1. (a) (i) Turbulent flow is the flow inwhich the speed and direction of the liquid particles passing any point change with time. (01 mark)

(ii) Laminar flow is the steady flow inwhich the liquid flows as a series of parallel layers. (01 mark)

(iii) Stream line flow is the steady flow in which the liquid particles at any point follow the same path at the same speed. (01 mark)

(b) (i) Consider the flow tube

(01 mark)

Let - A_1 and A_2 be cross-sectional areas at point 1 and 2 respectively.

- ρ_1 and ρ_2 be densities of the liquid at point 1 and 2 respectively.
- v_1 and v_2 be Velocities of the liquid at point 1 and 2 respectively.

from the Law of mass continuity

mass flux at point 1 = mass flux at point 2.

$$\left(\frac{\Delta m}{\Delta t}\right)_1 = \left(\frac{\Delta m}{\Delta t}\right)_2 .$$ (00½ mark)

but $m = \rho V = \rho \times A \times h$.

$$\rho_1 A_1 \frac{dh_1}{dt} = \rho_2 A_2 \frac{dh_2}{dt} .$$ (00½ mark)

but $\frac{dh_1}{dt} = V_1$

$\frac{dh_2}{dt} = V_2$,

$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2 .$$ (00½ mark)

$\rho_1 = \rho_2$ (the same liquid flow)

$$A_1 V_1 = A_2 V_2 ,$$ then continuity equation (00½ mark)

The condition under which the equation is valid

(i) the fluid should be incompressible

(ii) the fluid should be non-viscous

(iii) The fluid flow should be irrotational

(iv) The fluid flow should be steady and streamline (Laminar flow).

any Two - @ 00½

1. (b) (ii) From the Law of continuity

$$Q_1 = Q_2 + Q_3$$

where Q = rate of flow.

$$Q_1 = A_1 V_1$$
$$Q_2 = A_2 V_2$$
$$Q_3 = A_3 V_3$$

$$A_1 V_1 = A_2 V_2 + A_3 V_3$$ (01 mark)

$$A_3 V_3 = A_1 V_1 - A_2 V_2 .$$

Let $V_3 = V$

$$A_3 V = A_1 V_1 - A_2 V_2 ,$$

$$V = \frac{A_1 V_1 - A_2 V_2}{A_3}$$ (01 mark)

$$V = \frac{3A - 1.5A}{1.5A}$$

$$V = \frac{1.5A}{1.5A} = 1 m/s$$

$\therefore$ The Velocity $V = 1 m/s$. (01 mark)

1. (c) (i) When wind flows with a high velocity above the roof of a house, it causes a Lowering of pressure above the roof while pressure below the roof is still atmospheric. The net upward force is

$$F_{net} = F - f_1 = P_a A - P_1 A = A(P_a - P_1)$$

where P_a = atmospheric pressure inside the house
P_1 = air pressure above the roof.
$P_a > P_1$

Hence, a small pressure difference over a large area can produce a large upward force, eventually blows off the roof.

(02 marks)

1. (C) (ii) Data

$d_1 = 20\ cm$

$d_2 = 4\ cm$

$V_1 = 2\ m/s$

$P_1 = 10^7$

From continuity equation

$A_1 V_1 = A_2 V_2$. (001/2 mark)

$$V_2 = \frac{A_1 V_1}{A_2} = \frac{\frac{\pi d_1^2}{4} \cdot V_1}{\frac{\pi d_2^2}{4}} = \frac{V_1 d_1^2}{d_2^2}$$

$$V_2 = V_1 \left(\frac{d_1}{d_2}\right)^2$$

1. c(ii) $V_2 = 2 \times \left(\frac{20}{4}\right)^2$

$V_2 = 2 \times 5^2 = 50\,m/s.$

∴ The velocity is 50 m/s. (01 mark)

Also from

$$\Delta p = \frac{1}{2}\rho\left(V_2^2 - V_1^2\right)$$

$$P_2 - P_1 = \frac{1}{2}\rho\left(V_2^2 - V_1^2\right)$$

$$P_2 = P_1 + \frac{1}{2}\rho\left(V_2^2 - V_1^2\right)$$ (00 1/2 mark)

$$P_2 = 10^7 + \frac{1}{2} \times 1000\left(50^2 - 2^2\right).$$

$$P_2 = 10^7 + 500\left(2500 - 4\right).$$

$$P_2 = 1348,000\ Pa.$$

∴ The pressure at the constriction,

$P_2 = 1348000\ Pa.$ (01 mark)

1. (d) Data:

$\rho_o = 0.95 g/cm^3$

$\rho_a = 0.0013 g/cm^3$

$V_T = 1.142 \times 10^{-2} cm/s$

$\eta = 181 \times 10^{-6} cm^{-1} s^{-1}$

$r = ?$

From

$$V_T = \frac{2r^2 g}{9\eta}(\rho_o - \rho_a)$$ (01 mark)

$$r^2 = \frac{9\eta V_T}{2g(\rho_o - \rho_a)}.$$ (01 mark)

$$r^2 = \frac{9 \times 1.142 \times 10^{-2} \times 181 \times 10^{-6}}{2 \times 980 \times (0.95 - 0.0013)} cm^2$$ (01 mark)

$$r^2 = 5.52 \times 10^{-5}$$ (01 mark)

$$r = \sqrt{5.52 \times 10^{-5}} = 0.00735 cm$$

∴ Radius of the drop, $r = 0.00735 cm$

(01 mark) (05)

2. (a) (i) From

$$f' = \left(\frac{V - V_0}{V}\right) f_0$$ (0.0 1/2 mark)

but $V = V_0$

$$f' = \left(\frac{V_0 - V_0}{V}\right) f_0$$ (0.0 1/2 mark)

$$f' = \left(\frac{0}{V}\right) f_0$$

$$f' = 0 \text{ Hz}.$$ (0.0 1/2 mark)

Since the apparent frequency is zero, therefore, he will not hear any sound. (0.0 1/2 mark)

2. (a) (ii) From

$$f_1 = f\left(\frac{v + V_1}{v - V_1}\right)$$ (0.0 1/2 mark)

Where v is the speed of sound $= 340\text{m/s}$.

