TANZANIA HEAD OF ISLAMIC SCHOOLS COUNCIL
FORM SIX INTERISLAMIC MOCK EXAMINATION
PHYSICS – 2

PROPOSED MARKING SCHEME

1\. (a) (i) The Bernoulli's theorem for the horizontal flow states that: "For steady motion and non-viscous fluids the sum of the pressure energy and kinetic energy per unit volume at every point in the flow is always constant." such that $\left[P + \frac{1}{2}\rho V^2 = \text{constant}\right]$ (01 mark)

(ii) This is due to the viscosity of water. When water flows, work is done against the viscous force. This workdone is taken from the pressure energy. Hence pressure of water falls as it flows through a pipe.
(02 marks)

(iii) Given that

$D_A = 30\,cm$, $D_B = 10\,cm$, $\Delta P = 100\,cm$ of water

Assume horizontal pipe

$P + \frac{1}{2}\rho V^2 = \text{Constant}$

$P_A + \frac{1}{2}\rho V_A^2 = P_B + \frac{1}{2}\rho V_B^2$ (01 mark)

Since $D_A > D_B$ this means that $P_A > P_B$

$P_A - P_B = \frac{1}{2}\rho(V_B^2 - V_A^2)$

$\Delta P = \frac{1}{2}\rho(V_B^2 - V_A^2)$ ——— (i) (01 mark

From continuity equation

$$A_A V_A = A_B V_B$$

$$\frac{\pi D_A^2}{4} V_A = \frac{\pi D_B^2}{4} V_B$$

$$D_A^2 V_A = D_B^2 V_B$$

$$V_B = \left(\frac{D_A}{D_B}\right)^2 V_A = \left(\frac{30}{10}\right)^2 V_A$$

$$V_B = 9 V_A \quad \text{———} \quad (ii)$$

(01 mark)

Putting equation (ii) into equation (i) above we have

$$\Delta P = \frac{1}{2} \rho \left((9V_A)^2 - V_A^2\right)$$

$$\Delta P = \frac{1}{2} \rho \left(81 V_A^2 - V_A^2\right)$$

$$\Delta P = \frac{1}{2} \rho \left(80 V_A^2\right) = 40 \rho V_A^2$$

$$V_A = \sqrt{\frac{\Delta P}{40 \rho}} = \sqrt{\frac{\rho_w g h}{40 \rho}}$$

$$V_A = \sqrt{\frac{1000 \times 9.8 \times 1}{40 \times 1000}} = 0.495 \, m/s$$

(01 mark)

Rate of discharge, $Q = A_A V_A$

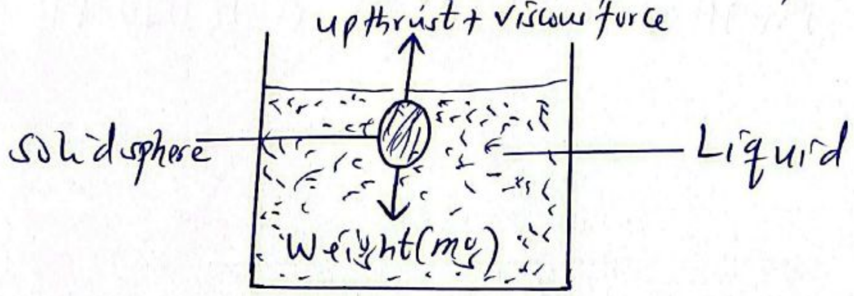
$$Q = \frac{\pi D_A^2}{4} \times V_A = \frac{\pi (0.3)^2}{4} \times 0.495 \, m/s$$

$$Q = 0.035 \, m^3 s^{-1}$$

$\therefore$ Rate of flow of water, $Q = 0.035 \, m^3 s^{-1}$

(01 mark)

1. (b) (i) Consider an object of density ρ dropped into a viscous liquid of density σ



At equilibrium

$W = F + U$ — (i) where F – Viscous force (01 mark)
U – Upthrust
W – weight of body

Recall

from stoke's law

$F = 6\pi\eta r V$ — (ii)

$W = mg = \frac{4}{3}\pi r^3 \rho g$ — (iii)

