Class-XII

Session - 2022-23

Subject - Physics (Theory)

Sample Question Paper - 29

With Solution

BLUE PRINT

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	16	3 (Q. 1, 3, 16)			1 (Q. 31)		8
2	Electrostatic Potential and Capacitance		1 (Q. 4)	1 (Q. 21)				3
3	Current Electricity		2 (Q. 5, 6)		1 (Q. 27)			5
4	Moving Charges and Magnetism	17	1 (Q. 2)			1 (Q. 32)		6
5	Magnetism and Matter		1 (Q. 7)					1
6	Electromagnetic Induction		2 (Q. 8, 9)	1 (Q. 22)			1 (Q. 35)	8
7	Alternating Current			1 (Q. 19)				2
8	Electromagnetic Waves	18	1 (Q. 10)					1
9	Ray optics and Optical Instruments		3 (Q.11, 12, 18)	1 (Q. 25)	1 (Q. 29)			8
10	Wave Optics			2 (Q. 20, 23)		1 (Q. 33)		9
11	Dual Nature of Radiation and Matter	12			1 (Q. 28)			3
12	Atoms						1 (Q. 34)	4
13	Nuclei		3 (Q. 13, 14, 17)	1 (Q, 24)				5
14	Semiconductor Electronics: Materials, Devices and Simple Circuits	7	1 (Q. 15)		2 (Q. 26, 30)			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. The force between two small charged spheres having charges of 1×10^{-7} C and 2×10^{-7} C placed 20 cm apart in air is
(a) 4.5×10^{-2} N (b) 4.5×10^{-3} N (c) 5.4×10^{-2} N (d) 5.4×10^{-3} N

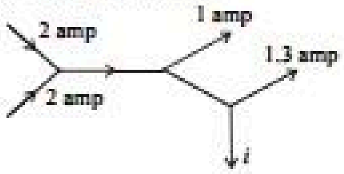
2. The coil of a moving coil galvanometer is wound over a metal frame in order to
(a) reduce hysteresis (b) increase sensitivity
(c) increase moment of inertia (d) provide electromagnetic damping

3. Two point charges +8q and – 2q are located at x = 0 and x = L respectively. The point on x axis at which net electric field is zero due to these charges is
(a) 8L (b) 4L (c) 2 L (d) L

4. The total charge on the system of capacitors $C_1 = 1$ μF, $C_2 = 2$ μF, $C_3 = 4$ μF and $C_4 = 3$ μF connected in parallel is : (Assume a battery of 20 V is connected to the combination)
(a) 200 μC (b) 200 C (c) 10 μC (d) 10 C

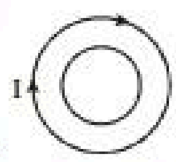
5. Two wires A and B of the same material, having radii in the ratio 1 : 2 and carry currents in the ratio 4 : 1. The ratio of drift speed of electrons in A and B is
(a) 16 : 1 (b) 1 : 16 (c) 1 : 4 (d) 4 : 1

6. The figure below shows currents in a part of electric circuit. The current i is
(a) 1.7 amp
(b) 3.7 amp
(c) 1.3 amp
(d) 1 amp



7. When the temperature of a magnetic material decreases, the magnetization
(a) decreases in a diamagnetic material (b) decreases in a paramagnetic material
(c) decreases in a ferromagnetic material (d) remains the same in a diamagnetic material

8. Two different wire loops are concentric and lie in the same plane. The current in the outer loop (I) is clockwise and increases with time. The induced current in the inner loop
(a) is clockwise
(b) is zero
(c) is counter clockwise
(d) has a direction that depends on the ratio of the loop radii.



9. When the current in a coil changes from 2 amp. to 4 amp. in 0.05 sec., an e.m.f. of 8 volt is induced in the coil. The coefficient of self inductance of the coil is
(a) 0.1 henry (b) 0.2 henry (c) 0.4 henry (d) 0.8 henry

10. Which is the correct ascending order of wavelengths?
(a) $\lambda_{visible} < \lambda_{X-ray} < \lambda_{gamma-ray} < \lambda_{microwave}$ (b) $\lambda_{gamma-ray} < \lambda_{X-ray} < \lambda_{visible} < \lambda_{microwave}$
(c) $\lambda_{X-ray} < \lambda_{gamma-ray} < \lambda_{visible} < \lambda_{microwave}$ (d) $\lambda_{microwave} < \lambda_{visible} < \lambda_{gamma-ray} < \lambda_{X-ray}$

11. An electromagnetic radiation of frequency n, wavelength λ, travelling with velocity v in air, enters a glass slab of refractive index μ. The frequency, wavelength and velocity of light in the glass slab will be respectively

(a) $\frac{n}{\mu}, \frac{\lambda}{\mu}$ and $\frac{v}{\mu}$ (b) $n, \frac{\lambda}{\mu}$ and $\frac{v}{\mu}$ (c) $n, 2\lambda$ and $\frac{v}{\mu}$ (d) $\frac{2n}{\mu}, \frac{\lambda}{\mu}$ and v

12. Two thin lenses are in contact and the focal length of the combination is 80 cm. If the focal length of one lens is 20 cm, then the power of the other lens will be
(a) 1.66 D (b) 4.00 D (c) –100 D (d) –3.75 D

13. When the number of nucleons in nuclei increases, the binding energy per nucleon
(a) increases continuously with mass number
(b) decreases continuously with mass number
(c) remains constant with mass number
(d) first increases and then decreases with increase of mass number

14. The nuclei of which one of the following pairs of nuclei are isotones?
(a) ${}_{34}Se^{74}, {}_{31}Ga^{71}$ (b) ${}_{38}Sr^{84}, {}_{38}Sr^{86}$ (c) ${}_{42}Mo^{92}, {}_{40}Zr^{92}$ (d) ${}_{20}Ca^{40}, {}_{16}S^{32}$

15. In ________ semiconductor, the fermi level lies in the energy gap, very close to conduction band.
(a) *p*-type (b) *n*-type (c) intrinsie (d) None of these

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) :** When a conductor is placed in an external electrostatic field, the net electric field inside the conductor becomes zero after a small instant of time.
Reason (R) : It is not possible to set up an electric field inside a conductor.

