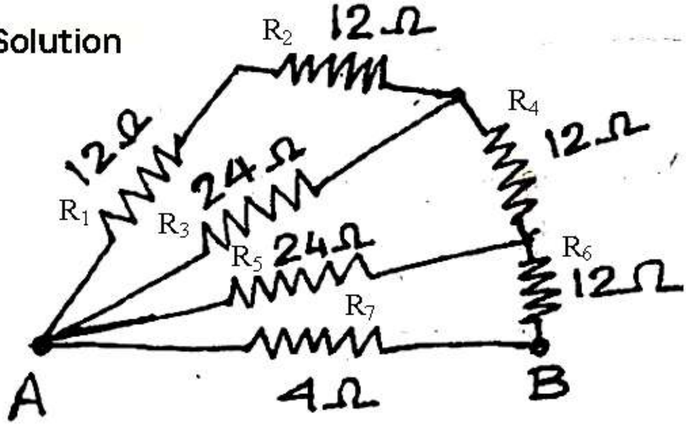
PHYSICS (Theory)

Full Marks : 70

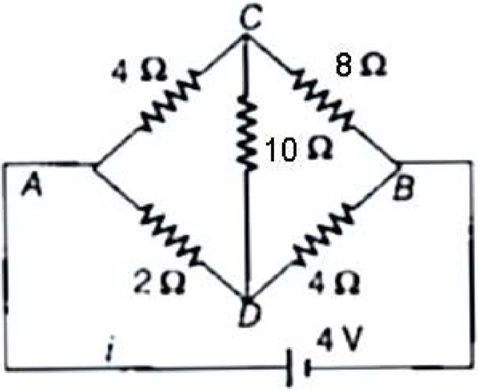
Pass Marks : 21 **Time : Three hours**

1(a)	Energy flux = power / area = $[M^1L^2T^{-3}]/[L^2]=[M^1L^0T^{-3}]$	1
1(b)		1
1(c)		1
1(d)	The polarity of plate 'A' will be positive with respect to plate 'B' in the capacitor.	1
1(e)	Since incident frequency is directly proportional to the magnitude of stopping potential , A has higher frequency than B .	1
1(f)	**69.3 %**	1
1(g)		1
1(h)		1
2		2
3		2

4	**Solution**  From left side, R_1 and R_2 are in series $\therefore R_{eq1} = R_1 + R_2 = 12 + 12 = 24\,\Omega$ Now, R_{eq1} and R_3 are in parallel $\therefore R_{eq2} = R_{eq1} \parallel R_3 = \frac{R_{eq1} \times R_3}{R_{eq1} + R_3} = \frac{24 \times 24}{24 + 24} = 12\ \Omega$ Again, R_{eq2} and R_4 are in series $\therefore R_{eq3} = R_{eq2} + R_4 = 12 + 12 = 24\,\Omega$ Now, R_{eq3} and R_5 are in parallel $\therefore R_{eq4} = R_{eq3} \parallel R_5 = \frac{R_{eq3} \times R_5}{R_{eq3} + R_5} = \frac{24 \times 24}{24 + 24} = 12\ \Omega$ and R_{eq4} and R_6 are in series $\therefore R_{eq5} = R_{eq4} + R_6 = 12 + 12 = 24\,\Omega$ and R_{eq5} and R_7 are in parallel $\therefore R_{eq6} = R_{eq5} \parallel R_7 = \frac{R_{eq5} \times R_7}{R_{eq5} + R_7} = \frac{24 \times 4}{24 + 4} = 3.428\,\Omega$	2

