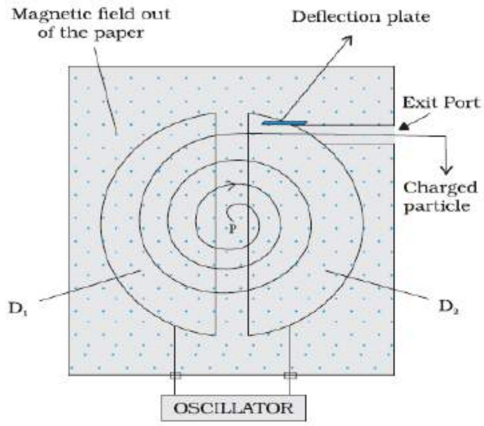
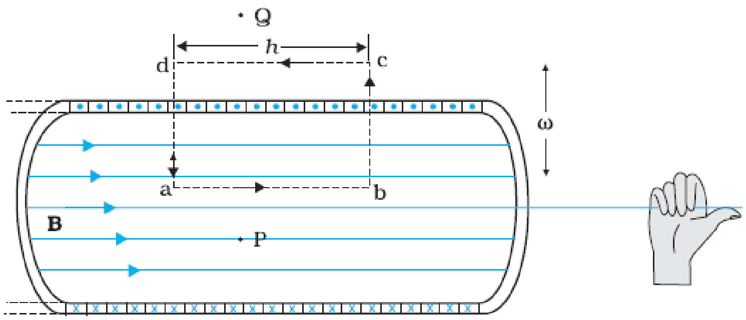
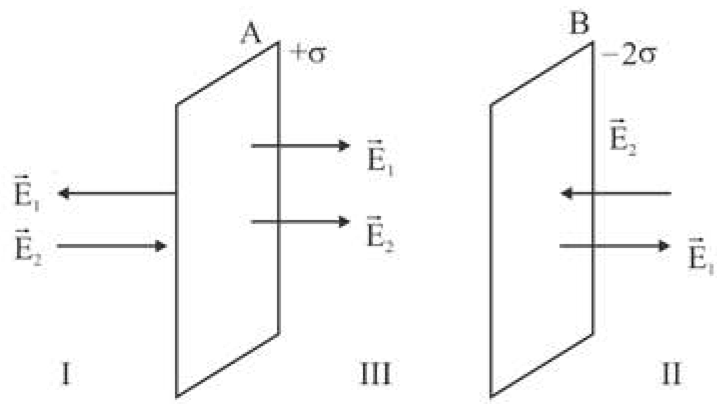
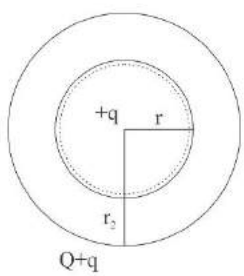
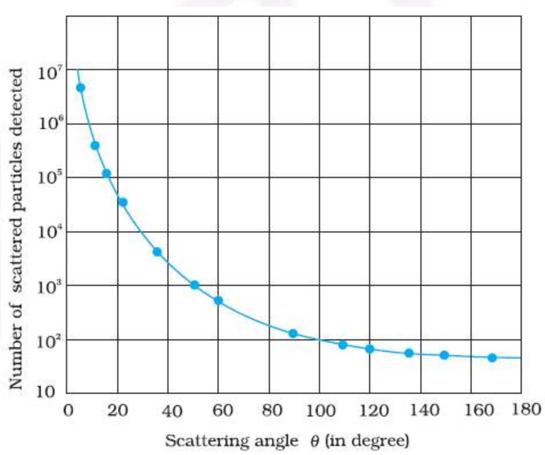
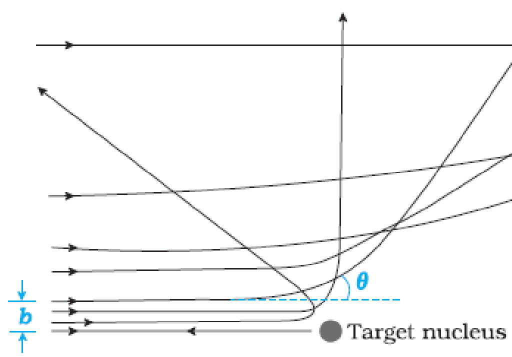
Q. No.	Value Points/Expected Answers	Marks	Total Marks
	$I = \frac{15}{1000} = 0.015A$	½	
	As zener diode and $1k\Omega$ resistor are in parallel, current through the zener diode is: $I = 0.02 - 0.015 = .005A$	½	3
15	• Diagram of cyclotron 1 • Explaining the working principle 1 • Showing frequency is independent of radius and speed 1		
	Diagram: 	1	
	Working principle: The cyclotron uses crossed electric and magnetic fields which increases the kinetic energy of a charged particle without changing its frequency of revolution.	1	
	$F_c = F_m$ $\frac{mv^2}{r} = qvB$	½	
	$\omega = \frac{qB}{m}$ $\nu = \frac{qB}{2\pi m}$	½	3
	OR		
	• Diagram of straight solenoid ½ • Derivation of magnetic field 1+1/2 • Difference between toroid and solenoid (any one) 1		
	Diagram		