17. **Assertion (A) :** Density of all the nuclei is same.
Reason (R) : Radius of nucleus is directly proportional to the cube root of mass numbers.

18. **Assertion (A) :** Critical angle is minimum for violet colour.
Reason (R) : Because critical angle $\theta_c = \sin^{-1}\left(\frac{1}{\mu}\right)$ and $\mu \propto \frac{1}{\lambda}$.

SECTION-B

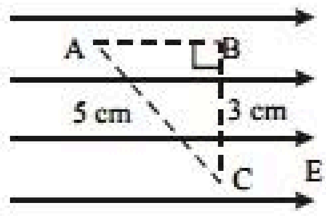
19. In an ideal transformer, the number of turns in the primary and secondary are 200 and 1000 respectively. If the power input to the primary is 10 kW at 200 V, calculate (i) output voltage and (ii) current in primary.

20. How will the interference pattern in Young's double slit experiment get affected, when
(i) distance between the slits S_1 and S_2 reduced and
(ii) the entire setup is immersed in water? Justify your answer in each case.

21. (i) Depict the equipotential surfaces for a system of two identical positive point charges placed a distance *d* apart.
(ii) Write the expression for the potential energy of a system of two point charges q_1 and q_2 brought from infinity to the points with positions r_1 and r_2 respectively in presence of external electric field *E*.

OR

A test charge, q is moved without acceleration from A to C along the path from A to B and then from B to C in electric field E as shown in the figure. (i) Calculate the potential difference between A and C. (ii) At which point (of the two) is the electric potential more and why?



22. (i) Define mutual induction.

(ii) A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20 A in 0.5 s, what is the change of flux linkage with the other coil?

23. Laser light of wavelength 630 nm incident on a pair of slits produces an interference pattern in which the bright fringes are separated by 7.2 mm. Calculate the wavelength of another source of laser light which produce interference fringes separated by 8.1 mm using same pair of slits.

24. (a) In a typical nuclear reaction, e.g.

$${}_1^2H + {}_1^2H \longrightarrow {}_2^3He + n + 3.27\ MeV$$

although number of nucleons is conserved, yet energy is released. How? Explain.

(b) Show that nuclear density in a given nucleus is independent of mass number A.

25. A telescope consists of an objective of focal length 75 cm and an eyepiece of focal length 5 cm. Calculate the minimum and maximum magnifying power of the telescope.

OR

A container is filled with two different liquids which do not mix. The liquid of refractive index 1.6 is 40 cm deep and the liquid of refractive index 1.5 is 30 cm deep. What is the apparent depth of the vessel when viewed normally?

SECTION-C

26. Compare n-type and p-type semiconductors.

27. A cell of emf 'E' and internal resistance 'r' is connected across a variable resistor 'R'. Plot a graph showing variation of terminal voltage 'V' of the cell versus the current 'I'. Using the plot, show how the emf of the cell and its internal resistance can be determined.

28. A deuteron and an alpha particle are accelerated with the same accelerating potential.
Which one of the two has

(a) greater value of de-Broglie wavelength, associated with it and

(b) less kinetic energy? Explain.

OR

(i) Monochromatic light of frequency 5.0×10^{14} Hz is produced by a laser. The power emitted is 3.0×10^{-3} W. Estimate the number of photons emitted per second on an average by the source.

(ii) Draw a plot showing the variation of photoelectric current versus the intensity of incident rediation on a given photosensitive surface.

29. An equiconvex lens of refractive index μ_1 focal length '*f*' and radius of curvature 'R' is immersed in a liquid of refractive index μ_2. For (i) $\mu_2 > \mu_1$, and (ii) $\mu_2 < \mu_1$, draw the ray diagrams in the two cases when a beam of light coming parallel to the principal axis is incident on the lens. Also find the focal length of the lens in terms of the original focal length and the refractive index of the glass of the lens and that of the medium.

30. Why do we say that an intrinsic semiconductor is like an insulator at 0 K?

OR

Describe full wave rectification by diode.

SECTION-D

31. (a) "The outward electric flux due to charge + Q is independent of the shape and size of the surface which encloses it." Give two reasons to justify this statement.

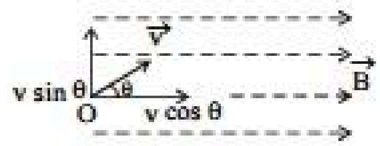
(b) Two large parallel plane sheets have uniform charge densities $+\sigma$ and $-\sigma$. Determine the electric field (i) between the sheets, and (ii) outside the sheets.

OR

(a) Define electric dipole moment. Is it a scalar or a vector? Derive the expression for the electric field of a dipole at a point on the equatorial plane of the dipole.

(b) Draw the equipotential surfaces due to an electric dipole. Locate the points where the potential due to the dipole is zero.

32. Describe the motion of a charged particle in a uniform magnetic field. Obtain an expression for the radius of the path of the charged particle moving perpendicular to uniform magnetic field. Show that the time taken to complete one revolution by the particle is independent of its speed.



OR

Two infinitely long straight parallel wires, '1' and '2', carrying steady currents I_1 and I_2 in the same direction are separated by a distance d. Obtain the expression for the magnetic field $\vec{B}$ due to the wire '1' acting on wire '2'. Hence find out, with the help of a suitable diagram, the magnitude and direction of this force per unit length on wire '2' due to wire '1'. How does the nature of this force changes if the currents are in opposite direction? Use this expression to define the S.I. unit of current.

33. (a) What is the phenomenon of diffraction?
(b) Why is the intensity maximum at the central maximum on the diffraction pattern?
(c) At what positions, secondary maxima and minima are obtained and, why is the intensity of light at secondary maxima less than that of central maximum in the diffraction pattern.

