Class-XII
Session - 2022-23
Subject - Physics (Theory)
Sample Question Paper - 35
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		1 (Q. 16)					1
2	Electrostatic Potential and Capacitance	16		2 (Q. 20, 23)				4
3	Current Electricity				2 (Q. 26, 27)	1 (Q. 31)		11
4	Moving Charges and Magnetism		2 (Q. 1, 4)	1 (Q. 19)			1 (Q. 35)	8
5	Magnetism and Matter		1 (Q.2)					1
6	Electromagnetic Induction	17				1 (Q. 32)		5
7	Alternating Current		1 (Q. 3)	1 (Q. 25)				3
8	Electromagnetic Waves		2 (Q. 5, 8)					2
9	Ray optics and Optical Instruments	18	1 (Q. 6)	1 (Q. 24)		1 (Q. 33)		8
10	Wave Optics		5 (Q. 7, 9, 10, 17, 18)		1 (Q. 28)			8
11	Dual Nature of Radiation and Matter		1 (Q. 11)				1 (Q. 34)	5
12	Atoms	12			1 (Q. 29)			3
13	Nuclei		2 (Q. 12, 13)	1 (Q. 21)				4
14	Semiconductor Electronics: Materials, Devices and Simple Circuits	7	2 (Q. 14, 15)	1 (Q. 22)	1 (Q. 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. A particle of mass m and charge q enters a magnetic field B perpendicularly with a velocity v. The radius of the circular path described by it will be

(a) Bq/mv (b) mq/Bv (c) mB/qv (d) mv/Bq

2. The magnetic susceptibility is negative for :

(a) diamagnetic material only (b) paramagnetic material only
(c) ferromagnetic material only (d) paramagnetic and ferromagnetic materials

3. If wattless current flows in the AC circuit, then the circuit is

(a) Purely Resistive circuit (b) Purely Inductive circuit
(c) LCR series circuit (d) RC series circuit only

4. Magnetic field at the centre of a circular coil of radius r, through which a current I flows is

(a) directly proportional to r (b) inverseley proportional to I
(c) directly proportional to I (d) directly proprotional to I^2

5. Which of the following electromagnetic waves has the longest wavelength?

(a) uv-rays (b) Visible light (c) Radio waves (d) Microwaves

6. The magnifying power of a telescope is 9. When it is adjusted for parallel rays, the distance between the objective and the eye piece is found to be 20 cm. The focal length of lenses are

(a) 18 cm, 2 cm (b) 11 cm, 9 cm (c) 10 cm, 10 cm (d) 15 cm, 5 cm

7. A plane wave passes through a convex lens. The geometrical shape of the wavefront that emerges is

(a) plane (b) diverging spherical
(c) converging spherical (d) None of these

8. The ratio of contributions made by the electric field and magnetic field components to the intensity of an electromagnetic wave is: (c = speed of electromagnetic waves)

(a) 1 : 1 (b) 1 : c (c) 1 : c^2 (d) c : 1

9. Wavefront is the locus of all points, where the particles of the medium vibrate with the same

(a) phase (b) amplitude (c) frequency (d) period

10. Two coherent monochromatic light beams of intensities I and 4I are superposed. The maximum and minimum possible intensities in the resulting beam are

(a) $5I$ and I (b) $5I$ and $3I$ (c) $9I$ and I (d) $9I$ and $3I$

11. A proton and α-particle are accelerated through the same potential difference. The ratio of their de-Broglie wavelength will be

(a) 1 : 1 (b) 1 : 2 (c) 2 : 1 (d) $2\sqrt{2} : 1$

12. If radius of the $^{27}_{13}\text{Al}$ nucleus is estimated to be 3.6 fermi then the radius of $^{125}_{52}\text{Te}$ nucleus be nearly

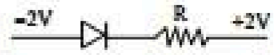
(a) 8 fermi (b) 6 fermi (c) 5 fermi (d) 4 fermi

13. The mass defect in a particular nuclear reaction is 0.3 grams. The amount of energy liberated in kilowatt hour is (Velocity of light = 3×10^8 m/s)

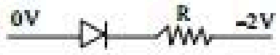
(a) 1.5×10^6 (b) 2.5×10^6 (c) 3×10^6 (d) 7.5×10^6

14. Which one of the following represents forward bias diode?

(a) 

(b) 

(c) 

(d) 

15. In half wave rectification, if the input frequency is 60 Hz, then the output frequency is would be:

(a) 30 Hz (b) 60 Hz (c) 120 Hz (d) Zero

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.

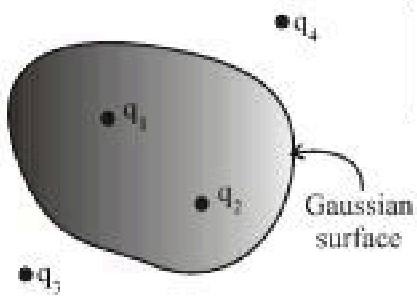
(a) Both A and R are true and R is the correct explanation of A

(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) :** Four point charges q_1, q_2, q_3 and q_4 are as shown in figure. The flux over the shown Gaussian surface depends only on charges q_1 and q_2.



Reason (R) : Electric field at all points on Gaussian surface depends only on charges q_1 and q_2.

17. **Assertion (A) :** Diffraction takes place for all types of waves mechanical or non-mechanical, transverse or longitudinal.

Reason (R) : Diffraction's effect are perceptible only if wavelength of wave is comparable to dimensions of diffracting device.

18. **Assertion (A) :** In Young's double slit experiment if wavelength of incident monochromatic light is just doubled, number of bright fringe on the screen will increase.

Reason (R) : Maximum number of bright fringe on the screen is inversely proportional to the wavelength of light used.