$U = m'g = \frac{4}{3}\pi r^3 \sigma g$ — (iii) (01 mark)

hence at terminal velocity, V_T

$F = W - U$

$6\pi\eta r V_T = \frac{4}{3}\pi r^3 \rho g - \frac{4}{3}\pi r^3 \sigma g$

$\frac{6\pi\eta r V_T}{6\pi\eta r} = \frac{\frac{4}{3}\pi r^3 g(\rho - \sigma)}{6\pi\eta r}$ (01 mark)

$V_T = \frac{4\pi r^3 g(\rho - \sigma)}{18\pi\eta r}$

$\therefore V_T = \frac{2r^2 g(\rho - \sigma)}{9\eta}$ (01 mark)

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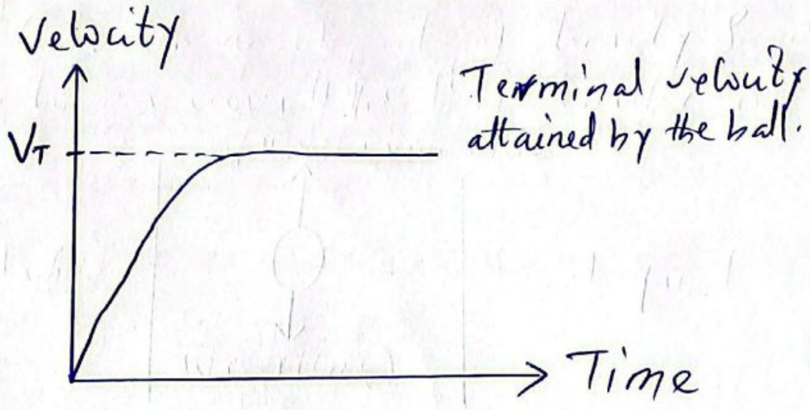
1. (b)(ii)



(02 marks)

(c)(i) recall from Poiseulle's formula

$$Q = \frac{V}{t} = \frac{\pi P r^4}{\eta l} \quad \text{—— (01/2 mark)}$$

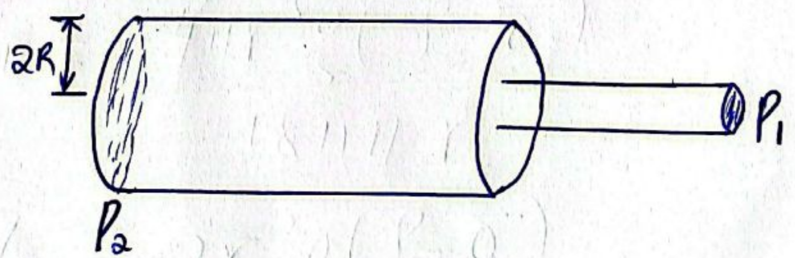
$$[\eta] = \frac{Q \pi P r^4}{Q l}$$

$$[\eta] = \frac{\pi [P][r]^4}{[Q][l]} = \pi \frac{[P/l][r]^4}{[Q]} \quad \text{—— (01/2 mark)}$$

$$[\eta] = \frac{[ML^{-2}T^{-2}][L]^4}{[L^3T^{-1}]}$$

$$\underline{[\eta] = ML^{-1}T^{-1}} \quad \text{—— (01 mark)}$$

(c)(ii) Consider the figure below



Let l and R be the length and radii of the first capillary respectively, and the second capillary be l and $2R$ and let P_1 and P_2 be the pressure of first and second capillary respectively.

- The pipes are series, same rate of flow

$$\frac{\pi P_1 R_1^4}{8\eta l} = \frac{\pi P_2 R_2^4}{8\eta l}$$ ——— (01 mark)

$$P_1 R_1^4 = P_2 (2R)^4$$

$$P_1 = \frac{P_2 (16R^4)}{R^4}$$

$$P_1 = 16P_2$$ ——— (01 mark)

but $P_1 + P_2 = 1m$

$$16P_2 + P_2 = 1m$$ ——— (01 mark)

$$\frac{17P_2}{17} = \frac{1m}{17}$$

$$P_2 = 0.059\,m \text{ of water}$$ (01 mark)

2. (a) (i) Progressive wave is the periodic disturbance of particles that causes transfer of energy from one point to another. (01 mark)

(ii) Refraction of waves is the bending of waves as they pass from one medium to another due to difference in natural properties of the material media (01 mark)

