1\. (a) (i) Velocity of efflux, $V = \sqrt{2gh}$
Since the velocity of efflux is independent of the area of the hole, it will remain the same. 02

(ii) Torricelli's theorem:

$V = \sqrt{2gh}$ 01 $= \sqrt{2 \times 9.8 \times 10}$

$V = 14 ms^{-1}$. 01

$Q = \frac{26.4}{60} m^3/s = 0.44 m^3/s$ 01

$Q = AV$ 01/2

$Q = \frac{\pi d^2}{4} \cdot V$

$d = \sqrt{\frac{4Q}{\pi V}} = \sqrt{\frac{4(0.44)}{3.14 \times 14}}$ 01/2

$\therefore d = 0.2m = 20 cm$. 01

(b) (i) $V = \frac{Q}{A}$ 01 $= \frac{8 \times 10^{-3} m^3/s}{40 \times 10^{-2} m^2}$ 01

$\therefore V = 2ms^{-1}$. 01

(ii) Total pressure = Static pressure + $\frac{1}{2}\rho v^2$ 01

Total pressure $= 3 \times 10^4 + \frac{1}{2}(1000)(2)^2$ 01

$= 3.2 \times 10^4 Pa$. 01

(iii) $\frac{1}{2}\rho V^2$ = Total pressure − static pressure $00\frac{1}{2}$

$$\frac{1}{2}\rho V^2 = (3.6\times10^4 - 3.0\times10^4)\,Pa$$

$$\frac{1}{2}\rho V^2 = 0.6\times10^4$$ $00\frac{1}{2}$

$$V = \sqrt{\frac{2(0.6\times10^4)}{1000}} = 3.5\,m/s$$ 01

(c)(i) $$\left[\frac{\rho V D}{\eta}\right] = \frac{ML^{-3}.LT^{-1}.L}{ML^{-1}T^{-1}}$$ $00\frac{1}{2}$

$$= \frac{ML^{-1}T^{-1}}{ML^{-1}T^{-1}}$$ $00\frac{1}{2}$

$$\therefore \left[\frac{\rho V D}{\eta}\right] = M^0L^0T^0$$ $00\frac{1}{2}$

∴ Reynolds number is dimensionless. $00\frac{1}{2}$

(ii) Volume of bigger drop = Volume of 2 small drops.

$$\frac{4}{3}\pi R^3 = 2\left(\frac{4}{3}\pi r^3\right)$$ 01

$$R = (2)^{1/3}.r$$

$$V_T \propto (\text{radius})^2$$

$$\frac{V_{T_1}}{V_{T_2}} = \frac{R^2}{r^2} = \frac{[(2)^{1/3}]^2.r^2}{r^2}$$ 01

$\therefore$ ~~V_{T_1}~~ $\quad V_{T_1} = (2)^{2/3}.r$ 01

2 (a) (i) Connect two wooden blocks by provided ~~by~~ string then pluck anywhere between the Length of the thread to form stationary wave. The position plucked determines the frequency of vibration of string and hence different pitches are formed 03

(ii) Transverse waves travel in form of crests and troughs that involve change in shape of medium. On the other hand longitudinal waves travel in form of compression and rarefaction that involve change in pressure (volume). 03
Solid have both elasticity of shape and Volume hence can support both transverse and longitudinal waves. Furthermore the gases possess only elasticity of volume hence cannot have elasticity of shape, so only Longitudinal waves can travel through gases.

2 (b) (i) In shower there is more humidity which decreases density of air as a result velocity of sound waves increases

$$V \propto \frac{1}{\sqrt{\rho}}$$

(02)

(ii) Let the fork frequency be f.
when length $l = 99\,cm$

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

$$f = \frac{1}{2(99)}\sqrt{\frac{T}{\mu}} \quad \text{---(1)}$$

01

When length of string

$$L = 100\,cm$$

$$f' = f - 4$$

thus,

$$f - 4 = \frac{1}{2(100)}\sqrt{\frac{T}{\mu}} \quad \text{---(11)}$$

Dividing eqn (1) by eqn (11)

