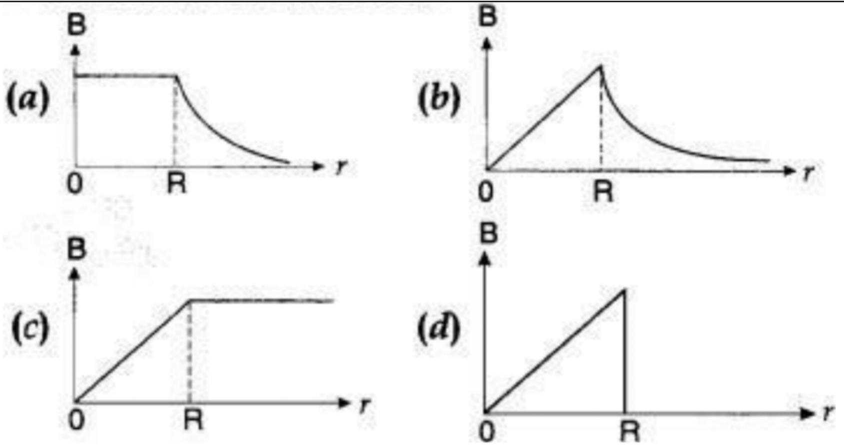
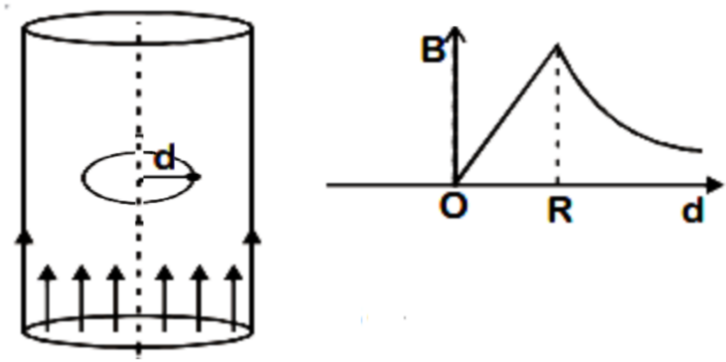
Pre-Board Examination : 2025-26

Sub : Physics

(The figures in the margin indicate full marks for the questions)

Time – 3 hours **Full marks-70**

1.	**Answer following questions : 1x8=8**
a	An electric dipole is placed at an angle of 30^0 with an electric field of intensity $2x10^5$ N/C. It experiences a torque equal to 4 N m. Calculate the magnitude of charge on the dipole, if the dipole length is 2 cm. (a) 6 mC (b) 4 mC (c) 2 mC (d) 8 mC
	We know, $\tau = pE.\sin\theta \Rightarrow p = \frac{\tau}{E.\sin\theta}$ $\Rightarrow q \times 2l = \frac{4}{2 \times 10^5 \times 0.5}$ ....($\because p = q \times 2l$) $\Rightarrow q = \frac{4}{2 \times 10^5 \times 0.5 \times 0.02}$ ....($\because 2l = 0.02$m given) $\Rightarrow q = 2 \times 10^{-3}$ C $= 2$ mC
b	.Kirchhoff's first law, i.e. $\Sigma I = 0$ at a junction, deals with the conservation of (a) Charge (b) Energy (c) Momentum (d) Angular momentum
	(a) Charge
c	The correct plot of the magnitude of magnetic field B vs distance r from centre of the wire is, if the radius of wire is R

	 1
	

Inside (d < R)

Magnetic field inside conductor $B = \frac{\mu_0}{2\pi}\frac{i}{R^2}d$

or $B \propto d$ **...(i)**

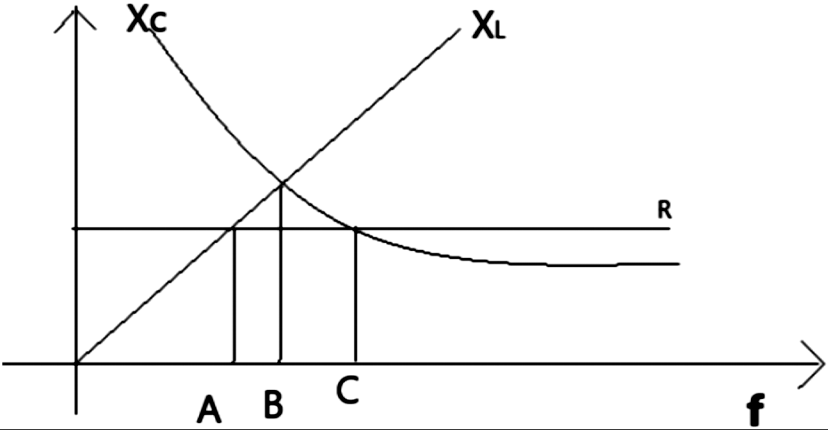
Straight line passing through origin

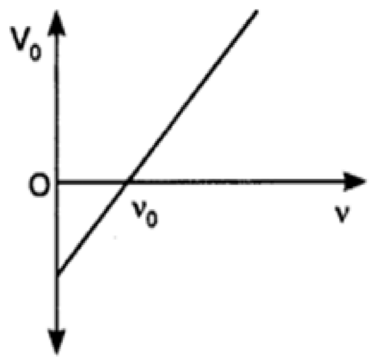
At surface (d = R) $B = \frac{\mu_0}{2\pi}\frac{i}{R}$ **...(ii)**