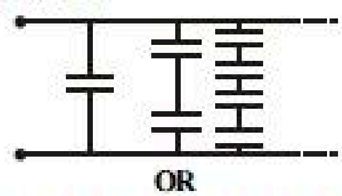
SECTION-B

19. A circular coil of closely wound N turns and radius, r carries a current, I. Write the expression for the following

(i) the magnetic field at its centre.

(ii) the magnetic moment of this coil.

20. An infinite number of the identical capacitors, each of the capacitance 1 μF, are connected, as shown. Then, what is the equivalent capacitance between the points A and B?



OR

A slab of material of dielectric constant K has the same area as that of the plates of a parallel plate capacitor but has the thickness 2d/3, where d is the separation between the plates. Find out the expression for its capacitance when the slab is inserted between the plates of the capacitor.

21. The three stable isotopes of neon: $^{20}_{10}Ne$, $^{21}_{10}Ne$ and $^{22}_{10}Ne$ have respective abundances of 90.51%, 0.27% and 9.22%. The atomic masses of the three isotopes are 19.99 u, 20.99 u and 21.99 u, respectively. Obtain the average atomic mass of neon.

22. A full wave rectifier uses two diodes, the internal resistance of each diode may be assumed constant at 30 Ω. The transformer r.m.s. secondary voltage from centre tap to each end of the secondary is 50V and load resistance is 970 Ω. Find (i) the mean load current (ii) the r.m.s. value of load current.

23. Derive an expression for the potential at a point due to a short dipole. Hence show what will be the potential at an axial and an equatorial point.

OR

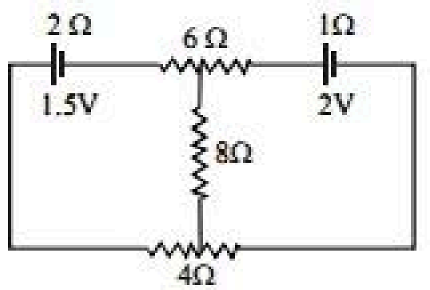
An electric dipole is free to move in a uniform electric field. Explain its motion when it is placed (i) parallel to the field and (ii) perpendicular to the field.

24. (a) Write the necessary conditions for the phenomenon of total internal reflection to occur.
(b) Write the relation between the refractive index and critical angle for a given pair of optical media.

25. When an alternating voltage of 220 V is applied across a device X, a current of 0.5 A flows through the circuit and is in phase with the applied voltage. When the same voltage is applied across another device Y, the same current again flows through the circuit but it leads the applied voltage by $\pi/2$ radian.
(a) Name the devices X and Y.
(b) Calculate the current flowing in the circuit when same voltage is applied across the series combination of X and Y.

SECTION-C

26. Two cells of e.m.f's 1.5V and 2V having internal resistances 2 Ω and 1 Ω respectively, have their negative terminals joined by a wire of 6 Ω and positive terminals joined by a wire of 6 Ω and positive terminals by a wire of 4 Ω resistance. A third resistance wire of 8 Ω connects middle points of these wires. Draw the circuit diagram. Using Kirchhoff's law, find the potential difference at the end of this third wire.



27. Two identical cells of e.m.f 1.5V each joined in parallel provide supply to an external circuit consisting of two resistance of 17 Ω each joined in parallel. A very high resistance voltmeter reads the terminal voltage of cells to be 1.4 V. Calculate the internal resistance of each cell.

OR

Two cells of e.m.f 6V and 12 V and internal resistances 1 Ω and 2 Ω respectively are connected in parallel so as to send current in the same direction through an external resistance of 15 Ω.
(i) Draw the circuit diagram.
(ii) Using Kirchhoff's laws calculate
(a) Current through each branch of the circuit
(b) Potential difference across the 15 Ω resistance.

28. What is the effect on the interference pattern observed in a Young's double slit experiment when
(i) monochromatic light is replaced by white light?
(ii) source is moved closer to the double-slit plane?
(iii) the widths of two slits are increased?

29. The ground state energy of hydrogen atom is– 13.6 eV. If an electron makes a transition from an energy level – 0.85 eV to – 1.51 eV, calculate the wavelength of the spectral line emitted. To which series of hydrogen spectrum does this wavelength belong?

30. In an intrinsic semiconductor, explain how current flow takes place.

OR

A specimen of Si is to be doped by 1 ppm of pentavalent As. If Si has 5×10^{28} atoms /m^3, calculate the number of electrons and holes.

SECTION-D

31. Define resistivity of material. State its S. I units and discuss its variation with temperature in case of (i) metals (ii) semiconductors and (iii) insulators.

OR

(i) State Kirchhoff's rules.
(ii) A battery of 10V and negligible internal resistance is connected across the diagonally opposite corners of a cubical network consisting of 12 resistors each of 1 Ω resistance. Use Kirchhoff's rules to determine.

(a) the equivalent resistance of the network and

(b) the total current in the network.

32. (a) Write an expression of magnetic moment associated with a current (I) carrying circular coil of radius r having N turns.

(b) Consider the above mentioned coil placed in YZ plane with its centre at the origin. Derive expression for the value of magnetic field due to it at point $(x, 0, 0)$.

OR

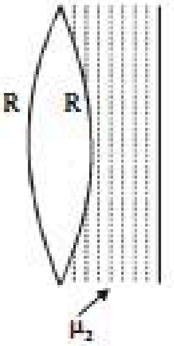
(a) Define current sensitivity of a galvanometer. Write its expression.

(b) A galvanometer has resistance G and shows full scale deflection for current I_g.

(i) How can it be converted into an ammeter to measure current upto I_0 $(I_0 > I_g)$?

(ii) What is the effective resistance of this ammeter?

33. A biconvex lens with its two faces of equal radius of cuivature R is made of a transparent medium of refractive index μ_1. It is kept in contact with a medium of refractive index μ_2 as shown in the figure.



(a) Find the equivalent focal length of the combination.

(b) Obtain the condition when this combination acts as a diverging lens.