5	**Solution** Given, Resistance of the galvanometer coil, $R_G = 12\ \Omega$ Current when meter shows full deflection, $I_g = 3\text{ mA} = 3 \times 10^{-3}\text{A}$ We need to convert this galvanometer to a volmeter of range 0 – 18 V $V = 18\text{ V}$ Let us a resistor of resistance R be connected in series with the galvanometer to convert it into a voltmeter. Then,  Then, the resistance of series resistor is given by $R = \frac{V}{I_g} - R_G$ $R = \frac{18}{3 \times 10^{-3}} - 12 = 5988\ \Omega$ Final Answer: Resistance in series with the galvanometer is 5988 Ω	2
6		2
7	**Solution** Given : $V_C = 120V$ $V_L = 40V$ $V_R = 60V$ $V_C - V_L = 120 - 40 = 80V$ Source voltage, $V_\circ = \sqrt{V_R^2 + (V_C - V_L)^2} = \sqrt{(60)^2 + (80)^2} = 100V$	2
8		2
9		2
10		2

11	Here, the wavelength of radiation is $\lambda = 3300A^o = 3300 \times 10^{-10}$ Therefore, the energy of a photon of the incident light, $E = \frac{hc}{\lambda} = \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{3300 \times 10^{-10}}$ $\Rightarrow E = 6.018 \times 10^{-19}\ J = \frac{6.018 \times 10^{-19}}{1.6 \times 10^{-19}} = 3.76eV$ Since the frequency is directly proportional to the energy of the radiation, It is found that the given incident energy is greater than V_o of Na but less than of Mo. Therefore, Mo will not give photoelectric emission. If the laser is brought closer, intensity of radiation increases, but this does not affect the result regarding Mo However, photoelectric current from Na will increase in proportion to intensity.	2

12	The equivalent circuit of the figure given in the equestion is shown as belwo .  It is a balanced Wheatstone bridge. So , resistance between C and D is ineffective . If equivalent resistance in R , then $\frac{1}{R} = \frac{1}{(4+8)} + \frac{1}{(2+4)} \Rightarrow \frac{1}{R} = \frac{1}{12} + \frac{1}{6}$ $\Rightarrow \quad R = 4 \cdot \Omega$ Now , $i = \frac{V}{R} = \frac{4}{4 \cdot} = 1\ A$	
13		3
14		
15		
16	Wavelength of incident radiation is $\lambda = 1100\mathring{A} = 1100 \times 10^{-10}$m. Therefore, frequency of incident radiation is $\nu = \frac{c}{\lambda} = \frac{3 \times 10^8}{1100 \times 10^{-10}} \simeq 0.3 \times 10^{16}$Hz Threshold wavelength is $\lambda_0 = 330\mathring{A} = 330 \times 10^{-10}$m. Therefore, threshold frequency is $\nu_0 = \frac{c}{\lambda_0} = \frac{3 \times 10^8}{330 \times 10^{-10}} \simeq 10^{16}$Hz Since $\nu < \nu_0$, no photoelectron is emitted.	

17	**Solution** $_{26}Fe^{56}$ nucleus contains 26 protons . Number of neutrons = (56 − 26) = 30 neutrons Now, Mass of 26 protons= 26 X 1.007825 = 26.20345u Mass of 30 neutrons= 30 X 1.008665 = 30.25995u Total mass of 56 nucleons= 56.46340u Mass of $_{26}Fe56$ nucleus= 55.934939u Therefore, Mass defect, $\triangle m = 56.46340 - 55.934939 = 0.528461u$ Total Binding Energy= 0.528461 X 931.5Mev = 492.26MeV Average binding energy per nucleon= $\frac{492.26}{56}$ = 8.790MeV	
18	**Solution** givern. $V = 6 \times 10^{+14}$Hz power emitted by light $p = 2 \times 10^{-3}$w energy of one photon is given by energy = hv → i Number of photons emitted per second = $\frac{\text{power}}{\text{enwrgy of one photon}}$ $= \frac{2 \times 10^{-3}}{6.63 \times 10^{-34} \times 6 \times 10^{14}} = 5.03 \times 10^{15} \rightarrow$ ii	