Maximum at surface

Outside (d > R) $B = \frac{\mu_0}{2\pi}\frac{i}{d}$

or $B \propto \frac{1}{d}$ **(Hyperbolic)**

d	Magnetic flux ϕ (in weber) linked with a closed circuit of resistance 10 ohm varies with time t (in seconds) as $\phi = 5t^2 - 4t + 1$ .The induced electromotive force in the circuit at t = 0.2 sec. is (a) 0.4volts (b) – 0.4volts (c) – 2.0volts (d) 2.0 volts
	The induced electromotive force (e) in a circuit is equal to the negative rate of change of magnetic flux (ϕ) through the circuit: $e = -\frac{d\phi}{dt}$ ....(i) $\phi = 5t^2 - 4t + 1$ ....(ii) $\frac{d\phi}{dt} = \frac{d}{dt}(5t^2 - 4t + 1) = 10t - 4$ So $e = -(10t - 4) = 4 - 10t$ Now, substitute $t = 0.2$ s the emf at that instant: $e = 4 - 10(0.2) = 4 - 2 = 2$ V
e	Q7. The figure shows variation of R, X_L and X_C with frequency f in a series L, C, R circuit. Then for what frequency point, the circuit is inductive (a) A (b) B (c) C (d) All points 

	Based on the variation of X_L and X_C with frequency f 1: Point A (Low Frequency): At low frequencies, capacitive reactance $(X_C = \frac{1}{2\pi f C})$ is high and inductive reactance $(X_L = 2\pi f L)$ is low. Since $X_C > X_L$, the circuit behaves capacitively. 2: Point B (Resonance): This is the point where the X_L and X_C curves intersect. At this frequency, $X_C = X_L$, and the circuit is purely resistive. 3:Point C (High Frequency): At higher frequencies beyond the resonance point, X_L continues to increase while X_C decreases. Since $X_L > X_C$ at this point, the circuit behaves inductively. Ans - The circuit is **inductive** at point **(c)**
f	The stopping potential V_0 for photoelectric emission from a metal surface is plotted along with the y-axis and frequency v of incident light along the x-axis. A straight line is obtained as shown. Planck's constant is given by  a) product of the slope of the line and charge on the electron b) intercept along y-axis divided by the charge on the electron c) product of the intercept along x-axis and mass of the electron

	(d) the slope of the line
	The correct option is (a) product of the slope of the line and charge on the electron. Thus, h = slope x e.
g	In Rutherford's α -particle scattering experiment, what will be correct angle for α scattering for an impact parameter b = 0 ? (a) 90º (b) 270º (c) 0º (d) 180º
	(d) 180^0
h	What is use of the filter in the output circuit of a full wave rectifier ? What type of filter it is ?
	In a full-wave rectifier, the conversion from AC to DC isn't perfect. The output is **pulsating DC**, meaning while the current flows in one direction, it fluctuates significantly in voltage. This is use of the filter in the output circuit of a full wave rectifier . The most common type of filter used in the output circuit of a full-wave rectifier is a **shunt capacitor filter** connected in parallel with the load.
2	A parallel plate capacitor is charged by a battery. The battery is disconnected and a dielectric slab is inserted between the plates. What will be the effect on its (i) Capacitance (ii) Charge (iii) Potential difference (iv) Electric field 2
	When a dielectric slab is inserted into a disconnected, charged parallel plate capacitor, its capacitance increases ($C = kC_o$), charge remains constant

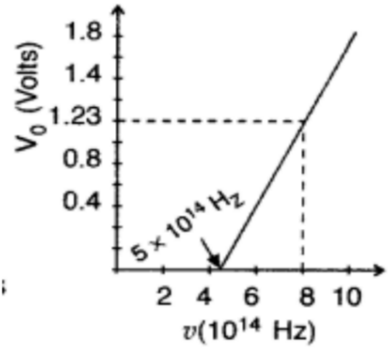
	(Q = constant), and both the potential difference ($V = V_o / k$) and electric field ($E = E_o / k$) decrease by a factor of the dielectric constant k. (i) Capacitance: Increases by a factor of k ($C = kCo$). (ii) Charge: Remains constant ($q = Q_o$). (iii) Potential difference: Decreases by a factor of k ($V=V_0 /k$). (iv) Electric field: Decreases by a factor of k ($E = E_0/k$)
3	Define temperature coefficient of resistance. The resistance of a tungsten filament at 150^0C is 133 **Ω**. What will be its resistance at 5000C? Given the temperature coefficient of tungsten is 0.0045 $^{\mathbf{0}}\mathrm{C}^{\mathbf{-1}}$. 2

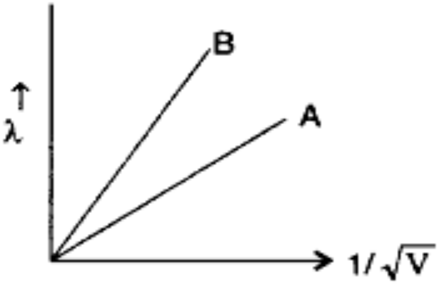
	Initial resistance at $T_1 = 150°C$: $R_1 = 133\ \Omega$ Final temperature: $T_2 = 500°C$ Temperature coefficient of resistance for tungsten: $\alpha = 0.0045\ °C^{-1}$ The resistance of a conductor at any temperature T is given by $R_T = R_0(1 + \alpha T)$, where R_0 is the resistance at 0°C. $\Rightarrow \frac{R_2}{R_1} = \frac{1+\alpha T_2}{1+\alpha T_1} \Rightarrow R_2 = R_1\left(\frac{1+\alpha T_2}{1+\alpha T_1}\right)$ $\Rightarrow R_2 = 133 \times \left(\frac{1+(0.0045\times 500)}{1+(0.0045\times 150)}\right) = 133 \times \left(\frac{1+2.25}{1+0.675}\right)$ $\Rightarrow R_2 = 133 \times \frac{3.25}{1.675} \approx 258.0597\ \Omega \approx$ **258.06 Ω**.
4	Find the expression for the displacement current . 2 Or Name the following parts of the electromagnetic spectrums. a) used in radar systems for aircraft navigation b) used to treat muscular strain c) used in hospitals for diagnosing diseases Also, briefly describe how these waves can be produced. 2
	(i) Microwave, **Production :** Klystron/magnetron/Gunn diode (ii) Infrared Radiation, **Production :** Hot bodies/vibrations of atoms and molecules. (iii) X-Rays,