Q. No.	Value Points/Expected Answers	Marks	Total Marks
		½	
	Derivation: Let n be the number of turns per unit length. The total number of turns is nh. The enclosed current is $I_e = I(nh)$ From Ampere's circuital law	½	
	$BL = \mu_0 I_e$ $Bh = \mu_0 I(nh)$ $B = \mu_o nI$	1	
	Difference between toroid and solenoid (any one) (a) Solenoid behaves like a bar magnet whereas toroid does not. Or If student writes solenoid is straight and the toroid is circular give half mark. Or there is fringe effect in case of straight solenoid but not in toroid (allot one mark.)	1	3
16	Proving magnetic moment as $\frac{evr}{2}$ — 2 Deducing expression of the magnetic moment of hydrogen atom — 1		
	The magnetic moment is $m = IA$		
	But current is $I = \frac{e}{T} = \frac{ev}{2\pi r}$	½ ½	
	Where $T = \frac{2\pi r}{v}$ and the area, $A = \pi r^2$	½	3
	$m = \frac{ev}{2\pi r}\pi r^2 = \frac{evr}{2}$	½	
	But from Bohr's second postulate $m_e vr = \frac{nh}{2\pi} = \frac{h}{2\pi}$ for n=1	½	
	$vr = \frac{nh}{2\pi m_e}$ Hence the magnetic moment is		

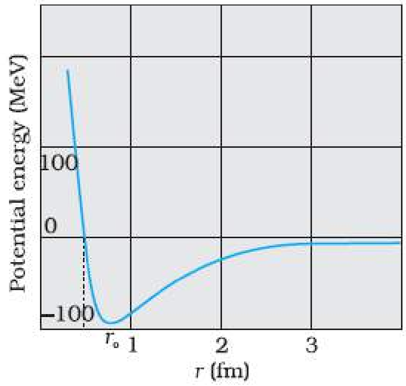
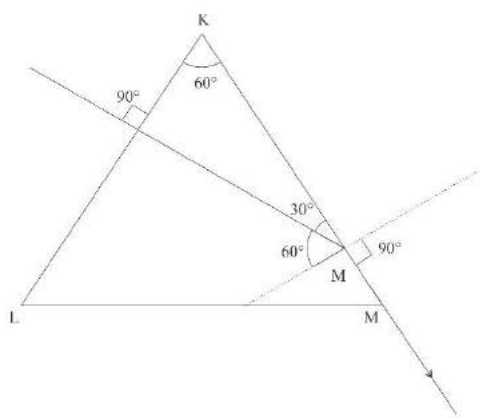
Q. No.	Value Points/Expected Answers	Marks	Total Marks
	$m = \frac{e}{2}\frac{h}{2\pi m_e} = \frac{eh}{4\pi m_e}$ (Here n=1)	½	
17	Diagram 1+1/2 Deducing electric field expression (i) To the left of first sheet (ii) To the right of second sheet (iii) Between the two sheets 1/2+1/2+1/2 Diagram 	1½	
	Electric field in the region left of first sheet $E_I = E_1 + E_2$ $E_I = \frac{\sigma}{\varepsilon_0} - \frac{\sigma}{2\varepsilon_0}$ $E_I = +\frac{\sigma}{2\varepsilon_0}$ It is towards right	½	3
	Electric field in the region to the right of second sheet $E_{II} = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{\varepsilon_0}$ $E_{II} = -\frac{\sigma}{2\varepsilon_0}$ It is towards left	½	
	Electric field between the two sheets		