01

$$\frac{f}{f-4} = \frac{200}{2(99)}$$

02

$$\therefore f = 400\ Hz$$

2) (c) soln

2

Data given

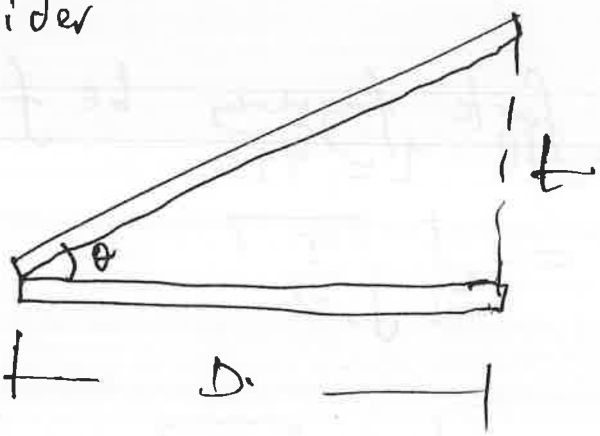
$\lambda = 589 nm = 589 \times 10^{-9} m$

$\Delta y = y_{167} - y_7 = 26.3 mm = 26.3 \times 10^{-3} m$

Distance (D) $= 25.6 mm = 25.6 \times 10^{-3} m$

Diameter (t) = ?

Consider



$\tan\theta = \frac{t}{D}$

$t = D\tan\theta$ — — (1)

02

Thickness

$\tan\theta = \frac{t}{y_n}$

$\tan\theta = \frac{2t}{2y_n}$ But $2t = n\lambda$

$\tan\theta = \frac{n\lambda}{2y_n}$ (2)

$y_n = \frac{n\lambda}{2\tan\theta}$

2) (c)

$$y_{167} = \frac{167\lambda}{2\tan\theta}$$

$$y_7 = \frac{7\lambda}{2\tan\theta}$$

$$\Delta y = y_{167} - y_7 = \frac{167\lambda}{2\tan\theta} - \frac{7\lambda}{2\tan\theta}$$

$$\Delta y = y_{167} - y_7 = \frac{160\lambda}{2\tan\theta}$$

02

$$\tan\theta = \frac{160\lambda}{2\Delta y} \quad \text{- - - (ii)}$$

eqn (i) = eqn (ii)

$$\frac{t}{D} = \frac{160\lambda}{2\Delta y}$$

$$t = \frac{160D\lambda}{2\Delta y}$$

02

$$= \frac{80 \times 25.6\times10^{-3} \times 589\times10^{-9}}{26.3\times10^{-3}}$$

$$t = 4.587\times10^{-5}\,m.$$

3 (a)(i) $P = \frac{1}{3}\frac{Nm\bar{c}^2}{V}$; V = volume.

If volume (V) is decreased, the pressure will increase. 02

(ii) $V_{rms} = \sqrt{\frac{3RT}{M}}$ $\frac{001}{2}$

$T = \frac{MV_{rms}^2}{3R}$ $\frac{001}{2}$

$T = \frac{32\times10^{-3}\,(11.2\times10^{3})^2}{3(8.3)}$ 01

$\therefore T = 1.612\times10^{5}$ K. 01

(b)(i) A cloth has narrow spaces in the form of fine capillaries. The capillary rise is given by

$h = \frac{2\gamma\cos\theta}{\rho g r}$ $\frac{001}{2}$

Addition of soap to water reduces the angle of contact θ. This will increase the value of $\cos\theta$ and hence h. Thus, the soap solution will rise more in the narrow spaces in the cloth $\frac{001}{2}$

and clean fabrice better than normal water can do alone. 01

(ii) $\Delta P = \frac{4\gamma}{R}$

$P_2 - P_1 = \frac{4\gamma}{R}$ 01

given ~~that~~

$P_2 - P_1 = \rho g h,$

$\Rightarrow \rho g h = \frac{4\gamma}{R}.$ 01

$\gamma = \frac{\rho g h \cdot R}{4}$ 01

$= \frac{800 \times 9.8 \times 2 \times 10^{-3} \times 1 \times 10^{-2}}{4}$

$\therefore \gamma = 3.92 \times 10^{-4} Nm^{-1}.$ 01

(c)(i) Energy stored, $W = \frac{1}{2} Fe$

$U = \frac{\text{Energy stored}}{\text{Volume}}$ 01/2

$U = \frac{1}{2} \frac{Fe}{AL}$

$U = \frac{1}{2}\left(\frac{F}{A}\right)\left(\frac{e}{L}\right)$ 01/2

$U = \frac{1}{2}(\text{stress})(\text{strain})$ 01/2 but $E = \dfrac{\text{stress}}{\text{strain}}$ $00\frac{1}{2}$