(c) Draw the ray diagram for the case $\mu_1 > (\mu_2 + 1) / 2$, when the object is kept far away from the lens. Point out the nature of the image formed by the system.

OR

(i) Draw a ray diagram to show refraction of a ray of monochromatic light passing through a glass prism. Deduce the expression for the refractive index of glass in terms of angle of prism and angle of minimum deviation.

(ii) Explain briefly how the phenomenon of total internal reflection is used in fibre optics.

SECTION-E

34. Case Study: Photoelectric Effect

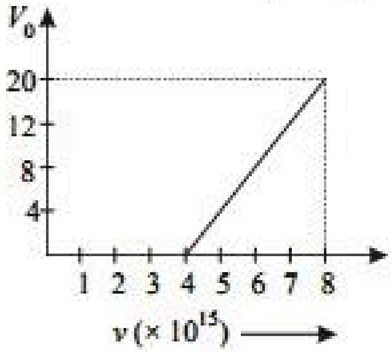
Read the following paragraph and answer the questions.

When a high frequency electromagnetic radiation is incident on a metallic surface, electrons are emitted from the surface. Energy of emitted photoelectrons depends only on the frequency of incident electromagnetic radiation and the number of emitted electrons depends only on the intensity of incident light.

Einstein's photoelectric equation $[K_{max} = hv - \phi]$ correctly explains the PE, where υ = frequency of incident light and ϕ = work function.

(i) Light of wavelength 3300 is incident on two metals A and B, whose work functions are 4 eV and 2 eV, respectively. Which metal will emit photoelectrons?

(ii) For photoelectric effect in a metal, the graph of the stopping potential V_0 (in volt) versus frequency υ (in hertz) of the incident radiation is shown in fig. Find work function of the metal (in eV).



(iii) Find the slope of the graph shown in fig. [here h is the Planck's constant and e is the charge of an electron]

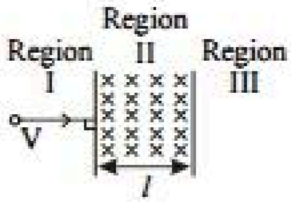
OR

(iii) Name the factor on which the magnitude of saturation photoelectric current depends.

35. Case Study: Motion of Charged Particle in Magnetic Field

Read the following paragraph and answer the questions.

A particle of mass m and charge q, moving with velocity V enters Region II normal to the boundary as shown in the figure. Region II has a uniform magnetic field B perpendicular to the plane of the paper. The length of the Region II is l.



(i) Find the velocity when path length of the particle in Region II is maximum.

(ii) If the direction of the initial velocity of the charged particle is neither along nor perpendicular to that of the magnetic field, then what will be the nature of orbit?

(iii) A charged particle moves with velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$. Find the magnetic force experienced by the particle.

OR

(iii) The force $\overline{F}$ experienced by a particle of charge q moving with velocity $\overline{v}$ in a magnetic field $\overline{B}$ is given by $\overline{F} = q(\vec{v} \times \overline{B})$. Which pair of vectors is always at right angles to each other?

Solutions

SAMPLE PAPER-8

1. (d) Force, $F = qVB = \frac{mv^2}{R}$ $\therefore R = \frac{mv}{Bq}$ (1 mark)

2. (a) Magnetic susceptibility χ for dia-magnetic materials only is negative and low $|\chi| = -1$; for paramagnetic substances low but positive $|\chi| = 1$ and for ferromagnetic substances positive and high $|\chi| = 10^2$. (1 mark)

3. (b) Wattless current flow in a circuit only when circuit is resistanceless i.e. circuit is purely capacitive or inductive. (1 mark)

4. (c) Field at the center of a circular coil of radius r is

$$B = \frac{\mu_0 I}{2r}$$ (1 mark)

5. (c) Radio waves has the longest wavelength in the electromagnetic spectrum. (1 mark)

6. (a) $\frac{f_0}{f_e} = 9$, $\therefore f_0 = 9f_e$

Also $f_0 + f_e = 20$ ($\because$ final image is at infinity)

$9f_e + f_e = 20$, $f_e = 2$ cm, $\therefore f_0 = 18$ cm (1 mark)

7. (c) Converging spherical (1 mark)

8. (a) The energy in electromagnetic wave is divided equally between the electric and magnetic field.

So, in an electromagnetic wave, half of the intensity is provided by the electric field and half by the magnetic field.

Hence, required ratio should be 1 : 1. (1 mark)

9. (a) Wavefront is the locus of all points, where the particles of the medium vibrate with the same phase. (1 mark)

10. (c) $I_{max} = I + 4I + 2\sqrt{I \times 4I} = 9I$,

and $I_{min} = I + 4I - 2\sqrt{I \times 4I} = I$. (1 mark)

11. (d) $qV = \frac{1}{2}mv^2$ or $mv = \sqrt{2qVm}$;

So $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2qVm}}$ i.e., $\lambda \propto \frac{1}{\sqrt{qm}}$;

so $\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{q_\alpha m_\alpha}{q_p m_p}} = \sqrt{2 \times 4} = 2\sqrt{2}$ (1 mark)

12. (b) $R = R_0(A)^{1/3}$

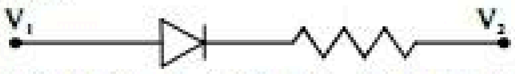
$\therefore \frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3} = \left(\frac{27}{125}\right)^{1/3} = \frac{3}{5}$

$R_2 = \frac{5}{3} \times 3.6 = 6$ fermi (1 mark)

13. (d) $E = \Delta m.c^2 \Rightarrow E = \frac{0.3}{1000} \times (3 \times 10^8)^2 = 2.7 \times 10^{13}$ J