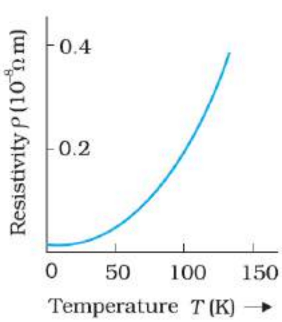
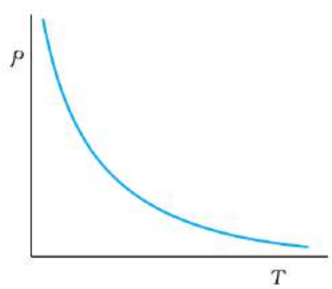
Q. No.	Value Points/Expected Answers	Marks	Total Marks
	$E_{III} = E_1 + E_2$ $E_{III} = \frac{\sigma}{\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}$ $E_{III} = \frac{3\sigma}{2\varepsilon_0}$ Electric field is towards the right	½	
	OR		
	Diagram ½ Finding the surface charge density in the inner and outer surface of the shell 1+1/2 Electric field in the cavity 1		
	(a) Diagram  	½	
	The surface charge density on inner surface of the shell is $\sigma_1 = -\frac{q}{4\pi r_1^2}$	1	
	The surface charge density on outer shell is $\sigma_2 = \frac{Q+q}{4\pi r_2^2}$	½	
	(b) Consider a Gaussian surface inside the shell, net flux is zero since $q_{net} = 0$. According to Gauss's law it is independent of shape and size of shell.	1	3
18	• Derive expression for amplitude modulated wave. 2 • Deducing expression for lower and upper side bands. ½ • Obtaining expression for modulation index. ½		
	Let a carrier wave be given by $c(t) = A_c \sin \omega_c t$ where $\omega_c = 2\pi f_c$ And signal wave be $m(t) = A_m \sin \omega_m t$ where $\omega_m = 2\pi f_m$ The modulated signal is $c_m(t) = (A_c + A_m \sin \omega_m t)\sin\omega_c t$	½	

Q. No.	Value Points/Expected Answers	Marks	Total Marks
	$c_m(t) = A_c(1+\frac{A_m}{A_c}\sin\omega_m t\ )\sin\omega_c\text{t}$ $c_m(t) = A_c\sin\omega_c\text{t}+\mu\frac{A_c}{2}\ \cos(\omega_c-\omega_m)t-\mu\frac{A_c}{2}\ \cos(\omega_c+\omega_m)t$ The modulation index $\mu=\frac{A_m}{A_c}$ Lower frequency band $\omega_c-\omega_m$ Upper frequency band $\omega_c+\omega_m$	½ ½ ½ ½ ½	3
19	• Draw a plot of α -particle scattering to show variation of scattering particle. 1 • Describe briefly how large scattering explains existence of nucleus. 1 • Explain with the help of impact parameter picture how Rutherford scattering serves powerful way to determine upper limit of nucleus. 1  The data shows that large number of α -particle do not suffer large scattering but small number suffer greater scattering it is concluded that (i) most of the atom is empty space (ii) massive positively charged nucleus occupies small region.	1 ½ ½	