$$\text{stress} = E\,(\text{strain})$$

$$U = \tfrac{1}{2}(E \cdot \text{strain}) \cdot \text{strain}$$ $00\frac{1}{2}$

$$\therefore U = \tfrac{1}{2}E\,(\text{strain})^2.$$ $00\frac{1}{2}$

(ii) Young's modulus

$$E = \frac{F/A}{e/L} = \frac{FL}{Ae}$$ $00\frac{1}{2}$

$$\Rightarrow E = \frac{F}{A} \cdot \frac{L}{e}$$

$00\frac{1}{2}$

$$E_s = \frac{F}{A} \cdot \frac{L_s}{e_s}$$ $00\frac{1}{2}$

$$E_c = \frac{F}{A} \cdot \frac{L_c}{e_c}$$ $00\frac{1}{2}$

$$\Rightarrow \frac{E_s}{E_c} = \frac{L_c}{e_c} \cdot \frac{e_s}{L_s}$$

$$\frac{e_s}{e_c} = \frac{E_c}{E_s} \cdot \frac{L_s}{L_c}$$ $00\frac{1}{2}$

$$\frac{e_s}{e_c} = \frac{1.1\times10^{11}}{2.0\times10^{11}} \times \frac{2}{2.2} = \frac{1}{2}$$

$$e_c = 2e_s$$ $00\frac{1}{2}$

$$e_c + e_s = 1.2\,\text{mm}$$

$$2e_s + e_s = 1.2\,mm$$

$$3e_s = 1.2\,mm$$

$$e_s = \frac{1.2\,mm}{3} = 0.4\,mm$$

$$e_c = 0.8\,mm = 8\times10^{-4}\,m.$$ 01/2

$$A_c = \frac{\pi d_c^2}{4} = \frac{\pi}{4}(1\times10^{-2})^2$$

$$= 7.85\times10^{-5}\,m^2$$ 01/2

For copper

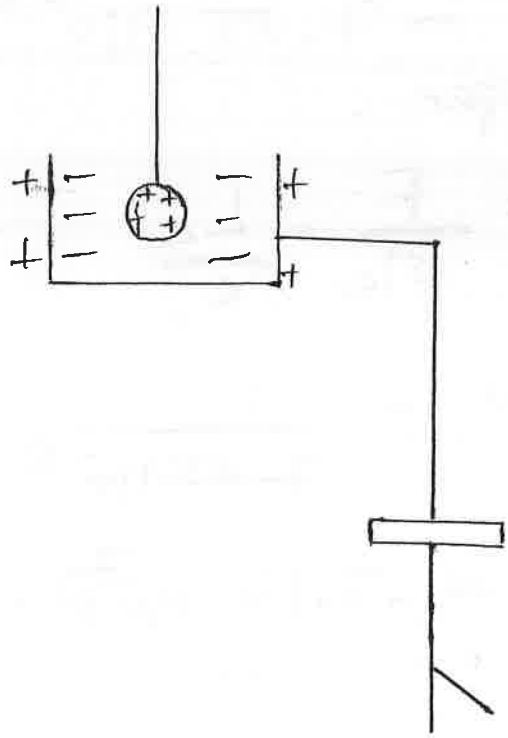
$$E_c = \frac{F}{A_c}\cdot\frac{L_c}{e_c}$$ 01

$$1.1\times10^{11} = \frac{F}{7.85\times10^{-5}} \times \frac{2.2}{8\times10^{-4}}$$

$$\therefore F = 3.14\times10^{3}\,N$$ 01

4 (a) (i) A metal sphere is tied to an insulating thread and is given a positive charge. The sphere is then lowered into a can connected to the gold leaf electroscope but not allowed to touch the can 1