(iii) Diffraction of wave is the spreading of waves as they pass through an aperture. (small aperture means greater diffraction and vice versa) (01 mark)

(iv) Standing waves these are resultant waves formed when two progressive waves with the same amplitude, wavelength and frequency travelling in opposite direction are superimposed in a certain medium. (01 mark)

(b) From principle of superposition of waves

$Y = Y_1 + Y_2$ — (01 mar

$Y = 5\sin(\omega t + \pi/3) + 5\sin(\omega t - \pi/3)$

$Y = 5[\sin(\omega t + \pi/3) + \sin(\omega t - \pi/3)$

from factor formula

$\sin A + \sin B = 2\sin\left(\frac{A+B}{2}\right)\cos\left(\frac{A-B}{2}\right)$ — (01 ma

2 $Y = 5\left[2\sin\left(\frac{(\omega t+\pi/3)+(\omega t-\pi/3)}{2}\right)\cos\left(\frac{(\omega t+\pi/3)-(\omega t-\pi/3)}{2}\right)\right]$

$Y = 10[\sin(\omega t)\cos(\pi/3)]$ — (01 mark)

$Y = 10\cos(\pi/3)\sin(\omega t+0)$

Comparing with

$Y = A\sin(\omega t+\phi)$

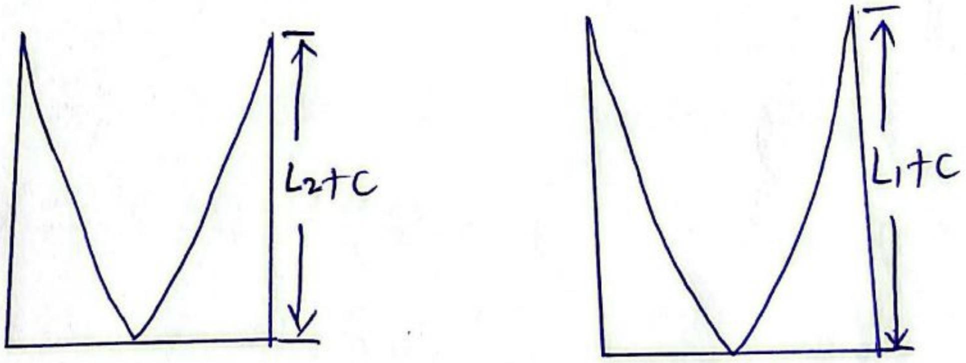
hence $A = 10\cos(\pi/3) = 10\times 0.5 = 5$ units

$\phi = 0$

$\therefore$ The resultant amplitude, $A = 5$ units

The phase angle, $\phi = 0$. — (01 mark)

(C) Consider the figure below



$L_2 = 20.5$ cm
$f_2 = 384$ Hz

$L_1 = 31.6$ cm
$f_1 = 256$ Hz

from the figures above

$\frac{\lambda}{4} = L_1 + C$ and $\frac{\lambda}{4} = L_2 + C$

$\lambda = 4(L_1+C)$ and $\lambda = 4(L_2+C)$ — (01 m

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2 but $V = f\lambda$

$V_1 = \lambda f_1$ and $V_2 = \lambda f_2$

$4f_1(L_1+c) = 4f_2(L_2+c)$

$f_1L_1 + f_1c = f_2L_2 + f_2c$ — (01 mark)

$(f_2 - f_1)c = f_1L_1 - f_2L_2$

$$c = \frac{f_1L_1 - f_2L_2}{(f_2 - f_1)}$$

$$c = \frac{(256Hz \times 31.6) - (384 \times 20.5)}{(384Hz - 256Hz)}$$

$c = 1.7\,cm$ — (01 mark

The end correction, c is 1.7 cm

But $V = 4f_1(L_1+c)$

$V = 4 \times 256Hz(0.316m + 0.017m)$

$V = 340.992 m/s$ — (02 mar

The velocity of sound in air is 340.992m

2. (d) (i) – When the source of sound as well as the listener are in the same direction with the same speed. (01 mark)

– When source or observer is at the center of the circle and the other is moving around the circle at constant speed. (01 mark)

(ii) For bright fringes $Y_n = \frac{n\lambda D}{d}$ — 01 mark

$$\lambda = \frac{d\,Y_n}{nD} = \frac{(0.03\times10^{-3}m)\times(4.5\times10^{-2}m)}{2\times1.2m}$$

$$\lambda = 5.625\times10^{-7}m$$ — (02 mark)

∴ The wavelength is $5.625\times10^{-7}m$.

