}} = 0.707\ Io$	Ampere
8.	Inductive Reactance	$X_L = L\omega$	ohm
9.	Capacitive Reactance	$X_c = 1/C\omega$	ohm
10.	Impedence in LRC circuit	$Z = \sqrt{R^2 + (XL - Xc)^2}$	ohm
11.	Q factor	$Q = \frac{1}{R}\sqrt{L/C}$ [M'09]	No unit
12.	Power factor in choke coil	$\frac{r}{\sqrt{r^2 + \omega^2 l^2}}$	No unit

Govt. Exam Questions:

01. The average power consumed over one cycle in an ac circuit is Erms Irms Cos Φ [M'06]

02. In an ac circuit with capacitor only , if the frequency of ac signal is zero , then the capacitive reactance is [J'07]

a) infinity b) zero c) finite maximum d) finite minimum

03. A rectangular coil is uniformly rotated in a uniform magnetic field such that the axis of rotation is perpendicular to the direction of the magnetic field . when the plane of the coil is perpendicular to the magnetic field ----- **[O'10]**

Ans: magnetic flux is maximum , induced emf is zero

Note: $\theta = 0$; $\Phi = BA \cos\theta$; $e = E_o \sin \omega t$

04.Direction of induced current is determined by Lenz law, *Fleming Right Hand rule (or) Generator rule.* **[O'06]**

05. Angle between area vector A and the plane of the area is $\pi/2$. **[M'06]**

06. I_{rms} (Or) $I_{eff} = \frac{I_o}{\sqrt{2}} = 0.707\, I_o$; E_{rms} (Or) $E_{eff} = \frac{E_o}{\sqrt{2}}$; $I_o = 1.414\, I_{rms}$ **[J'10]**

07. i) AC with Resistor : current and voltage are in phase.

ii) AC with Inductor : current lags behind the voltage by the phase angle $\pi/2$ **[J'06,M'11]**

[or] Voltage leads the Current by the phase angle $\pi/2$.

iii) AC with Capacitor: current leads the voltage by the phase angle $\pi/2$.

[or] Voltage lags behind the Current by the phase angle $\pi/2$.

08. Cores of chokes used in low frequency(AF) AC circuits are made of iron. **[O'09]**

Air chokes are used for radio frequency (high frequency)[wireless receiver circuit]

09. For a d.c circuit, the value of *capacitive reactance* Xc is infinity [$\gamma = 0$ for A.C] **[J'08]**

10. In RLC circuit, if $X_L = X_C$ then, the impedance is minimum. { Current is maximum ; Z= R ; $\upsilon_o = 1/2\pi\sqrt{LC}$; current is in phase with voltage] **[M'07,O'08,09,10 ,S'15]**

11. If the flux associated with a coil varies at the rate of 1 wb/minute, then the induced emf is 1/60 V. **[M'06]**

12. The resonant frequency of RLC circuit is γ_o . The inductance is doubled. The capacitance is also doubled. Now the resonant frequency of the circuit is ---

a) $2\gamma_o$ **b) $\gamma_o/2$** c) $\gamma_o/4$ d) $\gamma_o/\sqrt{2}$ **Hint: $\upsilon_o = 1/2\pi\sqrt{LC}$** **[J'11]**

13. When the frequency of an a.c circuit increases, the capacitive reactance offered by capacitor connected in the circuit decreases. **[J'11]**

14. The co efficient of self induction of long solenoid is independent of : **[O'12]**

a) number of turns in the coil b) the area of cross section of the coil

c) the length of the coil **d) the current passing through the coil**

15. The instantaneous emf and current equations of an a.c circuit respectively e = 200 sin$\left(\omega t + \frac{\pi}{3}\right)$ and i = 10 sin ωt. The average power consumed over one complete cycle is: **[M'13]**

a) 2000 W b) 1000 W **c) 500 W** d)707 W

16. If an emf of 25 V is induced when the current in the coil changes at the rate of 100 As^{-1} then the co efficient of self induction of the coil is: **M'14**

a) 0.3 H **b) 0.25H** c) 2.5H d)0.25mH

17. In an A.C. circuit, the instantaneous values of emf and current are respectively e = 200 sin $\left(\omega t - \frac{\pi}{3}\right)$; I = 10 sin $\left(\omega t + \frac{\pi}{6}\right)$ the phase relation between current and voltage is: **M'15**

a. Voltage lags behind current by a phase angle of π/3
b. Current leads voltage by a phase angle of π/6
c. **Current leads voltage by a phase angle of π/2**
d. Voltage leads current by a phase angle of π/2

18. In a LCR series a.c circuit, the phase difference between current and voltage is 60^0. If the net reactance of the circuit is 17.32Ω, the value of the resistance is: **O'14**

a. 30 Ω b. 17.32 Ω **c. 10 Ω** d. 1.732 Ω

19. The instantaneous values of emf and current equations of an RLC series circuit are e = 200 sin $\left(\omega t - \frac{\pi}{6}\right)$; I = 20 sin $\left(\omega t + \frac{\pi}{6}\right)$ The average power consumed per cycle is:

a) zero b) 2000 W **c) 1000 W** d) 500 W **M'16**

20. A rectangular coil of wire is placed in a uniform magnetic field such that the plane of the coil is parallel to the magnetic field. The magnetic flux linked with the coil and the emf induced are respectively: **M'16**

a) zero and zero b) zero and maximum c) maximum and zero d) maximum and maximum

Frequently Asked Questions:

1. ***Hans Christian Oersted*** **demonstrated that current carrying conductor is associated with magnetic field.**
2. **Magnetic flux $\phi = \vec{B} \cdot \vec{A} = B A \cos\theta$**
3. **Energy associated with an inductor is ½ LI_o^2**
4. **Principle used in A.C generator is electromagnetic induction.**
5. **The direction of Eddy current is given by Lenz's Law.**
6. **Number of lines of force crossing unit area is called magnetic induction.**

7. **Transformer is based on the principle of electromagnetic induction.**
8. **For an ideal Transformer efficiency η = 1.(or) input power $I_p E_p$ = output power $E_s I_s$. But practically Efficiency always less than 1.(100%)**
9. **The average value of ac over a complete cycle is zero.**
10. **The r.m.s value of an ac is 0.707 times[or] $\frac{1}{\sqrt{2}}$ times the peak value of the a.c = 70.7 %**
11. **Three phase generator transmits power with less cost and high efficiency.**
12. **Q factor has values lying in between *10 to 100 for normal frequencies*.**
13. **The average power of an AC is also called *true power* of the circuit.**
14. **In a step down transformer , K< 1, where $K = \frac{Es}{Ep} = \frac{Ns}{Np} = \frac{Ip}{Is}$**

    In a step up transformer , K >1

    [K → transformer ratio]

    Step up: Es >Ep , Ns>Np , Ip>Is, K>1 Step down: Ep>Es , Np>Ns , Is>Ip, K<1
15. **In a step down transformer Which of the following condition is satisfied?**

    (a) Es > Ep **(b) K< 1** (c) Ip > Is (d) Np < Ns
16. **In an a.c circuit, the current I = Io Sin (ωt- π/2) lags behind the emf E = Eo Sin(ωt+π/2) by π.**
17. **Which of the following component is not used in AC generator?**

    a) split rings **b) slip rings c) Armature d) Brushes**
18. **Induction motors are used in fans.**
19. **_Q factor_ measures the selectivity or sharpness of a resonant circuit.**
20. **The phase difference between the emf's produced by a three phase generator is *120º*=2π/3**

    Note: Coils are inclined at an angle 120º
21. **Eddy current can be minimized by *thin laminated sheets*.**
22. **A circuit will have flat resonant if its Q-value is low.**
23. **If the coil has N number of turns and Φ is the flux linked with each turn of the coil , then the total flux linked with the coil at any time is N Φ .**
24. **AC frequency of 100 KHz to 100 MHz is required for ---------------**

    Ans: Transmission of audio and video signals
25. **The unit of self inductance is Henry (Or) $\frac{\text{Weber - Turns}}{\text{Ampere}}$**
26. **The reactance offered by a capacitor to an ac is X. When the capacitance is doubled, the reactance is X/2 . Note: Xc = 1/Cω**
27. **In an a.c circuit with capacitance only if the frequency of the signal is zero, then the capacitive reactance is infinity. [Note: Xc = 1/Cω = 1/C2πν ; ν = 0]**

Other Important Questions:

1. Power Loss = I^2R ; Power P = VI
2. Frequency of A.C current in India is 50 Hz.
3. In low power AC dynamos magnetic field is provided by permanent Magnets.
4. What frequency of AC is required for guided rockets? 400 Hz
5. The device used for controlling current in an AC circuit is choke coil.
6. Who discovered the production of induced emf by the effect of magnetic field[Reverse effect of Oersted experiment]? *Micheal Faraday.*
7. 400 MW power produced at 15,000V at Neyveli power station is stepped upto 230,000 V before transmission[Outside the city, the power is stepped down to 110,000 V and again to 11,000V]
8. The co-efficient of mutual induction between a pair of coil depends on

   1.Size and shape of the coils, 2. number of turns

   3.permeability of material on which the coils are wound 4. proximity of the coils
9. Power loss due to Joule's heating effect is also called copper loss.
10. As the coil rotates with an angular velocity ω in an uniform magnetic field , the emf induced is maximum when $\omega t = \pi/2$ { note : $e = E_o \sin \omega t$}
11. Choke coils are commonly seen in flourcent tubes
12. The coefficient of mutual induction between the two coils is large when two coils are placed in such a way that they have a common axis.

    Note: If the two coils are wound on a soft iron core the mutual induction is very large.
13. In an AC circuit containing pure inductance the current is given by $I = I_o \sin(\omega t - \pi/2)$ then emf in the circuit will be $e = E_o \sin \omega t$
14. The average power consumed over one cycle in an a.c circuit is $E_{rms} I_{rms} \cos \Phi$.
15. Before distribution to the user, the power is stepped down to 230 V or 440 V
16. Eddy currnts are used in

    a)nuclear reactor b)induction motor c)Dynamo d)Transformer
17. Q factor can be increased by having a coil of large inductance and low resistance.
18. Unit of magnetic flux : Wb (or) Tesla m^2 (or) Nm /A

Loss	Material Used
1.Hysteresis	Mumetal, Silicon Steel
2. Copper	Thick wire with low resistance
3. Eddy Current[Iron loss]	Stelloy (an alloy of steel) [M'08]
4. Flux	Shell type core

Frequently Asked Problems

01. An emf of 12V is induced when the current in the coil changes from 2A to 6A in 0.5 . Then the co. efficient of self induction, L is ---------? [J'06]

Solution: $e = -L\frac{dI}{dt}$ or $L = \frac{-e}{dI/dt}$

$L = \frac{-12}{4/0.5} = \frac{-12 \times 0.5}{4} = \boxed{1.5\text{ H}}$

02. In an A.C circuit the average power consumed is 200 W and the apparent power is 300 W . The power factor is -- [J'10]

Solution: P_{av} = Apparent power x Power factor

Power factor = P_{av} / Apparent power

= 200 / 300

Power factor = 0.66

03. In LCR series ac circuit , the phase difference between current and voltage is 30° . The reactance of the circuit is 17.32 Ω . The value of the resistance is -- [J'06]

Solution: $\tan\Phi = \frac{X_L - X_C}{R} = \frac{\text{Net reactance}}{\text{Resistance}} = \frac{17.32}{\tan 30} = \frac{10\sqrt{3}}{\frac{1}{\sqrt{3}}} = 30\ \Omega$

04. The reactance offered by 300mH inductor to an AC supply of frequency 50Hz is 94.2Ω. [O'07]

Solution: $X_L = L\omega = L \times 2\pi\nu = 300 \times 10^{-3} \times 2 \times 3.14 \times 50$

$X_L = \boxed{94.2\Omega}$

05. The r.m.s value of an a.c voltage with a peak value of 311 V is 220 V. [O'07,M'12 S'15]

Solution: $E_{rms} = E_0/\sqrt{2}$ (or) $E_0 \times 0.707 = 311 \times 0.707 = 219.87 \approx 220$ V

06. In step up transformer the output voltage is 11KV and the input voltage is 220V. The ratio of number of turns of secondary to primary is 50:1. [J'07]

Solution: $\frac{E_s}{E_p} = \frac{N_s}{N_p} = \frac{11000}{120} = 50:1$

07. A generator produce an emf of e = 141 sin 88 t, the frequency is------.

Solution: $e = E_0\sin\omega t$; $\omega = 88$; $2\pi\upsilon = 88$; $\upsilon = \frac{88}{2\pi}$ $\boxed{\upsilon = 14\text{ Hz}}$

08. The energy stored in a coil of inductance 5 H, resistance 20 Ω, emf 100 V is 125 J .

Solution: $\frac{1}{2} L I_0^2 = \frac{1}{2} L [\sqrt{2} I]^2 = \frac{1}{2} L . V^2 x2/ R^2 = 125$ J [Hint: $I_{rms} = I_0/\sqrt{2}$; V=IR]

09. A fuse wire has a current rating of 5 A. Then the peak value of the current in the fuse wire is

(a) 0.7 A (b) 1 A (c) 7.07 A (d) 70.7 A

Solution: $I_{RMS} = \frac{Io}{\sqrt{2}}$; $Io = I_{RMS}\sqrt{2} = 5 \times \sqrt{2} = 5 \times 1.414 = 7.07$ A

10. A field of magnetic induction 20 T acts as right angles to a coil of area 20 m^2 with 50 turns . The flux linked with the coil is
   (a) 2000 Wb (b) *20000 Wb* (c) 0 Wb (d) 200 Wb

   Solution: Φ = NBA Cos θ ; θ = 0

11. An aeroplane having a wingspan of 35 m flies at a speed of 100 m/s . if the vertical component of earth's magnetic field is 4 x 10^{-4} T, then the induced emf across the wingspan is ----

   Solution: e= - blv = - 4 x 10^{-4} X 35 X100 = -1.4 V

12. The equation of a 25 cycle current sine wave having rms value of 30 A° is--------

   Solution: i = Io sin ωt = Irms √2 sin $2\pi vt$ = 30√2 sin 2 x 3.14 x50t = <u>30√2 sin 157t</u>

13. How much current is drawn by the primary of a transformer connected to a 220 V supply, when it delivers power to a 110 V and 550 W refrigerator?

   Solution: input power = Ep Ip = 550 ; Ip = 550/ Ep = 550 / 220 = 2.5 A

14. The co efficient of mutual inductance of a pair of coils is 4 mH. If the current in one of the coils changes from 0.6 A to 0.61 A in 0.02 seconds, then induced emf is----

   Solution: $e = - M\frac{dI}{dt} = 4 \times 10^{-3} \times \frac{0.01}{0.02} = 4 \times 10^{-3} \times 0.5 = 2 \times 10^{-3} = 2$ mV In other coil

15. A wire cuts across a flux of 0.2 x 10^{-2} weber in 0.12 second. What is the emf induced in the wire?

   Solution: $e = -\frac{d\phi}{dt} = 0.2 \times 10^{-2} / 0.12 = 0.0167$ V

16. In a step down transformer , the input voltage is 22 KV and the out put voltage is 550 V , the ratio of number of turns in the primary to that in the secondary is --------

   Solution: $\frac{Es}{Ep} = \frac{Ns}{Np} = \frac{Ip}{Is} = K$ { k<1 for step down , K>1 for step up }

   $$\frac{Np}{Ns} = \frac{Ep}{Es} = \frac{22000}{550} = 40 : 1$$

17. The voltage rating of an alternating emf is 200 V , then the peak value of voltage is <u>282.8 V</u>

   Solution: Eo = Erms √2 = 200 √2 = 282.84 V

Other Important Problems :

01. A power of 11000 W is transmitted at 220 V . The current through the wire is –

Solution: P= VI ; I = P/V = 11000/220 = 50 A

Note: Power loss = I^2R = 2500(R) W , if V =22,000 V then I = 0.5 A , power loss = 0.25 (R) W

02. If in an LRC circuit , X_L = 500 Ω, Xc= 326.8 Ω , R= 100 Ω , then Φ =

(a) 60° (b) 30° (c) 45° (d) 90°

Solution: Tan Φ = $\frac{XL - XC}{R}$ = $\frac{500-326.8}{100}$ = 1.732 ∴ Φ =$\tan^{-1} 1.732$ = 60°

03. At What rate must the current change in a 65 mH coil to have a 1 volt self induced emf?

Solution: e = -L $\frac{dI}{dt}$ ∴ $\frac{dI}{dt}$= - $\frac{e}{L}$ = 1/ 65 x 10^{-3} = 1000/65 = 15.38 ≈ 15.4 As^{-1}

04. The peak voltage and peak current in a circuit containing resistor alone are 220 V and 1 A respectively , then the power in the circuit is------

Solution: P = Eo Io cos ϕ = $\frac{220}{\sqrt{2}}$ = 110 W { $\phi = 0$ }

05. Power transmission in an AC circuit in which voltage and current are given by E = 300 sin (ωt + $\frac{\pi}{2}$) and I = 6 sin ωt is ----

Solution: P_{av} = Eo Io cos π /2 = 0 {∵ $\phi = \pi /2$ }

06. An ideal transformer has a power input of 10 KW. The secondary current is 25 A. If the ratio of the number of turns in primary and the secondary coil is 5:1, the potential difference applied between the primary is ---

Solution: $\frac{Es}{Ep} = \frac{Ns}{Np} = \frac{Ip}{Is}$ = K ∴ Ep = Es $\frac{Np}{Ns}$ = 400 x 5 /1 = 2000 [Note: EsIs = 10000 ∴Es =400]

07. The inductive reactance and resistance value in an acceptor circuit are 1000 Ω and 20 Ω , the the Q factor is

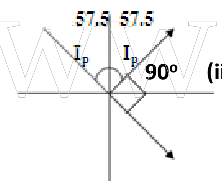
Solution: Q factor = $L\omega_o/R$ = 1000 / 20 = 50

08. A current of 2 ampere flows through an inductance of 5 henry. The energy stored in the inductance coil is = ½ LIo^2 = ½ x 5 x 2 x 2 = <u>10 J</u>

5. ELECTROMAGNETIC WAVES AND WAVE OPTICS

Govt. Exam Questions:

1. Velocity of EM wave is $C = \frac{1}{\sqrt{\mu_o \varepsilon_o}} = 3 \times 10^8\ ms^{-1}$ [J'06]
2. The existence of ElectroMagnetic was confirmed by Hertz in 1888. [M'06 O'11]
3. Stokes line- lower than incident frequency -- *longer wave length*- less energy [O'08]
4. In Newton's ring experiment the radius of n^{th} dark ring is proportional to $\sqrt{n}$
   Ratio : $\sqrt{1} : \sqrt{2} : \sqrt{3}$ Formula: $r_n = \sqrt{nr\lambda}$ [M'09]
5. In Fraunhofer diffraction incident wave front is plane. [O'08]
6. In Fresnel's diffraction incident wave front is spherical or cylindrical.
7. The transverse nature of light waves was confirmed by Polarisation. [M'08,J'10]
8. Uniaxial crystal Ex: calcite, quartz, ice, tourmaline [O'06,07,O'11]
9. Biaxial crystal Ex: mica, topaz, selenite, aragonite
10. The substance which rotates the plane of polarization a re said to be optically active.
    Eg: quartz ,sugar crystal ,turpentine oil, Nacl [M'07,O'09]
11. When a ray of light is incident on a glass surface at $I_p = 57.5^o$ $[57^o30']$, θ between angle of incidence and angle of reflection (r) is = 57.5 + 57.5 = 115° [M'06,J'06]



(ii) Angle between reflected ray and refracted ray is 90^0 [J'11]

12. Soap bubbles exhibit brilliant colours in sun light due to *interference* . [M'09]
13. Unpolarised light passes through a tourmaline crystal . The emergent light is analysed by an analyser . When the analyser is rotated through 90° , the intensity of light –
    Ans: Varies between maximuum and zero [M'06]
14. Which one of the following is not an electromagnetic wave ? [O'06]
    a) X- rays b) γ – rays c) UV rays d) β – rays
15. If C is the velocity of the light in vacuum ,the velocity of light in medium with refractive index μ is -----C/μ Note: $\mu = C_{air} / C_m$ [O'06]
16. The radiation used in physiotherapy is infrared. [M'07]
17. Electric filament lamp gives rise to Continuous emission spectrum. [J'07,M'08]
18. The phenomenon of light used in formation of newton ring is interference. [J'07]
19. Optical rotation does not depend upon intensity of the light used . [O'07]
20. In Raman effect the incident photon makes collision with an excited molecule of the substance gains energy . The scattered photon gives rise to – Anti stoke line. [M'10]
21. The dark lines found in the solar spectrum is called Fraunhofer line . [O'10]

22. In Young's double slit experiment, if the distance between the slits is halved and the distance between the slits and the screen is doubled, the new fringe width will be **Quadrupled.** **{ d' = d/2 , D' = 2D , β' =? }** **[J'07]**

Soln: $\beta = D\lambda/d$; $\beta' = \frac{2D\lambda}{d/2} = \frac{4D\lambda}{d}$ = *Quadrupled.* *[Or] 4 times*

23. Unit of grating element(e) : metre.

24. The combined width of a ruling and a slit is called grating element (e = a+b). [J'06,09,10]

25. Unit of N is [No. of grating element] = $metre^{-1}$

26. The number of grating element or number of lines per unit width of the grating N= 1/(a+b)

27. A ray of light incident on a glass surface such that the reflected ray is completely plane polarized. The angle between the reflected ray and the refracted ray is 90°. M'09]

28. Wave from two coherent sources interferes with each other. At a point where the trough of one wave superposes with the trough of the other wave, the intensity of the light is maximum. [Waves are in phase ie, phase difference is zero, constructive interference occurs.] **[M'11]**

29. The nature of wave front corresponding to extraordinary ray inside a calcite crystal is elliptical. [J'11]

30. In a pile of plate arrangement The angle between incident light and the reflected plane polarized light is 115° [since I_p = 57.5°] O'11

31. Which of the following is used to study the crystal structure? [O'12]

a) Micro wave b) Infrared rays c) Ultraviolet rays **d) X-rays**

32. In a plane transmission grating the width of the ruling is 12000 A° and the width of the slit is 8000 A^0 . The grating element is [O'12]

a) 20 µm **b) 2 µm** c) 1 µm d) 10 µm.

33. In young's double slit experiment, bandwidth β contains: [M'13]

a) a bright band only b) a dark band only c) either a bright band or dark band

d) both a bright band and a dark band

34. According to Foucault and Michelson experiment the velocity of light in rarer medium is: O'13 ,J'15]

a) greater than in a denser medium b) lesser than in a denser medium

c) equal to that in a denser medium d) either greater or lesser than in a denser medium

35. In Snell's law of refraction $\mu = \frac{\sin i}{\sin r}$, μ is: **[J'15]**

a) directly proportional to sin I
b) inversely proportional to sin r
c) both (a) and (b)
d) independent of (a) and (b)

36. A light of wavelength 4000 Å after traveling a distance of 2 μm produces a phase change of: **M'15**

a. zero b. 3π c. $\frac{\pi}{2}$ d. $\frac{\pi}{3}$

37. In a plane transmission grating the width of a ruling is 12000 Å and the width of a slit is 8000 Å, the grating element is: **M'15**

a. 20 μm b. **2 μm** c. 200 μm d. 10 μm

Frequently Asked Questions:

1. **<u>Angle</u> between the electric and magnetic component of an EM wave is <u>π/2.</u>** **M'12**
   <u>Note:</u> Phase difference = 0 [zero]
2. **If i is the angle of incidence , the angle between incidence wavefront and normal to the reflecting surface is <u>90-i .</u>** **M'12**
3. **In a nicol prism, the ordinary ray is prevented from coming out of Canada balsam by the phenomenon of <u>total internal reflection.</u>** **J'12**
4. **Frequency of EM waves produced by Hertz = *5 x 10^7 Hz* , $\nu = \frac{1}{2\pi\sqrt{LC}}$ Wave length=6m.**
5. **IR spectrum is used to study *<u>molecular structure</u>*.**
6. **UV rays are used to find <u>structure of atoms</u>. γ – rays-nuclear structure,cancer treatment.**
7. **Wave length of two Sodium lines are 5896 A°, 5890 A° . [589.6 nm ,589 nm]**
8. **Line spectrum is used to <u>identify the gas</u>.**
9. **Band absorption spectra is used for <u>making dyes</u>.**
10. **Elements present in the suns atmosphere can be identified using <u>Fraunhofer lines.</u>**
11. **Blue colour of the sky is due to *<u>scattering of light by atmosphere</u>*.**
12. **<u>Stokes line-</u> <u>lower</u> than incident <u>frequency</u> -- *longer wave length*- less energy** [loss]
13. **<u>Anti-stokes-</u> <u>higher</u> than incident <u>frequency</u> - shorter wave length- more energy**[gain]
14. **Intensity of stokes line <u>greater</u> than Anti stokes lines.**
15. **Raman Shift(Δν) does not depend on <u>frequency of incident light. But it is the characteristic of the substance producing Raman effect .</u>**
16. **Raman shift $\Delta\nu = \nu_o - \nu_s$ - is the character of the substance.**

17. Δv is Positive(+ve) for stoke, Negative(-ve) for Anti stoke lines.

18. The frequency of the wave does not change when a wave is reflected or refracted, but *wave length changes* on refraction.

19. If the path difference between two monochromatic wave is δ, then the phase difference is $\phi = \frac{2\pi}{\lambda} \times \delta$ **S'15**

20. $\mu_m = \frac{\text{Velocity of light in vacuum (air) (Ca)}}{\text{Velocity of light in medium (Cm)}} = \frac{\lambda a}{\lambda m}$

Note: First medium rarer , second medium denser.

21. Colours in thin film is due to interference of light.

22. A ray of light traveling in rarer medium and getting reflected at the surface of a denser medium, undergoes an automatic Phase change of π (or) *Additional path difference λ/2.*

23. Bending of waves around the edges of obstacles is called *diffraction.*

24. In the arrangement of Piles of plats, the plates are inclined at an angle of 32.5º to the axis of the tube. * ∴*angle of incidence = 57.5º* [90º – 32.5º]

25. Nicol prism is based on the principle of *double refraction*.

26. Wavelength range of visible portion of electromagnetic spectrum is from ---------------

Ans: 4×10^{-7}m – 8×10^{-7}m [4000 Aº – 8000 Aº]

27. For a given angle of incidence , a refracted wave front is not possible if sin r >1

[**Note:** If sin *r* = 1 (or) *r* = 90º. i.e a refracted wave front is just possible, if r < 90º (or) sin r <1 refracted wave front is possible]

28. Thin Film:

Intereference	Condition for Bright [constructive interference]	Condition for dark [destructive interference]
1.Due to reflected ray	$2\mu t \cos r + \frac{\lambda}{2} = n\lambda$ $2\mu t \cos r = (2n-1)\frac{\lambda}{2}$	$2\mu t \cos r + \frac{\lambda}{2} = (2n+1)\frac{\lambda}{2}$
2. When light incident normally ,i=0,r=0	$2\mu t = (2n-1)\frac{\lambda}{2}$	**2μt = nλ**
3. For *transmitted light*	**2 μt cos r = nλ**	$2\mu t \cos r = (2n-1)\frac{\lambda}{2}$

29. Which phenomenon is used in polaroids? *Selective absorption*
30. Infrared lamps are used in physiotheraphy.
31. The instrument used to determine the optical rotation produced by a substance is called *polarimeter.*
32. *Sugar* is the most common optically active substance.
33. Strength of optically active substance can be found using by measuring the *rotation of plane of polarization.*
34. The dark lines in the solar spectrum are called Fraunhofer lines.
35. Polarising angle for glass is 57.5°
36. In Newton's ring experiment the radius of nth bright ring is proportional to $\sqrt{(2n-1)}$

    Ratio: $\sqrt{1} : \sqrt{3} : \sqrt{5}$

Other Important Questions:

1. Who discovered ElectroMagnetic waves? Maxwell is 1865.
2. In EM waves electric and magnetic fields are perpendicular (right angle) to each other.
3. In an Electro Magnetic[EM] wave power is transmitted in a direction perpendicular to both the fields[electric and magnetic fields].
4. Energy of EM wave is due to Kinetic Energy of the oscillating charge.
5. All the EM waves travel with the *velocity of light.*
6. The physical properties of EM waves are determined by their wave length not by method of excitation.
7. Frequency range of EM spectrum is 10^3 Hz – 10^{22} Hz.
8. Frequency range of AM band – 530 KHz – 1710 KHz
9. TV -- 54 MHz – 890 MHz
10. Cell phones – Ultra High Frequency
11. Microwaves are used in radar communication system.
12. Continuous spectra depend only the temperature of the source and *independent* of the *characteristic* of the source.

    Eg: Incandescent solids , carbon arc, electric filament lamp
13. Band spectrum is used to study the molecular structure of the substance.
14. Solar spectrum is an example of line absorption spectrum.
15. Central core of the sun is photosphere.,(14 MK), It emits *continuous spectrum*.
16. Sun's outer layer chromosphere (6000 K).It contains various elements in gaseous state.
17. Life time of atoms of the substance exhibiting the phenomenon of fluorescence is less than 10^{-5} s.
18. Delayed fluorescence is called phosphorescence.
19. Corpuscular theory – Newton – $V_d > V_r$.
20. The energy associated with each photon is $E = h\nu$

21. Strength of scattering depends on the wave length of the light, *size of the particle*.
22. Ultra violet radiations are used to destroy bacteria, sterilizing surgical instruments.
23. Electromagnetic waves are not deflected by electric and magnetic fields, because they are charge less waves.
24. Spectrum produced by incandescent solid at high temperature is Continuous emission spectrum.
25. If A denotes the amount of scattering, the wavelength of light is proportional inversely to $A^{1/4}$.
26. If an electromagnetic wave is propagating along x – directon and electric field variation is along y-direction then the magnetic field variation will be along z-direction.
27. Radiation used in the detection of forged documents and finger prints in forensic laboratories is UV rays.
28. When the light emitted by the source is directly examined by a spectrometer , the spectrum obtained is emission spectrum.
29. When the light emitted from a source is made to pass through an absorbing material and then examined with a spectrometer, the obtained spectrum is called absorption spectrum. It is the characteristic of the absorbing substance.
30. When the temperature of the solid is increased, the spectrum spread from Red to blue
31. In Hertz experimental arrangement, the two metal plates A and B are placed with a separation of 60 cm. [0.6m]
32. Experimental results of Focaults on velocity of light do not support Corpuscular theory
33. "No material medium was necessary for the propagation of lightwaves" .This statement is true according to electromagnetic theory.
34. Light waves behaves like Waves in low energy range ; particle in high energy range.
35. Absorption of light by the molecules followed by its re-radiation in different directions is called Scattering.
36. If the refractive index of secone medium with respect to the first medium is greater than one , then it implies that first medium is rarer and the second medium is denser.
37. In the interference pattern the energy is conserved but it is redistributed.
38. If the energy of the electromagnetic wave is 'E' then the energy associated with electric field vector is E/2.
39. The overlapping in certain parts of the electromagnetic spectrum revels that the particular wave can be produced by different method.

40. In Young's double slit experiment, if the distance between the coherent sources is increased twice that of initial value then the new bandwidth will be decreased 2 times. Soln: $\beta = D\lambda/d$; $\beta' = D\lambda/2d$; Decreased by 2 times

41. The ratio of velocity of light in air to the velocity of light in medium is refractive index of the medium.

42. Atoms and molecules in an electrical discharge produce UV rays.

43. A linear source of light at a finite substance in an isotropic medium emits *Spherical wave front*.

44. Using Newton Rings,
    1. Wave length of monochromatic light
    2. Refractive index of a liquid can be calculated. [$\mu = r_n^2 / r'^2_n$]

    r_n is the radius of the nth dark ring in air, r'_n is the radius of the nth dark ring in medium.

45. In the propagation of light wave, angle between
    1) direction of propagation & plane of polarization = 90°
    2) plane of vibration & plane of polarization = 90°

46. The phenomenon of restricting the vibration into a particular plane is Polarisation.

47. Tourmaline crystal is used to show polarization.

48. A device used to produce plane polarized light is Polariser.

49. A device used to analyze plane polarized light is *analyzer.*

INTENSITY	TYPE OF WAVE
1. Does not vary	Unpolarised
2. Maximum to zero	Plane polarized
3. Maximum to min	Partially plane polarized

50. The angle of incidence at which the reflected beam is completely plane polarised is *polarizing angle*.

51. Brewster Law, $\mu = \tan i_p$

52. The pile of plates is used as a polarizer and analyzer.

53. In Nicol prism face angles are 72°, 108°

54. For Na lamp, μ(Refractive index) of ordinary light: 1.658, Extraordinary light: 1.468, Canada balsam: 1.550.

55. Polaroids consists of micro crystals of herapathite.

56. In H.K polaroids, polyvinyl alcohol is used.

57. Dextro – rotatory →clockwise ; Laevo – rotator →anti clockwise.

58. The wave front produced by the point source at
    i) finite distance – spherical
    ii) infinite distance – plane

59. Specific rotation is used to compare the rotational effect of optically active substance.

60. Diffraction in sound is more predominant than light due to its greater wavelength.

Frequently Asked Problems:

1. A ray of light passes from denser medium to rarer medium . For an angle of incidence of 45° the refracted ray grazes the surface of the separation of the two media. The refractive index of the denser medium is ------ [O'06]

Solution: $I = 45^\circ$, $r = 90$, $\mu = ?$

$$ {}_1\mu_2 = \frac{\sin i}{\sin r} = \frac{\sin 45}{\sin 90} = \frac{\frac{1}{\sqrt{2}}}{1} = \frac{1}{\sqrt{2}} \; ; \mu_m = 1/\,{}_1\mu_2 = 1/\frac{1}{\sqrt{2}} = \sqrt{2} $$

(OR) $\mu = 1/\sin c = 1/\sin 45 = \sqrt{2}$

2 . In Newton rings experiment , the light of wave length 5890 A° is used . The order of the dark ring produced where the thickness of the air film is 0.589 μm is 2. [M'07]

Solution: $2t = n\lambda \;\therefore\; n = \frac{2t}{\lambda} = \frac{2 \times 5890 \times 10^{-10}}{5890 \times 10^{-10}} = 2$

3. The refractive index of the glass is 1.5 . The velocity of light in glass is --- [M'10]

Solution: $\mu = C_a / C_m \;\therefore\; C_m = C_a / \mu \Rightarrow \frac{3 \times 10^8}{1.5} = 2 \times 10^8 \; ms^{-1}$

4.The polarising angle for water is 53°4' . If the light is incident at this angle on the surface of the water , the angle of refraction of water is [J'08 ,M'13]

Solution: $i_p + 90 + r = 180 \;\therefore\; i_p + r = 90$; $r = 90 - i_p = 90 - 53^\circ 4' = 36^\circ 56'$

5. If the velocity of light in a medium is 2.25 x 10⁸ m/s, then the refractive index of the medium will be 1.33 [J'08]

Solution:

$$ \mu_m = \frac{\text{Velocity of light in vacuum } (C_a)}{\text{Velocity of light in medium } (C_m)} = \frac{3 \times 10^8}{2.25 \times 10^8} = 1.33 $$

6. The ratio of the radii of 4th and 9th dark rings in Newton's rings experiment is 2:3.

Solution: $r_n = \sqrt{nR\lambda}$; $R_4 : R_9 = \sqrt{4R\lambda} : \sqrt{9R\lambda} = 2 : 3$ **[J'09]**

7. Refractive index of a material for a polarising angle of 55° is 1.4281 J'12

8. A ray of light travelling in air is incident on a denser surface at an angle of 60⁰ . If the velocity of light in the densesr medium is 2 x 10⁸ m s⁻¹ , the angle of refraction inside the denser medium is: M'16

a) 30^0 b) $\sin^{-1}(0.75)$ **c) $\sin^{-1}(\frac{1}{\sqrt{3}})$** d) $\sin^{-1}(0.6666)$

9. The ratio of scattering powers of two wavelength 400 nm and 6000A° is-------.

Solution: **81: 16 . S α $1/\lambda^4$ = $(1/4000)^4 / (1/6000)^4$ = $6^4 / 4^4$ = 81:16**

10. The path difference between two coherent waves of λ = 4000 A° is 2 x 10^{-7}m.What is the phase difference?

Solution: $$\phi = \frac{2\pi\delta}{\lambda} = \frac{2\pi \times 2 \times 10^{-7}}{4 \times 10^{-7}} = \pi$$

11. The grating element of a grating is 2 x 10^{-6} m, the number of lines per unit length is ---

Solution: $$N = \frac{1}{a+b} = \frac{1}{2 \times 10^{-6}}$$ **[given: a + b]**

$$N = 0.5 \times 10^6 = 5 \times 10^5 \ m^{-1}$$

12. A grating contains 6000 lines / cm . The grating element is <u>0.166 x 10^5m.</u>

Solution: **: 6000 x 10^2 lines / m ; N = 1/6000 x 10^2 = <u>0.166 x 10^5m.</u>**

13. In Young's double slit experiment, sodium light is employed and interference fringes are obtained in which the bandwidth of 3rd bright fringe is 2.2 mm. What will be the bandwidth of 2nd dark fringe? 2.2 mm

Note : **Bandwidth is same.**

14. The distance between the corresponding points in a grating is 2 x 10^{-4} cm. The grating element is <u>2 x 10^{-4} cm.</u>

Note: Points on successive slits separated by a distance equal to the grating element are called corresponding points.

15. The distance between the two corresponding points in a grating is 2 x 10^{-4}cm. The number of lines per meter width of the grating will be <u>500000.</u>

Solution: **N= 1/ (a+b) = 1/(2x10^{-6}) = 0.5 x 10^6 = 5,00,000**

16. The refractive index of the medium for the polarizing angle 60° is <u>1.732</u>

Solution: μ = tan Ip = tan (60) = 1.732

17. In Newton ring experiment, the radius of the nth dark ring is twice the radius of 3rd dark ring. The value of n is <u>12</u>.

Solution: $r_n = \sqrt{nR\lambda}$; $r_n = 2\sqrt{3R\lambda}$; $r_n = \sqrt{12R\lambda}$ ∴ n = 12

19. Newton's rings were obtained with a light of wavelength 5460A^0. the thickness of the air film where 2nd dark ring is formed is <u>5.46 x 10^{-7}m.</u>

Solution: **2t = nλ ; t = nλ / 2 ; = (2 x 5460 x 10^{-10}) / 2 = 5.46 x 10^{-7}**

19. The frequency of light in air is 5 x 10^{14}. Then its frequency in a medium of refractive index 1.5 is 5 x 10^{14}. [Note: Frequency of light does not change

Other Important Problems:

1. In the Raman effect the wavelength of stokes and antistokes lines are 4870 A° and 4810 A° **, the wavelength of unmodified parent line is about** **<u>4840 A°.</u>**

2. In Raman effect, if frequencies of incident radiation and Stoke 's lines are respectively 6.198 X 10^{15}Hz and 6.1602 X 10 ^{15} Hz then the value of Raman shift is 0.038x10^{15} Hz

Solution: $\Delta v = v_o - v_s$ = **6.198 X 10^{15} - 6.1602 X 10 ^{15}** = 0.0378x10^{15} Hz

3. If the wavelength of light wave in vacuum is 6.4 x 10^{-7} m, then wavelength of light wave in water of refractive index 1.33 will be 4.8 x 10^{-7} m

Solution: $\mu_m = \lambda_a/\lambda_m$; $\lambda_m = \lambda_a/\mu_m$ = **6.4 x 10^{-7}/ 1.33 = 4.8 x 10^{-7} m**

4. In Young's double slit experiment, lights of wavelength 5.48 x 10^{-7} m and 6. 85 x 10 $^{-8}$m are used, in turn keeping D and d constant . The ratio of respective bandwidths in the two cases will be. 8 : 1

Solution: $\beta = D\lambda/d$; $\frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2} = \frac{5.48 \times 10^{-7}}{6.85 \times 10^{-8}} = \frac{5480}{685}$ = 8: 1

5. The refractive indices for glass and water respectively is 1.5 and 1.33 , then the ratio of velocity of light in glass and water is 8 : 9

Solution: $\mu_m = C_a/C_m$; $C_g = C_a/\mu_g$; $C_w = C_a/\mu_w$

C_g / C_w = 1.33 / 1.5 = (4/3)/1.5 = 4 /4.5 = 8 : 9

6. The time taken by the light to travel a distance of 200 m in a medium of refractive index 1.5 is **<u>10^{-6} s.</u>**

Solution: $\mu_m = C_a/C_m$; $C_m = C_a/\mu_m$ = 3 x 10^8 / 1.5 = 2 x 10^8

Velocity = d/t ; t = d/v = 200 / 2 x 10^8 = 100 x 10^{-8} = 10^{-6} s

7. In a plane transmission grating experiment, the wavelength of light is $\frac{1}{\sqrt{2}}$times of grating element used. The angle of diffraction for the first order maximum will be **<u>45°.</u>**

Solution: $\lambda = (a+b)/\sqrt{2}$; θ_1 = ?

(a+b) Sin θ = nλ ; $\sin\theta_1 = \lambda/(a+b)$ = { (a+b) / √2 }/ (a+b) = 1/√2 ; θ = 45 °

8. If the wave length of light is reduced to half then the amount of scattering will **<u>increases by 16 times.</u>**

Solution: $S \propto 1/\lambda^4$ = $1/(\lambda/2)^4$ = 16 x $1/\lambda^4$ ∴ increases by 16 times.

6. ATOMIC PHYSICS

Govt. Exam Questions:

01. When *electric field* applied to an atom each of the spectral line split in to several atom stark effect. **[J'09]**

Magnetic field - Zeeman effect.

02. Ionisation Potential of H_2 atom = 13.6 V. **[M'09]**

03. *Fine structure* of spectral lines, elliptical orbits of electrons was explained by *Sommerfeld .*

$\frac{b}{a} = \frac{l+1}{n}$ n → Principal quantum number. **[M'07]**

l → orbital (azimuthal) quantum number.

a ,b → Semi major, minor axis.

04. Rydberg's constant R = 1.094 x 10^7 m^{-1} **[J'09, O'07]**

05. Wave number $\bar{\upsilon}$ is defined as *number of waves per unit length* (In a distance of one metre) . It is equal to reciprocal of λ. Unit: m^{-1} **[M'06,O'08,O'10]**

$\bar{\upsilon} = 1/\lambda = \upsilon / C$ [$c = \upsilon\lambda$]

06. Maser material: 1. Paramagnetic ions , Ammonia gas. **[J'08]**

2. Chromium/Gadolinium ions doped as impurities in ionic crystals.

07. The energy of the electron in the first orbit of the hydrogen atom is – 13.6 eV. Its potential energy is -27.2 eV. **[J'06]**

08. In sommerfeld atom model , for a given value of n , the number of values l can take is

a) n b) n+1 c) n-1 d) 2n+1 **[O'06,M'11]**

09. In holography , which of the following is (are) recorded on the photographic film ?

a) frequency and amplitude b) phase and frequency **[O'06,J'11 J'12]**

c) phase and amplitude d) frequency only

10. If R is Rydberg constant ,the minimum wavelength of hydrogen spectrum is 1/R. **[J'07]**

11. The spectral series of hydrogen in UV region are called Lyman series. **[J'08]**

12. Maser materials are paramagnetic ions. **[J'08]**

13. In a discharge tube the source of positive rays(canal rays)is *gas atoms present in the discharge tube.* **[M'09]**

14. A three dimensional image of an object can be formaed by holography. **[O'08]**

15. The direction of viscous force in millikan oil drop experiment is ----- **[O'09]**

Ans: Opposite to the direction of the motion of the oil drop

16. In Sommerfeld atom model , for the principal quantum number n=3, which of the following subshells represents circular orbit? **[M'10]**

a) 3 S b) 3P **c) 3d** d) none of these

17. The specific charge [e/m] of cathode ray particle **[M'13,J'10]**

a) depends upon the nature of the cathode b) depends upon the nature of the anode

c) depends upon the nature of the gas atoms present inside the discharge tube

d) is independent of all these

18. The wave number of a spectral line of hydrogen atom is equal to Rydberg's constant. The line is series limit of lyman series. **[M'11]**

19. In Millikan's oil drop experiment, charged oil drop is balanced between the two plates. Now the viscous force ----- **[J'11]**

a) acts downwards b) acts upwards c) is zero d) acts either upwards or downwards

Hint: Viscous force = 6πηav. Oil drop is balanced ∴ v = 0 and Viscous force = zero. [But when oil drop is in downward direction, viscous force will act opposite to the direction of motion of the oil drop ie. upward direction]

20. Arrange the spectral lines H_α H_β H_γ H_δ in the increasing order of the wavelength: **J'12**

Ans: H_δ H_γ H_β H_α

21. In Millikan's oil drop experiment, charged oil drop moves under the influence of electric field. Now the viscous force **O'13**

a) is zero **b) acts downwards**

c) acts upwards d) acts first upwards and then downwards

22. In Thomson's experiment, cathode rays moving with a velocity 'v' enter perpendicular to an electric field of intensity 'E'. The deflection produced by the cathode rays is directly proportional to **J'14**

a) v b) v^{-1} c) v^2 **d)** v^{-2}

23. The direction of the electric field in Millikan's oil drop experiment acts: **M'15**

a. **downwards** b. upwards c. first upwards then downwards

d. first downwards, then upwards

24. If 'R' is the Rydberg's constant, the shortest wavelength of Paschen series is: **O'14**

a. $\frac{R}{9}$ **b.** $\frac{9}{R}$ c. $\frac{16}{R}$ d. $\frac{25}{R}$

25. A beam of cathode rays moves from left to right in a plane of the paper and it enters into a uniform magnetic field acting perpendicular to the plane of the paper and inwards. Now, the cathode rays are deflected: **M'16**

a) downwards b) in a direction perpendicular to the plane of the paper and inwards

c) upwards d) in a direction perpendicular to the plane of the paper and outwards

Pressure	Action
110 mm of Hg	No discharge
100 mm of Hg	Irregular streaks with cracking sound.
10 mm of Hg	Positive column
0.01mm of Hg	Crooks dark space(cathode rays)

Frequently Asked Questions:

1. The fluorescent screen used in α- particle experiment is coated with zinc sulphide.
2. All elements are made up of H_2(Hydrogen) – *Prout*
3. According to Thomson, radius of an atom = 10^{-10} m
4. According to Ruther ford,
   Diameter of atom = 10^{-10} m : Diameter of nucleus = 10^{-14} m
5. Ground state energy of the atom = -13.6 ev. [1 eV= 1.602 x 10^{-19} J]
6. According to Bohr, Radius of n^{th} orbit $r_n = n^2 \times 0.53$ A^0 . O'15
7. Energy of an electron in n^{th} orbit = $-\frac{13.6}{n^2}$ ev
8. The energy required to transfer the electron in H_2 atom from the ground state to the first Excited state = 13.6 ~ 3.4 = 10.2 ev.
9. 1 ev = 1.602 X 10^{-19} J ; 1 M ev = 1.602 X 10^{-13} J
10. X-rays are EM waves of short wavelength in the range 0.5A° to 10A°.
11. X-rays – wave length (λ) above 4A° – less frequency, energy –> *soft x-rays.*
12. X -rays – wave length (λ) 1A° - high frequency and energy –> *Hard X-rays*.
13. The spacing between the atoms is of the order of 10^{-10}m.
14. The minimum wavelength of the radiation (Continuos X-rays)$\lambda_{min} = \frac{hc}{eV} = \frac{12400}{V}$ A°
15. In ruby Laser, red light of wave length 6943 A° is emitted.
16. The life time of atoms in excited state is *10^{-8}s.*
17. The crystal used in Laue Experiment is Zns.(Zinc sulphide).
18. The life time of meta Stable state is 10^{-3} s, normal 10^{-8} s.
19. The ionization potential energy of H_2 atom is 13.6 ev, the energy of atom in n=2 state = - 3.4ev. ; n=3 state = -1.51ev.
20. When electrons jumps from M shell to K shell it gives- *K_β line* . M'12

[Energy Level Diagram problem]

21. Energy of electron in the n[th] orbit of hydrogen atom $E_n = \frac{-13.6}{n^2}$ eV

22. Energy of first orbit [n=1] $E_1 = \frac{-13.6}{1^2}$ = - 13.6 eV { Ground state energy of H_2 atom }

23. Energy of second orbit[n=2] $E_2 = \frac{-13.6}{2^2}$ = - 3.4 eV { First Excited state }

24. Energy of third orbit[n=3] $E_3 = \frac{-13.6}{3^2}$ = - 1.51 eV { second Excited state }

25. Energy of fourth orbit[n=4] $E_4 = \frac{-13.6}{4^2}$ = - 0.85 eV { third Excited state}

26. Energy of fifth orbit[n=5] $E_5 = \frac{-13.6}{5^2}$ = - 0.54 eV { Fourth Excited state}

27. Energy is maximum when n=∞ $E_\infty = \frac{-13.6}{\infty}$ = 0 [outer most orbit]

<u>Note:</u> Energy Required to raise an atom from its normal state into an excited state is <u>Excitation potential energy.</u>

28. Energy required to transfer electron in H_2 atom from ----
29. ground state to first excited = 13.6 - 3.4 = 10.2 eV
30. ground state to second excited = 13.6 - 1.51 = 12.09 eV
31. ground state to third excited = 13.6 - 0.85 = 12.75 eV
32. first excited to second excited = 3.4 - 1.51 = 1.89 eV
33. second excited to third excited = 1.51 -0.85 = 0.66 eV

34. First orbit (or) Ground state to outer most orbit = 13.6 - 0 = <u>13.6 eV</u> {This energy (13.6 eV) is called **Ionisation potential energy** of H_2 atom}

35. Ionisation Potential of H_2 atom is = 13.6 V

36. The minimum potential required to excite a free neutral atom from its ground state to higher state is called <u>Critical potential (13.6 V for H_2)</u>

37. The energy of electron in the first orbit of hydrogen atom is -13.6 eV. Its potential energy is -27.2 eV, kinetic energy = +13.6 eV [**Note:** PE = 2 TE ; KE = - TE ; TE = PE+KE]

$$E_p = \frac{(Ze)(-e)}{4\pi\varepsilon_o r_n} = \frac{-Ze^2}{4\pi\varepsilon_o r_n}$$

$$\boxed{E_k = \frac{1}{2}\left[\frac{1}{4\pi\varepsilon_o}\frac{Ze^2}{r_n}\right] = \frac{Ze^2}{8\pi\varepsilon_o r_n}}$$

$$\boxed{E_n = \frac{-Ze^2}{8\pi\varepsilon_o r_n}}$$

38. Fine holes are drilled in diamonds using <u>laser beam.</u>

39. Ratio of area of first three Bohr orbits ----- 1: 16: 81

Other Important Questions:

1. Electric current may be passed through a gas
   (i) by applying large potential difference, with very low pressure
   (ii) by allowing x-rays to pass through them.
2. *J.J. Thomson* discovered electron.
3. *Roentgen* discovered x-rays
4. α particle is nothing but $_2He^4$ atom.
5. Velocity of cathode ray is $(1/10)^{th}$ of velocity of light = 3×10^7 ms^{-1}.
6. Millikan Experiment is used to measure charge of an electron.
7. Matter is made up of extremely small particle called atoms – *Dalton*
8. According to Thomson, electrons of an atom are located is a symmetrical pattern with respect to centre of the sphere.
9. For a material, the amount of absorbed intensity = μIdx or.[dI= - μIdx]
10. Stability of the atom was explained by Bohr atom model.
11. Na, Hg vapour lamps work on the principle of hot cathode positive column.
12. In hydrogen atom the value of Bohr radius is $n^2 \times 0.53$ A°.
13. Target in coolidge tube is tungsten .(or) molybdenum
14. *Wavelength* of X-rays depend Kinetic Energy of the electron.
15. *Continuous* X-ray spectra consist of radiations of *all possible wavelengths*.
   Characteristic X-ray spectra consist of radiations of definite, well defined *wavelength*.
16. In Laser action all the photons have same energy, same frequency and same phase with each other.
17. Maser provides a very strong tool for analysis in *Molecular spectroscopy*.
   Note :For the given operating voltage *minimum wavelength* is same for all metals. X-ray is the phenomenon of conversion of Kinetic Energy in to radiation.
18. The wavelength of radiations absorbed by chromium ions is Ruby laser is *5500 A°*
19. Sommerfeld model explains the Back ground of fine structure of spectral lines.
20. For a given operating voltage the minimum wavelength of X – rays is _____
   Ans: *The same for all metals*
21. Based on Thomson atom model, the wavelength of spectral line obtained from Hydrogen atom is *1300 A°*.
22. Bohr quantization condition is $Mvr = nh/2\pi$; Frequency condition $hv = E_2 - E_1$
23. Mosley's law led to the discovery of chemical element _______
   Ans: Rhenium(75) , Hafnium(72), Tecnetium(43)

24. When X – rays fall on certain metals, they liberate <u>Photoelectrons .</u>

25. In He – Ne laser, the ratio of helium and neon is _________

Ans: **1 : 4** (Note: For neon and helium 4:1)

26. Hard X-rays are produced by <u>applying very high potential difference.</u>

27. For the principal quantum number 3, the possible orbital quantum number l values are <u>2, 1, 0.</u>

Sommerfeld atom model

principal quantum number (n)	orbital quantum number (*l*)	sub-shell *b/a = [l+1]/n*		orbit
1	0	b=a		1s - Circular
2	0, 1	n=2, l=0	b = a/2	2S - Elliptical
		n=2, l=1	b = a	2p - Circular
3	0, 1, 2	n =3, l=0	b = a/3	3S- Elliptical
		n=3,l=1	b = a/2	3P- Elliptical
		n=3,l=2	b = a	3d- Circular

28. When the electron jumps from any of the outer orbits to the first orbit, the spectral line is <u>Lyman series.</u>

29. The energy of meta stable state of Ne in He-Ne laser is <u>20.66 eV.</u>

30. Achieving more atoms in the excited state than in the ground state is <u>population inversion.</u>

31. Bohr's models fails because it explains only spectral series of <u>hydrogen atom and hydrogen like atoms.</u>

32. Einstein's photoelectric theory and Bohr's theory of hydrogen spectral lines confirmed <u>dual nature of radiant energy.</u>

33. Rydberg constant Formula: $R = \dfrac{me^4}{8\varepsilon_o^2 ch^3}$ $R = 1.094 \times 10^7 m^{-1}$

Frequently Asked Problems:

1. A Coolidge tube operates at 24800 V, The maximum frequency is------. [O'09, O'11]

Solution: $\lambda_{min} = \frac{12400}{V} A^o = \frac{12400}{24800} A^o = 0.5\ A^o = 0.5 \times 10^{-10}$ m

$\upsilon = C/\lambda = \frac{3\times10^8}{0.5 \times 10^{-10}} = 6 \times 10^{18}$ Hz.

2. If the minimum wavelength of X-rays produced in a Coolidge tube is 0.62A°, the operating potential is-----------. [M'06,08]

Solution: $\lambda_{Min} = \frac{12400}{V} A^o$; $V = \frac{12400}{\lambda_{Min}} A^o = \frac{12400 \times 10^{-10}}{0.62\times 10^{-10}} = 20000V = 20$ KV.

3. A crystal diffracts X–rays. If the angle of diffraction for the 2nd order is 90°, then that for the first order will be <u>30°</u> . [M'07]

Solution: step 1 $2d\sin\theta = n\lambda$; $2d \sin 90 = 2\lambda$; $2d = 2\lambda$; $d = \lambda$

step 2: $2d \sin\theta = (1)\lambda$; $2d \sin\theta = \lambda$; $\sin\theta = \lambda/2d = \lambda/2\lambda = ½$; $\theta = \sin^{-1}(½) = 30^o$

4. For a first order X –ray diffraction, the wavelength of X- ray equal to the inter planar distance at a glancing angle of _________ [O'07]

Solution: $2d\sin\theta = n\lambda$; $2d\sin\theta = 1\lambda$; $\sin\theta = \lambda/2d = \lambda/2\lambda = 1/2 \therefore \theta = 30^o$

5. If R is Rydberg constant , the shortest wavelength of Paschen series is ----- [J'10]

a) R/9 b) 9/R c) 16/R d) R/16

Hint: $n_1=3, n_2=\infty$ [for long wave length $n_1=3, n_2=4$]

6. In Millikan's oil drop experiment two plates separated by 16 mm and are maintained at a potential of 10,000 V. The electric field intensity is _________ [J'10]

Solution: $E = V/d = 10000 / 16 \times 10^{-3} = 6.25 \times 10^5$ V/m

7. A Coolidge tube operates at 18600 V. The maximum frequency of X-radiation emitted from it is --- [O'07]

Solution: $\lambda_{min} = \frac{12400}{18600} A^o = \frac{2}{3} A^o$ | $\upsilon = \frac{C}{\lambda} = \frac{3 \times 10^8}{2/3} \times 10^{10} = 4.5 \times 10^{18}$Hz

8. The minimum wavelength of X-rays produced in an X-ray tube at 1000 KV is ---- [M'09]

Solution: $\lambda_{min} = \frac{12400}{V} A^o = \frac{12400 \times 10^{-10}}{10^6} = 12400 \times 10^{-16}$m $= 0.0124 \times 10^{-10}$m $= 0.0124\ A^o$

9. The radius of 2nd orbit of H_2 atom is ---------.

Solution: $r_n = n^2 \times 0.53 A^o = 2^2 \times 0.53 = 4 \times 0.53 = 2.12\ A^o$

10. The charge of an oil drop is 12.8 x 10^{-19} C. Then the no of elementary charges are --

Solution: q= ne ; n= q/e $= \frac{12.8 \times 10^{-19}}{1.6 \times 10^{-19}} = 8$

11. An electron with speed of 2.5 x 10^7 m/s suffers a deflection in a magnetic field of induction 2 x 10^{-3} T then the electric field that would give the same deflection is

Solution: V = E/B ; E = BV = 2x 10^{-3} x 2.5 x 10^7 = 5x10^4 V/m

12. The potential difference between the cathode and the target of Coolidge tube is 1.24 x 10^5V, then the minimum wavelength of continuous X-rays is _____

Solution: $\lambda min = \frac{12400}{V} A^o = \frac{12400}{1.24 \times 10^5} A^o = \frac{1.24 \times 10^4}{1.24 \times 10^5} A^o = 0.1 A^o$

13. Radius of first orbit of hydrogen atom is 0.53A° then the radius of third orbit is ---

Solution: : $r_n = n^2 \times 0.53 A^o$; $r_3 = 3^2 \times 0.53 A^o = 4.774 A^o$

14. The minimum wavelength an X-ray coming out of X-ray tube under a potential difference of 1000 volt is ________

Solution: $\lambda min = \frac{12,400}{V} A^o = \frac{12,400}{1000} = 12.4 A^o$

15. In Millikan's oil drop experiment, two plates separated by 5 cm in air are at a potential of 5V, then the electric field is _________

Solution: E = V/ d = 5 / 5 x 10^{-2} = 100 V/m

Other Important Problems

1. A crystal diffracts monochromatic X – rays. If the angle of diffraction for first order is 30°, then that for second order will be ________

Solution:

$2d\sin\theta = n\lambda$

$2d \sin 30 = 1\lambda$

$2d \cdot ½ = \lambda$

$d = \lambda$

step 2: $2d \sin\theta = (2)\lambda$

$2d \sin\theta = 2\lambda$

$\sin\theta = 2\lambda/2d = 2\lambda/2\lambda = 1$

$\theta = \sin^{-1}(1) = 90^o$

2. The glancing angle of monochromatic X-ray of wavelength 1A° is 30°. The lattice space between the second order reflection is _______

Solution: : $2d\sin\theta = n\lambda$; $2d\sin 30 = 2\lambda$; $d = \lambda / \sin 30 = 1A^o / ½ = 2\times10^{-10}$m = 2 A°

3. In a Bragg's spectrometer the glancing angle for the fourth order of spectrum of X-ray found to be 30°. What will be the glancing angle for the occurrence of first order spectrum?