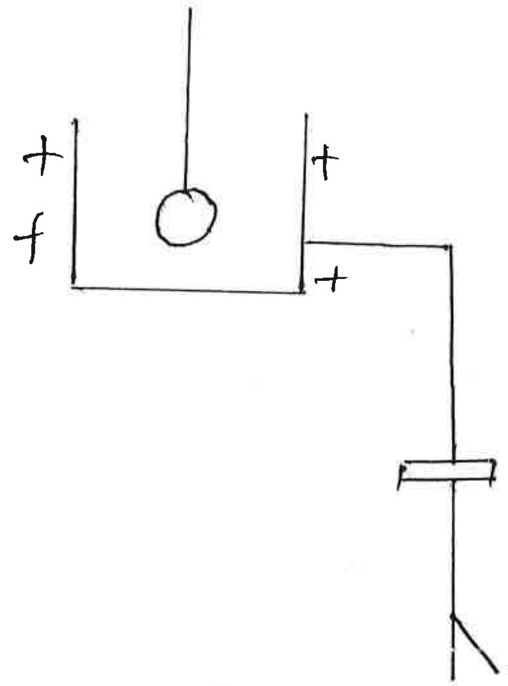
- The leaf diverges this means that a charge must have been induced outside the can. 1



- The sphere is then moved ~~bout~~ about inside the can and no change in divergence was observed. 1

- The sphere was then allowed to touch the inside of the can. No charge in divergence was observed. 1

4 (a)



— The sphere was then removed and tested for (1) charge. It was found to have lost all the charge. This means that there was equal and opposite charge inside the can which neutralized the charge on sphere.

CONCLUSION

— When a charged body is enclosed in a (1) hollow conductor, it induces equal and opposite charge on the inside wall, and an equal charge but of the same sign as the charge on the

4 (b) (i) Introduction of dielectric slab reduces the electric field (E) and hence reduces the potential difference between the plates. Since charge on capacitor plates remain the same, the capacitance of capacitor increases.

02

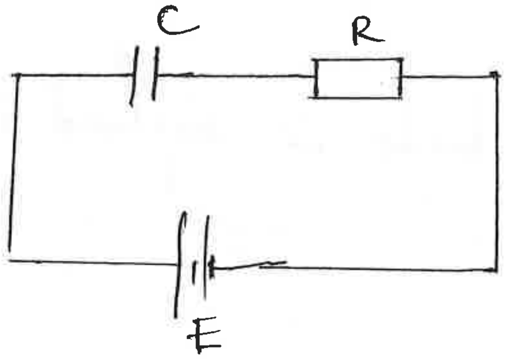
(ii) Data given

$C = 8 \times 10^{-6} F$

$R = 0.5 \times 10^{6} \Omega$

$E = 200V$

Consider



(i) Initial charging current

$$I_0 = E/R$$

$$= \frac{200}{0.5 \times 10^{6}}$$

02

$$I_0 = 4 \times 10^{-4} A$$

4 (b) (ii) — Current after 4 seconds

$$I = I_0 e^{-t/CR}$$

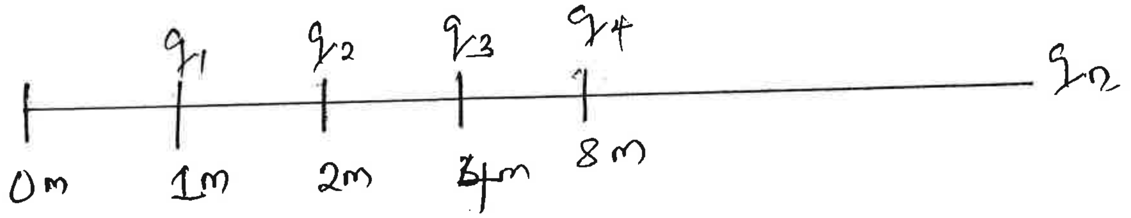
$$I = 4\times10^{-4} e^{\frac{-4}{(8\times10^{-6}\times0.5\times10^{6})}}$$

$$I = 1.47\times10^{-4} \cancel{A}$$

02

(c) (i) Suppose the charges to be in Coulomb's and distance in (m) ~~and~~

Assumption! charges are placed in Vacuum



Case I Charges of the same signs

Potential

$$V = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{1} + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} \cdots\right)$$

Taking

$$1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} - - .$$

$$S_\infty = \frac{a_1}{1-r}$$

4 (c) (i)

$$S_\infty = \frac{1}{1-\frac{1}{2}} = 2.$$

Then,

$$V = \frac{q}{4\pi\varepsilon_0}(2)$$

$1\frac{1}{2}$

$$V = \frac{q}{2\pi\varepsilon_0}.$$

Field intensity, E

Intensity at $x=0$,

$$E = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{4^2} + \frac{1}{8^2} \cdots\right)$$

$$= \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{1} + \frac{1}{4} + \frac{1}{16} + \frac{1}{64} \cdots\right)$$