OR

(i) In a single narrow slit (illuminated by a monochromatic source) diffraction experiment, deduce the conditions for the central maximum and secondary maxima and minima observed in the diffraction pattern. Also explain why the secondary maxima go on becoming weaker in intensity as the order increases.
(ii) Answer the following questions
(a) How does the width of the slit affect the size of the central diffraction band?
(b) When a tiny circular obstacle is placed in the path of light from a distant source, why is a bright spot seen at the centre of the shadow of the obstacle?

SECTION-E

34. **Case Study: Energy Levels and the Line Spectra of Hydrogen Atom**

Read the following paragraph and answer the questions.

The energy levels of a hypothetical one electron atom as shown below.

$n = \infty$ ———————— 0 eV
$n = 5$ ———————— –0.80 eV
$n = 4$ ———————— –1.45 eV
$n = 3$ ———————— –3.08 eV
$n = 2$ ———————— –5.30 eV
$n = 1$ ———————— –15.6 eV

(i) Find the ionization potential of the atom.
(ii) Find the short wavelength limit of the series terminating at $n = 2$.
(iii) Find the excitation potential for the state $n = 3$.

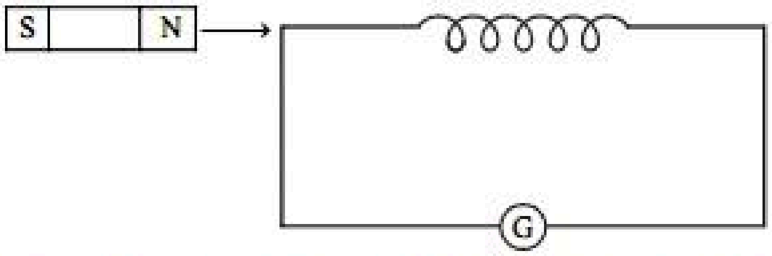
OR

(iii) Find the wave number of the photon emitted for the transition $n = 3$ to $n = 1$.

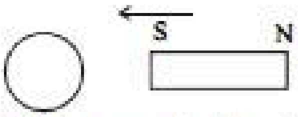
35. **Case Study: Electromagnetic Induction**

Read the following paragraph and answer the questions.

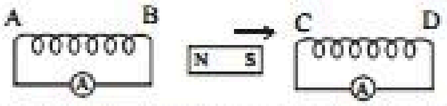
When the magnet with its N-pole facing the coil is moved towards the coil, the galvanometer shows some deflection while the magnet is in motion showing that an electric current is produced in the coil even though no conventional source of e.m.f. is in the circuit. The current is called the induced current and the e.m.f. responsible for it is called the **induced e.m.f.**



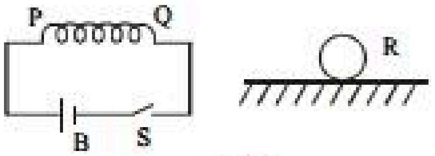
(i) In which direction will the current be induced in the closed loop if the magnet is moved as shown in the figure.



(ii) A magnet is moved in the direction indicated by an arrow between two coils AB and CD as shown in the figure. Find the direction of current in each coil.



(iii) The following figure shows a horizontal solenoid 'PQ' connected to a battery 'B' and switch 'S'. A copper ring 'R' is placed on a frictionless track, the axis of the ring being along the axis of the solenoid. What would happen to the ring as the switch 'S' is closed?



OR

(iii) A bar magnet falls from a height 'h' through a metal ring. Will its acceleration be equal to g? Give reason for your answer.

Solutions

SAMPLE PAPER-5

1. (b) Here, $q_1 = 1 \times 10^{-7}C$, q_2 and 2×10^{-7} C, $r = 20$ cm $= 20 \times 10^{-2}\ m$

$$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2} = \frac{9\times10^9 \times 1\times10^{-7}\times2\times10^{-7}}{(20\times10^{-2})^2}$$

$= 4.5\times10^{-3}\ N$ (1 mark)

2. (d) The coil of a moving coil galvanometer is wound over metallic frame to provide electromagnetic damping so it becomes dead beat galvanometer. (1 mark)

3. (c) Let P is the observation point at a distance r from –2q and at (L+r) from +8q.

Given now, net EFI at P = 0

$\therefore \vec{E}_1$ = EFI (Electric Field Intensity) at P due to +8q

$\vec{E}_2$ = EFI (Electric Field Intensity) at P due to – 2q

$$|\vec{E_1}| = |\vec{E_2}| \quad \therefore \frac{k(8q)}{(L+r)^2} = \frac{k(2q)}{r^2} \therefore \frac{4}{(L+r)^2} = \frac{1}{(r)^2}$$

$4r^2 = (L+r)^2 \Rightarrow 2r = L+r$ (1 mark)

$r = L$ $\quad \therefore$ P is at $x = L + L = 2L$ from origin

4. (a) Given that all capacitors are connected in parallel so, the equivalent capacitance will be $C_{eq} = C_1 + C_2 + C_3 + C_4 = 1 + 2 + 4 + 3 = 10\ \mu F$

Voltage of battery V = 20 V

We have, $Q = CV = 10\ \mu F \times 20 = 200\ \mu C$ (1 mark)

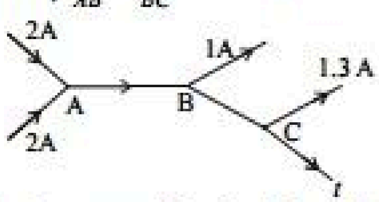
5. (a) Current flowing through the conductor, I = n e v A. Hence

$$\frac{4}{1} = \frac{nev_{d_1}\pi(1)^2}{nev_{d_2}\pi(2)^2} \text{ or } \frac{v_{d_1}}{v_{d_2}} = \frac{4\times1}{1} = \frac{16}{1}.$$ (1 mark)

6. (a) According to Kirchhoff's first law

At junction A, $i_{AB} = 2 + 2 = 4$ A

At junction B, $i_{AB} = i_{BC} - 1 = 3$A



At junction C, $i = i_{BC} - 1.3 = 3 - 1.3 = 1.7$ amp (1 mark)

7. (d) When the temperature of a magnetic material decreases, the magnetization remains the same in a diamagnetic material. (1 mark)

8. (c) As I increases, ϕ increases

$\therefore I_i$ is such that it opposes the increases in ϕ.