Distance between two successive bright fringes is given by,

$$Y = \frac{\lambda D}{d}$$ — (01 mar

$$Y = \frac{5.625\times10^{-7}\times1.2}{0.03\times10^{-3}} = 0.0225m$$

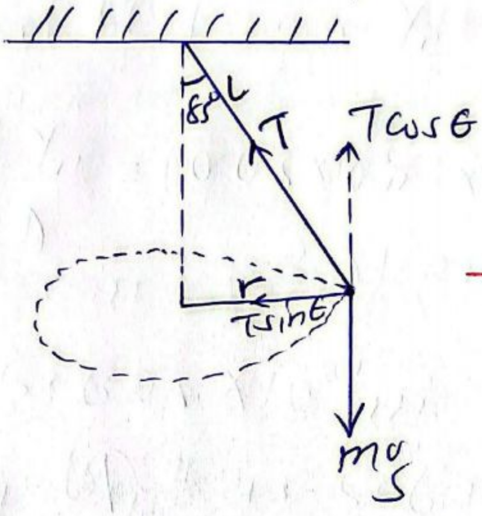
$$Y = 0.0225m$$ (01 mar

∴ Distance between two adjacent bright fringes is 22.5mm

03. (a) (i) Ultimate strength is the maximum stress that a material can experience before fractures (01 marks)

(ii) Because liquids and gases can not be deformed along one dimension only and also can not undergo shear strain (02 marks).

(iii) Let a stone rotate with a speed v in a horizontal circular path of radius, r



—— (00½ mark)

$\sin\theta = r/L \longrightarrow r = L\sin\theta$ —— (i)

$T\cos\theta = mg$ —— (ii)

$T\sin\theta = \dfrac{mv^2}{r}$ —— (iii) —(00½ m

from eqn (ii)

$T = \dfrac{mg}{\cos\theta} = \dfrac{0.589}{\cos 85^\circ} = 56.19$

$T = \underline{56.19 N}$ —— (01 mark

from $Y = \frac{F/A}{\Delta L/L}$ —— (01 mark)

$\therefore \Delta L = \frac{TL}{YA} = \frac{56.19 \times 0.8}{7\times10^{10} \times \pi (0.35\times10^{-3})^2}$

$\Delta L = 1.67 mm$

Increase in length, $\Delta L = 1.67 mm$ (01 mark)

3 (b)(i) The liquid assumes spherical ~~sph~~ shape because when a liquid nothing, surface tension is the only force acting on it.
(01 mark)

(ii) Initial pressure in cylinder is

$P_0 = 10^5 N/m$

Pressure inside bubble $P_1 = P_0 + \frac{4T}{R}$

let V_1 be initial volume of soap ~~bubble~~ bubble
P be air pressure in cylinder when the bubble is compressed to $R/2$. —— (01 mark

Now,
Pressure inside the bubble become

$P_2 = P + \frac{4T}{R/2} = P + \frac{8T}{R}$ —— (01 mar

Volume of bubble is given by

$V_2 = \frac{4}{3}\pi\left(\frac{R}{2}\right)^3 = \frac{1}{8} \times \frac{4}{3}\pi R^3$

3 $V_2 = \frac{1}{8} V_1$ ——— (01mark)

Temperature remains constant, hence

$$P_1 V_1 = P_2 V_2$$

$$\left(P_0 + \frac{4T}{R}\right)V_1 = \left(P + \frac{8T}{R}\right)\frac{V_1}{8}$$ ——— (01mark)

$$P = 8P_0 + \frac{24T}{R}$$

$$P = 8 \times 10^5 N/m^2 + \frac{24 \times 0.08}{2.4 \times 10^{-4}}$$

$$\underline{P = 8.08 \times 10^5 N/m^2}$$ ——— (01mark)

(c)(i) From average kinetic energy of molecules

$$\overline{K.E} = \frac{1}{2} m V^2 = \frac{3}{2} KT$$ ——— (01mark)

$$\overline{K.E} \propto T$$

If $T = 0K$, then $\frac{1}{2} m V^2 = 0$ (01mark)

Therefore; at 0K, the molecular motion stops.