Taking.

$$1 + \frac{1}{4} + \frac{1}{16} + \frac{1}{64} \cdots$$

$$S_\infty = \frac{a}{1-r}$$

$1\frac{1}{2}$

$$= \frac{1}{1-\frac{1}{4}} = \frac{1}{\frac{3}{4}}$$

$$S_\infty = \frac{4}{3}.$$

.4 (c) (1) Then

$$E = \frac{q}{4\pi\varepsilon_0} \cdot \frac{4}{3}$$

$$E = \frac{q}{3\pi\varepsilon_0}$$

Case II charge of opposite signs

$$V = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{1} - \frac{1}{2} + \frac{1}{4} - \frac{1}{8} - - - \right)$$

Taking

$$1 - \frac{1}{2} + \frac{1}{4} - \frac{1}{8} - - -$$

$$S_\infty = \frac{a_1}{1-r}$$

$$= \frac{1}{1 - -\frac{1}{2}} = \frac{1}{\frac{3}{2}}$$

$1\frac{1}{2}$

$$S_\infty = \frac{2}{3}$$

Then

$$V = \frac{q}{4\pi\varepsilon_0} \cdot \frac{2}{3}$$

$$V = \frac{q}{6\pi\varepsilon_0}$$

4 (c) (i) Electric field strength

$$E = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{4^2} - \frac{1}{8^2} \cdots\right)$$

$$E = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{1} - \frac{1}{4} + \frac{1}{16} - \frac{1}{64} \cdots\right)$$

Taking

$$1 - \frac{1}{4} + \frac{1}{16} - \frac{1}{64} \cdots$$

$$S_\infty = \frac{a}{1-r}$$

$$= \frac{1}{1 - -\frac{1}{4}}$$

$$= \frac{1}{1+\frac{1}{4}} = \frac{1}{\left(\frac{5}{4}\right)}$$

$1\frac{1}{2}$

$$S_\infty = \frac{4}{5}$$

Then

$$E = \frac{q}{4\pi\varepsilon_0}\left(\frac{4}{5}\right)$$

$$E = \frac{q}{5\pi\varepsilon_0}.$$

4 ⓒ (ii) Data given

$E = 1.2 \times 10^5 \; V/m$

$d = 20mm = 20 \times 10^{-3} m$

Force on electron

$F = eE$

$F = 1.6 \times 10^{-19} \times 1.2 \times 10^5$

$F = 1.92 \times 10^{-19} N$

— Its acceleration (a)

$F = ma$

(02-Marks)

$a = \frac{F}{m}$

$a = \frac{1.92 \times 10^{-19}}{9.1 \times 10^{-31}}$

$a = 2.108 \times 10^{16} m/s.$

5 (a) (i) From

$$F = BqV$$

Since charge is stationary in magnetic field, $V = 0$

Thus, $F = Bq(0)$. 02

$F = 0$

Therefore, no force is experienced by a stationary charge in magnetic field.

(ii) As the current is switched on, the electromagnet is magnetized thus it attracts the metal disc. Soon a change in magnetic flux takes place and an induced emf which according to Lenz's law opposes the cause which produces it hence metal disc is thrown up.

02

(iii) The causes of damping is the induced emf produced in the copperplates due to change in magnetic flux.

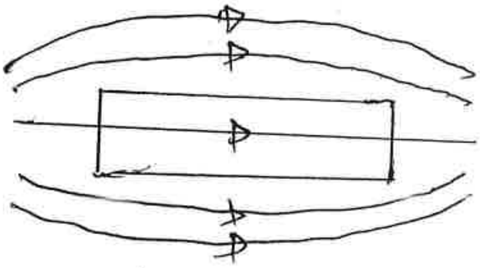
OR

Damping is caused by eddy current generated in copper disc which always opposes the mechanical oscillatory motion.