Hence, ϕ decreases (By Right Hand Rule). The induced current will be counter clockwise. (1 mark)

9. (b) $\varepsilon = M\frac{di}{dt}$ or $8 = M\left[\frac{(4-2)}{0.05}\right]$

$\therefore\ M = \frac{8\times0.05}{2} = 0.2$ henry (1 mark)

10. (b) The wave having highest energy, has lowest wavelength as,

$E_\gamma > E_{x-rays} > E_{visible} > E_{microwave}$

$\Rightarrow \lambda_\gamma < \lambda_{x-rays} < \lambda_{visible} < \lambda_{microwave}$ (1 mark)

11. (b) We know that frequency of electromagnetic radiation remains the same when it changes the medium. Further

$$\mu = \frac{\text{wavelength of light in vacuum}}{\text{wavelength of light in medium}} = \frac{\lambda_v}{\lambda_m}$$

$$\lambda_m = \frac{\lambda_v}{\mu} = \frac{\lambda}{\mu}$$ (1 mark)

$$\text{Similarly, } \mu = \frac{\text{velocity of light in vacuum}}{\text{velocity of light in medium}}$$

$$\lambda_m = \frac{v}{\mu}$$

12. (d) $P_2 = P - P_1 = \frac{100}{80} - \frac{100}{20} = -3.75$ D (1 mark)

13. (d) Average BE/nucleon increases first, and then decreases, as is clear from BE curve. (1 mark)

14. (a) Isotones means equal number of neutrons *i.e.*, $(A-Z) = 74-34 = 71-31 = 40$. (1 mark)

15. (b) Donar energy (fermi) level lies just below the conduction band in *n*-type semiconductor. (1 mark)

16. (c) Assertion is correct. The induced field cancels the external field. Reason is false. When a current is set up in a conductor, there exists an electric field inside it. (1 mark)

17. (a) $R = R_0(A)^{1/3}$ (1 mark)

18. (b) $\theta_c = \sin^{-1}\left(\frac{1}{\mu}\right)$ and $\mu \propto \frac{1}{\lambda}$ (1 mark)

19. Given $N_p = 200$, $N_s = 1000$, $P_{output} = 10$ kW $= 10^4$ W, $E_p = 200$V.

For an ideal transformer $P_{output} = P_{input} = 10^4$ W

$$\Rightarrow E_sI_s = E_pI_p \Rightarrow \frac{E_s}{E_p} = \frac{N_s}{N_p}$$

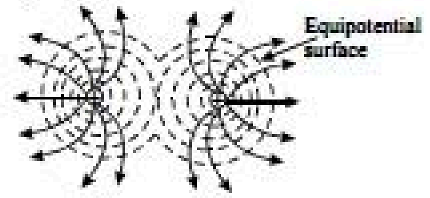
$$\therefore E_s = \frac{N_s}{N_p}\times E_p = \frac{1000}{200}\times200 = 1000\text{V}.$$ (1 mark)

Input power $= E_p I_p = 10^4 \Rightarrow I_p = \frac{10^4}{200} = 50$A (1 mark)

20. (i) The fringe-width of interference pattern increases with the decrease in separation between S_1S_2 as $\beta \propto \frac{1}{d}$ (1 mark)

(ii) The fringe-width decrease as wavelength gets reduced when interference set up is taken from air to water. (1 mark)

21. (i) The figure is shown below.



(1 mark)

Equipotential surfaces of two identical positive charges

(ii) By definition, electric potential energy of any charge q placed in the region of electric field is equal to the work done in bringing charge q from infinity to that point and given by

$U = qV$

Expression for Potential energy,

$$U = q_1V_1 + q_2V_2 = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q_1q_2}{|r_2 - r_1|}$$ (1 mark)

OR

(i) $\because$ Electric field intensity and potential difference are related as

$$E = -\frac{\Delta V}{\Delta r}$$

$$\Rightarrow \Delta V = -E\Delta r$$

$$\Rightarrow V_A - V_C = -(2+2)E$$

$$V_A - V_C = -4E$$

$$V_C - V_A = 4E$$ (1 mark)

(ii) As $V_C - V_A = 4E$, is positive

$\therefore V_C > V_A$

Potential is greater at point C than point A, as potential decreases along the direction of electric field. (1 mark)

22. (i) Mutual induction: It is the phenomenon in which a change of current in one coil induces an emf in another coil placed near it. The coil in which the current changes is called the primary coil and the coil in which the emf is induced is called the secondary coil.

(ii) As we know, $e = -M\frac{dI}{dt}$

$$e = -1.5\times\frac{20-0}{0.5} = -60V$$

So, the flux linked with the other coil is given by

$$\Delta\phi = e\times\Delta t = -60\times 0.5 = -30 \text{ Wb}$$ (2 × 1 = 2 marks)

23. $\because$ Fringe width, $(\beta) = \frac{D\lambda}{d}$

$$\Rightarrow \frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2} \quad (\because \text{ D and d are same})$$

Here, $\beta_1 = 7.2\times10^{-3}$ m

$\beta_2 = 8.1\times10^{-3}$ m

and $\lambda_1 = 630\times10^{-9}$ m (1 mark)

Wavelength of another source of laser light

$$\Rightarrow \lambda_2 = \frac{\beta_2}{\beta_1}\times\lambda_1 = \frac{8.1\times10^{-3}}{7.2\times10^{-3}}\times630\times10^{-9}\text{ m}$$

or $\lambda_2 = 708.75\times10^{-9}$ m

$\therefore \lambda_2 = 708.75$ nm (1 mark)

24. (a) In the nuclear reaction, for example

$${}_1^2H + {}_1^2H \longrightarrow {}_2^3He + {}_0n^1 + 3.27\text{ MeV}$$

Total number of nucleons is conserved.

i.e. number of neutrons + protons of the reactants is equal to the number of neutrons + protons of the products.