Solution: $2d\sin\theta_4 = n\lambda$; $2d\sin 30 = 4\lambda$; $2d\,½ = 4\lambda$; $d = 4\lambda$

$2d \sin\theta_1 = (1)\lambda$; $\sin\theta_1 = \lambda/2d = \lambda/8\lambda = 1/8 = 0.125$: $\theta = \sin^{-1} 0.125 = 7^o10'$

4. **The ionization potential energy of the hydrogen atom is 13.6 eV. The energy of the atom in n=2 state is __________**

Solution: $E_n = -\frac{13.6}{n^2}$ eV ; n = 2 ; $E_2 = -\frac{13.6}{2^2}$ = -3.4 eV

5. **An electron moves through an electric field of intensity 9 x 10^3 V/m. If the mass of the electron is 9.1 x 10^{-31}kg, then the acceleration of electron is __________**

Solution: $a = \frac{Ee}{m} = \frac{9 \times 10^3 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}} = 1.6 \times 10^{15}\ ms^{-2}$

6. **The minimum wavelength of X-rays produced from a Coolidge tube is 0.05 nm. Find the operating voltage of the Coolidge tube.** [J'11]

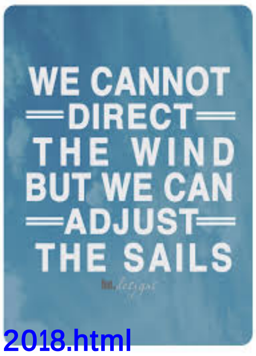
Solution:

$\lambda min = \frac{12,400\ A^o}{V}$ $\therefore V = \frac{12400 \times 10^{-10}}{\lambda_{min}} = \frac{12400 \times 10^{-10}}{0.05 \times 10^{-9}} = \frac{12400 \times 10^{-10}}{0.5 \times 10^{-10}}$ = 24800 V

EXCLUSIVE

Rydberg's constant R = 1.094 x 10^7 m^{-1}

Series→	Lyman	Balmer	Paschen	Brackett	Pfund
Formula $\bar{\nu}$	$R[1/n1^2 - 1/n_2^2]$	$R[1/n_1^2 - 1/n_2^2]$	$R[1/n_1^2 - 1/n_2^2]$	$R[1/n_1^2 - 1/n_2^2]$	$R[1/n_1^2 - 1/n_2^2]$
Short λ_s	n_1=1 , $n_2 = \infty$	n_1=2 , $n_2 = \infty$	n_1=3 , $n_2 = \infty$	n_1=4 , $n_2 = \infty$	n_1=5 , $n_2 = \infty$
[$\lambda = 1/\bar{\nu}$]	1/R =911.6 A°	4/R=3656 A°	9/R=8226 A°	16/R=14625A⁰	25/R=22851A°
$\bar{\nu}$	1.094 x 10^7	2.735 x 10^6	1.215 x 10^6	6.83 x 10^5	4.37 x 10^5
Long λ_L	n_1=1 , n_2 = 2 $\frac{4}{3R}$	n_1=2 , n_2 = 3 $\frac{36}{5R}$	n_1=3 , n_2 = 4 $\frac{144}{7R}$	n_1=4 , n_2 = 5 $\frac{400}{9R}$	n_1=5 , n_2 = 6 $\frac{900}{11R}$
	1215A°	6581 A°	18803 A°	40625 A°	74788 A°
Region	ultra violet	visible	Infra red	Infra red	Infra red



7. DUAL NATURE OF RADIATION AND MATTER AND RELATIVITY

Govt. Exam Questions

1. De broglie wavelength of electron = $\frac{12.27}{\sqrt{V}}$ A° = $\frac{h}{\sqrt{2meV}}$ = $\frac{h}{\sqrt{2mE}}$ [O'10 O'11,M'12]
2. Wave nature of moving electron is the basis for electron micro scope. [M'10]
3. The photon has Zero mass but has energy. [M'08,J'08]
4. The graph plotted between frequency of radiation and stopping potential is a straight line. [M'11]
5. According to special theory of relativity the *only constant* in all frames of reference is velocity of light. [O'06,M'07,M'09]
6. *At threshold frequency* the stopping potential is Zero.{The Velocity of photoelectron is zero] [M'06,O'06]
7. If the radius of third Bohr orbit in hydrogen is r , then the de Broglie wavelength of electron in this orbit is $\frac{2\pi r}{3}$ [M'06]
8. Two photons each of energy 2.5 eV are simultaneously incident on the metal surface. If the work function of the metal is 4.5 ev then from the surface of the metal-- [J'06]

   Ans: Not a single electron will be emitted [since energy of photon less than work function]

9. A photon of frequency ν is incident on a metal surface of threshold frequency ν_0, the kinetic energy of the emitted photo electron is $h(\nu - \nu_0)$ [O'07,8]
10. When a material particle of rest mass m_o attains the velocity of light, its mass becomes infinity (∞) . [O'07]
11. An electron of mass m and charge e accelerated from rest through a potential of V volt then its final velocity is $\sqrt{\frac{2Ve}{m}}$ [O'08]
12. Einstein's photo electric equation is $W + \frac{1}{2} m V^2_{max} = h\nu$ [J'09]

    Another form : $h\nu - h\nu_o = \frac{1}{2} m V^2_{max}$
13. A photon of energy 2E incident on a photosensitive surface of photoelectric work function E. The maximum kinetic energy of photoelectron emitted is – [J'11]

    a) E b) 2 E c) 3E d) 4E

    Hint: $W + \frac{1}{2} m V^2_{max} = h\nu$. Here $E + \frac{1}{2} m V^2_{max} = 2E$ ∴ $\frac{1}{2} m V^2_{max} = 2E - E = E$
14. In the photoelectric phenomenon if the ratio of the frequency of the incident radiation incident on a photosensitive surface is 1:2:3, The ratio of photoelectric current is –

    Ans: 1:1:1 M'12
15. When the momentum of the particle increases , its de broglie wavelength decreases. J'12

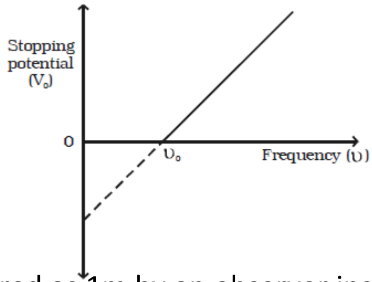
16. when an electron is accelerated with potential difference V. Its de Broglie wavelength is directly proportional to **[O'12]**

a) V b) V^{-1} c) $V^{½}$ **d) $V^{-½}$**

17. The number of de Broglie waves of an electron in the nth orbit of an atom is **[M'13]**

a) n b) n-1 c) n+1 d)2n

18. In the photoelectric effect, a graph is drawn taking the frequency of incident radiation along X-axis and the corresponding stopping potential along the Y-axis. The nature of the graph is **J'14**



a) a straight line passing through origin
b) a straight line having positive Y-intercept
c) a straight line having negative Y-intercept
d) a parabola

19. The length of the rod placed inside a rocket is measured as 1m by an observer inside the rocket which is at rest. When the rocket moves with a speed of 36 x 10^6 km/hr the length of the rod as measured by the same observer is: **M'16**

a) 0.997 m b)1.003 m **c) 1 m** d) 1.006 m

Frequently Asked Questions

1. **Photo electric effect was discovered by Heinrich Hertz.**
2. **Stopping potential *depends* upon velocity of the fastest electron.**
3. **Saturation current is *proportional* to the intensity of radiation.**
4. **Stopping *potential is independent* of intensity of light.**
5. **When the frequency of incident radiation increases the value of stopping potential will increase.**
6. **Photoelectric current is directly proportional intensity of incident radiation.**
7. **The threshold frequency depends on the photo sensitive material.[i.e different for different metals.**
8. **Photo electric current depends on**
   a) intensity of incident light **b) frequency of incident light**
   c) the potential difference between two plates **d) all the above**
9. **The maximum KE of the photoelectrons ________**
   Ans: Varies linearly with the frequency of incident light
10. **Photon is neither a particle nor a wave.**
11. ***Photo electric cell* converts light energy into electrical energy.**
12. **In photo emissive cell *cathode* is coated with Caesium oxide.**[Low work function]
13. **In Newtonian Mechanics, mass, time, length and space were treated as absolute.**

14. In ***Einstein's*** view, time, mass, length and space are interdependent and are not absolute.
15. Rest energy of a particle of mass m_o is m_oC^2.
16. When a particle of rest mass 'm_o' attains the velocity of light, its mass becomes infinity. Hint: $m = \frac{mo}{\sqrt{1-v^2/v^2}} = \frac{mo}{0} = \infty$
17. *Photo electric effect* can be explained on the basis of quantum theory.
18. Electrons having de Broglie wavelength of the order of X-rays can be focused easily using electric and magnetic fields.
19. The resolving power ratio of optical and electron microscope is $1 : 10^5$.
20. ***Doughnut*** shaped electromagnet is used in electron microscope.
21. Sharp focus depend ***intensity of magnetic field***.
22. The resolving power of a microscope is limited by the wave length of the radiation.
23. In electron microscope potential difference required is 60,000 V (Or) 6×10^4 V, the wavelength is about 5×10^{-12} m.
24. Resolving power of electron microscope is ***1,00,000 or 10^5*** times greater than that of optical microscope.
25. Sharp focussing in electron microscope is obtained by adjusting the intensity of magnetic fields produced by electro magnets.
26. Resolving power of electron microscope is inversely proportional to wavelength of radiation.
27. Unit of work function is joule.
28. Einstein's photoelectric effect proved that the light is having particle nature.
29. ***The resolving power of a microscope is the least distance between two points which can be distinguished.***
30. The linear momentum of de Broglie wave is h / λ.
31. Einstein's photoelectric equation can be experimentally verified by Millikan.
32. In a photo emissive cell , the anode is made up of platinum wire.
33. Special theory of relativity discards the absolute motion through space and deals with objects or observers.

Other Important Questions:

1. Electrons accelerated in a particle accelerator with a very high velocity acquire increased *mass.*
2. When an electron meets its antiparticle position, both of them *annihilate* and from two photons.
3. Work done in bringing the fastest electron to rest = kinetic energy of electron.

   Note: $eV_0 = \frac{1}{2} m v^2_{max}$
4. "The matter is also having dual nature" . This was suggested by de Broglie , based on symmetrical property.
5. Wave nature of photon: interference, diffraction, polarisation

   Particle nature of photon: emission, absorption, interaction with matter (photo electric effect). Light photon has dual nature.
6. The energy required to bring the electrons of maximum velocity to rest is eV_o
7. Newton's laws are not valid in Non- inertial frames
8. Hallwachs demonstrated photoelectric effect experimentally first.
9. Light of frequency 1.5 times the threshold frequency is incident on a photosensitive material. If the frequency is halved and intensity is double, the photoelectric becomes zero [∵ frequency is less than threshold frequency ie 0.75 times threshold frequency]

11. The minimum negative (retarding) potential given to the anode for which the photo electric current becomes zero is called the cut-off or stopping potential.

Frequently Asked Problems:

Note: $\boxed{1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}}$ $\quad 1 \text{ J} = 1 / 1.6 \times 10^{-19} \text{ eV}$

Eg: $5 \text{ eV} = 5 \times 1.6 \times 10^{-19} \text{ J}$

$5 \text{ eV} = 8 \times 10^{-19} \text{ J}$

$8 \times 10^{-19} \text{ J} = \frac{8 \times 10^{-19}}{1.6 \times 10^{-19}} \text{ eV}$

$8 \times 10^{-19} \text{ J} = 5 \text{ eV}$

01. Threshold frequency of a metal is 3×10^{14} then the work function is------

Solution: $W = h\upsilon_0 = 6.6 \times 10^{-34} \times 3 \times 10^{14} = 1.98 \times 10^{-19}$ J

02. The work function of the metal is 6.626×10^{-19} J. The threshold frequency is –

Solution: $W = h\upsilon_o$; $W/h = \upsilon_o$; $6.626 \times 10^{-34} / 6.626 \times 10^{-19} = 1 \times 10^{15}$ Hz

03. The wavelength of proton having frequency of 1.5×10^{13} Hz is $\underline{2 \times 10^{-5}\ m}$

Solution: $C = \upsilon\lambda$; $\lambda = C/\upsilon = 3 \times 10^{8} / 1.5 \times 10^{13} = 2 \times 10^{-5} m$

04. If the momentum of a radiating photon is $3.3 \times 10^{-29} kg\ ms^{-1}$ then its wavelength is -------

Solution: $\lambda = \dfrac{h}{P} = \dfrac{6.6 \times 10^{-34}}{3.3 \times 10^{-29}} = 2 \times 10^{-5} m$

05. The de Broglie wavelength of electron having momentum 3.3×10^{-24} Kg ms^{-1} is --.

Solution: $\lambda = \dfrac{h}{p} = \dfrac{6.6 \times 10^{-34}}{3.3 \times 10^{-24}} = 2 \times 10^{-10} = 2\ A^{0}$

06. The work function of a photoelectric material is 3.3eV. The threshold frequency will be equal to __________ [M'08]

Solution: $W = h\nu_0$; $\nu_0 = W/h = \dfrac{3.3 \times 1.6\ 10^{-19}}{6.6 \times 10^{-34}} = 0.8 \times 10^{15} = 8 \times 10^{14}$ Hz

07. The de Broglie wave length of an object of mass 0.03 kg moving with the velocity 20 m/s is ----------.

Solution: $\lambda = h / mv = \dfrac{6.626 \times 10^{-34}}{0.03 \times 20} = 1.1 \times 10^{-33}$ m

08. The wavelength of electrons accelerated by a potential difference of 60,000 V is about

Solution: $\lambda = \dfrac{12.27\ A^{o}}{\sqrt{V}} = \dfrac{12.27 \times 10^{-10}}{\sqrt{60000}} = 5 \times 10^{-12}$ m

09. The momentum of photon of wavelength 6600 A° is -----

Solution: $\lambda = \dfrac{h}{P}$ $\therefore$ $p = \dfrac{h}{\lambda} = \dfrac{6.6 \times 10^{-34}}{6.6 \times 10^{-7}} = 10^{-27}$ Kg m s^{-1}

Other Important Problems:

01. The frequency of photon having an energy of 413 eV is __________

Solution: $\upsilon = \dfrac{W}{h} = \dfrac{413 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}} = \dfrac{6.6 \times 10^{-17}}{6.6 \times 10^{-34}} = 10^{17}$ Hz

02. The wave number of light of radiation of wavelength 5000 A is _________

Solution: $\bar{\nu} = \frac{1}{\lambda} = \frac{\nu}{c} = 1/ 5000 \times 10^{-10} = 2 \times 10^{6} m^{-1}$

03. Threshold frequency of a metal is 3×10^{13} Hz, then its work function is _-------

Solution: $W = h\upsilon_o = 6.6 \times 10^{-34} \times 3 \times 10^{13} = 1.98 \times 10^{-20} \approx 2 \times 10^{-20}$

04. De Broglie wavelength of a proton moving with 1/ 15^{th} of velocity of light is -------

Solution: $\lambda = \dfrac{h}{mv} = \dfrac{6.6 \times 10^{-34}}{1.67 \times 10^{-27} \times \frac{1}{15} \times 3 \times 10^{8}} = 1.97 \times 10^{-14} \approx 2 \times 10^{-14} m$

05. A light of wavelength 4000 A° falls on metal surface of work function 2 eV. Then the maximum kinetic energy of emitted photon is 1.1 eV

Solution: $\frac{1}{2}mV^2 = h\upsilon - W = 3.09 - 2 = 1.1$ eV

[Hint: $h\upsilon = h\frac{C}{\lambda} = 6.6 \times 10^{-34} \times 3 \times 10^8 / 4 \times 10^{-7} = 3.09$]

06. Threshold frequency of metal is 10^5 Hz, the frequency of incident light is 2×10^{15}Hz then the energy of photo electron emitted is 6.625×10^{-19}J

Solution: $W = h(\upsilon - \upsilon_o) = 6.625 \times 10^{-34}(2 \times 10^{15} - 1 \times 10^{15}) = 6.6 \times 10^{-19}$ J

07. The energy of incident UV rays on aluminium metal of work function 4.2 eV is 6.2eV. Then the kinetic energy of emitted photoelectron is 3×10^{-19}J

Solution: $KE = h\upsilon - W = 6.2 - 4.2 = 2$ eV $= 2 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}$

$\approx 3 \times 10^{-19}$ J

08. If the wave length of the electron is 50×10^{-11} m, then the potential difference applied is ------

Solution: $\lambda = \frac{12.27 \text{ A}^o}{\sqrt{V}} \Rightarrow \sqrt{V} = \frac{12.27 \times 10^{-10}}{\lambda} = \frac{12.27 \times 10^{-10}}{50 \times 10^{-11}} = 2.545$

$\therefore V = (2.545)^2 = 6.02$ V

09. If the electron is moving with a velocity of 500 km/s then the de Broglie wavelength is

Solution: $\lambda = \frac{h}{mv} = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 500 \times 10^3} = 14.5$ A°

10. The momentum of a proton and an alpha particle are equal. The mass of alpha particle is four times the mass of proton. The ratio of wave length associated with them is-----

Solution: 1 : 1 [Since momentum is equal and h is constant the ratio is 1:1]

11. The frequency of photon of energy 65 eV is -------

Solution: $W = h\upsilon \therefore \upsilon = \frac{W}{h} = \frac{65 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}} = 1.57 \times 10^{16}$ Hz

12. If the threshold wavelength of sodium is 6800 A°, its work function is –

Solution: $W = h\upsilon_o = \frac{hC}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{6800 \times 10^{-10}} = 2.91 \times 10^{-19}$ J $= 1.819$ eV

13. The de Broglie wave length of an electron having K.E of 20ev is 2.75 A° .

Solution: $\lambda = h/\sqrt{2mE} = 6.6 \times 10^{-34}/(\sqrt{2 \times 9.1 \times 10^{-31} \times 20 \times 1.6 \times 10^{-19}})$

8. NUCLEAR PHYSICS

Govt. Exam Questions

1. Isotones: Same number of Neutrons.

   Ex: $_8O^{16}$ and $_6C^{14}$: $_7N^{14}$ and $_6C^{13}$: $_{11}Na^{24}$ and $_{10}Ne^{23}$ [M'11]

2. $T_{1/2} = \frac{0.6931}{\lambda} = 0.6931\,\tau$ (OR) $\tau = \frac{T_{1/2}}{0.6931}$ [M'08]

3. Energy of Slow neutron: 0 to 1000 eV. [J'08]

   Thermal neutron: 0.025 eV.

   Fast neutron: 0.5 MeV to 10 MeV.

4. 1amu= 1.66×10^{-27}Kg ; 1ev = 1.6×10^{-19} joule ; 1 amu = 931 MeV. [J'06,O'06,O'08,J'09]

5. The time taken by a radioactive element to reduce to $e^{-1/2}$ times its original amount is its mean life period Solution: $N/No = e^{-\lambda\tau/2} = e^{-\lambda(1/2\lambda)} = e^{-1/2}$ [J'06]

   2

   Note: The time taken by a radioactive element to reduce to e^{-1} (or) 1/e times its original amount is its meanlife .

   Solution: $N = N_o e^{-\lambda t} \rightarrow 1/e\, N_o = N_o e^{-\lambda t} \rightarrow e^{-1} = e^{-\lambda t} \rightarrow \lambda t = 1 \rightarrow t = 1/\lambda = \tau$

6. The penetrating power is maximum for gamma rays. [O'06]

7. $_{13}Al^{27} + {_2He^4} \rightarrow X + {_0n^1}$; $X = {_{15}P^{30}}$ [O'06]

8. The particle which exchange between the nucleons and responsible for the origin of the nuclear force are mesons. [M'06,J'07,M'09,O'09]

9. The fuel used in *Kamini* [Kalpakkam mini reactor] is $_{92}U^{233}$ [The only operating reactor in the world which uses $_{92}U^{233}$ as a fuel] [O'07,O'09]

10. In the following reaction $_7N^{14} + {_0n^1} \rightarrow X + {_1H^1}$ the element X is ---- $_6C^{14}$ [M'06]

11. Which of the following particle is a lepton? [M'06]

    a) *electron* b) photon c) neutron d) π meson

12. The moderator used in the nuclear reactor is Heavy water [M'07]

13. Particle that has no charge and no rest mass but travels with the velocity of light is Photon. [O'08]

14. In the nuclear reaction $_4Be^9 + X \rightarrow + {_6C^{12}} + {_0n^1}$, X stands for α-particle [$_2He^4$] [M'10]

15. Which of the following belongs to Baryon group?

    a)photon b)electron c)pion d)proton

16. The coolant used in the fast breeder reactor is liquid sodium. [O'10,S'15]

17. Arrange α β and γ rays in the increasing order of their ionising power---

Ans: γ ,β ,α [M'11]

18. When mass number increases nuclear density remains constant. [J'11]
Hint: The nuclear density is **1.816×10^{17} kg m^{-3}** which is almost a **constant** for all the nuclei irrespective of its size.

19. Unit of disintegration Constant[λ] is second^{-1} [M'12, S'15]

20. Which of the following is massless and chargeless but carrier of energy and spin?

a) Neutrino b) Muon c) Pion d)Kaon [J'12]

21. In proton proton cycle four protons fuse together to give [O'12]

b) an α paricle, two positrons,two neutrinos and energy of 26.7 Mev.

22. The radius of the nucleus is 5.2 F. the number of nucleons in the nucleus is [O'12]

a) 52 b)104 c) 64 d)128

Isotope	Uses
Radio Cobalt (Co^{60})	Cancer treatment
Radio sodium Na^{24}	To detect blocks in blood vessels, effective function of heart. M'08]
Radio iodine I^{131}	Thyroid gland, brain tumour.
Radio –iron Fe^{59}	Anemia
Radio PhosphorousP^{32}	Skin diseases, Fertilizer.

Element	Half life
Neutrons	13 minutes.
Nitrogen	10.1 minutes
Phosphorous	3 minutes.
C^{14}	5570 years.
Radon	3.8 days
Po^{218}	3 minute.
Tritium	12.5 years.

Frequently Asked Questions

1. Nucleus was discovered by *Earnest Rutherford.*
2. Radio activity was discovered by *Henri Becquerel.*
3. Artificial radioactivity was discovered by *Irene curie and F.Joliot*.
4. Neutron was discovered by *Chadwick.*
5. Nuclear fission was discovered by Otto Hahn and F.Strassman.
6. Isotopes: Same atomic number (z), different mass number (A)
(or)*same number of protons but different number of neutrons.* Ex: $_1H^1$, $_1H^2$
7. Isobars: Same mass number (A), different Atomic number (z). Ex: $_8O^{16}$, $_7N^{16}$
8. Isotones: Same number of Neutrons.
Ex: $_8O^{16}$ and $_6C^{14}$: $_7N^{14}$ and $_6C^{13}$: $_{11}Na^{24}$ and $_{10}Ne^{23}$

9. **Nuclear forces were explained by Yukawa.**

10. **Radius of nucleus R = $r_o A^{1/3}$**

r_o = 1.3 F = 1.3×10^{-15} m [1 Fermi = 10^{-15}m]

11. **Nuclear Density = 1.816×10^{17}Kg m^{-3} ; It is constant for all nuclei.**

12. **Safe limit of radiation exposure is 250 milli roentgen per week.**

13. **Binding Energy per nucleon of Uranium is 7.6 Mev.**

14. **Unit of activity is Becquerel. Another unit of Activity is curie.**

15. **1 curie = 3.7×10^{10} disintegration per second.**

= 3.7×10^{10} becquerel. [1 becquerel = 1 disintegration per second] **[M'13]**

= activity of one gram of radium.

16. **Nuclear force is 10^{40} times greater than the gravitational force.**

17. **Nuclear force is very strong, if the distance is 10^{-15} m.**

18. **In α – decay, ($_2He^4$) (i) Atomic no. decreases by two**

$_ZX^A \rightarrow {}_{Z-2}Y^{A-4} + {}_2He^4$ (ii) Mass no. decreases by four

19. **The energy of primary cosmic ray is 10^8MeV.**

20. **Average number of neutron released per fission of Uranium is *2.5* .**

21. **Natural Uranium consists of 99.28% of U^{238} and 0.72% of U^{235}**

22. **In β-decay ($_{-1}e^0$) (i) Atomic no. increases by one.(OR)**

$_ZX^A \rightarrow {}_{Z+1}Y^A + {}_{-1}e^0$ Neutron no. decreases by one.(OR) No change in mass number.

➤ **Important equations:**

01. $_5B^{10} + {}_2He^4 \rightarrow + {}_7N^{13*} + {}_0n^1$

02. $_{13}Al^{27} + {}_2He^4 \rightarrow {}_{15}P^{30*} + {}_0n^1$

03. $_7N^{13*} \rightarrow {}_6C^{13} + {}_1e^0$

04. $_{15}P^{30*} \rightarrow {}_{14}Si^{30} + {}_1e^0$

05. $_{15}P^{31} + {}_0n^1 \rightarrow {}_{15}P^{32*} + \gamma,$

06. $_{11}Na^{23} + {}_0n^1 \rightarrow {}_{11}Na^{24*} + \gamma$

07. $_{11}Na^{23} + {}_1H^2 \rightarrow {}_{11}Na^{24*} + {}_1H^1$

08. $_7N^{14} + {}_2He^4 \rightarrow {}_8O^{17} + {}_1H^1$

➤ **Nuclear fusion reaction:**

$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\ {}_0n^1 + Q$$

$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{54}Xe^{140} + {}_{38}Sr^{94} + 2\ {}_0n^1 + Q$$

➤ **Nuclear fusion reaction:**

$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3{}_0n^1 + Q$$

➤ **Fission in hydrogen bomb:**

$$_1H^3 + {}_1H^2 \rightarrow {}_2He^4 + {}_0n^1 + \text{energy}$$

➤ ***Proton – Proton cycle*** ***M'11***

$_1H^1 + _1H^1 \rightarrow _1H^2 + _1e^0 + \nu$ (emission of positron and neutrino)

$_1H^1 + _1H^2 \rightarrow _2He^3 + \gamma$ (emission of gamma rays)

$2\,_2He^3 \rightarrow _2He^4 + 2\,_1H^1$

The reaction cycle is written as

$4\,_1H^1 \rightarrow _2He^4 + 2\,_1e^0 + 2\nu$ + energy (26.7 MeV)

- **Carbon – Nitrogen Cycle :** ***The following cycle of reactions take place in carbon – nitrogen cycle in which carbon acts as a catalyst.***

$_1H^1 + _6C^{12} \rightarrow _7N^{13*} + \gamma$ (emission of gamma rays)

$_7N^{13*} \rightarrow _6C^{13} + _1e^0 + \nu$ (emission of positron and neutrino)

$_1H^1 + _6C^{13} \rightarrow _7N^{14} + \gamma$ (emission of gamma rays)

$_1H^1 + _7N^{14} \rightarrow _8O^{15*} + \gamma$ (emission of gamma rays)

$_8O^{15*} \rightarrow _7N^{15} + _1e^0 + \nu$ (emission of positron and neutrino)

$_1H^1 + _7N^{15} \rightarrow _6C^{12} + _2He^4$

The overall reaction of the above cycle is given as

$4\,_1H^1 \rightarrow _2He^4 + 2\,_1e^0 + 2\nu$ + energy (26.7 MeV)

- **Discovery of neutron:**

$_4Be^9 + _2He^4 \rightarrow _6C^{12} + _0n^1$

23. Half life period T ½ = 0.6931 / λ ; Mean life τ = 1/ λ

24. The boiling point of liquid sodium is <u>1000⁰C.</u>

25. In the reaction $_{90}Th^{234} \rightarrow + _{91}Pa^{234} + X$; the particle emitted is β

26.Half life of neutron is <u>13 minutes.</u>

27. *One roentgen* = 1.6 x 10^{12} pairs of ions in 1g of air.

28. when $_5B^{10}$ is bombarded with neutron α particle is emitted , the residual <u>nucleus is $_3Li^7$</u>

Note: $_5B^{10} + _0n^1 \rightarrow _3Li^7 + _2He^4$

29. An equation for free neutron decay is $_0n^1 \rightarrow _1H^1 + _{-1}e^0 + \bar{\nu}$

30. In Carbon Nitrogen-cycle the Catalyst is <u>Carbon.</u>

31. If the nuclear density of $_1H^2$ nuclei is 1.816 x 10^{17} Kg m^{-3} then nuclear density of $_2He^4$ nuclei is <u>1.816 x 10^{17} Kg m^{-3}</u> [note: nuclear density is constant for all the nuclei]

32. The type of nuclear fusion reaction that takes place in stars and sun is---

<u>Ans:</u> Carbon- Nitrogen and Proton – Proton cycle.

33. Ratio of C^{14} and C^{12} in atmosphere is <u>1:10^6</u>.

34. Radiation exposure is measured by the unit <u>roentgen.</u>

35. ***Electrostatic Oscillator:*** (i) Cockcroft – Walton (ii)Van de graft generator.

    Energy: Few million electron volt.

36. Synchronous accelerator.

    Ex: Linear accelerator, Cyclotron, betatron, synchrotoron. Energy: 10^9ev.[Gev]

37. Which of the following is not a moderator?

    a) Heavy water b) *paraffin* c) Graphite d) water

38. Which can serve as both moderator and coolant?

    Ans: Heavy water.

39. Energy release per nuclear fusion is 26.7 MeV.

40. The average energy released per fission is 200 MeV.

Other Important Questions

1. If the binding energy is large, the nucleus is *stable*.
2. Binding Energy Per nucleon = $\frac{\text{Binding energy of the nucleus}}{\text{Total number of nucleons.}}$
3. Infinite time is required for the complete disintegration of all the atoms.
4. U^{238} is fissionable only by *fast neutrons.*
5. In atom bomb U^{235} in used.
6. First nuclear reactor was built in 1942 at *Chicago* USA.
7. The temperature required to start nuclear fusion is 10^7 K.
8. The Explosion of an atom bomb produces the temperature of the order of 50 million degree Celsius.
9. The temperature of the interior of the sun is 1.4×10^7 K.
10. Total Energy radiated by Sun = 3.8×10^{26} joules per second.
11. The energy released in proton-proton cycle and also is Carbon-Nitrogen cycle in 26.7 Mev.
12. Intensity of cosmic rays : (i)Maximum at Poles(90°). O'11

    (ii) Minimum at equators(0°). (iii)Constant at : 42^0 and 90^0
13. Intensity of cosmic ray is maximum at a height of 20 Km.
14. A radioactive substance is allowed to decay for a time equal to its mean life. Then the fraction of the element that has decayed is 1/e.
15. Rest mass of proton = 1836 times the mass of electron.
16. Half life period inversely proportional to *decay constant*.
17. Half life of nitrogen is 10.1 minutes
18. Half life of carbon-14 (C^{14}) is 5570 Years.

19. According to the present view of the nuclear force, the force that binds the protons and neutrons is not a fundamental force of nature but it is secondary.
20. Nuclear force acting between (n–n), (p–p) and (n–p). Nuclear force is not electrostatic in nature.
21. Nuclear force is the strongest known force in nature.[short range force] O'11
22. Muons belong to *leptons*.
23. The natural radio active gas is radon.
24. In a nuclear reactor there is a conversion of *mass and energy*.
25. Nuclear fusion principle is used in hydrogen bomb. O'11 M'12
26. Temperature produced by an atom bomb is 50 million degree Celsius. Fusion process is carried out in high temperature like 10^7 K Fuel: deuteron[$_1H^2$]& triton[$_1H^3$]
27. Major group of elementary particles are

    i) Photons ii) Leptons iii) Mesons iv) Baryons.
28. In BE/A graph , beyond A = 120 , the binding energy per nucleon is Decreases slowlely.
29. Which one travel with the velocity of light?

    a) α – ray (b) β – ray (c) γ – ray (d) cathode ray
30. The exposure of radiation dosage which causes diseases like Leukemia is 100 R(safe limit is 250 mR)
31. Which of the following is the strongest force in nature?

    a) electrostatic force (b) gravitational force (c) nuclear force (d) Magnetic force
32. The first instrument to record the visual observations of the tracks of the charged particles when they pass through matter is Wilson Cloud chanper.
33. Since the atoms of isotopes have identical electronic structure, they have identical chemical properties.
34. The particle that has no charge and no rest mass but travels with the velocity of light is photon.

Frequently Asked Problems:

01.The numbers of α and β particles emitted when an isotope $_{92}U^{238}$ undergoes and decays to form $_{82}Pb^{206}$ are respectively __8 ,6 .__ [M'07]

Solution: 238 - 206 = 32 => (A) ; 8 α decay => 8 * $_2He^4$ = 32 (A) , 16 (Z)

92 – 82 = 10 => (Z) ; 6 β decay => 6 * $_{-1}e^o$ = <u>0 (A) , -6 (Z)</u>

<u>32(A), 10(Z) .</u>

2. An element z X ^{A}, undergoes 3α , 4β decay and change in to Y. Find mass number(A) , Atomic number (Z) of Y. [J'07,M'08]

Solution: 3 α decay => 3 * $_2He^4$ = 12(A), 6(Z) decreases.

4 β decay => 4 * $_{-1}e^o$ = <u>0 (A), -4(Z)</u>

<u>12(A), 2(Z)</u> ; decreases.

A =12, Z = 2 ; Y = $_{z-2}Y^{A-12}$

03. $_{92}U^{238} \xrightarrow{\alpha\ ,\beta} {}_{88}Rn^{226}$, the number of α ,β particles emitted is <u>3 and 2</u> .

04. If the nuclear radius is 2.6 x 10^{-15}m, the mass number will be __8 .__ [J'08]

Solution: $R = r_0 A^{1/3}$; $A^{1/3}$ =2

$A^{1/3}$= R/ro $= \frac{2.6 \times 10^{-15}}{1.3 \times 10^{-15}}$ = 2 ; A = 2^3 ; $\boxed{A = 8}$

05. A radioactive substance has a half life period of 300 days . The disintegration constant is -------- M'09]

Solution: $T_{1/2}$=0.6931/ λ ; λ = 0.6931/ $T_{1/2}$ = 0.6931/ 300 = 0.0023/ day

06. The mean life of radon is 5.5 days . Its half life is--- [J'09]

Solution: $T_{½}$ = 0.6931 / λ = 0.6931 τ = 0.6931 x 5.5 = 3.812 ≈ 3.8 days

07. According to law of disintegration $N=N_0 e^{-\lambda t}$, the number of radioactive atoms that have been decayed during a time of t is

a) N_0 b) N <u>*c) $N_0 - N$*</u> d) $\frac{N0}{2}$ [J '10]

08. Charge of $_8O^{16}$ nuclei is = ……..

Solution: q = ne ; => 8 x 1.6 x 10^{-16} = $\boxed{1.28 \times 10^{-18} C}$

09. A nucleus contains 64 nuclons. The nuclear radius is <u>5.2 F</u>

Solution: $R = r_0 A^{1/3}$ =1.3 x 10^{-15} x(4^3)$^{1/3}$ = 5.2 x 10^{-15} m = 5.2 F

10. If the half life of neutron is 13 minutes what is its mean life?

Solution: τ = 1/λ ; $T_{1/2}$=0.6931/ λ : = 0.6931 τ

τ = $T_{1/2}$/0.6931 = 13 x 60 / 0.6931 = 1125 s

11. The nuclear radius of $_4Be^8$ is -----------

Solution: $R = r_0 A^{1/3} = 1.3 \times 10^{-15} \times 8^{1/3} = 1.3 \times 10^{-15} \times 2 = 2.6 \times 10^{-15}$ m

12. The ratio of radii of two nuclei 1:2 . The ratio of mass numer is -----------

Solution: $R = r_0 A^{1/3}$; $R_1/ 2R_1 = A_1^{1/3}/ A_2^{1/3}$; $\therefore A_1 : A_2 = 1 : 8$

13. The mass defect of certain nucleus is found to be 0.03 amu . Its binding energy is -----

Solution: BE = 0.03 x 931 = 27.93 Mev

11. 7/8 part of the radioactive substance decays in 45 days. Then the half life period of the substance is 15 days.

Solution: 7/8 = 0.875 = 87.5% decayed in 45 days.

Number of half life required for 87.5% decay = [50 +25 +12.5] = 3

3 half life period = 45 days ∴ Half life period = 15 days

11. The half life of radioactive substance is 5 minutes. The amount of substance decayed in 20 minutes will be -----

Solution: Amount decayed after 5 min = 50 %

Amount decayed after 10 mins = 75 % (50 % +25 %)

Amount decayed after 15 mins = 87.5 % (50 % +25 % +12.5 %)

Amount decayed after 20 mins = 93.75 % (50 % +25 % +12.5 % + 6.25%)

(OR) $N = N_0(1/2)^n = 100\,(1/2)^4 = 100/16 = 6.25$ ∴ 100- 6.25 = 93.75 %

12. In nuclear fission 0.1 % mass is converted in to energy. The energy released by the fission of 1 kg mass will be ---------

Solution: $E = mc^2 = 0.1/100 \times 9 \times 10^{16} = 9 \times 10^{13}$ J

13. The percentage of initial quantity of a radioactive element remaining undecayed after six half life periods is-----

Solution: Decayed : 50 % +25 % +12.5 % + 6.25%+ 3.125%+1.5625% = 98.4375%

Undecayed : 100 - 98.4375 = 1.5625 ≈ 1.5 %

14. A radioactive material of mass 40 milligram becomes 5 milligram in 6 years then the half life period of the element is-----

Solution: 40 ⟶ 20 ; 20 ⟶ 10 ; 10 ⟶ 5 ∴ 3 half life in 6 years ∴ $T_{1/2}$ = 2 year

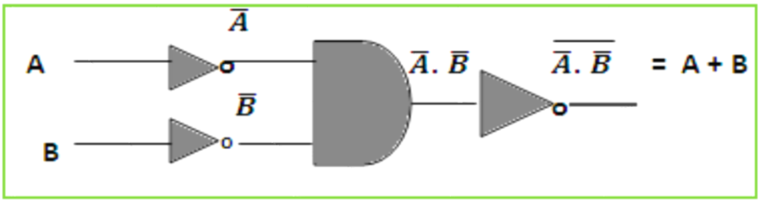
9. SEMICONDUCTOR DEVICES AND THEIR APPLICATIONS

Govt. Exam Questions

Material	Forbidden energy gap	
Insulator	More than 3 ev	
Germanium	0.7 ev.	[M'06]
Silicon	1.1 ev.	[M'08,09,O'10]
Conductor	Zero	[M'10]

01. The condition for oscillator is $A = \frac{1}{\beta}$ (or) $\beta = \frac{1}{A}$ (or) A β = 1 (or) β = 1/A with positive feed back. [M'06,M'07]

02. Find the output of this logic circuit [M'07]



OR Gate

03. A logic gate which has an output '1', When the *inputs are* *__complement__* to each other is __EXOR__. [O'07]

04. __Pentavalent atoms[Donar-N type]:__ Bismuth, antimony, Phosphorous, arsenic [M'08]
__Trivalent atoms[Acceptor –P type]:__ Aluminium , gallium, indium, boron.

05. The potential barrier is __0.7 V for silicon__, __0.3 V for germanium__ in PN Junction. [J'06,O'06 S'15]

06.

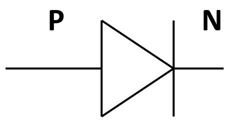


Fig (i): diode

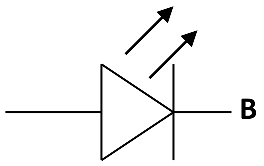
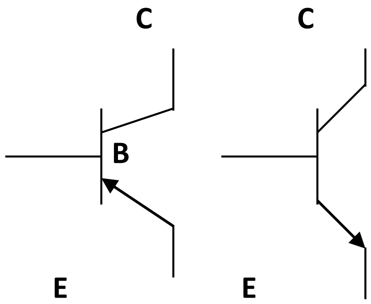


Fig (ii) LED [J'07]



Fig(iii) PNP - Transistor - NPN

07. *__Sinusoidal oscillator:__* The out put voltage is a sine wave.
__Eg:__ Lc oscillator, Rc oscillator, Crystal Oscillator, Colpitt's oscillator.
__Non sinusoidal oscillator__: Output is square, rectangle wave. __Eg:__ Multivibrator [M'09]

08. The Boolean expression to represent NAND operation is $Y = \overline{AB}$ [J'06]

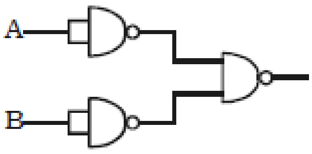
09. In the pin configuration of IC 741 , pin 3 represents __non-inverting input.__ [M'10,O'14]

10. The phase reversal between input and output voltage in CE amplifier is __180^0__. Or __π__ [J'08 O'11]

11. In a transistor the value of $\left(\frac{1}{\alpha} - \frac{1}{\beta}\right) = 1$ [M'11]

12. A logic gate for which there is an output <u>only</u> when both the inputs are zero is <u>NOR.</u> **[J'11]**

13. The following arrangement performs the logic function of --------Gate **M'12**



Y = A+B OR Gate

14. The following arrangement performs the logic function of --------Gate

Y = AB AND gate

15. In a PN junction diode on the side of N but very close to the junction there are -----

a) donor atoms b) acceptor atoms *c) immovable positive ions* **J'12**

e) immovable negative ions

16. In N-type semiconductor donor level lies **[O'12]**

a) <u>Just below the conduction band</u> b) Just above the conduction band

c) Just below the valance band d) just above the valance band

17. For a transistor connected in common emitter mode the slope of the input characteristic curve gives: **[M'13]**

a)Input impedence b) current gain c) <u>reciprocal of input impedence</u> d) voltage gain

18. In CE single stage amplifier if the voltage gain at the mid frequency is A_M, then the voltage gain at the lower cut off frequency is: $\frac{A_M}{\sqrt{2}}$ **O'13**

20. A ($\bar{A}$ +B) = ? **M'16**

a) A b) B **c) AB** d) A+B

Frequently Asked Questions

1. **<u>Resistivity of insulator</u>: 10^{11} and 10^{16} Ω m.**
2. **<u>Conductivity of semiconductor:</u> 10^2 mho m^{-1}**
3. **<u>The resistivity of semiconductor:</u> 10^{-2} and 10^4 Ω m .**
4. **Resistance of semiconductor <u>decreases</u> with increase in temperature.**
5. **<u>Efficiency of</u> half wave rectifier is 40.6% , Bridge rectifier is 81.2 %**
6. **<u>N-type semiconductor</u> – Pentavalent impurity :Positively charged immobile ion. Free electrons are majority charge carriers, Holes are minority charge carriers.**
7. **<u>P-type semiconductor</u> – Trivalent impurity. Holes are <u>majority</u> charge carriers, free electrons are minority charge carriers.**
8. **In a junction transistor the *emitter regoin* is <u>*heavily doped*</u> since, emitter has to supply to the base <u>majority carriers.</u>**

9. In a junction transistor the collector regoin is ***lightly doped*** since it has to accept **majority charge carriers**.

10. OP-AMPS are used in analog computer operation and in **timing circuits**.

11. Current amplification factor (OR) **Current gain** = $\dfrac{\text{Output current}}{\text{Input current}}$

    In common base current gain $\alpha = \dfrac{I_C}{I_E}$

    In Common emitter current gain $\beta = \dfrac{I_C}{I_B}$

    $\boxed{\beta = \dfrac{\alpha}{1-\alpha}}$ $\boxed{\dfrac{1}{\alpha} - \dfrac{1}{\beta} = 1}$ $\boxed{\alpha = \dfrac{\beta}{1+\beta}}$

12. The important function of a transistor is **amplification**.

13. Zener diodes are used as **regulators** and are used along with rectifier and filter circuits.

14. Zener current is ***independent*** of applied voltage.

15. A forward biased diode will act as an ***ON* switch**.

16. Emitter's main function is to supply **Majority charge carriers**.

17. The thickness of the base of a transistor is of the order of **25microns.** (25 µm).

18. The reverse saturation current[or leakage current] in a PN junction diode is only due to **minority carriers,** which depends on junction **temperature**.

19. Amount of impurity to be added to a intrinsic semiconductor is of the order of **100 ppm.**

20. **Bandwidth:** The frequency interval between the lower cut off and upper cut off frequencies. $B_W = f_u - f_L$

21. When LC circuit is used to store energy it is called **tank circuit**. The frequency of oscillation is $F = \dfrac{1}{2\pi\sqrt{LC}}$

22. The Boolean Expression for EXOR gate is $Y = A \oplus B = A\overline{B} + \overline{A}B$

23. **De Morgan's theorem**: (i) $\overline{A+B} = \overline{A}\,.\,\overline{B}$ ii) $\overline{A\,.\,B} = \overline{A} + \overline{B}$.

24. OP-AMP consist of **20 Transistors, 11 resistors and one capacitor**.

25. A d.c Voltage or a.c Signal placed on the

    a. inverting input = *180⁰* out of phase at the output.

    b. Non-inverting input will be ***in phase*** at the output (Zero) .

26. During the normal operation of a transistor, if its base current is increased then its, **Ic will increase.**

27. A logic gate for which a there is 'Low' output only when both the inputs are 'high' is NAND.
28. In any transistor which of the following is true?

    a) $I_B = I_E/I_C$ (b) $I_C - I_E + I_B$ *c)* $I_E = I_B + I_C$ d) $I_C - I_E + I_B$
29. In NPN transistor, CE mode, input impedance is very high. $r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$
30. In NPN transistor, CE mode, output impedance is Low. $r_o = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)_{I_B}$
31. In NPN transistor, CE mode, current gain is high $\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}$
32. Common emitter configuration has

    (i)high input impedance (ii) low output admittance (iii) higher current gain.
33. The gain of the amplifier is constant at *mid frequency range.*
34. Pin numbers 1 and 5 of OP-AMP IC is used for null adjustments.
35. In CRO the inner surface of the glass tube is coated with graphite.
36. CRO gives visual representation of electrical quantities such as voltage and frequency.
37. Multimeter[AVO] measures, Voltage, current and resistance.
38. A galvanometer can be converted into ohm meter by connecting, a battery and suitable resistance in series.
39. The "mil" equal to 0.001 inch.
40. The current gain of common base amplifier is *less than one*.[α = 0.95 to 0.99]
41. The current gain of common emitter amplifier is β = 50 to 300 [maximum 1000].
42. A negative feedback is used to improve overall performance of amplifier.
43. Multivibrator produces rectangular waveform.
44. ________is the most widely used method of providing bias and stabilization to a transistor.

    Ans: Voltage divider biase
45. Voltage gain of the amplifier with positive feedback is $\frac{A}{1-\beta A}$

    Aß- Loop gain , A-feed back ratio
46. Variations of d.c output voltage as a function of d.c load current is called Regulation.

Other Important Questions:

1. A solid state electronic device mainly consists of a semiconducting material.
2. Resistivity of semiconductor (10^{-2} and 10^{4} Ω m) is greater than that of conducting material($10^{-6} – 10^{-8}$ Ω m) but less than that of insulator.($10^{11} – 10^{16}$ Ω m.)
3. In glass the valence band is completely filled at 0 K. The energy gap between valence band and conduction band is of the order of 10 eV.[1.6 X 10^{-18} J]
4. A Zener diode working in the *break down region* can act as a voltage regulator.
5. When an electron in the conduction band recombines with a hole in the valence band energy is released.
6. *Zener diode* is a reverse biased, heavily doped semiconductor PN junction diode.
7. The difference of potential from one side of the barrier to the other side is called potential barrier.
8. In forward biased junction diode the voltage at which current starts to increase rapidly is known as cut-in voltage or knee voltage.
9. The output of a half wave rectifier is unidirectional and pulsating.
10. Percentage of regulation = $\frac{V_{noload} – V_{load}}{V_{load}}$ x 100
11. In all transistors, *collector rejoin* is made physically larger than any other region.
12. OPAMP is a Linear IC.
13. In intrinsic semiconductor the number of free electrons and holes are equal.
14. In input characteristic curve the region between the origin and knee point is called *saturation region*.
15. Electrons in an intrinsic semiconductor, which move into the conduction band at high temperatures are called Intrinsic carrier.
16. Width of the potential barrier in a PN junction diode depend on Nature of the material
17. Voltage gain of a RC amplifier depends on the ______over which the amplifier operates

    Ans: Frequency
18. The positive feedback *increases* the amplifier gain.
19. The negative feed back reduces the amplifier gain
20. During the normal operation of a transistor , if its base current is increased then its, Ic will increase.

21. A d.c. voltage or a.c signal placed on the <u>inverting</u> input will be <u>180^{o}</u> out of phase at the output.

22. A d.c. voltage or a.c. signal placed on the <u>non-inverting</u> input will be <u>in phase</u> at the output.[i.e phase difference is <u>zero</u>]

23. At lower cut off frequencies, the gain of the amplifier is <u>$\frac{1}{\sqrt{2}}$ times</u> of mid frequency gain.[ie $\frac{A_M}{\sqrt{2}}$]

24. When a number of amplifiers are connected in cascade, the overall voltage gain is equal to the ***<u>product of voltage gain</u>*** of individual stages.

25. When a fraction of β of output voltage V_o is fed in to input voltage V_i , the new input voltage will be $V'_i = V_i \pm \beta V'_o$

26. Frequency of oscillation in Colpitts oscillator is $f = \frac{1}{2\pi}\sqrt{\frac{(C_1 + C_2)}{LC_1C_2}}$

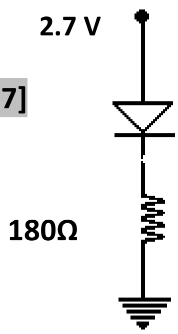
27. What will be the input of A and B for the Boolean expression $(\overline{A+b}).(\overline{A.B}) = 1$?

Ans: 0,0

28. <u>An amplifier</u> is a circuit capable of magnifying the amplitude of weak signals.

Frequently Asked Problems:

01. Find the output Voltage across the resistor as shown in the figure. [M'07]
(Silicon diode is used).



Solution:

Potential = Total Potential difference – Barrier potential
= 2.7 – 0.7
= 2 V.

02. In CE Single stage amplifier, the voltage gain at mid - frequency is 10. The voltage gain at upper cutoff frequency is <u>7.07.</u> [O'06]

Solution: $A_H = \frac{Am}{\sqrt{2}}$; $\frac{10}{\sqrt{2}} = 7.07$

03. The output of the given OP-AMP is ----- [J'07]

Solution: $V_{out} = -\frac{R_f}{R_{in}} \times V_{in} = -\frac{(100)}{10} \times 0.2.\text{Sin}\ \omega t$

$V_{out} = -2\ \text{Sin}\omega t$

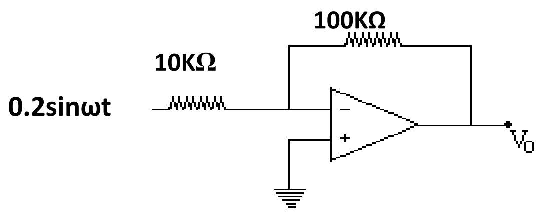


Fig: Inverting amplifier

04. The Output voltage of the OP-AMP given below is ---[O'07]

Solution:

$V = -(V1 + V2)$ +2

$= -(2 - 3)$

$V = 1\ V$ -3

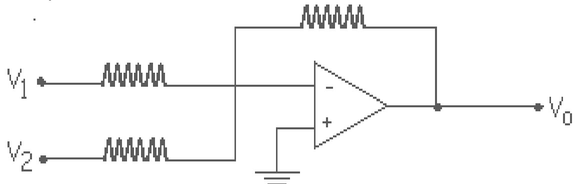
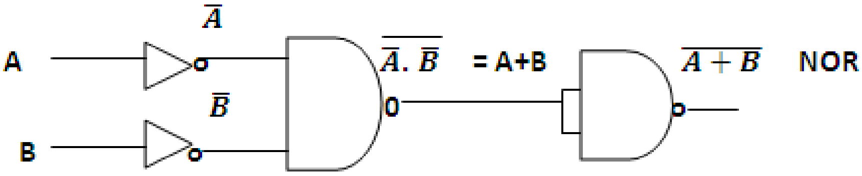
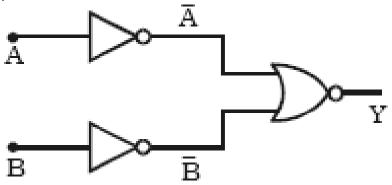


Fig: Summing amplifier

05. The following arrangement performs the logic function of --------- **[O'08]**



06. The following arrangement performs the logic function of ---------



[J'08]

[M'10]

Ans: AND

Ans: AND

07. In a common base coniguration of a transistor Ic = 12.5 mA and I_E = 13mA , then the base current of the transistor is -----

Solution: $I_E = I_B + I_C \therefore I_B = I_E - I_C = 13 - 12.5 = 0.5$ mA

08. The output of the given circuit is ……….

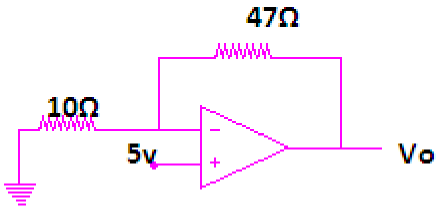


Fig: Non Inverting amplifier

Non –inverting:

$V_{out} = (1 + R_f / R_{in})\ V_{in}$

$= [1 + (47/10)] \times 5$

Vout $= 28.5$ V.

09. In a transistor β= 40, I_B = 25 μA, Ic = ?

Solution: $\beta = \frac{I_C}{I_B}$; $I_C = \beta . I_B = 40 \times 25\ \mu A$

$= 1000\ \mu A$

$\boxed{I_C = 1\ mA.}$

10. The input impedence of a transistor is 1000 ohm and β = 100 then the base to emitter voltage required for collector current of 1 mA is ---

Solution: $r_i = \frac{\Delta V_{BE}}{\Delta I_B}$ $\therefore V_{BE} = r_i\ I_B = 1000 \times 10^{-5} = 10$ mV { Note: $\beta = I_C/I_B$; $I_B = 10^{-5}$}

11. In CE configuration , the I_C changes from 2 mA to 4 mA . If V_{CE} is increased from 5 V to 10 V, the output admittance must be------

Solution: $r_o = V_{CE} / I_C = 5 / 2 \times 10^{-3} = 2.5 \times 10^{-3}$ ohm

12. Three amplifier have gain 10 , 50, 80 respectively , when they are connected in cascade the overall gain is --------

Solution: Overall gain = $A_1 \cdot A_2 \cdot A_3 = 10 \times 50 \times 80 = 40{,}000$

13. In common emitter transistor circuit , the base current of the transistor is 50 μA and the collector current is 25 mA. then the current gain is 500.

Solution: $\beta = \frac{I_C}{I_B} = \frac{25 \times 10^{-3}}{50 \times 10^{-6}} = 500$

14. The gain of the amplifier at the mid frequency is 200. The gain of the amplifier at the lower cut off frequency is 141.4

Solution: lower cut off frequency = [1/√2] mid frequency = 200 /√2 = 141.4

15. In a transistor the value of α is 0.99 then the value of β is ----

Solution: $\beta = \frac{\alpha}{1-\alpha} = \frac{0.99}{1-0.99} = \frac{0.99}{0.01} = 99$

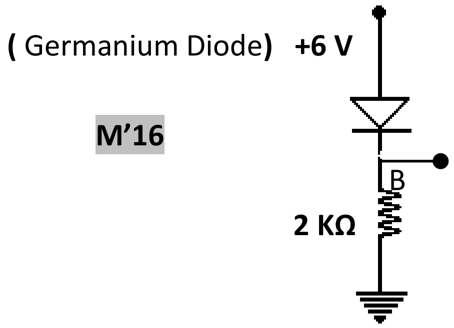
16. In a common base connection α = 0.95, I_E = ImA then the value of collector current is --

Solution: $\alpha = \frac{I_C}{I_E}$ $I_C = \alpha\ I_E = 0.95 \times 1$ mA

$\boxed{I_C = 0.95 \text{ mA}}$

17. The voltage at B in the figure is : **M'16**

a) 5.3 V **b) 5.7 V** c) 6.3 V d) 6V



10. COMMUNICATION SYSTEM

Important Formulas:

1) Channel Width = 2 x Maximum frequency of the modulating signal
   = 2 x $(fs)_{max}$
2) Carrier Swing = 2 x Frequency Deviation
   = 2 x Δf
3) Upper side Band Frequency = fc + fs
4) Lower side Band Frequency = fc - fs
5) Modulation Factor m = E_S/Ec
6) Amplitude of side Band = mEc/2
7) Intermediate Frequency = Frequency of local oscillator – Frequency of radio station
8) fs – Frequency of signal wave ; fc - Frequency of carrier wave
9) Es – Amplitude of signal wave ; Ec - Amplitude of carrier wave

Government Exam Qn:

1. The radio waves after refraction from different parts of ionosphere on reaching the earth are called *sky waves*. [O'06]
2. The audio frequency range is *20 – 20000 Hz.* [M'08]
3. Intermediate frequency is the difference between Oscillator frequency and radio frequency. It is equal to 455 KHz for AM receiver. [J'09,J,11]
4. Intermediate frequency of FM Receiver is 10.7 MHz. [O'10, J'12]
5. In Television *blanking pulse* is applied to control grid. [M'06,O'09,M'11]
6. In interlaced scanning time taken to scan one *line* is 64µs = $\frac{1}{15625}$ s [J'07]
   To scan one field is 20 m s.
7. A modem (modulation and demodulation) is used to convert digital signal into analog signal. [M'07,O'09]
8. Optical fiber works on the principle of total internal reflection. [O'06,M'10]
9. The first man made satellite is Sputnik [O'07]
10. Skip distance is the shortest distance between point of transmission and point of reception. [O'08]

Frequently Asked Questions

11. Space wave propagation is suitable for the waves having frequency above *30 MHz.*
12. Maximum deviation of FM broadcast is 75 KHz.
13. Tuned Station frequency = Local Oscillator frequency – 455 KHz.
14. The principle of vidicon Camera is *photo conductivity*.
15. In most of the television system, the frame repetition rate (Scanning frequency) is 25 per second.