	Production : Bombarding high energy electrons on metal target/x-ray tube/inner shell electrons.
5	In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of 2.0×10^{10} Hz and amplitude 48 V m^{-1}. (a) What is the wavelength of the wave? (b) What is the amplitude of the oscillating magnetic field? Or Show that the average energy density of the E field equals the average energy density of the B field. [$c = 3 \times 10^8$ m s^{-1}.] 2
	Frequency of the electromagnetic wave, $v = 2.0 \times 10^{10}$ Hz Electric field amplitude, $E_0 = 48$ V m^{-1} Speed of light, $c = 3 \times 10^8$ m/s **(a)** Wavelength of a wave is given as: $\lambda = \frac{c}{v} = \frac{3 \times 10^8}{2 \times 10^{10}} = 0.015$ m **(b)** Magnetic field strength is given as: $B_0 = \frac{E_0}{c} = \frac{48}{3 \times 10^8} = 1.6 \times 10^{-7}$ T Or

	Energy density of the electric field is given as: $U_E = \frac{1}{2} \epsilon_0 E^2$ And, energy density of the magnetic field is given as: $U_B = \frac{1}{2\mu_0} B^2$ Where, ϵ_0 = Permittivity of free space, μ_0 = Permeability of free space. We have the relation connecting E and B as: $E = cB$ ……………(1) Where, $c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$ ……….(2) $(1) \Rightarrow E = \frac{1}{\sqrt{\epsilon_0 \mu_0}} B$ $\Rightarrow E^2 = \frac{1}{\epsilon_0 \mu_0} B^2 \Rightarrow \epsilon_0 E^2 = \frac{B^2}{\mu_0}$ $\Rightarrow \frac{1}{2} \epsilon_0 E^2 = \frac{1}{2} \frac{B^2}{\mu_0} \Rightarrow U_E = U_B$
6	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' (i) $\mu_2 > \mu_1$ (ii) $\mu_2 < \mu_1$ Draw the ray diagram in the two cases when a beam of light coming parallel to principal axis is incident on the lens. Also find the focal length of the lens in terms of the original focal length of the refractive index of the glass of the lens and that of the medium. 2

	For an equiconvex lens in air (refractive index 1), the focal length f is given by the Lens Maker's Formula: $\frac{1}{f} = (\mu_1 - 1)(\frac{1}{R} - \frac{1}{-R}) = \frac{2(\mu_1 - 1)}{R}$ $\implies \frac{2}{R} = \frac{1}{f(\mu_1 - 1)}$ ....(i) When the lens is immersed in a liquid of refractive index μ_2, the relative refractive index becomes $\frac{\mu_1}{\mu_2}$. The new focal length f_l is: $\frac{1}{f_l} = (\frac{\mu_1}{\mu_2} - 1)\frac{2}{R}$ ....(ii) Putting (i) in (ii) => $\frac{1}{f_l} = (\frac{\mu_1 - \mu_2}{\mu_2})\frac{1}{f(\mu_1 - 1)}$ $\implies f_l = \frac{f\mu_2(\mu_1 - 1)}{\mu_1 - \mu_2}$ **Case (i): $\mu_2 > \mu_1$** Since $\mu_1 - \mu_2 < 0$, the focal length f_l becomes **negative**. The equiconvex lens acts as a **diverging lens.** **Case (ii): $\mu_2 < \mu_1$** Since $\mu_1 - \mu_2 > 0$, the focal length f_l remains **positive**. The lens remains **converging**, but $f_l > f$
7	Using the graph shown in the figure for stopping potential v/s the incident frequency of photons, calculate Planck's constant.

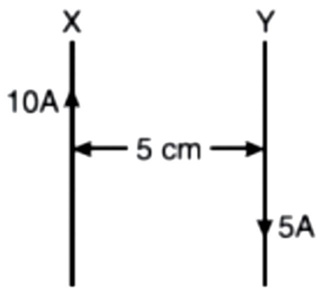
	 2
	Based on the graph of stopping potential (V_0) versus incident frequency (f), Planck's constant (h) is calculated using the slope of the line, which represents $\frac{h}{e}$. The Einstein photoelectric equation is $$V_0 = \left(\frac{h}{e}\right) f - \frac{\phi}{e}.$$ The slope of the V_0 vs f graph is $\frac{h}{e}$. **Calculate the Slope ($\Delta V_0/\Delta f$):** Using typical graph values (e.g., from $f = 5 \times 10^{14}$ Hz to $f = 8 \times 10^{14}$ Hz, with V_0 changing from 0 to 1.23 V), $$\text{Slope} = \frac{1.23 - 0}{(8-5)\times 10^{14}} = \frac{1.23}{3\times10^{14}} \approx 4.1\times10^{-15}\ \text{V}\cdot\text{s}$$ The relationship is $h = \text{slope} \times e = \frac{\Delta V_0}{\Delta f} \times e$, $$h = (4.1 \times 10^{-15}) \times (1.6 \times 10^{-19}) \approx 6.56 \times 10^{-34}\ \text{Js}$$
8	Derive the expression for the de Broglie wavelength of an electron moving under a potential difference of V volts . 2

9	Two lines, A and B, in the plot given below show the variation of de-Broglie wavelength, λ versus 1/√V , Where V is the accelerating potential difference, for two particles carrying the same charge. Which one of two represents a particle of smaller mass ?  . 2
	$\therefore \lambda = \frac{h}{\sqrt{2meV}} \Rightarrow \lambda = \frac{h}{\sqrt{m}.\sqrt{2e}}.\frac{1}{\sqrt{V}}$ $\Rightarrow \frac{1}{\sqrt{m}} = \frac{\sqrt{2e}}{h}.\left(\frac{\lambda}{1/\sqrt{V}}\right)$ $\therefore \frac{1}{\sqrt{m}} = \frac{\sqrt{2e}}{h} \times \left(\text{Slope of } \lambda \& \sqrt{V}\text{graph}\right)$ $\therefore \text{Slope of B} > \text{Slope of A} \frac{1}{\sqrt{m_B}} > \frac{1}{\sqrt{m_A}}$ $\Rightarrow \sqrt{m_B} < \sqrt{m_A} \therefore m_B < m_A$ Therefore, line B represents a particle of smaller mass.
10	(a) The radius of the innermost electron orbit of a hydrogen atom is 5.3×10^{-11} m. Calculate its radius in n = 3 orbit. (b) The total energy of an electron in the first excited state of the hydrogen atom is -3.4 eV. Find out its (i) kinetic energy and potential energy in this state. 2