But the sum of the masses of the reactants and the sum of the masses of the products is not the same i.e. there is some mass defect (Δm). Energy equivalent to the mass defect is released in the nuclear reaction.

According to Einstein's mass energy equivalence relation,

$\Delta E = \Delta mc^2$ (1 mark)

(b) Let A be the mass number and R the radius of the nucleus.

Then mass of the nucleus = A amu

$M = A\times1.6\times10^{-27}$ kg

Now, $R = R_0A^{1/3}$

where R_0 is a constant whose numerical value is (1.2×10^{-15})

$\therefore$ Volume of the nucleus $= \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R_0^3 A$

$\therefore$ Density of the nucleus

$$= \frac{M}{V} = \frac{A\times1.6\times10^{-27}\text{kg}\times3}{4\times3.14\times\left(1.2\times10^{-15}\right)^3\times A}$$

$= 2.2\times10^{17}$ kg m^{-3} which is independent of A. (1 mark)

25. Given : $f_0 = 75$ cm, $f_e = 5$ cm.

minimum magnifying power, $m = \frac{f_0}{f_e} = \frac{75}{5} = 25$ (1 mark)

Max. magnifying power,

$$m = \frac{f_0}{f_e}\left(1+\frac{d}{f_e}\right) = \frac{75}{5}\times\left(1+\frac{25}{5}\right) = 25\times(1+5)$$

$= 25\times6 = 150$ (1 mark)

OR

Apparent depth.

$$d = \frac{d_1}{n_1}+\frac{d_2}{n_2} = \frac{40}{1.6}+\frac{30}{1.5} = 25+20 = 45\text{ cm.}$$ (2 marks)

26.

N-type semicoductor	P-tpye semiconductor
1. Intrinsic semiconductor is doped by pentavalent atoms e.g. As, Sb etc.	1. Intrinsic semiconductor is doped by trivalent atoms e.g. Al, B etc.
2. It has an extra electron from the impurity.	2. It has an extra hole from the impurity.
3. Dopant atom is positively charged.	3. Dopant atom is negatively charged.
4. Electrons are majority charge carriers.	4. Holes are majority charge carriers.
5. n_e (no. of electron) >> n_h (no. of holes)	5. n_h (no. of holes) >> n_e (no. of electron)
6. Donar energy level is close to conduction band.	6. Acceptor level is close to valence band.

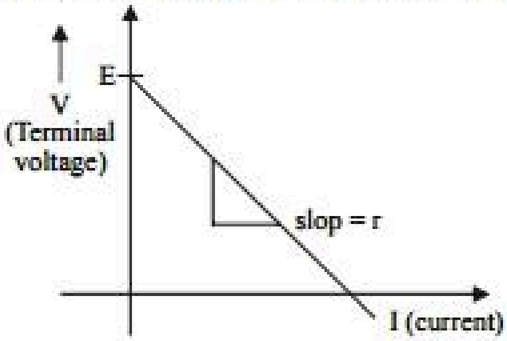
(6 × ½ = 3 marks)

27. If E is the emf of the cell, r is the internal resistance of the cell and I is the current through the circuit. Then Terminal voltage 'V' of the cell is $V = E - Ir$

So, $V = -Ir + E$ (1 mark)

Comparing with the equation of a straight line

$y = mx + c$, we get: $y = V; x = I; m = -r; c = E$



(2 marks)

Graph showing variation of terminal voltage 'V' of the cell versus the current 'I'

Where, Emf of the cell = Intercept on V axis

Internal resistance = slope of line. (1 mark)

28. (a) de-Broglie wavelength of a charged particle is given by $\lambda \propto \frac{1}{\sqrt{mq}}$

$2m_p$ and e are mass and charge of a deuteron respectively, and, $4m_p$ and $2e$ are mass and charge of an alpha particle respectively.

$$\frac{\lambda_D}{\lambda_\alpha} = \sqrt{\frac{m_\alpha q_\alpha}{m_D q_D}} = \sqrt{\frac{(4m_p)(2e)}{(2m_p)(e)}} = \frac{2}{1}$$

Thus, de-Broglie wavelength associated with deutron is twice of the de-Broglie wavelength of alpha particle. (2 marks)

(b) (For same accelerating potential K.E $\propto q$)

Charge of a deuteron is less as compared to an alpha particle. So, deuteron will have less value of K.E. (1 mark)

OR

(i) Energy of a photon is given by
$E = h\nu$

Number of photons emitted per second, $n = \frac{P}{E}$ where,

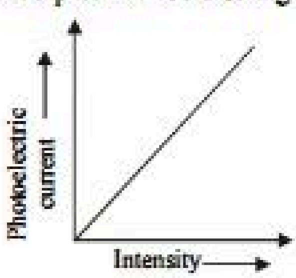
P = Power emitted

On putting the values, we get,

$n = 3 \times 10^{-3} / 6.63 \times 10^{-34} \times 5 \times 10^{14}$

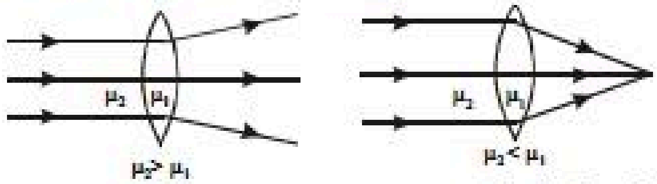
$= 9.05 \times 10^{15}$ (2 marks)

(ii) The photoelectric current is known to be directly proportional to the intensity of incident light with fixed frequency. So, the plot will be a straight line shown as,



(1 mark)

29. (i) Ray diagram : (ii)



(2 × 1 = 2 marks)

As the lens is equiconvex, therefore,

$R_1 = R_2 = R,$

Using the expression

$$\frac{f_L}{f_a} = \frac{\left({}_a\mu_g - 1\right)}{\left(\frac{{}_a\mu_g}{{}_a\mu_L} - 1\right)} = \frac{\mu_1 - 1}{\left(\frac{\mu_1}{\mu_2} - 2\right)}$$

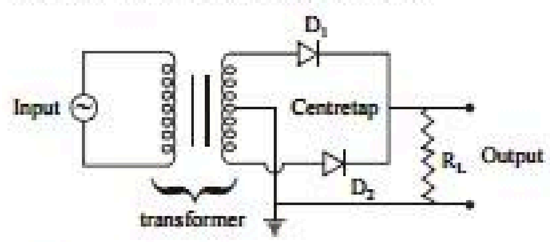
or, $f_L = \frac{(\mu_1 - 1)\mu_2}{(\mu_1 - \mu_2)} \times f_a$ (1 mark)

30. An intrinsic semiconductor at 0 K is like an insulator because all its electrons are in the valence band in form of bound electrons and hence not free to conduct current. At T > 0 K, some of these electrons pick up thermal energy and move to conduction band.