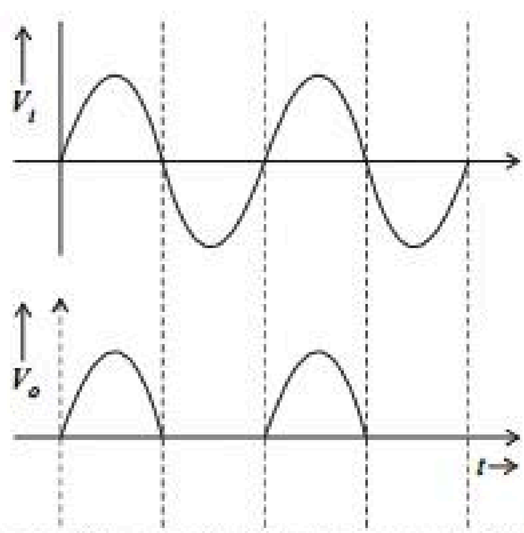
$= \frac{2.7 \times 10^{13}}{3.6 \times 10^6} = 7.5 \times 10^6$ kWh. (1 mark)

14. (d)



In forward bias, $V_1 > V_2$ i.e., in figure (d) p-type semiconductor is at higher potential w.r.t. n-type semiconductor. (1 mark)

15. (b)



We can see from graph, of input and output of Half Wave Ractifier

$T_{input} = T_{output} \Rightarrow f_{input} = f_{output}$ $\left[\because T = \frac{1}{f}\right]$ (1 mark)

16. (c) Electric field at any point depends on presence of all charges. (1 mark)

17. (c) Diffraction takes place for all types of wave. (1 mark)

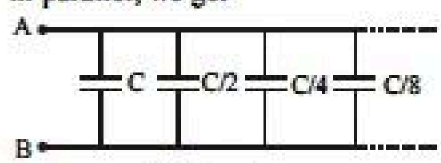
18. (a) Maximum number of bright fringe is inversely proportional to wavelength of light used. (1 mark)

19. (i) Magnetic field at centre due to circular current carrying coil (B) $= \frac{\mu_0 NI}{2r}$ (1 mark)

(ii) Magnetic moment $M = NIA = NI(\pi r^2)$

$M = \pi NIr^2$ (1 mark)

20. Combining the capacitances in series in the each branch between the points A and B and then, combining them in parallel, we get



$C_{eq} = C + \frac{C}{2} + \frac{C}{4} + \frac{C}{8} + ...$

$= C\left(1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + ...\right)$

$= C\left(\frac{1}{1 - 1/2}\right) = 2C = 2\mu F$ (2 marks)

OR

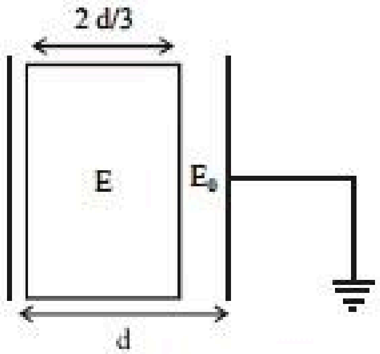
Let the potential difference across the plates of a parallel plate capacitor be V and d is the distance between them

A = area of the plates

Then electric field E_0 between them is given by

$$E_0 = \frac{V}{d} = \frac{Q}{A\epsilon_0}$$

When a slab of thickness $t = \frac{2}{3}d$ and dielectric constant K is introduced between the plates



Then $V = E_0\left(d - \frac{2d}{3}\right) + E \times \frac{2d}{3}$ (1 mark)

$$= E_0 \frac{d}{3} + \frac{E_0}{K}\frac{2d}{3} = E_0 \frac{d}{3}\left[1 + \frac{2}{K}\right]$$

or $V = \frac{Q}{A \in_0}\frac{d}{3}\left[1 + \frac{2}{K}\right]$ $\left(\because E_0 = \frac{Q}{A \in_0}\right)$

Therefore capacitance

$$C = \frac{Q}{V} = \frac{3A \in_0}{d\left(1 + \frac{2}{K}\right)}$$ (1 mark)

This is the required expression.

21. The masses of the three isotopes are 19.99u, 20.99u and 21.99u.

Their abundance are 90.51%, 0.27% and 9.22%

$\therefore$ Average atomic mass of neon is

$$\frac{90.51 \times 19.99 + 0.27 \times 20.99 + 9.22 \times 21.99}{90.51 + 0.27 + 9.22}$$

$= \frac{2017.7}{100} = 20.17$ u. (2 marks)

22. Here, $r = 30\,\Omega$, $R = 970\,\Omega$, $V_{rms} = 50$V,

$V_0 = \sqrt{2}V_{rms} = \sqrt{2} \times 50 = 70.7$V

Max. load current $I_0 = \frac{V_0}{r + R} = \frac{70.7}{30 + 970}$

$= \frac{70.7}{1000} = 70.7 \times 10^{-3}$ A $= 70.7$ m A. (1 mark)

(i) Mean load current,

$I_m = \frac{2I_0}{\pi} = \frac{2 \times 70.7\text{mA}}{3.14} = 45$ m A (½ mark)

(ii) r.m.s. value of load current,

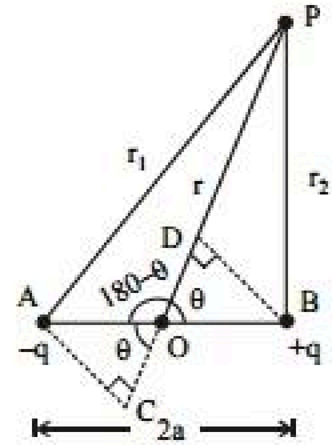
$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{70.7}{\sqrt{2}} = \frac{70.7}{1.414} = 50$ m A. (½ mark)

23. Let P be the point where the potential due to the dipole has to be calculated.

Dipole moment $= p = q \times 2a$

$OP = r$, $\angle BOP = \theta$; $AP = r_1$, $BP = r_2$

Draw AC $\perp$ PO produced and BD $\perp$ PO.



