Class-XII
Session - 2022-23
Subject - Physics (Theory)
Sample Question Paper - 32
With Solution

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Ch. No.	Chapter Name	Per Unit Marks	Section-A MCQs 1 Mark	Section-B SA 2 Marks	Section-C LA-I 3 Marks	Section-D LA-II 5 Marks	Section-E Case Study 4 Marks	Total Marks
1	Electric Charges and Fields			1 (Q. 21)				2
2	Electrostatic Potential and Capacitance	16	2 (Q. 1, 16)			1 (Q. 31)	1 (Q. 34)	11
3	Current Electricity				1 (Q. 27)			3
4	Moving Charges and Magnetism		1 (Q.3)	1 (Q.23)	1 (Q.26)			6
5	Magnetism and Matter		1 (Q.5)					1
6	Electromagnetic Induction	17	2 (Q. 2, 6)	1 (Q. 19)				4
7	Alternating Current		1 (Q. 4)			1 (Q. 32)		6
8	Electromagnetic Waves		2 (Q. 7, 18)					2
9	Ray optics and Optical Instruments	18	2 (Q. 8, 9)	1 (Q. 25)				4
10	Wave Optics		1 (Q. 17)	1 (Q. 20)		1 (Q. 33)	1 (Q. 35)	12
11	Dual Nature of Radiation and Matter		1 (Q. 10)		1 (Q. 29)			4
12	Atoms	12	1 (Q. 12)		1 (Q. 28)			4
13	Nuclei		1 (Q. 11)		1 (Q. 30)			4
14	Semiconductor Electronics: Materials, Devices and Simple Circuits	7	3 (Q. 13, 14, 15)	2 (Q. 22, 24)				7
	Total Marks (Total Questions)		**18 (18)**	**14 (7)**	**15 (5)**	**15 (3)**	**8 (2)**	**70 (35)**

NOTE : The number given inside the bracket denotes question number, ask in the sample paper, while the number given outside the bracket are the number of questions from that particular chapter.

Time Allowed : 3 Hours **Max. Marks : 70**

General Instructions

1. There are 35 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.
3. Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.
4. There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.

SECTION-A

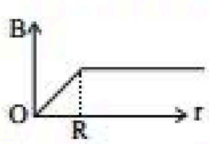
1. A charge Q is enclosed by a Gaussian spherical surface of radius R. If the radius is doubled, then the outward electric flux will
(a) increase four times (b) be reduced to half (c) remain the same (d) be doubled

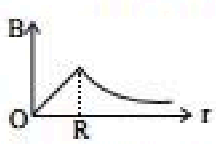
2. A magnet is moved towards a coil (i) quickly (ii) slowly, then the induced e.m.f. is
(a) larger in case (i) (b) smaller in case (i)
(c) equal in both the cases (d) larger or smaller depending upon the radius of the coil

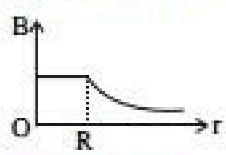
3. If both the number of turns and core length of an inductor is doubled keeping other factors constant, then its self-inductance will be-
(a) Unaffected (b) doubled (c) halved (d) quadrupled

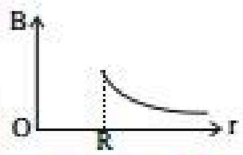
4. If the susceptibility of dia, para and ferromagnetic materials are χ_d, χ_p, χ_f respectively, then
(a) $\chi_d < \chi_p < \chi_f$ (b) $\chi_d < \chi_f < \chi_p$ (c) $\chi_f < \chi_d < \chi_p$ (d) $\chi_f < \chi_p < \chi_d$

5. An infinitely long hollow conducting cylinder with radius R carries a uniform current along its surface. Choose the correct representation of magnetic field (B) as a function of radial distance (r) from the axis of cylinder.

(a) 

(b) 

(c) 

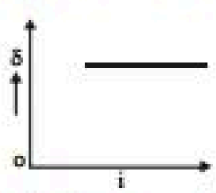
(d) 

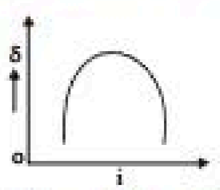
6. A current carrying conductor placed in a magnetic field experiences maximum force when angle between current and magnetic field is
(a) $3\pi/4$ (b) $\pi/2$ (c) $\pi/4$ (d) zero

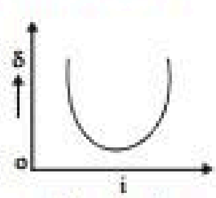
7. Select the wrong statement. EM waves
(a) are transverse in nature.
(b) travel in free space at a speed of light.
(c) are produced by accelerating charges.
(d) travel in all media with same speed.

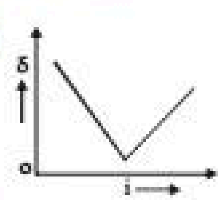
8. Light travels in two media A and B with speeds 1.8×10^8 ms^{-1} and 2.4×10^8 ms^{-1} respectively. Then the critical angle between them is
(a) $\sin^{-1}\left(\frac{2}{3}\right)$ (b) $\tan^{-1}\left(\frac{3}{4}\right)$ (c) $\tan^{-1}\left(\frac{2}{3}\right)$ (d) $\sin^{-1}\left(\frac{3}{4}\right)$

9. The graph between angle of deviation (δ) and angle of incidence (i) for a triangular prism is represented by

(a) 

(b) 

(c) 

(d) 

10. If the kinetic energy of a free electron doubles, it's de-Broglie wavelength changes by the factor
(a) 2 (b) $\frac{1}{2}$ (c) $\sqrt{2}$ (d) $\frac{1}{\sqrt{2}}$

11. In terms of Bohr radius r_0, the radius of the second Bohr orbit of a hydrogen atom is given by

(a) $4r_0$ (b) $8r_0$ (c) $\sqrt{2}r_0$ (d) $2r_0$

12. M_p denotes the mass of a proton and M_n that of a neutron. A given nucleus, of binding energy B, contains Z protons and N neutrons. The mass M(N, Z) of the nucleus is given by (c is the velocity of light)