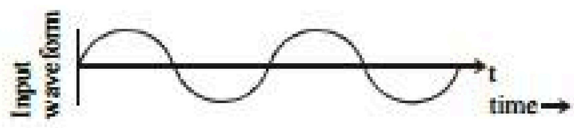
(3 marks)

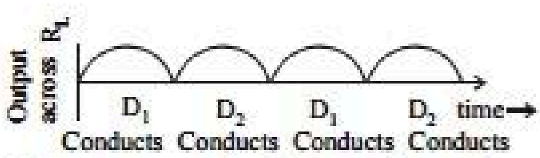
OR

Here we use two diodes to rectify voltage corresponding to both positive and negative half of the a.c. cycle. Here, the p–side of the two diodes are connected to ends of secondary which is centre tapped in this transformer. For positive half cycle, D_1 is forward biased and conducts and for negative half cycle D_2 conducts. (1 mark)



(1 mark)





The output across load is a continuously, varying pulse of the shape of half sinusoids. (1 mark)

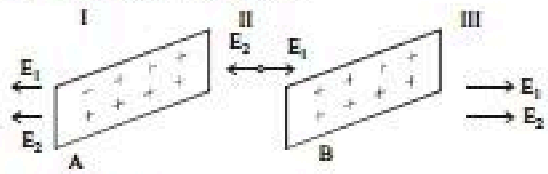
31. (a) The outward electric flux due to charge +Q is independent of the shape and size of the surface, which encloses it because :

(i) Number of electric field lines coming out from a closed surface enclosing the charge depends on the charge enclosed by the surface,

(ii) Number of electric field lines coming out from a closed surface enclosing the charge is independent of the position of the charge inside the closed surface.

(2 × 1 = 2 marks)

(b) Let us consider two positively charged thin parallel sheets A and B with uniform surface densities of charge σ_1 and σ_2 respectively.



Let $\sigma_1 > \sigma_2 > 0$

In region I, $E_I = -E_1 - E_2 = \frac{-\sigma_1}{2\varepsilon_0} - \frac{\sigma_2}{2\varepsilon_0}$

$\Rightarrow \quad E_I = -\frac{1}{2\varepsilon_0}(\sigma_1 + \sigma_2)$

In region II, $E_{II} = E_1 - E_2$

$$= \frac{\sigma_1}{2\varepsilon_0} - \frac{\sigma_2}{2\varepsilon_0} = \frac{\sigma_1 - \sigma_2}{2\varepsilon_0}$$

In region III, $E_{III} = E_1 + E_2$

$$= \frac{\sigma_1}{2\varepsilon_0} + \frac{\sigma_2}{2\varepsilon_0} = \frac{\sigma_1 + \sigma_2}{2\varepsilon_0}$$

In $\sigma_1 = \sigma$ and $\sigma_2 = -\sigma$ then $E_I = 0$, $E_{III} = 0$

$E_{II} = \frac{2\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0} =$ constant

Clearly, field (i) between the sheets

$E_{II} = \frac{\sigma}{\varepsilon_0}$ = constant and

(ii) outside the sheets $E_I = E_{III} = 0$ (3 marks)

OR

(a) Electric dipole moment is defined as the product of either charge of the dipole and the distance between them.

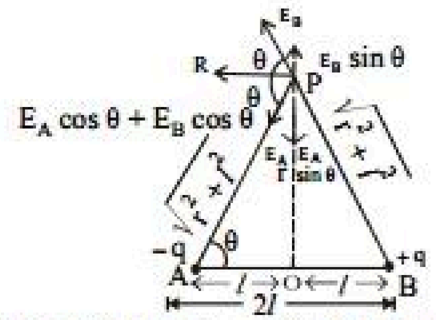
i.e. $\vec{p} = q \times \overline{2l}$, where $\overline{2l}$ is the vector distance from the –ve to +ve charge

It is a vector quantity. (1 mark)

Expression for the electric field of a dipole at a point on the equatorial plane of the dipole :

Let there be a point P (on the equatorial plane of the dipole) at a distance r from the centre of a dipole formed by two charges –q and +q and having dipole moments $\vec{p} = 2\,\vec{ql}$.

We have to find the electric field intensity at point P.



The electric field intensity at point P due to +q (at B)

$$E_A = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{(r^2 + l^2)} \text{ along BP}$$

and electric field intensity at P due to – q charge (at A)

$$E_B = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{(r^2 + l^2)} \text{ along PA}$$

Clearly, $E_A = E_B$ in magnitude. (1 mark)

E_A and E_B can be resolved into two rectangular components.

Components of E_A

(i) $E_A \cos\theta$ along PX

(ii) $E_A \sin\theta$ along PY

Components of E_B

(i) $E_B \cos\theta$ along PX

(ii) $E_B \sin\theta$ along YP

Vertical components being equal and opposite cancel each other.