In ΔAOC, $\cos\theta = \frac{OC}{OA} = \frac{OC}{a}$

$\therefore$ $OC = a\cos\theta$ and $OD = a\cos\theta$

$\therefore$ Potential at P due to AB = V

$= \frac{kq}{r_2} - \frac{kq}{r_1} = kq\left[\frac{1}{r_2} - \frac{1}{r_1}\right]$ (1 mark)

$r_1 = AP \simeq CP = OP + OC = r + a\cos\theta$;

$r_2 = BP = DP = OP - OD = r - a\cos\theta$

$\therefore$ $V = kq\left[\frac{1}{r - a\cos\theta} - \frac{1}{r + a\cos\theta}\right]$

$= kq\left[\frac{r + a\cos\theta - r + a\cos\theta}{r^2 - a^2\cos^2\theta}\right]$

$= \frac{kq \times 2a\cos\theta}{r^2 - a^2\cos^2\theta} = \frac{kq \times 2a\cos\theta}{r^2 - a^2\cos^2\theta}$

$= \frac{kp\cos\theta}{r^2 - a^2\cos^2\theta}$,

where $p = 2aq$ = dipole moment

When P lies on the axial line of the dipole

$\theta = 0°$, $\cos\theta = 1$

$\therefore$ $V = \frac{kp}{r^2 - a^2}$ If $a << r$, $V = \frac{kp}{r^2}$

When P lies on the equatorial line of the dipole, $\theta = 90°$, $\cos 90° = 0$ $\therefore V = 0$. (1 mark)

OR

The torque acting on a dipole placed in a uniform electric field at an angle θ is

$\tau = pE\sin\theta$

(i) When the dipole is parallel to the field, $\overline{p}$ is along $\overline{E}$

$\therefore$ $\theta = 0$

$\therefore$ $\tau = pE\sin\theta = 0$ (1 mark)

(ii) When the dipole is perpendicular to the field is perpendicular to $\overline{E}$

$\therefore$ $\theta = 90°$

$\therefore$ Torque acting on it is maximum.

$\therefore$ $\tau_{max} = pE$ (1 mark)

24. (a) The necessary conditions for the phenomenon of total internal reflection to occur are :

(i) The light rays must pass from the denser medium to rarer medium.

(ii) The angle of incidence in the denser medium must be greater than the critical angle C. (½ × 2 = 1 mark)

(b) If ${}^a\mu_b$ is the refractive index of the denser medium (b) w.r.t. the rarer medium (a) and C be the critical angle, then

$${}^a\mu_b = \frac{1}{\sin C}$$ (1 mark)

25. (a) Since, the current and the voltage are in phase in X so X is resistance and in Y current leads the voltage by π/2 so it is capacitor. (1 mark)

(b) In X, resistance $= R = \frac{V}{I} = \frac{220}{0.5} = 440\,\Omega$

∵ The current is same through Y for the same voltage, so the reactance of Y is same as that of X.

$X_C = 440\,\Omega$

For series combination of X and Y, Impedance

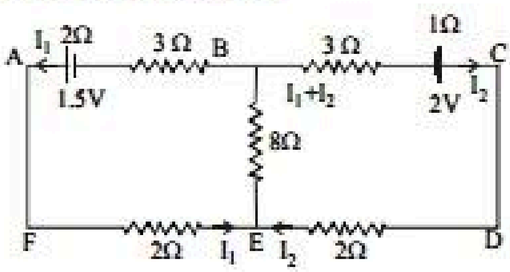
$= Z = \sqrt{R^2 - X_C^2} = \sqrt{440^2 + 440^2} = 440\sqrt{2}$

∴ Current through the series combination,

$$I = \frac{V}{Z} = \frac{220}{440\sqrt{2}} = \frac{220\sqrt{2}}{440 \times 2} = \frac{\sqrt{2}}{4} = \frac{1.414}{4}$$

$= 0.35$ A (1 mark)

26. The equivalent circuit is



For the loop ABEFA,

$-1.5 = -(2+3+2)I_1 - 8(I_1+I_2)$

$\frac{15}{10} = 7I_1 + 8I_1 + 8I_2$

$\Rightarrow\ 15I_1 + 8I_2 = \frac{15}{10}$ ....(1) (1 mark)

For the loop BCDEB,

$2 = (3+1+2)I_2 + 8(I_1+I_2)$

$2 = 6I_2 + 8I_1 + 8I_2 \Rightarrow 8I_1 + 14I_2 = 2$

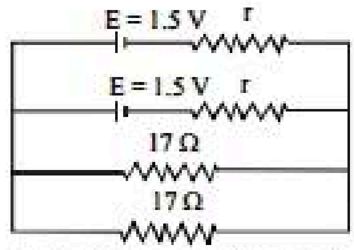
$\Rightarrow\ 4I_1 + 7I_2 = 1$ ....(2) (1 mark)

Solving we get $I_1 = \frac{5}{146}$A and $I_2 = \frac{9}{73}$A

∴ Potential difference across 8 Ω $(I_1 + I_2)$

$= 8\left(\frac{5}{146} + \frac{9}{73}\right) = 8 \times \frac{23}{146} = \frac{92}{73}$ V. (1 mark)

27.



Let the internal resistance of each cell is r.

E = 1.5 volt, V = 1.4 volt.

The equivalent resistance of two 17 Ω in parallel is $R = \frac{17 \times 17}{17+17} = \frac{17}{2} = 8.5\,\Omega$ (1 mark)

∴ $I = \frac{E}{R + \frac{r}{2}}$ and V = IR

∴ $R + \frac{r}{2} = \frac{E}{I} = \frac{ER}{V}$ (1 mark)

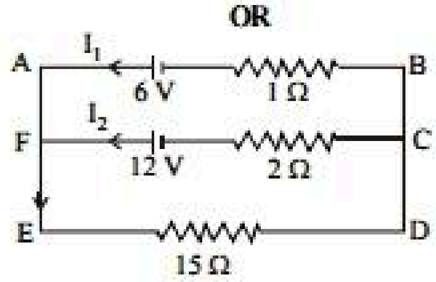
∴ $\frac{r}{2} = \frac{E}{V}R - R = \left(\frac{E}{V} - 1\right)R$

$\Rightarrow\ r = 2\left(\frac{E}{V} - 1\right)R = 2\left(\frac{1.5}{1.4} - 1\right)8.5 = 1.21\,\Omega$. (approx.)