16. In a 625 line system, transmitting 25 frames per second, the horizontal frequency in 625 x 25 = 15,625 Hz.
17. The front of picture tube is coated with *phosphor*.
18. Orbit of Geo stationary satellite is 36,000 Km.
19. Long distance radio communication is possible through *sky wave propagation.*
20. *Ground wave propagation* is of prime importance for medium and long wave signals.
21. Modulation factor determines the strength and quality of the transmitted signal.
22. In TV transmission sound signals are *frequency modulated*.
23. In Vidicon camera front side coated with *tin oxide* back side coated with antimony tri sulphide.
24. How many synchronizing pulses are used for scanning? Ans: Three.
25. In interlaced scanning, the vertical scanning frequency in 50 fields per second.
26. In twisted cable, wire is twisted to decreasing external noise.
27. For the purpose of coupling the transmitter and the receiver to the space link, we use Antennas.
28. During scanning, the scene is scanned ……

    Ans: in horizontal and Vertical direction simultaneously.
29. Time taken for vertical scanning : 20×10^{-3} s = 20 ms.
30. The mechanism involved in sky wave propagation is refraction.
31. Transmitting antenna converts electrical signal in to electromagnetic energy.
32. Receiving antenna converts electromagnetic energy in to electrical signal.
33. Blanking pulse used for TV scanning is High negative potential
34. In TV transmission, the picture should not be scanned during the return journey of the scanning. This is done by Blanking pulse.
35. The greatest technical problem in analog communication is noise.
36. Any form of information that has been put into digital form is called Data
37. In amplitude modulation, only the amplitude of the carrier wave is changed.
38. The magnitude of both the upper and lower side bands is m/2 times the carrier amplitude Ec.
39. Principle of radar is radio echoes.
40. As the ionisation density increases for a wave approaching the given layer at an angle, the refractive index of the layer is reduced.

Other Important Questions

1. Troposphere extends up to 15Km from the surface of the Earth.
2. For effective modulation the degree of modulation should not exceed 100%.
3. Human voice or music, frequency is 300 - 3000 Hz.
4. If the modulation factor m is equal to *unity*, then each side band has amplitude equal to half of the carrier amplitude.

5. Phase modulation facilitates highest transmission speeds
6. A signal which can take any value within the given range is ***analog signal.***
7. Radio waves can be sent from one place to another by
   (i) Ground wave propagation.
   (ii) Sky wave propagation
   (iii) Space wave propagation.
8. The radiation of electrical energy is practicable only at High frequencies.
9. The propagation of electromagnetic waves depend on the properties of the waves and the environment.
10. Ground wave propagationtakes place when the transmitting and receiving antennas are close to the ground.
11. The refractive indices of the various layers in the ionosphere vary with respect to electron density and the frequency of the incident wave.
12. The high frequency signals can be sent through thousands of kilometers with comparatively small power.
13. If the modulation factor m is equal to unity, then each side band has amplitude equal to half of the carrier amplitude.
14. When exposed to light , the resistance of the photoconductive material decreases
15. In radar receiver, the returning echo pulse appears slightly displaced from the transmitted pulse and this displacement is a measure of the range of the target.
16. Satellite orbiting the earth will be geostationary when it is about 36,000 km away from the earth.
17. The uplink and downlink frequencies in satellite communication have a shift of 2 GHz
18. The ionosphere contains free electrons, positive and negative ions
19. Commercial:
    Up link transmission : 500 MHz band with near 6 GHz.
    Down link transmission : 500 MHz band with near 4 GHz .
    Actual:
    Up link transmission : 5.725 - 7.075 GHz
    Down link transmission : 3.4 - 4.8 GHz
20. Modulation factor m < 1, the amount of carrier amplitude variation is small. Hence the audio signal being transmitted will not be very strong.
21. When the modulation factor m > 1, distortion is produced in the transmitted wave. Hence, the signal wave is not exactly reproduced.
22. For effective modulation, the degree of modulation should never exceed 100 %.

Frequently Asked Problems

01. In an AM Super heterodyne receiver, the local Oscillator frequency (L.O.C) is 1.245 MHz. The tuned station frequency (T.S.F) is ________. **[J'06]**

Solution : T.S.F = L.O.F – 455

= 1.245 MHZ – 455 KHZ.

= 1245 KHZ – 455 KHZ.

$\boxed{\text{T.S.F} = 790 \text{ KHz}}$

02. If 900 kHz station is tuned, then the local oscillator will have to produce a frequency of _______ kHz. **J,14**

Solution : TSF = LOF – 455 KHz

LOF = TSF + 455 = 900 + 455 = 1355KHz

03. A 5 MHz sinusoidal carrier wave of amplitude 10mV is modulated by a 5 kHz sinusoidal audio signal wave of amplitude 6 mV. Find the lower and upper side band frequencies.

Solution : fc = 5 MHz ; fs = 5 kHz = 5 x 10^{-3} MHz = 0.005 MHz

I. Upper side band = fc + fs = 5 + 0.005 = 5.005 MHz

II. Lower side band = fc – fs = 5 - 0.005 = 4.995 MHz

04. A carrier wave of amplitude 10 mV is modulated by a sinusoidal audio signal wave of amplitude 6 mV, the modulation factor is 0.6

Solution : Modulation factor = $\frac{\text{Signal Amplitude}}{\text{Carrier Amplitude}} = \frac{6}{10} = 0.6$

05. In an A.M receiver, the local Oscillator frequency is 2750 KHz. The tuned station frequency (T.S.F) is ________. **[J '10]**

Solution : T.S.F = L.O.F – 455 KHz

= 2750 – 455

T.S.F = 2295 KHz

06. An FM signal has a resting frequency of 105 MHz and highest frequency of 105.03 MHz when modulated by a signal. Then the carrier swing is 0.06 MHz . **[M'09]**

1 . Electrostatics

Self Evaluation Questions:

1. State coulomb's law of electrostatic and represent it in vector form.
[J'07, M'10, J'10,O'15, J'12, M'15,M'18]

Coulomb's law states that the force of attraction or repulsion between two point charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between them. The direction of forces is along the line joining the two point charges.

$$F \propto \frac{q_1 q_2}{r^2} \quad : \quad \vec{F}_{12} = k\frac{q_1 q_2}{r_{21}^2}\,\hat{r}_{21} \quad : \quad \vec{F}_{21} = k\frac{q_1 q_2}{r_{12}^2}\,\hat{r}_{12}$$

2. What is permittivity and relative permittivity? How are they related?

(i) Permittivity is the ability of the medium to allow the electric force to pass through it.
Permittivity *of the medium* = permittivity of free space x Relative permittivity.
$\varepsilon = \varepsilon_0\, \varepsilon_r$. Its unit is $C^2N^{-1}m^{-2}$

(ii) Relative permittivity [dielectric constant] (ε_r) is the ratio of permittivity of the medium (ε) to the permittivity of free space (ε_0). It has no unit. $\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$

3. Define electric field intensity?(Electric field strength (or) electric field)

Electric field intensity at a point, in an ***electric field*** is defined as the force experienced by a unit positive charge kept at that point. It is a vector quantity. The unit of electric field intensity is $N\,C^{-1}$. $|\vec{E}| = \frac{|\vec{F}|}{q_o}$

4. What are the properties of electric lines of force? [J'10, O'12,M'16]

Electric line of force is an imaginary straight or curved path along which a unit positive charge tends to move in an electric field.

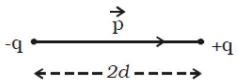
1. *Lines of force start from positive charge and terminate at negative charge.*
2. *Lines of force never intersect.*
3. *The tangent to line of force at any point gives the direction of the electric field (E) at that point.*
4. The number of lines per unit area, through a plane at right angles to the lines, is proportional to the magnitude of E. This means that, where the lines of force are close together, E is large and where they are far apart, E is small.
5. *Each unit positive charge gives rise to $1/\varepsilon_0$ lines of force in free space. Hence number of lines of force originating from a point charge q is $N = q / \varepsilon_0$ in free space.*

5. What does an electric dipole experience when kept in a uniform electric field and non-uniform electric field?

- When a dipole is placed in a uniform electric field it will experience a ***torque***.
- When a dipole is placed in a non-uniform electric field at an angle θ, it will experience *a force in addition to the torque*.

6. What is electric dipole? Define electric dipole moment? [O'09,J'11,M'14,M'17]

- Two equal and opposite charges separated by a small distance constitute an electric dipole. Ex: Water, ammonia, carbon–dioxide and chloroform.
- The magnitude of the dipole moment is given by the product of the magnitude of one of the charges and the distance between them. Electric dipole moment p =2dq. Its unit is C m (coulomb metre). Dipole moment is a vector quantity and acts from –q to +q.



7. Define electric potential at a point. Is it a scalar or a vector quantity? **[J'09,M'07, O'13]**

The electric potential in an electric field at a point is defined as the amount of work done in moving a unit positive charge from infinity to that point against the electric forces. Electric potential is a scalar quantity. **Unit :** volt

8 . Differentiate between electric potential and potential difference.

Electric Potential	Potential difference
1. The electric potential in an electric field at a point is defined as the amount of work done in moving a unit positive charge from infinity to that point against the electric forces.	1. The potential difference between two points in an electric field is defined as the amount of work done in moving a unit positive charge from one point to the other against the electric force.
2. It is the potential at a point.	2. It is the difference in electric potential between two points.
3. Electric potential at a point due to positive charge is positive, due to a negative charge is negative.	3. It is only a magnitude and it is always positive.

9. What is an equipotential surface?

If all the points of a surface are at the same electric potential, then the surface is called an equipotential surface. The work done in moving a charge between two points on equipotential surface is zero.

Ex: In case of an isolated point charge, all points equidistant from the charge are at same potential. Thus, equipotential surfaces in this case will be a series of concentric spheres with the point charge as their centre.

10. Define electric flux, and write its unit. **[J'08, J'12]**

The electric flux is defined as the total number of electric lines of force, crossing through the given area. The unit of flux is N m^2 C^{-1}. It is a Scalar quantity. The electric flux $d\phi$ through the area ds is, $d\phi = \vec{E} \cdot \vec{ds} = E\, ds \cos\theta$

11. State Gauss's law. **[M'09, J'06,O'06,M'11,J'15,M'16]**

Gauss's law states that the total electric flux of the electric field E over any closed surface is equal to $1/\varepsilon_0$ times the net charge enclosed by the surface. $\Phi = q / \varepsilon_0$

Note: This law relates the flux through any closed surface and the net charge enclosed within the surface.

12. What is capacitor? Define its capacitance. **[M'09,O'12]**

Capacitor is a charge storage device. The capacitance of a conductor (capacitor) is defined as the ratio of the charge given to the conductor to the potential developed in the conductor. $C = q / V$. The unit of capacitance is farad.

13. Why is it safer to be inside a car than under a tree during lightning? [M'10,J'09,M'06,J'06, J'14,J'15,M'17]

(i) The metal body of the car provides electrostatic shielding.

(ii) The electric field inside a car is zero.

(iii) During lightning electric discharge passes through the body of the car.

14. What is meant by dielectric polarisation? [O'09,O'06 O'11, J'14]

The alignment of the dipole moments of the permanent or induced dipoles in the direction of the applied electric field is called polarisation or *electric polarisation*.

The magnitude of the induced dipole moment p is directly proportional to the external electric field E.

$\therefore$ $p \propto E$ or $p = \alpha E$ where α is the constant of proportionality and is called molecular polarisability. **Unit: $C^2\ m\ N^{-1}$**

Other Important Questions:

1. What is a point charge?

Any charge which occupies the space with dimension much less than its distance away from an observation point can be considered as a point charge.

2. Define Coulomb based on coulomb's law. [Or] Define unit of charge. (Or) **Define Coulomb.** [M'06,O'10, M'13]

Unit of charge is Coulomb. One Coulomb is defined as the quantity of charge, which when placed at a distance of 1 metre in air or vacuum from an equal and similar charge, experiences a repulsive force of 9×10^9 N.

3. Define the unit of potential difference. (OR) Define One Volt.

The unit of potential difference is Volt. The potential difference between two points is one Volt if one joule of work is done in moving 1 Coulomb of charge from one point to another against the electric force.

4. What is electrostatic shielding? [M'08]

Electrostatic shielding is the process of isolating a certain region of space from external field. It is based on the fact that electric field inside a conductor is zero.

5. What is electrostatic induction? Where it is used?

i) It is possible to obtain charges without any contact with another charge. They are known as induced charges and the phenomenon of producing induced charges is known as electrostatic induction.

ii) It is used in electrostatic machines like Van de Graaff generator and capacitors.

6. Define the unit of capacitance (OR) (Define one Farad).

The unit of capacitance is Farad. A conductor has a capacitance of one farad, if a charge of 1 coulomb given to it, rises its potential by 1 volt. Practical units of capacitances are μ F and p F.

7. Write down the application of the capacitors. [O'07,M'11, M'12,O'16]

(i) They are used in ignition system of automobile engines to eliminate sparking.

(ii) They are used to reduce voltage fluctuations in power supplies and to increase the efficiency of power transmission.

(iii) Capacitors are used to generate electromagnetic oscillation and in tuning the radio circuits.

8. What is action of points (Corona discharge)? Where it is used? O'08,J'07,'14,O'15

(i) The leakage of electric charges from the sharp points on the charged conductor is known as action of points or corona discharge.

(ii) This principle is made use of in the electrostatic machines for collecting charges and in lightning arresters (conductors).

9. Define electric potential energy of *an electric dipole*.

The electric potential energy of an electric dipole in an electrostatic field is the work done in rotating the dipole to the desired position in the field. $U = -pE \cos\theta$

10. Explain the function of microwave oven. [J'08, O'14]

i) It is used to cook the food in a short time. When the oven is operated, the micro waves are generated, which in turns produce a non uniform oscillating electric field.

ii) The water molecules in the food which are the electric dipoles are excited by an oscillating *torque*.

iii) Hence few bonds in the water molecules broken, and heat energy is produced. This is used to cook food.

11. What is electric potential energy?

The Electric potential energy of two point charge is equal to the work done to assemble the charges **or** work done in bringing each charge **or** work done in bringing a charge from infinite distance. **Unit:** joule

$$\text{Potential energy (U)} = \frac{q_1 q_2}{4\pi\varepsilon_o r}$$

12. What is polar, non polar molecule? Give two examples. [M'07,O'10, J'11, M'13,J'16]

Polar molecule[M'18]	Non Polar molecule [O'13]
1. A Polar molecule is one in which the centre of gravity of the positive charges is separated from the centre of gravity of the negative charges by a finite distance.	1. A non polar molecule is one in which the centre of gravity of the positive charges coincide with the centre of gravity of the negative charges.
2. They have a permanent dipole moment.	2. They do not have a permanent dipole moment.
3. Ex: N_2O, H_2O, HCl, NH_3.	3. Ex: O_2, N_2, H_2

13. What is lightning conductor? Write down the principle used.

i) It is a simple device used to protect tall buildings from the lightning.

ii) The principle used is *electrostatic induction and action of points.*

14. What is potential gradient?

The change of potential with distance is known as potential gradient. The electric field is equal to the negative gradient of potential.

$E = - dV/dX$ Unit: Vm^{-1}

15. What do mean by 'Additive nature of charge'? Give an example. [O'07]

The total charge of the system is equal to the algebraic sum of electric charges located in the system. For example, if two charged bodies of charges +2q and -5q are brought in contact, the total charge of the system is -3q.

16. State conservation of electric charge.

Electric charges can neither be created nor destroyed. According to the law of conservation of electric charge, the total charge in an isolated system always remains constant. But the charges can be transferred from one part of the system to another, such that the total charge always remains conserved.

$$_{92}U^{238} \longrightarrow {}_{90}Th^{234} + {}_{2}He^{4}$$

Total charge before decay = +92e, total charge after decay = 90e + 2e.

The total charge is conserved. i.e. it remains constant.

17. What are dielectrics? Give example.

1. A dielectric is an insulating material in which all the electrons are tightly bound to the nucleus of the atom. There are no free electrons to carry current.
2. Ebonite, mica and oil are few examples of dielectrics.
3. The electrons are not free to move under the influence of an external field.

18. Differentiate between conductor and insulators (dielectrics).

- Bodies which allow the charges to pass through are called conductors. e.g. metals, human body, Earth etc.
- Bodies which do not allow the charges to pass through are called insulators. e.g. glass, mica, ebonite, plastic etc.

19. Write a note on quantization of electric charges.

- The fundamental unit of electric charge (e) is the charge carried by the electron and its unit is coulomb. e has the magnitude 1.6×10^{-19} C.
- In nature, the electric charge of any system is always an integral multiple of the least amount of charge. It means that the quantity can take only one of the discrete set of values. The charge, q = ne where n is an integer.

Frequently Asked Problems

1.7 Calculate (i) the potential at a point due a charge of 4×10^{-7}C located at 0.09m away (ii) work done in bringing a charge of 2×10^{-9} C from infinity to the point.

Data : $q_1 = 4 \times 10^{-7}$C, $q_2 = 2 \times 10^{-9}$ C, r = 0.09 m

Solution :

(i) The potential due to the charge q_1 at a point is

$$V = \frac{1}{4\pi\varepsilon_o}\frac{q_1}{r}$$

$$= \frac{9\times10^9\times4\times10^{-7}}{0.09} = 4 \times 10^4 \text{ V}$$

(ii) Work done in bringing a charge q_2 from infinity to the point is

$W = q_2 V \quad = 2 \times 10^{-9} \times 4 \times 10^4$

$\mathbf{W = 8 \times 10^{-5} J}$

1.8 A sample of HCl gas is placed in an electric field of 2.5×10^4 N C^{-1}. The dipole moment of each HCl molecule is 3.4×10^{-30} C m. Find the maximum torque that can act on a molecule. **M'15**

Data : E = 2.5×10^4 N C^{-1}, p = 3.4×10^{-30} C m.

Solution : Torque acting on the molecule **τ = pE sin θ** for maximum torque, $\theta = 90^o$

$= 3.4 \times 10^{-30} \times 2.5 \times 10^4$

Maximum Torque acting on the molecule is = $\mathbf{8.5 \times 10^{-26}}$ **N m.**

1.11 An infinite line charge produces a field of 9×10^4 N C^{-1} at a distance of 2 cm. Calculate the linear charge density.

Data : E = 9×10^4 N C^{-1}, r = 2 cm = 2×10^{-2} m

Solution : E = $\lambda / 2\pi\varepsilon_o r$ or $\mathbf{\lambda = E \times 2\pi\varepsilon_o r}$

$= 9 \times 10^4 \times \frac{1}{18\times10^9} \times 2\times10^{-2}$ $\quad \therefore 2\pi\varepsilon_o = \frac{1}{18\times10^9}$

$\mathbf{\lambda = 10^{-7}\ C\ m^{-1}}$

1.14 A parallel plate capacitor with air between the plates has a capacitance of 8 pF. What will be the capacitance, if the distance between the plates be reduced to half and the space between them is filled with a substance of dielectric constant 6.

Solution : **Data : Co = 8 pF , ε_r = 6, distance d becomes, d/2 with dielectric**

$$C_o = \frac{A\varepsilon_o}{d} = 8\text{pF}$$

when the distance is reduced to half and dielectric medium fills the gap, the new capacitance will be

$$C = \frac{\varepsilon_r A\varepsilon_o}{d/2} = \frac{2\varepsilon_r A\varepsilon_o}{d} = 2\varepsilon_r C_o \quad \boxed{C = 2\times6\times8 = 96\text{ pF}}$$

1.45 An electric dipole of charges 2×10^{-10}C and -2×10^{-10}C separated by a distance 5 mm, is placed at an angle of 60^o to a uniform field of $10Vm^{-1}$. Find the (i) magnitude and direction of the force acting on each charge. (ii) Torque exerted by the field.

Data: $q = 2 \times 10^{-10}$ C , $E = 10\ Vm^{-1}$, $\theta = 60^o$, $2d = 5$ mm $= 5 \times 10^{-3}$m, $F, \tau = ?$

Solution:

1) Magnitude of the force **F= Eq**

$$F = 10 \times 2 \times 10^{-10} = 2 \times 10^{-9} N$$

Direction: Along the field.

2) **Torque = pEsin θ** $= q \times 2d\ E\sin\theta$

$$= 2 \times 10^{-10} \times 5 \times 10^{-3} \times 10 \times \sin 60^o$$

$$\tau = 100 \times \sqrt{3}/2 \times 10^{-13} = 0.866 \times 10^{-11}\ Nm$$

1.50 Find the electric flux through each face of a hollow cube of side 10 cm, if a charge of 8.85 μC is placed at the centre.

Solution : $\Phi = q/\varepsilon_o = \dfrac{8.85 \times 10^{-6}}{8.854 \times 10^{-12}} = 10^6\ N\,m^2\,C^{-1}$

Flux through each face= $10^6/6$ = $\mathbf{1.67 \times 10^5\ N\,m^2\,C^{-1}}$

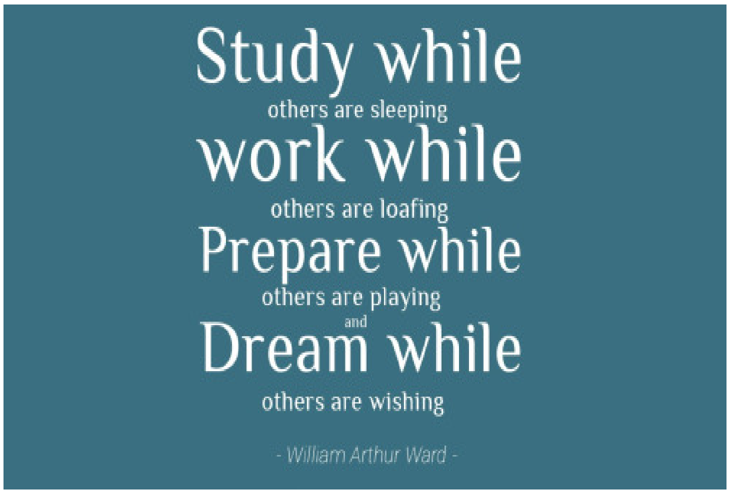
1.52 The area of each plate of a parallel plate capacitor is 4×10^{-2} sq m. If the thickness of the dielectric medium between the plates is 10^{-3} m and the relative permittivity of the dielectric is 7. Find the capacitance of the capacitor.

Data:

$\varepsilon_r = 7$, $\varepsilon_o = 8.854 \times 10^{-12}\ C^2N^{-1}m^{-2}$, $A = 4 \times 10^{-2}$ sq.m ; $d = 10^{-3}$m ; $C = ?$

Solution:

$$C = \frac{\varepsilon_0 \varepsilon_r A}{d} = \frac{8.854 \times 10^{-12} \times 7 \times 4 \times 10^{-2}}{10^{-3}} = 2.478 \times 10^{-9} F$$



2 .Current Electricity

Self Evaluation Questions:

1. Why is copper wire not suitable for a potentiometer wire?

(i) The metal wire used in potentiometer should have high resistivity and low temperature coefficient of resistance.

(ii) Copper wire has low resistivity and high temperature coefficient of resistance. Hence copper wire is not used as potentiometer wire.

2. Distinguish between drift velocity and mobility.

[M'10,O'09, J'09,M'09,O'08, O'06, M'07,M'08,O'10,M'11, O'11,J'15,O'15,M'16]

Drift velocity (v_d)	Mobility(μ)
1. It is the velocity with which the free electrons get drifted towards the positive terminal when an electric field is applied. $v_d = \frac{eE}{m}\tau = \mu E$	1. It is the drift velocity acquired per unit electric field. $\mu = \frac{e\tau}{m}$
2. The drift velocity of electrons is directly proportional to the electric field.	2. It is a constant for a particular material.
3. Its unit is m/s [OR] ms^{-1}	3. Its unit is $m^2V^{-1}S^{-1}$

3. State ohm's law. [M'06, O'07, O'09, M'10, J'12, O'12, M'13, O'14,J'16,M'17]

Ohm's law states that at a constant temperature, the steady current flowing through a conductor is directly proportional to the potential difference between the two ends of the conductor. $I \; \alpha \; V$.

4. Define electrical resistivity (*specific resistance*). [O'12, M'15,M'18]

Electrical resistivity (*or*) specific resistance of a material is defined as the resistance offered to current flow by a conductor of unit length having unit area of cross sections. $\rho = RA/L$. The unit of specific resistance is ohm-metre (Ω m).

Note: The reciprocal of resistivity is conductivity. Unit: mho m^{-1} [or] Ω^{-1} m^{-1}

5. List the applications of super conductors. [J'06, O'06, J'07, O'07, M'15]

i) Super conductors can be used as memory or *storage elements in* computers.

ii) Super conductors form the basis of *energy saving power system,* namely super conducting generators.

iii) Super conducting magnets have been used to *levitate trains* above its rails.

iv) Super conducting magnetic propulsion systems may be used to *launch satellites*.

v) Since the current flows without change in magnitude, it is used as *transmission lines.*

6. The colours of the carbon resistor is orange, orange, orange. What is the value of the resistor?

The first orange ring corresponds to 3.

The second orange ring corresponds to 3.

The third orange ring corresponds to 10^3.

The value of the resistor is $33 \times 10^3 = 33{,}000\ \Omega = 33\ K\Omega$.

7. What is the effective resistance of resistors which are connected in series and parallel?

(i) The effective resistance (R_s) of resistors which are connected in *series* is equal to the sum of the resistance of individual resistors. $R_s = R_1+R_2+R_3+R_4....$

(ii)The reciprocal of effective resistance of resistors which are connected in *parallel* is equal to that sum of the reciprocal of the resistance of individual resistors.

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$$

8. State Kirchoff's laws. [J'06, M'07, M'08, M'12]

Current law:(*First law)*

The algebraic sum of the currents meeting at any junction in a circuit is zero. This law is a consequence of conservation of charges.

Voltage law: (*Second law*) [M'09, J'11, M'14,O'15]

The Kirchoff's voltage law states that the algebraic sum of the products of resistance and current in each part of any closed circuit is equal to the algebraic sum of the emf's in that closed circuit. This law is a consequence of conservation of energy.

9. Define temperature coefficient of resistance. [J'08,M'11, J'14,M'16]

The temperature coefficient of resistance is defined as the ratio of increase in resistance per degree rise in temperature to its resistance at 0° C. Its unit is per ^{0}C.

$$\alpha = \frac{R_t - R_o}{R_o t}$$

10. What are superconductors? O'13

The ability of certain metals, their compounds and alloys to conduct electricity with *zero resistance at very low temperature* is called superconductivity. The materials which exhibit this property are called superconductors.

11. Distinguish electric power and electric energy. [J'09, J'08, O'13 ,J'14 ,O'14]

Electric power	Electric energy
1. It is the rate of doing electric work.	1. It is the capacity to do work.
2. SI unit of power is watt.	2. SI unit of energy is Joule.
3. Practical unit is watt (or) Horse power.	3. Practical unit is Kilo watt hour.
4. Power = VI = I^2R	4. Electric energy = VIt = I^2Rt

12. Why automobile batteries have low internal resistance?

The automobile batteries have to deliver a ***high current*** if required. They have to be recharged very large number of times without any deterioration in properties. That is why it should have low internal resistance.

13. State Faradays laws of electrolysis. [M'06,O,10 J'10,J'15,M'17]

First law:- The mass of a substance liberated at an electrode is directly proportional to the charge passing through the electrolyte. $m \propto q$ (or) $m = zIt$

Where Z is a constant for the substance being liberated called as electrochemical equivalent. Its unit is kg C^{-1}.

Second law: The mass of a substance liberated at an electrode by a given amount of charge is proportional to the ***chemical equivalent*** of the substance. $m \propto E$.

Other Important Questions :

1. Define current and current density.

(i) The current is defined as the rate of flow of charges across any cross sectional area of a conductor. If a net charge *q* passes through any cross section of a conductor in time *t*, then the current I = q / t. The unit of current is *ampere*. Current is a *scalar quantity.*

(ii) *Current density at a point is defined as the quantity of charge passing per unit time through unit area, taken perpendicular to the direction of flow of charge at that point.* J = I /A. It is a vector quantity. It is expressed in A m^{-2} [O'16]

2. What is charging and discharging in secondary cells?

(i) The process of reproducing active materials is called charging.

(ii) The chemical process of obtaining current from a secondary cell is called discharge.

3. Write down the applications of secondary cells. [O'08, O'11, M'12]

i) These can be recharged a very large number of times without any deterioration in properties.

ii) These are used in all automobiles like cars, two wheelers etc.

iii) They have low internal resistance and can deliver a high current.

iv) It is easy to monitor the specific gravity between 1.28 to 1.12 during charging and discharging.

4. Differentiate between emf and potential difference. [O'08,J'07,J'11,J'12,M'13, M'15,M'18]

Emf(electro motive force)	Potential difference
1. The difference in potential between the two terminals of a cell in an *open* circuit is called emf.	1. The difference in potential between any two points in a *closed* circuit is called potential difference.
2. It is independent of external resistance of the circuit.	2. It is proportional to the resistance between any two points.

5. Define resistance of a conductor.

Resistance of a conductor is defined as the ratio of potential difference across the conductor to the current flowing through it. The unit of resistance is ohm (Ω).

$$R = \frac{mL}{nAe^2\tau}$$

6. Differentiate primary and secondary cell. [O'16]

Primary cell	Secondary cell
1. Irreversible chemical reaction takes place.	1. Reversible chemical reaction takes place.
2. These are not rechargeable.	2. These are rechargeable.
3. It gives current only by chemical reaction (no charging).	3. It gives current only after charging.
4. It has high internal resistance.	4. It has low internal resistance.
5. Eg: Daniel cell , Leclanche cell	5. Eg: Lead acid accumulator

7. Define internal resistance of a cell.

During this process of flow of current inside the cell, a resistance is offered to current flow by the electrolyte of the cell. This is termed as the internal resistance of the cell.

8. State the principle of the potentiometer.

For a steady current passing through the potentiometer wire, emf of the cell is directly proportional to its balancing length. $E \propto l$

9. What is transition (or) critical temperature? [M'12,J'16]

The temperature at which the electrical resistivity of the material suddenly drops to zero and the material changes from normal conductor to superconductor is called transition or critical temperature.

10. What are the changes observed at transition (critical) temperature when the conductor becomes a superconductor? [J'10, M'14]

At transition temperature the following changes are observed.

1. The electrical resistivity drops to zero.
2. The conductivity becomes infinity.
3. The magnetic flux lines are excluded from the material.

11. Define electrochemical equivalent.

The electrochemical equivalent of a substance is defined as the mass of substance liberated in electrolysis when one coulomb charge is passed through the electrolyte. Its unit is kg C^{-1}. *$m = ZIt$. Z is electrochemical equivalent.*

12. Write a note on wattmeter.

1. A wattmeter is an instrument used to measure electrical power consumed i.e energy absorbed in unit time by a circuit.
2. The wattmeter consists of a movable coil arranged between a pair of fixed coils in the form of a solenoid.
3. A pointer is attached to the movable coil.
4. The free end of the pointer moves over a circular scale.
5. When current flows through the coils, the deflection of the pointer is directly proportional to the power.

13. Define chemical equivalent.

$$^{*}\text{Chemical equivalent} = \frac{\text{Relative atomic mass}}{\text{Valency}} = \frac{\text{mass of the atom}}{1/12 \text{ of the mass } C^{12} \text{ atom x valency}}$$

It is defined as the ratio of relative atomic mass of an atom to its valency.

Frequently Asked Problems

2.5 **The resistance of a nichrome wire at 0°C is 10 Ω. If its temperature coefficient of resistance is 0.004/°C, find its resistance at boiling point of water. Comment on the result.**

Data: At 0°C, R_o = 10 Ω ; α = 0.004/°C ; t = 100 °C ; At t °C, Rt = ?

Solution:

$R_t = R_o (1+ \alpha t)$

$= 10 (1 + (0.004 \times 100))$

$\mathbf{R_t = 14\ \Omega}$

As temperature increases the resistance of wire also increases.

2.6 **Two wires of same material and length have resistances 5 Ω and 10 Ω respectively. Find the ratio of radii of the two wires.**

Data: Resistance of first wire R1 = 5 Ω ; Radius of first wire = r_1

Resistance of second wire R2 = 10 Ω ; Radius of second wire = r_2

Length of the wires = l ;Specific resistance of the material of the wires = ρ

Solution:

$R = \frac{\rho l}{A}$; $A = \pi r^2$ ∴ $R1 = \frac{\rho l}{\pi r_1^2}$; $R2 = \frac{\rho l}{\pi r_2^2}$

$$\frac{R_2}{R_1} = \frac{r_1^2}{r_2^2} \text{ or } \frac{r_1}{r_2} = \sqrt{\frac{R_2}{R_1}} = \sqrt{\frac{10}{5}} = \frac{\sqrt{2}}{1} \qquad \therefore \boxed{r_1 : r_2 = \sqrt{2} : 1}$$

2.13 **A 10 Ω resistance is connected in series with a cell of emf 10V. A voltmeter is connected in parallel to a cell, and it reads. 9.9 V. Find internal resistance of the cell.**

Data: R = 10 Ω ; E = 10 V ; V = 9.9 V ; r = ?

Solution:

$$r = \left(\frac{E-V}{V}\right)R = \left(\frac{10-9.9}{9.9}\right)\times 10 = \mathbf{0.101\ \Omega}$$

2.38 **The resistance of a platinum wire at 0 °C is 4 Ω. What will be the resistance of the wire at 100 °C if the temperature coefficient of resistance of platinum is 0.0038 /° C.**

Data: At 0°C, R_o = 4 Ω ; α = 0.0038/°C ; t = 100 °C ; At t °C, R_t = ?

Solution:

$R_t = R_o (1+ \alpha t)$

$= 4(1 + (0.0038 \times 100))$

$\mathbf{= 5.52\ \Omega}$

2.41 **An electric iron of resistance 80 Ω is operated at 200 V for two hours. Find the electrical energy consumed.**

Data: R = 80 Ω , V= 200 V , t = 2 Hrs , E=?

Solution: Electric Energy = electric power x time = $(V^2/R)t$

$= \frac{200^2 \times 2}{80}$ = 1000 Wh = **1 KWh**

2.1 *If 6.25 × 10^{18} electrons flow through a given cross section in unit time, find the current. (Given : Charge of an electron is 1.6 × 10^{-19} C)*

Data : $n = 6.25 \times 10^{18}$; $e = 1.6 \times 10^{-19}$ C ; $t = 1$ s ; $I = ?$

Solution : $I = \frac{q}{t} = \frac{ne}{t} = \frac{6.25 \times 10^{18} \times 1.6 \times 10^{-19}}{1} = 1$ A

2.3 *An incandescent lamp is operated at 240 V and the current is 0.5 A. What is the resistance of the lamp ?*

Data : V = 240 V ; I = 0.5 A ; R = ?

Solution : From Ohm's law

$$V = IR \quad \text{or} \quad R = \frac{V}{I} = \frac{240}{0.5} = 480\ \Omega$$

2.4 *The resistance of a copper wire of length 5m is 0.5 Ω. If the diameter of the wire is 0.05 cm, determine its specific resistance.*

Data : l = 5m ; R = 0.5 Ω ; d = 0.05 cm = 5×10^{-4} m ;
$r = 2.5 \times 10^{-4}$ m ; ρ = ?

Solution : $R = \frac{\rho l}{A}$ or $\rho = \frac{RA}{l}$

$$A = \pi r^2 = 3.14 \times (2.5 \times 10^{-4})^2 = 1.9625 \times 10^{-7}\ m^2$$

$$\rho = \frac{0.5 \times 1.9625 \times 10^{-7}}{5}$$

$$\rho = 1.9625 \times 10^{-8}\ \Omega m$$

2.31 *How much time 10^{20} electrons will take to flow through a point, so that the current is 200 mA? (e = 1.6 × 10^{-19} C)*

Data : $n = 10^{20}$, $e = 1.6 \times 10^{-19}$ C, I = 200 mA = 200×10^{-3} A

Solution : $I = \frac{q}{t} = \frac{ne}{t}$

$$t = \frac{ne}{I} = \frac{10^{20} \times 1.6 \times 10^{-19}}{200 \times 10^{-3}}$$

t = 80 s

2.32 A manganin wire of length 2m has a diameter of 0.4 mm with a resistance of 70 Ω. Find the resistivity of the material.

Data : l = 2m, d = 0.4 mm = 0.4×10^{-3} m ;

r = 0.2 mm = 0.2×10^{-3} m ; R = 70 Ω, ρ = ?

Solution : Resistivity of the material, $\rho = \frac{\pi r^2 R}{l}$

$$= \frac{3.14 \times (0.2 \times 10^{-3})^2 \times 70}{2}$$

ρ = **4.396×10^{-6} Ωm**

2.39 A cell has a potential difference of 6 V in an open circuit, but it falls to 4 V when a current of 2 A is drawn from it. Find the internal resistance of the cell.

Data : p.d in an open circuit (E) = 6 V

when current is drawn from the cell the voltage is (V) = 4V

Current = 2A

Internal resistance (r) = ?

V = E – Ir

4 = 6 – 2r

or 2r = 6 – 4

$\therefore$ **r = 1 Ω**

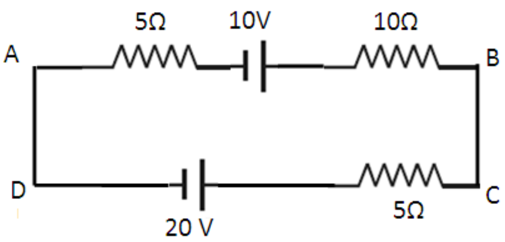
2.41 In a Wheatstone's bridge, if the galvanometer shows zero deflection, find the unknown resistance. Given P = 1000 Ω ,Q = 10000 Ω and R = 20 Ω.

Data : P = 1000Ω, Q = 10000 Ω and R = 20 Ω ; S = ?

$$\frac{P}{Q} = \frac{R}{S} \text{ or } S = \frac{QR}{P} = \frac{10{,}000 \times 20}{1000}$$

$\therefore$ **S = 200 Ω**

M'11 Find the magnitude and direction of the current in the following circuit. O'14



{Assumed direction: Clockwise.}

<u>Solution:</u> 5 I + 10 I + 5 I = 10-20

20 I = -10 ; I = - 0.5 A

<u>Direction:</u> Anticlockwise (or) DCBA

3. Effects of Electric Current

Self Evaluation Questions:

1. State joules law of heating.

Joule's law implies that the heat produced is

1. directly proportional to the square of the current for a given R
2. directly proportional to resistance R for a given I and
3. directly proportional to the time of passage of current.
4. The heat produced is inversely proportional to resistance R for a given V. [$H = (V^2/R)t$]

2. What is Peltier coefficient? Write its unit. [J-06, J'11, M'12, M'14]

The amount of heat energy absorbed or evolved at one of the junctions of a thermocouple when one ampere current flows for one second is called Peltier coefficient and it is denoted by π . Its unit is volt. If H is the quantity of heat absorbed or evolved at one junction then $H = \pi It$.

3. What is Thomson coefficient? [O'12,J'15]

The amount of heat energy absorbed or evolved when one ampere current flows for one second (one coulomb) in a metal between two points which differ in temperature by 1^0 C is called Thomson coefficient. It is denoted by σ. Its unit is volt per ^{0}C.

4. State Biot - savart law.

According to Biot and Savart, the magnetic induction dB at P due to the element of length dl is

1. directly proportional to the current(I)
2. directly proportional to the length of the current element(dl)
3. directly proportional to the sine of the angle between the direction of the current and line joining to the current element to the point.
4. inversely proportional to the square of the distance r of the point from current element.

$$dB \propto \frac{Id\, l \sin\theta}{r^2} \qquad \vec{dB} = \frac{\mu_o}{4\pi}\frac{I\vec{dl}\times\vec{r}}{r^3} \quad \text{or} \quad \vec{dB} = \frac{\mu_o}{4\pi}\frac{I\vec{dl}\times\hat{r}}{r^2}$$

5. State tangent law. [Principle of Tangent galvanometer] [M'11,O'16]

According to tangent law, when a magnetic needle suspended at a point where there are two crossed field right angles to each other will come to rest in a direction the resultant of the two field.

6. What is Ampere's circuital law? [M'09, J'14,M'18]

Ampere's circuital law states that the line integral $\oint \vec{B}.\vec{dl}$ for a closed curve is equal to μ_0 times the net current I_0 through the area bounded by the curve.

$$\oint \vec{B}.\vec{dl} = \mu_o I_o$$

7. Define ampere. [M'08, J'08, O'11,O'14]

Ampere is defined as that constant current which when flowing through two parallel infinitely long straight conductors of negligible cross section and placed in air or vacuum at a distance of one metre apart, experience a force of 2×10^{-7} newton per unit length of the conductor.

Other Important Questions:

1. Differentiate Joules heating effect and Peltier effect. **[M'06]**

Joules heating effect	Peltier effect
1. It takes place throughout the conductor.	1. It takes place only at the junction.
2. Independent of the direction of current.	2. It depends on the direction of current.
3. Irreversible effect.	3. Reversible effect.
4. This gives always heating effect.	4. It gives heating and cooling effect.
5. Rate of evolution of heat is directly proportional to square of current.	5. Rate of evolution or absorption of heat is directly proportional to the current.

2. In a galvanometer, increasing the current sensitivity does not necessarily increase the voltage sensitivity. Explain. **[M-07].**

Current sensitivity $\frac{\theta}{I} = \frac{nBA}{C}$

Voltage sensitivity $= \frac{\theta}{V} = \frac{nBA}{CG}$.

When the number of turns (n) is doubled, current sensitivity is also doubled. But increasing the number of turns correspondingly increases the resistance (G). Hence the voltage sensitivity remains unchanged. So increasing the current sensitivity does not necessarily increase the voltage sensitivity.

3. What is Seebeck effect? **[J'16]**

In a circuit consisting of two dissimilar metals such as iron and copper , an emf is developed if the junctions of the metals are maintained at different temperature is called Seebeck effect.

4. State end rule. [The magnetic polarity of the current carrying solenoid]

When looked from one end, if the current through the solenoid is along clock wise direction the near end corresponds to south pole and the other end is north pole. In case of anti clock wise direction the near end corresponds to north pole and the other end is south pole.

5. State right hand palm rule. [Direction of magnetic field due to circular closed loops (solenoid)]

The coil is held in the right hand so that the fingers point the direction of the current in the windings. The extended thumb, points in the direction of the magnetic field. This rule is used to find the direction of magnetic field in solenoid.

6. State Fleming left hand rule. **[M'09,O'10,M'15]**

The fore finger, the middle finger and the thumb of the left hand are stretched in mutually perpendicular directions.

If Fore finger ---- points the direction of the magnetic field.
Middle finger ---- points the direction of the current.
Thumb ---- points the direction of the *force of the conductor.*

Note: This rule is used to find the force on a current carrying conductor placed in a magnetic field .

7. On what factor current sensitivity of a galvanometer depends upon? [O'09]

The deflection produced when unit current passed through the galvanometer is called current sensitivity of a galvanometer. It can be increased by,

I. Increasing the number of turns
II. Increasing the magnetic induction
III. Increasing the area of the coil
IV. Decreasing the couple per unit twist of the suspension wire.

$$\boxed{\frac{\theta}{I} = \frac{nBA}{C}}$$

8. Define neutral temperature and temperature of inversion. [O'08]

In Seebeck experiment keeping the temperature of cold junction constant, the temperature of the hot junction is increased. The thermo emf rises the *maximum* at a temperature called *neutral temperature* and then gradually decreases and becomes *zero* at a particular temperature called *temperature inversion.*

9. Why Nichrome is used as a heating element in the heating devices? [J'07, M'10,O'15,M'17]

Nichrome which is an alloy of nickel and chromium is used as the heating element for the following reasons.

1. It has high specific resistance.
2. It has high melting point.
3. It is not easily oxidized.

10. State Maxwell's right hand cork screw rule.

If a right handed cork screw is rotated to advance along the direction of the current through a conductor, then the direction of rotation of the screw gives the direction of the magnetic lines of force around the conductor.

Note: This rule is used to find the direction of magnetic field around the current carrying conductor.

11. Define Voltage sensitivity.

The Voltage sensitivity of a galvanometer is defined as the deflection per unit voltage.

Voltage sensitivity $= \frac{\theta}{V} = \frac{nBA}{CG}$. Unit: radian volt^{-1}

where G is the galvanometer resistance.

12. Why an ammeter is always connected in series?

(i) The effective resistance of the ammeter R_a is $R_a = GS/G+S$

(ii) R_a is very low; when ammeter connected in series the ammeter does not appreciably change the resistance and current in the circuit.

G→Galvano meter resistance ; S→ Shunt resistance

13. Define magnetic moment of a current loop.

The magnetic moment of a current loop is defined as the product of the current and the loop area. $M = IA$ Unit: Am^2

14. Distinguish current sensitivity and voltage sensitivity.

current sensitivity	voltage sensitivity
1. Deflection produced per unit current	1. Deflection produced per unit voltage.
2. It varies with number of turns	2. It remains constant if the number of turns changes.
3. Unit is radian A^{-1}	3. Unit is radian volt^{-1}

15. What are the limitations of cyclotron? **[M'13]**

(i) Maintaining a uniform ***magnetic field*** over a large area of the Dees is **difficult**.

(ii) At high velocities, relativistic variation of mass of the particle upsets the **resonance** condition.

(iii) At high frequencies, relativistic variation of mass of the electron is appreciable and hence **electrons cannot be accelerated** by cyclotron.

16. Define Peltier effect.

In 1834, a French scientist Peltier discovered that when electric current is passed through a circuit consisting of two dissimilar metals, heat is evolved at one junction and absorbed at the other junction. This is called Peltier effect. Peltier effect is the converse of Seebeck effect.

17. What is a thermopile?

Thermopile is a device used to detect thermal radiation. It works on the principle of Seebeck effect. When thermal radiation falls on one set of junctions a difference in temperature between the junctions is created and a large thermo emf is produced. The deflection in the galvanometer is proportional to the intensity of radiation.

18. What is thermoelectric current?

Two dissimilar metals connected to form two junctions are called thermocouple. The emf is developed when the junctions are maintained in different temperature. This emf is called thermo electric emf. The current through the circuit is called thermoelectric current.

19. What do you infer from thermo electric series of metal?

The thermo-electric series of metals is :

Bi, Ni, Pd, Pt, Cu, Mn, Hg, Pb, Sn, Au, Ag, Zn, Cd, Fe, Sb.

(i) The direction of the current at the hot junction is from the metal occurring earlier in the series to the one occurring later in the series.

(ii) The magnitude of thermo emf is larger for metals appearing farther apart in the series.

(iii) The position of the metal in the series depends upon the temperature.

20. State the principle of moving coil Galvanometer.

Moving coil galvanometer is a device used for measuring the current in a circuit. Moving coil galvanometer works on the principle that a current carrying coil placed in a magnetic field experiences a torque.

21. State Ampere's hypothesis.

Ampere demonstrated that a simple current loop behaves like a bar magnet and put forward that all the magnetic phenomena is due to circulating electric current. This is Ampere's hypothesis.

22. On what factor Peltier coefficient depends on?

The Peltier coefficient at a junction is the Peltier emf at that junction. The Peltier coefficient depends on the pair of metals in contact and the temperature of the junction.

23. What is Thomson Effect?

Thomson suggested that when a current flows through unequally heated conductors, heat energy is absorbed or evolved throughout the body of the metal. This effect is called Thomson effect.

Frequently Asked Problems

3.2. Calculate the resistance of the filament of a 100 W, 220 V electric bulb.

Data : P = 100 W, V = 220 V, R = ?

Solution : $P = \frac{V^2}{R}$

$$\therefore R = \frac{V^2}{P} = \frac{(220)^2}{100} = 484\ \Omega$$

3.4 A long straight wire carrying current produces a magnetic induction of 4 × 10^{-6}T at a point, 15 cm from the wire. Calculate the current through the wire.

Data : B = 4 × 10^{-6}T, a=15 x 10^{-2}m, I=?

Solution : $B = \frac{\mu_o I}{2\pi a}$

$$\therefore I = \frac{B \times 2\pi a}{\mu_o} = \frac{4\times10^{-6}\times2\pi\times15\times10^{-2}}{4\pi\times10^{-7}}$$

$\therefore$ I = 3A

3.29 Find *the magnetic induction at a point, 10 cm from a long straight wire carrying a current of 10 A.*

Data : a = 10 cm = 10 × 10^{-2}m ; I = 10A, B = ?

Solution : Magnetic induction at a point due to a long straight wire

$$B = \frac{\mu o I}{2\pi a} = \frac{4\pi\times10^{-7}\ \mathbf{X\ 10}}{2\times3.14\times10\times10^{-2}} = \mathbf{2 \times 10^{-5}\ T}$$

3.32 *A straight wire of length one metre and of resistance 2 Ω is connected across a battery of emf 12V. The wire is placed normal to a magnetic field of induction 5 × 10-3 T. Find the force on the wire.*

Data : l = 1 m , R = 2 Ω, V = 12 V θ = 90°, B = 5 × 10^{-3}T, F = ?

Solution:

$$F = BIl \sin\theta$$

$$F = BIl = B\left(\frac{V}{R}\right)l \qquad \left(\because I = V/R\right)$$

$$= 5\times10^{-3}\times\left(\frac{12}{2}\right) \qquad \therefore \mathbf{F = 3 \times 10^{-2}\ N}$$

3.39 A galvanometer has a resistance of 40 Ω. It shows full scale deflection for a current of 2 mA. How you will convert the galvanometer into a voltmeter of range 0 to 20V?

Data : G = 40 Ω, I_g = 2 mA = 2 × 10^{-3}A, V = 20 v, R = ?

Solution:

To convert a Galvanometer in to Voltmeter The resistance R to be connected is

$$R = \frac{V}{I_g} - G = \frac{20}{2\times10^{-3}} - 40 = 10000 - 40 = 9960\,\Omega$$

9960 Ω should be connected in series.

3.40 ***A galvanometer with 50 divisions on the scale requires a current sensitivity of 0.1 m A/division. The resistance of the galvanometer is 40 Ω. If a shunt resistance 0.1 Ω is connected across it, find the maximum value of the current that can be measured using this ammeter.***

Data : No. of divisions in the galvanometer = 50
Current sensitivity = 0.1 mA/div.
$G = 40\,\Omega$, $S = 0.1\Omega$, $I = ?$

Solution : Ig = current sensitivity × No. of division = 0.1 × 50 = 5 mA

$$I = Ig\left(\frac{G+S}{S}\right) = 5\times10^{-3}\left(\frac{40+0.1}{0.1}\right)$$

$I = 2.005$ A or $\mathbf{I = 2A}$

3.9 An α-particle moves with a speed of 5 × 10^5 ms^{-1} at an angle of 30o with respect to a magnetic field of induction 10^{-4} T. Find the force on the particle. [α particle has a +ve charge of 2e]

Data : $B = 10^{-4}$ T, $q = 2e$, $\upsilon = 5\times10^5\ ms^{-1}$, $\theta = 30^o$, $F = ?$

Solution

$$F = Bq\upsilon \sin\theta$$
$$= B(2e)\,\upsilon \sin 30^o$$
$$= 10^{-4}\times 2\times 1.6\times10^{-19}\times 5\times10^5\times\frac{1}{2}$$
$$F = 8\times10^{-18}N$$

3.12 A conductor of length 50 cm carrying a current of 5A is placed perpendicular to a magnetic field of induction 2 × 10^{-3} T. Find the force on the conductor.

Data : l = 50 cm = 5×10^{-1}m, I= 5A, B = 2×10^{-3}T; θ = 90^o, F = ?

Solution: $F = BIl \sin\theta$

$$= 2\times10^{-3}\times5\times5\times10^{-1}\times\sin 90^0$$

$$\therefore F = 5\times10^{-3}\ N$$

4 .Electromagnetic Induction and Alternating Current

Self Evaluation Questions:

1. What is an electromagnetic induction? **[M'08,O'16]**

The phenomenon of producing an induced emf due to the changes in the magnetic flux associated with a closed circuit is known as electromagnetic induction.

2. State Faradays laws of electromagnetic induction. **[J'06, J'07, O'07, O'13,O'14]**

First Law: **whenever the amount of magnetic flux linked with a closed circuit changes an emf is induced in the circuit. The induced emf lasts so long as the change in magnetic flux continues.**

***Second law*:** **The magnitude of induced emf in a closed circuit is directly proportional to the rate of change of magnetic flux linked with the circuit.** $e \; \alpha \; \frac{d\phi}{dt}$

3. Define self inductance (or) coefficient *of self induction*. Give its unit. **[J'09,O'15]**

The self inductance (coefficient of self induction) of a coil is numerically equal to the opposing emf induced in the coil when the rate of change of current through the coil is unity. Its unit is Henry. $e = -L\frac{dI}{dt}$

[OR]

The coefficient of self induction of a coil is numerically equal to the flux linked the coil when unit current flows through it. **[Φ = LI]**

4. Define the unit of self inductance (Define one Henry). **J'12**

The unit of self inductance is Henry. One Henry is the self inductance of a coil in which the change in current of one ampere per second produces an opposing emf of one volt.

5. Define mutual inductance (Or) coefficient of mutual induction?

The coefficient of mutual induction of a pair of coil is numerically equal to the magnetic flux linked with one coil when unit current flows through neighboring coil.

[OR]

The coefficient of mutual induction of a pair of coil is numerically equal to the emf induced in one coil when the rate of change of current through the other coil is unity.

$$M = -\frac{e_s}{\left(\frac{dI_P}{dt}\right)}$$

6. State Fleming's right hand rule (Generator rule). **[M-07. M'09, O'09,M'10 J'11,M'17]**

The forefinger, the middle finger and the thumb of the right hand are held in the three mutually perpendicular directions.

- **If the forefinger points along the direction of magnetic field and**
- **The thumb points along the direction of motion of the conductor then**
- **The middle finger points in the direction of the *induced current.***

7. Give the practical application of self-induction.

The phenomenon of self induction is applied in the choke coil fitted with fluorescent lamp (discharge tube).Audio frequency chokes are used in low frequency a.c circuits. Radio frequency chokes are used in wireless receiver circuits.

8. Define RMS value of alternating current.[Define I_{RMS} or I_{eff}] **[J'07, O'09, M'13, J'14]**

The rms value of alternating current is defined as that value of the steady current, which when passed through a resistor for a given time, will generate the same amount of heat as generated by an alternating current when passed through the same resistor for the same time. [The rms value is also called effective value of an a.c. and is denoted by I_{rms} or I_{eff}.]

9. State the methods of producing induced emf? [M'06, O'10 ,M'11, M'12,M'16,J'16]

The induced emf can be produced

i) By changing the magnetic induction (B)

ii) By changing the area (A) enclosed by the coil

iii) By changing the orientation of the coil (θ) with respect to the magnetic field.

10. What is called polyphase generator?

If a number of armature windings are used in the alternator it is known as polyphase generator. It produces voltage waves equal to the number of windings or phase.

11. What is inductive reactance?

Inductive reactance is the kind of resistance offered by an inductor to the flow of a.c current through it. It is given as $X_L = L\omega = 2\pi\nu L$, where ν is the frequency of the a.c. supply, L is the self inductance . Its unit is ohm.

For d.c. $\nu = 0$; $\therefore X_L = 0$. Thus a pure inductor offers zero resistance to d.c. But in an a.c. circuit the reactance of the coil increases with increase in frequency.

12. What is capacitive reactance?

Capacitive reactance is the kind of resistance offered by the capacitor to the flow of a.c current through it. It is given as $X_c = 1/C\omega$, where C is the capacitance and ν is the frequency of a.c supply. Its unit is ohm.

13. Mention the difference between a step up and step down transformer.

Step up transformer	Step down transformer
1. Output voltage is greater than input voltage.	1. Output voltage is less than input voltage
2. Current in the secondary is lesser than the primary.	2. Current in the secondary is more than the primary
3. Number of turn in the secondary is more than the primary.	3. Number of turn in the secondary is lesser than the primary.
4. Transformer ratio K >1	4. Transformer ratio K < 1

14. Define alternating current and give its expression.

Alternating current is defined as that electric current in which the emf induced in the coil varies in magnitude and direction periodically. Instantaneous value of AC is $I = I_0 \sin \omega t$. I_0 = Peak vale of a.c current and ω is the angular frequency.

15. What is called resonant frequency in LCR circuit?

In the series RLC circuit, the particular frequency ν_o at which the impedance of the circuit become minimum and therefore the current is maximum is called resonant frequency of the circuit.

$\omega L = 1/\omega C$, Z = R , I is in phase with V . **Such a circuit which admits maximum current is called series resonant circuit or acceptor circuit.**

16. Define power factor.

Power factor = $\frac{P_{av}}{\text{Apparent power}}$

The average power of an AC circuit is $P_{av} = I_{rms} \cdot E_{rms} \cdot \cos\Phi$

Here cosΦ is called power factor where Φ is the phase difference between current and voltage. **Power factor is defined as the ratio of the average power consumed in an ac circuit to the apparent power.**

17. Why a dc ammeter can't read AC?

D.C current always flows in only one direction. But A.C. current changes its direction alternately in a very fast manner. The average value of ac over a complete cycle is zero. A D.C ammeter reads the average value. So D.C ammeter cannot read A.C

18. Define Q factor (quality factor). [O'06, J'11, J'12, O'12 ,M'15,M'18]

The Q factor (quality factor) of a series resonant circuit is defined as the ratio of the voltage across a coil(L) or a capacitor(C) to the applied voltage.

Q = $\frac{\text{Voltage across L or C}}{\text{Applied voltage.}}$

19. A capacitor blocks d.c. but allows a.c. explain. O'11

i) **The capacitive reactance $X_c = 1/C\omega = 1/ 2\pi \nu C$. In the case of D.C the frequency $\nu = 0$, therefore X_C = infinity. Since the capacitor offers infinite resistance to D.C. it blocks D.C.**

ii) **For an a.c. the capacitive reactance varies inversely as the frequency of a.c. and also inversely as the capacitance of the capacitor.**

20. What happens to the value of current in RLC series circuit, if frequency of the source is increased?

1. **In RLC circuit, if the frequency is increased, impedance in the circuit decreases and hence current increases.**
2. **At a frequency $\nu_o = \frac{1}{2\pi\sqrt{LC}}$ current becomes maximum.**
3. **If frequency is increased beyond ν_0 current decreases.**

21. State Lenz's law in electromagnetic induction. [O'08,J'10, M'14]

Lenz's law states that the induced current produced in a circuit always flows in such a direction that it opposes the change or cause that produces it.

$$e = -\frac{d}{dt}(N\phi) \qquad e = -\frac{Nd\phi}{dt} = -\frac{N(\phi_2 - \phi_1)}{t}$$

22. Differentiate between self inductance and mutual inductance.

Self inductance	Mutual inductance
1. The self inductance of a coil is numerically equal to the opposing emf induced in the coil when the rate of change of current through the coil is unity.	1. The mutual inductance of a pair of coil is numerically equal to the magnetic flux linked with *one coil when unit current flows through neighboring coil.*
2. It depends area of cross section, number of turns and the permeability of the material of the core.	2. It depends the size and shape of the coils, number of turns , permeability of the material of the core and proximity of the coil.