19	**Solution** Let E_1, E_2, E_3 represents the energy of 1st, 2nd and 3rd energy levels respectively such that $E_1 = E \qquad E_2 = 4E \qquad E_2 = 2E$ Now, we know that during transition of electron from higher energy level to lower energy level, energy in released in the form of photon having energy equal to the energy difference between two energy levels. transition from $3 \rightarrow 1$ energy level. Energy of photon released $= E_3 - E_1$--------(1) As we know that energy of photon is given by $= \frac{hc}{\lambda}$ from (1) $\frac{hc}{\lambda} = E_3 - E_1 = E \quad \Rightarrow \lambda = \frac{hc}{E}$-------(2) On transition from $2 \rightarrow 1$ energy level. Energy of photon released $= E_2 - E_1$--------(2) Let, wavelength of photon released be λ $\Rightarrow$ Energy of photon released $= \frac{hc}{\lambda}$ From (3) $E_2 - E_1 = \frac{hc}{\lambda,} \quad \Rightarrow 3E = \frac{hc}{\lambda,}$ $\Rightarrow \lambda' = \frac{hc}{3E} = \frac{1}{3}\left(\frac{hc}{E}\right) \quad \Rightarrow \lambda' = \frac{1}{3}(\lambda)(\text{from }(2)) \quad \Rightarrow \lambda' = \frac{\lambda}{3}$ Hence, wavelength of photon emitted for transition $2 \rightarrow 1$ in $\frac{\lambda}{3}$.	3
20		3
21	**Solution** let magnitude of charge be Q. so,magnitude of electric field (E) at a distance r=0.5m away in given by:- $E\frac{KQ}{r^2}$, which gives: $Q = \frac{Er^2}{k} = \frac{2 \times (0.5)^2}{9 \times 10^9} \simeq 5.56 \times 10^{-11} c$ Q=55.6pc	5

	Solution Let the charge is placed at distance x from 2μc Now the net force acting on charge q should be zero. $\Rightarrow \frac{k(1\times10^{-6})q}{(10-x)^2} = \frac{(2\times10^{-6})q}{x^2}$ $\Rightarrow \frac{1}{10-x} = \frac{\sqrt{2}}{x}$ $\Rightarrow x = 10\sqrt{2} - x\sqrt{2}$ $\Rightarrow x(1+\sqrt{2}) = 10\sqrt{2}$ $\Rightarrow x = \frac{10\sqrt{2}}{1+\sqrt{2}} = \frac{14.14}{2.414} = 5.857cm$ or	
22	Here, $I_1 = 15A, I_2 = 25A,$ $r_1 = 2 \times 10^{-2}m, r_2 = (2+10) \times 10^{-2}m$ Force on BC, $F_1 = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r_1} \times lenghtBC$ $= 10^{-7} \times \frac{2 \times 15 \times 25}{(2 \times 10^{-2})} \times (25 \times 10^{-2})$ $= 9 \cdot 375 \times 10^{-4}N$ (repulsive, away from XY) Force on DA, $F_2 = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r_2} \times lengthDA$ $= 10^{-7} \times \frac{2 \times 15 \times 25}{(2+10) \times 10^{-2}} \times 25 \times 10^{-2}$ $= 1 \cdot 5625 \times 10^{-4}N$ (attractive towards XY) Net force on the loop $F = F_1 - F_2$ $= (9 \cdot 375 - 1 \cdot 5625) \times 10^{-4}$ $= 7 \cdot 8175 \times 10^{-4}N$	5

	Or Magnitude of magnetic field at a distance r due to straight current carrying conductor is given by $B = \frac{\mu_0}{2\pi}\frac{i}{r}$ Given : i = 90 A and r = 1.5 m $B = 2 \times 10^{-7} \times \frac{90}{1.5} = 1.2 \times 10^{-5} T$	
23	Initial current, $I_1 = 5.0A$ Final current, $I_2 = 0A$ Change in current, $dI = I_1 - I_2 = 5A$ Time taken for the charge, t = 0.1s Average emf, e = 200V For self inductance(L) of the coil, we have the relation for average emf as: $e = L\frac{di}{dt}$ $L = \frac{e}{\frac{di}{dt}}$ $= \frac{200}{\frac{5}{0.1}} = 4H$ Hence the self inductance of the coil is 4H.	5

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