(a) $M(N, Z) = NM_n + ZM_p + B/c^2$ (b) $M(N, Z) = NM_n + ZM_p - Bc^2$

(c) $M(N, Z) = NM_n + ZM_p + Bc^2$ (d) $M(N, Z) = NM_n + ZM_p - B/c^2$

13. If a small amount of antimony is added to germanium crystal

(a) it becomes a *p*–type semiconductor

(b) the antimony becomes an acceptor atom

(c) there will be more free electrons than holes in the semiconductor

(d) its resistance is increased

14. The drift current in a p-n junction is from the

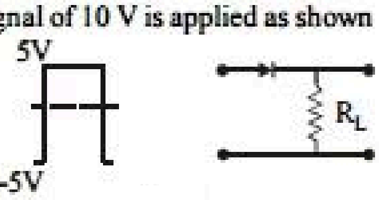
(a) n-side to the p-side

(b) p-side to the n-side

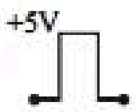
(c) n-side to the p-side if the junction is forward-biased and in the opposite direction if it is reverse biased

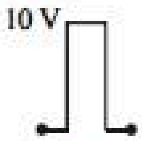
(d) p-side to the n-side if the junction is forward-biased and in the opposite direction if it is reverse-biased

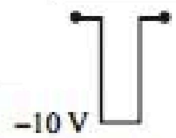
15. If in a p-n junction diode, a square input signal of 10 V is applied as shown



Then the output signal across R_L will be

(a) 

(b) 

(c) 

(d) 

For question numbers 16, 17 and 18, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false and R is also false

16. **Assertion (A) :** Electric potential and electric potential energy are different quantities.

Reason (R) : For a system of positive test charge and point charge electric potential energy = electric potential.

17. **Assertion (A) :** Interference pattern is made by using yellow light instead of red light, the fringes becomes narrower.

Reason (R) : In YDSE, fringe width is given by $\beta = \frac{D\lambda}{d}$ and $\lambda_y < \lambda_R$

18. **Assertion (A) :** The velocity of electromagnetic waves depends on electric and magnetic properties of the medium.

Reason (R) : Velocity of electromagnetic waves in free space is constant.

SECTION-B

19. A 28 turns coil with average diameter of 0.02m is placed perpendicular to a magnetic field of 8000 T. If the magnetic field changes to 3000 T in 4s, what is the magnitude of the induced emf?

20. Answer the following question :

(i) In what way is diffraction from each slit related to the interference pattern in a double slit experiment?

(ii) When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the centre of the shadow of the obstacle. Explain, why?

21. An electric dipole is held in a uniform electric field.

(i) Show that no translatory force acts on it.

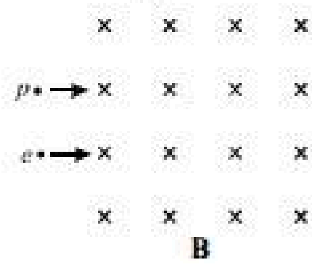
(ii) Derive an expression for the torque acting on it.

OR

Two point electric charges of unknown magnitude and sign are placed at a distance 'd' apart. The electric field intensity is zero at a point, not between the charges but on the line joining them. Write two essential conditions for this to happen.

22. What is depletion region? Explain how barrier is created in this region?

23. An electron and a proton moving with a same speed enter the same magnetic field region at right angles to the direction of the field. Show the trajectory followed by the two particles in the magnetic field. Find the ratio of the radii of the circular paths which the particles may describe.



24. How is p – n junction formed ? Explain.

25. Draw the ray diagram showing the formation of image of an object by the compound microscope.

OR

Explain with the help of lens maker's formula. Why does a convex lens behave as -

(i) Converging when immersed in water ($\mu = 1.33$) and

(ii) A diverging lens when immersed in CS_2 solution ($\mu = 1.6$).

SECTION-C

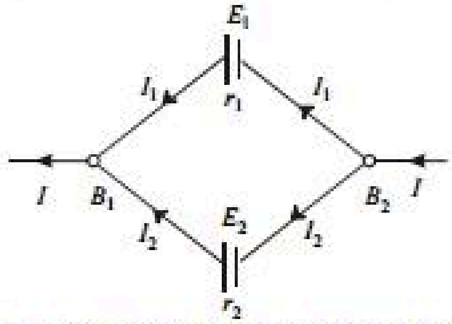
26. (a) Define the current sensitivity of a galvanometer.

(b) The coil area of a galvanometer is 25×10^{-4} m^2. It consists of 150 turns of a wire and is in a magnetic field of 0.15 T. The restoring torque constant of the suspension fibre is 10^{-6} N m per degree. Assuming the magnetic field to be radial, calculate the maximum current that can be measured by the galvanometer, if the scale can accommodate 30° deflection.

OR

State Biot-Savart law and give the mathematical expression for it.

How does a circular loop carrying current behave as a magnet?



27. Two cells of emf E_1 and E_2 having internal resistances r_1 and r_2 respectively are connected in parallel as shown. Deduce the expressions for the equivalent emf and equivalent internal resistance of a cell which can replace the combination between the points B_1 and B_2.

28. A 12.9 eV beam of electronic is used to bombard gaseous hydrogen at room temperature. Upto which energy level the hydrogen atoms would be excited ?
Calculate the wavelength of the first member of Paschen series and first member of Balmer series.

29. Sketch the graphs showing variation of stopping potential with frequency of incident radiations for two photosensitive materials A and B having threshold frequencies $v_A > v_B$.

(i) In which case is the stopping potential more and why ?

(ii) Does the slope of the graph depend on the nature of the material used ? Explain.

30 . The radius of nucleus of nucleon number 16 is 3×10^{-15} cm. Calculate the radius of nucleus of nucleon number 205.