23. What is magnetic flux?

The magnetic flux (Φ) linked with a surface held in a magnetic field (B) is defined as the number of magnetic lines of force crossing a closed area(A). If θ is the angle between the direction of the field and normal to the area, then $\Phi = BA \cos\theta$ Unit: weber (or) $Nm\,A^{-1}$

Other Important Questions:

1. Differentiate between self induction and mutual induction.

Self induction	Mutual induction
1. It is the induction due to the flow of current in the same coil.	1. It is the induction due to the flow of current in the adjacent coil.
2. It is directly proportional to the magnetic flux linked with the same coil .	2. It is directly proportional to the magnetic flux linked with one coil due to the flow of current in the other coil.
3. It is used in choke coil.	3. It is used in transformer.

2. What is an acceptor circuit?

A circuit which admits maximum current is called series resonant circuit or acceptor circuit. By offering minimum impedance to current at the resonant frequency it is able to select or accept most readily the particular frequency among many frequencies.

3. Distinguish between AF choke and RF choke.[High Frequency choke] **[J'08]**

AF choke	RF choke
1. AF choke has iron core.	1. RF choke has air core
2. Used in low frequency ac circuits.	2. Used in wireless receiver circuits.
3. The inductance is high.	3. The inductance is low.

4. What are the factors affecting coefficient of mutual induction?

(i) Size and shape of the coil

(ii) Number of turns and permeability of material on which the coils are wound.

(iii) Proximity of the coil.

5. Define self induction.

The property of a coil which enables to produce an opposing induced emf in it when the current in the coil changes is called self induction.

6. Define mutual induction.

i) Whenever there is a change in the magnetic flux linked with a coil, there is also a change of flux linked with the neighbouring coil, producing an induced emf in the second coil.

ii) The phenomenon of producing an induced emf in a coil due to the change in current in the other coil is known as mutual induction.

7. What are eddy currents? How are they minimised?

i) When a mass of metal moves in a magnetic field or when the magnetic field through a stationary mass of metal is altered, induced current is produced in the metal. This induced current flows in the metal in the form of closed loops resembling 'eddies' or whirl pool. Hence this current is called eddy current.

ii) Eddy current can be minimised by using <u>thin laminated sheets</u> instead of solid metal.

8. Define the efficiency of the transformer. **[O'12,J'15,J'16]**

Efficiency of a transformer is defined as the ratio of output power to the input power. The efficiency η = 1 (ie. 100%), only for an ideal transformer where there is no power loss.

$$\eta = \frac{output\ \ power}{input\ \ power} = \frac{E_sI_s}{E_pI_p}$$

9. Can a transformer be used to step up DC? Explain.

- **No. A transformer can't be used to step up DC[Direct current]. Because it works only on AC.[Alternating current].**
- **The frequency of DC is zero.**
- **When a DC is applied to the primary of the transformer, a changing magnetic flux cannot be produced in the secondary. Hence emf cannot be induced in the secondary.**

10. What are the advantages of a.c over d.c?

1. **The significance of an alternating emf is that it can be changed to lower or higher voltages conveniently and efficiently using a transformer.**
2. **Also the frequency of the induced emf can be altered by changing the speed of the coil. This enables us to utilize the whole range of electromagnetic spectrum for one purpose or the other.**
3. **Alternating current can be transmitted over a long distance using transformer without much power loss.**
4. **The a.c can be easily converted in to d.c.**

Frequently Asked Problems

4.1 Magnetic field through a coil having 200 turns and cross sectional area 0.04 m^2 changes from 0.1 wb m^{-2} to 0.04 wbm^{-2} in 0.02 s Find the induced emf.

Data: N = 200, A = 0.04 m^2, B1 = 0.1 wb m^{-2}, B2 = 0.04 wb m^{-2}, t = 0.02 s, e = ?

Solution:

$$e = -\frac{d\phi}{dt} = -\frac{d}{dt}(\phi)$$

$$e = -\frac{d}{dt}(\text{NBA}) = -\text{NA}\ .\ \frac{dB}{dt} = -\text{NA}.\ \frac{(B_2 - B_1)}{dt}$$

$$e = -200 \times 4 \times 10^{-2}\ \frac{(0.04 - 0.1)}{0.02}$$

$$\mathbf{e = 24\ V}$$

4.2 An aircraft having a wingspan of 20.48 m flies due north at a speed of 40 ms^{-1}. If the vertical component of earth's magnetic field at the place is 2 × 10^{-5} T, Calculate the emf induced between the ends of the wings.

Data: l = 20.48 m; v = 40 ms^{-1}; B = 2 × 10^{-5}T; e = ?

Solution: $e = -Blv$

$= -2 \times 10^{-5} \times 20.48 \times 40$

e = – 0.0164 volt

4.6 Write the equation of a 25 cycle current sine wave having rms value of 30 A.

Solution : **i = Io sin ωt** $= I_{rms}\sqrt{2}\sin 2\pi\nu t = 30\sqrt{2}\ \sin 2\pi \times 25\ t =$ **42.42 sin 157 t**

4.4 Calculate the mutual inductance between two coils when a current of 4 A changing to 8 A in 0.5 s in one coil, induces an emf of 50 mV in the other coil.

Data: $I_1 = 4A$; $I_2 = 8A$; $dt = 0.5s$; $e = 50\ mV = 50 \times 10^{-3}V$, $M = ?$

Solution:

$$\therefore\ M = -\frac{e}{\left(\frac{dI}{dt}\right)} = -\frac{e}{\left(\frac{I_2 - I_1}{dt}\right)} = -\frac{50\times10^{-3}}{\left(\frac{8-4}{0.5}\right)} = -\ 6.25 \times 10^{-3}\ \text{H}$$

$$e = -\ M\ .\ \frac{dI}{dt}$$

M = 6.25 mH (in magnitude)

4.5 An a.c. generator consists of a coil of 10,000 turns and of area 100 cm². The coil rotates at an angular speed of 140 rpm in a uniform magnetic field of 3.6 × 10⁻² T. Find the maximum value of the emf induced. **M'15**

Data: $N = 10{,}000$ $A = 10^2\ cm^2 = 10^2 \times 10^{-4} = 10^{-2}\ m^2$

$v = 140$ rpm $= 140/60 = 7/3$ rps, $B = 3.6 \times 10^{-2}T$, $E_o = ?$

Solution:

$E_o = NAB\omega = NAB\ 2\pi v$

$= 10^4 \times 10^{-2} \times 3.6 \times 10^{-2} \times 2\ \pi \times 7/3$

Eo = 52.75 V

4.55 Two rails of a railway track insulated from each other and the ground is connected to a millivoltmeter. The train runs at a speed of 180 Km/hr. Vertical component of earth's magnetic field is 0.2 × 10⁻⁴ Wb/m² and the rails are separated by 1m. Find the reading of the voltmeter. **O'14**

Data: $v = 180$ Km/hr $= 180 \times 1000/3600 = 50\ ms^{-1}$

$l = 1$ m; $B = 0.2 \times 10^{-4}T$; $e = ?$

Solution: $e = -\ B\ l\ v$

$= -0.\ 2 \times 10^{-4} \times 1 \times 50$

e = $-\ 10^{-3}$ volt **= -1 mV**

O'08: An ideal transformer has transformation ratio 1 :20 . If the input power and primary voltage are 600 mW and 6 V respectively, find the primary and secondary currents.

Data: Input power = 600 mW = 600×10^{-3} W , $E_p = 6$ V , Es/Ep = 1:20 , Ip ,Is =?

Solution:

Input power $E_p I_p = 600 \times 10^{-3}$ $\therefore$ **Ip** $= \frac{600 \times 10^{-3}}{6} = 100 \times 10^{-3}$ = **100 mA**

Output power Es Is = 600×10^{-3} [∵ In ideal transformer Input power = Output power]

∵ Is $= \frac{600 \times 10^{-3}}{Es} = \frac{600 \times 10^{-3}}{6/20}$ [∵ Es/Ep = 1/20 , Es = Ep/20 = 6/20]

Is $= 20 \times 100 \times 10^{-3}$ = **2 A**

O'06: The wings of aeroplane are 10 m apart. The plane is moving horizontally towards the north at a place where the vertical component of earth's magnetic field is 3 x 10⁻⁵ T. Calculate the induced emf set up between the tips of the wings if the velocity of the aeroplane is 720 Km/hr.

Data: l = 10 m;; B = 3 × 10^{-5}T; v = 720 x 1000/3600 = 200 ms^{-1} , e = ?

Solution: ***e = – B l v***

$= -3 \times 10^{-5} \times 10 \times 200$

e = – 6 x 10^{-2} volt = 0.06 V

4.61. ***A resistance of 50 Ω, an inductance of 0.5 H and a capacitance of 5 μF are connected in series with an a.c. supply of e = 311 sin (314t). Find (i) frequency of a.c. supply (ii) maximum voltage (iii) inductive reactance (iv) capacitive reactance (v) impedance.***

Data : R = 50 Ω, L = 0.5 H; C = 5μF, e = 311 sin 314 t

Solution : Comparing e = 311 sin 314 t with e = E_o sin ωt

we get, ωt = 314 t ω = 314 2πν = 314

$$\nu = \frac{314}{2 \times \pi} = 50\text{Hz}$$

(i) Frequency of a.c. supply = 50 Hz

(ii) E_o = 311 V (Peak voltage)

(iii) Inductive reactance $X_L = L\omega = 0.5 \times 314 = 157\ \Omega$

(iv) Capactive reactance $X_C = \frac{1}{C\omega} = \frac{1}{314 \times 5 \times 10^{-6}} = 636.9\Omega$

(v) Impedance of the circuit $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$$Z = \sqrt{50^2 + (157 - 636.9)^2} = \sqrt{2500 + 230400} = 482.59\ \Omega$$

5. Electromagnetic Waves and Wave Optics

Self Evaluation Questions:

1. What are electromagnetic waves?

The variation of electric and magnetic fields perpendicular to each other produces electromagnetic disturbances in space. These disturbances have the properties of a wave and propagate through space without any material medium. Theses waves are called electromagnetic wave.

2. Mention the characteristics of electromagnetic waves. [,J'15]

i) Electromagnetic waves are produced by accelerated charges.
ii) No material medium is required for propagation.
iii) It travels with a velocity of 3×10^8 m/s. given by the relation C = $\frac{1}{\sqrt{\mu_o \varepsilon_o}}$
iv) Variation of maxima and minima in both $\vec{E}$ and $\vec{B}$ occurs simultaneously.
v) Being charge less, it is not deflected by electric or magnetic field.
vi) The energy of electromagnetic wave is equally divided between electric and magnetic field vectors.
vii) It is transverse in nature.

3. Explain emission, absorption spectrum. [M-06,O'16]

i) When the light emitted directly from a source is examined with a spectrometer, the emission spectrum is obtained. Every source has its own characteristic emission spectrum.
ii) When the light emitted from a source is made to pass through an absorbing material and then examined with a spectrometer, the obtained spectrum is called absorption spectrum. It is the characteristic of the absorbing substance.

4. What is fluorescence and phosphorescence?

When an atomic or molecular system is excited in to higher energy state by absorption of energy, it returns back to lower energy state in a time less than 10^{-5} second and the system is found to glow brightly by emitting radiation of longer wave length. This is called Fluorescence.

There are some substances in which the molecules are excited by the absorption of incident ultraviolet light and they do not return immediately to their original state. The emission of light continues even after the exciting radiation is removed. This type of *delayed fluorescence* is called phosphorescence.

5. What is Tyndal scattering? [M-07, J'09,J'10, O'10, O'12]

When light passes through a colloidal solution its path is visible inside the solutions. This is because light is scattered by the particles of the solutions. The scattering of light by the colloidal particles is called Tyndal scattering.

6. State Huygen's principle. [O'09, O'11, M'12 ,O'15,M'18]

i) Huygen's principle states that every point on a given wave front may be considered as the source of secondary wavelets which spread out with the speed of light in that medium.
ii) The new wave front is the forward envelope of the secondary wavelets at that instant.

7. Distinguish between the corpuscle and photon.

Corpuscle	Photon
1. These are tiny mass less and perfectly elastic particle.	1. These are discrete pockets of energy.
2. Light energy is the kinetic energy of the corpuscles.	2. Energy of quanta E=h v.
3. Using this photoelectric effect cannot be explained.	3. Using this photoelectric effect can be explained.
4. Different colours are due to variation in size of corpuscles.	4. Different colours are due to different amount of energy.

8. How are stokes lines and anti stokes lines are formed?

If a photon strikes an atom or a molecule in a liquid, part of the energy of the incident photon may be used to excite the atom of the liquid and the rest scattered. The spectral line will have lower frequency and it is called *stokes line.*

If a photon strikes an atom or a molecule in a liquid, which is in the excited state, the scattered photon gains energy. The spectral line will have higher frequency and it is called Anti-stokes line.

9. Why does the sky appear blue in colour? [J'06, O'13 ,J'14]

i) The blue appearance of the sky is due to scattering of light by the atmosphere. This scattered radiation causes the sky to appear blue in colour.

ii) According to Rayleigh, the amount of scattering is inversely proportional to the fourth power of wavelength.

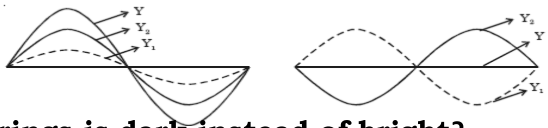
iii) The shorter wave length region of the solar spectrum blue scattered much more than the longer wave length.

10. State the principle of superposition of waves.

When two or more waves simultaneously pass through the same medium, each wave acts on every particle of the medium, as if the other waves are not present. The resultant displacement of any particle is the vector addition of the displacements due to the individual waves. This is known as principle of superposition.

let $\vec{Y1}$, $\vec{Y2}$ be the displacements of the individual wave the resultant displacement is the sum of individual displacements.

$$\vec{Y} = \vec{Y1} + \vec{Y2}$$



11. Why the central image of the Newton's rings is dark instead of bright? [M'09,O'16]

I. The thickness of the air film at the point of contact of lens L with glass plate P is zero. Hence, there is no path difference between the interfering waves. So, it should appear bright.

II. But the wave reflected from the denser glass plate has suffered a phase change of π while the wave reflected at the spherical surface of the lens has not suffered any phase change. Hence the central image of the Newton's ring appears dark.

12. Differentiate Fresnel and Fraunhofer diffraction. [M'10]

Fresnel Diffraction	Fraunhofer Diffraction
1. Source and screen are at finite distance from the obstacle.	1. Source and screen are at infinite distance from the obstacle.
2. Wave front undergoes diffraction is either spherical or cylindrical.	2. Wave front undergoes diffraction is plane wave front.
3. No lens is used.	3. Convex Lens is used.
4. Can be seen with naked eyes.	4. Can be observed only with a spectrometer.

13. Differentiate between polarized and Unpolarised light.

Polarized light	Unpolarised light
1. It will not produce any glare.	1. It will produce glare.
2. Vibrations are restricted to only one plane perpendicular to the direction of propagation.	2. Vibrations are present in all planes.
3. If a crystal is rotated in its path, the outgoing light will vary its intensity	3. If a crystal is rotated in its path, the outgoing light will not vary its intensity

14. What are Newton's rings?

1. When a plano convex lens of long focal length is placed over an optically plane glass plate, a thin air film with varying thickness is enclosed between them.
2. The thickness of the air film is zero at the point of contact and gradually increases outwards from the point of contact.
3. When the air film is illuminated by monochromatic light normally, alternate bright and dark concentric circular rings are formed with dark spot at the centre. These rings are known as Newton's rings.

15. Differentiate ordinary ray and extraordinary ray.

Ordinary ray	Extraordinary ray
1. It obeys the law of refraction.	1. It does not obey the law of refraction.
2. It moves with constant velocity in all direction.	2. It moves different velocity in different direction.
3. If produces spherical wave front inside a crystal.	3. It produces elliptical wave front inside a crystal.
4. The ratio between sine of the angle of incidence to the sine of the angle refraction is constant.	4. The ratio between sine of the angle of incidence to the sine of the angle refraction is not a constant.
5. In the case of calcite crystal for Sodium light the refractive index corresponding to the ordinary ray is 1.658.	5. In the case of calcite crystal for sodium light the refractive index corresponding to the extra ordinary ray is 1.486.

16. What is optical activity (*rotation*)? On what factors does it depend?

When a plane polarized light is made to pass through certain substances, the plane of polarization of the emergent light is not the same as that of incident light, but it has been rotated through some angle. This phenomenon is known as optical activity.

Note: The substances which rotate the plane of polarisation are said to be optically active.

Examples : quartz, sugar crystals, turpentine oil, sodium chloride etc.

The amount of optical rotation depends on: **[J'08, J'11 ,M'15]**

- **i) Thickness of crystal.**
- **ii) Density of the crystal (or concentration in the case of liquid)**
- **iii) Wave length of the light used.**
- **iv) The temperature of the solution**

17. Give the condition for sustained interference. **O'14**

1) **The two sources should be coherent.**
2) **Two sources should be very narrow.**
3) **The sources should lie very close to each other to form distinct and broad fringes.**

Other Important Questions

1. What are the uses of IR rays? **O'08,M'17]**

- **(i) Infrared lamps are used in *physiotherapy*.**
- **(ii) Infrared photographs are used in *weather forecasting*.**
- **(iii) IR radiations are not absorbed by air, fog, mist , they are used to take *photograph of long distance objects*.**
- **(iv) Infrared absorption spectrum is used to study the *molecular structure*.**

2. What are the uses of UV rays? **[M'14,J'16]**

- **i) They are used to *destroy the bacteria* and for sterilizing surgical instruments.**
- **ii) These radiations are used in detection of forged documents, finger prints in forensic laboratories.**
- **iii) They are used to preserve food items.**
- **iv) They help to find the structure of atoms.**

3. What are Fraunhofer lines? Give its uses. How are they formed? **[M'13]**

- **(i) If the solar spectrum is closely examined, it is found that it consists of large number of dark lines. The *dark lines* in the solar spectrum are called Fraunfofer lines.**
- **(ii) By comparing the absorption spectra of various substances with the Fraunfofer lines in the solar spectrum, the *elements presents in the sun's atmosphere have been identified*.**
- **III) Formation:** When light from the central core of the sun passes through sun's atmosphere, certain wavelengths are absorbed by the elements present in the chromosphere and the spectrum is marked by dark lines.

4. During the sunset or sunrise the sun appear reddish in colour. Why?

1. **At sunrise and sunset the rays from the sun have to travel a larger part of the atmosphere than at noon.**
2. **Therefore most of the blue light is scattered away and only the red light which is least scattered reaches the observer.**
3. **Hence, sun appears reddish at sunrise and sunset.**

5. What is diffraction? Give example. **[O'07]**

The bending of waves around the edges of an obstacle is called diffraction. Diffraction is a characteristic property of waves. The waves are diffracted, only when the size of the obstacle is comparable to the wavelength of the wave.

Ex: A series of coloured images are observed when white light passes through fine piece of cloth.

6. What are polariser and analyzer?

A device which produce plane polarised light is called a polariser. A device which is used to examine whether a light is plane polarised or not is an analyzer.

Ex: Nicol prism serves both polariser and analyzer.

7. Define Polarisation, plane of vibration and plane of Polarisation.

i) The phenomenon of restricting the vibrations into a particular plane is known as polarisation.

ii) The plane containing the optic axis in which the vibrations occur is known as plane of vibration.

iii) The plane which is at right angles to the plane of vibration and which contains the direction of propagation of the polarised light is known as the plane of polarisation.

8. What is double refraction?

When a ray of unpolarised light is incident on a calcite crystal two refracted rays are produced. This phenomenon is called double refraction. This phenomenon is exhibited by severalother crystals like quartz, mica etc.

9. What is optic axis? **[J'07,J'10]**

i) Inside the crystal there is a particular direction in which ordinary ray and extraordinary ray travel with same velocity called optic axis.

ii) The refractive index is same for both rays and there is no double refraction along this direction.

10. What are polaroids? Give its uses. **[M'16]**

A Polaroid is a material which polarises light. The phenomenon of selective absorption is used to construct Polaroid.

Uses: Polaroids are

(i) used to produce and analyse plane polarised light.

(ii) used as polarising sun glasses.

(iii) used to eliminate head light glare in motor cars.

(iv) used to produce three dimensional moving picture.

(v) used to improve colour contrast in old oil painting.

11. Define specific rotation. **[M'08, M'10, O'13, J'14]**

Specific rotation for a given wavelength of light at a given temperature is defined as the rotation produced by one decimeter length of the liquid column containing 1 gram of the active material in 1 cc of the solution. $S = \theta / l c$

Note: The term specific rotation is used to compare the rotational effect of all optically active substances.

12. Define polarising angle.

When the light is allowed to be incident at a particular angle, (for glass it is 57.5°) the reflected beam is completely plane polarised. The angle of incidence at which the reflected beam is completely plane polarised is called the polarising angle.

13. What is interference of light? Give Example. **[O'07]**

The redistribution of intensity of light on account of the superposition of two waves from a coherent source is called interference.

Ex: **1.** An important application of interference in thin films is the formation of Newton's rings.

2. The brilliant colours exhibited by a thin oil film spread on the surface of water and also by a soap bubble

14. Write the condition for total internal reflection to take place. **[M'14]**

I. **Light must travel from denser medium to rarer medium.**

II. **The angle of incidence inside the denser medium must be greater than critical angle [i>c].**

15. State Brewster's law. **[M'11]**

The tangent of the polarising angle is numerically equal to the refractive index of the medium. $\tan i_p = \mu$

16. What is electromagnetic spectrum?

The orderly distribution of electromagnetic waves according to their wavelength or frequency is called the electromagnetic spectrum.

17. What is diffraction grating?

(i) An arrangement consisting of a large number of equidistant parallel narrow slits of equal width separated by equal opaque portions is known as a <u>diffraction grating</u>.

(ii) The combined width of a ruling and a slit is called <u>grating element</u> (e).

(iii) Points on successive slits separated by a distance equal to the grating element are called <u>*corresponding points.*</u>

18. What are uniaxial and biaxial crystals? **[,O'15]**

Crystals like calcite, quartz, ice and tourmaline having only one optic axis are called uniaxial crystals.

Crystals like mica, topaz, selenite and aragonite having two optic axes are called biaxial crystals.

19. Give the difference between interference and diffraction. **[,M'16]**

	Interference	Diffraction
1.	It is due to the superposition of secondary wavelets from two different wavefronts produced by two coherent sources.	It is due to the superposition of secondary wavelets emitted from various points of the same wave front.
2.	Fringes are equally spaced.	Fringes are unequally spaced.
3.	Bright fringes are of same intensity	Intensity falls rapidly
4.	Comparing with diffraction, it has large number of fringes	It has less number of fringes.

20. What is the test for plane polarised light and partially polarised light?

A ray of light is allowed to pass through an analyser.

1. If the intensity of the emergent light *does not vary*, when the analyser is rotated, then the incident light is unpolarised.
2. If the intensity of light varies between *maximum and zero*, when the analyser is rotated through 90°, then the incident *light is plane polarised.*
3. If the intensity of light varies *between maximum and minimum (not zero)*, when the analyser is rotated through 90°, then the incident light is partially plane polarised.

21. Give the condition for obtaining clear and broad interference bands.

(i) The screen should be as far away from the source as possible.

(ii) The wavelength of light used must be larger.

(iii)The two coherent sources must be as close as possible.

22. Diffraction effect of sound is more than light. Give reason.

1. The amount of bending produced at an obstacle depends upon the wavelength of the incident wave.
2. Since the sound waves have a greater wavelength, the diffraction effects are pronounced.
3. As the wavelength of light is very small, compared to that of sound wave and even tiny obstacles have large size, compared to the wavelength of light waves, diffraction effects of light are very small.

Frequently Asked Problems

5.1 In Young's double slit experiment two coherent sources of intensity ratio of 64 : 1, produce interference fringes. Calculate the ratio of maximum and minimum intensities.

Data: $I_1 : I_2 :: 64 : 1$ $I_{max} : I_{min} = ?$

Solution: $\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{64}{1}$ $\therefore \frac{a_1}{a_2} = \frac{8}{1}$; $a_1 = 8a_2$

$$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(8a_2 + a_2)^2}{(8a_2 - a_2)^2} = \frac{(9a_2)^2}{(7a_2)^2} = \frac{81}{49}$$

$$I_{max} : I_{min} :: 81 : 49$$

5.2 In Young's experiment, the width of the fringes obtained with light of wavelength 6000 Å is 2 mm. Calculate the fringe width if the entire apparatus is immersed in a liquid of refractive index 1.33. O'14

Data: λ = 6000 Å = 6×10^{-7} m; β = 2mm = 2×10^{-3} m , μ = 1.33; β' = ?

Solution: $\beta' = \frac{D\lambda'}{d} = \frac{\lambda D}{\mu d} = \frac{\beta}{\mu}$ $\left[\because \mu = \frac{\lambda}{\lambda'}\right]$

$$\therefore \beta' = \frac{2 \times 10^{-3}}{1.33} = 1.5 \times 10^{-3} \text{ m (or) } 1.5 \text{ mm}$$

5.4 A plano – convex lens of radius 3 m is placed on an optically flat glass plate and is illuminated by monochromatic light. The radius of the 8th dark ring is 3.6 mm. Calculate the wavelength of light used. **M'15**

Data: $R = 3m$; $n = 8$; $r_8 = 3.6\ mm = 3.6 \times 10^{-3}\ m$; $\lambda = ?$

Solution: $r_n = \sqrt{nR\lambda}$

$r_n^2 = nR\lambda \quad \therefore \quad \lambda = \frac{r_n^2}{nR} = \frac{(3.6\times10^{-3})^2}{8\times3} = 5400 \times 10^{-10}\ m$ (or) 5400 Å

5.5 In Newton's rings experiment the diameter of certain order of dark ring is measured to be double that of second ring. What is the order of the ring?

Data: $d_n = 2d_2$; $n = ?$

Solution: $d_n^2 = 4nR\lambda \qquad [\ d=2r \therefore\ r_n^2 = (d/2)^2 = d^2/4 = nR\lambda\ ]$

$d_2^{\,2} = 8R\lambda \qquad \frac{d_n^2}{d_2^2} = \frac{n}{2} \quad \therefore \quad \frac{4d_2^2}{d_2^2} = \frac{n}{2} \qquad$ **n = 8**

5.6 Two slits 0.3 mm apart are illuminated by light of wavelength4500 Å. The screen is placed at 1 m distance from the slits. Find the separation between the second bright fringe on both sides of the central maximum.

Data: $d = 0.3\ mm = 0.3 \times 10^{-3}\ m$; $\lambda = 4500$ Å $= 4.5 \times 10^{-7}\ m$, $D = 1\ m$; $n = 2$; $2x = ?$

Solution:

$$2x = 2\,\frac{D}{d}\,n\lambda$$

$$= \frac{2\times1\times2\times4.5\times10^{-7}}{0.3\times10^{-3}} \qquad \therefore\ 2x = 6 \times 10^{-3}\ m \text{ (or) } 6\ mm$$

5.8 A 300 mm long tube containing 60 cc of sugar solution produces a rotation of 9° when placed in a polarimeter. If the specific rotation is 60°, calculate the quantity of sugar contained in the solution.

Data: $l = 300\ mm = 30\ cm = 3$ decimeter $\theta = 9^o$; $S = 60^o$; $v = 60$ cc $m = ?$

Solution: $S = \frac{\theta}{l\times c} = \frac{\theta}{l\times(m/v)} \quad \therefore \quad m = \frac{\theta . v}{l \times s} = \frac{9\times60}{3\times60}$ **= 3 g**

5.45 A light of wavelength 6000 Å falls normally on a thin air film, 6 dark fringes are seen between two points. Calculate the thickness of the air film. **[J'11]**

Data: $\lambda = 6000\ A^o = 6\text{x}\ 10^{-7}\ m$, $n=6$, $\theta = 90$, $t = ?$

Solution:

Path difference for dark fringe $2t = n\lambda$

$\therefore\ t = n\lambda/2 = 6 \times 6 \times 10^{-7}/2 = 18 \times 10^{-7}\ m$

5.49 The refractive index of the medium is √3 . Calculate the angle of refraction if the unpolarised light is incident on it at the polarising angle of the medium.

Data: $\mu = \sqrt{3}$, $r = ?$

Solution: **$\mu = \tan i_p = \sqrt{3}$ or $i_p = 60^0$**

Angle of refraction $r = 90 - i_p$

$r = 90 - 60 =$ **30^o**

5.50 A 20 cm long tube contains sugar solution of unknown strength. When observed through polarimeter, the plane of polarisation is rotated through 10°. Find the strength of sugar solution in g/cc. Specific rotation of sugar is 60° / decimetre / unit concentration.

Data: L = 20 cm = 2 decimeter, $\theta = 10^{o}$ $S_{\lambda'}$ = 60°/decimeter , C=?

Solution:

$$C = \frac{\theta}{L\,S_{\lambda'}} = \frac{10^0}{2 \times 60^0} = \frac{1}{12} = 0.0833 \text{ g/cc}$$

5.43 In Young's experiment a light of frequency 6×10^{14} Hz is used. Distance between the centers of adjacent fringes is 0.75 mm. Calculate the distance between the slits, if the screen is 1.5 m away.

Data: $\nu = 6 \times 10^{14}$, β = 0.75 mm = 0.75×10^{-3} m , D=1.5 m, d=?

Solution:

$$\lambda = C/\nu = \frac{3 \times 10^8}{6 \times 10^{14}} = 5 \times 10^{-7} \text{ m}$$

Band Width $\beta = \frac{\lambda D}{d}$ $\therefore d = \frac{\lambda D}{\beta} = \frac{5 \times 10^{-7} \times 1.5}{0.75 \times 10^{-3}} = 10^{-3}\text{ m} = \mathbf{1\ mm}$

5.40 ***An LC resonant circuit contains a capacitor 400 pF and an inductor 100 µH. It is sent into oscillations coupled to an antenna. Calculate the wavelength of the radiated electromagnetic wave.***

Data:

C= 400 pF= 400 x 10^{-12} F ; L= *100 µH* = *100* x 10^{-6} H

Solution:

i) Frequency of the wave is $\nu = \frac{1}{2\pi\sqrt{LC}}$

ii) Wavelength $\lambda = C/\nu$

$$\nu = \frac{1}{2 \times 3.14 \times \sqrt{400 \times 10^{-12} \times 100 \times 10^{-6}}}$$

$$\lambda = 3 \times 10^8 \times 2 \times 3.14 \times 20 \times 10^{-6} \times 10 \times 10^{-3}$$

λ = 120 x 3.14 = 376.8 = **377m**

5.44 The fringe width obtained in Young's double slit experiment while using a light of wavelength 5000 Å is 0.6 cm. If the distance between the slit and the screen is halved, find the new fringe width.

Data: β = 0.6 cm , λ=5000 x 10^{-10} m ; D=D/2, β' =?

Solution:

$$\beta = \frac{\lambda D}{d} \quad ; \quad \beta' = \frac{\lambda D'}{d} = \frac{\lambda D}{2d} = \frac{\beta}{2}$$

$$= \frac{0.6 \times 10^{-2}}{2} = 0.3 \times 10^{-2} = \mathbf{3\ mm}$$

6. Atomic Physics

Self Evaluation Questions:

1. What are cathode rays?

In a discharge tube at the pressure about *0.01 mm* of Hg, the positive column disappears and the Crooke's dark space fills the whole tube. At this (final) Stage the greenish glow is found to be a fluorescence of the glass produced by some invisible rays emanating from the cathode. These rays are called cathode rays.

2. Write the properties of cathode rays. [,O'15]

1) Cathode rays travel in a straight line.
2) They possess momentum and kinetic energy.
3) They affect photographic plate.
4) They ionize the gas through which it passes.
5) They travel with a velocity up to $1/10^{th-}$ of velocity of light.
6) Cathode rays produce heat, when allowed to fall on matter.

3. Write the result of Rutherford alpha particle scattering experiment.

According to alpha scattering experiment, Rutherford concluded that

i) In an atom the whole of the positive charge was concentrated in a tiny space of about 10^{-14}m. This region of the atom was named as nucleus.

ii) The atom has a lot of *empty space* around the nucleus.

4. What are the disadvantages of Rutherford's atom model? [O'08]

According to electromagnetic theory, an accelerated electric charge must radiate energy in the form of electromagnetic waves. The energy of an electron continuously decreases and spiral down into the nucleus. ***So the atom is unstable. But most of the atoms are stable.***

According to classical electromagnetic theory, the accelerating electron must radiate energy at a frequency proportional to the angular velocity. As the electron spiral down, the angular velocity become infinity and frequency of emitted energy will be infinity. ***This results a continuous spectrum with all possible wavelengths. But experiments reveal only line spectra of fixed wavelength from an atom.***

5. State the Postulates of Bohr atom model.

i) Quantization condition: An electron can't revolve round the nucleus in all possible orbits. The electron can revolve round the nucleus only in those permissible orbits for which the angular momentum of the electron is an integral multiple of $h/2\pi$. These orbits are called stationary orbits or non radiating orbits and an electron revolving in these orbits does not radiate any energy.

ii) Frequency condition: An atom radiates energy ($h\nu$) only when an electron jumps from a stationary orbit of higher energy (E_2) to an orbit of lower energy (E_1). ($h\nu = E_2 - E_1$)

6. What is meant by energy level diagram?

Taking the energies of orbits on a linear scale horizontal lines are drawn which represent energy levels of hydrogen atom. This diagram is known as energy level diagram.

7. What are the drawbacks of sommerfeld atom model? O'11

i) Though Sommerfeld's modification gave a theoretical background of the fine structure of spectral lines of hydrogen, it could not predict the correct number of observed *fine structure* of these lines.

ii) It could not explain the distribution and arrangement of electrons in atoms.

iii) It was unable to explain the *spectra of alkali metals* such as sodium, potassium etc.

iv) It could not explain Zeeman and Stark effect.

v) This model does not give any explanation for the *intensities* of the spectral lines.

8. Define excitation potential energy and ionization potential energy. [J'09]

- The energy required to raise an atom from its normal state into an excited state is called ***excitation potential energy***.
- The energy required to remove an electron from first orbit to outer most orbit is known as ***ionization potential energy.*** For hydrogen atom, the energy required to remove an electron from first orbit to its outermost orbit($n=\infty$) 13.6-0=13.6eV. This energy is known as the *ionization potential energy* for hydrogen atom.

9. What are x-rays?

X-rays are electromagnetic waves of short wave length in the range of $0.5\ A^0$ to $10\ A^0$, which are produced when fast moving electrons strike a metal target of suitable material.

10. Distinguish between soft X-rays and hard X-rays. [M'14]

Soft X-Rays	Hard X-Rays
1. X- rays having wave length of $4A^0$ or above.	1. X-rays having low wave length of the order $1A^0$.
2. Have lesser frequency and hence lesser energy.	2. Have high frequency and hence high energy.
3. Low penetrating power.	3. Penetrating power is high.
4. They are produced at comparatively low potential difference.	4. They are produced at comparatively high potential difference.

11. What are the properties of X-rays?

i) They travel in a straight line with the velocity of light.

ii) They ionize the gas through which it passes.

iii) They affect the photographic plate.

iv) They undergo reflection, refraction etc. like light.

v) They are not deflected by electric or magnetic field.

vi) When it falls on certain metals, they liberate photo electron.

12. What is meant by normal population?

i) In a system of thermal equilibrium, the number of atoms in the ground state is more than the number of atoms in the excited state. This is called **normal population.**

ii) If the number of atoms in the excited state is more than the number of atoms in the ground state, that position is called population inversion.

13. State Moseley's law . [M'07, M'08, M'09, M'11, J'14,J'15 ,M'16]

The frequency of the spectral line in the characteristic X-ray spectrum is directly proportional to the square of the atomic number (Z) of the element considered. This is known as Moseley's law.

$\upsilon \ \alpha \ z^2$ or $\sqrt{\upsilon}$ a (z-b).

Where a, b are constants depending upon the particular spectral line.

14. Write differences between spontaneous emission and stimulated emission.

Spontaneous emission	Stimulated emission
1. Atoms return to lower energy state without the help of an external agency. (No need of stimulating photon.	1. Atoms return to lower energy state with the help of photon. (It needs stimulating photon hv = E_2-E_1).
2. No secondary photon is produced.	2. Secondary photon is produced.
3. Atoms returns to lower energy level immediately.	3. Atoms stay for some time in meta stable state and return to lower level.
4. The excited energy level is an ordinary level.	4. The excited energy level is a meta stable state.
5. Life time of atoms in the excited state is 10^{-8} s.	5. Life time of atoms in the meta stable state is 10^{-3} s.

15. Why ordinary plane transmission gratings can't be used to produce diffraction effects in x-rays?

i) Diffraction effects can only be observed if the spacing between the lines ruled on the grating is of the order of magnitude of wavelength of the wave used.

ii) Thus, in order to diffract X–rays, grating with much finer rulings, having distance between rulings comparable to the wave length of X–rays are required.

iii) It is impossible to construct a grating of such fine dimensions artificially.

16. What are the characteristics of laser? [O-06, J'09, M'10,J'10, J'12, O'12]

The laser beam

i) is monochromatic

ii) is coherent, with the waves , all exactly in phase with one another

iii) doesn't diverge at all

iv) is extremely intense.

17. What are the various applications of laser in medical field? [M'08, O'09, J'11, O'11,O'16]

1) In medicine, micro surgery has become possible due to narrow angular spread of the laser beam.

2) The laser beams are used in endoscopy.

3) It can also be used for the treatment of human and animal cancer.

4) It can be used in the treatment of kidney stone tumour, in cutting and sealing the small blood vessels in brain surgery and retina detachment.

Other Important Questions:

1. **What are canal rays (positive rays)?**

At a pressure of about 1 mm of mercury in a discharge tube , a luminous stream of particles were observed behind the perforated cathode proceeding in a direction opposite to that of the cathode rays are called canal rays. These are the streams of positive ions of the gas enclosed in the discharge tube.

2. **What is meant by distance of closest approach?**

It is the distance r_0 up to which an α –particle directed towards the centre of the nucleus will move close up to where its kinetic energy will appear as electrostatic potential energy and there after it begins to retrace its path.

3. **Define wave number.**

The wave number $\bar{\nu}$ of a radiation is defined as the number of waves per unit length. It is equal to the reciprocal of the wavelength. Unit: m^{-1}

4. **What are the results of Laue experiment?** [O'07 ,J'08, M'13]

(i) X-rays are electromagnetic waves of extremely short wavelength.
(ii) The atoms in a crystal are arranged in a regular three dimensional lattice.

5. **What is Holography?** [O'07]

i) When an object is photographed by a camera, a two dimensional image of three dimensional object is obtained. A three dimensional image of an object can be formed by holography.
ii) In ordinary photography, the amplitude of the light wave is recorded on the photographic film.
iii) In holography, both the phase and amplitude of the light waves are recorded on the film. The resulting photograph is called hologram.

6. **What is MASER?**

The term MASER stands for Microwave Amplification by Stimulated Emission of Radiation.
(i) It is based on the principle of population inversion followed by stimulated emission.
(ii) Emitted photon belongs to microwave frequencies.
(iii) Paramagnetic ions are used as a Maser material.
(iv). Maser provides a very strong tool for analysis in molecular spectroscopy.

7. **Write the condition to achieve laser action.** [M'06, J'07, O'13,J'14,J'16,M'18]

1. There must be an inverted population i.e. more atoms in the excited state than in the ground state.
2. The excited state must be a metastable state.
3. The emitted photons must stimulate further emission. This is achieved by the use of the reflecting mirrors at the ends of the system.

8. **Define ionization potential .** [M-07, O'10 ,M'15]

The ionization potential is that accelerating potential which makes the impinging electron acquires sufficient energy to knock out an electron from the atom and thereby ionize the atom. 13.6 V is the ionization potential of hydrogen atom.

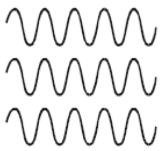
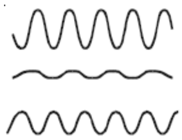
9. Define excitation potential.

The accelerating potential required to raise an atom from its normal state to excited state is called excitation potential .The energy required to transfer the electron in hydrogen atom from the ground state to the first excited state = (13.6-3.4) = 10.2eV. The energy required to raise it to the second excited state = (13.6 – 1.51) = 12.09 eV. The potentials corresponding to these energies are called as the excitation potential.

10. What is cleavage (lattice) plane?

In crystal, the atoms or molecules are arranged symmetrically in three dimensional spaces. Any plane containing an arrangement of atom is known as lattice plane or cleavage plane.

11. How does a laser light differ from an ordinary light?

Laser light	Ordinary light
1. Coherent 2. Monochromatic 3. Extremely intense 4. Does not diverge 	1. Incoherent 2. May or may not be monochromatic 3. Intense 4. Diverge 

12. Define critical potential.

The excitation potential and ionization potential are called as the critical potentials of the atom. The critical potential of an atom is defined as the minimum potential required to excite a free neutral atom from its ground state to higher state.

13. What are the applications of Moseley's Law? [O'12 ,O'14]

1) Any discrepancy in the order of the elements in the periodic table can be removed by Moseley's law by arranging the elements according to the atomic numbers and not according to the atomic weight.
2) Moseley's law has led to the discovery of new elements like hafnium(72), technetium(43), rhenium(75) etc.
3) This law has been helpful in determining the atomic number of rare earths, thereby fixing their position in the periodic table.

14. What is Bragg's law?

If the path difference $2d\sin\theta$ is equal to integral multiple of wavelength of X-ray .i.e. $n\lambda$, then the constructive interference will occur between the reflected beams and they will reinforce with each other. Therefore the intensity of the reflected beam is maximum.

$2d\sin\theta = n\lambda$; n= 1,2,3,..etc d→crystal lattice spacing

θ → glancing angle λ →wavelength of x-rays

15. How can X-rays be detected?

(i) By blackening a photographic plate.

(ii) The ionization produced by x-rays in a gas or vapour. An ionization chamber, which utilizes the property of ionization, is generally used to detect and measure the intensity of X-rays.

16. What are the applications of laser in scientific field?

Scientific and Engineering applications:

1) The semiconductor laser is the best light source for optical fiber communication.
2) The earth-moon distance has been measured with the help of lasers.
3) It is used in laser Raman Spectroscopy.
4) Laser is also used in holography.

17. What are the basic requirements for the production of X-ray?

The basic requirements for the production of X–rays are:

(i) a source of electrons

(ii) effective means of accelerating the electrons a target of suitable material of high atomic weight

18. What are the applications of X-ray in scientific and industrial field?

Scientific research :

1) X–rays are used for studying the structure of crystalline solids and alloys.
2) X–rays are used for the identification of chemical elements including determination of their atomic numbers.
3) X–rays can be used for analyzing the structure of complex molecules by examining their X–ray diffraction pattern.

Industrial applications:

1) X–rays are used to detect the defects or flaws within a material
2) X–rays can be used for testing the homogeneity of welded joints, insulating materials etc.
3) X-rays are used to analyse the structure of alloys and the other composite bodies.
4) X–rays are also used to study the structure of materials like rubber, cellulose, plastic fibres etc.

19. What are the various applications of laser in Industrial field? [J'07]

1. The laser beam is used to drill exactly fine holes in diamonds and hard sheets etc.
2. They are used for cutting thick sheets of hard metals and welding.
3. They can be used to test the quality of the materials.
4. The laser beam is used to vaporize the unwanted material during the manufacture of electronic circuit on semiconductor chips.

20. What are the characteristics of anode used in a Coolidge tube?

The anode should have the following characteristics:

1) high atomic weight – to produce hard X-rays
2) high melting point – so that it is not melted due to the bombardment of fast moving electrons, which cause lot of heat generation.
3) high thermal conductivity – to carry away the heat generated.

21. *Give the principle of Millikan's oil drop experiment.* **[,J'15]**

This method is based on the study of the motion of uncharged oil drop under free fall due to gravity and charged oil drop in a uniform electric field. By adjusting uniform electric field suitably, a charged oil drop can be made to move up or down or even kept balanced in the field of view for sufficiently long time and a series of observations can be made.

22. State the two basic concepts of Sommerfeld atom model.

1. **According to Sommerfeld, the path of an electron around the nucleus, in general, is an ellipse with the nucleus at one of its foci.**
2. **The velocity of the electron moving in an elliptical orbit varies at different parts of the orbit. This causes the relativistic variation in the mass of the moving electron.**

23. What are the drawbacks of Thomson atom model?

1. According to electromagnetic theory, the vibrating electron should radiate energy and the frequency of the emitted spectral line should be the same as the electron. In the case of hydrogen atom, **Thomson's model gives only one spectral line of about 1300 Å. But the experimental observations reveal that hydrogen spectrum consists of five different series with several lines in each series.**
2. **It could not account for the scattering of α-particles through large angles.**

24. What are the methods in which gases allow electricity to pass through them?

(i) By applying a large potential difference across a gas column at very low pressure and
(ii) By allowing X-rays to pass through the gases.

25. What are the various applications of X-rays in medical field? **[M'17]**

1. **X–rays are being widely used for detecting fractures, tumours, the presence of foreign matter like bullet etc., in the human body.**
2. **X–rays are also used for the diagnosis of tuberculosis, stones in kidneys, gall bladder etc.**
3. **Many types of skin diseases, malignant sores, cancer and tumours have been cured by controlled exposure of X-rays of suitable quality.**
4. **Hard X–rays are used to destroy tumours very deep inside the body.**

26. In Millikani's experiment, an oil drop of mass 4.9×10^{-14} kg is balanced by applying a potential difference of 9.8 kV between the two plates which are 8 mm apart. Calculate the number of elementary charges on the drop. Take $g = 10\ ms^{-2}$. **M'16**

Solution: $Eq = mg$ (or) $(V/d)\,ne = mg$: $n = \dfrac{mgd}{Ve} = \dfrac{4.9 \times 10^{-14} \times 10 \times 12.8 \times 10^{-3}}{9.8 \times 10^{3} \times 1.6 \times 10^{-19}}$

n = 4

Frequently Asked Problems

6.9 Calculate the longest wavelength that can be analysed by a rock salt crystal of spacing d = 2.82Å in the first order.

Data: d = 2.82 Å = 2.82×10^{-10} m ; n = 1 ; λ_{max} = ?

Solution:

For longest wavelength, $(\sin\theta)_{max} = 1$

$\therefore 2d(\sin\theta)_{max} = \lambda_{max}$

$$\text{(or) } \lambda_{max} = \frac{2 \times 2.82 \times 10^{-10} \times 1}{1}$$

$$\boxed{\lambda_{max} = 5.64 \times 10^{-10} \text{ m}}$$

6.7 The Rydberg constant for hydrogen is $1.097 \times 10^7 m^{-1}$. Calculate the short and long wavelength limits of Lyman series.

Data: R = 1.097×10^7 m^{-1}

For short wavelength limit of Lyman Series $n_1 = 1$, $n_2 = \infty$, λ_s = ?

For long wavelength limit of Lyman series, $n_1 = 1$, $n_2 = 2$, λ_l = ?

Solution: The wave number for Lyman series is, $\bar{\nu} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

For short wavelength limit	For long wavelength limit M'15
$\bar{\nu}_s = \frac{1}{\lambda_s} = R\left[\frac{1}{1^2} - \frac{1}{(\infty)^2}\right] = R$ (or) $\lambda_s = \frac{1}{R} = \frac{1}{1.097 \times 10^7} = 911.6\text{Å}$	$\bar{\nu}_l = \frac{1}{\lambda_l} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3}{4}R$ $\lambda_l = \frac{4}{3R} = \frac{4}{3 \times 1.097 \times 10^7}$ = 1215 A^0

6.49 An X-ray diffraction of a crystal gave the closest line at an angle of 6°27 '. If the wavelength of X-ray is 0.58Å, find the distance between the two cleavage planes. O'14

Solution: n=1 , θ = 6° 27' , λ = 0.58×10^{-10}m , d=?

$$2d\sin\theta = n\lambda \quad \therefore d = \frac{n\lambda}{2\sin\theta} = \frac{1 \times 0.58 \times 10^{-10}}{2\sin 6^\circ 27'} = \frac{0.58 \times 10^{-10}}{0.2247} = 2.581 \times 10^{-10} \text{ m}$$

6.50 How much should be the voltage of an X-ray tube so that the electrons emitted from the cathode may give an X-ray of wavelength 1Å after striking the target.

Solution: λ = 1 A° , V=?

$$\lambda_{min} = \frac{12400 \times 10^{-10}}{V} \quad \therefore V = \frac{12400 \times 10^{-10}}{\lambda} = \frac{12400 \times 10^{-10}}{1 \times 10^{-10}} = 12400 \text{ V} = 12.4 \text{ KV}$$

6.52 Find the minimum wavelength of X-rays produced by an X-ray tube at 1000 kV[or 10^6V]

Solution: V= 1000 kV = 10^6 V , λ_{min} =?

$$\lambda_{min} = \frac{hC}{eV} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19} \times 10^6} = 0.0124 \times 10^{-10} \text{ m} = 0.0124 \text{ A}^o$$

[Or]

$$\lambda_{min} = \frac{12400 \text{ A}^o}{V} = \frac{12400 \times 10^{-10}}{10^6} = 12400 \times 10^{-16} = 0.0124 \times 10^{-10} \text{ m} = 0.0124 \text{ A}^o$$

7. Dual Nature of Radiation and Matter and Relativity

Self Evaluation Questions:

1. What is photoelectric effect?

Photoelectric emission is the phenomena by which a good number of substances, chiefly metals, emit electrons under the influence of radiation such as γ rays, X-rays, ultraviolet and even visible light. This effect was discovered by Heinrich Hertz.

2. Define stopping or cut off potential? [O'09, O'12, O'13]

i) For a given metallic surface C, keeping the intensity *(I)* and frequency of the incident radiation constant, the effect of potential difference between the plates on the photoelectric current can be studied.

ii) **The minimum negative (retarding) potential given to the anode for which the photoelectric current becomes zero is called stopping potential or cut off potential.**

3. Define threshold frequency. M'15

The threshold frequency is defined as the minimum frequency of incident radiation below which the photoelectric emission is not possible completely, however high the intensity of incident radiation may be.

4. Define work function.

A part of the energy of the photon is used in extracting the electron from the surface of metal, since the electrons in the metal are bound to the nucleus. This energy W spent in releasing the photo electron is known as photoelectric work function of the metal.

The work function of a photo metal is defined as the minimum amount of energy required to liberate an electron from the metal surface.

5. State the laws of photoelectric effect.

i) **For a given photosensitive material, there is a minimum frequency called the *threshold frequency*, below which the emission of photoelectron stops completely, however great the intensity may be.**

ii) **For a given photosensitive material, the photoelectric current is directly proportional to the intensity of incident radiation, provided the frequency is greater than the threshold frequency.**

iii) **The photoelectric emission is an instantaneous process.**

iv) **The maximum kinetic energy of photoelectron is directly proportional to the frequency of incident radiation, but independent of its intensity.**

6. What are photo-cells? Give its types. [O'14,J'16]

The photoelectric cell is a device which converts light energy into electrical energy. Three types of photo cells are

i). Photo emissive cell ii). Photo voltaic cell iii). Photo conductive cell.

7. What are matter waves?

The moving particles should possess wave like properties under suitable conditions. These are called matter waves. [Waves associated with moving particles, proposed by de Broglie are called matter waves]. The wave length of matter waves **$\lambda = h/mv = h/p$**.

h→ Planck's constant, **m**→mass of the particle, **v**→velocity of the particle

8. State the postulates of special theory of relativity. [J'07,J'09, M'11, M'13,M'17]

The two fundamental postulates of special theory of relativity are.

i) The laws of physics are the same in all inertial frames of reference.

ii) The velocity of light in free space is a constant in all the frames of reference.

9. What are the applications of photo-cells. [J'06, M'10, O'10, J'12, M'14,J'14]

i) Reproducing sound in cinematography.

ii) Controlling the temperature of furnaces.

iii) Automatic on and off switching in the street light.

iv) Obtaining electrical energy from sun light during space travel.

v) Opening and closing of door automatically.

vi) The study of temperature and spectra of stars.

10. Mention the applications of electron microscope. [M'06 ,O'15 ,M'16,O'16,M'18]

i) It is used in the industry, to study the structure of textile fibres, surface of metals, composition of paints etc.

ii) In medicine and biology, it is used to study virus, and bacteria.

iii) In physics it has been used in the investigation of atomic structure and structure of crystals in detail.

11. Define frame of reference. Give Ex. And types.

A system of co-ordinate axes which defines the position of a particle in two or three dimensional space is called a frame of reference.

Ex: Earth Types: (i) inertial and (ii) non – inertial frames.

12. If a body moves with the velocity of light, what will be its mass? Comment on your result.

If a body moves with the velocity of light, the mass of the body becomes infinity. This is not possible. Hence we can infer that nobody can move with the velocity of light.

$m_o \rightarrow$ rest mass ; m $\rightarrow$ mass of the body when it moves with the velocity v.

$$\boxed{m = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}}}$$

Other Important Questions:

1. Define Inertial, non Inertial frame of reference. [O'06, M'08, O'11]

Inertial (or) Unaccelerated frames: A frame of reference is said to be inertial, when the bodies in this frame obey Newton's law of inertia and other laws of Newtonian mechanics. In this frame, a body remains at rest or in continuous motion unless acted upon by an external force.

Non – Inertial (or) accelerated frames: A frame of reference is said to be non-inertial frame, when a body not acted upon by an external force, is accelerated. In this frame, Newton's laws are not valid.

2. What is saturation current?

The maximum value of the photoelectric current that can be obtained with the increase of positive potential keeping the intensity and the frequency of the incident radiation constant is known as saturation current.

3. What are the limitations of electron microscope? [M-06, M'09, M'12,J'15]

i) An electron microscope is operated only in high vacuum.

ii) This prohibits the use of the microscope to study living organisms which would evaporate and disintegrate under such conditions.

4. What is the concept of Space according to classical mechanics?

i) Fixed frame of reference by which the position or motion of any object in the universe could be measured.

ii) The geometrical form of an object remains the same irrespective of changes in position or state of motion of the object or observer.

5. What is the concept of time according to classical mechanics? [J'10]

i) The time interval between two events has the same value for all observers irrespective of their motion.

ii) If two events are simultaneous for an observer, they are simultaneous for all observers, irrespective of their position or motion. This means simultaneity is absolute.

6. Explain the variation of mass with velocity.

According to Newtonian mechanics, the mass of the body does not change with velocity. But according to Einstein the mass of the body changes with velocity.

$$\boxed{m = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}}}$$

m_o → rest mass ; m → mass of the body when it moves with the velocity v

Example : Electrons accelerated in a particle accelerator, cyclotron with a very high velocity acquire increased mass, exactly as predicted by the above expression.

7. Calculate the rest energy of electron in Mev.

Solution: Rest energy = m_oc^2 = $9.11 \times 10^{-31} \times [3 \times 10^8]^2$

$= 8.199 \times 10^{-14}$ J

$= \frac{8.199 \times 10^{-14}}{1.6 \times 10^{-19}}$ ev

Rest energy = 0.5125 M ev

7.5 What is the de Broglie wave length of an electron of kinetic energy 120 *eV*?

Data : $K.E = 120\ eV = 120 \times 1.6 \times 10^{-19}\ J$; λ = ?

Solution : $\lambda = \frac{h}{\sqrt{2mE}}$

$$\lambda = \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 120 \times 1.6 \times 10^{-19}}}$$

$$\lambda = 1.121 \times 10^{-10}\ \text{m.}$$

8. Nuclear Physics

Self Evaluation Questions:

1. What is mass defect? What is binding energy? [O'09, O'10,O'16]

The difference in the total mass of the nucleons and the actual mass of nucleus is known as mass defect.

$$\Delta m = (Zm_p + Nm_n) - m$$

When the protons and neutrons combine to form a nucleus, the mass that disappears is converted in to an equivalent amount of energy. This energy is called binding energy of the nucleus.

$$\text{Binding Energy} = [Zm_p + Nm_n - m] C^2$$
$$BE = \Delta m C^2$$

2. Calculate the energy equivalence of 1 atomic mass unit.

According to Einstein's mass energy relation $E = mC^2$

$m = 1 \text{ amu} = 1.66 \times 10^{-27}$ Kg , $C = 3 \times 10^8$ m/s

$E = 1.66 \times 10^{-27} (3 \times 10^8)^2 = 14.94 \times 10^{-11}$ J. [$1 \text{ eV} = 1.6 \times 10^{-19}$ J.]

$$E = \frac{1.66 \times 10^{-27} (3 \times 10^8)^2}{1.6 \times 10^{-19}} \text{ eV} = 931 \times 10^6 \text{ eV.}$$

E= 931 Mev.

3. Show that nuclear density is almost a constant for all the nuclei.

Nuclear density = Nuclear mass / Nuclear volume.

$$\rho_N = \frac{A\ m_N}{\frac{4}{3}\pi(r_o A^{1/3})^3} = \frac{m_N}{\frac{4}{3}\pi r_o^3}$$

Substituting the known values, for any element the nuclear density is calculated as 1.816×10^{17} Kg/m^3 which is almost a constant for all the nuclei irrespective of its size.

4. Explain different characteristics of nuclear forces. [J'08 M'09]

i) Nuclear force is charge independent. (Whether it is n-n, n-p, p-p pair)

ii) Nuclear force is the strongest force in nature.

iii) Nuclear force is not a gravitational force. It is 10^{40} times stronger than gravitational force.

iv) Nuclear force is a short-range force, which exist within 10^{-15} m.

5. Define radioactivity.

The phenomenon of spontaneous emission of highly penetrating radiation such as α,β and γ rays by heavy elements having atomic number greater than 82 is called radioactivity. The elements, which emit these radiations, are called radioactive elements. ***Example:*** Uranium, Thorium.

6. Define curie [O'06, M'08,M'10, O'10, O'13 ,M'15,M'17]

The activity of a substance is generally expressed in curie. One curie is defined as the quantity of a radioactive substance which gives 3.7×10^{10} disintegration per second or 3.7×10^{10} becquerel .This is equal to the activity of 1 g of radium.

7. What do you mean by artificial radioactivity? [J'12, O'12]

The phenomenon by which even light elements are made radioactive by artificial or induced methods is called artificial radioactivity.

Example:-

$${}_{13}Al^{27} + {}_{2}He^{4} \longrightarrow {}_{15}P^{30*} + {}_{0}n^{1}$$

Radio-phosphorous decays into a stable isotope of silicon with the emission of a positron. The half life of radioactive phosphorous is about 3 minutes.

$${}_{15}P^{30*} \longrightarrow {}_{14}Si^{30} + {}_{1}e^{0}$$

8. How do you classify the neutrons in terms of its kinetic energy? [J'09]

Neutrons are classified according to their kinetic energy as slow neutrons and fast neutrons. Neutrons with energies between 0 to 1000 ev are called slow neutron. Neutrons with energies between 0.5 Mev and 10 Mev are called fast neutrons.