(1 mark)

OR

(i)



(1 mark)

(ii) Applying Kirchhoff's 1st law at pointF,

$I_1 + I_2 = I_3$ .....(1)

For the loop ABCFA, applying Kirchhoff's 2nd law, $12 - 6 = -1I_1 + 2I_2$

$\Rightarrow\ 6 = 2I_2 - I_1$ ....(2)

For the loop FCDEF applying Kirchhoff's 2nd law,

$-12 = -2I_2 - 15I_3$

$12 = 2I_2 + 15(I_1 + I_2)$

$12 = 2I_2 + 15I_1 + 15I_2$

$12 = 15I_1 + 17I_2$ .....(3)

Solving we get, $I_1 = -\frac{78}{47}$ A, $I_2 = \frac{102}{47}$ A and

$I_3 = \frac{24}{47}$ A

Potential difference across the 15 Ω resistance

$= 15 \times I_3 = 15 \times \frac{24}{47} = 7.66$ V. (2 marks)

28. (i) The central bright fringe is white.

(ii) When the source is moved closer to the double-slits, the interference pattern becomes less sharp and if the source is too close to the slits the fringes disappear.

(iii) Due to the increase in the widths of the two slits, the brightness of fringes increase. (3 × 1 = 3 marks)

29. According to Bohr's theory of hydrogen atom, energy of photon released, $E_2 - E_1 = h\nu$

Given, $E_1 = -1.151\text{ eV}$

$E_2 = -0.85$

$E_2 - E_1 = -0.85 - (-1.51) = 1.51 - 0.85$

$E_2 - E_1 = 0.66\text{ eV}$

$\therefore\ E = E_2 - E_1 = 0.66\text{ eV}$ (1 mark)

So, the wavelength of emitted spectral line,

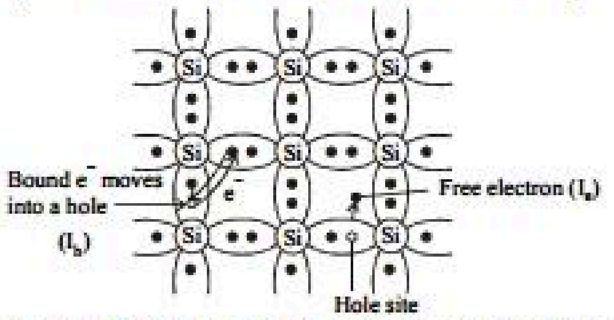
$$\lambda = \frac{1242\text{ eV} - nm}{E(\text{in eV})} = \frac{1242\text{ eV} - \text{nm}}{0.66\text{ eV}}$$

$\lambda = 1.88 \times 10^{-6}\text{ m}$ (1 mark)

As here, $\lambda = 1.88 \times 10^{-6}\text{ m} \approx 18751 \times 10^{-10}\text{ m}$

The wavelength belongs to Paschen series of hydrogen spectrum. (1 mark)

30. In an intrinsic semiconductor, each of the 4 valence electrons is between two atoms (Si or Ge) in a shared covalent bond. It is bound at low temperatures, but at high temperatures it can pick thermal energy and move out of the valence band and into the interstitial space. This electron is free to conduct. The vacancy left behind by it is called a **hole** and it also conducts charge.



Another electron from a different band can come and occupy this vacancy, hence creating a vacancy elsewhere and causing motion of bound electrons. These holes move towards the negative potential giving rise to hole current I_h. The total current I, is sum of hole current I_h and electron current I_e. (3 marks)

OR

$1\text{ ppm} = 1\text{ part per million} = \frac{1}{10^6}$

$\therefore$ No. of As atoms $= \frac{5 \times 10^{28}}{10^6} = 5 \times 10^{22}/\text{m}^3$ (1 mark)

One As atom gives one free electron.

$\therefore\ n_e = 5 \times 10^{22}/\text{m}^3$

Now $n_i^2 = n_e n_h \Rightarrow n_h = \frac{n_i^2}{n_e} = \frac{(1.5 \times 10^{16})^2}{5 \times 10^{22}}$ (1 mark)

(intrinsic Si concentration $= 1.5 \times 10^{16}/\text{m}^3$)

$\Rightarrow\ n_h = 4.5 \times 10^9/\text{m}^3$. (1 mark)

31. The resistivity of the material of a conductor is defined as the resistance of unit length and unit area of cross–section of the conductor. The S. I unit of resistivity is ohm metre (Ωm).

Resistivity of a material, $\rho = \frac{m}{ne^2\tau}$ or $\rho \propto \frac{1}{n\tau}$ Where m is the mass of electron, n is the number density of electron and τ is the average relaxation time. This shows that the resistivity is related to two parameters of the material namely n and τ. (2 marks)

The variation of resistivity with temperature is different in different materials.

(i) **For metallic conductors**

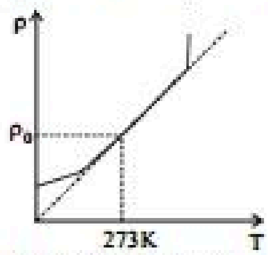
The temperature dependence of resistivity of a metal is given by the relation,

$$\rho = \rho_0[1 + \alpha(T - T_0)] \quad \text{......(1)}$$

Where ρ and ρ_0 are the resistivity at temperature T and T_0 respectively and α is called temperature coefficient of resistivity.

$$\therefore\ \alpha = \frac{\rho - \rho_0}{\rho_0(T - T_0)} = \frac{d\rho}{\rho_0} \cdot \frac{1}{dT} \quad \text{....(2)}$$

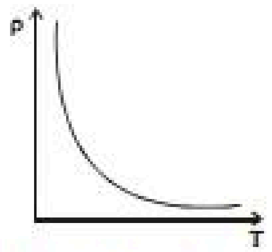
The resistivity of a conductor increases with increase in temperature since α is positive. The variation of resistivity of copper with temperature is as shown.