	In the Bohr model of the hydrogen atom, the radius of the n-th orbit r_n is $r_n = n^2 r_1$ Given the innermost radius ($n = 1$) is $r_1 = 5.3 \times 10^{-11}$ m, for the $n = 3$ orbit: $r_3 = 3^2 \times (5.3 \times 10^{-11}\ \text{m})$ $= 9 \times 5.3 \times 10^{-11}$ m $= 47.7 \times 10^{-11}$ m $= 4.77 \times 10^{-10}$ m For an electron in a hydrogen atom, the total energy E, kinetic energy K, and potential energy U as: **Kinetic Energy:** $K = -E$ **Potential Energy:** $U = 2E$ Given the total energy in the first excited state ($n = 2$) is $E = -3.4$ eV **Kinetic Energy:** $K = -(-3.4\ \text{eV}) = 3.4\ \text{eV}$ **Potential Energy:** $U = 2 \times (-3.4\ \text{eV}) = -6.8\ \text{eV}$
11	Calculate the energy released in MeV in the following nuclear reaction: $^{238}_{92}\text{U} \longrightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He} + Q$ **[Mass of $^{238}_{92}$U = 238.05079 u,** **Mass of $^{234}_{90}$Th = 234.043630 u,** **Mass of $^{4}_{2}$He = 4.002600 u, 1u = 931.5 MeV/c²]** 2

	The reaction represents the alpha decay of Uranium-238 into Thorium-234 and an alpha particle (Helium-4 nucleus): $^{238}_{92}\mathrm{U} \rightarrow ^{234}_{90}\mathrm{Th} + ^{4}_{2}\mathrm{He} + Q$ Mass of $^{238}_{92}\mathrm{U} \approx 238.05079\ \mathrm{u}$ Mass of $^{234}_{90}\mathrm{Th} \approx 234.04363\ \mathrm{u}$ Mass of $^{4}_{2}\mathrm{He} \approx 4.00260\ \mathrm{u}$ Conversion factor: $1\ \mathrm{u} = 931.5\ \mathrm{MeV}/c^2$ The mass defect is $\Delta m = M(^{238}\mathrm{U}) - [M(^{234}\mathrm{Th}) + M(^{4}\mathrm{He})]$ $\Delta m = 238.05079 - (234.04363 + 4.00260)$ $\Delta m = 238.05079 - 238.04623 = 0.00456\ \mathrm{u}$ Using the mass-energy equivalence principle $Q = 0.00456\ \mathrm{u} \times 931.5\ \mathrm{MeV} \approx 4.24764\ \mathrm{MeV}$
12	Find the electric potential due to an electric dipole at an arbitrary point . 3 Or Prove that there is always loss of energy on sharing charges between two capacitors . 3
13	(i) The amount of charge passing through cross-section of wire is $q = t^2 + 4t + 1$,find the value of current at t = 1s (ii) The resistance of a thin wire of silver is = 1.0 Ω at 20°C. The wire is placed in a liquid bath and its resistance rises to 1.2Ω. find the temperature of the bath in°C .($\boldsymbol{\alpha} = 3.8 \times 10^{-3}$ /°C) 1½+1½=3

	Given $q = t^2 + 4t + 1$ $I = \frac{dq}{dt} = \frac{d}{dt}(t^2 + 4t + 1)$ => $I = 2t + 4$ The instantaneous current at $t = 1$ s, $I(1) = 2(1) + 4 = 6$ A The resistance of a conductor at a specific temperature is $R_T = R_0[1 + \alpha(T - T_0)]$ Where: $R_T = 1.2\ \Omega$ is the final resistance. $R_0 = 1.0\ \Omega$ is the initial resistance at $20^\circ C$ $\alpha = 3.8 \times 10^{-3}\ /^\circ C$ is the temperature coefficient of silver $T_0 = 20^\circ C$ is the initial temperature. T is the final temperature of the bath. $R_T - R_0 = R_0\alpha(T - T_0)$ => $1.2 - 1.0 = 1.0 \times (3.8 \times 10^{-3}) \times (T - 20)$ => $0.2 = 0.0038 \times (T - 20)$ => $T - 20 = \frac{0.2}{0.0038}$ => $T - 20 = 52.63^\circ C = 20 + 52.63 = 72.63^\circ C$
	Or (i) Prove that $v_d = \frac{I}{neA}$, where symbols are having usual meanings . (ii) A copper wire has a cross-sectional area of 7.85×10^{-7} m^2. The number density of copper is 8.5×10^{28} m^{-3}. Calculate the mean drift velocity of the electrons through the wire when the current is 1.4 A. 1½+1½=3

	The relationship between electric current I and drift velocity v_d is given by the formula: $$I = nAev_d$$ Where: $I = 1.4$ A (Current) $n = 8.5 \times 10^{28}\ \text{m}^{-3}$ (Number density) $A = 7.85 \times 10^{-7}\ \text{m}^2$ (Cross-sectional area) $e = 1.60 \times 10^{-19}$ C $$v_d = \frac{I}{nAe}$$ $$v_d = \frac{1.4}{(8.5 \times 10^{28}) \times (7.85 \times 10^{-7}) \times (1.60 \times 10^{-19})}$$ $$v_d = \frac{1.4}{10676} = 1.3113 \times 10^{-4}\ \text{m/s}$$
14	(i) Find the expression for force acting on a current carrying conductor placed in a uniform magnetic field. (ii) Two parallel straight wires X and Y separated by a distance 5 cm in air carry current of 10 A and 5 A respectively in opposite direction as shown in diagram. Calculate the magnitude and direction of the force on a 20 cm length of the wire Y.  1+½+1½=3
	(ii)