Q. No.	Value Points/Expected Answers	Marks	Total Marks
		½	
	From the picture it is clear that for small impact parameter suffers large scattering thus it shows the upper limit to the size of nucleus.	½	3
20	(i) Change in capacitance 1 (ii) Change in electric field 1 (iii) Change in electric density 1		
	Dielectric slab of thickness 5mm is equivalent to an air capacitor of thickness $=\frac{5}{10}mm$.	½	
	Effective separation between the plates with air in between is $=(5+0.50)mm=5.5mm$		
	(i) Effective new capacitance $=200\mu F\times\frac{5mm}{5.5mm}=\frac{2000}{11}\mu F$ $\approx 182\mu F$	1	
	(ii) Effective new electric field $=\frac{100\,V}{5.5\times10^{-3}m}=\frac{20000}{11}$ $\approx 18182\,V/m$	½	
	(iii) $\frac{New\ energy\ stored}{Original\ energy\ stored}=\frac{\frac{1}{2}C'V^2}{\frac{1}{2}CV^2}=\frac{C'}{C}=\frac{10}{11}$	1	
	New Energy density will be $\left(\frac{10}{11}\right)^2$ of the original energy density $=\frac{100}{121}$ of the original energy density.		
	Note: If the student writes $C=\frac{A\varepsilon_0}{d}$ $C_m=\frac{KA\varepsilon_0}{d}$		

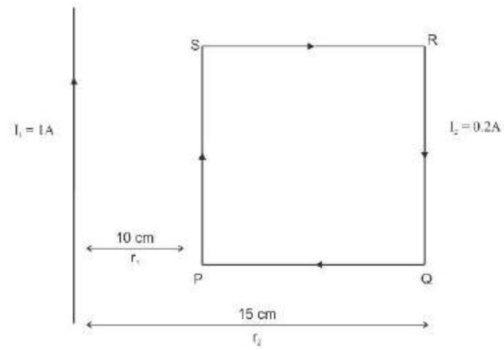
Q. No.	Value Points/Expected Answers	Marks	Total Marks
	$E' = \frac{V}{d}$ $U = \frac{1}{2}\varepsilon_0 E^2$ Award full marks		
21	• Reason for difficulty in detecting presence of anti-neutrino during $\beta - decay$ ½ • Define decay constant of radioactive nucleus ½ • Derive expression for mean life in terms of decay constant 2		
	• Penetrating power is high • Do not interact with matter (weak interaction) any one	½	
	• Decay constant is the reciprocal of the time duration in which undecayed radioactive nuclei reduce to 1/e times the nuclei present initially.	1	
	$\tau = \frac{\text{total life time of all nuclei}}{\text{total number of nuclei}}$	½	
	$\tau = \frac{\int_0^\infty t dN}{N_0}$	½	
	$\tau = \frac{\int_0^\infty t(N_0 \lambda \varepsilon^{-\lambda t} dt)}{N_0} = \lambda \int t e^{-\lambda \tau} dt$		
	$\tau = \frac{1}{\lambda}$	½	3
	OR		
	(a) Stating distinguishing feature of nuclear force. 1 (b) Drawing a plot showing variation of potential energy. 1 (c) Marking the regions. 1/2+1/2		
	(1) Short rang force (2) Strongest force (3) Attractive in nature (4) Does not depend on charge (any two)	1	

Q. No.	Value Points/Expected Answers	Marks	Total Marks
	(b) Figure 	1	
	$r < r_0$ repulsive force	½	
	$r > r_0$ attractive force	½	3
22	• Tracing path of ray passing through prism 1 • Calculating angle of emergence and angle of deviation 1 ½+1/2		
	Ray diagram: 	1	
	• A=60° • $\frac{2}{\sqrt{3}}\sin 60^o = \sin r$ • $\sin r = \frac{2\sqrt{3}}{2\sqrt{3}} = 1$	1½	3
	• $r = 90^o$ Angle of deviation is equal to 30°	½	
23	• Proving the phase difference 1 • Calculation of Amplification factor 1 • Calculation of load resistance 1		