(ii) $$V_{r.m.s} = \sqrt{\frac{V_1^2 + V_2^2 + V_3^2 + V_4^2 + V_5^2}{n}}$$ ——— (01mark)

$$V_{r.m.s} \sqrt{\frac{(300m/s)^2 + (500)^2 + (400m/s)^2 + (600m/s) + (200m/s)^2}{5}}$$ ——— (01mark)

03-(c) ii) $V_{r.m.s} = \sqrt{180000}$

$= 424.26 m/s$ — (01 mark)

$\therefore$ Root mean square $(V_{r.m.s}) = 424.26 m/s$

(iii) Recall from — (01 mark)

$\Delta U = \frac{3}{2} nKT$

$U = \frac{3}{2} \times 2 \times 1.38 \times 10^{-23} \times 240K$

$\underline{U = 9.936 \times 10^{-21} J}$ — (01 mark)

4. (a)(i) When a vehicle is in motion, the tyres rub against the road and get charged by friction. If the accumulated charge become excessive, sparking may occur and the inflammable materials may catch fire the chain rope touching the ground is use as the earthing hence the fire accident is avoided. (02 marks)

(ii) – Two equalpotential surface can never intersect

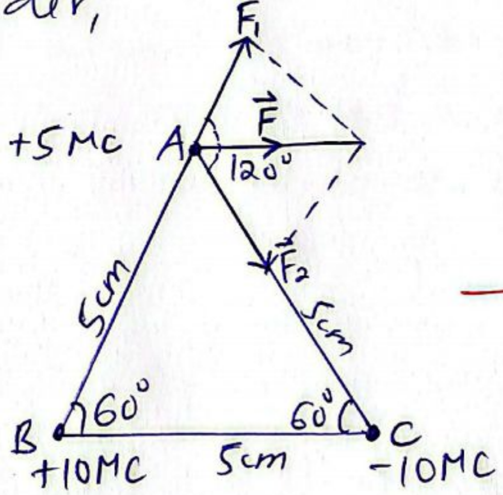
– Electric field is always normal to equalpotential at every point

4. (a) (ii) – No work is done by net electric field as a charge moves on an equipotential surface.

– The spacing between equipotential surface enables to identify regions of strong and weak potential.

(1@ = 2 marks)

(iii) Consider,



— (01 mark)

Repulsive force on charge at A due to charge at B

$$\vec{F_1} = 9\times10^9 \times \frac{(10\times10^{-6})\times(5\times10^{-6})}{(0.05)^2}$$

$\vec{F_1} = 180N$ along $\overline{BA}$ — (1½ mark)

Attractive force on charge at A due to charge at C

$$F_2 = \frac{9\times10^9\times(10\times10^{-6})\times(5\times10^{-6})}{(0.05)^2}$$

$\vec{F_2} = 180N$ along $\overline{AC}$ — (1½ mark)

4. Resultant force $F = F_1 \cos 60^\circ + F_2 \cos 60^\circ$

$F = 180 \cos 60^\circ + 180 \cos 60^\circ$

$F = 180N$ — (01 marks)

∴ The resultant force, $F_A = 180N$

(b)(i) Since the capacitor stores charge, when the circuit is switched off. the capacitor may still be charged and hence can cause electric shock on a body. — (02 marks)

(ii) from

$$C = \frac{\varepsilon_0 A}{d}$$

$$C = \frac{8.85 \times 10^{-12} \times 90 \times 10^{-4}}{2.5 \times 10^{-3}}$$

$C = 3.2 \times 10^{-11} F$ — (01 mark)

then, Electrostatic energy, $U = \frac{1}{2} CV^2$

$$U = \frac{1}{2} \times 3.2 \times 10^{-11} \times (400)^2$$

$U = 2.56 \times 10^{-6} J$ — (02 mark)

and Energy density $= \frac{U}{Ad} = \frac{2.56 \times 10^{-6} J}{90 \times 10^{-4} \times 2.5 \times 10^{-3}}$ Jm^{-3}