(1 mark)

(ii) **For Semiconductors**

For Semiconductors, the resistivity decreases as temperature increases since the value of α is negative.



(1 mark)

(iii) **For insulators**

The resistivity increases exponentially with decrease in temperature. It becomes infinitely large at temperatures near absolute zero. (1 mark)

OR

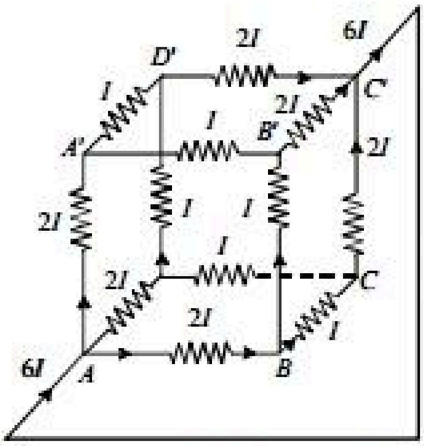
(i) **Kirchhoff's Ist rule or junction rule** The algebraic sum of electric currents at any junction of electric circuit is equal to zero i.e.,

Kirchhorff's IInd rul or Voltage Law in any closed mesh of electrical circuit, the algebraic sum of emfs of cells and the product of currents and resistances is always equal to zero.

i.e., $\sum E + \sum IR = 0$

(ii) Let $6I$ current be drawn from the cell. Since the paths AA', AD and AB are symmetrical, current through them is same. (2 × 1 = 2 marks)

As per Kirchhoff's junction rule, the current distribution is shown in the figure.



Let the equivalent resistance across the combination be R.

$E = V_A - V_B = (6I)R \Rightarrow 6IR = 10 \; [\because E = 10V]$ ...(i)

(1 mark)

Applying Kirchhoff's second rule in loop $AA'B'C'A$

$-2I \times 1 - I \times 1 - 2I \times 1 + 10 = 0 \Rightarrow 5I = 10$

$I = 2\text{A}$

Total current in the network $= 6I$

$= 6 \times 2 = 12$ A (1 mark)

From Eq. (i), $6IR = 10$

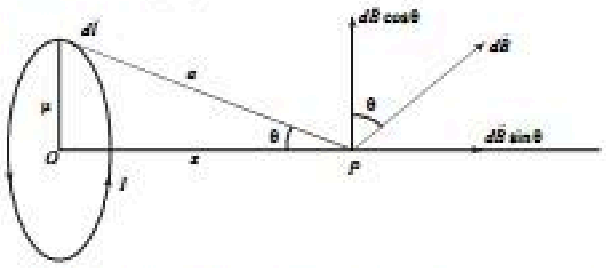
$6 \times 2 \times R = 10$

$R = \frac{10}{12} = \frac{5}{6}\Omega = \frac{5}{6}\Omega$ (1 mark)

32. (a) Magnetic moment associated with a current carrying circular coil of radius r having N turns, (1 mark)

$\vec{M} = NI(\pi r^2)\hat{n}$

(b)



From Biot-savart law, the magnetic field at point $P(x, 0, 0)$ due to current element $\overline{dl}$,

$$\overline{dB} = \frac{\mu_0}{4\pi}\frac{I\,dl \sin 90°}{a^2}$$ (2 marks)

Now, the vertical component $\cos\theta$ will cancel out for entire coil. So,

$\bar{B}$ at $P \Rightarrow B = \int dB \sin\theta$

$$B = \frac{\mu_0 I}{4\pi a^2}\sin\theta \int dl$$

Now $\int dl = 2\pi r \;\therefore\; B = \frac{\mu_0 I}{4\pi a^2} \times \frac{r}{a} \times 2\pi r \left[\because \sin\theta = \frac{r}{a}\right]$

$$B = \frac{\mu_0 I r^2}{2a^3} = \frac{\mu_0 I r^2}{2(r^2 + x^2)^{3/2}}\hat{i}.$$

For coil having N turns, $= \frac{\mu_0 I N r^2}{2(r^2 + x^2)^{3/2}}\hat{i}$. (2 marks)

OR

(a) Current sensitivity

It is defined as the deflection produced in the galvanometer when a unit current flows through it.

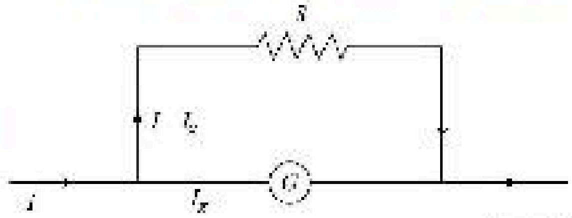
Current sensitivity $I_c = \frac{NBA}{K}$

Where N = no. of turns in the coil

B = Magnetic field

A = area of coil of galvanometer. (1 mark)

(b) (i)



(1 mark)

Galvanometer can be converted into ammeter by connecting a shunt (small resistance) S with parallel to galvanometer.

As galvanometer and shunt are connected in parallel, so,

Potential across G = Potential across the S

$I_g G = (I - I_g)S \;\therefore\; S = \frac{I_g}{I - I_g}G.$ (2 marks)

(ii) Effective resistance of this ammeter will be

$$\frac{1}{R_A} = \frac{1}{G} + \frac{1}{S}$$

$$R_A = \frac{GS}{G+S}.$$ (1 mark)

33. From the lens maker formula, we have

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Let f_1 anf f_2 be the focal lengths of the two mediums.