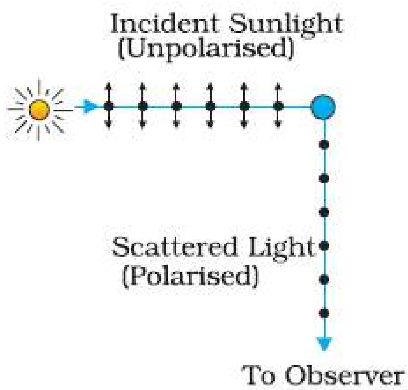
Q. No.	Value Points/Expected Answers	Marks	Total Marks
	Input signal, $V_i = \Delta I_B r_i$ Output signal, $V_o = -\Delta I_c R_L$ Voltage amplification, $A_V = \frac{V_o}{V_i}$ • $A_V = -\frac{\Delta I_B}{\Delta I_C} \times \frac{r_i}{R_L}$ • $A_V = -\beta \times \text{resistance gain}$ Here negative sign indicates that output is 180° out of phase w.r.t. input signal. • $\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{4\times 10^{-3}}{30\times 10^{-6}} = \frac{400}{3}$ $r_i = \frac{\Delta V_{BE}}{\Delta I_B} = \frac{0.02}{30\times 10^{-6}} = \frac{2\times 10^{-2}}{3\times 10^{-5}}$ • $r_i = \frac{2}{3}\times 10^3 \Omega$ $A_V = \beta \frac{R_L}{r_i}$ $R_L = \frac{A_V \times r_i}{\beta} = \frac{400\times 2\times 10^3 \times 3}{400\times 3} = 2\times 10^3 \Omega$	½ ½ 1 ½ ½	3
24	• Showing the plot of variation of resistivity ½ + ½ • Expression for resistivity 1 • Explaining variation of resistivity for conductor and semiconductor ½ + ½ 	½ ½	

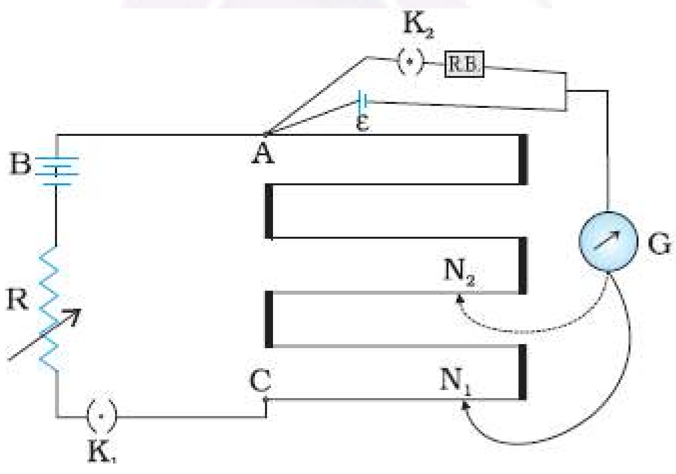
Q. No.	Value Points/Expected Answers	Marks	Total Marks
	• $\rho = \frac{m}{ne^2\tau}$ • In case of conductors with increase in temperature, relaxation time decreases, so resistivity increases. • In case of semiconductors with increase in temperature number density (n) of free electrons increases, hence resistivity increases.	1 ½ ½	3
25	• Deriving expression for e.m.f. 3 • Finding induced e.m.f. between the axel and rim of wheel 2 Flux linked with the coil at any instant of time is: $\phi = \text{NBA}\cos\omega t$ $\frac{d\phi}{dt} = NBA\omega(-\sin\omega t)$ S $\varepsilon = -\frac{d\phi}{dt}$ $\varepsilon = \text{NBA}\omega\sin\omega t$ $\varepsilon = \varepsilon_0 \sin\omega t \quad (\text{Here } \varepsilon_0 = NBA\omega)$ (b) $l = 0.5m,\ \nu = 120rpm = 2rps$ $\omega = 2\pi\nu = 4\pi\ rad/s, \quad B = 4\times10^{-4}T, \quad \delta = 30^0$ $B_H = 4\times10^{-4}\times\frac{\sqrt{3}}{2}$ $B_H = 2\sqrt{3}\times10^{-4}T$ $\varepsilon = \frac{1}{2}B\omega l^2$ $\varepsilon = \frac{1}{2}\times2\sqrt{3}\times10^{-4}\times4\pi\times(0.5)^2$ $\varepsilon = 5.4\times10^{-4} volt$	½ 1 ½ ½ ½ 1 1	5
	OR • Deriving expression for magnetic energy stored in inductor and expression for energy density 1½+ ½ • Calculating the resultant magnetic force and torque 2½+ ½ (a) When external source supplies current to the inductor, e.m.f. is induced in it due to self induction. So the external supply has to do work to establish current. The amount of work done is: $dw = \|\varepsilon\| Idt \qquad \because \varepsilon = L\frac{dI}{dt}$ $dw = LIdt$	½	