Energy density $= 0.1138 \, Jm^{-3}$ — (02 mark)

04. (c) When a metal (like a car) is charged, the charges spread out on the outer surface and the car behaves like a Faraday cage

(i) Inside the car the passenger is "isolated" there is no potential difference across their ~~she~~ bodies and no path to the ground. This makes passengers to remain safe.
(02 marks)

(ii) When the passengers step out, they act like a bridge between the car and the Earth. This creates a massive potential difference across their bodies, allowing the current to flow through the body. This makes the passengers at risk of electrocution.
(02 marks)

5. (a) (i) The magnetic field exerts a force in the horizontal plane. on the electron. The direction of this force can be found by right-hand rule for cross product. Under the given conditions, the electron will keep on revolving clockwise in a circular path with constant speed.
(02 marks)

(ii) The turns of the solenoid are parallel and carry current in the same direction Since parallel conductors carrying current in the same direction attract each other, a current carrying solenoid tends to contract. (02 marks)

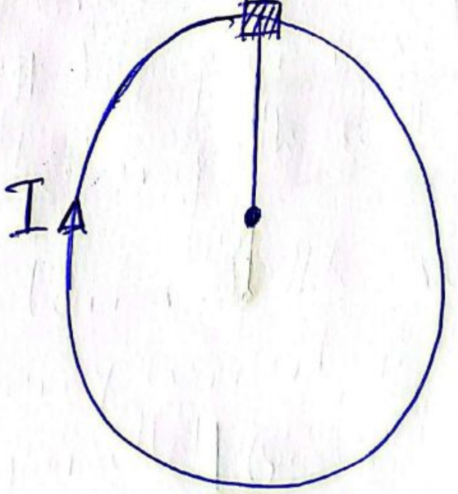
(iii) - Increasing the number of turns N in the coil
- Increasing the strength of magnetic field B
- Increasing the area A of the coil
- Decreasing torsion constant K of the spring.
(1@ = 3 marks)

5. (b)(i) It states that; "For every small element, dl of a conductor carrying current I, the magnitude of the magnetic flux density is directly proportional to the current flowing in a conductor, small element dl, sin θ and inversely proportional to the square of distance from the point to the small element dl.

i.e $dB \propto \frac{I\,dl\sin\theta}{r^2}$. — (01 mark)

<u>Magnetic field at the Centre of the circle Coil</u>

Consider,



— 00½ mark

from Biot-Savart law

$$dB = \frac{\mu_0 I \sin\theta\, dl}{4\pi r^2} \therefore \sin\theta = 1$$ — $0\frac{1}{2}$ mark

$$\int_0^B dB = \int_0^{2\pi r} \frac{\mu_0 I\, dl}{4\pi r^2}$$

$$[B]_0^B = \frac{\mu_0 I}{4\pi r^2} [L]_0^{2\pi r}$$ — $0\frac{1}{2}$ mark

$$B = \frac{\mu_0 I}{4\pi r^2} [2\pi r - 0]$$

$$B = \frac{\mu_0 I}{2r}$$ — $0\frac{1}{2}$ mark

for N – Number of turns

$$B = \frac{\mu_0 N I}{2r}$$ hence shown. — 01 mark

where;

B – Magnetic flux density at a point

N – Number of turns

I – Current flowing in a circular coil

r – Radius of circular coil.

5. b) (ii) Consider from induced e.m.f

$$\varepsilon = N\frac{d\Phi}{dt}, \text{ and } \text{——(i)}$$

from ohm's law

$$V = IR \quad \text{——— (01 mark)}$$

$$I = \frac{V}{R}$$

$$\frac{dq}{dt} = \frac{V}{R} \quad \text{———(ii)}$$

Substitute eqn (i) into (ii)

$$\frac{dq}{dt} = N\frac{d\Phi}{dt} \times \frac{1}{R}$$

$$q = \frac{N\Phi}{R} \quad \text{——— (01 mark)}$$

but $\Phi = BA$ (for maximum flux)

$$q = \frac{NBA}{R}$$

$$q = \frac{400 \times 2.5\times10^{-3}\,T \times 30\times10^{-4}\,m^2}{200\,\Omega}$$

$$q = 1.5\times10^{-5}\,C \quad \text{—— (01 mark}$$

$\therefore$ The maximum charge induced is $1.5\times10^{-5}\,C$ (15 μC)