Then, $\frac{1}{f_1} = (\mu_1 - 1)\left[\frac{1}{R} - \left(-\frac{1}{R}\right)\right] \Rightarrow \frac{1}{f_1} = (\mu_1 - 1)\left(\frac{2}{R}\right)$

$$\frac{1}{f_2} = (\mu_2 - 1)\left[\left(-\frac{1}{R}\right) - \frac{1}{\infty}\right]$$

$\Rightarrow \frac{1}{f_2} = (\mu_2 - 1)\left(-\frac{1}{R}\right)$ (1 mark)

(a) If f_{eq} is the equivalent focal length of the combination, then

$$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} \Rightarrow \frac{1}{f_{eq}} = \frac{2(\mu_1 - 1)}{R} - \frac{(\mu_2 - 1)}{R}$$

$$\Rightarrow \frac{1}{f_{eq}} = \frac{2\mu_1 - \mu_2 - 1}{R}$$

$\Rightarrow f_{eq} = \frac{R}{2\mu_1 - \mu_2 - 1}$ (2 marks)

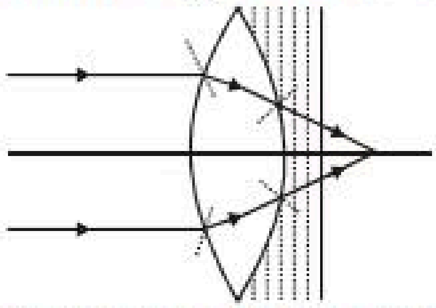
(b) For the combination to behave as a diverging lens, $f_{eq} < 0$

$$\Rightarrow \frac{R}{2\mu_1 - \mu_2 - 1} < 0 \Rightarrow 2\mu_1 - \mu_2 - 1 < 0$$

$$\Rightarrow \mu_1 < \frac{(\mu_2 + 1)}{2}$$ (1 mark)

which is the required condition

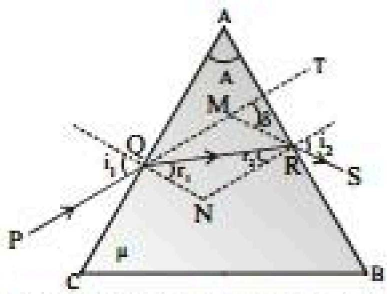
(c) For $\mu_1 > (\mu_2 + 1)/2$, the combination will behave as the converging lens. So, an object placed far away from the lens will form image at the focus of the lens.



The image so formed will be real and diminished in nature. (1 mark)

OR

(i) (1 mark)



Let, PQ and RS are incident and emergent rays. Let, incident ray get deviated by δ by prism i.e.,

$$\angle TMS = \delta$$

Suppose, δ_1 and δ_2 are deviation produced at refractors taking place at AB and AC respectively.

$$\therefore \quad \delta = \delta_1 + \delta_2$$

$$\delta = (i_1 - r_1) + (i_2 - r_2)$$

$$\delta = (i_1 + i_2) - (r_1 + r_2) \quad .....(i)$$ (1 mark)

Also, in quadilateral, AQNR,

$A + \angle QNR = 180°$

[∵ QN and RN are normal on two surfaces]

Also, in ΔQNR,

$\angle QNR + r_1 + r_2 = 180°$

$\Rightarrow \quad A = r_1 + r_2 \quad .....(ii)$ (1 mark)

From eqs. (i) and (ii), we get,

$\delta = (i_1 + i_2) - A z \quad .....(iii)$

Angle of deviation produced by prism varies with angle of incidence.

When prism is adjusted at angle of minimum deviation, then

$$i_1 = i_2 = i$$

At $\delta = \delta_{m'} \Rightarrow r_1 = r_2 = r$

From eqs, (i) and (ii), we have

$$\delta_m = 2i - 2r \text{ and } 2r = A \Rightarrow i = \frac{A + \delta_m}{2} \quad r = \frac{A}{2}$$

∴ Refractive index of material of prism

$$\mu = \frac{\sin i}{\sin r} = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin\frac{A}{2}}$$ (1 mark)

(ii) When light is incident on one end of the optical fibre at an angle of incidence greater than the critical angle for the glass cladding pair of media. The light suffers repeated total internal reflections and light travels through the optical fibre without any loss of energy from one place to other inside the optical fibre. (1 mark)

34. (i) Energy of incident photon

$$E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{3300 \times 10^{-10}} = 3.75 \text{ eV}$$

A will not emit photoelectrons because energy of incident photon is less than work function of *A*. (2 marks)

(ii) $eV_0 = h(v - v_0)$

When $V_0 = 0$, $v = v_0$, the threshold frequency.

From the graph it follows that

$v_0 = 4 \times 10^{15}$ Hz

Therefore, work function is

$\phi = hv_0 = 6.6 \times 10^{-34} \times 4 \times 10^{15} = 16.5$ eV (1 mark)

(iii) $eV_0 = hv - hv_0$

$$V_0 = \frac{h}{e}v - \frac{h}{e}v_0$$

$$Y = mn + e$$

$$\text{Slope} = \frac{h}{e}$$ (1 mark)

OR

(iii) Magnitude of saturation photoelectric current depends on intensity of incident radiation. (1 mark)

35. We know that $r = \frac{mV}{qB}$

$$\therefore \quad V > \frac{qBl}{m}$$

(i) If $V = \frac{qBl}{m}$ then particle will cover semi circular path in this condition the path length of the particle in region II is maximum. (2 marks)

(ii) Nature of orbit is helix. (1 mark)

(iii) $F = q(\vec{V} \times \vec{B})$ if $V \parallel B$, then $\vec{F} = 0$ (1 mark)

OR

(iii) Pair of vectors always right angle are $\overline{F}$ and $\overline{v}$, $\overline{F}$ and $\overline{B}$. (1 mark)