Q. No.	Value Points/Expected Answers	Marks	Total Marks
	$W = \frac{1}{2}LI^2$	1	
	Energy density $= \frac{Energy}{Volume}$		
	$u = (1/2LI^2)/volume$	½	3
	(b)		



Q. No.	Value Points/Expected Answers	Marks	Total Marks
	Force of attraction experienced by the length SP of the loop per unit length		
	$F_1 = \frac{2\mu_0 I_1 I_2}{4\pi r_1}$	½	
	$f_1 = \frac{2\times10^{-7}\times1\times0.2}{10\times10^{-2}} = 4\times10^{-7}\,Nm^{-1}$	½	
	Force is attractive		
	$f_2 = \frac{2\mu_0 I_1 I_2}{4\pi r_2}$	½	
	$f_2 = \frac{2\times10^{-7}\times1\times0.2}{15\times10^{-2}} = 2.6\times10^{-7}\,Nm^{-1}$	½	
	Force is repulsive		
	So the net force experienced by the loop is (per unit length)		
	$f = (f_1 - f_2)$		
	Total force experienced by the loop is:		
	$F = (f_1 - f_2)l = (1.4\times10^{-7})\times5\times10^{-2}$	½	
	$F = 7\times10^{-7}\,N$		
	Net force is attractive in nature	½	5
	As the lines of action of forces coincide torque is zero.		

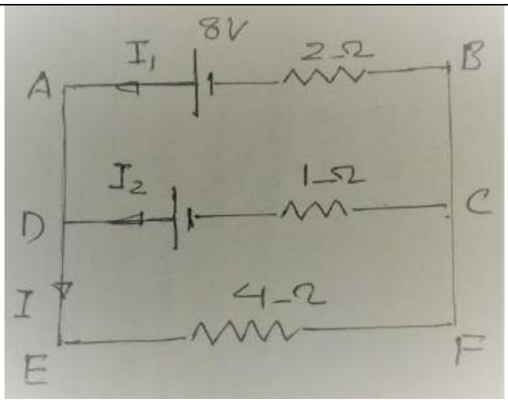
Q. No.	Value Points/Expected Answers	Marks	Total Marks
26	• Diagram production of polarized light by scattering of sun light 1 • Explanation 1 • Calculation of intensity of light transmitted through P_1, P_2 *and* P_3 ½ +1+1½		
	Diagram:  	1	
	Explanation: Charges accelerating parallel to the double arrows do not radiate energy towards the observer. The radiation scattered by the molecules therefore is polarised perpendicular to the plane of the figure. ALTERNATIVELY : If the student writes " scattered light when viewed in a perpendicular direction is found to be polarised " (award one mark)		
	Intensity of light transmitted by 1st Polaroid is, $I_1 = \frac{I}{2}$	1	
	Intensity of light transmitted by 2nd Polaroid is, $I_2 = I_1 \cos^2 45^0 = \frac{I}{2}\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{I}{4}$	½	
	Intensity of light transmitted by 3rd Polaroid is, $I_3 = I_2 \cos^2 45^0 = \frac{I}{2}\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{I}{8}$	1	5
	OR	1½	
	• Reason ½ • Deriving the expression for resultant intensity and condition for constructive and destructive interference $1\frac{1}{2}$ + ½ + ½ • Calculating the separation 2		
	(a) Because two independent sources cannot be coherent OR they are not coherent		
	(b) $y_1 = a\cos\omega t$ $y_2 = a\cos(\omega t + \phi)$	½	