OR

The Sun is believed to be getting its energy from the fusion of 4 p^+ to form a He nucleus and a pair of positrons. Calculate release of energy per fusion in Mev. $m(p^+) = 1.007825$ u. $m(e^+) = 0.000549$ u, $m(He) = 4.002603$ u, 1 a.m.u = 931.5 MeV.

SECTION-D

31. (i) Show that the effective capacitance, C of a series combination of three capacitors C_1, C_2 and C_3 is given by

$$C = \frac{C_1C_2C_3}{(C_1C_2 + C_2C_3 + C_3C_1)}$$

(ii) A parallel plate capacitor with air has a capacitance of 10 pF. If the distance between the plates is reduced to half and the space between them is filled with a material of dielectric constant 10, find the new capacitance.

OR

(i) A parallel plate capacitor is charged by a battery to a potential. The battery is disconnected and a dielectric slab is inserted to completely fill the space between the plates. How will

(a) its capacitance,
(b) electric field between the plates and
(c) energy stored in the capacitor be affected? Justify your answer giving necessary mathematical expressions for each case.

(ii) Sketch the pattern of electric field lines due to
(a) a conducting sphere having negative charge on it.
(b) an electric dipole.

32. Show diagramatically two different arrangements used for winding the primary and secondary coils in a transformer. Assuming the transformer to be an ideal one, write expression for the ratio of it's.
(i) Output voltage to input voltage.
(ii) Output current to input current.
Mention the reasons for energy losses in an actual transformer.

OR

What is impedance? Give its SI unit. Using the phasor diagram or otherwise derive an expression for the impedance of an a.c. circuit containing L, C and R in series. Find the expression for resonant frequency.

33. (a) Using Huygen's construction of secondary wavelets explain how a diffraction pattern is obtained on a screen due to a narrow slit on which a monochromatic beam of light is incident normally.
(b) Show that the angular width of the first diffraction fringe is half that of the central fringe.
(c) Explain why the maxima at $\theta = \left(n + \frac{1}{2}\right)\frac{\lambda}{a}$ become weaker and weaker with increasing n.

OR

Define the term wavefront. State Huygen's principle.
Consider a plane wavefront incident on a thin convex lens. Draw a proper diagram to show how the incident wavefront traverses through the lens and after refraction focusses on the focal point of the lens, giving the shape of the emergent wavefront.

SECTION-E

34. Case Study: Electrostatic Potential
Read the following paragraph and answer the questions.
Electrostatic potential at a point in an electric field is *the minimum work done by an external agent in moving a unit positive charge from infinity or a reference point to that point against the electrical force of the field.*
An equipotential surface is that at every point of which electric potential is same.
(i) Is electrostatic potential necessarily zero at a point where electric field strength is zero.
(ii) Write down the relation between electric field and potential at a point.
(iii) Draw an equipotential surface in a uniform electric field.

OR

(iii) What is an equipotential surface? Show that the electric field is always directed perpendicular to an equipotential surface.

35. Case Study: Interference of Light
Read the following paragraph and answer the questions.
When two coherent sources interact with each other, there will be production of alternate bright and dark fringes on the screen. Young's double-slit experiment demonstrates the idea of making two coherent sources. For better visibility, one has to choose proper amplitude for the sources. The phenomena is good enough to satisfy the conservation of energy principle. The pattern formed in YDSE is of uniform thickness and is nicely placed on a long distance screen.
(i) The light waves from two coherent sources have same intensity $I_1 = I_2 = I_0$. In interference pattern the intensity of light at minima is zero. What will be the intensity of light at maxima ?
(ii) The path difference between two interfering waves at a point on screen is 171.5 times the wavelength. If the path difference is 0.01029 cm. Find the wavelength.
(iii) What is the effect on the interference fringes in a Young's double slit experiment when slits are of unequal width?

OR

(iii) Two beams of light of intensity I_1 and I_2 interfere to give an interference pattern. If the ratio of maximum intensity to that of minimum intensity is 25/9, then find I_1/I_2.

Solutions

SAMPLE PAPER-3

1. (c) By Gauss's theorem, $\phi = \frac{Q_{in}}{\epsilon_0}$
Thus, the net flux depends only on the charge enclosed by the surface. Hence, there will be no effect on the net flux if the radius of the surface is doubled. (1 mark)

2. (a) When the magnet is moved quickly, the rate of change of flux is larger. This implies larger emf is induced. (1 mark)

3. (b) $L = \mu_0 \frac{N^2}{l} A$

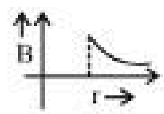
$L' = \mu_0 \frac{(2N)^2}{2l} A$

$\sin C = \frac{1}{\mu} = \frac{V_1}{V_2} = 2\mu_0 \frac{N^2}{l} A = 2L$ (1 mark)

4. (a) $\chi_d < \chi_p < \chi_f$ (1 mark)
For diamagnetic substance χ_d is small negative (10^{-5})
For paramagnetic substances χ_p is small and positive (10^{-3} to 10^{-5})
For ferromagnetic substanes χ_f is very large (10^3 to 10^5)

5. (d) $\vec{B} = O,\ r < R$

$= \frac{\mu_0 I}{2r},\ r \geq R$



So, $B = 0, r < R$

$\propto \frac{1}{2}, r \geq R$. Therefore graph will be as such (1 mark)

6. (b) $F = iBl\sin\theta$. This is maximum when $\sin\theta = 1$ (1 mark) or $\theta = \pi/2$.