9. What is artificial transmutation?

Artificial transmutation is the conversion of one element into another by artificial methods.

Example:-

When nitrogen was bombarded with alpha particles of sufficient energy, a rare isotope of oxygen (${}_{8}O^{17}$) and a proton were formed.

$${}_{7}N^{14} + {}_{2}He^{4} \rightarrow {}_{8}O^{17} + {}_{1}H^{1}$$

10. What is meant by the Breeder reactor? [M'09,J'15]

i) ${}_{92}U^{238}$ and ${}_{90}Th^{232}$ are not fissile materials but are abundant in nature.

ii) In the breeder reactor, these can be converted into a fissile material ${}_{94}Pu^{239}$ and ${}_{92}U^{233}$ respectively by absorption of neutrons.

iii) The process of producing more fissile material in a reactor in this manner than consumed during the operation of the reactor is called breeding.

11. What are thermo nuclear reactions? [Nuclear fusion]

The nuclear fusion reactions are known as thermo-nuclear reactions. Nuclear fusion is a process in which two or more lighter nuclei combine to form a heavier nucleus. The mass of the product nucleus is always less than the sum of the masses of the individual lighter nuclei. The difference in mass is converted into energy.

12. What are cosmic rays? [J'08,J'10 ,O'14]

The ionizing radiation many times stronger than γ-rays entering the earth from all the directions from cosmic or interstellar space is known as cosmic rays. The name, cosmic rays was given by Millikan.

13. How do you classify the elementary particle in to four groups?

On the basis of their masses elementary particles are classified as

i) *Photons* having zero rest mass

ii) *Leptons* having masses less than or equal to 207 m_e

iii) *Mesons* having mass between 250 m_e and 1000 m_e.

iv) *Baryons* which consists of nucleons and hyperons forms the heavier group. [Mass of hyperons 2180 m_e to 3275 m_e]

Other Important Questions:

1. Define one atomic mass unit (amu) , electron volt.

(i)One atomic mass unit is considered as one twelfth of the mass of carbon atom ${}_6C^{12}$.

$$1 \text{ amu} = 1.66 \times 10^{-27} \text{ Kg.}$$

(ii) One electron volt is defined as the energy of an electron when it is accelerated through a potential difference of 1 volt.

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ joule.}$$

2. What is half life and mean life period?

(i) The half life period of a radioactive element is defined as the time taken for one half the radioactive element to undergo disintegration.

$$T_{1/2} = \frac{0.6931}{\lambda}$$

(ii) The mean life period of a radioactive element is defined as the ratio of total life time of all radioactive atoms to the total number of atoms in it. $\tau = 1 / \lambda$

3. What are the precautions to be taken in radiation laboratory? M'15

(i) Radioactive materials are kept in thick walled lead container.

(ii) Lead aprons and lead gloves are used while working in hazardous area.

(iii) All radioactive samples are handled by a remote control process.

(iv) A small micro film badge is always worn by the person and is checked periodically for the safety limit of radiation.

4. Define critical size and mass. [O'08 ,O'15]

Critical size of a system containing a fissile material is defined as the minimum size in which atleast one neutron is available for further fission reaction. The mass of the fissile material at the critical size is called critical mass.

5. What is pair production and annihilation of matter? [M'06 J'06, M'07,M'14,M'18]

The conversion of photon in to electron positron pair on its interaction with the strong electric field surrounding a nucleus is called pair production.

The converse of pair production in which an electron and positron combine to produce a photon is known as annihilation of matter.

6. Write the properties of neutron. [J'06, M'08, J'11, O'11, M'14,M'17]

1) Neutrons are the constituent particles of all nuclei, except hydrogen.
2) Neutrons are neutral particles with no charge and mass slightly greater than that of proton.
3) Half life of neutron is 13 minutes.
4) They can easily penetrate any nucleus.
5) They are not deflected by electric and magnetic field

7. Define unit of radiation (Roentgen). [J'07, O'08]

One roentgen is defined as the quantity of radiation which produces 1.6×10^{12} pairs of ions in 1 gram of air.

8. Differentiate nuclear fission and fusion.

Nuclear fission	Nuclear fusion
1. A heavy nucleus is split into two nuclei of nearly equal masses.	1. Two or more lighter nuclei combine to form a heavier nucleus.
2. Takes place even at room temperature.	2. Occurs only at high temperature of about 10^7 K.
3. It emits harmful radiations like α , β and γ rays.	3. It does not emit any harmful radiations.

9. What are isotopes , isobars and isotones?

Isotopes	Isobars	Isotones
Atoms having same atomic number(Z) but different mass number. Ex: $_1H^1$, $_1H^2$, $_1H^3$	Atoms having same mass number (A) but different atomic number(Z). Ex: $_7N^{16}$, $_8O^{16}$	Atoms having same number of neutrons. Ex: $_6C^{14}$, $_8O^{16}$

10. What are mesons?

i) Mesons are fundamental particles carrying a single unit of charge and possessing mass intermediate between electron and proton. It consists of π- mesons κ –mesons and η–meson.

ii) Yukawa suggested that the nuclear force existing between any two nucleons may be due to the continuous exchange of particles called mesons.

11. Write a note on lepton. [J'07, M'12 ,O'15]

i) Leptons are lighter particles having mass equal to or less than about 207 times the mass of an electron except neutrino and antineutrino

ii) This group contains particles such as electron, positron, neutrino ,antineutrino, positive and negative muons.

iii) The neutrinos and antineutrinos are mass less and charge less particles but carrier of energy and spin.

12. What is the use of control rod in the reactor? Mention any two control rods. [O'07]

The control rods are used to control the chain reaction. They are very good absorbers of neutrons. The commonly used control rods are made up of elements like boron or cadmium.

i) The control rods are inserted into the core and they pass through the space in between the fuel tubes and through the moderator.

ii) By pushing them in or pulling out, the reaction rate can be controlled.

iii) In our country, all the power reactors use boron carbide (B_4C), a ceramic material as control rod.

13. What is α-decay ? Give example. [M'06, M'13]

When a radioactive nucleus disintegrates by emitting an α-particle, the atomic number decreases by two and mass number decreases by four. The α-decay can be expressed as $_ZX^A \rightarrow {}_{Z-2}Y^{A-4} + {}_2He^4$ **Ex:** $_{88}Ra^{226} \rightarrow {}_{86}Rn^{222} + {}_2He^4$

14. What is β-decay? Give example. [,M'16]

When a radioactive nucleus disintegrates by emitting a β− particle, the atomic number increases by one and the mass number remains the same. β −decay can be expressed as

$_{Z}X^{A} \rightarrow {}_{Z+1}Y^{A} + {}_{-1}e^{0}$ **Ex:** $_{90}Th^{234} \rightarrow {}_{91}Pa^{234} + {}_{-1}e^{0}$

15. State radioactive disintegration law. [O'13,J'16]

The rate of disintegration at any instant is directly proportional to the number of atoms of the element present at that instant. This is known as radioactive law of disintegration.

16. Write the methods of production of artificial radio isotopes. [J'14]

i) Artificial radio-isotopes are produced by placing the target element in the nuclear reactor, where plenty of neutrons are available.
ii) Another method of production of artificial radio-isotope is to bombard the target element with particles from particle accelerators like cyclotron.

17. Write any three conclusions obtained from binding energy curve. [M'06]

i) The binding energy per nucleon increases sharply with mass number A up to 20. It increases slowly after A = 20.
ii) The binding energy per nucleon reaches a maximum of 8.8 MeV at A=56, corresponding to the iron nucleus ($_{26}Fe^{56}$). Hence, iron nucleus is the most stable.
iii) The average binding energy per nucleon is about 8.5 MeV for nuclei having mass number ranging between 40 and 120.
iv) For higher mass numbers the curve drops slowly and the BE/A is about 7.6 MeV for uranium.
v) The lesser amount of binding energy for lighter and heavier nuclei explains nuclear fusion and fission respectively.

18. Define activity of a substance.

The activity of a radioactive substance is defined as the rate at which the atoms decay. If *N* is the number of atoms present at a certain time *t*, the activity *R* is given by

$$R = -\frac{dN}{dt}$$

The unit of activity is becquerel . 1 becquerel = 1 disintegration per second

The activity of a radioactive substance is generally expressed in curie.

19. Write the proton-proton cycle that take place sun and stars. [M'11]

$_{1}H^{1} + {}_{1}H^{1} \rightarrow {}_{1}H^{2} + {}_{1}e^{0} + \nu$ (emission of positron and neutrino

$_{1}H^{1} + {}_{1}H^{2} \rightarrow {}_{2}He^{3} + \gamma$ (emission of gamma rays)

$2{}_{2}He^{3} \rightarrow {}_{2}He^{4} + 2{}_{1}H^{1}$

The reaction cycle is written as

$4{}_{1}H^{1} \rightarrow {}_{2}He^{4} + 2{}_{1}e^{0} + 2\nu$ + energy (26.7 MeV)

20. What are particle accelerators? Give its type.

A particle accelerator is a device used to accelerate the charged particles, which are required in the study of artificial transmutation of elements. Hence the accelerator is the basic device in high energy particle physics.

Accelerators can be divided broadly into two types.

i) Electrostatic accelerators ii) Cyclic or synchronous accelerator

21. Differentiate between electrostatic accelerators and synchronous accelerator.

Electrostatic accelerators:

i) Charged particles are accelerated by applying a constant potential difference.
ii) The final energy is determined by the amount of the potential difference.
iii) Ex: The Cockcroft – Walton and Van de Graaff generators
iv) These accelerators can accelerate particles only upto a few million electron-volts.

Cyclic (or) Synchronous accelerator:

i) They accelerate particles in multiple steps imparting a small energy in each successive step.
ii) Ex : Linear accelerator, cyclotron, betatron, synchrocyclotron and synchrotron.
iii) They can accelerate particles to energy of the order of 10^9 eV (GeV),

22. What are the uses of nuclear reactor? [J'11, M'13 ,M'16]

1. Nuclear reactors are mostly aimed at power production, because of the large amount of energy evolved with fission.
2. Nuclear reactors are useful to produce radio-isotopes.
3. Nuclear reactor acts as a source of neutrons, hence used in the scientific research.

Frequently Asked Problems

8.47 The half-life of $_{84}Po^{218}$ is 3 minute. What percentage of the sample has decayed in 15 minutes?

Solution: Amount decayed after 3 minutes = 50 %
Amount decayed after 6 minutes = 75 % (50 % +25 %)
Amount decayed after 9 minutes = 87.5 % (50 % +25 % +12.5 %)
Amount decayed after 12 minutes = 93.75 % (50 % +25 % +12.5 % + 6.25%)
Amount decayed after 15 minutes = 96.875 % (50 % +25 % +12.5 % + 6.25%+3.125)
(OR)

$N = N_0(1/2)^n = 100\,(1/2)^5 = 100/32 = 3.125 \quad \therefore \quad 100 - 3.125 = 96.875\ \%$

8.52 Tritium has a half life of 12.5 years. What fraction of the sample of will be left over after 25 years?

Solution: Fraction of sample decayed in first 12.5 years = ½
Fraction of sample decayed in next 12.5 years = ¼
Total fraction decayed = ¾
Fraction of sample left = 1 – 3/4 = ¼

8.58 The half life of radon is 3.8 days. Calculate its mean life

Solution $\tau = T_{1/2}/0.6931 = 3.8/0.6931 = 5.482$ days

8.59 If 50% of a radioactive sample decays in 5 days, how much of the original sample will be left over after 20 days?

Solution: Number of half life $n = \frac{\text{Total life}}{\text{Half life}} = \frac{20}{5} = 4$

Amount left after n=4,

$N = N_0(1/2)^n = 100\,(1/2)^4 = 100/16 = 6.25\%$

8.54 The disintegration constant λ of a radioactive element is 0.00231 per day. Calculate its half life and mean life.

Solution: $T_{½} = 0.6931/\lambda = 0.6931/0.00231 = 300$ days

$\tau = 1/\lambda = 1/0.00231 = 432.9$ days

M'12. Select the pairs of Isotopes, isobar, isotones: $_{11}Na^{22}$, $_{12}Mg^{24}$, $_{11}Na^{24}$, $_{10}Ne^{23}$

Solution: Isotopes: $_{11}Na^{22}$, $_{11}Na^{24}$

Isobar: $_{12}Mg^{24}$, $_{11}Na^{24}$

Isotones: $_{11}Na^{24}$, $_{10}Ne^{23}$

M'11. What percentage of given radioactive substance will be left after 5 half life periods?

Solution: $N = N_0(1/2)^5 = 100\,(1/2)^5 = 100/32 = 3.125\ \%$

(OR)

1. Amount decayed after1st Half life = 50 %
2. Amount decayed after2nd Half life = 75 % [50+25]
3. Amount decayed after3rd Half life = 87.5 % [50+25+12.5]
4. Amount decayed after4th Half life = 93.75 % [50+25+12.5+ 6.25]
5. Amount decayed after5th Half life = 96.875 %[50+25+12.5+ 6.25+3.125]
6. *Amount left after 5 half life periods = 100 – 96.875 = 3.125 %*

8.48. Calculate the radius of $_{13}Al^{27}$ nucleus.

Solution: $R = r_0 A^{1/3} = 1.3 \times 10^{-15} \times 27^{1/3} = 1.3 \times 10^{-15} \times 3 = 3.9 \times 10^{-15}\ m = 3.9\ F$

8.57. The radioactive isotope $_{84}Po^{214}$ undergoes a successive disintegration of two α–decays and two β-decays. Find the atomic number and mass number of the resulting isotope.

Solution: $_{84}Po^{214} \xrightarrow{\alpha} {}_{82}A^{210} \xrightarrow{\alpha} {}_{80}B^{206} \xrightarrow{\beta} {}_{81}C^{206} \xrightarrow{\beta} {}_{82}D^{206}$

The resulting isotope formed is an element having atomic number 82 and mass number 206.

8.60 The isotope $_{92}U^{238}$ successively undergoes three α-decays and two β-decays. What is the resulting isotope?

Solution: $_{92}U^{238} \xrightarrow[3({}_2He^4)]{3\alpha} {}_{92-6}X^{238-12} = {}_{86}X^{226} \xrightarrow[2({}_{-1}e^0)]{2\beta} {}_{86+2}Y^{226+0} = {}_{88}Ra^{226}$

Note: During a single α decay the atomic number decreases by two and mass number decreases by four. During single β decay the atomic number increases by one and the mass number remains the same.

9.Semiconductor Devices and their Applications

Self Evaluation Questions:

1. What do you understand by intrinsic and extrinsic semiconductor?

'06,J-06, J'08, O'10, M'17]

The purest form of semiconductor is called intrinsic semiconductor. In an intrinsic semiconductor, the number of free electrons and holes are equal.

Example: Ge, Si

An extrinsic semiconductor is one in which an impurity with a valency higher or lower than the valency of the pure semi conductor is added, so as to increase the electrical conductivity of the semiconductor. [M'11, O'13 ,J'14]

2. What is rectification? [M'07, M'09 ,O'14]

The process in which alternating voltage or alternating current is converted into direct voltage or direct current is known as rectification. The device used for this process is called as rectifier.

3. What is zener breakdown? [O'06, J'07, M'08, J'12,J'16]

(i) When both sides of PN junction are heavily doped, consequently the depletion layer is small.

(ii) When a small reverse bias is applied a very strong electric field is produced across this layer.

(iii) This field breaks the covalent bonds, extremely large number of electrons and holes are produced, which gives rise to the reverse saturation current. This is called zener breakdown.

4. Why is a transistor called as current amplification device?

i) The important function of a transistor is the amplification. An amplifier is a circuit capable of magnifying the amplitude of weak signals.

ii) In the working of transistor a variation in the base current in micro amperes produces corresponding variations in the collector current in the milliamperes. So the transistor is called as current amplification device.

5. Why CE configuration is preferred over CB configuration for operating transistor as an amplifier?

A good design of an amplifier circuit must possess high input impedance, low output impedance and high current gain.

The CE configuration has high input impedance, low output impedance and high current gain when compared with CB configuration. So we prefer CE configuration to CB configuration.

6. Define bandwidth of an amplifier. [M'07, O'11, J'12, O'12,O'16,M'17]

Bandwidth is defined as the frequency interval between lower cut off and upper cut off frequencies. $BW = f_U - f_L$

7. What is meant by feedback? Explain its types.

i) Feedback is said to exist in an amplifier circuit, when a fraction of the output signal is returned [or feed back] to the input and combined with the input signal. The two types of feedback are positive feedback and negative feedback.

ii) If the magnitude of the input signal is reduced by the feed back, the feed back is called negative or degenerative. If the magnitude of the input signal is increased by the feed back, such feed back is called positive or regenerative.

8. What are the advantages of negative feedback?

[J'07, O'07, J'08, M'11, M'13,J'15,J'16,M'18]

The following are the advantages of negative feedback.

i) Highly stabilized gain.
ii) Reduction in the noise level.
iii) Increased bandwidth.
iv) Increased input impedance and decreased output impedance.
v) Less distortion.

9. Give the Barkhausen criteria for oscillation. [O'07, O'08, J'09,M'10 ,O'15,J'16,O'16]

The gain of the amplifier with positive feedback is given by

$$A_f = \frac{A}{1 - A\beta}$$

A → Voltage gain without feedback

β → feedback ratio Aβ → loop gain

The Barkhausen condition for oscillation is

(i) The loop gain $A\beta = 1$; $A_f \longrightarrow \infty$ [infinity]

(ii) The net phase shift round the loop is 0^o or integral multiples of 2π .

10. Give the function of OR and NAND gate.

OR gate:- If A and B are the inputs of an OR gate , the output is high when any one or all of the inputs are high. The output Y=A+B.

OR gate

Inputs		Output
A	B	Y = A+B
0	0	0
0	1	1
1	0	1
1	1	1

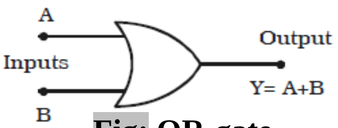


Fig: OR-gate

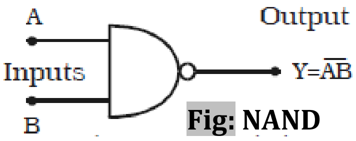


Fig: NAND

NAND gate

Inputs		Output
A	B	Y = $\overline{AB}$
0	0	1
0	1	1
1	0	1
1	1	0

NAND gate:- The output is 1, if at least one of the input is 0.

11. Differentiate between Linear Ics and Digital Ics.

Linear Ics	Digital Ics
1. It process analog signals.	1. It process digital signals.
2. These are used in radio &TV.	2. Used in calculators, computers.
3. Variable input is given.	3. Digital input is given (0 or 1).

12. What are universal gates? Why they are called so? [J'12, O'13 ,M'16]

NOR and NAND gates are called universal gates. Because basic gates such as AND, OR and NOT gates can be constructed by using these gates.

13. What is an integrated circuit? [J'07, J'09 ,O'14]

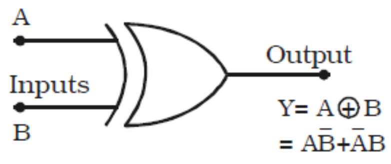
An integrated circuit (IC) consists of a single – crystal chip of silicon, containing active (diodes and transistors) and passive elements (resistors, capacitors) and their interconnections.

14. What is EXOR gate? Give the Boolean expression for the EXOR operation.

EXOR gate has an output 1, only when the inputs are compliment to each other. The Boolean expression for the EXOR operation is $Y = A \oplus B = A\bar{B} + \bar{A}B$

Truth Table

A	B	$Y = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0



(a) Logic symbol

15. State and prove De-Morgan's theorems.[M-08, M'09,J'10,M'12,M'13,M'15,M'18]

First theorem:- The complement of a sum is equal to the product of their complements.

If A and B are inputs, then $\overline{A+B} = \bar{A} \,.\, \bar{B}$

Second theorem:- The complement of a product is equal to the sum of the complements.

If A and B are inputs, then $\overline{A \,.\, B} = \bar{A} + \bar{B}$

Truth table to prove De-Morgan's theorems :

				Second Theorem		First Theorem	
A	B	$\bar{A}$	$\bar{B}$	$\overline{A.B}$	$\bar{A}+\bar{B}$	$\overline{A+B}$	$\bar{A}.\bar{B}$
0	0	1	1	1	1	1	1
0	1	1	0	1	1	0	0
1	0	0	1	1	1	0	0
1	1	0	0	0	0	0	0

16. Identify the analog and digital signals from the following.

Ans: (i) Square wave – digital signal 2) sine wave – analog signal.

17. Explain the term virtual ground of an operational amplifier.*

In an inverting amplifier, the voltage between inverting and non-inverting inputs is essentially equal to zero volt. Therefore, the inverting input terminal is also at 0 volt. For this reason the inverting input is said to be at virtual ground.

18. Give the important parameters [character] of an operational amplifier. [O'07,M'14]

i) Very high input impedance
ii) Very high current gain
iii) Very low output impedance.

Other Important Questions:

1. What is called valence band, conduction band, forbidden energy gap?

i) A band which is occupied by valance electrons or a band having highest energy is defined as ***valence band.***

ii) The electrons loosely attached to the nucleus which are responsible for the conduction of current are called conduction electrons. The band occupied by these electrons is called conduction band.

iii) The separation between valence band and conduction band is known as forbidden energy gap.

2. What is doping? [O-09]

The process of addition of very small amount of impurity into an intrinsic semiconductor is called doping.

3. What are the different methods of doping? [O-09 ,M'15]

i) The impurity atoms are added to the semiconductor in its molten state.

ii) The pure semiconductor is bombarded by ions of impurity atoms.

iii) When the semiconductor crystal containing the impurity atoms is heated, the impurity atoms diffuse into the hot crystal.

4. What is operation point?[quiescent point]

The point of intersection of the load line in the active region of the output characteristics of NPN transistor with suitable value of the base current I_B, such that the output voltage is symmetrical is called operating point for the amplifier.

5. What is transistor biasing?

The proper selection of operating point of a transistor and maintenance of proper emitter voltage during the passage of the signal is known as transistor biasing.

The most commonly used methods of obtaining transistor biasing are;

(i) base bias, (ii) base bias with emitter feedback (iii) base bias with collector feedback and (iv) voltage divider bias.

The principle involved in all these types is to obtain the required base current corresponding to the operating point under zero signal conditions.

6. What is knee voltage (cut in voltage)?

In P-N junction forward bias characteristics, the voltage at which the current starts to increase rapidly is known as knee voltage.

7. Mention the advantages of IC. [M-06, O'06,J'10, J'11, M'14 ,M'16]

i) Extremely small in size
ii) Low power consumption
iii) Reliability
iv) Reduced cost
v) Very small weight
vi) Easy replacement.

8. What are the advantages of Bridge rectifier?

(i) It is suited for high voltage application.
(ii) Smaller transformer can be used.
(iii) Centre tap on the secondary of the transformer is not necessary.

9. What is avalanche break down?

(i) When both sides of PN junction are lightly doped and the depletion layer becomes large, the electric field across the depletion region is not so strong.
(ii) The minority carriers accelerated by the field collide with the semiconductor atoms and produce electron hole pairs by breaking covalent bonds.
(iii) These charge carriers in turns produce more and more charges. This cumulative process is called avalanche break down.

10. What are the uses of CRO? [J-09 ,O'14]

CRO is used to,

1. Measure a.c and d.c voltage
2. Study the wave forms of a.c voltage
3. Find the frequency of a.c voltage
4. Study the beating of heart in cardiology.

11. How is a PN junction formed?

If one side of a single crystal of pure semiconductor is doped with acceptor impurity atoms and the other side is doped with donor impurity atoms, a PN junction is formed.

12. What is a depletion region?

The region which is formed due to the recombination of holes and electrons and does not have any mobile charges close to the junction in a PN junction diode is called a depletion region.

13. What is potential barrier?

In PN junction diode there is a barrier at the junction which opposes the movement of the majority charge carriers. The difference in potential from one side of the barrier to the other side is called potential barrier.

14. What is reverse saturation current or leakage current?

i) In PN junction diode reverse bias characteristics when voltage is increased from zero, reverse current (μ A) increases and reaches the maximum value at the small value of the reverse voltage.
ii) When the voltage is further increased, the current is almost independent of the reverse voltage up to a certain critical value. This reverse current is known as reverse saturation current or leakage current.

15. Define lower cut off frequency.

Lower cut off frequency is defined as the frequency in the low frequency range at which the gain of the amplifier is 1 / √2 times the mid frequency gain.

16. Define upper cut off frequency.

Upper cut off frequency is defined as the frequency in the *high frequency* range at which the gain of the amplifier is 1 / √2 times the mid frequency gain.

17. Define input impedance of the transistor. [J'06, J'11]

The input impedance of the transistor is defined as the ratio of small change in base emitter voltage to the corresponding change in base current at a given V_{CE}.

It is very high in CE mode. **Unit:** Ohm

$$\text{Input impedance } R_I = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$$

18. Define output impedance of the transistor. [O-08, O'09]

The output impedance r_0 is defined as the ratio of variation in the collector emitter voltage to the corresponding variation in the collector current at a constant base current in the active region of the transistor characteristic curves. It is very low in CE mode.

$$\text{Output impedance } r_o = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)_{I_B}$$ **Unit:** Ohm

19. Define current gain.

The current gain is defined as the ratio of a small change in the collector current to the corresponding change in the base current at a constant V_{CE}. **No unit**. It has very high value.

$$\text{Current gain} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}$$

20. Give the three coupling devices used in multistage amplifier.

1. Resistance - Capacitance (RC) coupling
2. Transformer coupling
3. Direct coupling

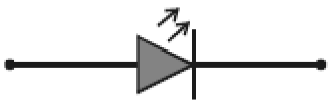


Fig: Light Emitting Diode

21. What is a light emitting diode (LED)? Give any one of its uses.

A light emitting diode (LED) is a forward biased PN junction diode, which emits visible light when energized. [M'07,J'15 ,O'15,O'16]

LEDs are used for instrument displays, calculators and digital watches.

22. What is an oscillator? Differentiate the types of oscillator.

i) An oscillator is an electronic circuit which converts energy from a d.c source into particular varying output. Oscillators are classified according to the range of frequency as audio frequency(AF) and radio frequency oscillators(RF).

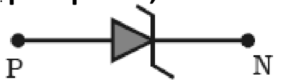
ii) Oscillators are classified according to the output voltage in two types, viz. Sinusoidal Oscillator and Non - Sinusoidal Oscillator.

Sinusoidal Oscillator	Non - Sinusoidal Oscillator
The output voltage is a sine wave function of time. Ex: LC Oscillators, RC Oscillators and crystal Oscillators.	The output voltage is non sinusoidal form such as square, rectangular waves. Ex: Multivibrator.

23. What are the essential components of an LC oscillator? [O'10, M'14]

The essential components are

1. Tank circuit: It consists of inductance coil (L)connected in parallel with capacitor (C).
2. Amplifier: The transistor amplifier receives d.c. power from the battery and changes it into a.c. power for supplying to the tank circuit.
3. Feedback circuit: It provides positive feedback (i.e.) this circuit transfers a part of output energy to LC circuit in proper phase, to maintain the oscillations.



24. What is Zener diode? O'10, O'11

Fig: symbol for Zener diode

Zener diode is a reverse biased heavily doped semiconductor (silicon or germanium) PN junction diode, which is operated exclusively in the breakdown region.

Note: A Zener diode working in the breakdown region can act as voltage regulator.

25. Distinguish between P-type and N-type semiconductor.

N-type	P-type
1. When a small amount of pentavalent impurity such as arsenic is added to a pure germanium semiconductor crystal, the resulting crystal is called N-type semiconductor.	1. When a small amount of trivalent impurity (such as indium,boron or gallium) is added to a pure semiconductor crystal, the resulting semiconductor crystal is called P-type semiconductor.
2. Free electrons are the majority charge carriers and holes are the minority charge carriers.	2. Holes are the majority charge carriers and free electrons are the minority charge carriers.
3. These impurity is called donors.	3. These impurity is called acceptor.

26. State the principle used in the process of rectification.

The junction diode has the property of offering low resistance and allowing current to flow through it, in the forward biased condition. This property is used in the process of rectification.

27. In a transistor emitter and collector cannot be interchanged. Why?

In a transistor, the emitter region is heavily doped, since emitter has to supply majority carriers. The base is lightly doped. The collector region is lightly doped. Since it has to accept majority charge carriers, it is physically larger in size. Hence, emitter and collector cannot be interchanged.

28. What are the biasing conditions to be followed in normal operation of a transistor? J'12

(i) The emitter-base junction is *forward biased*, so that majority charge carriers are repelled from the emitter and the junction offers very low resistance to the current.

(ii) The collector-base junction is *reverse biased*, so that it attracts majority charge carriers and this junction offers a high resistance to the current.

29. Define current amplification factor.

The current amplification factor or current gain of a transistor is the ratio of output current to the input current.

Common base mode: $\alpha = I_C/I_E$ Common emitter mode: $\beta = I_C/I_B$

Frequently Asked Problems

9.2 A transistor is connected in CE configuration. The voltage drop across the load resistance (R_C) 3 k Ω is 6 V. Find the base current. The current gain α of the transistor is 0.97

Solution:

Voltage across the collector load resistance (R_C) = 6 V , $\alpha = 0.97$; $R_C = 3\ k\Omega$

The voltage across the collector resistance is, $= I_C R_C = 6V$

$$\text{Hence, } I_C = \frac{6}{R_C} = \frac{6}{3\times10^3} = 2mA$$

$$\text{Current gain } \beta = \frac{\alpha}{1-\alpha} = \frac{0.97}{1-0.97} = 32.33$$

$$\therefore I_B = \frac{I_C}{\beta} = \frac{2\times10^{-3}}{32.33} = 61.86\ \mu A$$

9.3 When the negative feedback is applied to an amplifier of gain 50, the gain after feedback falls to 25. Calculate the feedback ratio.

Data : $A = 50$; $A_f = 25$

Solution: Voltage gain after feedback, $A_f = \frac{A}{1+A\beta}$

$$25 = \frac{50}{1+50\beta}$$ Hence, the feedback ratio β = 0.02

9.4 Prove the Boolean identity ; (A+B) (A+C) = A+BC

Proof : Applying the law of distribution on LHS of the equation, we get

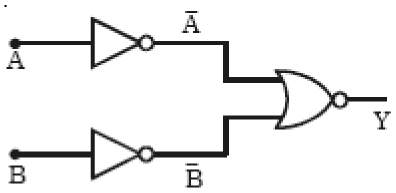
(A+B) (A+C) = AA + AC + BA + BC

= A+ AC + AB + BC

= A(1+C+B) + BC

= A + BC [∵ 1 + C + B = 1]

9.5 The outputs of two NOT gates are NORed, as shown in figure. What is this combination equivalent to?



Solution:

From the logic circuit it follows that the output

$$y = \overline{\bar{A} + \bar{B}}$$

Applying DeMorgan's first theorem,

$$y = \bar{\bar{A}} \bullet \bar{\bar{B}} = AB$$

Hence given logic circuit is AND operation.

9.50 The base current of the transistor is 50 μA and collector current is 25 mA. Determine the values of β and α.

Solution: $I_B = 50\ \mu A = 50 \times 10^{-6}$ A ; $I_C = 25$ mA $= 25 \times 10^{-3}$ A

(i) $\beta = I_C / I_B = \frac{25\times10^{-3}}{50\times10^{-6}} = 500$ (ii) $\alpha = \frac{\beta}{1+\beta} = \frac{500}{1+500} = \frac{500}{501} = 0.998$

9.52 The gain of the amplifier is 100. If 5% of the output voltage is fed back into the input through a negative feedback network, Find out the voltage gain after feedback.

Solution: A= 100 ,β = 5%

Overall gain after feedback $A_f = \dfrac{A}{1+A\beta}$

$$= \frac{100}{1+[100 \times \frac{5}{100}]} = \frac{100}{6} = 16.66$$

9.58 Prove the following logic expression using the laws and theorems of Boolean algebra.

$$ABC + A\overline{B}C + AB\overline{C} = A(B+C)$$

Proof:

$Y = ABC + A\overline{B}C + AB\overline{C}$

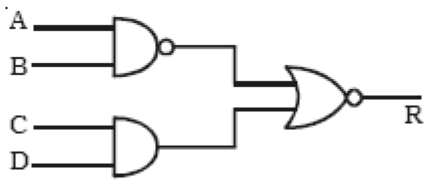
$= AC[B+\overline{B}] + AB\overline{C}$

$= AC + AB\overline{C}$

$= A[C + B\overline{C}]$ $\quad [C + B\overline{C} = C + B]$

$= A[C+B] = \mathbf{A[B+C]}$

9.57 Give the Boolean equation for the given logic diagram.



Solution:

Output of first NAND gate is $\overline{A.B}$

Output of first AND gate is C.D

Output of first NOR gate is $\overline{\overline{A.B} + C.D} = \overline{\overline{A.B}}\,.\,\overline{C.D}$

$= AB\,.[\overline{C} + \overline{D}]$

9.59 Simplify the following logic expression using the laws and theorems of Boolean albegra.

$\mathbf{A\overline{B} + AB + BC + CA}$

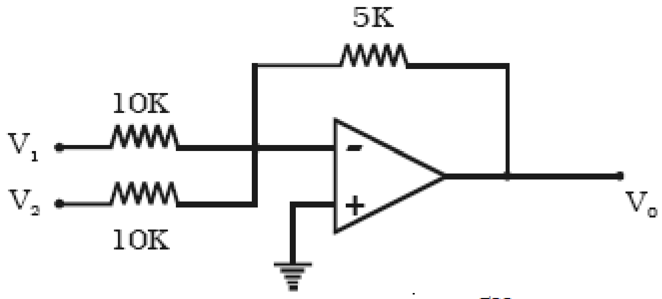
Solution: $Y = A\overline{B} + AB + BC + CA$

$= A[B+\overline{B}] + BC + CA$

$= A+BC+CA$

$y = A+CA+BC = A[1+C]+BC = \mathbf{A+BC}$

9.60 Find the output of the given circuit.



Solution:

Output of summing amplifier

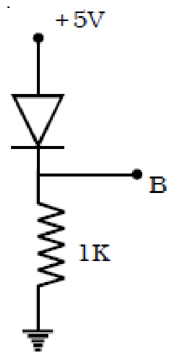
$$v_{out} = -\left(\frac{R_f}{R_1}v_1 + \frac{R_f}{R_2}v_2\right)$$

$V_{out} = -\dfrac{R_f}{R}(V_1+V_2)$ $\quad \{\because R_1=R_2\}$

$= -5/10\,[V_1+V_2]$

$V_{out} = -\frac{1}{2}(V_1+V_2)$

9.51 Find *the voltage at the point B in the figure (Silicon diode is used).*



Solution:

Potential at B = Total potential difference - barrier potential

= 5 – 0.69

= +**4.31 V**

M'06: The gain of the amplifier without feedback is 100 and the gain with positive feedback is 200. Calculate the feedback fraction.

Data: $A=100$, $A_f=200$, $\beta=?$

Solution:

Positive feedback $A_f = \dfrac{A}{1-A\beta}$

$$200 = \frac{100}{1-100\beta}$$

$1-100\beta = 0.5 \quad \therefore 100\beta = 0.5 \quad \therefore \quad$ **$\beta=0.005$**

O'06: The voltage gain of the amplifier without feedback is 100. If negative feedback is applied with feedback fraction β=0.1, calculate the voltage gain after feedback.

Data: $A=100$, $\beta=0.1$, $A_f=?$

Solution:

Negative feedback $A_f = \dfrac{A}{1+A\beta}$

$$= \frac{100}{1+[0.1 \times 100]}$$

$$= \frac{100}{11} \qquad \therefore \mathbf{A_f = 9.09}$$

O'13 Prove the following logic expression. $(\bar{A} + B)(A + B) = B$

Solution:

$$(\bar{A} + B)(A + B) = \bar{A}A + \bar{A}B + BA + BB$$

$$= \bar{A}B + AB + B \qquad (\because \bar{A}A = 0 \text{ and } BB = B)$$

$$= B(\bar{A} + A + 1) = B \qquad (\because \bar{A} + A + 1 = 1)$$

J'14: **Distinguish between analog signal and digital signal**.

Analog Signal	Digital Signal
1. An analog signal is a continuously varying voltage or current.	1. A digital system is a more general case of a binary system.
2. It is used in analog communication.	2. It is used in digital communication.
3. It takes on any value within the overall range allowed.	3. In binary system, only two signal values can exist [0 and 1].
4. The voice signal is an analog signal.	4. Light beams in optical fibers and wave guides operating in the microwave frequency extensively use digital communication.
5. The greatest technical problem with an analog communication system is noise.	5. The transmission quality is high and almost independent of the distance between the terminals.

Diagrams

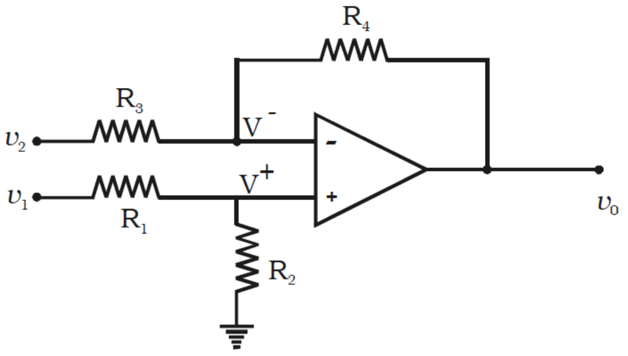


Fig 9.61 Difference amplifier

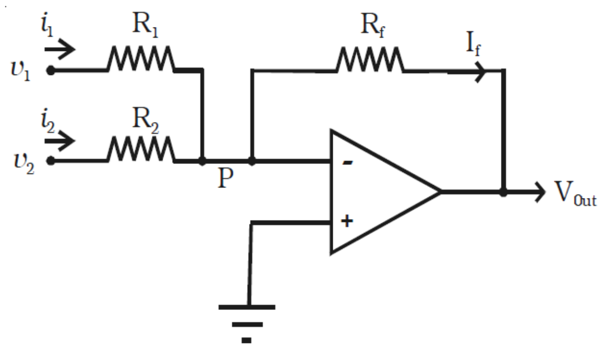


Fig 9.60 Summing amplifier

,M'17

Output:

$$V_o = \left(\frac{R_3+R_4}{R_3}\right)\left(\frac{R_2}{R_1+R_2}\right)v_1 - \left(\frac{R_4}{R_3}\right)v_2$$

If $R_1 = R_2 = R_3 = R_4 = R$

$V_o = V_1 - V_2$

Output:

$$v_{out} = -\left(\frac{R_f}{R_1}v_1 + \frac{R_f}{R_2}v_2\right)$$

If $R_1 = R_2 = R_f = R$

$V_0 = -(V_1 + V_2)$

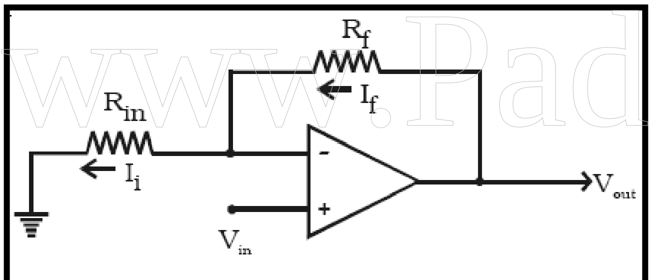


Fig 9.59 Non-inverting amplifier

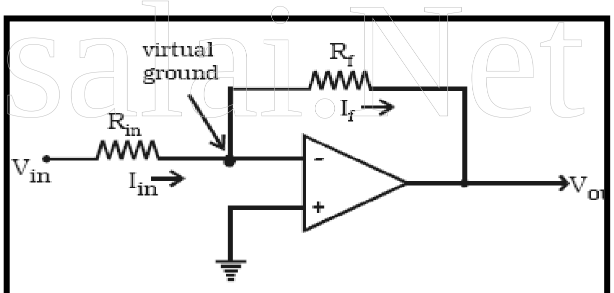


Fig 9.58 Inverting amplifier

$$V_{out} = \left(1+\frac{R_f}{R_{in}}\right)V_{in}$$

$$V_{out} = \frac{-R_f}{R_{in}} \times V_{in}$$

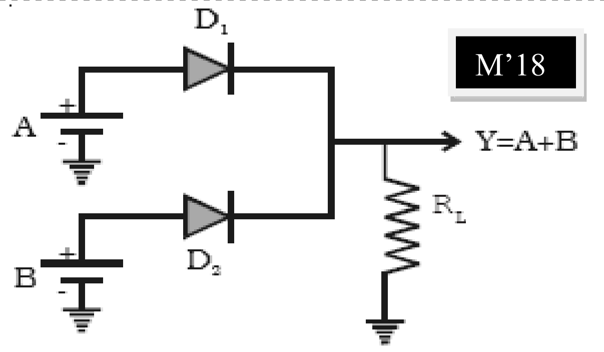


Fig 9.47 OR gate using diodes

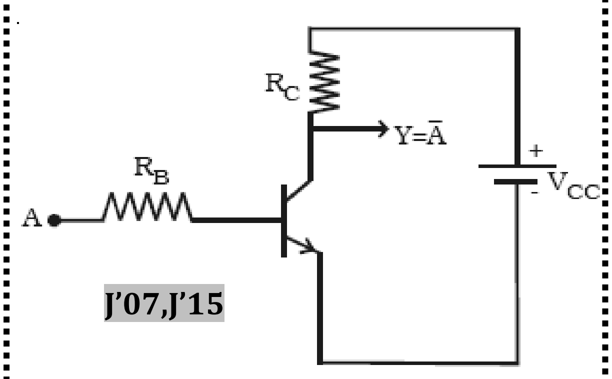


Fig 9.51 NOT gate using transistor

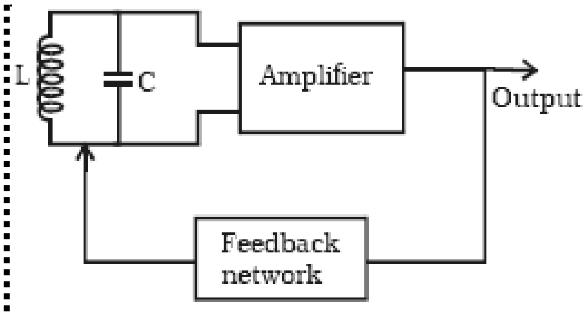


Fig 9.42 Oscillator block diagram

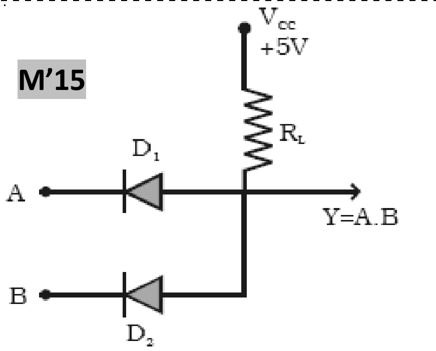
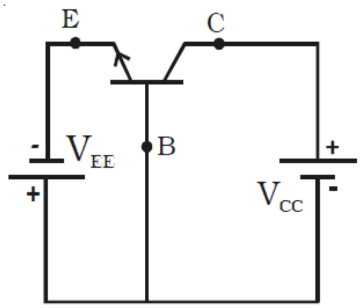
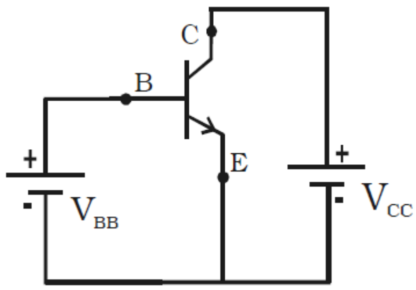


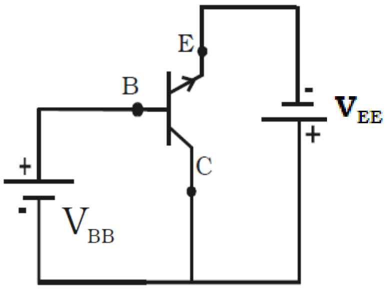
Fig 9.49 AND gate using diodes



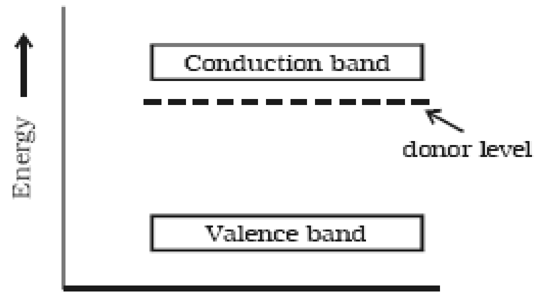
(a) CB mode



(b) CE mode



(c) CC mode



Energy Band Diagram of N type semiconductor

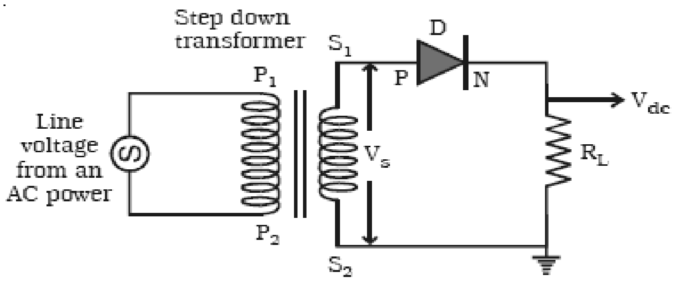
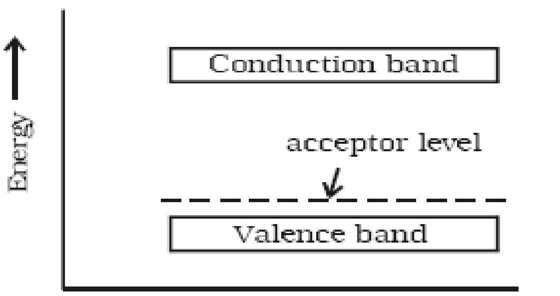


Fig 9.14 Half wave rectifier



Energy Band Diagram of P- type Semiconductor

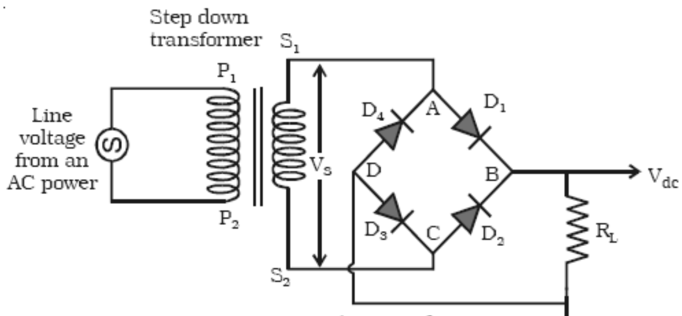


Fig 9.16 Bridge rectifier

10.Communication System

Self Evaluation Questions:

1. What are the different types of radio wave propagation? [M'17]

The different types of wave propagation are

i) Ground (surface) wave propagation

ii) Space wave propagation

iii) Sky wave or ionospheric propagation.

2. What is skip distance? [J-09, M'11,O'10, J'12, O'13, M'14 ,O'15 ,M'16]

In the sky wave propagation, for a *fixed frequency*, the shortest distance between the point of transmission and the point of reception along the surface is known as the skip distance.

3. What is the necessity of modulation? [O-07]

The energy of a wave increases with frequency. So, the audio frequency can't be transmitted over long distances. The high frequency signal can be sent through thousands of kilometers with comparatively small power.

The audio signal must be superimposed on high frequency (radio frequency) wave called carrier. The resultant wave is known as modulated waves and this process is called *modulation*. So to transmit long distance modulation is necessary.

4. Define amplitude modulation. M'12

When the amplitude of high frequency carrier wave is changed in accordance with the intensity of the signal, the process is called *amplitude modulation*.

5. Define modulation factor. [M-06, J'08, O'09,M'10, J'11 ,M'15]

Modulation factor is defined as the ratio of the change of amplitude in carrier wave after modulation to the amplitude of the unmodulated carrier wave.

$$\text{Modulation factor} = \frac{\text{Amplitude change of carrier wave after modulation}}{\text{Amplitude of carrier wave before modulation}}$$

$$\text{Modulation factor } m = \frac{\text{Signal amplitude}}{\text{Carrier amplitude}} = \frac{E_S}{E_C}$$

6. Define bandwidth (channel width).

The bandwidth (channel width) is given by the difference between extreme frequencies i.e. maximum frequency of USB and minimum frequency of LSB.

Channel width = 2 x maximum frequency of the modulating signal

$= 2 \times (f_s)_{max}$

7. What are the limitations of amplitude modulation?

- Noisy reception:- As the radio receiver can't distinguish between amplitude variation that represent noise and those that contain the desired signal, the reception is noisy.
- Low efficiency: The sideband power for an AM wave is low. Hence the efficiency of AM is low.
- Small operating range: Due to low efficiency, the messages can't be transmitted over long distances.

8. Define frequency modulation.

1. When the frequency of carrier wave is changed in accordance with the intensity of the signal, the process is called frequency modulation.
2. In frequency modulation, the amplitude and phase of the carrier wave remains constant. Only, the frequency of the carrier wave is changed in accordance with the signal.
3. The frequency variation of the carrier wave depends upon the instantaneous amplitude of the signal.

9. What is phase modulation?

In the phase modulation, the phase of the carrier wave is varied in accordance with the amplitude of the modulating signal and the rate of variation is proportional to the signal frequency.

10. Define directivity.

Directivity is the ability of the antenna to concentrate the electromagnetic waves in the most desired directions (during transmission) or to have maximum reception from most preferred directions (during reception).

11. What is meant by scanning?

Scanning is the process by which an electron beam spot is made to move across a rectangular area, so as to cover it completely. This rectangular area may be the target surface in a television camera or the screen of a picture tube in a television receiver.

12. What is interlaced scanning? [O'12]

1. In the interlaced scanning, the total number lines are divided in to two groups called fields. During the presentation of the first field, only the odd numbered lines are scanned, while during the second field all the even numbered lines are scanned.
2. Half way along the bottom of the first field, the vertical retrace returns the scanning beam to the top of the image and completes the unfinished lines. This method is known as interlaced scanning.

13. What are the applications of radar? [J-06]

1. **Air and sea navigation is made entirely safe, with radar installations.** High flying planes and ship at sea, can get detailed reports of mountains, ice bergs, rivers, lakes, shore lines etc., which they can avoid.
2. Radar systems are used for the safe landing of air crafts even during low visibility.
3. Rain drops may reflect suitable radar signals and thus enable meteorologists to measure the distance of the clouds, with great accuracy for forecasting.
4. The pulses can be used for the discovering the position of buried metals, oils and ores.

14. What are the advantages of fiber optic communication system? [O'08,J'15]

i) Transmission loss is low.

ii) Fiber is lighter and less bulky than equivalent copper cable.

iii) More information can be carried by each fiber.

iv) There is no interference in the transmission of light from electrical disturbances or electrical noise.

15. Explain the principle of modem.

1. The name modem is the abbreviation of the term Modulator and Demodulator.
2. As the name implies, both functions are included in a modem. A modem is used to covert digital signals into analog signals capable of being transmitted over telephone lines.
3. At the receiving end of the system, modem is used to demodulate the analog signals and reconstruct the equivalent digital output.

16. What are the different types of wires and cable used for telecommunication system?

The main types of wire and cable used in data communications are

i) Twisted pair
ii) Multi conductor flat cable
iii) Coaxial cable.

Other Important Questions:

1. What is Duplexer? Explain its function.

1) The transmitting system consists of a transmitter and a pulser. The receiving system consists of a receiver and an indicator.
2) In most of the cases, a single antenna is used for both transmission and reception and this is achieved with the use of TR switch (Transmitter Receiver Switch). This switching arrangement is called as 'duplexer'.
3) Duplexer connects the antenna to the transmitter during transmission and to the receiver during reception. It isolates the sensitive receiver from the damaging effects of high power transmitter.

2. What is a buffer?

(i) A buffer is an electronic circuit used for the purpose of providing isolation between two other stages. This also prevents the impedance changes between the two stages.
(ii) A buffer is a low frequency amplifier which isolates the crystal oscillator from the phase modulator.

3. Define modulation.

Modulation is defined as the process in which the audio signal is superimposed on a high frequency carrier wave by changing the amplitude or frequency or phase of a carrier wave in accordance with the intensity of the audio signal.

Demodulation: The process of extracting audio signal from the modulated wave.

4. Define skip zone. [J'07,M'08,J'14]

The region between the point where there is no reception of the ground waves and the point where the sky wave is received first is known as skip zone. In the *skip zone*, there is no reception at all.

5. What are the components of space wave?

Space wave usually consists of two components.

i) A component which travels straight from the transmitter to the receiver.
ii) A component which reaches the receiver after reflection from the surface of the earth.

6. What is FAX? Mention its uses. [O'06 ,O'14]

Fax or Facsimile is an electronic system for transmitting graphical information by wire or radio. It is used to send the printed material by scanning and converting into electronic signals. These signals modulate a carrier to be transmitted over the telephone wires.

7. What are the advantages of digital communication? [M'07J'10, M'13,M'18]

1) The transmission quality is high and almost independent of the distance between the terminals.
2) The capacity of the transmission system can be increased.
3) The newer type of transmission media such as light beams in optical fibers and wave guides operating in the microwave frequency extensively use digital communication.

8. What are the disadvantages of digital communication?

1) A digital system requires larger bandwidth.
2) It is very difficult to gradually change over from analog to digital transmission.

9. What are the advantages and disadvantages of Frequency modulation? [M'09]

1. It gives noiseless reception.
2. The operating range is quite large.
3. The efficiency of transmission is very high.

Disadvantage:

1. A much wider channel is required by FM.
2. FM transmitting and receiving equipments tend to be more complex.

10. What are the advantages and disadvantages of Amplitude modulation?

1. Easy transmission and reception.
2. Lesser bandwidth requirements.
3. Low cost

Disadvantage:

1. Noisy reception
2. *Low efficiency*
3. *Small operating range*

11. What is an antenna?

An antenna is a long conductor (wire and rod) that acts as a conversion device. It converts an electrical signal into electromagnetic energy when used as a transmitting antenna. In receiving antenna, the electromagnetic energy is converted into an electrical signal.

12. What are the demerits of satellite communication?

(i) Between talks there is a *time gap* which becomes quite annoying. This time delay also reduces the efficiency of satellite in data transmission.
(ii) An *imperfect impedance* match may cause echo, received back after a delay. Echo suppressor has to be used.
(iii) *Repair* of satellite is almost impossible, once it has been launched.

12. What are the merits of satellite communication? **[O'16,J'16]**

1. Mobile communication can be easily established by satellite communication.
2. Satellite communication is economical compared with terrestrial communication particularly where long distances areinvolved.
3. Compared to the optical fiber communication, satellite communication has the advantages that, quality of transmitted signal and location of sending and receiving stations are independent of distance.
4. For thin traffic remote areas like north east regions in India, Ladakh etc., satellite communication is most economical.
5. For search, rescue and navigation, satellite communication is far superior and economical compared to other systems.

Problems

10.2 An FM signal has a resting frequency of 105 MHz and highest frequency of 105.03 MHz when modulated by a signal. Determine (i) frequency deviation and (ii)carrierswing.

Solution :

Frequency deviation (Δf) = fm – f

Δf = 105.03 – 105 = **0.03 MHz**

Carrier swing = **2 × Δf** = 2 × 0.03 = 0.06 MHz **= 60 kHz**

10.33 In a broadcasting studio, a 1000 kHz carrier is modulated by an audio signal of frequency range, 100–5000 Hz. Find (i) maximum and minimum frequencies of USB (ii) maximum and minimum frequencies of LSB and (iii) width of the channel.