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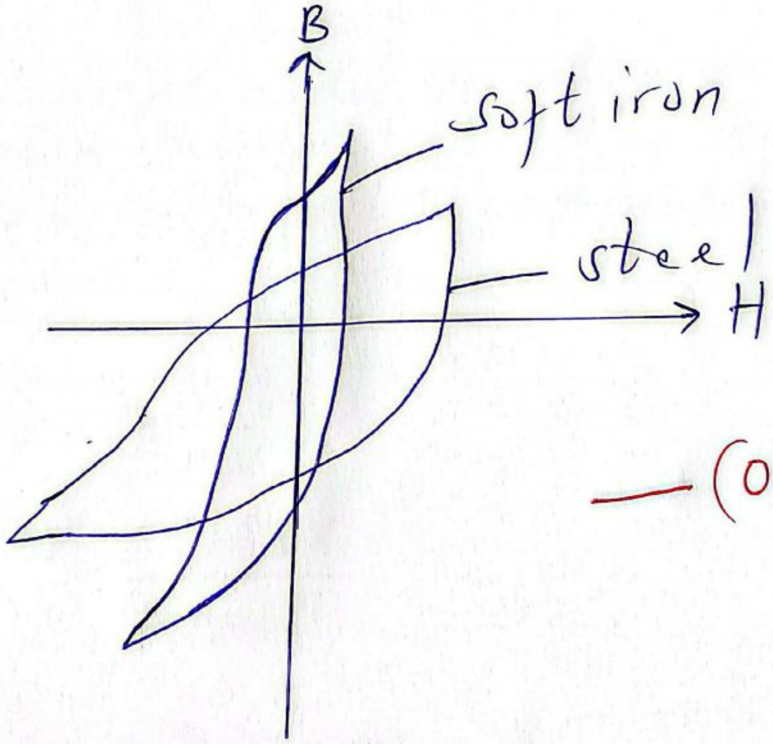
5. a) i) Diamagnetism is a natural reaction to the applied magnetic field. Therefore, it is present in all materials but is weaker even than paramagnetism. As a result diamagnetism is overwhelmed by paramagnetic and ferromagnetic effects in materials that display these other forms of magnetism.

(02 marks)

(ii)



(01 mark)

Soft Iron	steel
- It has narrow hysterisis loop	- It has large hysterisis loop
- Has low coercivity	- Has high coercivity

(03 marks)

6. a) i) – In Rutherford's model, electron revolve around the nucleus in any orbit. — 01/2 mark

WHILE

In Bohr's model, the electron revolve around the nucleus in orbit of defite radii. (00 1/2 mark)

– In Rutherford's model, electron lose energy continously. —— (00 1/2 mark)

WHILE

In Bohr's model, one atom emit radiation only when electron makes change of one energy level to another state. —(00 1/2 mark)

ii) from $\lambda_e = \frac{h}{mv}$

$$\lambda_e = \frac{6.63 \times 10^{-34}\,Js}{(9.1 \times 10^{-31})kg \times 10^5 m/s}$$

—— (02 marks)

$\lambda_e = 7.3\,nm$

$\therefore$ Wavelength of electron, $\lambda_e = 7.3\,nm$

$$\lambda_p = \frac{h}{mV}$$

$$\lambda_p = \frac{6.63 \times 10^{-34}}{(1.67 \times 10^{-27}) \times 10^5} = 3.97 \times 10^{-3}\,nm$$

$\therefore$ Wavelength of proton, $\lambda_p = 3.97 \times 10^{-3}\,nm$

—(02 ma

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6. b) From

$$E_n = \frac{R_H hc}{n^2} = -\frac{13.6eV}{n^2}$$

Also,

$$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{975 \times 10^{-10}}$$

$$E = 2.04 \times 10^{-18} J$$

$$E = 12.75 \, eV$$ —— (01 mark)