7. (d) The speed of EM-waves depends on the properties of the medium. (1 mark)

8. (d) $\sin C = \frac{1}{\mu} = \frac{v_1}{v_2} \Rightarrow C = \sin^{-1}\left(\frac{v_1}{v_2}\right) = \sin^{-1}\left(\frac{3}{4}\right)$ (1 mark)

9. (c) For the prism as the angle of incidence (i) increases, the angle of deviation (δ) first decreases goes to minimum value and then increases. (1 mark)

10. (d) de-Broglie wavelength,

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2.m.(K.E)}}\ \therefore\ \lambda \propto \frac{1}{\sqrt{K.E}}$

If K.E is doubled, λ becomes $\frac{\lambda}{\sqrt{2}}$ (1 mark)

11. (a) As $r \propto n^2$, therefore, radius of 2nd Bohr's orbit = $4r_0$ (1 mark)

12. (d) Mass defect $= \frac{B.E}{c^2}$ (1 mark)
Mass of nucleus = Mass of proton + mass of neutron – mass defect

13. (c) When small amount of antimony (pentavalent) is added to germanium crystal then crystal becomes n-type semi conductor. Therefore, there will be more free electrons than holes in the semiconductor. (1 mark)

14. (a) The drift current in p-n junction is from the n-side to the p-side. (1 mark)

15. (a) The current will flow through R_L when the diode is forward biased. (1 mark)

16. (c) Electrostatic potential = electrostatic potential energy per unit charge (1 mark)

17. (a) Fringe width, $\beta \propto \lambda$ (1 mark)

18. (b) Velocity of electromagnetic wave is a medium

$V_{medium} = \frac{1}{\sqrt{\mu\varepsilon}}$ (1 mark)

19. Given, n = 28, dB = 8000 – 3000 = 5000 T, dt = 4s

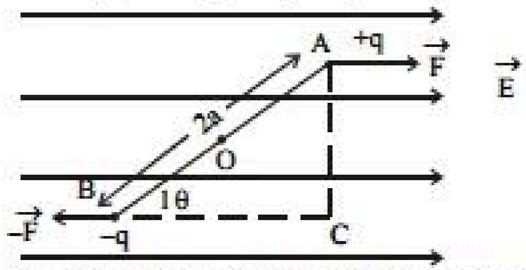
$d = 0.02$ m., $A = \frac{\pi d^2}{4} = \frac{22}{7} \times \frac{(0.02)^2}{4}$

$e = \frac{d\phi}{dt} = \frac{d}{dt}(nBA) = nA\frac{dB}{dt}$

$e = 28 \times \frac{22}{7} \times \frac{(0.02)^2}{4} \times \frac{5000}{4} = 11$ volt. (2 marks)

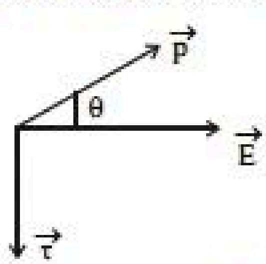
20. (i) The intensity of interference fringes in a double slit experiment is modulated by the diffraction pattern of each slit.
(ii) The waves diffracted from the edge of the circular obstacle interfere constructively at the centre of the shadow producing a bright spot. (1 + 1 mark)

21.



(i) Let the dipole AB is held in the uniform electric field $\overline{E}$ at an angle θ.
Force on + q = $q\overline{E}$ along $\overline{E}$.
and force on –q = – q $\overline{E}$ opposite to $\overline{E}$.
∴ Net force on the dipole = $q\overline{E} - q\overline{E} = 0$ (1 mark)
(ii) Two equal and parallel forces from a couple which will rotate the dipole in clockwise direction and tends to align it along the direction of the field.
∴ Torque = force × perpendicular distance between the forces

$\tau = F \times AC = qE \times AB\sin\theta$
$= qE \times 2a\sin\theta$
$\tau = pE\sin\theta$,
where $p = q \times 2a$
$\therefore\ \vec{\tau} = \vec{p} \times \overline{E}$



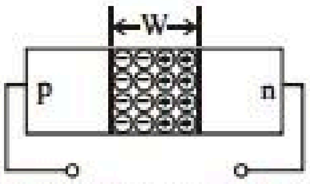
(1 mark)

OR

(a) The two charges are of opposite sign so that force will be attractive in nature.

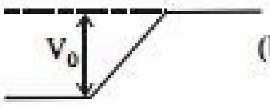
(b) The two charges have different magnitudes – the charge of smaller magnitude will be nearer to the point where the total field intensity is zero. (1 + 1 mark)

22. Electrons diffuse from $n \rightarrow p$ and holes diffuse from $p \rightarrow n$ side leaving a positively charged donor atom on n–side and negatively charged acceptor atom on p–side. This space charge region on either side is called depletion region. Near the junction this region depletes the movement of free charges. Hence, electric field due to positive space charge on n–side and negative space charge on p–side is created. Due to this electrons and holes now drift in opposite direction in this field and further extend this region.



Diode under equilibrium V = 0

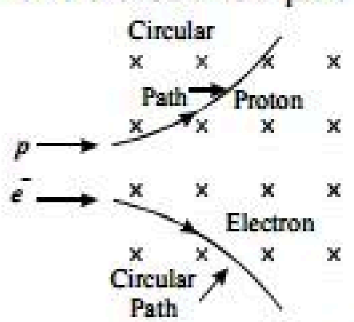
Thus a different polarity potential is developed which prevents movement of electron from n–region to p–region, called **barrier potential** and there is no net current.



(b) Barrier potential under no bias

(1 + 1 mark)

23. When a charged particle enters the magnetic field at right angle, then the particle experiences a magnetic force due to which it follows a circular path.



Radius of the circular path, $r = \frac{mv}{qB}$

For same speed v, and same charge

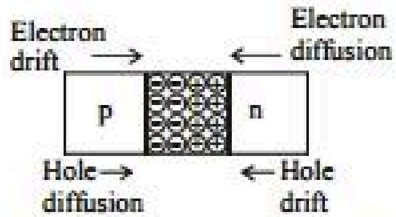
Magnetic field $r \propto m$

$\because$ As, $m_e < m_p$

$\Rightarrow$ therefore, $r_e < r_p$ (2 marks)

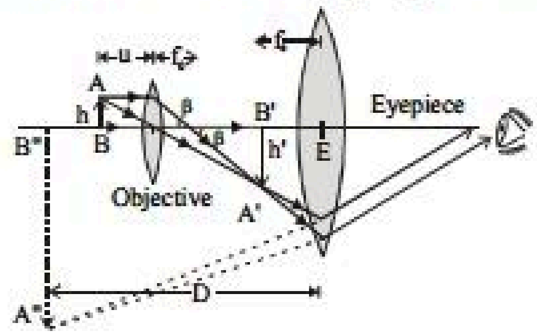
The curvature of path of Proton is much more and in opposite direction of the curvature of path of electron.