Q. No.	Value Points/Expected Answers	Marks	Total Marks
	So resultant displacement is give by $y = y_1 + y_2$ $y = a\cos\omega t + a\cos(\omega t + \phi)$ $y = 2a\cos(\phi/2)\cos(\omega t + \phi/2)$ The amplitude of the resultant displacement is $2a\cos(\phi/2)$ and therefore intensity at that point will be $I = 4I_0\cos^2(\phi/2)$ For constructive interference: $\phi = 0, \pm 2\pi, \pm 4\pi, ...$ For destructive interference: $\phi = \pm\pi, \pm 3\pi, \pm 5\pi, ...$ (c) Position of second maxima $y_2 = \frac{5}{2}\frac{\lambda D}{a}$ Separation between the positions of the second maxima with λ_1 and λ_2 is: $\Delta y = \frac{5D(\lambda_2 - \lambda_1)}{2a} = \frac{5 \times 1.5 \times (596 - 590) \times 10^{-9}}{2 \times 2 \times 10^{-6}} = 11.25 \times 10^{-3} m$	1 ½ ½ ½ 1 1	5
27	• Circuit diagram and describing the method to measure internal resistance of cell by potentiometer 1+1 • Reason 1 • Calculating balancing length and reason (circuit works or not) 1½ +1 (a) Circuit diagram:  Brief description: Plug in the key k_1 and keep k_2 unplugged and the find the balancing length l_1 such that: $E = kl_1$ (1) With the key k_2 also plugged in find out balancing length l_2 again such that:	1 ½	

Q. No.	Value Points/Expected Answers	Marks	Total Marks
	$V = kl_2 \quad (2)$		
	As $r = \left(\frac{E}{V} - 1\right)R$	½	
	$r = \left(\frac{l_1}{l_2} - 1\right)R$		
	(b) The potentiometer is preferred over the voltmeter for measurement of e.m.f. of a cell because potentiometer draws no current from the voltage source being measured.	½ s	
	(c) $V = 5V,\ R_{AB} = 50\Omega,\ R = 450\Omega$		
	$I = \frac{5}{450+50} = \frac{1}{100} = 0.01A$	½	
	$V_{AB} = 0.01 \times 50 = 0.5V$		
	$k = \frac{0.5}{10} = 0.05Vm^{-1}$	½	
	$l = \frac{V}{k} = \frac{300 \times 10^{-3}}{0.05} = 6m$	½	
		½	
	With 2V driver cell current in the circuit is $I = \frac{2}{450+50} = 0.004A$.		
	P.d. across AB is =0.004×50=200mV. Hence the circuit will not work.	½	
	OR		
	• State the working principle of meter bridge — 1 • Reasons — 1/2 +1/2 • Calculation of potential difference using Kirchhoff's rules — 3		
	(a) Meter bridge is based on the principle of balanced Wheatstone bridge.	1	
	(b) (i) Thick copper strips are used to minimize resistance of connections which are not accounted for in the bridge formula	½	
	(ii) Balance point is preferred near midpoint of bridge wire to minimize percentage error in resistance (R).	½	
	(c)		

Marking Scheme

55/2/1

Q. No.	Value Points/Expected Answers	Marks	Total Marks
		1	
	$I = I_1 + I_2$ (1) *In loop ABCDA* $-8 + 2I_1 - 1\times I_2 + 6 = 0$ (2)	1	
	In loop DEFCD $-4I - 1\times I_2 + 6 = 0$	½	
	$4I + I_2 = 6$ $4(I_1 + I_2) + I_2 = 6$ $4I_1 + 5I_2 = 6$ (3)	½	
	From equations (1) *and* (2) *we get* $I_1 = \frac{8}{7}A,\ I_2 = \frac{2}{7}A,\ I = \frac{10}{7}$ Potential difference across resistor 4Ω is: $V = \frac{10}{7}\times 4 = \frac{40}{7} volt$		5