Data: Carrier frequency f_c = 1000 KHz

Signal Frequency f_s = 100 – 5000 Hz = 0.1 – 5 KHz

Solution:

Upper and Lower side band frequencies are [$f_c + f_s$] and [$f_c - f_s$]

For 0.1 KHz:

Side Band frequencies = [$f_c + f_s$] and [$f_c - f_s$]

= [1000+0.1] and [1000 – 0.1]

= 1000.1 KHz and 999.9 KHz

For 5 KHz:

Side Band frequencies = [$f_c + f_s$] and [$f_c - f_s$]

= [1000 + 5] and [1000 – 5]

= 1005 KHz and 995 KHz

Band width = Difference between extreme frequencies

= 995 KHz to 1005 KHz = **10 KHz**

Result:

1) ***maximum and minimum frequencies of USB= 1005*** **KHz and 1000.1 KHz**

2) ***maximum and minimum frequencies of LSB =*** **999.9 kHz and 995 kHz**

3) ***width of the channel = 10*** **KHz**

Frequently Asked Problems

LESSON	3 MARKS		5 MARKS	
	SOLVED	BOOK.EX	SOLVED	BOOK.EX
1	1.7, 1.8, 1.11, 1.14,1.15	1.45,1.46,1.50, 1.51,1.53,1.55	1.2, 1.3, 1.4, 1.5, 1.6, 1.9, 1.10 , 1.13, 1.15, 1.16	1.44,1.47
2	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.9, 2.10 ,2.13	2.31,2.32,2.34, 2.35,2.38,2.39, 2.41,2.43	2.7, 2.11, 2.12	2.30,2.33,2.34, 2.36
3	3.2,3.3,3.4,3.7,3.8 3.9,3.10,3.11,3.12	3.28,3.29,3.32, 3.33,	3.5,3.13,3.16, 3.18,	3.30,3.36,3.39, 3.40
4	4.1,4.2,4.4,4.5,4.6, 4.7	4.55,	4.3,4.8	4.61,4.63,4.64
5	5.1, 5.2, 5.4, 5.5, 5.6, 5.7, 5.8	5.44,5.45,5.49 5.50	5.3	5.41,5.46,5.47, 5.48,
6	6.1, 6.4, 6.7,6.9	6.47,6.49,6.50, 6.51,6.52	6.3, 6.5 ,6.7, 6.8	6.46,6.48
7	7.4, 7.5, 7.7	7.41	7.8, 7.9	7.34, 7.39, 7.42
8	8.2	8.47,8.48,8.52 8.54,8.55,8.57,8. 58,8.59, 8.60	8.1, 8.4, 8.5, 8.7, 8.10	8.50,8.51,8.56
9	9.2,9.3,9.4,9.5,9.8, 9.9	9.50,9.51,9.52,9. 56,9.57,9.60	9.8, 9.9	9.58 9.53
10	10.2	--	10.1	10.33

FREQUENTLY ASKED QUESTIONS

(I) Properties- Questions:

1. *Write the properties of lines of forces.*
2. *Write the basic properties of electric charge.*
3. *What are the special features of magnetic Lorentz force?*
4. *What are the characteristics of electromagnetic waves?*
5. *Write the properties of cathode rays.*
6. *Write the properties of canal rays.*
7. *Write the properties of X –rays? .*
8. *Write the properties of α , β and γ-rays.*
9. *Write the properties of neutron.*
10. *Write the properties of nuclear forces.*

(II) Applications/Uses:

1. *Applications of Gauss's law.*
2. *Give the applications of superconductors.*
3. *Explain the application of Joule heating effect.*
4. *Explain the applications of eddy current.*
5. *Explain the uses of electromagnetic spectrum.*
6. *Give the uses of Polaroid.*
7. *Give the application of X-ray.*
8. *Give the application of laser.*
9. *What are the applications of photo-cells?*
10. *List the uses and limitations of electron microscope.*
11. *Explain the application of radio isotope in various fields.*
12. *What are the advantages and disadvantages of Frequency modulation?*
13. *What are the advantages and disadvantages of Amplitude modulation?*
14. *Write the applications of RADAR.*
15. *What are the advantages and disadvantages of digital communication?*
16. *What are the advantages of fiber optic communication system?*
17. *What are the merits and demerits of satellite communications?*

(III) <u>Other Important questions:</u>

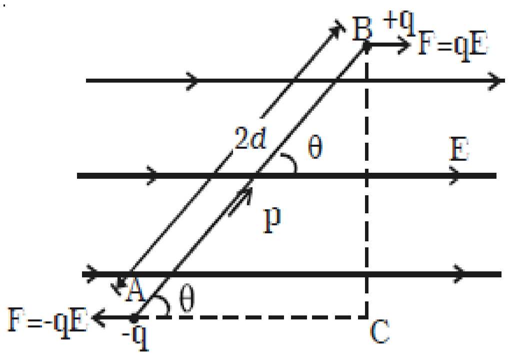
1. *Obtain the condition for bridge balance in Wheatstone bridge.*
2. *Explain the reactions at the electrodes of Daniel cell.*
3. *Explain how you will convert a galvanometer into an ammeter/voltmeter.*
4. *Explain varies power losses in a transformer. How are they minimized?*
5. *Explain how an emf can be induced by changing the area enclosed by the coil.*
6. *State and explain Brewster's law.*
7. *Write a note on Nicol prism.*
8. *Explain the spectral series of hydrogen atom.*
9. *State and obtain Bragg's law.*
10. *Explain the origin of characteristic x-rays.*
11. *State the laws of photoelectric emission.*
12. Obtain Einstein's photo electric equation.
13. *Derive an expression for de Broglie wavelength of matter waves& electron.*
14. *Explain length contraction.*
15. *Explain time dilation.*
16. *Explain the latitude effect of cosmic rays.*
17. *Deduce the relation between α and β of a transistor.*
18. *State and prove De Morgan's theorems.*
19. *Explain the working of a half wave diode rectifier.*
20. *Explain the function of an AM radio transmitter with the help of the block diagram.*

<u>Short Answers - Question Types</u>

1. Laws / principle/ theorem / rule.
2. Uses / applications / limitations /draw backs.
3. Define.
4. Reasoning. (Eg: Why does sky appear blue in colour?)
5. Differentiate.
6. Define unit.(Eg Define one coulomb)
7. Diagram.(Eg: unit 9,10)
8. Properties / characteristics/results.
9. Advantages / Disadvantages/ merits / demerits.
10. **Problem:** Refer unit: 2, 4, 5, 6, 8, 9

1. ELECTROSTATICS

1. Derive an expression for the torque acting on the electric dipole when placed in a uniform field.



1. *The dipole AB is at an angle θ with the electric field.*
2. *The force acting on q is q E., The force on –q is -qE*
3. *The net force acting on the dipole is zero.*
4. *A torque acts on the dipole which tends the dipole in the direction of the field.*
5. *The two equal and unlike parallel forces are not passing through the same point, resulting in torque on the dipole*

   $\tau = F \times 2d \sin\theta$

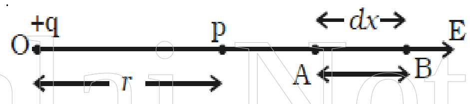
$\tau = qE \times 2d \sin\theta = pE \sin\theta$ ($\because q \times 2d = P$)

In vector notation, $\vec{\tau} = \vec{p} \times \vec{E}$

2. Obtain an expression for electric potential due to a point charge.

Let +q be an isolated point charge situated in air at O. P is a point at a distance r from +q.

The potential difference between A and B is,



dV = –E dx

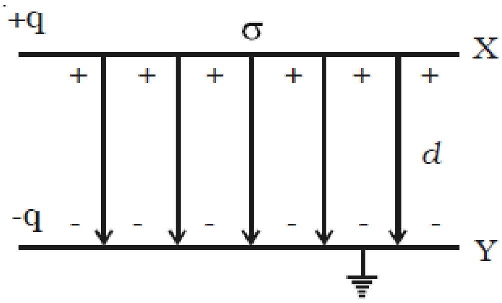
$$E = \frac{1}{4\pi\varepsilon_o} \cdot \frac{q}{x^2}$$

$$\therefore \quad dV = -\frac{1}{4\pi\varepsilon_o}\frac{q}{x^2} \cdot dx$$

The electric potential at the point P due to the charge +q is the total work done in moving a unit positive charge from infinity to that point.

$$V = -\int_{\infty}^{r} \frac{q}{4\pi\varepsilon_o x^2} \cdot dx = \frac{q}{4\pi\varepsilon_o r}$$

3. Deduce an expression for the capacitance of the parallel plate capacitor.



- It consists of two parallel metal plates X and Y each of area A, separated by a distance d.
- σ is surface charge density ,the medium between the plates is air.
- A charge +q is given to the plate X. It induces a charge –q on the upper surface of earthed plate Y.

The electric field at a point between the two plates is,

$$E = \frac{\sigma}{\varepsilon_o}$$

Potential difference between the plates X and Y is

$$V = \int_d^0 -E\, dr = \int_d^0 -\frac{\sigma}{\varepsilon_o}\, dr = \frac{\sigma d}{\varepsilon_o}$$

The capacitance (C) of the parallel plate capacitor

$$C = \frac{q}{V} = \frac{\sigma A}{\sigma d/\varepsilon_o} = \frac{\varepsilon_o A}{d} \qquad [\text{since, } \sigma = \frac{q}{A}]$$

$$\therefore \quad C = \frac{\varepsilon_o A}{d}$$

---

4. *Prove that the energy stored in a parallel plate capacitor is $q^2/2c$ (or) ½ $CV.^2$*

The capacitor is a charge storage device. This work done to store the charges is stored as electrostatic potential energy in the capacitor.

If dq is the additional charge given to the plate, work done is, dw = Vdq

$$\left[dW = \frac{q}{C}\ dq \qquad \left[\because V = \frac{q}{C}\right]\right]$$

Total work done $W = \int_0^q \frac{q}{C}\ dq,\ W = \frac{q^2}{2C}$

This work done is stored as electric potential energy $U = \frac{q^2}{2C}$

$$\boxed{U = \frac{1}{2}CV^2 \qquad [\because q = CV]}$$

---

5. What are the properties of electric lines of force?

1. *Lines of force start from positive charge and terminate at negative charge.*
2. *Lines of force never intersect.*
3. *The tangent to line of force at any point gives the direction of the electric field (E) at that point.*
4. The number of lines per unit area, through a plane at right angles to the lines, is proportional to the magnitude of E. This means that, where the lines of force are close together, E is large and where they are far apart, E is small.
5. *Each unit positive charge gives rise to 1/ ε_0 lines of force in free space. Hence number of lines of force originating from a point charge q is N =q / ε_0 in free space.*

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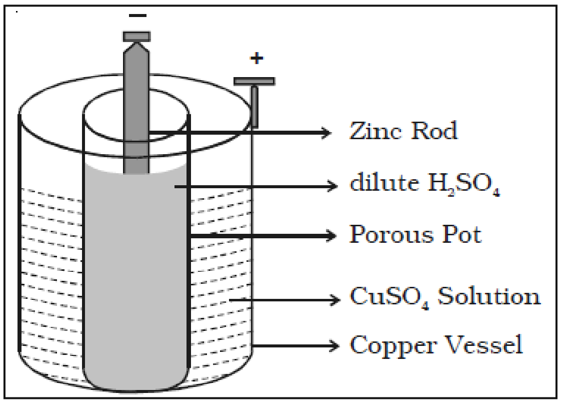
2. CURRENT ELECTRICITY

1. Explain the reactions at the electrodes of Daniel cell.

Construction:

Daniel cell is a primary cell which cannot supply steady current for a long time.

- **Anode:** Copper **Cathode:** Zinc Rod
- **Electrolyte:** $CuSO_4$, **Dil** H_2SO_4
- **Vessel:** Copper



Action:

- ❖ The zinc rod reacting with dilute sulphuric acid produces Zn^{++} ions and 2 electrons.
- ❖ Zn++ ions pass through the pores of the porous pot and reacts with copper sulphate solution producing Cu^{++} ions.
- ❖ When Daniel cell is connected in a circuit, two electrons on the zinc rod reach the copper vessel and neutralizing the copper ions.
- ❖ Current passes from *copper to zinc.*
- ❖ Emf produced by Daniel cell: **1.08 V**

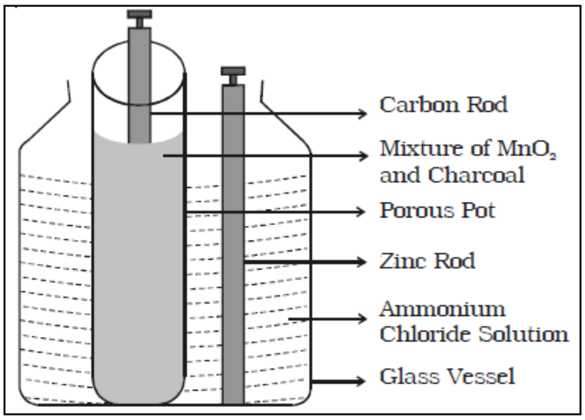
2. Explain the reactions at the electrodes of Leclanche cell.

Construction:

Anode: Carbon rod **Cathode:** Zinc rod

Electrolyte: Ammonium chloride solution

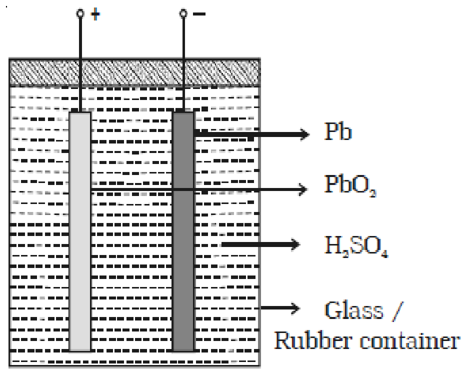
Vessel: Glass



Action:

- ❖ At the zinc rod, due to oxidation reaction Zn atom is converted into Zn++ ions and 2 electrons.
- ❖ Zn^{++} ions react with ammonium chloride produces zinc chloride and ammonia gas.
- ❖ $Zn^{++} + 2\ NH_4Cl \rightarrow 2NH_3 + ZnCl_2 + 2\ H^+ + 2e^-$
- ❖ The positive charge of hydrogen is transferred to carbon rod.
- ❖ The two electrons from the zinc rod move towards carbon and neutralizes the positive charge.
- ❖ Current flows from carbon to zinc.
- ❖ Emf of the cell is about **1.5 V**
- ❖ Current produced by the cell **0.25 A.**

3. Explain the action of the lead acid accumulator.



Construction:

Anode: Lead Oxide **Cathode:** Spongy lead

Electrolyte: Dilute Sulphuric Acid

Vessel: Rubber or Glass

Action:

Oxidation:

❖ The spongy lead reacting with dilute sulphuric acid produces lead sulphate and two electrons.

Reduction:

❖ At the positive electrode, lead oxide on reaction with sulphuric acid produces lead sulphate and the two electrons are neutralized in this process.

❖ The conventional current to flow from positive electrode to negative electrode

❖ Emf of freshly charged cell: 2.2 V

❖ Emf falls to 2 V during discharge.

❖ The cell has low internal resistance and hence can deliver high current.

---

4. Explain the reactions at the electrodes of simple Voltic cell.

Construction:

- **Anode:** Copper **Cathode:** Zinc Rod
- **Electrolyte:** Dilute sulphuric Acid
- **Vessel:** Copper

Action:

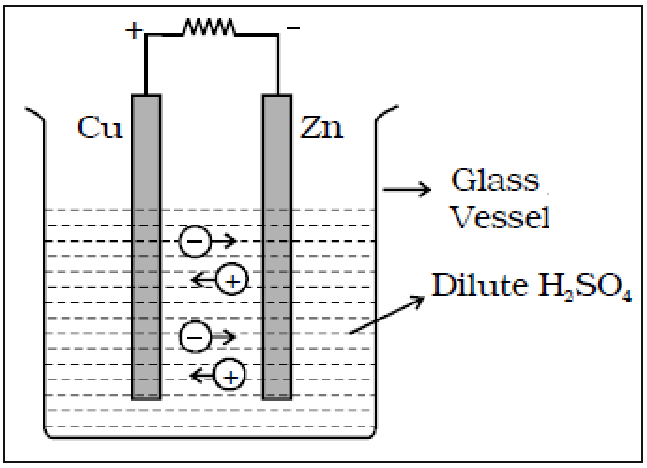
❖ This cell converts chemical energy into electrical energy.

❖ Zinc rod reacts with H_2SO_4 and becomes negative charge by removing Zn^{++} atom.

❖ Copper neutralizes 2H+ ions and becomes positive.

❖ The current passes from copper to zinc in the external circuit.

❖ Emf produced by the cell: **1.08 V**



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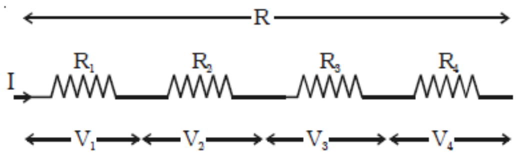
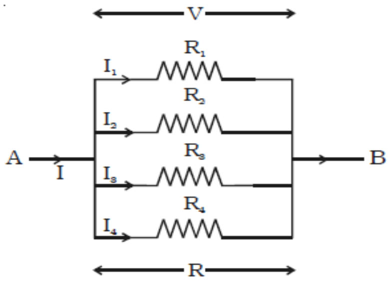
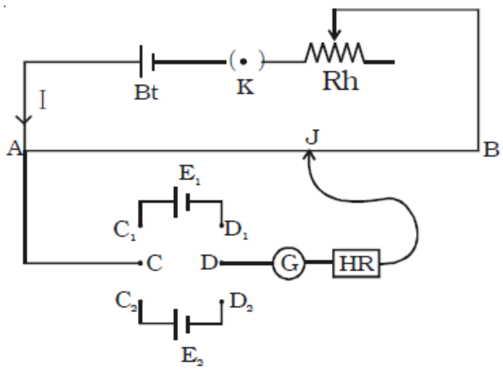
5. *Explain the effective resistance of a series network and parallel network.*

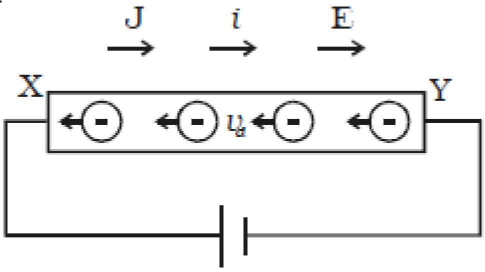
Resisters in series	Resisters in parallel
1. R_1, R_2, R_3, R_4Resisters are connected in series. R_s is the effective resistance.	1. R_1, R_2, R_3, R_4 are Resisters connected in parallel. R_P is the effective resistance.
2. 	2. 
3. Current flowing through each resistor is the same.	3. Potential difference (V) across each resistor is same.
4 . $V = V_1 + V_2 + V_3 + V_4$	4. $I = I_1 + I_2 + I_3 + I_4$.
5. $V_1 = IR_1$, $V_2 = IR_2$, $V_3 = IR_3$, $V_4 = IR_4$ and $V = IR_s$ $IR_S = IR_1 + IR_2 + IR_3 + IR_4$ **(Or)$R_S = R_1 + R_2 + R_3 + R_4$**	5. $I_1 = \frac{V}{R_1}$, $I_2 = \frac{V}{R_2}$, $I_3 = \frac{V}{R_3}$, $I_4 = \frac{V}{R_4}$ $\boxed{I = \frac{V}{R_P}}$ $\frac{V}{R_P} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} + \frac{V}{R_4}$ $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$
6.The equivalent resistance of a number of resistors in series connection is equal to the sum of the resistance of individual resistors.	6. The sum of the reciprocal of the resistance of the individual resistors is equal to the reciprocal of the effective resistance of the combination.

6. How can emf of two cells be compared using potentiometer?



- The end A of potentiometer is connected to the terminal C of a DPDT switch.
- Battery, key and rheostat are connected in series with B. Terminal D is connected to the jockey (J) through a galvanometer and high resistance.
- Let I be the current flowing through the primary circuit and r be the resistance of the potentiometer wire per metre length.
- The jockey is moved on the wire and adjusted for zero deflection in galvanometer.
- $E_1 = Irl_1$ ---------------→(1)
- $E_2 = Irl_2$---------------→(2)

$$\boxed{\frac{E_1}{E_2} = \frac{l_1}{l_2}} \qquad \boxed{E_2 = E_1 \frac{l_2}{l_1}}$$



7. *Establish a relation between drift velocity and current.*

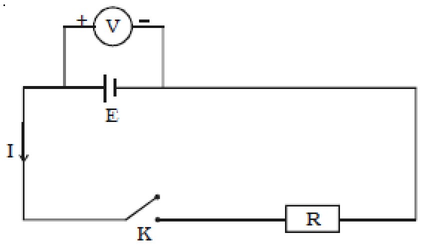
1. *Consider a conductor XY of length L and area of cross section A .*
2. *An electric field E is applied between its ends.*
3. Let *n* be the number of free electrons per unit volume.
4. The total charge passing through the conductor *q=(nAL)e*
5.

The time in which the charges pass through the conductor, $t = \frac{L}{v_d}$

The current flowing through the conductor, $I = \frac{q}{t} = \frac{(nAL)e}{(L/v_d)}$

$$I = nAev_d$$

8. *Explain the determination of the internal resistance of a cell using voltmeter.*



1. When key K open, the emf of cell E is found by connecting a high resistance voltmeter across it.
2. A small value of resistance R is included in the external circuit and Key K is closed.
3. The potential difference across R is equal to the potential difference across cell(V).

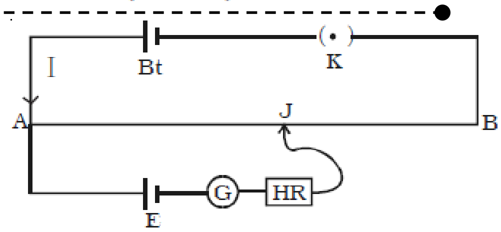
The potential drop across R, **V = IR**...................(1)

Internal resistance of the cell (r) , V is less than E

Then V = E – Ir(or) **Ir = E–V**...................(2)

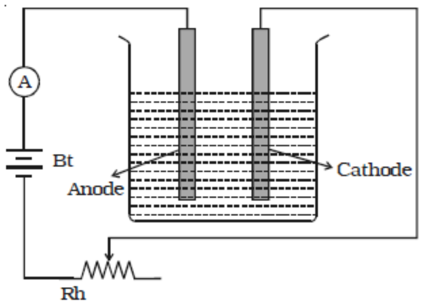
Dividing equation (2) by equation (1) $\frac{Ir}{IR} = \frac{E-V}{V}$ or $r = \left(\frac{E-V}{V}\right)R$

9. *Explain the principle of a potentiometer.*



1. The potentiometer wire B is connected in series with a battery (Bt), Key (K), rheostat (Rh) This forms the primary circuit.
2. A primary cell is connected in series with the positive terminal A of the potentiometer, a galvanometer, high resistance and jockey. This forms the secondary circuit.
3. If the potential difference between A and J is equal to the emf of the cell, no current flows through the galvanometer. It shows zero deflection.
4. If the balancing length is *l* the potential difference across AJ = I*rl* where *r* is the resistance per unit length of the potentiometer wire
5. E = Ir*l*, *since I and r are constants* E α *l*
   Emf of the cell(E) is directly proportional to its balancing length.

10. *State and verify Faraday's first laws of electrolysis*.



First Law : *The mass of a substance liberated at an electrode is directly proportional to the charge passing through the electrolyte.*

Explanation:

1. A battery, a rheostat, a key and an ammeter are connected in series to an electrolytic cell.
2. A current I_1 is passed for a time t. the mass m_1 of the substance deposited is obtained.
3. A different current I_2 is passed for the same time t. The mass m_2 of the substance deposited is obtained.

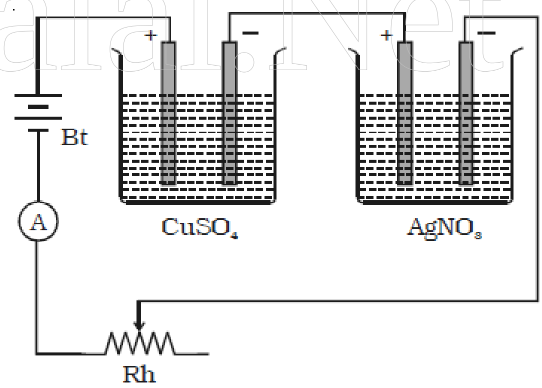
$$\frac{m_1}{m_2} = \frac{I_1}{I_2}$$

$$\therefore \quad m \propto I$$

4. The experiment is repeated for same current I but for different times t_1 and t_2. If the masses of the deposits are m_3 and $m_4$respectively.
5. $\frac{m_3}{m_4} = \frac{t_1}{t_2} \quad \alpha \ t$

$m \ \alpha \ It$ or $m \ \alpha \ q$ Thus, the first law is verified.

11. *State and verify Faraday's second law of electrolysis.*



Second Law: The mass of a substance liberated at an electrode by a given amount of charge is proportional to the chemical equivalent of the substance.

Explanation: Two electrolytic cells containing different electrolytes,$CuSO_4$ solution and $AgNO_3$ solution are connected in series with a battery, a rheostat and an ammeter. The circuits are connected as shown in the diagram. The current is passed for time 't'.

The mass of copper deposited is found as m_1 . (E_1-chemical equivalent of copper)

The mass of silver deposited is found as m_2. (E_2-chemical equivalent of silver)

$$\frac{m_1}{m_2} = \frac{E_1}{E_2}$$

$$\boxed{m \ \alpha \ E}$$

3.EFFECTS OF ELECTRIC CURRENT

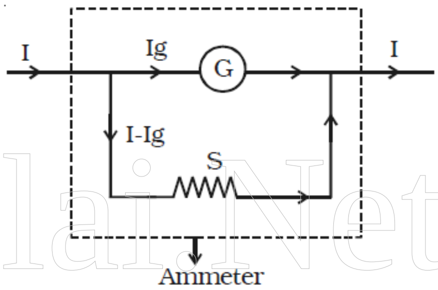
1. *What are the special features of magnetic Lorentz force?*

1. The force F on the charge is zero, if the charge is at rest. (i.e) the moving charges alone are affected by the magnetic field.
2. The force is zero, if the direction of motion of the charge is either parallel or anti-parallel to the field and the force is maximum, when the charge moves perpendicular to the field.
3. The force is proportional to the magnitude of the charge (q)
4. The force is proportional to the magnetic induction (B)
5. The force is proportional to the speed of the charge (v)
6. The direction of the force is oppositely directed for charges of opposite sign .

$$\vec{F} = q\,(\vec{v} \times \vec{B})$$

---

2. *Explain how you will convert a galvanometer into an ammeter.*



1. A galvanometer is converted into an ammeter by connecting a **low resistance** (*shunt resistance*) **in parallel** with it.
2. Let Ig be the maximum current that can be passed through the galvanometer. Galvanometer resistance = G
   Shunt resistance = S
   Current in the circuit = I
   ∴Current through the shunt resistance = Is = (I–Ig)
3. Since the galvanometer and shunt resistance are parallel, potential is common.
4. $$I_g \cdot G = (I - I_g)S$$
   $$S = G\,\frac{I_g}{I - I_g}$$
5. **Effective Resistance**:
   $$\frac{1}{R_a} = \frac{1}{G} + \frac{1}{S}$$
   $$R_a = \frac{GS}{G+S}$$
6. An ideal ammeter is one which has zero resistance.

---

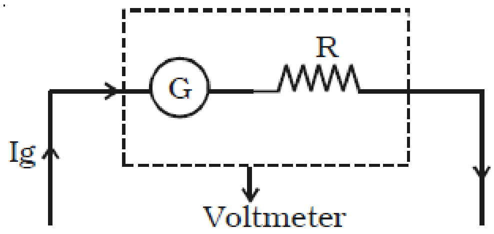
3. *Explain how you will convert a galvanometer into a voltmeter.*

- A galvanometer can be converted into a voltmeter by connecting a **high resistance in series** with it.
- Galvanometer resistance = G

The current required to produce full scale deflection in the galvanometer = Ig

Range of voltmeter = V

Resistance to be connected in series = R



❖ $$I_g = \frac{V}{R+G}$$

$$R = \frac{V}{I_g} - G$$

❖ The effective resistance of the voltmeter is Rv = G + R

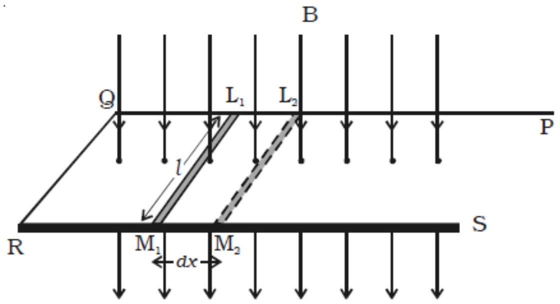
❖ An ideal voltmeter is one which has infinite resistance.

4. ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT

1. Explain varies power losses in a transformer. How are they minimized?

S.No	Losses	Reason	Method of minimization
1.	**Hysteresis loss**	The repeated magnetisation and demagnetisation of the iron core caused by the alternating input current.	Using a core with a material having the least hysterisis loss. Alloys like **mumetal** and silicon steel.
2.	**Copper loss**	The current flowing through the primary and secondary windings lead to Joule heating effect.	**Thick wires** with considerably **low resistance** are used to minimize this loss.
3.	**Eddy current loss (Iron loss)**	The varying magnetic flux produces eddy current in the core. This leads to the wastage of energy in the form of heat.	Laminated core made of stelloy, an alloy of steel.
4.	**Flux loss**	The flux produced in the primary coil is not completely linked with the secondary coil due to leakage.	By using a shell type core.
Due to the vibration of the core, sound is produced, which causes a loss in the energy.			

2. *Explain how an emf can be induced by changing the area enclosed by the coil.*



- PQRS is a conductor bent in the shape. L_1M_1 is a sliding conductor of length l.
- The closed area of the conductor is L_1QRM_1
- When L_1M_1 is moved, due to the change in area there is a change in the flux. Therefore, an induced emf is produced.
- dA = l dx
- dϕ = B.dA = Bl dx

$$e = -\frac{d\phi}{dt}$$

$$\therefore \quad e = -\frac{Bldx}{dt} = -Blv$$

v is the velocity with which the sliding conductor is moved.

3. *Obtain an expression for the self–inductance of a long solenoid.*

Let us consider a solenoid of N turns with length l and area of cross section A. It carries a current I. If B is the magnetic field at any point inside the solenoid,

Magnetic flux per turn ϕ = B × area of each turn

$$B = \frac{\mu_o NI}{l}$$

$$\phi = \frac{\mu_o N^2 IA}{l} \qquad \text{-------------(1)}$$

$$\phi = LI \qquad \text{---------------(2)}$$

From (1) and (2) $\boxed{L = \frac{\mu_o N^2 A}{l}}$

If the core is filled with a magnetic material of permeability μ, $L = \frac{\mu N^2 A}{l}$

4. *Obtain an expression for the mutual inductance.*

S_1 and S_2 are two long solenoids each of length *l*. The solenoid S_2 is wound closely over the solenoid S_1.

N_1 and N_2 are number of turns and I_1 is the current flowing through the solenoid S_1

$$B_1 = \mu_o \frac{N_1}{l} I_1$$

The magnetic flux linked with each turn of S_2 is equal to B_1A.

$$\phi_2 = B_1AN_2$$

$$\phi_2 = \left(\mu_o \frac{N_1}{l} I_1\right) A \ N_2$$

$$\phi_2 = \frac{\mu_o N_1 N_2 A I_1}{l} \quad \ldots(2)$$

But $\phi_2 = MI_1 \quad \ldots(3)$

From equations (2) and (3)

$$MI_1 = \frac{\mu_o N_1 N_2 A I_1}{l}$$

$$M = \frac{\mu_o N_1 N_2 A}{l}$$

If the core is filled with a magnetic material of permeability μ.

$$M = \frac{\mu N_1 N_2 A}{l}$$

---

5. ***Derive an expression for energy associated with an inductor.***

1. Whenever current flows through a coil, the self–inductance opposes the growth of the current.
2. Hence, some work has to be done by external agencies in establishing the current.

$$e = -L\frac{dI}{dt}$$

$$dw = e.I \ dt$$

$$= -L \frac{dI}{dt} \ I.dt$$

Total work done

$$w = \int dw = \int_0^{I_o} -L \ I \ dI$$

$\therefore$ Energy stored in the coil

$$= -L\int_0^{I_o} IdI = -\frac{1}{2} L I_o^2$$

---

6. What are eddy current? ***Give the applications of eddy current. How are they minimized ?***

Eddy Current: when a mass of metal moves in a magnetic field or when the magnetic field through a stationary mass of metal is altered, induced current is produced in the metal. This induced current flows in the metal in the form of closed loops resembling 'eddies' or whirl pool. Hence this current is called eddy current.

Minimize: Eddy current can be minimized by using thin laminated sheets instead of solid metal.

(i) <u>Dead beat galvanometer:</u>

1. When current is passed through a galvanometer, the coil oscillates about its mean position before it comes to rest.
2. To bring the coil to rest immediately, the coil is wound on a metallic frame.
3. When the coil oscillates, eddy currents are set up in the metallic frame, which opposes further oscillations of the coil.
4. So the coil attains its equilibrium position almost instantly.

<u>(ii)Speedometer:</u>

1. In a speedometer, a magnet rotates according to the speed of the vehicle.
2. The magnet rotates inside an aluminium cylinder (drum).
3. Eddy currents are produced in the drum due to the rotation of the magnet and it opposes the motion of the rotating magnet.
4. The drum in turn experiences a torque and gets deflected through a certain angle depending on the speed of the vehicle.

(iii) <u>Induction furnace:</u>

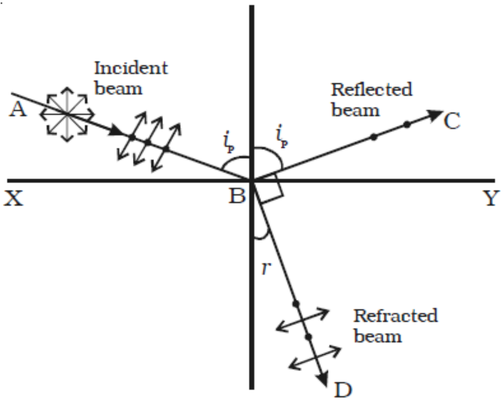
1. In an induction furnace, high temperature is produced by generating eddy currents.
2. The material to be melted is placed in a varying magnetic field of high frequency.
3. Hence a strong eddy current is developed inside the metal.
4. Due to the heating effect of the current the metal melts.

<u>(iv) Electromagnetic brakes:</u>

1. A metallic drum is coupled to the wheels of a train. The drum rotates along with the wheel when the train is in motion.
2. When the brake is applied, a strong magnetic field is developed and hence, eddy currents are produced in the drum which opposes the motion of the drum.
3. Hence, the train comes to rest.

5. ELECTROMAGNETIC WAVES AND WAVE OPTICS

1. State and explain Brewster's law.



Statement: The tangent of the polarising angle is numerically equal to the refractive index of the medium.

1. $i_p + 90^0 + r = 180^0$

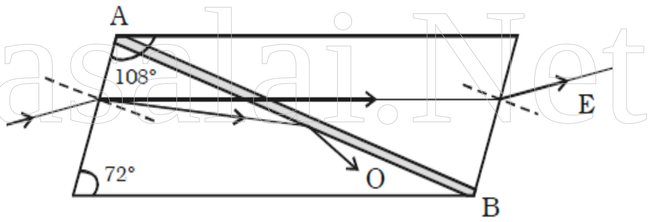
   $r = 90^0 - i_p$

2. $\dfrac{\sin i_p}{\sin r} = \mu$

   $\dfrac{\sin i_p}{\sin(90 - i_p)} = \mu$; $\dfrac{\sin i_p}{\cos i_p} = \mu$

3. $\boxed{\tan i_p = \mu}$

2. ***Write a note on Nicol prism.***



1. Nicol prism is made by taking a calcite crystal, whose length is three times its breadth.
2. It is cut into two halves along the diagonal with face angles are **72^0 and 108^0**.
3. The two halves are joined together by a layer of Canada balsam, a transparent cement.
   - For sodium light, the refractive index for
   - Ordinary light -----------1.658
   - Extra–ordinary light ---1.486.
   - Canada balsam is 1.550 for both rays.
4. A monochromatic beam of unpolarised light is incident on the face of the nicol prism splits up into two rays as ordinary ray (O) and extraordinary ray (E).
5. The ordinary ray is totally internally reflected at the layer of Canada balsam.
6. The **extraordinary ray** alone is transmitted through the crystal which is **plane polarised**.
7. The nicol prism serves as a polariser and also an analyser.

3. ***Obtain an expression for the radius of the n^{th} dark ring in Newton's ring experiment.***

Let us consider the vertical section SOP of the plano convex lens through its centre of curvature C. Let R be the radius of curvature of the plano convex lens. Let t be the thickness of the air film at S and P.

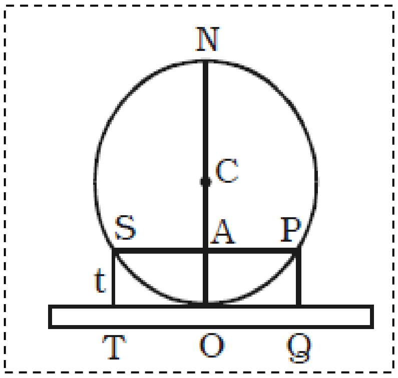
$SA = AP = r_n$

$$SA.\ AP = OA.\ AN$$

$$r_n^2 = t(2R-t)$$

$$r_n^2 = 2\ Rt \text{ (neglecting } t^2 \text{ comparing with } 2R)$$

$$2t = \frac{r_n^2}{R}$$



According to the condition for darkness

$$2t = n\lambda$$

$$\frac{r_n^2}{R} = n\lambda$$

$$r_n^2 = nR\lambda \quad \text{or} \quad r_n = \sqrt{nR\lambda}$$

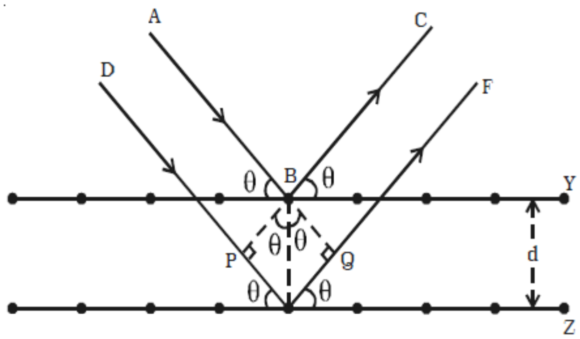
The radius of the dark ring is directly proportional to square root of its order(n).

6. ATOMIC PHYSICS

1. State and obtain Bragg's law.

Statement: If the path difference 2d sin θ is equal to integral multiple of wavelength of X-ray i.e. nλ, then constructive interference will occur between the reflected beams and they will reinforce with each other. Therefore the intensity of the reflected beam is maximum.

- Consider homogeneous X–rays of wavelength λ incident on a crystal at a glancing angle θ.
- Let the crystal lattice spacing between the planes be d.
- The incident rays AB and DE after reflection from the lattice planes Y and Z travel along BC and EF.



$$\text{In the } \Delta PBE,\ \sin\theta = \frac{PE}{BE} \text{ (or) } PE = BE\sin\theta = d\sin\theta$$

$$\boxed{\text{In the } \Delta QBE,\ \sin\theta = \frac{EQ}{BE} \text{ (or) } EQ = BE\sin\theta = d\sin\theta}$$

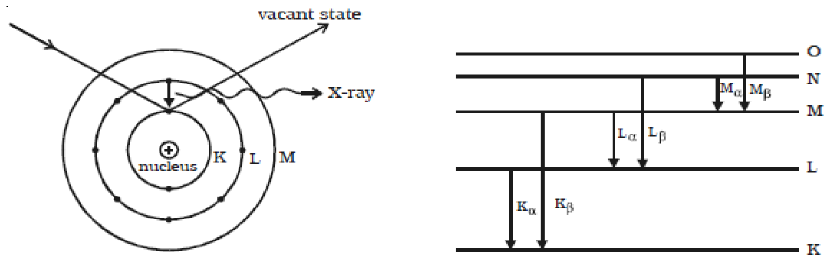
$$\therefore \quad \text{Path difference} = PE + EQ = d\sin\theta + d\sin\theta = 2d\sin\theta$$

2d sin θ = nλ where, $\boxed{n = 1, 2, 3 \ldots \text{etc}}$

2. *Explain the spectral series of hydrogen atom.*

S.No	Series	Explanation	Formula	Region
1.	**Lyman series**	The electron jumps from any of the outer orbits to the **first** orbit.	$n_1 = 1, n_2 = 2,3,4,..$ $\bar{\nu} = R\left(1 - \frac{1}{n_2^2}\right)$	ultraviolet
2.	**Balmer series**	The electron jumps from any of the outer orbits to the **second** orbit.	$n_1 = 2, n_2 = 3,4,5,..$ $\bar{\nu} = R\left(\frac{1}{2^2} - \frac{1}{n_2^2}\right) = R\left(\frac{1}{4} - \frac{1}{n_2^2}\right)$	visible
3.	**Paschen series**	The electron jumps from any of the outer orbits to the **third** orbit.	$n_1 = 3, n_2 = 4,5,6,..$ $\bar{\nu} = R\left(\frac{1}{3^2} - \frac{1}{n_2^2}\right) = R\left(\frac{1}{9} - \frac{1}{n_2^2}\right)$	infrared
4.	**Brackett series**	The electron jumps from any of the outer orbits to the **fourth** orbit.	$n_1 = 4, n_2 = 5,6,7,..$ $\bar{\nu} = R\left(\frac{1}{4^2} - \frac{1}{n_2^2}\right) = R\left(\frac{1}{16} - \frac{1}{n_2^2}\right)$	infrared
5.	***Pfund* series**	The electron jumps from any of the outer orbits to the **fifth** orbit.	$n_1 = 5, n_2 = 6,7,8,..$ $\bar{\nu} = R\left(\frac{1}{5^2} - \frac{1}{n_2^2}\right) = R\left(\frac{1}{25} - \frac{1}{n_2^2}\right)$	infrared

3. *Explain the origin of characteristic x-rays.*



(a) (b)

1. *It consists of definite, <u>well defined wavelengths</u> superimposed on the continuous spectrum.*
2. *A fast moving electrons with velocity $(1/10)^{th}$ of the velocity of light may penetrate the surface atoms <u>and knock out the tightly bound electrons</u>.*
3. *When the fast moving electrons knock off one electron from K Shell and the vacancy is filled by the nearby electron from the L shell.*
4. *X-rays of very small wave length is radiated.[Kα – line]The frequency v1 of this line is* $(E_K - E_L) = h\nu_1$.
5. *Suppose, the electron from M shell jumps to the K shell, it gives out K_β line and so on.*
6. *If an electron jumps from the M Shell to the vacant state in L-Shell, it contributes Lα line*
7. *The frequency of radiation depends upon the target material.*
8. *The X-ray spectra consist of sharp lines and is the characteristic of target material.*

4. Compare the properties of cathode, canal and X- rays:

S.No	Properties	Cathode rays	Canal Rays	X-rays
1.	**Explanation**	It comprises of electrons which are fundamental constituents of all atoms.	They are the streams of positive ions of the gas enclosed in the discharge tube.	Electromagnetic waves of very short wavelength.
2.	**Velocity**	$\frac{1}{10}$ th of the velocity of light.	Much smaller than cathode rays.	Travels with velocity of light.
3.	**Deflection by electric and magnetic field.**	Deflected by electric and magnetic fields.	Deflected by electric and magnetic fields.	**Not** deflected by electric and magnetic fields.
4.	**Ionization power.**	Ionize the gas.	Ionize the gas.	Ionize the gas.
5.	**Photographic plates.**	Affect	Affect	Affect
6.	**Fluorescence**	Produce fluorescence	Produce fluorescence.	Produce fluorescence.
7.	**Direction**	Travel is straight line.	Travel is straight line.	Travel is straight line.
8.	**Special Character**	When it strikes a solid substance of large atomic weight, X-rays are produced.	----	Penetrate through the substances which are opaque to ordinary light e.g. wood,

7. DUAL NATURE OF RADIATION AND MATTER AND RELATIVITY

1. Obtain Einstein's photo electric equation.

1. Albert Einstein, successfully applied quantum theory of radiation to photoelectric effect.
2. According to Einstein, the emission of photo electron is the result of the interaction between a single photon of the incident radiation and an electron in the metal.
3. When a photon of energy h ν is incident on a metal surface, its energy is used up in **two** ways:

4. A part of the energy of the photon is used in extracting the electron from the surface of metal; this energy is known as photoelectric work function of the metal.
5. The remaining energy of the photon is used to impart kinetic energy to the liberated electron.

$$h\nu = W + \frac{1}{2}mv^2$$

6. If the electron does not lose energy by internal collisions, {$v = v_{max}$} as it escapes from the metal, the entire energy ($h\nu - W$) will be exhibited as the kinetic energy of the electron.
7. $h\nu = W + \frac{1}{2}mv^2_{max}$

   This equation is known as Einstein's photoelectric equation.

---

2. *Derive an expression for de Broglie wavelength of matter waves.*

1. De Broglie equated the energy equations of Planck (wave) and Einstein (particle).
2. **$E = h\nu$** ....(1) where h is Planck's constant.
3. According to Einstein's mass energy relation,

   $E = mc^2$............(2) where c is the velocity of light.
4. **$\therefore h\nu = mc^2$**
5. $$\frac{hc}{\lambda} = mc^2 \text{ (or) } \lambda = \frac{h}{mc} \quad ...(3) \quad (\text{since } \nu = \frac{c}{\lambda})$$
6. For a particle moving with a velocity v, if c = v

$$\boxed{\lambda = \frac{h}{mv} = \frac{h}{p}}$$

---

3. *Derive an expression for* de Broglie wavelength of an electron.

- ❖ Kinetic Energy of an electron $\frac{1}{2}mv^2 = eV$ (or) $v = \sqrt{\frac{2eV}{m}}$ ...(1)
- ❖ The de Broglie wavelength is $\lambda = \frac{h}{mv}$
- ❖ Substituting the value of v from (1) $\lambda = \frac{h}{m\sqrt{\frac{2eV}{m}}} = \frac{h}{\sqrt{2meV}}$ ...(2)
- ❖ Substituting the known values $\boxed{\lambda = \frac{12.27}{\sqrt{V}} Å}$
- ❖ Since E = eV :Equation (2) becomes $\lambda = h/\sqrt{2mE}$

---

4. Explain time dilation.

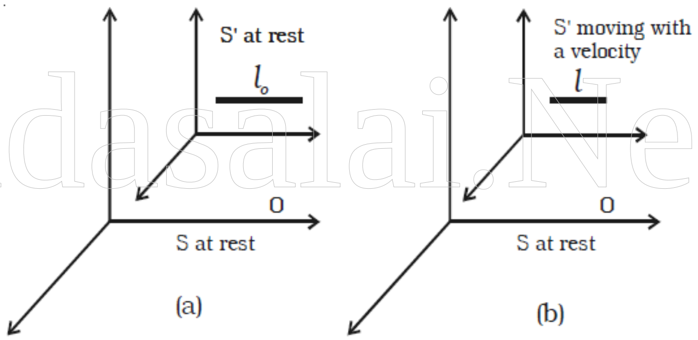
- The clock in the frame of reference S' gives out signals in t_0 seconds.
- The time measured by the observer is t in the frame of reference S.

$$\boxed{t = \frac{t_o}{\sqrt{1 - \frac{v^2}{c^2}}}}$$

- **$t > t_o$**
- The time interval appears to be lengthened by a factor $\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$
- ***Example:*** The clock in the moving space ships will appear to go slower than the clocks on the earth.

5. *Explain length contraction.* **{Lorentz – Fitzgerald contraction}**

- Consider two frames of references S and S′. The length of the rod as measured by the observer in S frame of reference is ℓ_o.
- Consider the frame of reference S' moves with the velocity v in x- axis. Now the length measured by the observer is ℓ.
- $l = l_o \sqrt{1 - \frac{v^2}{c^2}}$
- $l < l_o$



- The length of the rod contracted by a factor $\sqrt{1 - \frac{v^2}{c^2}}$
- **Example:** A circular object will appear as an ellipse for a fast moving observer.

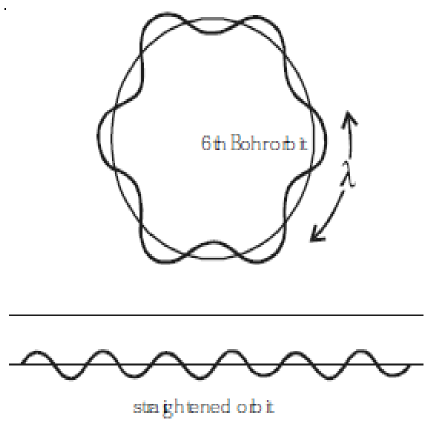
6. *Wave mechanical concept of atom*

- De Broglie wavelength $\lambda = \frac{h}{mv}$ ....(1)
- The electrons in various orbits behave like a wave.

- Stationary orbits are those in which orbital circumference ($2\pi r$) is an integral multiple of de Broglie wavelength λ.
- $2\pi r = n\lambda$ ....(2)

n = 1, 2, 3 … and r is the radius of the circular orbit.

Substituting equation (1) in equation (2)



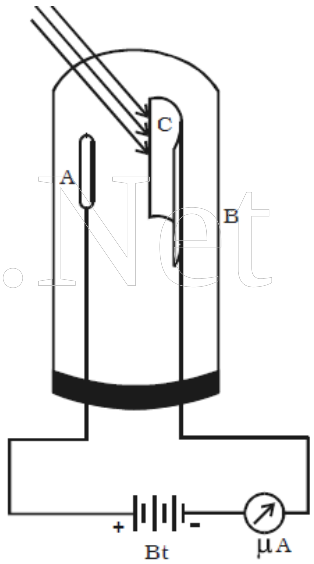
- $$\boxed{2\pi r = n\lambda\left(\frac{h}{mv}\right) \quad \text{(or)} \quad mv\,r = \frac{nh}{2\pi}}$$
- de Broglie's concept confirms the Bohr's postulate.

7. Explain the construction and working of a photo emissive [electric] cell

The photoelectric cell is a device which converts light energy into electrical energy.

Construction:

- It consists of a highly evacuated bulb B made of glass or quartz.
- Cathode→semi cylindrical metal plate(C)
- Anode → thin platinum wire (A)
- Cathode is coated with a low work function material caesium oxide.



Working:

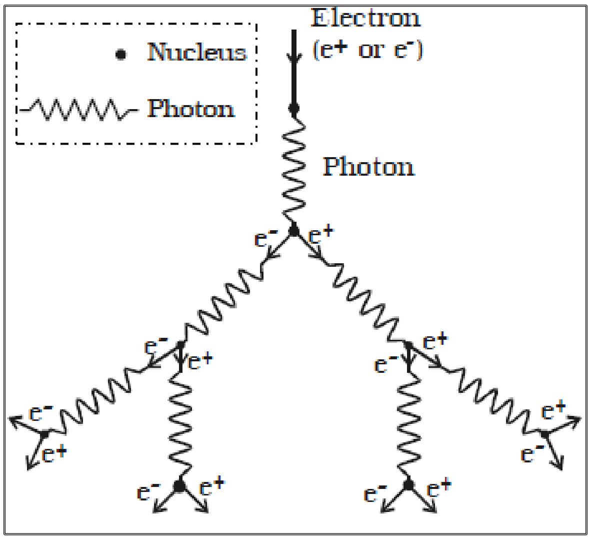
- When a light of suitable wave length falls on the cathode, photo electrons are emitted, which are attracted by the anode A.
- The resulting current is measured by a micro ammeter.
- The current produced is proportional to the intensity of the incident light for a given frequency.

8. NUCLEAR PHYSICS

1. Compare the properties of Alpha, Beta and Gamma rays:

S.No	Properties	Alpha	Beta	Gamma
1.	**Explanation**	Helium nucleus consisting of two protons and two neutrons. It carries two units of positive charge.	Carry one unit of negative charge and mass equal to that of electron.	Electromagnetic waves of very short wavelength.
2.	**Velocity**	high velocities	0.3 C to 0.99 C	velocity of light
3.	**Deflection by electric and magnetic field.**	Deflected by electric and magnetic fields.	Deflected by electric and magnetic fields.	**Not** deflected by electric and magnetic fields.
4.	**Ionization power.**	Intense ionisation.	Low	less ionisation.
5.	**Photographic plates.**	Affect	Affect	Affect
6.	**Fluorescence**	Produce, when they fall on zinc sulphide or barium platinocyanide.	Produce fluorescence when they fall on barium platinocyanide.	Produce.
7.	**Penetrating power**	Low	High. Penetrate through thin metal foils .	Very high.

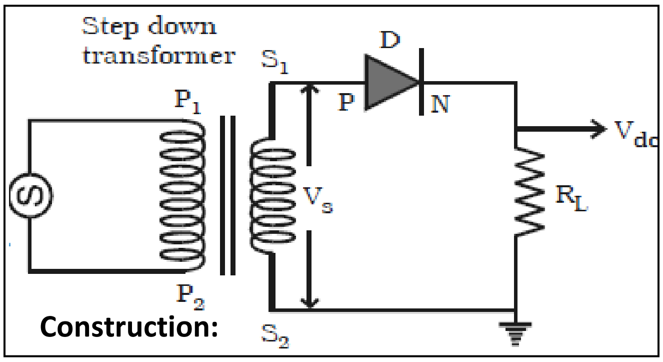
2. Explain how a cosmic ray shower is formed?

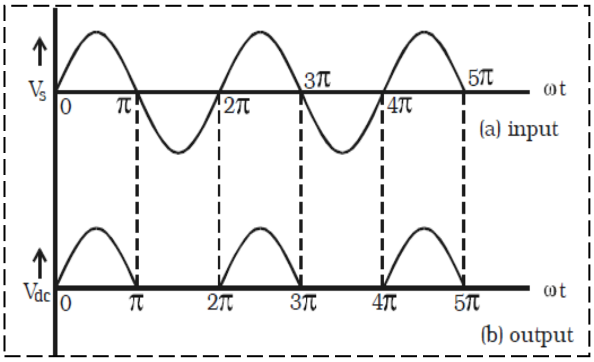


- According to cascade theory the shower production involves two processes:
  1. radiative collision 2.pairproduction
- An energetic electron or positron present in cosmic rays collides with the nuclei of atoms in earth's atmosphere and produce photon.
- The photons interact with an atomic nucleus and produce an electron position pair.
- The above reactions repeat again and again.
- The result is the generation of a large number of photons, electrons and positrons having a common origin like a shower and hence it is known as cosmic ray shower.
- This reaction will stop if individual energy of the particles fall below the 'critical energy'.

9. SEMICONDUCTOR DEVICES AND THEIR APPLICATIONS

1. *Explain the working of a half wave diode rectifier.*





Construction:

- A circuit which rectifies half of the a.c wave is called half wave rectifier.
- The a.c. voltage (Vs)to be rectified is given to secondary ends S_1 S_2 of the transformer.
- The P-end of the diode D is connected to $S_1$and N end connected to S_2 through R_L.

Working:

Positive Half cycle:S_1 will be positive and the diode is forward biased and hence it conducts. Current flows through the circuit and there is a voltage drop across R_L.

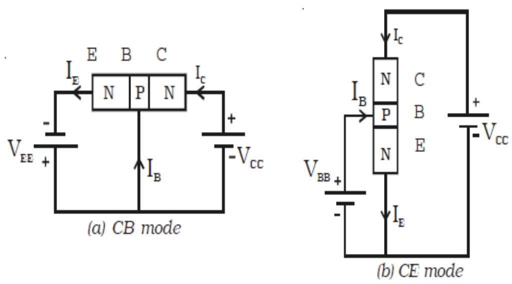
Negative Half cycle:S_1 will be negative and the diode is reverse biased and hence the diode does not conduct. Hence no output voltage is obtained.

Efficiency: The ratio of d.c. power output to the a.c. power input is known as rectifier efficiency. The efficiency of half wave rectifier is approximately 40.6%

2. *Deduce the relation between α and β of a transistor.*

The current amplification factor or current gain of a transistor is the ratio of output current to the input current.

- *In common base mode, the current gain* $\alpha = \frac{I_C}{I_E}$
- *In common emitter mode the current gain* $\beta = \frac{I_C}{I_B}$
- The collector current is almost equal to the emitter current. The range of α is 0.95 to 0.99.



$$\alpha = \frac{I_C}{I_E} = \frac{I_c}{I_B + I_C} \qquad (\because\ I_E = I_B + I_C)$$

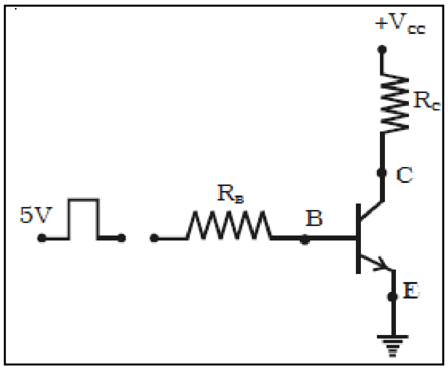
$$\frac{1}{\alpha} = \frac{I_B + I_C}{I_C} = \frac{I_B}{I_C} + 1$$

$$\frac{1}{\alpha} - 1 = \frac{1}{\beta}$$

$$\therefore \quad \beta = \frac{\alpha}{1-\alpha}$$

Usually β lies between 50 and 300. Some transistors have β as high as 1000.

3. *Explain the function of a transistor as a switch.*



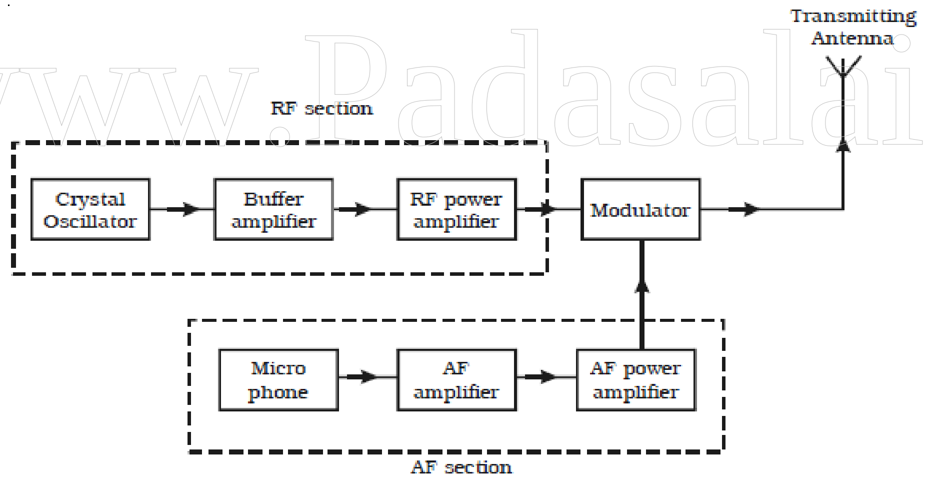
1. NPN transistor is connected in common emitter configuration and a resistor R_B is connected in series with the base.
2. The load resistance Rc is connected in series with the collector.
3. A pulse type waveform is applied as the input to the transistor through R_B.

<u>Working:</u>

- When the <u>input is high</u>, base emitter junction is <u>forward biased</u> and current flows through R_B into the base.
- The values of R_B and R_C are saturating the transistor.
- When the transistor is saturated, it is said to be ON.
- When the input is low (i.e.) at 0 V, the base emitter junction is not forward biased.
- So, no base current flows. Hence the transistor is said to be OFF.

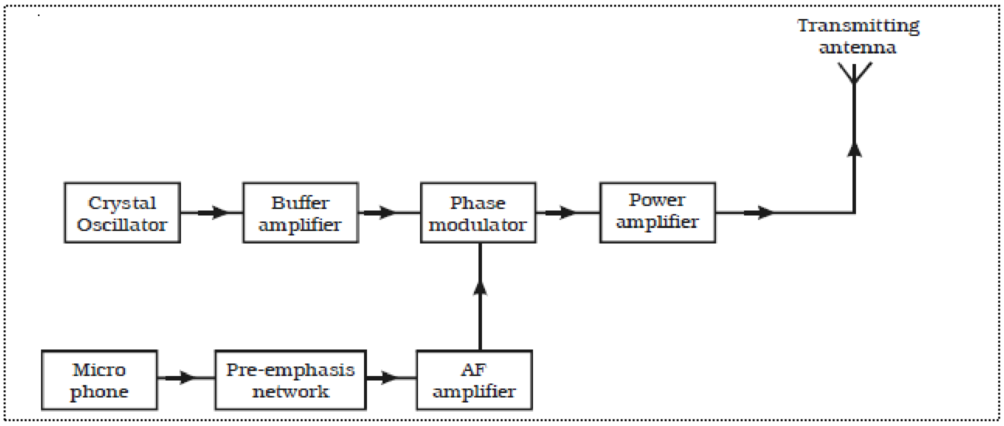
<u>10.COMMUNICATION SYSTEMS</u>

3. *Explain the function of an AM radio transmitter with the help of the block diagram.*



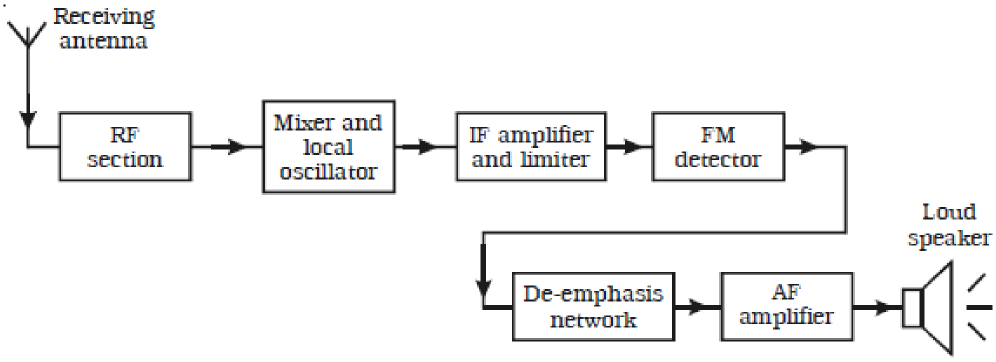
- **AF section:** It generates the modulating wave (signal). The conversion of sound energy into electrical energy is performed by the microphone.
- Amplifier amplifies the low electric energy from the micro phone and the output is given to AF power amplifier.
- **RF section:** The high frequency carrier wave is generated by a crystal controlled oscillator.
- The buffer isolates the RF power amplifier from the oscillator.
- The output of the crystal controlled oscillator is power amplified by RF power amplifier.
- In the modulator the RF wave and modulating AF signal are mixed to produce the amplitude modulated wave.
- The output of this section is fed to the antenna for transmission.