24. When p– and n– type semiconductors are joined in thin wafer form they form a junction. In p– type semiconductor concentration of holes is more and on n – side electrons are in majority, hence due to this gradient both electrons and holes diffuse to the other side leaving behind ionised donor and acceptor atoms which are immobile.



As charges diffuse a layer of negative charges (acceptor) is found on p–side and positive charges (donor) on n–side near the junction. This is depletion layer and creates an electric field due to which electrons on p– side move to n– side. This is called drift current. Thus space charge region of either side extends, forming p–n junction. (2 marks)

25.



(2 marks)

OR

As $\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

for lens material $\mu_2 = 1.5$

(i) If the convex lens is immersed in water ($\mu = 1.33$) its focal length will be positive hence it behaves as converging lens.

(ii) If the convex lens is immersed CS_2 solution ($\mu = 1.6$) its focal length will be negative hence it behaves as diverging lens. (1 + 1 mark)

26. (a) The current sensitivity of a galvanometer is defined as the deflection per unit current. (1 mark)

(b) Given :

$A = 25 \times 10^{-4}\ m^2$, $n = 150$

$B = 0.15\ T$, $C = 10^{-6}\ Nm$

$\theta = 30°$ $I = ?$

From the expression

$$I = \frac{c\theta}{nBA}$$

$$= \frac{10^{-6} \times 30}{150 \times 0.15 \times 25 \times 10^{-4}} = 5.3 mA$$ (2 marks)

OR

Biot-Savart law : For the magnetic field $\vec{dB}$ at a point P associated with a current element of length $\vec{d\ell}$ of a wire carrying a steady current I.

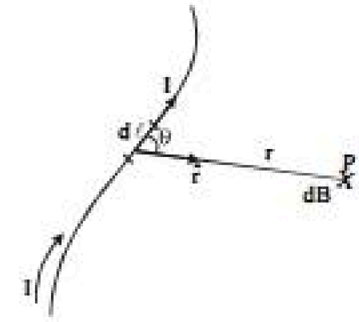
$dB \propto I$
$dB \propto d\ell$

$dB \propto \frac{1}{r^2}$

$dB \propto \sin\theta$

Combining all these

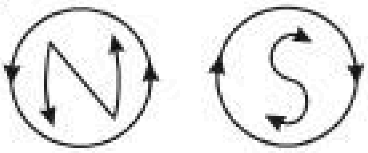
$dB \propto \frac{Id\ell \sin\theta}{r^2}$



or, $dB = \frac{\mu_0}{4\pi} \times \frac{I\,d\ell \sin\theta}{r^2}$ (1½ marks)

μ_0 is called **permeability of free space**

As current carrying loop has the magnetic field lines around it, thus it behaves as a magnet with two mutually opposite poles.



(1½ marks)

(a) (b)

The anticlockwise flow of current behaves like a north pole where clockwise flow as south pole. Hence, loop behaves as a magnet.

27. By Kirchhoff's current rule

$$I = I_1 + I_2$$

Across cell E_1, potential difference (V)

$$V = V_{B_2} - V_{B_1} = E_1 - I_1 r_1$$

Across cell E_2, potential difference (V)

$$V = V_{B_2} - V_{B_1} = E_2 - I_2 r_2$$

On solving above equations we get,

$$I_1 = \frac{E_1 - v}{r_1} \text{ and } I_2 = \frac{E_2 - v}{r_2}$$

$$\therefore \quad I = \left(\frac{E_1 - V}{r_1}\right) + \left(\frac{E_2 - V}{r_2}\right)$$

$$\Rightarrow \quad I = \left(\frac{E_1}{r_1} + \frac{E_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

$$V\left(\frac{r_1 + r_2}{r_1 r_2}\right) = \left(\frac{E_1 r_2 + E_2 r_1}{r_1 r_2}\right) - I$$

$$V = \left(\frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}\right) - I\left(\frac{r_1 r_2}{r_1 + r_2}\right)$$

Let equivalent emf and equivalent internal resistance of combination are E_{eq} and r_{eq}, then potential difference across combination is given

$$V = E_{eq} - Ir_{eq}$$

On comparing we get,

$$E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2} \text{ and } r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$$ (3 marks)

28. Energy of the electron in the n^{th} state of an atom is given

as, $E_n = \frac{-13.6Z^2}{n^2}$eV (1 mark)

Here, z is the atomic number of the atom.

For hydrogen atom, $z = 1$

Energy required to excite an atom from initial state (n_i) to final state (n_f)

$$= -\frac{13.6}{n_f^2} + \frac{13.6}{n_i^2}\text{eV}$$

This energy must be equal to or less than the energy of the incident electron beam.

$$\therefore -\frac{13.6}{n_f^2} + \frac{13.6}{n_i^2} = 12.9$$

Energy of the electron in the ground state $= \frac{13.6}{1^2} = -13.6$ eV

$$\therefore -\frac{13.6}{n_f^2} + 13.6 = 12.9 \Rightarrow 13.6 - 12.9 = \frac{13.6}{n_f^2}$$

$$n_f^2 = \frac{13.6}{0.7} = 19.43 \Rightarrow n_f = 4.4$$

State cannot be a fraction number.

$\therefore n_f = 4$

Hence, the hydrogen atom would be excited up to 4^{th} energy level. (1 mark)

Rydberg's formula for the spectrum of the hydrogen atom is given by,

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

Here, λ is the wavelength.