	Current in wire X: $I_1 = 10\ \text{A}$ Current in wire Y: $I_2 = 5\ \text{A}$ Distance between wires: $d = 5\ \text{cm} = 0.05\ \text{m}$ Length of the segment: $L = 20\ \text{cm} = 0.2\ \text{m}$ Permeability of free space: $\mu_0 = 4\pi \times 10^{-7}\ \text{T} \cdot \text{m/A}$ The magnetic force F between two parallel current -carrying wires is $F = \frac{\mu_0 I_1 I_2 L}{2\pi d}$ $F = \frac{(4\pi \times 10^{-7}) \times 10 \times 5 \times 0.2}{2\pi \times 0.05}$ $F = \frac{2 \times 10^{-7} \times 10 \times 1}{0.05} = \frac{2 \times 10^{-6}}{0.05} = 4 \times 10^{-5}\ \text{N}$ According to the laws of electromagnetism, parallel wires carrying currents in opposite directions experience a repulsive force. Since the currents in wire X and wire Y are in opposite directions, the force on wire Y will act away from wire X.
	Or Find the expression for the magnetic field due to a bar magnet at a point on its axial line . 3
15	Describing the principle of a moving coil galvanometer . Find the expression for its current sensitivity and voltage sensitivity . On what factors these depend. 3 Or (a)Distinguish the magnetic properties of dia, para and ferromagnetic substances in terms of

	(i) susceptibility and (ii) permeability. Give one example of each of these materials. (b) Why does the magnetisation of a paramagnetic material decrease on cooling? 3

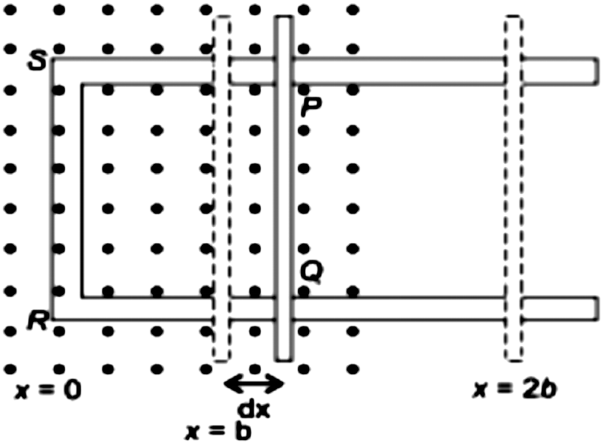
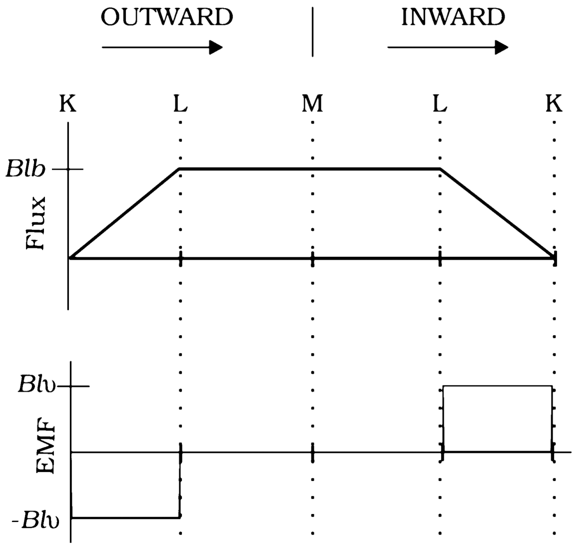
(a) Distinction of Magnetic Properties

Property	Diamagnetic	Paramagnetic	Ferromagnetic
(i) Susceptibility (χ_m)	Small and **negative**	Small and **positive**	Large and **positive**
(ii) Relative Permeability (μ_r)	Slightly **less than 1** ($\mu_r < 1$)	Slightly **greater than 1** ($\mu_r > 1$)	**Very large** ($\mu_r \gg 1$)
Example	Water, Bismuth, Copper	Aluminum, Platinum, Oxygen	Iron, Cobalt, Nickel

(b) Magnetization of Paramagnetic Materials and Temperature

Actually, the magnetization of a paramagnetic material increases on cooling (it decreases on heating).

16	Figure shows a rectangular conductor PQRS in which the conductor PQ is free to move in a uniform magnetic field B perpendicular to the plane of the paper. The field extends from x = 0 to x = b and is zero for x > b. Assume that only the arm PQ possesses resistance r. When the arm PQ is pulled outward from x = 0 to x = 2b and is then moved backward to x =0 with constant speed v, obtain the expressions for the flux and the induced emf. Sketch the variations of these quantities with distance $0 \le x \le 2b$.

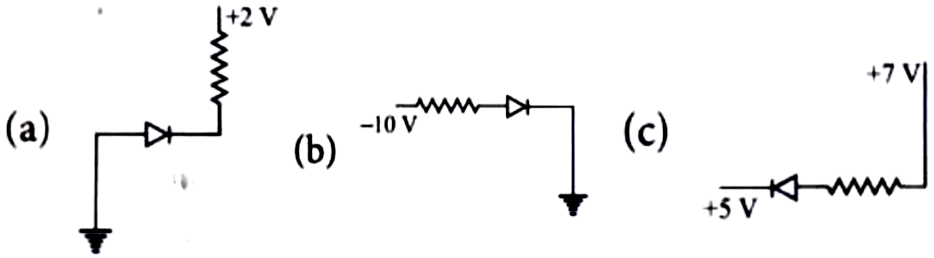
	 3
	Let us first consider the forward motion from $x = 0$ to $x = 2b$ The flux Φ_B linked with the circuit SPQR is $\Phi_B = Blx \qquad 0 \le x < b$ $= Blb \qquad b \le x < 2b$ The induced emf is, $\varepsilon = -\frac{d\Phi_B}{dt}$ $= -Blv \qquad 0 \le x < b$ $= 0 \qquad b \le x < 2b$ 