Therefore, net electric field intensity along PX

$E = E_A \cos\theta + E_A \cos\theta \quad (\because E_A = E_B)$

$= 2E_A \cos\theta$ along PX

$= 2 \cdot \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{(r^2 + l^2)} \cdot \frac{1}{\sqrt{r^2 + l^2}}$ (1 mark)

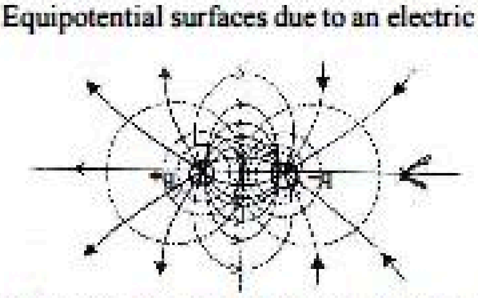
or, $E = \frac{1}{4\pi\epsilon_0} \cdot \frac{p}{(r^2 + l^2)^{3/2}}$ along PX $(\because p = q \times 2l)$

If $l << r$ so that it can be neglected, then

$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{p}{r^3}$ along PX

$\therefore \quad E \propto \frac{1}{r^3}$ (1 mark)

(b) Equipotential surfaces due to an electric dipole.



Potential due to the dipole is zero at the line bisecting the dipole length. (1 mark)

32. Let a charged particle is moving in the magnetic field with a velocity $\vec{v}$ making angle θ with $\vec{B}$.

The component of $\vec{v}$ along $\vec{B}$ is v cosθ, due to which no force will act on the particle, so it will cover a distance

along the magnetic field with a constant speed.
The perpendicular component v sin θ will provide a force, F = qBvsinθ which provide the necessary centripetal force for the circular motion of the charged particle

$$\therefore \quad Bqv\sin\theta = \frac{m(v\sin\theta)^2}{r} \Rightarrow v\sin\theta = \frac{Bqr}{m} \quad \text{(1 mark)}$$

and r = radius of the path = $\frac{mv\sin\theta}{Bq}$ (1 mark)

If $\sin\theta = 1$, i.e. $\theta = 90°$ then $r = \frac{mv}{Bq}$ (1 mark)

Angular velocity of rotation of the particle in magnetic field $\omega = \frac{v\sin\theta}{r} = \frac{Bq}{m}$

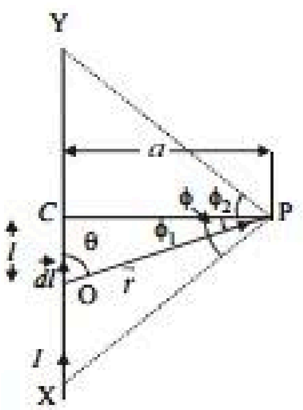
$\therefore$ Time taken to complete one revolution $T = \frac{2\pi}{\omega}$

$\Rightarrow \quad T = \frac{2\pi m}{Bq}$ (1 mark)

which is independent of its speed.
Under the combined action of both the velocities the charged particle will undergo a linear as well as a circular motion. So the resultant path will be a helix. (1 mark)

OR

Consider a straight conductor XY lying in the plane of paper. Consider a point P at a perpendicular distance '*a*' from straight conductor.



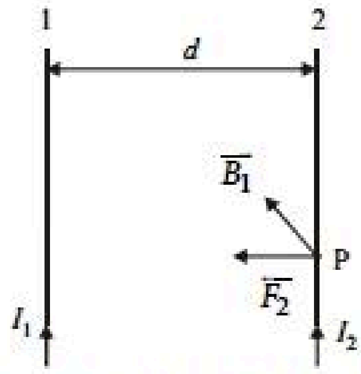
Now Magnetic field induction at a point P due to current I passing through conductor XY is given by

$$B = \frac{\mu_0 I}{4\pi a}[\sin\phi_1 + \sin\phi_2] \quad \text{(1 mark)}$$

At the centre of the infinite long wire,
$\phi_1 = \phi_2 = 90°$

$$\therefore B = \frac{\mu_0 I}{4\pi a}[\sin 90° + \sin 90°]$$

$$\Rightarrow \quad B = \frac{\mu_0}{4\pi}\frac{2I}{a} \quad ....(1) \quad \text{(1 mark)}$$



Consider two infinite straight conductors 1 and 2. Let I_1 and I_2 current flowing through the conductor 1 and 2 and they are *d* distance apart from each other.
The magnetic field induction (B) at a point P on conductor 2 due to current I_1 passing through conductor 1 is given by $B_1 = \frac{\mu_0 2I_1}{4\pi d}$

According to right hand rule, the direction of this magnetic field is perpendicular to the plane of the paper inward.
Now force experienced (F_2) by unit length of conductor 2 will be $F_2 = B_1 I_2 \times 1 = B_1 I_2$

$$\therefore \quad F_2 = \frac{\mu_0}{4\pi}\frac{2I_1 I_2}{d} \quad \text{(1 mark)}$$

Conductor 1 also experiences the same amount of force, directed towards the conductor 2. Hence, conductor 1 and conductor 2 attract each other. Thus, two linear parallel conductors carrying currents in the same direction attract and repel each other when the current flows in the opposite direction.
Let $I_1 = I_1 = 1A$; $r = 1\ m$

Then, $F_1 = F_2 = F = 10^{-7}\ \frac{2 \times 1 \times 1}{1}$

$\Rightarrow \quad F = 2 \times 10^{-7}$ N/m (1 mark)

Definition of one ampere : One ampere is that value of constant current which when flowing through each of the two parallel uniform long linear conductors placed in free space at a distance of 1 m from each other will attract or repel each other with a force of 2×10^{-7} N per metre of their length. (1 mark)

33. (a) The phenomenon of spreading of light waves as they pass through a narrow opening is called diffraction of light. (1 mark)

(b) In the region of central maximum, the intensity is maximum because the path difference between the waves arising from all parts of the slit is zero.

(c) The position of secondary maxima are at θ $= \left(n + \frac{1}{2}\right)\frac{\lambda}{a}$ and secondary minima are at θ $= \frac{n\lambda}{a}$

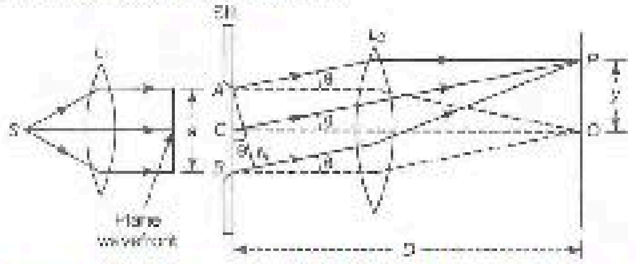
where n = ± 1, ± 2,.... and a is the slit width.