Rydberg's constant, $R = 1.097 \times 10^7 m^{-1}$

For the first member of the Paschen series:

$n_1 = 3$; $n_2 = 4$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left[\frac{1}{3^2} - \frac{1}{4^2}\right] \text{ or } \lambda = 18761 \text{ Å}$$

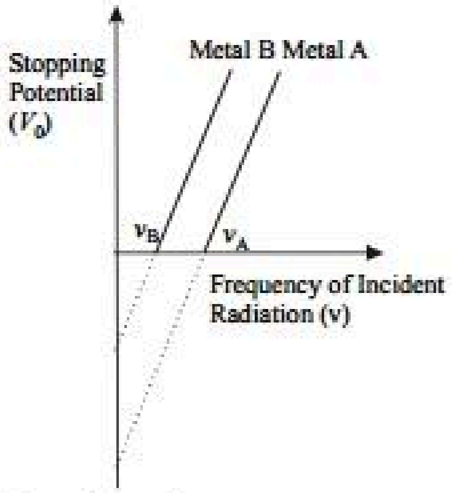
For the first member of Balmer series:

$n_1 = 2$

$n_2 = 3$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left[\frac{1}{2^2} - \frac{1}{3^2}\right] \quad \lambda = 6563 \text{ Å}$$ (1 mark)

29. Graph between stopping potential and the frequency of the incident radiation.



(1 mark)

From the graph,

(i) The stopping potential is inversely proportional to the threshold frequency. Hence the stopping potential is higher for metal B. (1 mark)

(ii) The slope of the graph does not depend on the nature of the material used

As we know,

$$K_{max} = h\nu - \phi_0 = eV_0$$

Dividing the whole equation by e, we get

$$\frac{h\nu}{e} - \frac{\phi_0}{e} = V_0$$

From the above equation, the slope of the graph is $\frac{h}{e}$ (on comparing with the straight line equation). Thus, we see that the slope is independent of the nature of the photoelectric material. (1 mark)

30. Using, $\frac{R_2}{R_1} = \left(\frac{A_2}{A_1}\right)^{1/3}$ where $A_1 = 16$, (1 mark)

$A_2 = 205$, $R_1 = 3 \times 10^{-15}$.

$\therefore \quad R_2 = R_1\left(\frac{205}{16}\right)^{1/3} = R_1(12.8)^{1/3} = 3 \times 10^{-15}(12.8)^{1/3}$

Solving $R_2 = 3 \times 10^{-15} \times 2.35 = 7.05 \times 10^{-15}$ m. (2 marks)

OR

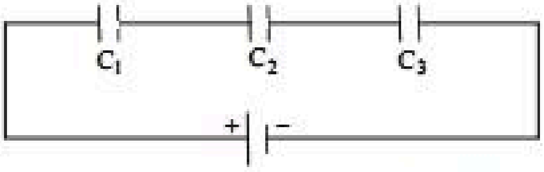
$$4\,^1_1H \longrightarrow \,^4_2He + 2(\,^{0}_{+1}e) + Q$$ (1 mark)

$\Delta m = 4 \times 1.007825 - 4.002603 - 2 \times 0.000549$

$= 0.0276$ u.

E fusion $= 0.0276 \times 931.5 = 25.7$ MeV (2 marks)

31. (i)



In series combination of capacitors, same charge lie on each capcitor for any value of capacitances. Also, potential difference across the combination is equal to the algebraic sum of potential differences across each capacitor i.e.,

$$V = V_1 + V_2 + V_3$$

As, $q = C_1V_1 \qquad \therefore V_1 = \frac{q}{C_1}$

Similarly, $V_2 = \frac{q}{C_2}$ $V_3 = \frac{q}{C_3}$ (½ mark)

$\therefore$ Total potential difference

$$V = \frac{q}{C_1} + \frac{q}{C_2} + \frac{q}{C_3} \Rightarrow \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

or, $C = \frac{C_1C_2C_3}{C_1C_2 + C_2C_3 + C_3C_1}$ (2½ marks)

(ii) Here $C_1 = \frac{\varepsilon_0 A}{d} = 10$ pF, $C_2 = \frac{k\varepsilon_0 A}{d/2}$

$= 10 \times 10 \times 2$ pF $= 200$ pF.

OR

(i) On introduction of dieletric slab in isolated charged capacitor.

(a) The capacitance (C') becomes K times of original capacitor as

i.e. $C' = \frac{K\varepsilon_0 A}{d}$ (1 mark)

(b) Charge remain conserved in the phenomenon.

$\phi = \phi'$

$$CV = C'V' \Rightarrow V' = \frac{CV}{C'} = \frac{CV}{KC}$$

or, $V' = \frac{V}{K}$

Potential difference decreases and become $\frac{1}{K}$ times of original value. (1 mark)

(c) Energy stored initially

$$U = \frac{q^2}{2C}$$

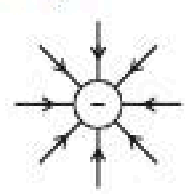
Energy stored later,

$$U' = \frac{q^2}{2(KC)} \quad [\because C' = KC]$$

$$\Rightarrow U' = \frac{1}{K}\left(\frac{q^2}{2C}\right) \Rightarrow U' = \frac{1}{K}(U)$$

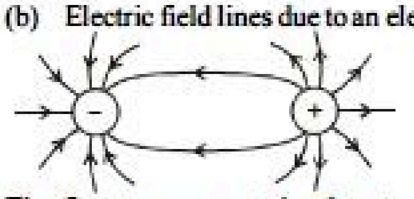
The energy stored in capacitor decrease and become $\frac{1}{K}$ times of original energy. (1 mark)

(ii) (a) Electric field lines due to a conducting sphere are shown in the figure.



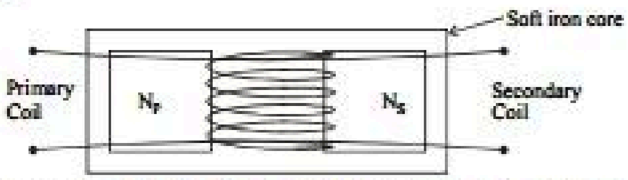
(1 mark)

(b) Electric field lines due to an electric dipole are shown

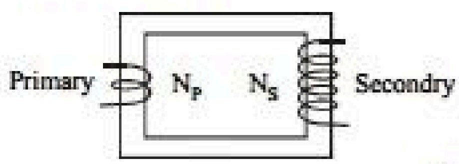


(1 mark)

32. The first arrangement is when two coils on top of each other.



The second arrangement is where two coils are wound on separate limbs of the core.