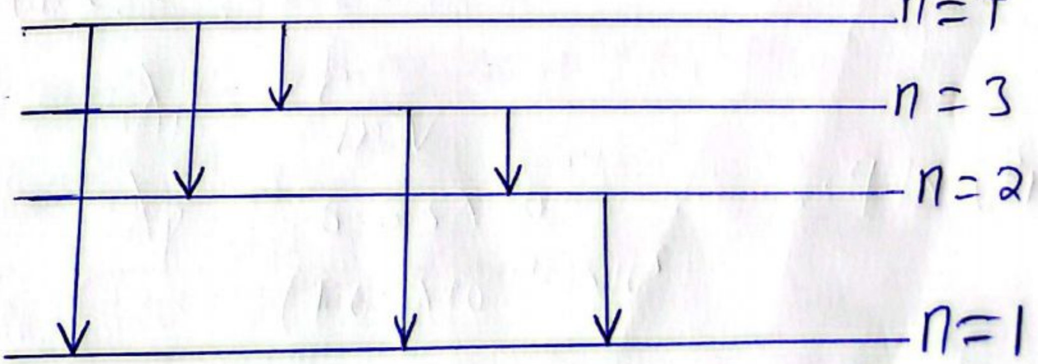
Now, suppose electron jump from $n=1$ to $n=n$

$$E_n = -\frac{R_H hc}{n^2} - \left(-\frac{R_H hc}{1^2}\right)$$

$$12.75 eV = R_H hc \left[1 - 1/n^2\right]$$

$$\underline{n = 4}$$ —— (01 mark)

The resulting transitions



It is clearly seen that there are six visible lines. —— (01 mark)

6. b) The longest wavelength is from $n=4$ to $n=3$

$$\Delta E = \frac{13.6\,eV}{3^2} - \frac{13.6\,eV}{4^2}$$ (01 mark)

$\Delta E = 0.667\,eV$

$\Delta E = 0.667 \times 1.6 \times 10^{-19}\,J$

but $\Delta E = \frac{hc}{\lambda}$

$$\lambda = \frac{hc}{\Delta E}$$

$$\lambda = \frac{6.637 \times 10^{-34} \times 3 \times 10^{8}}{0.667 \times 1.6 \times 10^{-19}}$$

$\lambda = 1.866 \times 10^{-6}\,m$ (01 mark)

c) i) Because neutron has no charge, it hits the nucleus directly with no any repelling or attracted by the nucleus of electron (01 mark)

ii) The binding energy per nucleon is the indicator of stability of the nucleus. The higher the binding energy per nucleon, the more stable the nucleus. (02 marks)

06. c) (iii) Oxygen has 8 protons and 8 neutrons.

$m_p = 8 \times 1.007593 = 8.060744$ a.m.u

$m_n = 8 \times 1.008982 = 8.071856$ a.m.u

(— 0½ mark)

Total mass of nucleons

$m_p + m_n = 8.060744 + 8.071856$

$= 16.132600$ a.m.u — (0½ mark)

Mass of oxygen $({}_{6}O^{16}) = 16.0000$ a.m.u

Δm (mass defect) $= M_{nucleus} - M_{nucleons}$

$= 16.132600 - 16.0000$

$= 0.1326$ a.m.u (0½ mark)

Binding energy

$= \Delta m \times 931$

$= 0.1326 \times 931$ MeV

$= 123.451$ MeV (0½ mark)

Now,

Binding energy per nucleon $= \dfrac{123.451}{16} = 7.71$ Me

$\therefore$ Binding energy per nucleon $= 7.71$ MeV

(01 mar

06 (d) given

K-E of neutron = 0.0327 eV

$$\frac{1}{2}mv^2 = 0.0327 \times 1.6 \times 10^{-19}$$

$$V = \sqrt{\frac{2 \times (0.0327 \times 1.6 \times 10^{-19})}{1.675 \times 10^{-27}\,kg}}$$

$$V = \underline{2.5 \times 10^3\, m/s}$$ — (01 mark)

Time taken by travel 10m is

$$t = \frac{distance}{velocity} = \frac{10m}{2.5 \times 10^3\, m/s}$$

$$time, t = \underline{4 \times 10^{-3}\, s.}$$ — (01 mark)

given ~~*~~ $T_{1/2} = 700s$

hence from

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/T_{1/2}} = \left(\frac{1}{2}\right)^{\frac{4 \times 10^{-3}}{700}} = 0.999996$$

Fraction of neutrons decayed

$$1 - 0.999996 = 0.000004.$$

— (01 mark)