	Or A horizontal wire of 10 m long extending from east to west is falling with a speed of 5 m/s at right angles to the horizontal component of earth's magnetic field equal to 0.30×10^{-4} Wb/m^2. (a) What is the instantaneous value of the emf induced in the wire? (b) What is the direction induced current? (c) Which end of the wire is at the higher electric potential?. 3
	Length of the wire, l = 10 m Falling speed of the wire, v = 5.0 m/s Magnetic field strength, $B = 0.3 \times 10^{-4}$ Wb m^{-2} a. Emf induced in the wire, $e = Blv = 0.3 \times 10^{-4} \times 5 \times 10 = 1.5 \times 10^{-3}$ V b. Using Fleming's right-hand rule, it can be inferred that the direction of the induced emf is from West to East. c. The eastern end of the wire is at a higher potential
17	A series LCR circuit with R = 20 Ω , L = 2H and C = 50 μF is connected to a 200 V A.C source of variable frequency- (i) What is the amplitude of the current and its rms value. (ii) what is the average power transferred to the circuit in one complete cycle at resonance (iii) Calculate the potential drop across the capacitor?

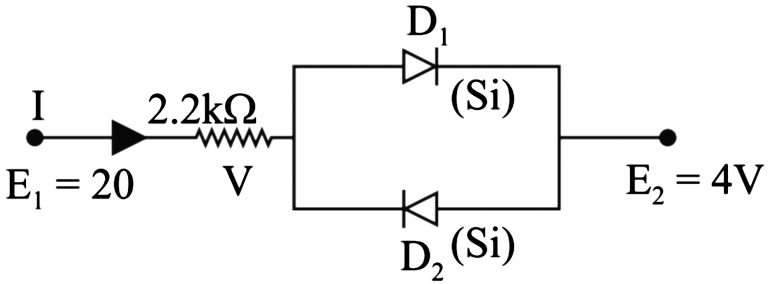
	1+1+1=3
	At resonance, the inductive reactance X_L and capacitive reactance X_C cancel each other out, making the impedance Z equal to the resistance R. The RMS current I_{rms} is: $$I_{rms} = \frac{V_{rms}}{R} = \frac{200}{20} = 10 \text{ A}$$ The peak value of AC is: $$I_0 = I_{rms}\sqrt{2} = 10 \times 1.414 = 14.14 \text{ A}$$ In a resonant LCR circuit, the power factor $\cos\phi$ is 1 because the phase difference between voltage and current is zero. The average power P_{avg} is given by: $$P_{avg} = I_{rms}^2 R = 10^2 \times 20 = 100 \times 20 = 2000 \text{ W}$$ The resonant angular frequency ω_0: $$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{2\times 50 \times 10^{-6}}} = \frac{1}{\sqrt{10^{-4}}} = 100 \text{ rad/s}$$ The capacitive reactance X_C is: $$X_C = \frac{1}{\omega_0 C} = \frac{1}{100 \times 50 \times 10^{-6}} = \frac{1}{5 \times 10^{-3}} = 200\ \Omega$$ The potential drop across the capacitor V_C is: $$V_C = I_{rms} \times X_C = 10 \times 200 = 2000 \text{ V}$$
	Or In an ideal transformer, the number of turns of primary and secondary is 1000 and 2000 respectively.

	(i) If maximum voltage in primary is 120V, what is the maximum voltage in secondary? (ii) if the current in primary coil is 5 Amp calculate current in secondary coil? 3
	In an **ideal transformer,** the ratio of the voltages is equal to the ratio of the number of turns in the coils. $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ Where V_s is the secondary voltage, V_p is the primary voltage, N_s is the number of secondary turns, and N_p is the number of primary turns. Rearranging for V_s: $V_s = V_p \times \frac{N_s}{N_p} = 120 \times \frac{2000}{1000} = \mathbf{240\ V}$ For an ideal transformer, power is conserved ($P_p = P_s$), which means the current is inversely proportional to the turns ratio: $\frac{I_s}{I_p} = \frac{N_p}{N_s}$ Where I_s is the secondary current and I_p is the primary current. Rearranging for I_s: $I_s = I_p \times \frac{N_p}{N_s} = 5 \times \frac{1000}{2000} = 5 \times 0.5 = \mathbf{2.5\ A}$
18	(i) Describe the formation secondary minimas in the difraction of light at a single slit . 2 (ii) Prove that size of the central maxima in the difraction pattern of light at single slit is twice that of the secondary maximas . 1

	Position of Minima: For a slit of width a and screen distance D, the minima occur at angles θ given by $a\sin\theta = n\lambda$. For small angles ($\sin\theta \approx \theta \approx \tan\theta$), $\theta \approx \tan\theta = \frac{y_n}{D}$, where y_n is the position of the n^{th} minimum So , $a\theta = n\lambda \Rightarrow a\frac{y_n}{D} = n\lambda \Rightarrow y_n = \frac{n\lambda D}{a}$ **Central Maxima Size:** The central maximum lies between left ($n = -1$) and the first minimum on the right ($n = +1$) Linear width = Distance (y_1) - Distance (y_{-1}) Width $= \left(\frac{\lambda D}{a}\right) - \left(-\frac{\lambda D}{a}\right) = \frac{2\lambda D}{a}$. **Secondary Maxima Size:** A secondary maximum exists between two consecutive minima (e.g., between $n = 1$ and $n = 2$). Linear width $= y_2 - y_1 = \frac{2\lambda D}{a} - \frac{\lambda D}{a} = \frac{\lambda D}{a}$ $\frac{\text{Width of Central Maxima}}{\text{Width of Secondary Maxima}} = \frac{\left(\frac{2\lambda D}{a}\right)}{\left(\frac{\lambda D}{a}\right)} = 2$. Therefore, the central maximum is twice as wide as the secondary maxima.
	Or (i) State Huygen's principle . (ii) Using Huygen's principle , establish the law of refraction . 1+2= 3
19	(i) Give the difference between valance band and

	conduction band ? (ii) What is the value of forbidden gap energy of germanium? (iii) Which of the following represents forward biasing and reverse biasing ?  1+½+1½=3
	(a) Reverse biased (b) Reverse biased (c) Forward biased
	Or For a P-N junction diode forward bias is increased form 2.0V to 2.5 V so forward current is changed from 16.5 mA to 26.5 mA. For same diode reverse bias is increased form 5V to 10 V so the reverse current changes from 20 microampere to 30 microampere. Calculate the dynamic resistance for this diode in both the situations. Why there is a huge difference in the two values of the resistances ? 3