02

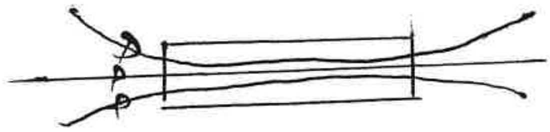
5 (b) (i) When a diamagnetic material is placed in external magnetic field the field lines are ~~1~~ repelled and the lines inside the material is reduced as shown below

(1½)



~~03~~-Marks

Whereas, when a paramagnetic material is placed in external magnetic field, the lines get concentrated inside the material and field inside is enhanced as shown below



(1½)

5) (b) (ii)

soln

Data given

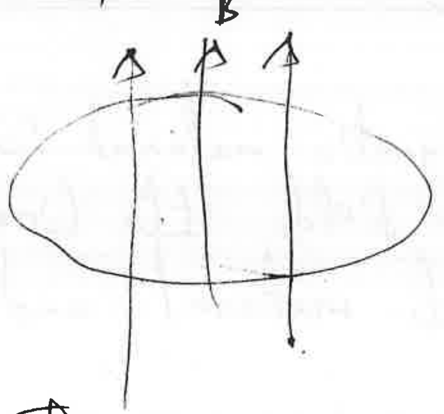
Number of turns $(N) = 50$ turns

Area $(A) = 8 \times 10^{-3}\ m^2$

$B = 4 \times 10^{-5}\ T$

$\Delta t = 0.1s$

Initially $(\theta = 0)$

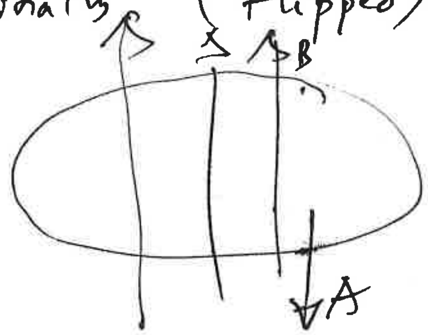


$\Phi_i = NBA\cos\theta$

$= 50(4\times10^{-5})(8\times10^{-3})\cos 0$

$\Phi_i = 1.6 \times 10^{-5}$ Wb 1

Finally (Flipped) $- \theta = 180^\circ$



$\Phi_f = NBA\cos\theta$

$= 50(4\times10^{-5})(8\times10^{-3})\cos 180^\circ$ 1

$= -1.6\times10^{-5}$ Wb

5) (b) (ii) change in magnetic flux

$$\Delta\Phi = \Phi_f - \Phi_i$$

$$= -1.6\times10^{-5} - 1.6\times10^{-5}$$

$$\Delta\Phi = -3.2\times10^{-5}\ Wb.$$

01

Induced Emf

By Faraday's law of induction

$$E = -N\frac{\Delta\Phi}{\Delta t}$$

$$= \frac{-50\times-3.2\times10^{-5}}{0.1}$$

$$= 1.6\times10^{-2}\ V$$

∴ Induced Emf is 1.6×10^{-2} V

6 (c) (i) At 8cm outside the conductor,

From,
$$B = \frac{\mu_0 I}{2\pi r}$$

Where, $I = 2A$, $r = 8cm = 0.08 m$

$$B = \frac{4\pi \times 10^{-7} \times 2}{2\pi (0.08)}$$

03

$$B = 5 \times 10^{-6} T$$

(ii) At 3cm inside the conductor

From, $$B = \frac{\mu_0 I r}{2\pi R^2}$$

Where

$R = 5cm = 0.05m$, $r = 3cm = 0.03 m$

$I = 2A$

Then,

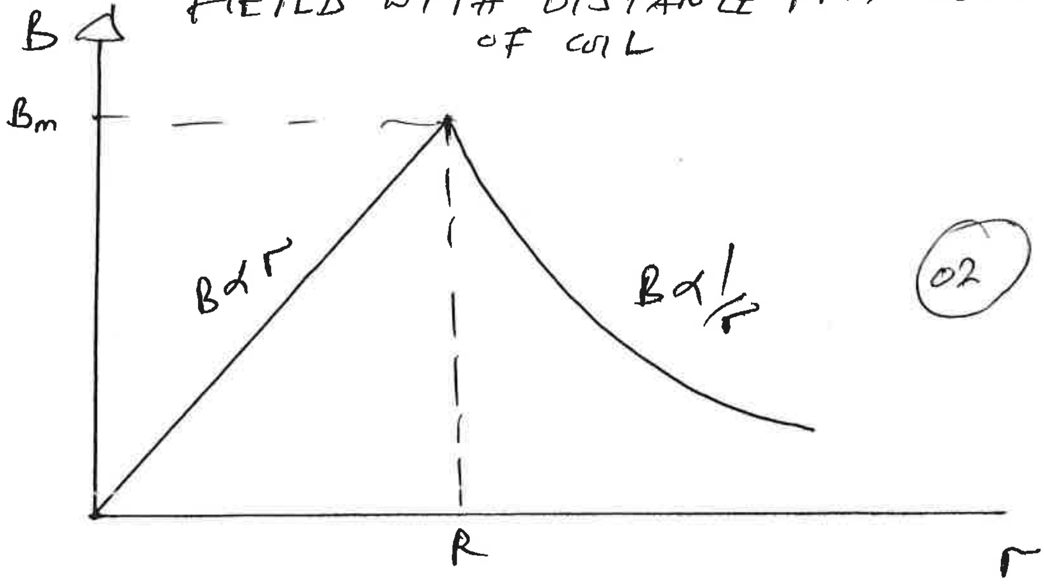
02

$$B = \frac{4\pi \times 10^{-7} \times 2 \times 0.03}{2\pi (0.05)^2}$$

$$B = 4.8 \times 10^{-6} T$$

5 (C) (iii)

GRAPH OF VARIATION OF MAGNETIC FIELD WITH DISTANCE FROM CENTRE OF COIL



(02)

6. (a) (i) It means that energy required to remove the single electron from the lowest energy level (state) of hydrogen atom to become free electron is 13.6eV. 02