4. *Explain the function of FM transmitter with neat block diagram.*



1. The crystal oscillator produces the carrier wave and the output of this is fed into the phase modulator.
2. The buffer is a low frequency amplifier which isolates the crystal oscillator from the phase modulator.
3. The modulating signal is produced from a microphone.
4. Pre-emphasis network converts uneven power of AF modulating signal to even power and output is amplified and sent for phase modulation.
5. The modulated output is then power amplified using a power amplifier and then fed into the transmitting antenna for transmission.

4. With the help of block diagram, explain the operation of an FM super heterodyne receiver.



1. The RF section selects the incoming modulated signals and is amplified.
2. It is then fed into the mixer and local oscillator.
3. Here the frequency of the modulated signal is changed to intermediate frequency (**IF**). [**IF** is 10.7 MHz]
4. Intermediate frequency wave is amplified using IF amplifier.
5. Then its amplitude is maintained constant using a limiter.
6. The output of this section is applied to the FM detector which demodulates the modulated wave.
7. De emphasis network converts various frequencies attain their original power distribution.
8. Finally it is fed into the loud speaker after performing AF amplification.

SIMPLIFIED FIVE MARK ANSWER

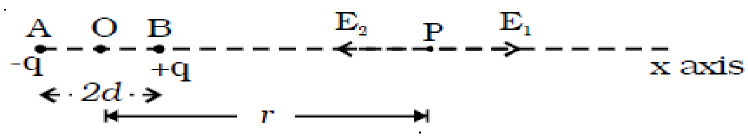
Important Note: This is only for average learners to score minimum marks. To score full mark refer text book.

1.ELECTROSTATICS

1. ***Derive an expression for electric field due to an electric dipole at a point on its axial line.***

1. AB is an electric dipole of two point charges –q and +q separated by a small distance 2d. P is a point along the axial line of the dipole at a distance r from the midpoint O of the electric dipole.

2.



3. The electric field due to + q $E_1 = \frac{1}{4\pi\varepsilon_o}\frac{q}{(r-d)^2}$ (along BP)

4. The electric field due to -q $E_2 = \frac{1}{4\pi\varepsilon_o}\frac{q}{(r+d)^2}$ (along PA)

5. $E = E_1 + (-E_2)$

6.

$$E = \left[\frac{1}{4\pi\varepsilon_o}\frac{q}{(r-d)^2} - \frac{1}{4\pi\varepsilon_o}\frac{q}{(r+d)^2}\right] \text{along BP.}$$

$$E = \frac{q}{4\pi\varepsilon_o}\left[\frac{1}{(r-d)^2} - \frac{1}{(r+d)^2}\right] \text{ along BP}$$

$$E = \frac{q}{4\pi\varepsilon_o}\left[\frac{4rd}{(r^2-d^2)^2}\right] \text{along BP.}$$

7. $d<<r$ and $\mathbf{p = 2dq}$

8.

$$E = \frac{q}{4\pi\varepsilon_o}\frac{4rd}{r^4} = \frac{q}{4\pi\varepsilon_o}\frac{4d}{r^3}$$

9.

$$E = \frac{1}{4\pi\varepsilon_o}\frac{2p}{r^3} \text{ along BP.}$$

10. E acts in the direction of dipole moment.

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2. Derive an expression for electric field due to an electric dipole at a point along the equatorial line.

1. Consider an electric dipole AB. Let 2d be the dipole distance and p be the dipole moment. P is a point on the equatorial line at a distance r from the midpoint O of the dipole.
2. Electric field at a point P due to the charge +q $E_1 = \frac{1}{4\pi\varepsilon_o}\frac{q}{(r^2+d^2)}$ along BP
3. Electric field at a point P due to the charge -q $E_2 = \frac{1}{4\pi\varepsilon_o}\frac{q}{(r^2+d^2)}$ along PA

4. The magnitudes of E_1 and E_2 are equal. The **vertical** components $E_1 \sin\theta$ and $E_2 \sin\theta$ **cancel** each other. The ***horizontal*** components $E_1 \cos\theta$ and $E_2 \cos\theta$ will get ***added*** along PR.
5. Resultant electric field $\mathbf{E = E_1 \cos\theta + E_2 \cos\theta}$ (along PR)

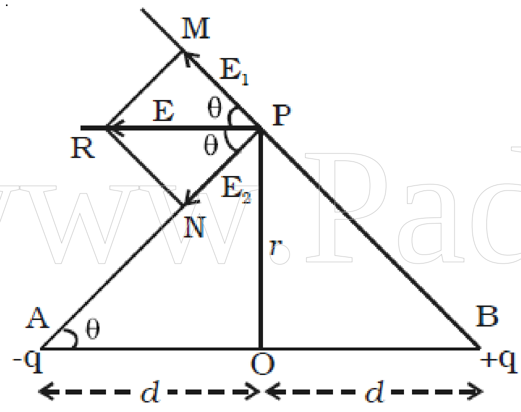
$$E = 2E_1 \cos\theta \quad (\because E_1 = E_2)$$

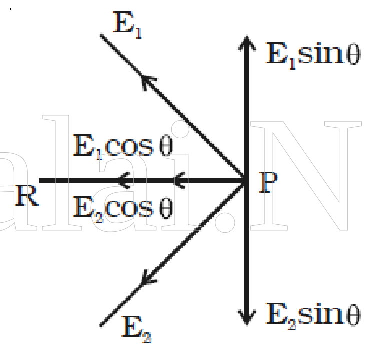
6. $E = 2 \times \frac{1}{4\pi\varepsilon_o}\frac{q}{(r^2+d^2)}\frac{d}{\sqrt{r^2+d^2}}$ $\left\{ \cos\theta = \frac{d}{\sqrt{r^2+d^2}} \right\}$

7. $$E = \frac{1}{4\pi\varepsilon_o}\frac{p}{(r^2+d^2)^{3/2}}$$

8. d<<r and **p= 2dq**
9. $$\boxed{E = \frac{1}{4\pi\varepsilon_o}\frac{p}{r^3}}$$

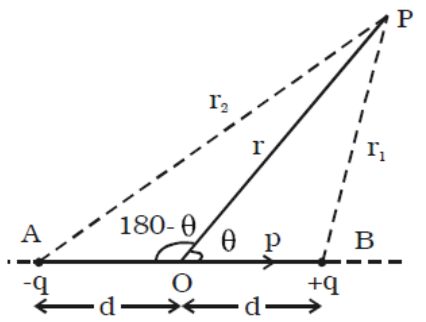
10. The direction of E is **opposite** to the direction of dipole moment.





3. *Derive an expression for electric potential due to an electric dipole. Discuss special cases.*

1. Consider an electric dipole AB. Let p be the point at a distance r from the midpoint of the dipole and θ be the angle between PO and the axis of the dipole OB.



2. Potential at P due to charge (+q) $= \frac{1}{4\pi\varepsilon_o}\frac{q}{r_1}$

Potential at P due to charge (−q) $= \frac{1}{4\pi\varepsilon_o}\left(-\frac{q}{r_2}\right)$

Total potential at P due to dipole is, $V = \frac{1}{4\pi\varepsilon_o}\frac{q}{r_1} - \frac{1}{4\pi\varepsilon_o}\frac{q}{r_2}$

$$V = \frac{q}{4\pi\varepsilon_o}\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \qquad \ldots(1)$$

3. Applying cosine law, $r_1^2 = r^2 + d^2 - 2rd\cos\theta$

Using the Binomial theorem and neglecting higher powers,

$$\frac{1}{r_1} = \frac{1}{r}\left(1 + \frac{d}{r}\cos\theta\right) \qquad \ldots(2)$$

4. Similarly, $r_2^2 = r^2 + d^2 - 2rd\cos(180-\theta) = r^2 + d^2 + 2rd\cos\theta$.

5. $$\frac{1}{r_2} = \frac{1}{r}\left(1 - \frac{d}{r}\cos\theta\right) \qquad \ldots(3)$$

6. Substituting equation (2) and (3) in equation (1) and simplifying

$$V = \frac{q}{4\pi\varepsilon_o}\frac{1}{r}\left(1 + \frac{d}{r}\cos\theta - 1 + \frac{d}{r}\cos\theta\right)$$

$$\therefore \quad V = \frac{q\,2d\cos\theta}{4\pi\varepsilon_o\,.\,r^2} = \frac{1}{4\pi\varepsilon_o}\frac{p\,.\cos\theta}{r^2} \qquad \ldots(4)$$

7. **Special cases:**

(i) If $\theta = 0^0$; $V = \dfrac{p}{4\pi\varepsilon_o r^2}$

(ii) If $\theta = 180^0$; $V = -\dfrac{p}{4\pi\varepsilon_o r^2}$

(iii) If $\theta = 90^0$; **V=0**

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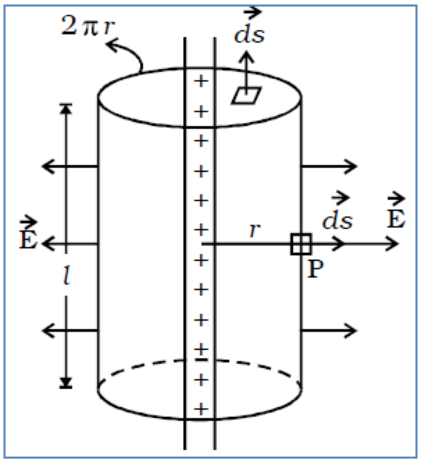
4. State Gauss's law. Applying this, calculate electric field due to (i) an infinitely long straight charge with uniform charge.

Gauss's law:

The law states that the total flux of the electric field E over any closed surface is equal to $\frac{1}{\varepsilon_o}$ times the net charge enclosed by the surface.

Field due to an infinite long straight charged wire:



1. Consider a uniformly charged wire. Let P be a point at a distance r from the wire. λ→linear charge density . Choose Gaussian surface of length l and radius r.

2. The electric flux (ϕ) through curved surface = $\oint E\,ds\cos\theta$

$$\phi = \oint E\,ds \qquad [\because \theta = 0; \cos\theta = 1]$$

$$= E\,(2\pi r l)$$

3. Since $\vec{E}$ and $\vec{ds}$ are right angles to each other, the electric fluxthrough the plane caps = 0.

4. Total flux through the Gaussian surface, $\phi = E.(2\pi rl)$
5. The net charge enclosed by Gaussian surface is, $q = \lambda l$
6. By Gauss's law,

$$E\ (2\pi rl) = \frac{\lambda l}{\varepsilon_o} \quad \text{or} \quad E = \frac{\lambda}{2\pi\varepsilon_o r}$$

7. The direction of electric field E is radially outward, if line charge is positive and inward, if the line charge is negative.

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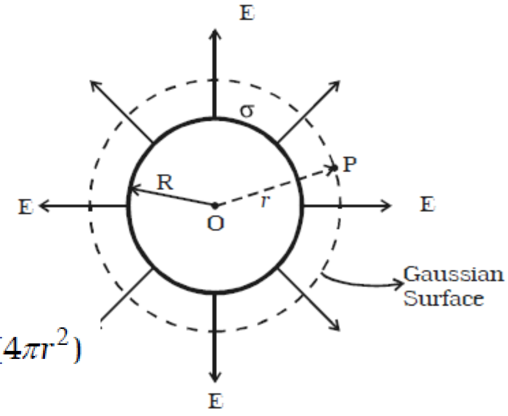
5. Derive an expression for electric field due to uniformly charged spherical shell:



__Case (i) At a point outside the shell.__

1. Consider a charged shell of radius R . Let P be a point outside the shell, at a distance r from the centre O.
2. Let us construct a Gaussian surface with r as radius. The electric field E is normal to the surface.
3. The flux crossing the Gaussian sphere normally in an outward direction is,

$$\phi = \int_S \vec{E}\ .\ \vec{ds} = \int_S E\ ds = E\ (4\pi r^2)$$

(Since angle between E and ds is zero)

4. By Gauss's law, $E\ .\ (4\pi r^2) = \dfrac{q}{\varepsilon_o}$

5. $$\boxed{E = \frac{1}{4\pi\varepsilon_o}\frac{q}{r^2}}$$

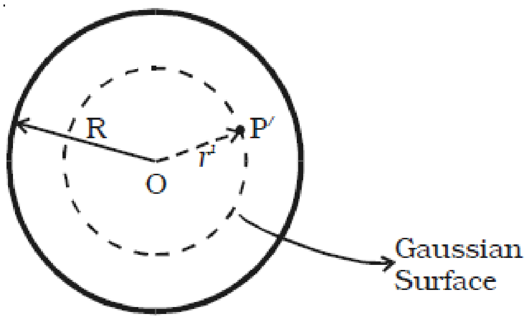
6. The electric field at a point outside the shell will be the same as if the total charge on the shell is concentrated at its centre.

__Case (ii) At a point on the surface.__

7. The electric field E for the points on the surface of charged spherical shell is,

$$E = \frac{1}{4\pi\varepsilon_o}\frac{q}{R^2}\ (\because\ r = R)$$

__Case (iii) At a point inside the shell.__



8. Consider a point P′ inside the shell at a distance r′ from the centre of the shell. Let us construct aGaussian surface with radius r′.
9. The total flux crossing the Gaussian sphere normally in an outward direction is:

$$\phi = \int_S \vec{E}\ .\ \vec{ds} = \int_S Eds = E \times (4\pi r'^2)$$

10. According to Gauss's law

$$E \times 4\pi r'^2 = \frac{q}{\varepsilon_o} = 0 \qquad \therefore\ E = 0$$

The field due to a uniformly charged thin shell is zero at all points inside the shell.

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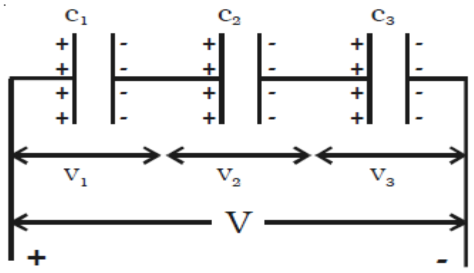
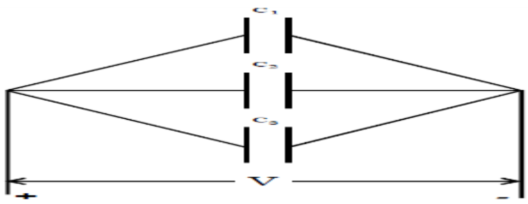
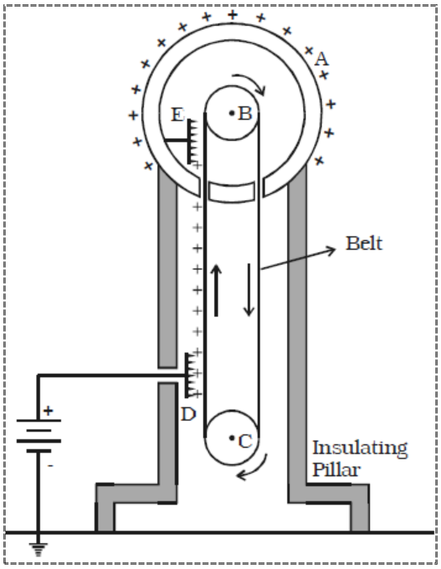
6. ***Deduce an expression for the equivalent capacitance of capacitors connected in series and parallel.***

Capacitors in series	**Capacitors in parallel**
1. C_1, C_2, C_3, capacitors are connected in series. Csis the effective capacitances.	1. C_1, C_2, C_3, capacitors are connected in parallel. $C_p$is the effective capacitances.
	
3. Charge in each capacitor is same.	3. Potential in each capacitor is same.
4 . $V = V_1 + V_2 + V_3$	4. $q = q_1 + q_2 + q_3$
5. $V_1 = \frac{q}{C_1}; V_2 = \frac{q}{C_2}; V_3 = \frac{q}{C_3}$ $V = \frac{q}{C_1} + \frac{q}{C_2} + \frac{q}{C_3} = q\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right]$	5. $q_1 = C_1 V$, $q_2 = C_2 V$, $q_3 = C_3 V$. $q = C_1V + C_2V + C_3V$
6. $V = \frac{q}{C_S}$ $\frac{q}{C_s} = \frac{q}{C_1} + \frac{q}{C_2} + \frac{q}{C_3}$	6. $q = C_p V$ $C_pV = V(C_1 + C_2 + C_3)$
7. $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$	7. $C_P = C_1 + C_2 + C_3$
8. The reciprocal of the effective capacitance is equal to the sum of reciprocal of the capacitance of the individual capacitors.	8.The effective capacitance of the capacitors connected in parallel is the sum of the capacitances of the individual capacitors.

7. *State the principle and explain the construction and working of Van de Graaff generator.*

Introduction: Van de Graaff generator is an electrostatic machine which produces large electrostatic potential difference of the order of **10^7 V.**

Principle: *electrostatic induction and action of points*.



Construction:

1. A hollow metallic sphere A is mounted on insulating pillars.
2. A pulley B is mounted at the centre of the sphere.
3. Pulley C is mounted near the bottom.
4. A belt made of silk moves over the pulleys.
5. The pulley C is driven continuously by an electric motor.
6. D and E are comb–shaped conductors.
7. The comb D is maintained at a positive potential of the order of **10^4 V.**

Working:

(i) ***Action of points:***

1. Because of the high electric field near the comb D, the air gets ionised due to action of points.
2. The negative charges in air move towards the needles.
3. Positive charges are repelled on towards the belt.
4. The positive charges stick to the belt and move up and reach near the comb E.

(ii) ***Electrostatic induction:***

5. As a result of electrostatic induction, the comb E acquires negative charge and the sphere acquires positive charge.
6. The acquired positive charge is distributed on the outer surface of the sphere.
7. The high electric field at the comb E ionises the air and neutralises the positive charge. Hence the descending belt will be left uncharged.

Leakage and prevention:

8. After reaching maximum charges on the sphere A, it starts leaking to the surrounding due to ionisation of the air.
9. This can be prevented by enclosing it in a gas filled steel chamber at a very high pressure.

Uses:

10. The high voltage produced in this generator can be used to **accelerate positive ions** (protons, deuterons) for the purpose of nuclear disintegration.

3.EFFECTS OF ELECTRIC CURRENT

1. ***Explain in detail the principle, construction, working and limitation of a cyclotron with neat diagram.***

Introduction: Cyclotron is a device used to accelerate charged particles to high energies.

Principle: A charged particle moving normal to a magnetic field experiences magnetic lorentz force due to which the particle moves in a circular path.

Construction:

- A hollow metal cylinder divided into two sections D_1 and D_2 called Dees.
- They are placed between the pole pieces of a strong electromagnet.
- The Dees are connected to a high frequency oscillator.

Working:

- A positive ion of charge q and mass m is emitted from the source.
- It is accelerated towards the Dee having a negative potential at that instant of time.
- The ion experiences magnetic lorentz force and moves in a circular path.
- When the ion arrives at the gap the polarities of the dees get reversed.
- Hence the particle moves into the other Dee with a greater velocity
- It moves in a spiral path of increasing radius, it hits a deflector plate (D.P).

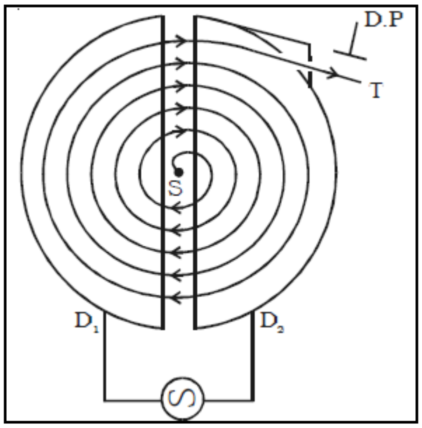
Derivation: Magnetic Lorentz force provides the necessary centripetal force.

$$Bq\upsilon = \frac{m\upsilon^2}{r} \quad \text{(OR)} \quad \frac{\upsilon}{r} = \frac{Bq}{m} = \text{constant} \quad \text{——(1)}$$

- The time taken to describe a semi-circle:

$$t = \frac{\pi r}{\upsilon} \qquad \text{(OR)} \qquad t = \frac{\pi m}{Bq}$$

- The time taken by the ion t describe a semi-circle is independent of (i) the radius (r) of the path and (ii) the velocity (v) of the particle



- Period of rotation T = 2t

$$T = \frac{2\pi m}{Bq} = \text{constant}$$

- The frequency of rotation of the particle,

$$\upsilon = \frac{1}{T} = \frac{Bq}{2\pi m}$$

Limitation:

- Electrons cannot be accelerated by cyclotron.
- Maintaining a uniform magnetic field over a large area of the Dees is difficult.
- Variation of mass of the particle upsets the resonance condition.

2. Derive an expression for magnetic induction due to infinitely long straight conductor carrying current.

Explanation:

- XY is an infinitely long straight conductor carrying a current I
- P is a point at a distance a from the conductor. AB is a small element of length dl.
- θ is the angle between the current element I dl and the line joining the element dl and the point P.

According to Biot- Savart law, $dB = \frac{\mu_o}{4\pi}\frac{Idl.\sin\theta}{r^2}$ ...(1)

AC is drawn perpendicular to BP from A.

$\angle OPA = \phi$, $\angle APB = d\phi$

In Δ ABC, $\sin\theta = \frac{AC}{AB} = \frac{AC}{dl}$

$\therefore AC = dl \sin\theta$ ...(2)

From Δ APC, $AC = r d\phi$ ...(3)

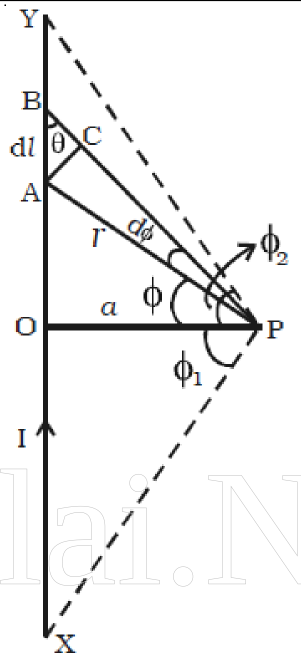
From equations (2) and (3), $r d\phi = dl \sin\theta$ ...(4)

substituting equation (4) in equation (1)

$$dB = \frac{\mu_o}{4\pi}\frac{I\, r d\phi}{r^2} = \frac{\mu_o}{4\pi}\frac{I\, d\phi}{r} \quad ...(5)$$

In Δ OPA, $\cos\phi = \frac{a}{r}$

$$\therefore r = \frac{a}{\cos\phi} \quad ...(6)$$



substituting equation (6) in equation (5)

$$dB = \frac{\mu_o}{4\pi}\frac{I}{a}\cos\phi\, d\phi$$

The total magnetic induction at P due to the conductor XY is

$$B = \int_{-\phi_1}^{\phi_2} dB = \int_{-\phi_1}^{\phi_2} \frac{\mu_o I}{4\pi a}\cos\phi\, d\phi$$

$$B = \frac{\mu_o I}{4\pi a}[\sin\phi_1 + \sin\phi_2]$$

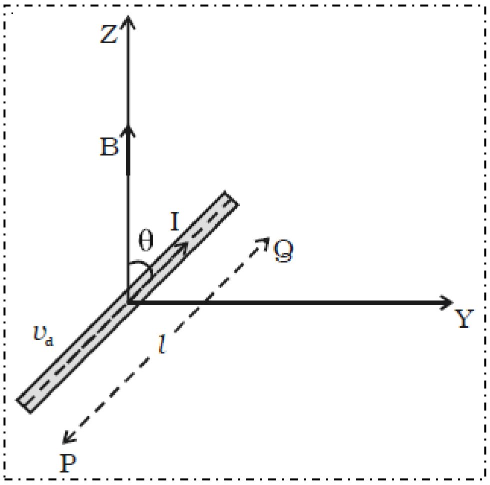
For infinitely long conductor, $\phi_1 = \phi_2 = 90^o$

$$\therefore \quad B = \frac{\mu_o I}{2\pi a}$$

If the conductor is placed in a medium of permeability μ,

$$B = \frac{\mu I}{2\pi a}$$

3. Derive an expression for Force on a current carrying conductor placed in a magnetic field.



Explanation:

- The conductor PQ of length ℓ is placed in a uniform magnetic field at angle θ.
- A current I flows along PQ. $V_d \rightarrow$ drift velocity of electron.
- n is the number of free electrons per unit volume.

Derivation:

- The current is $I = n A v_d e$

$$I\vec{l} = -nA\vec{v}_d e l$$

- The magnetic lorentz force on a moving electron $\vec{f} = -e\ (\vec{v}_d \times \vec{B})$
- The number of free electrons in the conductor $N = n A \ell$
- The magnetic lorentz force on all the moving free electrons $\vec{F} = N\vec{f}$

$$\vec{F} = nAl\ \{ -e\ (\vec{v}_d \times \vec{B}) \}$$

$$\vec{F} = -nAl\ e\ \vec{v}_d \times \vec{B}$$

$$\boxed{\vec{F} = I\vec{l} \times \vec{B}}$$

Magnitude of force: **$F = B I \ell \sin\theta$**

(i) $\theta = 0^o$: force $F = 0$. **(ii)** $\theta = 90^o$, $F = BI\ell$.

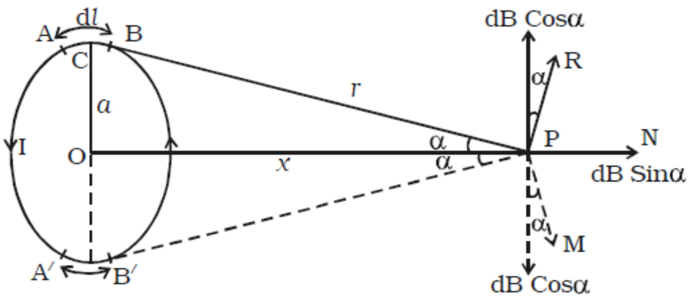
Direction of force: ***Fleming's Left Hand Rule.***

The forefinger, the middle finger and the thumb of the left hand are stretched in mutually perpendicular directions.

- If Forefinger points in the direction of magnetic field,
- Middle finger points in the direction of current,
- Thumb points in the direction of the **force** on the conductor.

4. *Deduce the relation for the magnetic induction at a point along the axis of a circular coil carrying current.*

1. Let us consider a circular coil of radius '*a*' with a current I.
2. P is a point along the axis of the coil at a distance *x* from the centre O of the coil.
3. AB is an infinitesimally small element of length d*l*.



4. According to Biot savart law the magnetic induction at P due to the element d*l* is
5. $$dB = \frac{\mu_o}{4\pi}\frac{I\,dl\,\sin\theta}{r^2}$$ {θ is the angle between Idl and r = 90°}

$$dB = \frac{\mu_o}{4\pi}\frac{I\,dl}{r^2}$$

6. The direction of dB is along PR perpendicular to CP.
7. The magnitude of dB at P due to A'B' element is the same as that for AB.
8. **Components**: dB cosα components due to two opposite elements cancel each other whereas dB sin α components get added up.
9. Total magnetic induction at P due to the entire coil is

$$B = \int dB\sin\alpha = \int \frac{\mu_o}{4\pi}\frac{Idl}{r^2}\frac{a}{r} = \frac{\mu_o}{4\pi}\frac{Ia}{r^3}\int dl$$

$$= \frac{\mu_o Ia}{4\pi r^3}2\pi a$$

$$= \frac{\mu_o Ia^2}{2(a^2+x^2)^{\frac{3}{2}}} \qquad (\because r^2 = a^2 + x^2)$$

If the coil contains n turns, the magnetic induction is

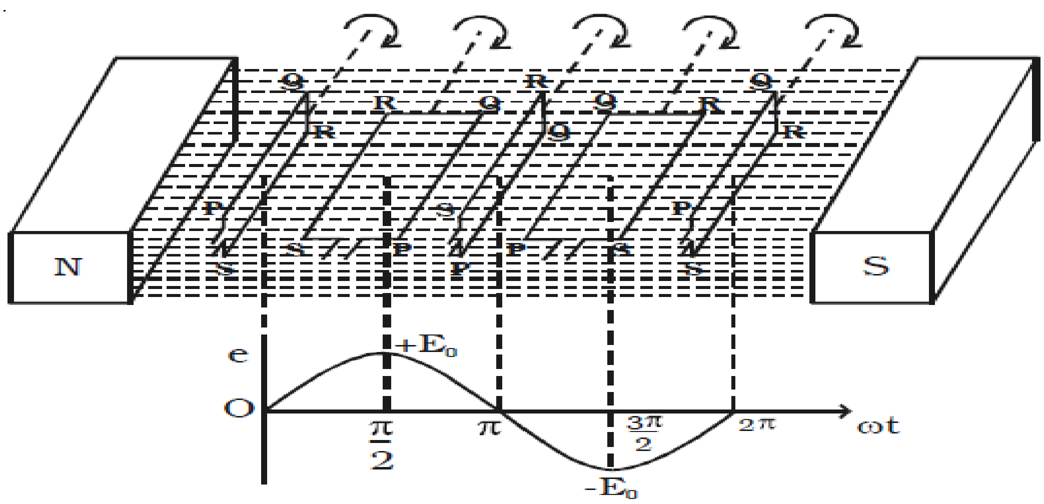
$$B = \frac{\mu_o nIa^2}{2(a^2+x^2)^{\frac{3}{2}}}$$

10. At the centre of the coil, $x = 0$

$$B = \frac{\mu_o nI}{2a}$$

Unit: 4: Electromagnetic Induction and Alternating Current

1. **Discuss with theory the method of inducing emf in a coil by changing its orientation with respect to the direction of the magnetic field.**



1. PQRS is a rectangular coil of N turns and area A is rotated clockwise with angular velocity ω about an axis perpendicular to the direction of uniform magnetic field B.
2. ϕ is the flux linked with the coil at this instant. **$\phi = NBA \cos \theta$**
3. The induced emf $e = -\frac{d\phi}{dt} = -NBA\frac{d}{dt}\cos(\omega t)$

   $\therefore \; e = NBA\omega \sin \omega t \; ...(1)$
4. **$e = E_o \sin \omega t$** and **$E_o = NAB\,\omega$**
5. The induced emf e varies sinusoidally with time t and the frequency being ν cycles per second.

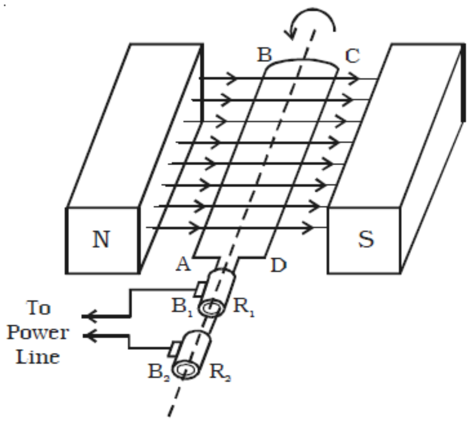
θ =ωt	Plane of the coil with magnetic field	Induced emf (e = E_o sin ωt)
0	Perpendicular	0
π/2	Parallel	E_o
π	Perpendicular	0
3π/2	Parallel	**- E_o**
2π	Perpendicular	0

If the ends of the coil are connected to an external circuit through a resistance R, current flows through the circuit, which is also sinusoidal in nature.

2. *Describe the principle, construction and working of a single – phase a.c generator.*

- **Introduction:** The ac generator is a device used for converting mechanical energy into electrical energy.
- **Principle:** Electromagnetic induction. (Change in flux produces induced emf in the coil)

  Construction: ***Essential Parts:***



(i) Armature: A large number of loops or turns of insulated copper wire wound over a laminated soft iron core.

(ii) Field magnets: permanent magnets in the case of low power dynamos and electromagnets in the case of high power dynamos.

(iii) Slip rings: The metal rings R_1 and R_2 connected to the ends of the armature and they rotate along with the armature.

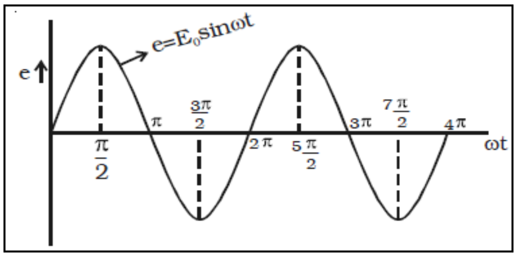
(iv) Brushes: B_1 and $B_2$are twoflexible carbon brushes. They provide contact with the slip rings and pass on the current from armature to external power.

Working:

- Armature (ABCD) rotates in anticlockwise direction in the magnetic field.
- Flux changes and emf is induced in the coil.
- The direction of induced emf is given by Fleming's right hand rule.

First half cycle	Second half cycle
1. **AB** moves downwards	1. **AB** moves upwards
2. **CD** moves upwards	2. **CD** movesdownwards
3. The current flows in the armature along **DCBA**	3. The current flows in the armature along **ABCD**
4. The current flows from **B_1 to B_2** in the external circuit.	4. The current flows from **$B_2$to B_1**in the external circuit.

Induced emf: **$e = E_o \sin \omega t$** and **$E_o = NAB\,\omega$**



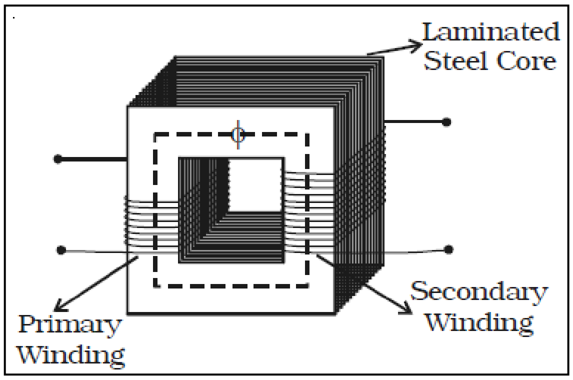
ω→ Angular velocity of the coil

E_o→ Peak value of emf

B→Magnetic field , N→ Number of turns, A→ Area enclosed in the coil.

3. *Explain the principle of transformer. Discuss its construction and working.*

Introduction: Transformer is an electrical device used for converting low alternating voltage into high alternating voltage and vice versa. It transfers electric power from one circuit to another.



Principle: Electromagnetic induction.

Construction:

1. It consists of insulated primary and secondary coils wound on a soft iron core.
2. A laminated iron core is used to minimise eddy current.
3. E_S , E_P → Emf in the primary and secondary coil
4. I_P , I_S → Currents in the primary and secondary coil
5. N_S , N_P → the number of turns in the primary and secondary coil

Working:

6. A varying alternating voltage is given to primary coil.
7. The magnetic flux changes in the primary coil.
8. Magnetic flux in the secondary coil also changes. An emf is induced in the secondary coils.

Derivation:

9. Flux linked with the primary and secondary coils are **equal**. The emf induced per turn of the two coils must be same.

$$\frac{E_P}{N_P} = \frac{E_s}{N_s} \quad \text{-------------(1)} \quad \text{(OR)} \quad \frac{E_s}{E_P} = \frac{N_s}{N_p}$$

10. For an ideal transformer, input power = output power

$$E_P I_P = E_S I_S \quad \text{(OR)} \quad \frac{E_s}{E_P} = \frac{I_P}{I_s} \quad \ldots(2)$$

11. From equations (1) and (2) $\quad \dfrac{E_s}{E_P} = \dfrac{N_s}{N_p} = \dfrac{I_P}{I_S} = k$

K → Transformer ratio.

Efficiency: $\eta = \dfrac{output\ \ power}{input\ \ power} = \dfrac{E_s I_s}{E_P I_P}$

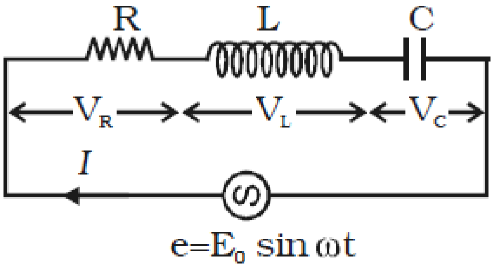
Power Losses: 1 . Hysteresis Loss 2. Copper loss

3. Eddy current loss 4. Flux loss

Step up transformer	Step down transformer
$E_S > E_P$	$E_P > E_S$
$N_S > N_P$	$N_P > N_S$
$I_P > I_S$	$I_S > I_P$
K >1	K < 1

4. R L C Series circuit- Impedance and phase relationship:

- Let an alternating source of emf e be connected to a series combination of a resistor of resistance R, inductor of inductance L and a capacitor of capacitance C.
- Let the current flowing through the circuit be **I**.
- $V_R = IR$ (V_R and I are in phase)
- $V_L = I X_L$ (V_L leads the current by $\frac{\pi}{2}$)
- $V_C = I X_C$ (V_C lags behind the current by $\frac{\pi}{2}$)
- V_L and V_C are 180° out of phase.
- The circuit is considered as predominantly inductive.



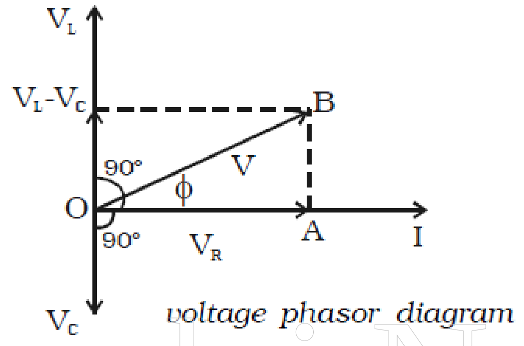
Effective Voltage:

$$V^2 = V_R^2 + (V_L - V_C)^2$$

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$V = \sqrt{(IR)^2 + (IX_L - IX_C)^2}$$

$$= I\sqrt{R^2 + (X_L - X_C)^2}$$



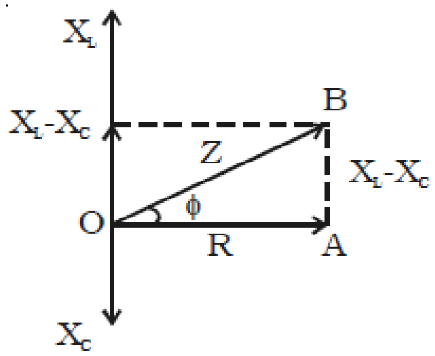
Impedance and phase between V and I :

1. $\frac{V}{I} = Z = \sqrt{R^2 + (X_L - X_C)^2}$

$$\tan\phi = \frac{V_L - V_C}{V_R} = \frac{I\,X_L - I\,X_C}{IR}$$

$$\tan\phi = \frac{X_L - X_C}{R}$$

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

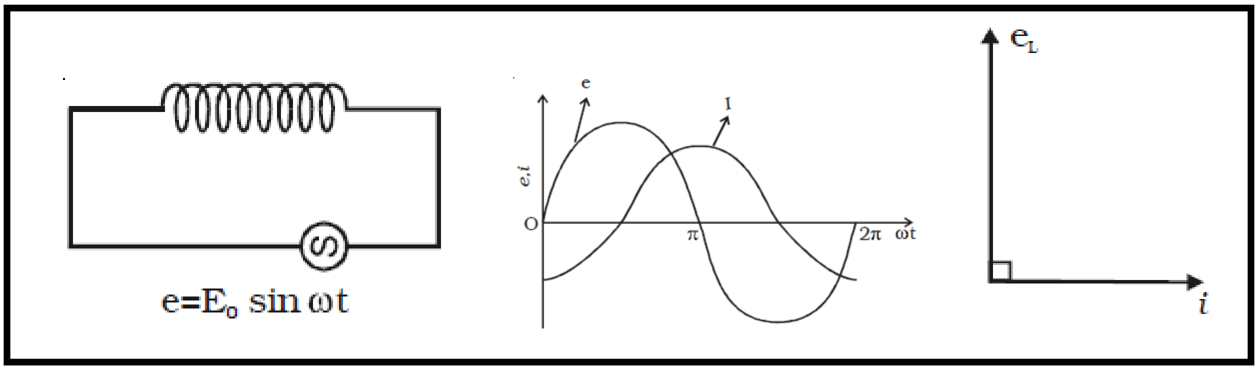


Instantaneous Current: $I_0 \sin(\omega t \pm \phi)$

ϕ is the phase angle between the voltage and current .

5. *Obtain an expression for the current in an ac circuit containing a pure inductance. Find the phase relationship between voltage and current.*

1. Let an alternating source of emf be applied to a pure inductor of inductance L.A self induced emf is generated which opposes the applied voltage.



2. The instantaneous value of applied emf e = Eo sin ωt

3. Induced emf $e' = -L \cdot \frac{di}{dt}$

4. In an ideal inductor circuit induced emf is equal and opposite to the applied voltage. **e= -e'**

5.

$$E_0 \sin \omega t = -\left(-L\frac{di}{dt}\right)$$

$$\therefore \quad E_0 \sin \omega t = L\frac{di}{dt}$$

$$di = \frac{E_o}{L} \sin \omega t \; dt$$

6. $$= i = \frac{E_o}{L}\int \sin \omega t \; dt \quad - \frac{E_o \cos \omega t}{\omega L}$$

7. $$i = \frac{E_o}{\omega L} \sin\left(\omega t - \frac{\pi}{2}\right)$$

8. $$i = I_0 \cdot \sin\left(\omega t - \frac{\pi}{2}\right)$$ **Here** $\boxed{I_0 = \frac{E_o}{\omega L}}$

9. *Inductive reactance* **X_L = Lω ,** Unit: **ohm**

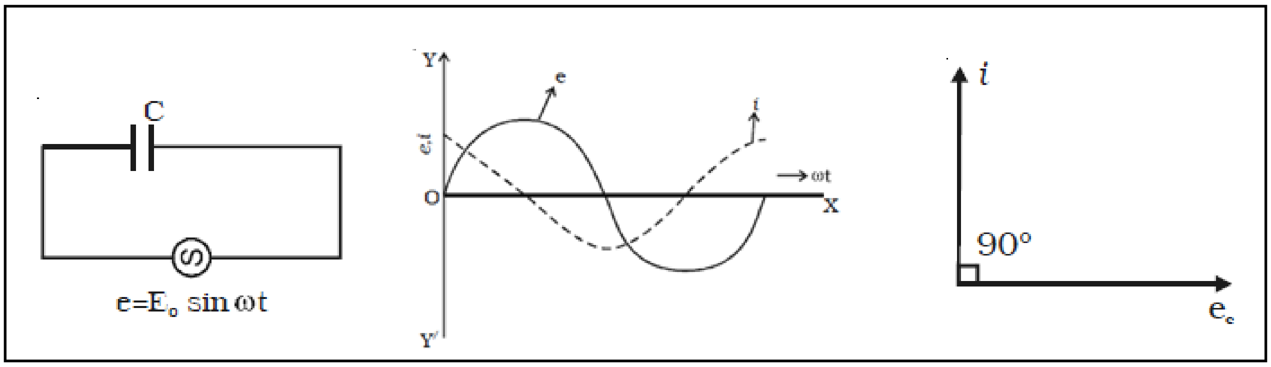
10. The voltage across L leads the current by the **phase angle of π/2.**

Inductive reactance for a.c and d.c:

- X_L = ωL = 2πν L, where ν is the frequency of the a.c. supply
- For AC circuit the reactance of the coil increases with increase in frequency.
- For d.c. ν = 0; ∴ X_L = 0

6. Obtain an expression for the current in an ac circuit containing Capacitance only. Find the phase relationship between voltage and current.

1. An alternating source of emf is connected across a capacitor of capacitance C.



2. The instantaneous value of applied emf e = Eo sin ωt

3. Potential difference across the capacitor = Applied emf $\therefore\ e = q/C,$

4. Current $i = \frac{dq}{dt} = \frac{d}{dt}(Ce)$

5. $$i = \frac{d}{dt}(C\,E_o \sin \omega t) = \omega\, CE_o .\cos \omega t$$

$$i = \frac{E_o}{(1/\omega C)}\sin\left(\omega t + \frac{\pi}{2}\right) \qquad \left\{ I_o = \frac{E_o}{(1/\omega C)} \right\}$$

$$i = I_o \sin\left(\omega t + \frac{\pi}{2}\right)$$

6. Capacitive reactance $X_C = \frac{1}{\omega C}$ **Unit:** Ohm

7. Current **leads** the voltage by a phase angle of π/2.

8. <u>**Capacitive reactance for a.c and d.c:**</u>

- $X_C = \frac{1}{\omega C} = \frac{1}{2\pi \nu C}$; ν is the frequency of the a.c. supply.
- In d.c. circuit ν = 0; $\therefore X_C = \infty$; so a capacitor does not allow d.c
- For an a.c. the capacitive reactance varies inversely to the frequency of a.c .$X_C \propto \frac{1}{\nu}$

5. ELECTROMAGNETIC WAVES AND WAVE OPTICS

1. *Explain the Raman scattering of light.*

Raman effect: The monochromatic light is scattered when it is allowed to pass through a substance. The scattered light contains some additional frequencies other than that of incident frequency.

- The lines having frequencies lower than the incident frequency are called Stoke's lines
- The lines having frequencies *higher* than the incident frequency are called Anti–stokes lines.

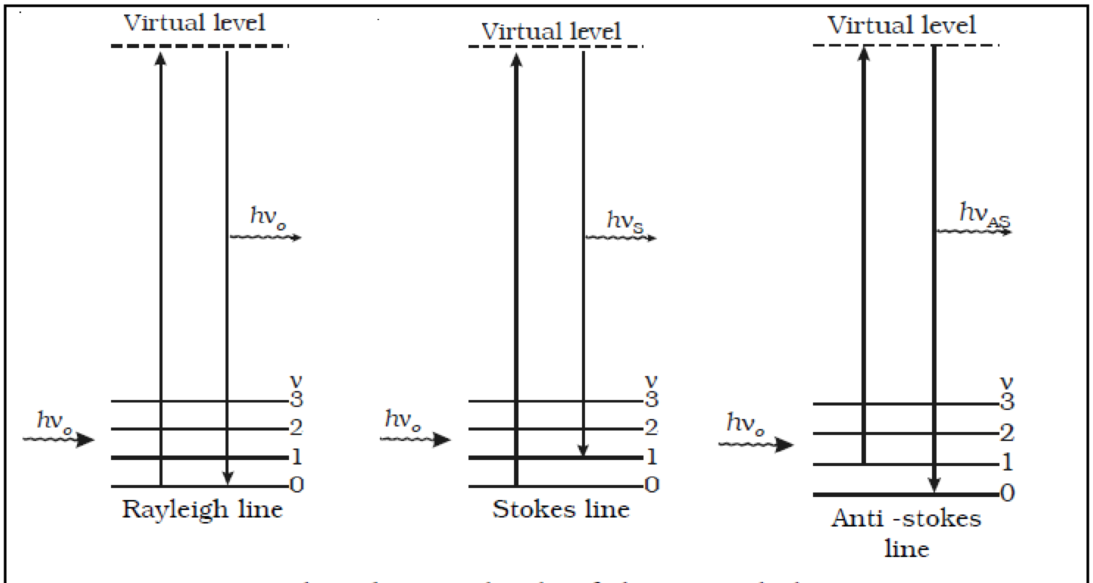
Stokes line: If a photon strikes an atom or a molecule in a liquid, part of the energy of the incident photon may be **used to excite the atom** of the liquid and the rest is scattered. The spectral line will have *lower frequency* and it is called stokes line.

Anti–stoke's line: If a photon strikes an atom or a molecule in a liquid, which is in an excited state, the scattered photon **gains energy**. The spectral line will have higher frequency and it is called Anti–stoke's line.

Rayleigh line: when a light photon strikes atoms or molecules, photons may be scattered elastically. Then the photons **neither gain norlose energy**. The spectral line will have unmodified frequency.

Raman Shift : $\Delta\nu = \nu_O - \nu_S$ where ν_o is the frequency of incident radiation. ν_S isthe frequency of scattered radiation.

- For Stoke's lines, $\Delta\nu$ is positive and for Anti–stoke's lines $\Delta\nu$ is negative.
- The Raman shift does not depend upon the frequency of the incident light but it is the characteristic of the substance producing Raman effect.
- The intensity of Stoke's line is always greater than the corresponding Anti–stoke's Line.



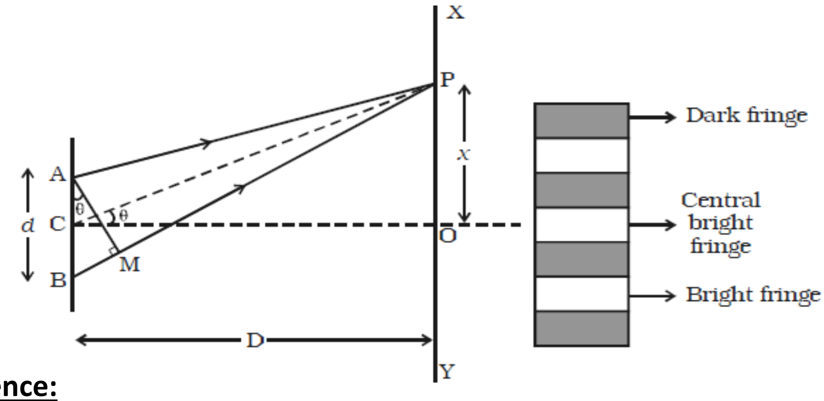
(ν = 0, 1, 2 .... are the vibration levels of the ground electronic state.)

2. *Derive an expression for bandwidth of interference fringes in Young's double slit experiment.*

Explanation:

- Let d be the distance between two coherent sources A and B of wavelength λ.
- A screen XY is placed parallel to AB at a distance D from the coherent sources.
- P is a point at a distance x from O. C is the midpoint of AB
- Waves from A and B meet at P in phase or out of phase depending upon the path difference between two waves.

Diagram:



Path Difference:

- The path difference δ = BP – AP
- δ = BP – AP = BP – MP = BM [AP = MP]
- In right angled Δ ABM, BM = d sin θ { If θ is small, sin θ = θ}
- *∴ The path difference δ = θ.d*
- *In right angled triangle COP,* $\tan\theta = \frac{OP}{CO} = \frac{x}{D}$ {small values of θ, tan θ = θ}

$$\boxed{\text{The path difference } \delta = \frac{xd}{D}}$$

Condition for Bright fringes: The path difference = nλ $\quad \therefore \frac{xd}{D} = n\lambda$

Wheren = 0,1,2 ..
$$\boxed{x = \frac{D}{d}n\lambda}$$

Condition for Dark fringes: The path difference = $(2n-1)\frac{\lambda}{2}$

$$\boxed{x = \frac{D}{d}(2n-1)\frac{\lambda}{2}}$$
where n = 1,2,3..

Band width (β): The distance between any two consecutive bright **or** dark bands is called bandwidth.

The distance between (n+1)th and nth order consecutive bright fringes from O is given by

$$x_{(n+1)} - x_n = \frac{D}{d}(n+1)\lambda - \frac{D}{d}n\lambda = \frac{D}{d}\lambda$$

$$\boxed{\text{Bandwitdth, } \beta = \frac{D}{d}\lambda}$$

3. *Explain emission and absorption spectra.*

Emission spectra:

When the light emitted directly from a source is examined with a spectrometer, the emission spectrum is obtained. Every source has its own characteristic emission spectrum.

1. Continuous emission spectrum:

- ✓ It consists of unbroken luminous bands of all wavelengths containing all the colours from violet to red.
- ✓ Eg: Incandescent solids, liquids, Carbon arc, electric filament lamps etc,

2. Line emission spectrum:

- ✓ Line spectra are sharp lines of definite wavelengths. It is the characteristic of the emitting substance. It is used to identify the gas.
- ✓ Eg: Atoms in the gaseous state, sodium in sodium vapour lamp

3. Band emission Spectrum:

- ✓ It consists of a number of bright bands with a sharp edge at one end but fading out at the other end.
- ✓ Eg: Calcium or Barium salts in a bunsen flame.

Absorption Spectra:

When the light emitted from a source is made to pass through an absorbing material and then examined with a spectrometer, the obtained spectrum is called absorption spectrum. It is the characteristic of the absorbing substance.

1. Continuous absorption spectrum:

- ✓ A pure green glass plate when placed in the path of white light, absorbs everything except green and gives continuous absorption spectrum.

2. Line absorption spectrum:

- ✓ Light from the carbon arc is made to pass through sodium vapour.
- ✓ Then examined by a spectrometer, a continuous spectrum of carbon arc with two dark lines in the yellow region is obtained.

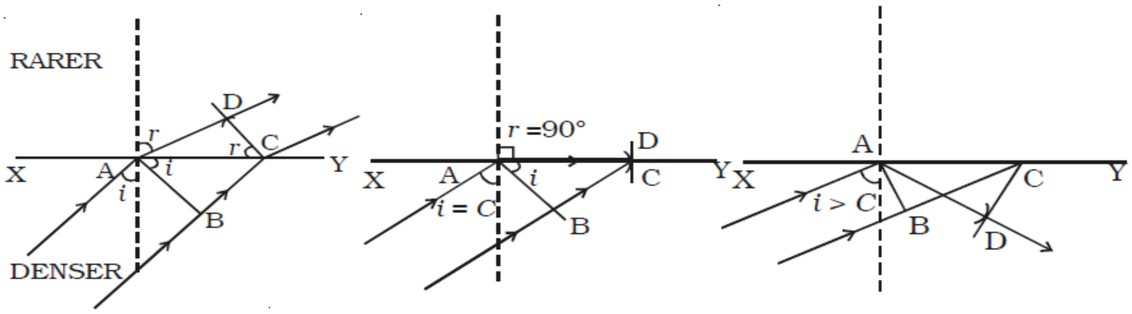
3. Band absorption spectrum:

- ✓ If white light is allowed to pass through iodine vapour or dilute solution of blood or solutions of organic and inorganic compounds, dark bands on continuous bright background are obtained.

4. On the basis of wave theory, explain total internal reflection.

1. Let XY be a plane surface which separates a rarer medium (air) and a denser medium.
2. C_a - velocity of the wavefront in air.
3. C_m - velocity of the wavefront in denser medium.
4. A plane wavefront AB passes from denser medium to rarer medium.
5. *i*--angle of incidence, *r* angle of refraction.

$$\frac{\sin i}{\sin r} = \frac{(BC/AC)}{(AD/AC)} = \frac{BC}{AD} = \frac{c_m t}{c_a t} = \frac{c_m}{c_a}$$



Since $\frac{c_m}{c_a} < 1$

i is less than r. This means that the refracted wavefront is deflected away from the surface XY.

S.No	Possibilities	$\sin r = \frac{AD}{AC}$	r	Refracted Wavefront
1	AD < AC	< 1	< 90°	Possible
2	AD = AC	= 1	= 90°	Just possible
3	AD > AC	>1	> 90°	Not possible

Note:

- The angle of incidence at which the angle of refraction is 90^0 is called the critical angle C.
- When the angle of incidence increases beyond the critical angle, the incident wavefront is totally reflected into the denser medium itself. This is called total internal reflection.

Condition:

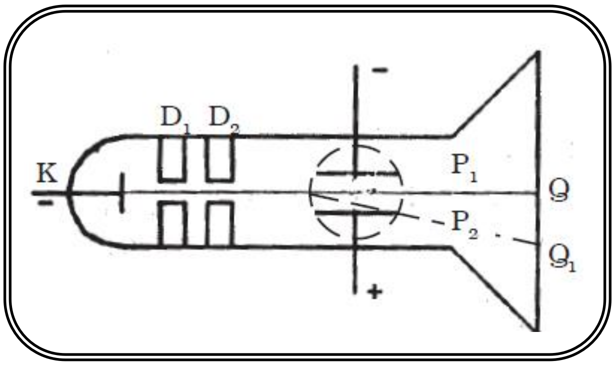
1. Light must travel from a denser medium to a rarer medium .
2. The angle of incidence inside the denser medium must be greater than the critical angle. i.ei> C.

Unit 6. Atomic Physics

1. Describe the J.J. Thomson method for determining the specific charge of electron.

Principle: cathode rays (electrons) are deflected by electric and magnetic fields.

Construction:



- A highly evacuated discharge tube used in this experiment. K-cathode, D_1, D2 are anode.
- A thin pencil of cathode ray passes between two parallel metal plates P_1 and P_2 and strike the flat face of the tube Q.
- When a potential difference V is applied between P_1 and P_2, the beam is deflected to point Q_1.
- Uniform magnetic field is produced perpendicular to the plane of the paper and outwards.

Determination of V:

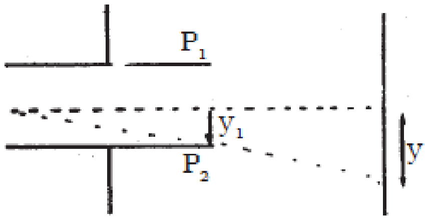
- Downward force Ee due to the electric field is balanced by the force Bev due to magnetic induction. Ee = Bev $\boxed{v = \frac{E}{B}}$

Determination of e/m:

- Now the magnetic induction is switched off. The deflection Q Q_1 = y caused by the electric field alone is measured.
- Velocity in the downward direction u = 0 ,acceleration $a = \frac{Ee}{m}$ and time $t = \frac{l}{v}$
- The deflection produced on the cathode rays along the downward direction is given by:

$$y_1 = \frac{1}{2}\left(\frac{Ee}{m}\right)\left(\frac{l}{v}\right)^2$$

- $$y_1 = \frac{1}{2}\left(\frac{Ee}{m}\right)\left(\frac{l^2}{E^2}\right)B^2 = \frac{1}{2}\frac{e}{m}\frac{l^2B^2}{E}$$
- **Y = K Y_1,** where K is a constant determined by the geometry of the discharge tube.
- $$y = K\frac{1}{2}\frac{e}{m}\frac{l^2B^2}{E}$$
- $$\boxed{\frac{e}{m} = \frac{2yE}{Kl^2B^2}}$$



- The value of e/m = 1.7592×10^{11} C kg^{-1}

2. State the postulates of Bohr atom model. Obtain the expression for the radius of the nth orbit of an electron based on Bohr's theory.

Quantization condition.

- The electrons can revolve round the nucleus only in allowed or permissible orbits.
- Angular momentum of the electron is an integral multiple of $\frac{h}{2\pi}$.