(½ mark)

Ratio of output voltage to input voltage, $\frac{E_S}{E_P} = \frac{N_S}{N_P}$

(1 mark)

Ratio of output current to input current, $\frac{I_S}{I_P} = \frac{N_P}{N_S}$

(1 mark)

Energy losses in a transformer

(i) **Copper loss:** Energy is lost as heat from the copper coils due to joule heating in the conducting wires.

(ii) **Iron loss:** Energy is lost as heat from the iron core of the transformer due to eddy current produced in the core. It can be minimised by the laminated core.

(iii) **Leakage of magnetic flux:** Due to this loss, magnetic flux linked with the primary will not be equal to that linked with secondary.

(iv) **Hysteresis loss:** Loss of heat energy due to repeated magnetisation and demagnetisation of the iron core.

(v) **Magnetostriction:** Humming noise of a transformer.

(2½ marks)

OR

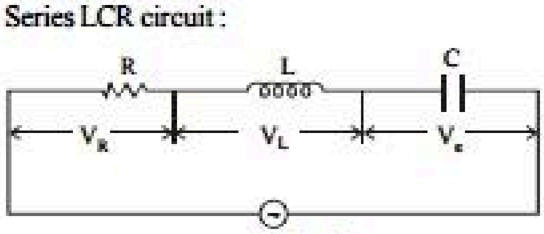
The obstruction posed by a circuit to the flow of a.c. is called its impedance (Z).

$$Z = \frac{V}{I} = \frac{\text{rms applied voltage}}{\text{rms current}}$$

(1 mark)

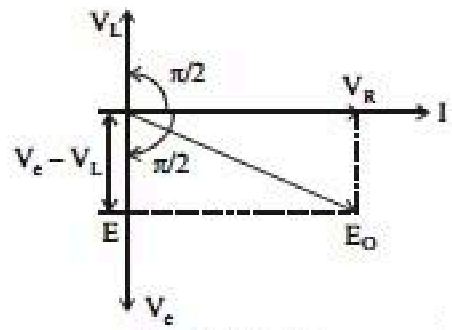
It's S.I. unit is ohm.

Series LCR circuit :



E = E_o sinωt

Series L-C-R circuit



Phasor diagram

(1 mark)

Consider a resistance (R), inductance (L) and capacitance (C) are connected in series and an alternating source of voltage $E = E_0 \sin \omega t$ is applied across it. Since they are connected in series, the current I flowing through all of them is same.

Let the voltage across the resistance R is V_R, voltage across inductance L is V_L and voltage across capacitance C is V_C. Since the current and the voltage across the resistor are in phase so they are represented by a phasor in the same direction. The voltage (V_L) across the inductor leads current by an angle $\pi/2$ while the voltage (V_C) across the capacitor lags behind the current by $\pi/2$. V_L and V_C are in opposite direction, so their resultant potential difference = $V_C - V_L$ (where $V_C > V_L$).

So the phasors V_R and ($V_C - V_L$) are perpendicular to each other. The resultant of them is equal to E, the applied instantaneous voltage.

$$\therefore \quad E^2 = V_R^2 + (V_C - V_L)^2$$

$$\Rightarrow \quad E = \sqrt{V_R^2 + (V_C - V_L)^2}$$

But $V_R = IR$, $V_C = X_C I$ and $V_L = X_L I$

where $X_C = \frac{1}{\omega C}$ and $X_L = \omega L$.

$$\therefore \quad E = \sqrt{I^2R^2 + (IX_C - IX_L)^2}$$

$$= I\sqrt{R^2 + (X_C - X_L)^2}$$

(2 marks)

$$\Rightarrow \quad Z = \sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}$$

The phase difference between voltage and current I can be given by the phase angle φ,

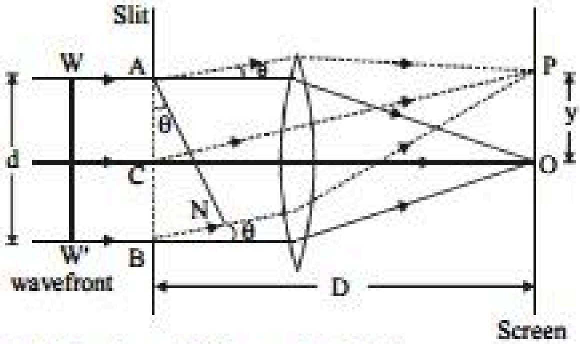
where, $\tan\varphi = \frac{X_C - X_L}{R}$

For resonance, $X_C - X_L = 0 \quad \therefore \varphi = 0$

Also, $\frac{1}{\omega C} = \omega L \Rightarrow \omega^2 = \frac{1}{LC}$

$\therefore$ Resonant frequency $= \omega_r = \frac{1}{\sqrt{LC}}$ (1 mark)

33. (a) A parallel beam of light with a plane wavefront WW' is made to fall on a single slit AB. As width of the slit AB = d is of the order of wavelength of light, therefore diffraction occurs on passing through the slit.



Diffraction of light at single slit

The wavelets from the single wavefront reach the centre O on the screen in same phase and hence interfere constructively to give central maximum (bright fringe).

The diffraction pattern obtained on the screen consists of a central bright band, having alternate dark and weak bright band of decreasing intensity on both sides.

Consider a point P on the screen at which wavelets travelling in a direction, making angle θ with CO, are brought to focus by the lens. The wavelets from points A and B will have a path difference equal to BN.

From the right angled Δ ANB, we have

BN = AB sin θ or BN = d sin θ (1 mark)

To establish the condition for secondary minima, the slit is divide into 2, 4, 6, ... equal parts such that corresponding wavelets from successive regions interfere with path difference of λ/2.

or for nth secondary minimum, the slit can be divided into 2n equal parts.