For secondary maxima, consider an angle, $\theta = \frac{3\lambda}{2a}$

(by putting n = 1). Now divide the slit into three equal parts. The first two halves of the slits will have a path difference of $\frac{\lambda}{2}$. Therefore waves coming out from these two halves will cancel each other. Only the remaining one third of the slit contributes to the intensity at a point between two minima. Consequently the intensity at the secondary maxima becomes less than that of central maximum.
(3 marks)

OR

(i) 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 ΔANB, we have

BN = AB sin θ

BN = a sin θ ..... (i) (1 mark)

Suppose, BN = λ and $\theta = \theta_1$

Then, the above equation gives

$\lambda = a \sin\theta_1$

$$\Rightarrow \sin\theta_1 = \frac{\lambda}{a} \quad ..... (ii)$$

Such a point on the screen will be the position of first secondary minimum.

If, BN = 2λ and $\theta = \theta_2$, then

$2\lambda = a \sin\theta_2$,

$$\sin\theta_2 = \frac{\lambda}{a} \quad ..... (iii)$$

Such a point on the screen will be the position of first secondary minimum.

In general, for nth minimum at point P,

$$\sin\theta_n = \frac{n\lambda}{a} \quad ..... (iv) \quad (1 \text{ mark})$$

If y_n is the distance of the nth minimum from the centre of the screen, then from right-angled ΔCOP, we have

$$\tan\theta_n = \frac{OP}{CO} = \frac{y_n}{D} \quad .... (v)$$

In case of θ_n is small $\sin\theta_n \approx \tan\theta_n$

There Eqs, (iv) and (v) are given

$$\frac{y_n}{D} = \frac{n\lambda}{a} \Rightarrow y_n = \frac{n\lambda D}{a}$$

If, $BN = \frac{3\lambda}{2}$ and $\theta = \theta_1'$, then from Eq. (i), we have

$$\sin\theta_1' = \frac{3\lambda}{2\lambda}$$

Such a point on the screen will be the position of the first secondary maximum. Corresponding to path difference.

If, $BN = \frac{5\lambda}{2}$ and $\theta = \theta_2'$ the second secondary maximum is produced

In general, for the nth maximum at point P,

$$\sin\theta_n' = \frac{(2n+1)\lambda}{2a} \quad ..... (vi) \quad (1 \text{ mark})$$

where n = 1, 2, 3, ... an integer.

If y_n is the distance of nth maximum from the centre of the screen, then the angular position of the nth maximum is given by,

$$\tan\theta_n' = \frac{y_n}{D} \quad ..... (vii)$$

In case of θ'_n is small, $\sin\theta_n' = \tan\theta_n'$

$$\Rightarrow Y_n' = \frac{(2n+1)\lambda D}{2a} \qquad \text{For } n = 1,\ \theta' = \frac{3\lambda}{2a}$$

[From Eq. (vi), small angle approximation,

$\sin\theta' = \theta' = \frac{(2n+1)\lambda}{2a}$]

The angle is midway between the two dark fringes. Divide the slit into three equal parts. If we take the first two-third part of the slit, the path difference between the two ends would be

$$\frac{2}{3}a \times \theta' = \lambda$$

The first two-third is divided into two halves which have path difference $\frac{\lambda}{2}$. The contribution due to these two halve is 180° out of phase and gets cancel. (1 mark)

Only the remaining one-third part of the slit contribute to the intensity at a point between the two minima which will be much weaker than the intensity of central maxima. Thus, with increase in the intensity, the maxima gets weaker.

(ii) (a) Size of central diffraction band is inversely proportional to the slit width i.e., size of central diffraction band $= \frac{2\lambda}{d}$ (½ mark)

(b) The light waves are diffracted by the edge of the tiny circular obstacle. These waves interfere constructively at the centre of shadow and appears as bright spot. (½ mark)

34. **(i)** Given that

$E_1 = -15.6\ eV,\ E_\infty = 0\ eV.$

Ionization energy of the atom :

$$E_\infty - E_1 = 0 - (-15.6\ eV) = 15.6\ eV$$

So, ionization potential = 15.6 V (1 mark)

(ii) For short wavelength limit of the series terminating at $n = 2$, a transition must take place from $n = \infty$ state to n

$= 2$ state. For this, $\Delta E = 5.30$ eV

$$\lambda = \frac{12400}{\Delta E(eV)} Å = \frac{12400}{5.30} Å = 2339Å$$ (2 marks)

(iii) The excitation energy for the $n = 3$ state is

$$\Delta E = E_3 - E_1 = 15.6 - 3.08 = 12.52 \text{ eV}$$

Excitation potential = 12.52 V (1 mark)

OR

(iii) $\lambda = \frac{12400}{E_3^z - E_1^z} = \frac{12400}{12.52} Å = 990Å$

Wave number

$$= \frac{1}{\lambda} = \frac{1}{990 \times 10^{-10} m} = 1.009 \times 10^7 m^{-1}$$

35. (i) Since the south pole of the magnet is approaching towards the loop, so by Lenz's law the induced current in the loop should be in such a direction that it should oppose the approach of the S-pole. So another S-pole should be produced at the near end of the coil. Therefore, the current should be in clockwise direction when viewed from the magnet side. (2 marks)

(ii) Induced current will be clockwise in both the coils, when viewed from the magnet side as the N-pole is moving away from coil AB so a S-pole should be created at the end B. The S-pole is approching towards CD, hence another S-pole should be produced at the end C to provent its approach. (1 mark)

(iii) As soon as the switch S is closed, an e.m.f. is induced in the ring R and it is repelled. (1 mark)

OR

(iii) When the magnet falls, the magnetic flux linked through the metal ring changes, so current is induced in the ring will be in such a direction according to Lenz's law that it opposes the motion of the magnet, so its acceleration will be less than g.