	Dynamic resistance (r_d) is the ratio of the change in voltage (ΔV) to the corresponding change in current (ΔI): $$\text{Dynamic Resistance } (r_d) = \frac{\Delta V}{\Delta I}$$ **A. Forward Dynamic Resistance (r_f)** Given: Forward voltage change (ΔV_f) = $2.5\text{V} - 2.0\text{V}$ $= 0.5\text{V}$ Forward current change (ΔI_f) = $26.5\text{mA} - 16.5\text{mA}$ $= 10.0\text{mA} = 0.01\text{A}$ $$r_f = \frac{\Delta V_f}{\Delta I_f} = \frac{0.5\text{ V}}{0.01\text{ A}} = \mathbf{50\ \Omega}$$ **B. Reverse Dynamic Resistance (r_r)** Given: Reverse voltage change (ΔV_r) = $10\text{V} - 5\text{V} = 5\text{V}$ Reverse current change (ΔI_r) = $30\mu\text{A} - 20\mu\text{A}$ $= 10\mu\text{A} = 10 \times 10^{-6}\text{A}$ $$r_r = \frac{\Delta V_r}{\Delta I_r} = \frac{5\text{ V}}{10 \times 10^{-6}\text{ A}} = \mathbf{500,000\ \Omega\ (500\ k\Omega)}$$
20	(i) In a p-n junction, width of depletion region is 300 nm and electric field of 7×10^5 V/m exists in it. Find the height of potential barrier. 1½ (ii) Determine the current I for the network. (Barrier voltage for Si diode is 0.7 volt).



1½

(i) The potential barrier height (V) in a p-n junction is related to the electric field (E) and the width of the depletion region (d) by the formula:

$$V = E \times d$$

Given :Electric field, $E = 7 \times 10^5$ V/m

Width of depletion region, $d = 300$ nm $= 300 \times 10^{-9}$ m

The potential barrier height is

$V = (7 \times 10^5 \text{ V/m}) \times (300 \times 10^{-9} \text{ m})$

$V = 2100 \times 10^{-4}$ v $= 0.21$ V

(ii) D_1 is forward biased and D_2 is reverse biased.

The voltage equation is -

$E_1 - IR - V_{D1} = E_2$

$\Rightarrow 20 - I \times 2.2 \times 10^3 - 0.7 = 4$

$\Rightarrow 20 - 0.7 - 4 = I \times 2.2 \times 10^3$

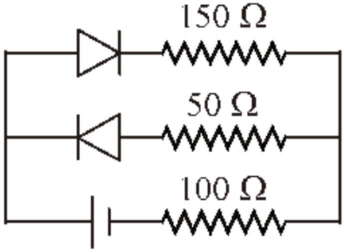
$\Rightarrow I \times 2.2 \times 10^3 = 15.3$

$\Rightarrow I = \dfrac{15.3}{2.2 \times 10^3} = 15.3 / 2.2 \times 10^3 = 0.00695 = 0.007$A

$\Rightarrow I = 7$mA

Or

As shown in the circuit below the forward resistance of both diodes is 50 Ω and reverse resistance in infinite. If' emf of the battery is 6 V then calculate the current flowing through 100Ω. 3



- Diode with 150Ω is forward biased . It acts as a resistor with R, = 50Ω.
- Diode D with 50Ω is reverse biased . Since its reverse resistance is infinite, it acts as an open circuit, meaning no current flows through 50Ω .

Calculate Total Resistance

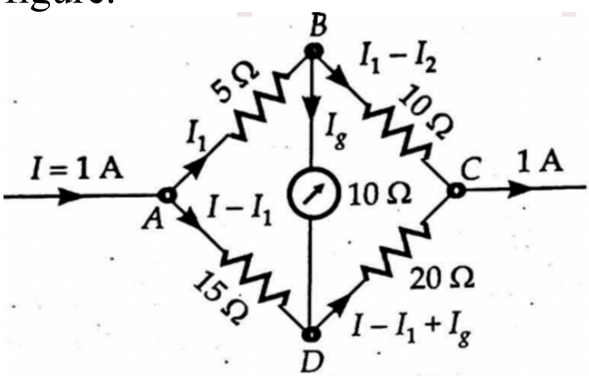
$$R_{total} = R_{D1} + R_{150} + R_{100}$$
$$= 50\,\Omega + 150\,\Omega + 100\,\Omega = 300\,\Omega$$

Using Ohm's Law , the current flowing through the circuit:

$$I = \frac{6\text{ V}}{300\,\Omega} = 0.02\text{ A}$$

21 (i) Give the difference between charging and discharging of a cell . 2

(ii) Determine the current flowing through the galvanometer G of Wheatstone Bridge shown in figure.