Frequency condition:

- An atom radiates energy, only when an electron jumps from a stationary orbit of higher energy to an orbit of lower energy. [hv = $E_2 - E_1$]

Explanation:

- Consider an atom whose nucleus has a positive charge Ze.
- Z → atomic number. e→charge of an electron.
- Let an electron revolve around the nucleus in the nth orbit of radius r_n.

Derivation:

1. The electrostatic force of attraction F = $\frac{1}{4\pi\varepsilon_o}\cdot\frac{(Ze)(e)}{r_n^2}$ ...(1)
2. Centripetal force of an electron F = $\frac{mv_n^2}{r_n} = mr_n\omega_n^2$ ...(2)
3. ($\frac{1}{4\pi\varepsilon_o}\cdot\frac{Ze^2}{r_n^2} = \frac{mv_n^2}{r_n}$ $\frac{1}{4\pi\varepsilon_o}\cdot\frac{Ze^2}{r_n^2} = mr_n\omega_n^2$
4. $\boxed{\omega_n^2 = \frac{Ze^2}{4\pi\varepsilon_o mr_n^3}}$ --------------(3)

1. The angular momentum of an electron in nth orbit is L = $m v_n r_n = mr_n^2\omega_n$
2. Bohr's first postulate, the angular momentum of the electron $L = \frac{nh}{2\pi}$
3. $mr_n^2\omega_n = \frac{nh}{2\pi}$ **(OR)** $\omega_n = \frac{nh}{2\pi mr_n^2}$
4. $\boxed{\omega_n^2 = \frac{n^2h^2}{4\pi^2m^2r_n^4}}$ ------------------(4)

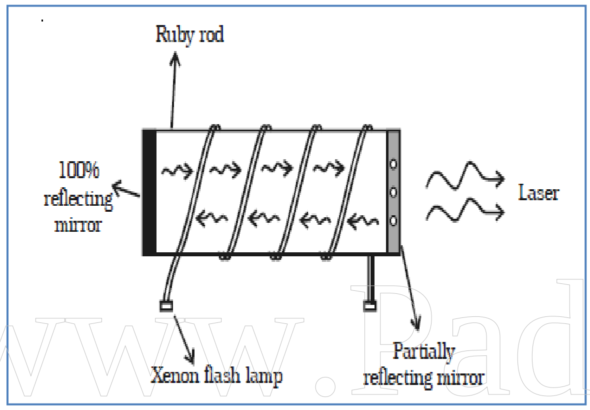
1. From (3) and (4) $\frac{Ze^2}{4\pi\varepsilon_o mr_n^3} = \frac{n^2h^2}{4\pi^2m^2r_n^4}$
2. $\boxed{r_n = \frac{n^2h^2\varepsilon_o}{\pi mZe^2}}$
3. For hydrogen atom, Z = 1 ; $r_n = \frac{n^2h^2\varepsilon_o}{\pi me^2}$; **ratio of radii :** 1: 4 : 9
4. Substituting the known values in the above equation we get, $\mathbf{r_n = n^2 \times 0.53}$ **Å**

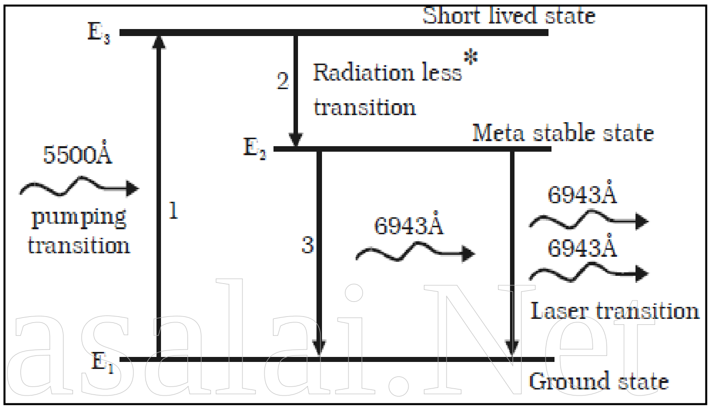
3. Explain the working of Ruby laser with neat sketch.

Construction:

1) The Ruby laser consists of a ***single crystal*** of ruby rod of length 10 cm and 0.8 cm in diameter.
2) A ruby is a crystal of **aluminium oxide Al_2O_3,** in which some of aluminium ions (Al^{3+}) are replaced by the chromium ions (Cr^{3+}).
3) The opposite ends of ruby rod are flat and parallel; one end is *fully silvered* and the other is *partially silvered* (i.e.) semi transparent.
4) The ruby rod is surrounded by a **helical xenon flash tube** which provides the pumping light to raise the chromium ions to upper energy level.

Energy level diagram:





Working:

Population inversion:

1) In normal state, most of the chromium ions are in the ground state E_1.
2) Chromium ions are pumped to the excited state E_3 by absorbing **5500 Å** flash of light.
3) The excited ion gives up part of its energy to the crystal lattice and decay without giving any radiation to the meta stable state E_2.
4) Since, the state E_2 has a much longer lifetime (10^{-3}s), the number of ions in this state goes on increasing.
5) Thus **population inversion** is achieved between the states E_2 and E_1.

LASER Transition:

6) When the excited ion from the meta stable state E_2 drops down spontaneously to the ground state E_1, it emits a photon of wavelength **6943 Å.**
7) This photon is **reflected back and forth** by the silvered ends and **emits a fresh photon in phase** with stimulating photon. It is called ***amplification by stimulated emission.***
8) Finally, a pulse of **red light of wave length 6943 Å** emerges through the partially silvered end of the crystal.

4. Explain the working of He–Ne laser with the help of energy level diagram.

Construction:

1. A continuous and intense laser beam can be produced with the help of **gas lasers**.
2. He – Ne laser system consists of a quartz discharge tube containing **helium and neon** in the ratio of **1 : 4** at a total pressure of about 1 mm of Hg.
3. One end of the tube is fitted with a **perfectly *reflecting mirror*** *and the other end with* ***partially reflecting mirror***.
4. A powerful **radio frequency generator** is used to produce a discharge in the gas, so that the helium atoms are excited to a higher energy level.

Working:

Population inversion:

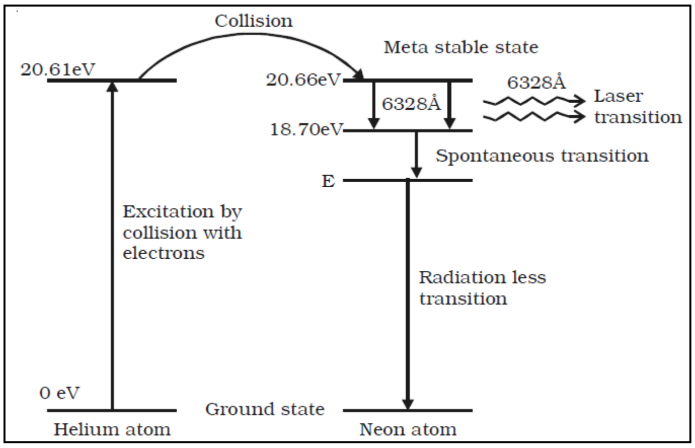
5. When an electric discharge passes through the gas *He*and *Ne* atoms are taken in to meta stable states of energy **20.61 eV and 20.66 eV.**
6. Some of the excited helium atoms transfer their energy to unexcited Ne atoms by collision.
7. Thus, He atom help in achieving a *population inversion* in Ne atoms.

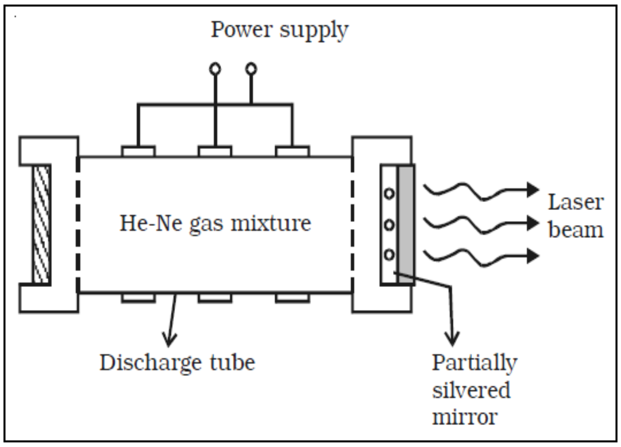
Laser Transition:

8. When an excited Ne atom drops down spontaneously from the meta stable state at **20.66 eV** to lower energy state at **18.70 eV,** it emits a **6328 Å** photon in the *visible region*.
9. This photon reflected back and forth by the reflector ends, and emits a fresh 6328 Å photon in phase with the stimulating photon.
10. This stimulated transition from 20.66 eV level to 18.70 eV level is the **laser transition.**

Final Transition:

11. The output radiations escape from the partially reflecting mirror.
12. The neon atoms drop down from the 18.70 eV level to lower state E, through spontaneous emission emitting incoherent light.
13. From this level E, the Ne atoms are brought to the ground state through collision with the walls of the tube. Hence the final transition is **radiation less.**





5. Describe Millikan's oil drop experiment to determine the charge of an electron.

Principle:

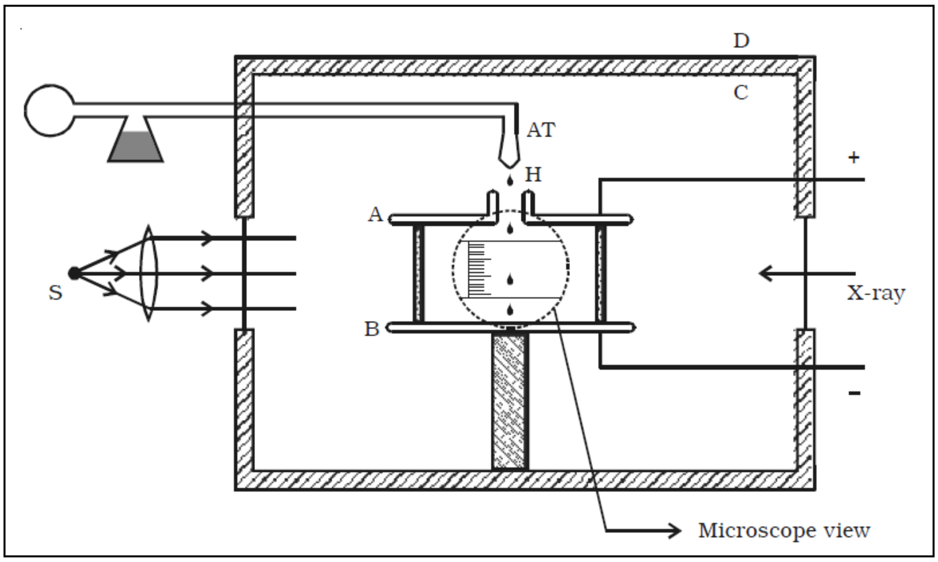
- This method is based on the study of the motion of uncharged oil drop under **free fall due to gravity** and charged oil drop in a uniform electric field.
- By adjusting uniform ***electric field suitably, a charged oil drop can be made to move up or down or even kept balanced*** in the field of view for sufficiently long time and a series of observations can be made.

Experimental arrangement:

1. The apparatus consists of two horizontal circular metal plates A and B, about **22 cm in diameter**and separated by a distance of about 16 mm.
2. The upper plate has a **hole**(H) in the middle.
3. These plates are held together by **insulating rods**. The plates are surrounded by a constant temperature bath D and the chamber C containing dry air
4. The plates are connected to a battery which can provide a potential difference of the order of **10000 V.**

Theory:

1. A spray of fine droplets of a highly viscous liquid (such as glycerine) is produced by means of an atomiser (AT) near the hole H and enter the space between A and B.
2. The droplets are illuminated by an arc lamp L and are seen through a microscope whose eyepiece is provided with a micrometer scale.
3. One such droplet is viewed through the microscope as it descends under gravity.
4. The viscous force due to air increases and soon it attains a constant terminal velocity and let it be *v*.



(i) Motion under gravity:

The gravitational force acting on the oil drop downwards = 4/3 $\pi a^3 \rho$ g

- a → radius of the oil drop,
- ρ →density of the oil
- g → the acceleration due to gravity.
- The upthrust experienced by the oil drop due to the displaced air =4/3 $\pi a^3 \sigma$ g
- σ → is the density of air.
- ∴**The net downward force acting on the oil drop** = weight of the oil drop – upthrust experienced by the oil drop.

$= 4/3\ \pi a^3 \rho g - 4/3\ \pi a^3 \sigma g$

$= 4/3\ \pi a^3 [\rho - \sigma]g$ ....(1)

The net downward force acting on the oil drop is equal to the viscous force {6 $\pi a \eta v$} acting opposite to the direction of motion of the oil drop.

$4/3\ \pi a^3 [\rho - \sigma]g = 6\pi a \eta v$ ....(2)

$$\boxed{a = \left[\frac{9\eta v}{2(\rho-\sigma)g}\right]^{\frac{1}{2}}}$$ ....(3)

(ii) Motion under electric field:

- The air inside the parallel plates is ionized by sending a beam of X-rays. The droplets pickup one or more electrons from the ionized air.

q →charge carried by the droplet

- E→electric field applied between the plates A and B
- v_1→terminal velocity.

  Since the velocity of the droplet is uniform,
- $Eq = 4/3\ \pi a^3 [\rho - \sigma]g + 6\pi a \eta v_1$
- $Eq - 4/3\ \pi a^3 [\rho - \sigma]g = 6\pi a \eta v_1$ ....(4)

  Adding equations (2) and (4),
- $Eq = 6\pi a \eta (v+v_1)$ ....(5)

  *Substituting the value of **a** in equation (5) from equation (3),*

$$Eq = 6\pi\eta^{3/2}(v+v_1)\left[\frac{9v}{2(\rho-\sigma)g}\right]^{\frac{1}{2}}$$ ....(6)

- *If V is the potential difference between A and B, d is the distance between them, then E =V/d.*
- The charge of an electron was found to be 1.602×10^{-19} coulomb.

8. NUCLEAR PHYSICS

1. *Discuss the principle and action of a Bainbridge mass spectrometer to determine the isotopic masses.*

Introduction: Bainbridge mass spectrometer is an instrument used for the accurate determination of atomic masses.

Construction and Working:

1. A beam of positive ions produced in a discharge tube is collimated into a fine beam by two narrow slits S_1 and S_2.
2. This fine beam enters into a velocity selector. The velocity selector allows the ions of a particular velocity to come out of it.
3. The velocity selector consists of two plane parallel plates P1 and P2, which produces a uniform electric field E and an electromagnet, to produce uniform magnetic field B.
4. The electric field and magnetic field are so adjusted that the deflection produced by one field is nullified by the other.

$$qE = Bqv \quad \text{(OR)} \quad \mathbf{v = E/B}$$

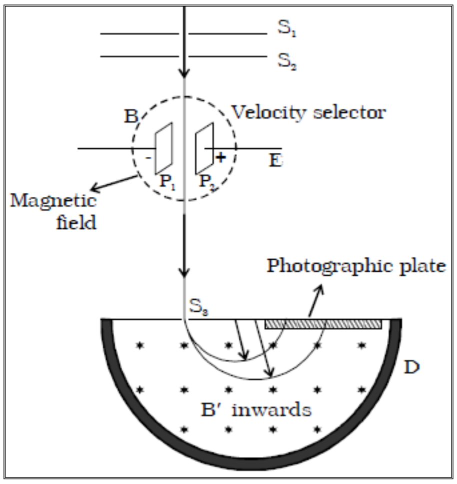
Effect of Magnetic field B':

5. Only those ions having this velocity v, pass out of the velocity selector and then through the slit S_3, to enter the evacuated chamber D.
6. These positive ions are subjected to another strong uniform magnetic field of induction B' at right angles to the plane of the paper acting inwards.
7. These ions are deflected along circular path of radius R and strike the photographic plate.

$$B'qv = \frac{mv^2}{R} \quad \textbf{(OR)} \quad m = \frac{B'qR}{v}$$

8. Substituting v = E/B

$$\boxed{m = \frac{BB'qR}{E}}$$



Measurement of R:

9. Ions with different masses trace semi-circular paths of different radii and produce dark lines on the plate.
10. The distance between the opening of the chamber and the position of the dark line gives the diameter 2R from which radius R can be calculated.

2. Obtain an expression to deduce the amount of the radioactive substance present at any moment. Obtain the relation between half life period and decay constant.

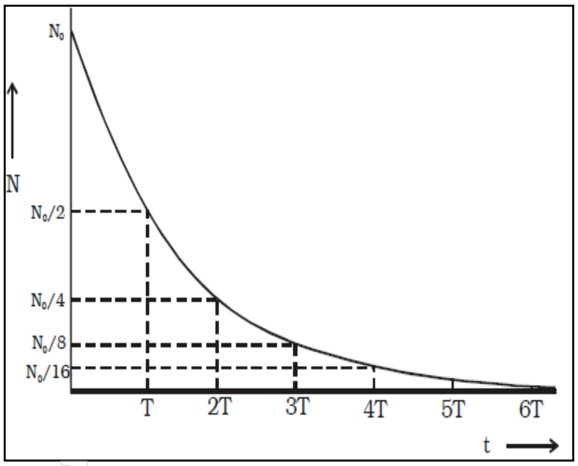
Statement: The rate of disintegration at any instant is directly proportional to the number of atoms of the element present at that instant.

- $N_0 \rightarrow$ Number of radioactive atoms present initially.
- $N \rightarrow$ Number of atoms at a given instant t.
- $dN \rightarrow$ number of atoms undergoing disintegration in a small interval of time dt.
- $\lambda \rightarrow$ decay constant

❖ The rate of disintegration is

$$-\frac{dN}{dt} \propto N \quad \text{-------------------------------(1)}$$

$$\frac{dN}{dt} = -\lambda N \quad \textbf{(OR)} \quad \frac{dN}{N} = -\lambda\, dt$$



❖ Integrating, $\log_e N = -\lambda t + C$ -----------------(2)

At t = 0, N = N₀ $\quad \therefore \log_e N_0 = C$

❖ Substituting for C, equation (2) becomes

$\log_e N = -\lambda t + \log_e N_0$

$$\log_e\left(\frac{N}{N_o}\right) = -\lambda t \quad \textbf{(OR)} \quad \frac{N}{N_o} = e^{-\lambda t}$$

$$\boxed{N = N_0\, e^{-\lambda t}}$$

❖ The number of atoms of a radioactive substance decreases exponentially with increase in time.

❖ Theoretically, an infinite time is required for the complete disintegration of all the atoms.

Half life period: The half life period of a radioactive element is defined as the time taken for one half of the radioactive element to undergo disintegration.

$$N = N_o e^{-\lambda t}$$

Let $T_{1/2}$ be the half life period. Then, at $t = T_{1/2}$, $N = \frac{N_0}{2}$

$$\therefore \quad \frac{N_0}{2} = N_o e^{-\lambda T_{1/2}}$$

$$\log_e 2 = \lambda T_{1/2}$$

$$T_{1/2} = \frac{\log_e 2}{\lambda} = \frac{\log_{10} 2 \times 2.3026}{\lambda} = \frac{0.6931}{\lambda}$$

❖ The half life period is inversely proportional to its decay constant.

❖ The half life and mean life(τ) are related as $T_{1/2} = \frac{0.6931}{\lambda} = 0.6931\ \tau$

3 .Explain the construction and working of a Geiger–Muller Counter.

Introduction: Geiger – Muller counter is used to measure the intensity of the radioactive radiation.

Principle: When nuclear radiations pass through gas, ***ionisation*** is produced. This is the principle of this device.

Construction:

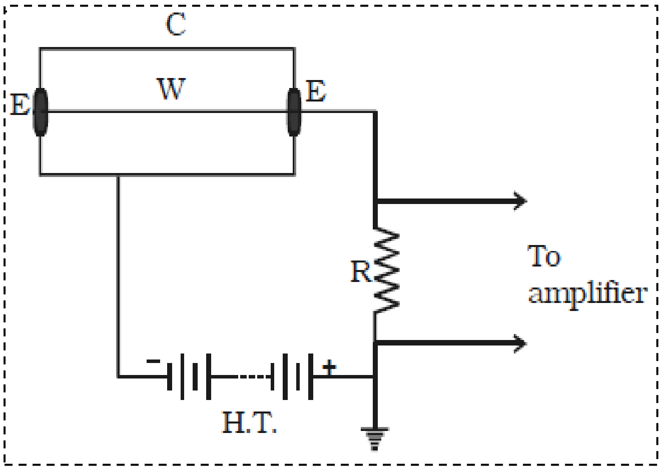
1. A metal tube with glass envelope (C) act as cathode.
2. A fine tungsten wire (W) along the axis of the tube acts as anode.
3. The tube is filled with an inert gas like argon at a low pressure.
4. One end is fitted with a thin mica sheet and this end acts as a window through which radiations enter the tube.
5. **1000 V** is applied between electrodes through a high resistance **100 mega ohm**.

Working:

- An ionising radiation enters the counter.
- Primary ionisation takes place and a few ions are produced.
- Due to high potential difference ions get greater energy and cause further ionisation.
- An *avalanche of electrons* is produced in a short interval of time.
- This avalanche of electrons on reaching the anode generates a current pulse.
- The current when passing through R develops a potential difference.
- This is amplified by electronic circuits and is used to operate an electronic counter.
- The counts in the counter is directly proportional to the intensity of the ionising radiation.

Draw back:

- The ionisation of the gas is independent of the type of the incident radiation.
- G.M. counter *does not distinguish* the type of radiation that enters the chamber.



4. What are cosmic rays? Explain the latitude effect of cosmic rays. Explain how the intensity of the cosmic rays changes with altitude.

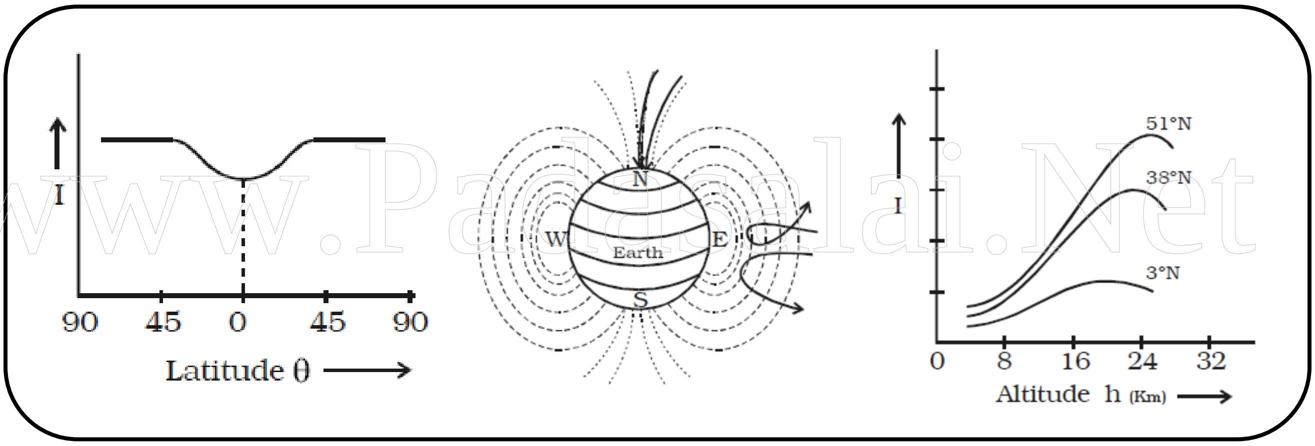
Cosmic Rays: The ionising radiation many times stronger than γ-rays entering the earth from all the directions from cosmic or interstellar space is known as cosmic rays.

Types:

- Primary and secondary cosmic rays.
- The primary cosmic rays consist of 90% protons, 9% helium nuclei and remaining heavy nuclei. The energy is in the order 10^8 MeV.
- Secondary cosmic ray consists of α-particles, protons, electrons, positrons, mesons, photons, etc. in different proportions.

Latitude effect: The variation of cosmic ray intensity with geomagnetic latitude is known as latitude effect.

- ❖ Intensity is maximum at the poles ($\theta = 90^0$),
- ❖ minimum at the equator ($\theta = 0$)
- ❖ Constant between latitudes of 42^0 and 90^0.



- ❖ The change in cosmic ray intensity is due to the earth's magnetic field.
- ❖ In poles the direction of charged particles and earth's magnetic field are in same. So they experience no force and reach the surface of earth.
- ❖ In equator the direction of charged particles is **perpendicular** to earth's magnetic field so they deflected away.

Altitude effect:

- ❖ The study of variation of cosmic ray intensity (I) with altitude (h) is known as altitude effect. The intensity increases with altitude and reaches a maximum at a height of about **20 km.**
- ❖ Above this height there is a fall in intensity. The experimental results are similar at different places of the earth.

5. What is a nuclear reactor? Explain the function of various parts. Give its uses.

Introduction: A nuclear reactor is a device in which the nuclear fission reaction takes place in a self sustained and controlled manner.

Uses:

- ✓ Nuclear reactors are mostly aimed at power production.
- ✓ Nuclear reactors are useful to produce radio-isotopes.
- ✓ Nuclear reactor acts as a source of neutrons, hence used in the scientific research.

Fissile material or fuel:

- ${}_{92}\mathbf{U}^{235}$, U^{233} and Pu^{239} are used as fuel.
- In pressurised heavy water reactors natural uranium oxide is used.

Moderator:

- ✓ It is used to slow down fast neutrons [2 MeV to 0.025 eV].
- ✓ The moderator is present in the space between the fuel rods in a channel.
- ✓ **Eg:** Ordinary water, heavy water and Graphite.

Neutron source:

- Neutron is required to initiate the fission chain reaction for the first time.
- **Eg:**A mixture of beryllium with plutonium **or** radium or polonium.

Control rods:

- ✓ The control rods are used to control the chain reaction.
- ✓ They arevery good absorbers of neutrons.
- ✓ The control rods are inserted into the core and they pass through the space in between the fuel tubes and through the moderator.
- ✓ **Eg:**Boron , cadmium boron carbide

The cooling system:

- The cooling system removes the heat generated in the reactor core.
- A good coolant must possess large specific heat capacity and high boiling point.
- **Eg:** Ordinary water, heavy water and liquid sodium [Boiling point : 1000° C].

Neutron reflectors:

- Neutron reflectors prevent the leakage of neutrons.
- In pressurised heavy water reactors the moderator itself acts as the reflector.
- In the fast breeder reactors depleted uranium is used.

Shielding:

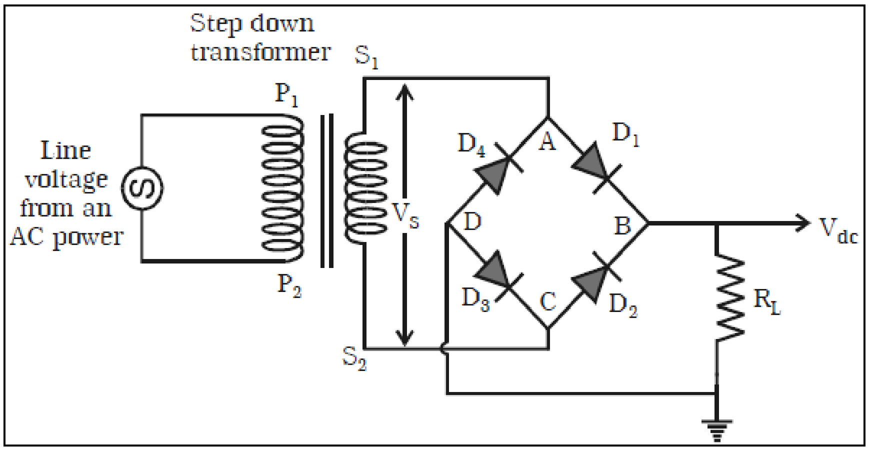
- As a protection against the harmful radiations, the reactor is surrounded by a concrete wall of thickness about 2 to 2.5 m.

9. SEMICONDUCTOR DEVICES AND THEIR APPLICATIONS

1.*What is rectification? Explain the working of bridge rectifier.*

Rectification: The process in which alternating voltage or alternating current is converted into direct voltage or direct current is known as rectification.

Diagram:



Construction:

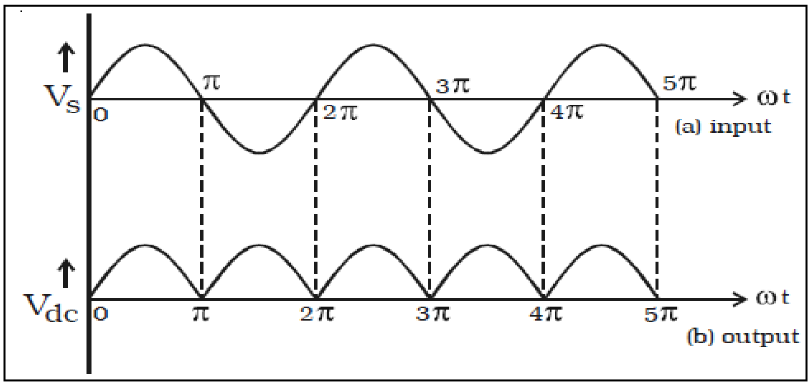
- Four diodes D_1, D_2, D_3 and D_4 are connected in the form a network.
- The input ends A and C are connected to the secondary ends S_1 and S_2 of the transformer.
- The output ends B and D are connected to the load resistance R_L.

Working:

Positive Half Cycle	Negative Half Cycle
1. D_1 and D_3 are forward biased and conduct.	1. D_2 and D_4 are forward biased and conduct.
2. D_2 and $D_4$are reverse biased and do not conduct.	2. D_1 and $D_3$are reverse biased and do not conduct.
3.Current flows along S_1ABDCS_2 through R_L	3. Current flows along S_2CBDAS_1 through RL.

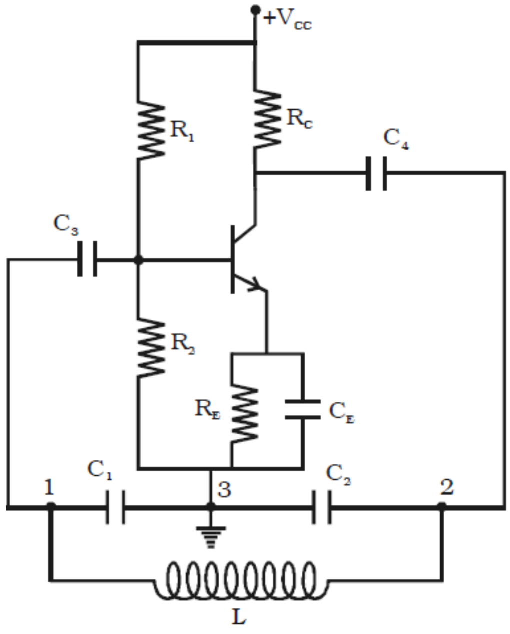
- Current flows through R_L in the same direction, during both half cycles of the input a.c. signals.
- The efficiency of the bridge rectifier is approximately 81.2%.

Input and output wave form:



2. Sketch the circuit of Colpitt's oscillator. Explain its working.

Construction:



1. *The resistance R_1, R_2 and R_E provide the sufficient bias for the circuit.*
2. *The frequency determining network is the parallel resonant circuits consisting of capacitors C_1, C_2 and the inductor L.Thejunction of C_1 and C_2 is earthed.*
3. *Thecapacitor C_4 blocksd.c and provide an a.c. path from the collector to the tankcircuit.*
4. *The voltage developed across C_1 provides the positive feedbackfor sustained oscillations.*

Working:

1. *When the collector supply voltage is switched on, the transient current produce damped harmonic oscillations.*
2. *The oscillations across C_1 are applied to the base emitter junction and appear in the amplified form in the collector circuit.*
3. *If terminal 1 is positive, terminal 2 will be negative with respect to terminal 3.*
4. *Hence points 1 and 2 are 180^o out of phase. The amplifier produces further phase shift of 180^o.*
5. *Thus the total phase shift is 360^o[energy supplied to the tank circuit is in phase with the oscillations]*
6. *if $A\beta = 1$, oscillations are sustained in the circuit.*
7. The frequency of oscillations is given by $f = \frac{1}{2\pi\sqrt{LC}}$

$$\text{where } C = \frac{C_1 C_2}{C_1 + C_2}$$

$$\therefore \quad f = \frac{1}{2\pi}\sqrt{\frac{(C_1 + C_2)}{L C_1 C_2}}$$

10.COMMUNICATION SYSTEMS

1.*Make an analysis of Amplitude Modulated wave with the help of frequency spectrum.*

- A carrier wave may be represented as : $e_C = E_C \cos\omega_c t$
- The modulating signal may be represented as: $e_S = E_S \cos\omega_S t$
- ec , Ec and ωc represent the instantaneous voltage, amplitude and angular frequency of the carrier wave.[similarly es , Es and ωs for signal wave]
- amplitude modulated wave is:

$$e = (E_c + E_s \cos\omega_s t)\cos\omega_c t$$

$$e = E_c\left[1+\left(\frac{E_s}{E_c}\right)\cos\omega_s t\right]\cos\omega_c t = E_c\left[1+m\cos\omega_s t\right]\cos\omega_c t$$

where m is the modulation factor which is equal to $\frac{E_s}{E_c}$.

$$\therefore\ e = E_c\cos\omega_c t + mE_c\cos\omega_c t\,.\,\cos\omega_s t$$

$$= E_c\cos\omega_c t + \frac{mE_c}{2}\left[2\cos\omega_c t\ \cos\omega_s t\right]$$

$$= E_c\cos\omega_c t + \frac{mE_c}{2}\left[\cos(\omega_c+\omega_s)t + \cos(\omega_c-\omega_s)t\right]$$

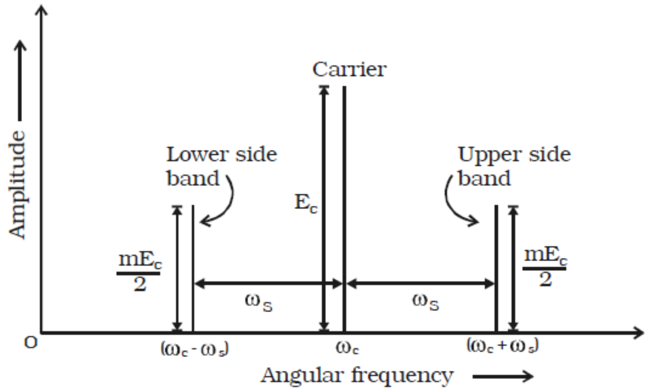
$$= E_c\cos\omega_c t + \frac{mE_c}{2}\cos(\omega_c+\omega_s)t + \frac{mE_c}{2}\cos(\omega_c-\omega_s)t$$

(i) $E_c\cos\omega_c t$: This component is same as the carrier wave.

(ii) $\frac{mE_c}{2}\cos(\omega_c+\omega_s)t$: This component has a frequency greater than that of the carrier and is called as the Upper Side Band (USB).

(iii) $\frac{mE_c}{2}\cos(\omega_c-\omega_s)t$: This component has a frequency lesser than that of the carrier and is called as the Lower Side Band (LSB).

Frequency spectrum:

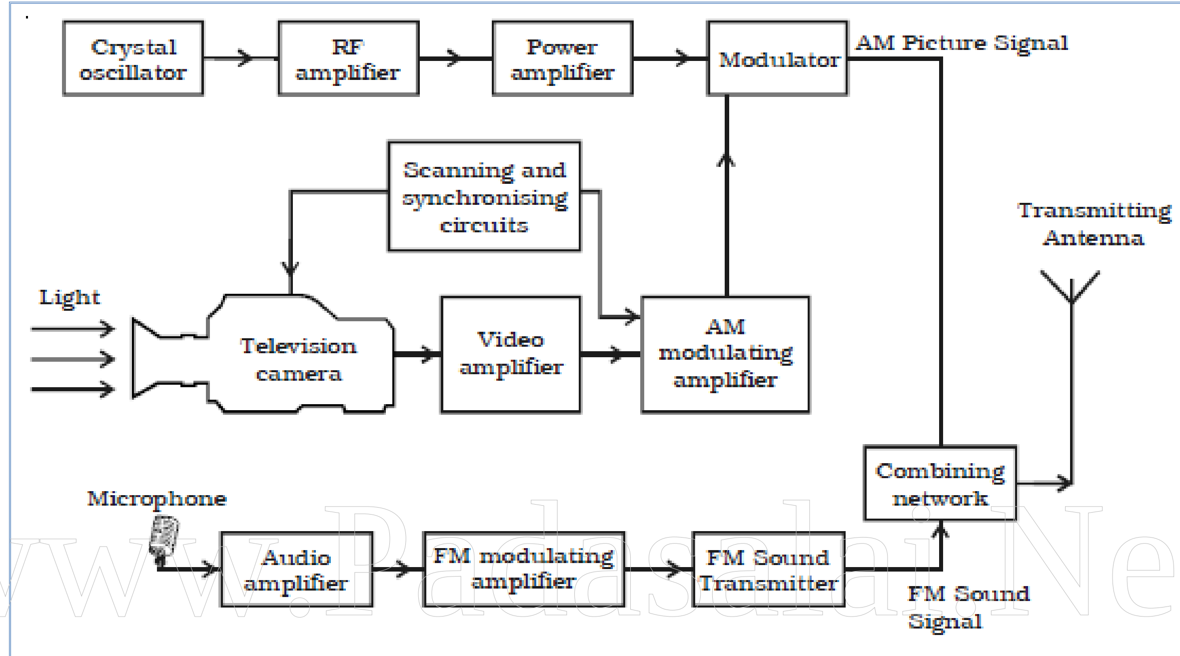


- LSB and USB are located ωs interval from carrier amplitude.
- The magnitude of both the upper and lower side bands is $\frac{m}{2}$ times the carrier amplitude Ec.
- If the modulation factor m is equal to unity, then each side band has amplitude equal to half of the carrier amplitude.

2. With the help of block diagram, explain the functions of various units in the monochrome television transmission.

(i)Introduction:

The functional block diagram can be broadly divided into two sections: (i) An amplitude modulated transmitter is used for video modulation. (ii) Frequency modulated transmitter is used for audio modulation.



Functional block diagram of a monochrome television transmitter

(ii)Scanning and synchronizing circuits:

1. They produce sets of pulses for providing synchronising pulses for proper functioning of the TV system.
2. This timing unit contains number of wave generating and wave shaping circuits.
3. The repetition rate of its various output pulse trains is controlled by a frequency stabilised master oscillator.

(iii) Video modulation:

4. The image signals together with the synchronising and blanking pulses are raised to a level suitable for modulating the RF carrier wave generated in the RF channel.
5. The allotted picture carrier frequency is generated by the crystal controlled oscillator.
6. The continuous wave output is given large amplification before feeding to the power amplifier.

7. In the modulator, its amplitude is made to vary in accordance with the modulating signal received from the modulating amplifier.

(iv) Audio modulation:

8. The microphone converts the sound associated with the picture into proportionate electrical signal.
9. The audio signal from the microphone after amplification is frequency modulated.

(v) Transmission section:

10. The output of the sound FM transmitter is finally combined with the AM picture transmitter output, through a *combining network* and fed to a common antenna for radiation of energy in the form of electromagnetic waves.

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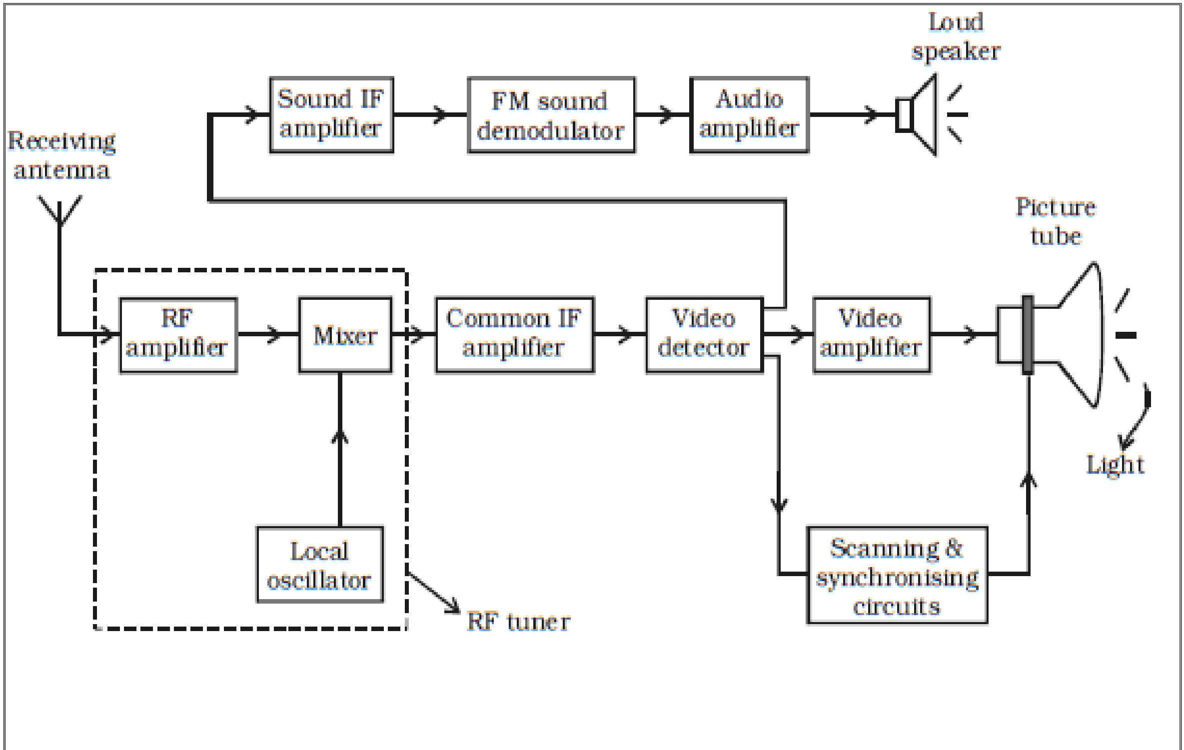
3. With the help of block diagram, explain the functional block diagram of a monochrome TV receiver.

(i)Antenna:

The receiving antenna intercepts radiated RF signals and the tuner selects the desired channel frequency band.



Elementary block diagram of a monochrome TV receiver

(ii)RF section:

1. The antenna provides RF picture and sound signals for the RF amplifier stage. The RF amplifier stage is then coupled into the mixer stage. The mixture is connected to the local oscillator.
2. The RF audio and video signals are heterodyned into intermediate frequency by the mixer and local oscillator.
3. The RF amplifier, mixer and local oscillator stages are combinely called as the RF tuner.

(iii)Common IF amplifier:

4. The output signal from the tuner circuit is amplified by using a common IF amplifier.

(iv)Detector:

5. The video and audio components are separated by a detector.

(v)Reproduction of sound:

6. The sound signals are detected from FM waves, amplified and then fed into the loud speaker, which reproduce the sound.

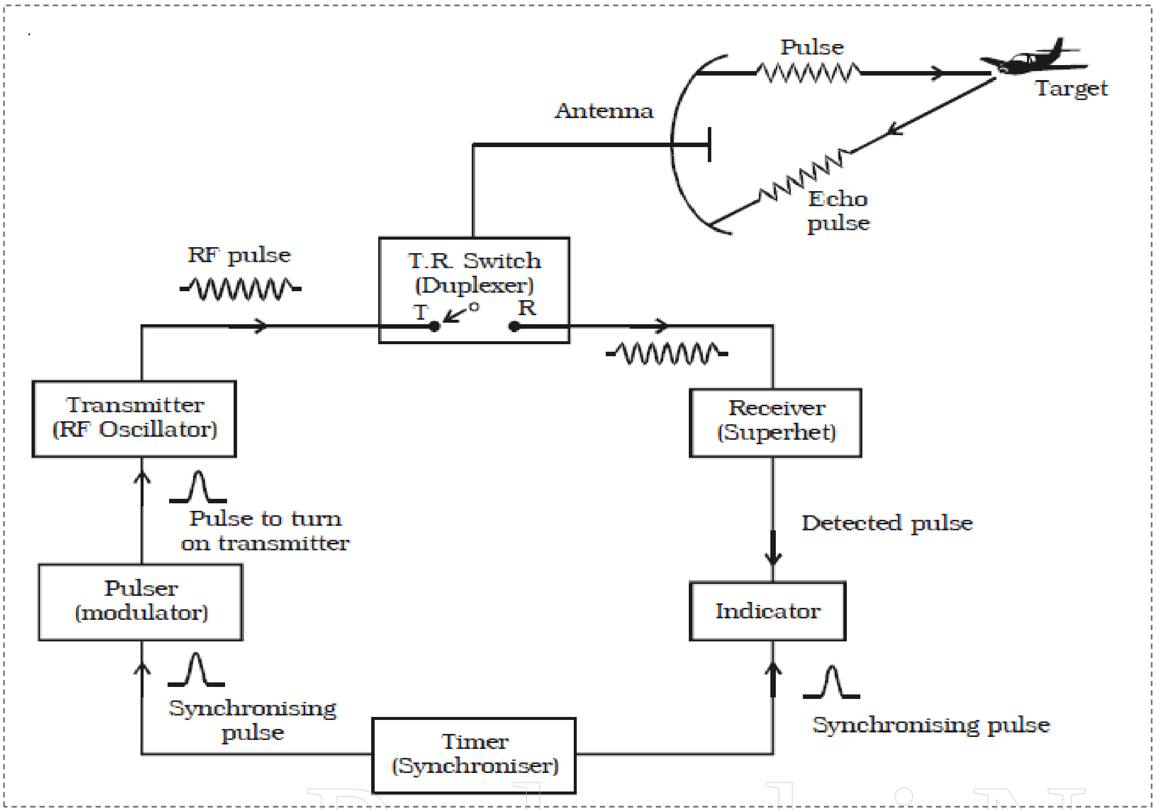
(vi)Reproduction of video:

7. Detector separates the picture signal from the synchronising pulses.
8. The line synchronising pulses and the frame synchronising pulses are fed into the horizontal and vertical deflector plates of the picture tube.
9. The blanking pulses are given to the control grid of the electron gun of the picture tube.

(vii)Picture formation:

10. The picture signals are applied to the filament of the electron gun of the picture tube.
11. According to the variations of potential in the picture, electrons are emitted from the electron gun.
12. Thus, the intensity of the fluorescent screen of the picture tube is in accordance with the variation of potential in the picture and the picture is reproduced.

4. Explain the principle and function of RADAR with neat block diagram.



Principle: Radio Echo

Transmission Section:

1. *The transmitter is a high power magnetron oscillatorwhich generates high power pulses of very short duration.*
2. *These short pulsesare fed to the antenna which radiates them into the space.*
3. *This transmitter is turned on andoff with a periodic pulse from the pulser.*
4. *TR switchconnects the antenna to the transmitter during transmission and to thereceiver during reception*

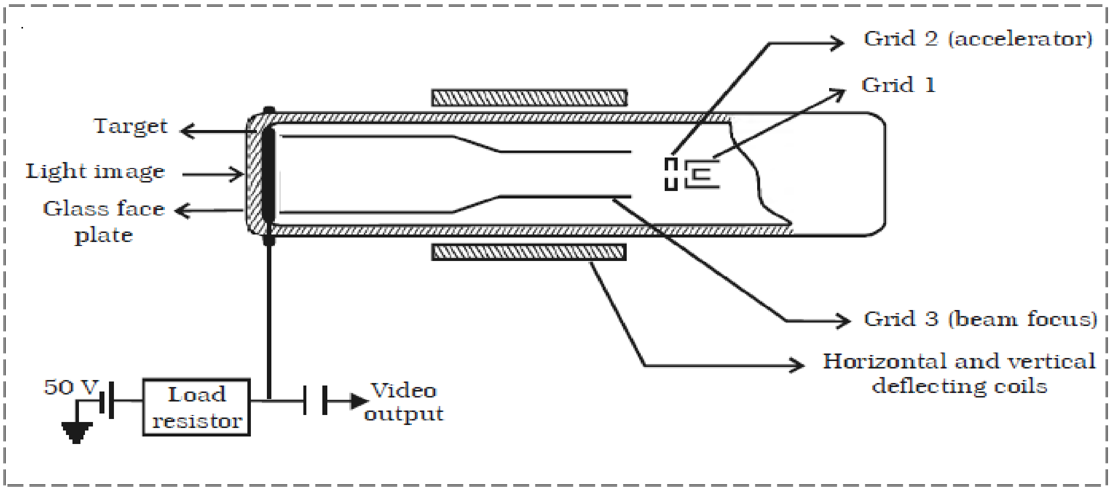
Reception Section:

1. If the transmitted pulse hits any target, a weak echo signalreturns to the same antenna.
2. This echo signal is amplified and demodulated by the superhet receiver.
3. The detected output is sent to the indicator[cathode ray tube].
4. The indicator records the transmitted pulse as well as the returning pulse simultaneously.
5. The returning echo pulse appears slightly displaced from the transmitted pulse and this displacement is a measure of the range of the target.

5.Explain the function of a Vidicon camera tube.

Vidicon camera is a television camera which converts the lightenergy into electrical energy.

Principle:photo conductivity, where the resistance of target material decreases when exposed to light.



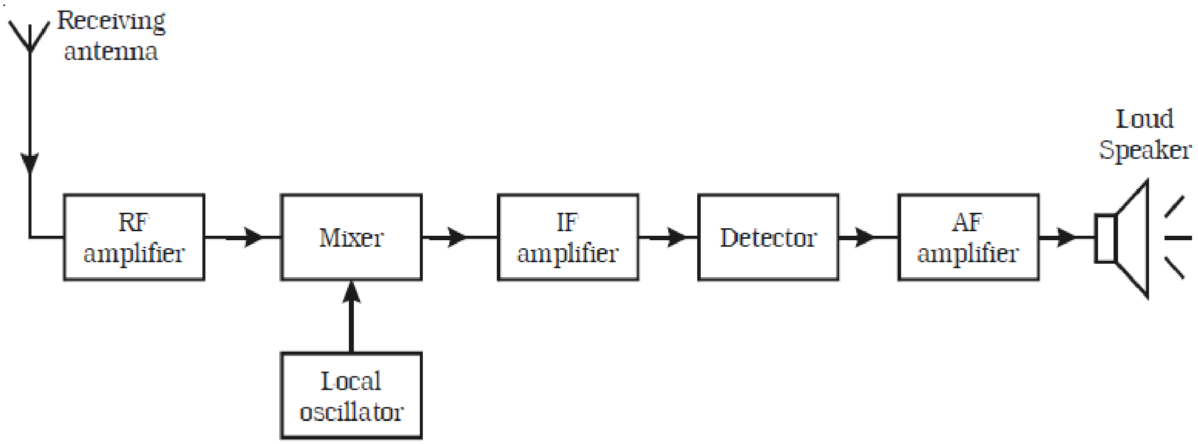
Construction:

1. The Vidicon consists of a glass envelope with an optically flat face plate.
2. A photosensitive, target platehas two layers.
   (i) A transparent to light but electrically conductivethin layer of tin oxide is in the front side.
   (ii)The other side of the target plate iscoated with a semiconductor, photosensitive antimony trisulphide.
3. The tin oxide layer is connected to a power supply of 50V.
   - Grid-1 is the electron gun
   - Grid-2 accelerate emitted electrons
   - Grid-3 focuses the accelerated electron on the photo conductive layer.
4. Verticaland Horizontal deflecting coilsare used to deflectthe electron beam for scanning the target.

Working:

5. The light from a scene passes through the face plate and tin oxide, incident on the photo conductive layer.
6. Due to the variations in the light intensity resistance of the photo conductive layer varies.
7. The emitted electrons from antimony trisulphide reach the positive tin oxide layer.
8. Each point on the photo conductive layer acquires positive charge. Hence a charge image that corresponds to the incident optical image is produced.
9. As the electron beam from the gun is incident on the charge image, drop in voltage takes place.
10. As a result, a varying current is produced. This current produces the video-signal output of the camera.

6. With the help of block diagram, explain the operation of a super heterodyne AM receiver.



(i) RF amplifier:

This stage selects the desired radio wave from antenna and enhances the strength of the wave to the desired level by using tuned parallel circuit.

(ii) Mixer and local oscillator:

1. The amplified output of RF amplifier and the output of a local oscillator beat together in the mixer stage and produce an intermediate frequency[IF=455 KHz].
2. The intermediate frequency is the difference between oscillator frequency and radio frequency.
3. Eg: If station frequency = 600 kHz, Local oscillator frequency will be 1055 KHz , so an intermediate frequency = 455 KHz

(iii) IF amplifier:

The output of the mixer circuit is fed to the tuned IF amplifier. This amplifier is tuned to one frequency (i.e. 455 KHz) and is amplified.

(iv) Detector:

The audio signals are extracted from the IF output using a diode detector for excellent audio fidelity.

(v) AF amplifier

The weakAF signal is amplified by the AF amplifier. Then the loud speaker converts the audio signal into sound waves corresponding to the original sound at thebroadcasting station.

ONE MARK QUESTIONS [JUNE 2016, SEPTEMBER, 2016 AND MARCH 2017]

1. A ray of light is incident normally on a glass surface of refractive index 1.5. The angle of refraction is
   a) 30° b) $\sin^{-1}(0.666)$ c) zero d) $\sin^{-1}(0.75)$

2. According to the laws of Boolean algebra, the expression (A+AB) is equal to :
   a) A b) AB c) B d) $\overline{A}$

3. In Newton's ring experiment, when a wavelength of light λ and a plano convex lens of radius of curvature 50cm is used, the radius of the 10th dark ring is $\sqrt{3}$ mm. Then with the same wavelength, a plano convex lens of radius of curvature 2m is used, the radius of the 10th dark ring is:
   a) 3mm b) $2\sqrt{3}$ mm c) $3\sqrt{3}$ mm d) $4\sqrt{3}$ mm

4. In an AC circuit containing only a capacitor the instantaneous current is given by equation i= $I_0 \sin\left(wt+\frac{\pi}{3}\right)$. The instantaneous emf is given by the equation:
   a) $e = E_0 \sin wt$ b) e= $E_0 \sin\left(wt-\frac{\pi}{6}\right)$
   c) $e = E_0 \sin\left(wt+\frac{5\pi}{6}\right)$ d) $e = E_0 \sin\left(wt+\frac{\pi}{6}\right)$

5. In radius of the nucleus which contains 64 nucleons is:
   a) 2.6F b) 5.2 F c) 10.4 F d) 7.8 F

6. The force between two charges situated in a medium of permittivity 'E' is:
   a) $\frac{\in}{4\pi}\frac{q_1q_2}{r^2}$ b) $9\times10^9 \in_r \frac{q_1q_2}{r^2}$
   c) $9\times10^9 \frac{q_1q_2}{r^2}$ d) $\frac{9\times10^9}{\in_r}\frac{q_1q_2}{r^2}$

7. In a multimeter, when the current scale shows full scale deflection, the ohmmeter scale reads
   a) Maximum but not infinity b) Infinity c) Zero d) Minimum but not zero

8. In a thermo couple, when the temperature of cold junction is increased (but less than neutral temperature) the temperature of inversion :
   a) increases b) decreases
   c) does not change d) first increases and then decreases

9. The instantaneous current in an AC circuit containing a pure inductor is i=I_0 sin wt. The instantaneous emf is :
   a) $e = E_0 \sin\left(wt+\frac{\pi}{2}\right)$ b) $e = E_0 \sin\left(wt-\frac{\pi}{2}\right)$
   c) $e = E_0 \sin(wt-\pi)$ d) $e = E_0 \sin(wt+\pi)$

10. The decay constant of a free neutron is :
    a) 0.013 minute^{-1} b) 0.053 minute^{-1} c) 3 minutes d) 0.069 minute^{-1}

11. In Raman effect, wavelength of incident light is 5990 A. The wavelength of stokes and antistokes lines are respectively:
    a) 5885 A and 5880 A
    b) 5895 A and 5900 A
    c) 5885 A and 5895 A
    d) 5895 A and 5885 A

12. In RLC series AC circuit at resonance :
    a) Resistance is zero
    b) Net reactance is zero
    c) Impedance is maximum
    d) voltage leads the current by a phase angle $\frac{\pi}{2}$

13. The resting frequency of FM transmitter is 98.5 MHz. The allowed minimum and maximum frequency on either side of the centre frequency are respectively :
    a) 98.400 MHz and 98.600 MHz
    b) 98.450 MHz and 98.550 MHz
    c) 98.425 MHz and 98.575 MHz
    d) 98 MHz and 99 MHz

14. Arrange electron (e), proton (p) and deuteron (d) in the increasing order of their specific charge :
    a) e,p,d
    b) d,p,e
    c) p,e,d
    d) d,ep

15. An LCR series circuit is connected to 240V A.C.supply. At resonance, the values of V_R, V_L and V_C are respectively:
    a) 80V, 80V and 80V
    b) 120V, 60V and 60V
    c) 240V, 120V and 120V
    d) 180V, 40V and 40V

16. In Raman effect, the wavelength of the incident radiation is 5890A. The wavelengths of Stokes' and anti-Stokes' lines are respectively:
    a) 5880A and 5900A°
    b) 5900 A and 5880 A°
    c) 5900 A and 5910 A°
    d) 5870 A and 5880 A°

17. In a Bainbridge mass spectrometer positive rays of the same element produce different traces. The traces correspond to :
    a) isotopes
    b) isobars
    c) isotones
    d) none of the above

18. Point charges q_1 and q_2 are placed in air a t a distance 'r'. The ratio of the force on charge q_1 by charge q_2 and force on charge q_2 by charge q_1 is:
    a) $\frac{q_1}{q_2}$
    b) $\frac{q_2}{q_1}$
    c) 1
    d) $\left(\frac{q_1}{q_2}\right)^2$

19. The colour code of a carbon resistor is, Brown, Black, Brown and Red. The value of the resistor is :
    a) $10\ \Omega \pm 5\%$
    b) $1\ \Omega \pm 2\%$
    c) 100 $\Omega \pm 2\ \%$
    d) $10\ \Omega \pm 2\%$

20. Light from a source is analysed by an analyser. When the analyser is rotated, the intensity of the emergent light :
    a) Does not vary
    b) Remains uniformly dark
    c) Varies between maximum and zero
    d) Varies between maximum and minimum

21. The threshold frequency of a photosensitive surface is $5\times10^{14}\,Hz$. Then which of the following will produce photoelectric effect from the same surface?
    a) Sodium vapour lamp
    b) Ruby laser
    c) He – Ne laser
    d) Both (b) and (c)

3 Marks:

1. A Galvanometer of resistance 100Ω which can measure the maximum current of 1 mA is converted in to an ohmmeter by connecting a battery of emf 1 V and fixed resistance of 900 Ω in series. When an external resistance is measured the current reading is 0.1 mA. Calculate the value of the resistance? **[March 2017]**

Solution:

$R = V/I_g$

$R = 1/0.1 \times 10^{-3} = 10000\ \Omega$

External resistance = R- G = 10000-100=**9000 Ω**

2. Calculate the power loss in the form of heat when a power of 11000 W is transmitted at 220 V.

Solution:

Power $P = VI$

$$\therefore \quad I = \frac{P}{V} = \frac{11,000}{220} = 50A$$

If R is the resistance of line wires,

Power loss $= I^2R = 50^2R = 2500(R)$ watts

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