(ii) $\frac{1}{\lambda} = R_H \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ 0 1/2

For the first member of Balmer series: $n_1 = 2$; $n_2 = 3$ 0 1/2 0 1/2

$\frac{1}{\lambda_{1B}} = R_H \left[\frac{1}{2^2} - \frac{1}{3^2}\right] = \frac{5R_H}{36}$ — (i) 0 1/2

For the first member of Lyman series: $n_1 = 1$; $n_2 = 2$ 0 1/2

$\frac{1}{\lambda_{1L}} = R_H \left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3R_H}{4}$ — (ii) 0 1/2

Take eqn. (i) ÷ (ii)

$\frac{\lambda_{1L}}{\lambda_{1B}} = \frac{5R_H}{36} \times \frac{4}{3R_H} = \frac{20}{108}$ 0 1/2

$\lambda_{1L} = \lambda_{1B} \times \frac{20}{108}$

$\lambda_{1L} = 6563 A^{\circ} \times \frac{20}{108}$ 00½

$\therefore \lambda_{1L} = 1215 A^{\circ}.$ 00½

(b) $W_0 = 1.9 eV$

$= 1.9 \times 1.6 \times 10^{-19} J$

$W_0 = 3.04 \times 10^{-19} J.$

(i) $\lambda_0 = ?$

$W_0 = \frac{hc}{\lambda_0}$ 01

$\lambda_0 = \frac{hc}{W_0} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{3.04 \times 10^{-19}}$

$\therefore \lambda_0 = 6.513 \times 10^{-7} m.$ 01

(ii) $\lambda = 4.5 \times 10^{-7} m$

$\frac{hc}{\lambda} = W_0 + KE_{max}$ 01

$KE_{max} = \frac{hc}{\lambda} - W_0$

$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{4.5 \times 10^{-7}} - 3.04 \times 10^{-19}$ ~~01~~

$\therefore KE_{max} = 1.36 \times 10^{-19} J.$ 01

(III) $V_s = ?$

$KE_{max} = eV_s$ 01

$V_s = \frac{KE_{max}}{e} = \frac{1.36 \times 10^{-19}}{1.6 \times 10^{-19}}$ 01

$\therefore V_s = 0.85 V$ 01

(c) (i) The binding energy per nucleon is an indicator of nuclear stability. The greater the binding per nucleon, the greater is the stability of the nucleus and vice-versa. 02

(ii) $A_0 = 12,000$ dis/min.

$A = ?$

$n = \frac{t}{T_{1/2}} = \frac{30}{15} = 2.$ 01

$\frac{A}{A_0} = \frac{1}{2^n}$ 01

$A = \frac{A_0}{2^n} = \frac{12,000 \text{ dis/min}}{2^2}$

$\therefore A = 3000$ dis/min. 01

0.50 dis/min —— 1.0 cm^3 01

3000 dis/min —— x —— ?

$? = \text{Volume} = \dfrac{3000\ cm^3/min \times 1.0\ cm^3}{0.5\ cm^3/min}$ 01

$\therefore$ Volume of blood $= 6000\ cm^3$ 01