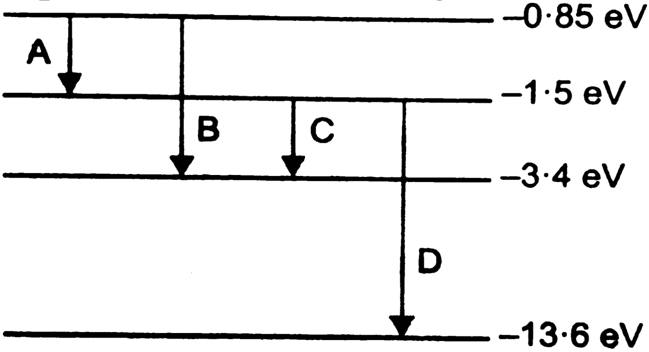


3

	To find I_g we apply Kirchhoff's voltage law. Loop ABDA $-5I_1 - 10I_g + 15I_2 = 0$ $\Rightarrow -5I_1 + 15I_2 = 10I_g$ $\Rightarrow -I_1 + 3I_2 = 2I_g$ .... (1) Loop BCDB : $-10(I_1 - I_g) + 20(I_2 + I_g) + 10I_g = 0$ $\Rightarrow -10I_1 + 10I_g + 20I_2 + 20I_g + 10I_g = 0$ $\Rightarrow I_1 - 2I_2 = 4I_g$ .... (2) Adding Eqs. (1) and (2), we get, $I_2 = 6\ I_g$ .... (3) Substituting for I_2 from Eq. (3) in Eq. (2). $\Rightarrow I_1 = 12I_g + 4I_g = 16I_g$ Now, $I_1 + I_2 = 2\ A \Rightarrow 16I_g + 6I_g = 1\ A$ $\Rightarrow 22I_g = 1\ A$ $\therefore I_g = \frac{1}{22}$ A from B to D
	Or, Define drift velocity and derive an expression for drift velocity of electrons in a conductor hence deduce Ohm's law. 1+2+2=5
22	**(i)** Deduce Lens Maker's formula . 3 **(ii)**A double convex lens is made of a glass of refractive index 1.55, with both faces of the same radius of curvature. Find the radius of curvature required, if the focal length is 20 cm. 2

	Refractive index of glass, $\mu = 1.55$ Focal length of the double-convex lens, $f = 20$ cm Radius of curvature of one face of the lens = R_1 Radius of curvature of the other face of the lens = R_2 Radius of curvature of the double-convex lens = R The value of R can be calculated as: $\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ $\quad$ $R_1 = R$ and $R_2 = -R$ $\Rightarrow \frac{1}{20} = (1.55 - 1)\left[\frac{1}{R} + \frac{1}{R}\right]$ $\Rightarrow \frac{1}{20} = 0.55 \times \frac{2}{R}$ $\Rightarrow R = 0.55 \times 2 \times 20 = 22$ cm
	Or **(i)** What is the focal length of a combination of a convex lens of focal length 30 cm and a concave lens of focal length 20 cm in contact? Is the system a converging or a diverging lens? Ignore thickness of lenses. 2 **(ii)** A tank is filled with water to a height of 12.5 m. The apparent depth of the needle lying at the bottom of the tank as measured by a microscope is 9.4 cm. What is the refractive index of water? If water is replaced by a liquid of refractive index 1.63 up-to the same height, by what distance would the microscope be moved to focus on the needle again? 2

	(i) Focal length of the convex lens, $f_1 = 30$ cm Focal length of the concave lens, $f_2 = -20$ cm Focal length of the system of lenses = f The equivalent focal length of a system of two lenses in contact is: $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$ $\Rightarrow \frac{1}{f} = \frac{1}{30} - \frac{1}{20} = \frac{2-3}{60} = -\frac{1}{60} \Rightarrow f = -60$ cm Hence, the focal length of the combination of lenses is 60 cm. The negative sign indicates that the system of lenses acts as a diverging lens. (ii) The refractive index n of a medium is $n_w = \frac{h}{d_w}$ Given $h = 12.5$ cm and $d_w = 9.4$ cm $\Rightarrow n_w = \frac{12.5}{9.4} = 1.33$ When the water is replaced by a liquid with a refractive index $n_l = 1.63$, the new apparent depth is d_l The refractive index n of a liquid is $n_l = \frac{h}{d_l}$ $\Rightarrow d_l = \frac{h}{n_l} = \frac{12.5}{1.63} \approx 7.67$ cm The microscope was initially focused at a depth of 9.4 cm from the surface. To focus at the new apparent depth of 7.67 cm, it must be moved. The distance moved Δd is: $\Delta d = d_w - d_l = 9.4 - 7.67 = 1.73$ cm So the microscope must be moved upward by 1.73 cm
23	(i) Show that the radius of the orbit in hydrogen atom varies as n^2, where n is the principal quantum number of the atom. 2

	(ii) The energy level diagram of an element is given here . Which transition corresponds to the emission of a spectral line of wavelength 102.7nm?  3
	(i) $\lambda = 102.7nm = 102.7 \times 10^{-9}m$ The energy of the emitted photons is, $E = \frac{hc}{\lambda}$ $E = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{102.7 \times 10^{-9}} = \frac{19.878 \times 10^{-26}}{102.7 \times 10^{-9}} = 1.9355 \times 10^{-18}J$ $\therefore$ Energy corresponds $= \frac{1.9355 \times 10^{-18}}{1.6 \times 10^{-19}}$ $eV = 12.097ev = 12.1eV$ Correspoding to Transition $E = -1.5 - (-13.6)eV = 12.1eV$
	Or **(i)** Distinguish between nuclear fission and fusion. Show how both these processes energy is released. **(ii)** Calculate the energy release in MeV in the deuterium-tritium fusion reaction:- ${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}H + \text{n}$ using the data mass of ${}^{2}_{1}H$= 2.014102 u, mass of ${}^{3}_{1}H$ = 3.016949 u,

	mass of $^{4}_{2}He$ = 4.002603 u, mass of neutron = 1.008665 u, 1u = 931.5 MeV , 2+3 =5
	(ii) $^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n + Q$ Deuterium Tritium Helium neutron The energy released in the process is given by $Q = \left[M_{^{2}_{1}H} + M_{^{3}_{1}H} - M_{^{4}_{2}He} - M_{^{1}_{0}n} \right] 931 \text{ MeV}$ $= [2.014102 + 3.016050 - 4.002603 - 1.008665] 931 \text{ MeV}$ $= (0.018884)\ 931 \text{ MeV} = 17.6 \text{ MeV}.$