Hence, for nth secondary minimum, path difference = $d \sin \theta_n = n\lambda$

or $\sin \theta_n = \frac{n\lambda}{d}$ (n = 1, 2, 3, ...) (1 mark)

To establish the condition for secondary maxima, the slit is divided into 3, 5, 7, ... equal parts such that corresponding wavelets from alternate regions interfere with path difference of λ/2.

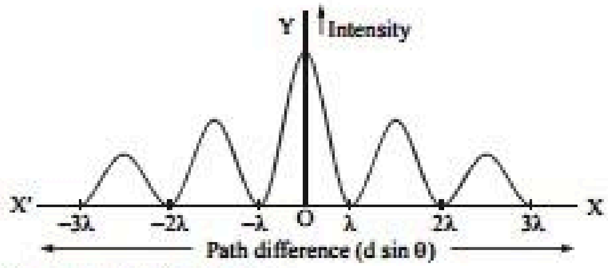
or for nth secondary maximum, the slit can be divided into (2n + 1) equal parts.

Hence, for nth secondary maximum,

$$d \sin \theta_n = (2n+1)\frac{\lambda}{2} \quad (n = 1, 2, 3, ...)$$

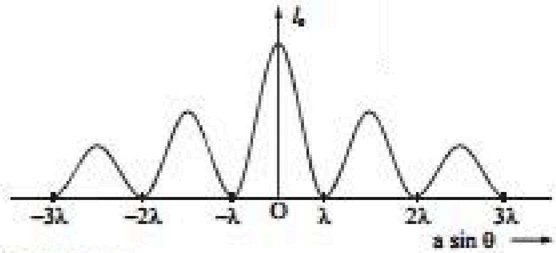
or $\sin \theta_n = (2n+1)\frac{\lambda}{2d}$ (1 mark)

Hence, the diffraction pattern can be graphically shown as below. The point O corresponds to the position of point with path difference, d sin θ = λ, 2λ, ... are secondary minima. The above conditions for diffraction maxima and minima are exactly reverse of mathematical conditions for interference maxima and minima.



(b) For central bright fringe,

$$\theta = 0^\circ$$



For first dark fringe,

$$a \sin \theta = \pm\lambda \text{ or } \sin \theta = \pm\frac{\lambda}{a}$$

If θ is small, then sin θ ≈ θ

So, $\theta = \pm\frac{\lambda}{a}$

So, the half angular width of central maximum is

$$\theta \approx \sin \theta = \frac{\lambda}{a}$$ (1 mark)

(c) On increasing the value of *n*, the part of slit contributing to the maximum decreases. Hence, the maxima becomes weaker. (1 mark)

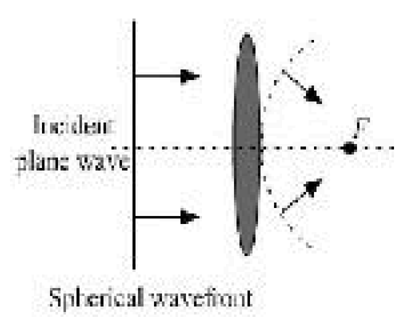
OR

Wavefront is defined as the locus of all the points in space that reach a particular distance by a propagating wave at the same instant. (1 mark)

Huygens Principle is based on the following assumptions:

Each point on the primary wavefront acts as a source of secondary wavelets, sending out disturbances in all directions in a similar manner as the original source of light does.

The new position of the wavefront at any instant (called secondary wavefront) is the envelope of the secondary wavelets at that instant. (2 marks)



(2 marks)

34. (i) No, it is not necessary.

$\because \quad E = -\frac{dV}{dr}$

$\therefore$ If V is constant, E will be zero.

Ex: The electric field inside a hollow spherical conductor is zero but potential is not zero. (1 mark)

(ii) Electric field, $E = -\frac{dV}{dr}$

i.e. electric field at a point is the negative of the electric potential gradient at that point. (1 mark)

(iii) It is a plane surface perpendicular to the electric field. (2 marks)

OR

(iii) An equipotential surface is that at every point of which electric potential is same. Consider two points A and B on the equipotential surface.

By definition, potential difference between two points A and B = work done in carrying a unit positive charge from A to B.

$\Rightarrow \quad V_A - V_B = W_{AB} = \bar{E}.d\bar{\ell}$

But $V_A = V_B \qquad \therefore \bar{E}.d\bar{\ell} = 0$

$\Rightarrow \quad Edl \cos\theta = 0 \Rightarrow \cos\theta = 0 \Rightarrow \theta = 90°$

$\therefore \quad \bar{E} \perp d\bar{\ell}$

$\therefore$ Electric field $(\bar{E})$ is directed perpendicular to the equipotential surface. (2 marks)

35. (i) Maximum intensity in interference pattern

$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(2\sqrt{I_0}\right)^2 = 4I_0.$ (1 mark)

(ii) Path difference $= 171.5\lambda = \frac{343}{2}\lambda$

= odd multiple of half wavelength .

It means dark fringe is observed.

According to question, $0.01029 = \frac{343}{2}\lambda$

$\Rightarrow \lambda = \frac{0.01029 \times 2}{343} = 6 \times 10^{-5}$ cm

$\Rightarrow \lambda = 6000$ Å. (1 mark)

(iii) When slits are of unequal width, then intensity of sources S_1 and S_2 is not equal. So, position of minimum intensity will not be completely dark. (2 marks)

OR

(iii) $\frac{I_{max}}{I_{min}} = \frac{25}{9}$ or $\left(\frac{a_1 + a_2}{a_1 - a_2}\right)^2 = \frac{25}{9}$

where a denotes amplitude.

$\frac{a_1 + a_2}{a_1 - a_2} = \frac{5}{3}$ or $5a_1 - 5a_2 = 3a_1 + 3a_2$

or, $5a_1 - 5a_2 = 3a_1 + 3a_2$ or $2a_1 = 8a_2$

or, $\frac{a_1}{a_2} = 4$ or $\left(\frac{a_1}{a_2}\right)^2 = 16 = \frac{I_1}{I_2}$. (2 marks)