For the other train with unknown speed V_2:

$$f_2 = f\left(\frac{v + V_2}{v - V_2}\right).$$ (0.0 1/2 mark)

Solving for beat frequency

- The beat frequency $f_b = |f_1 - f_2|$ is (0.0 1/2 mark)

Is given as 5 Hz

2 (a) We can set up the equation

(ii)

$$5 = \left| 400\left(\frac{340+25}{340-25}\right) - 400\left(\frac{340+V_2}{340-V_2}\right)\right|$$

($00\frac{1}{2}$ mark)

Solving for V_2

$$\frac{340+V_2}{340-V_2} = 1.146$$

($00\frac{1}{2}$ mark)

$$V_2 = 23.2 \text{ m/s.}$$

∴ The speed of the other train $V_2 = 23.2$ m/s ($00\frac{1}{2}$ mark)

(b) (i) Inphase vibration refers to a situation where two or more vibrating objects reach their peak displacement at the same time while out of phase vibrations objects reach their peak displacement at different times. (02 marks)

(ii) From superposition principle

$$Y = y_1 + y_2,$$

$$y = 3\sin\left(5x - \pi/2\right) + 4\sin\left(5x + \pi/2\right)$$

($00\frac{1}{2}$ mark)

08

Let $5x = A$, $\frac{\pi}{2} = B$

2 (b) (ii) recall

$\sin(A-B) = \sin A \cos B - \sin B \cos A$

$\sin(A+B) = \sin A \cos B + \sin B \cos A$. (0$\frac{01}{2}$ mark)

Then

$y = 3\left[\sin 5x \cos \frac{\pi}{2} - \sin \frac{\pi}{2} \cos 5x\right] + 4\left[\sin 5x \cos \frac{\pi}{2} + \sin \frac{\pi}{2} \cos 5x\right]$ (01 mark)

But $\cos \frac{\pi}{2} = 0$, $\sin \frac{\pi}{2} = 1$

$y = 3\left[0 - \cos 5x\right] + 4\left[0 + \cos 5x\right]$

$y = -3\cos 5x + 4\cos 5x$. (0$\frac{01}{2}$ mark)

$y = \cos 5x$

$\therefore$ Resultant displacement, $y = \cos 5x$. (0$\frac{01}{2}$ mark)

(c) (i) Yes, In Young's double slit experiment, the two slits acts as two coherent sources. The waves emerging from the slits originating from an incoherent source

(02 marks)

2. (c) (ii)

from

$$r_n = \sqrt{\frac{\left(n - \frac{1}{2}\right)\lambda R}{\mu}}$$ (00 $\frac{1}{2}$ mark)

where μ = refractive index,

$n = 5$

$\lambda = 5 \times 10^{-7}$ m.

$r_n = \frac{d_n}{2}$.

$$\therefore \left(\frac{d_n}{2}\right) = \sqrt{\frac{\left(5 - \frac{1}{2}\right) 5 \times 10^{-7} \times 0.35}{\mu}}$$ (00 $\frac{1}{2}$ mark)

square both sides

$$\frac{d_n^2}{4} = \frac{\left(5 - \frac{1}{2}\right) 5 \times 10^{-7} \times 0.35}{\mu}.$$ 00 $\frac{1}{2}$ mark

$$\mu = \frac{\left(5 - \frac{1}{2}\right) 5 \times 10^{-7} \times 0.35}{\frac{d_n^2}{4}}$$ (00 $\frac{1}{2}$ mark)

$$\mu = \frac{4.5 \times 4 \times 5 \times 10^{-7} \times 0.35}{(0.15 \times 10^{-2})^2}$$ 00 $\frac{1}{2}$ mark

2 (c) (ii)

$\mu = 1.4$.

$\therefore$ The refractive index $\mu = 1.4$. ($00\frac{1}{2}$ mark)

(d) (i) - Polarization is the process of restricting waves to vibrate in only one plane. ($00\frac{1}{2}$ mark)

- Angle of polarization is the angle of incidence where the reflected light is completely polarized. ($00\frac{1}{2}$ mark)

(ii) method of polarization

- By polaroid
- By reflection
- By double refraction.

any two @ $00\frac{1}{2}$ mark

(iii) From Brewster's Law

$\tan\theta = \eta$ $\quad 00\frac{1}{2}$ mark

$n = \tan 48^\circ = 1.11$ $\quad 00\frac{1}{2}$ mark

and also $\theta_i + \theta_r = 90^\circ$

$\theta_r = 90^\circ - \theta_i$

2 (d) $\theta_r = 90^\circ - 48^\circ = 52^\circ$

(iii) ∴ Angle of refraction, $\theta_r = 52^\circ$ (0.0½ mark)

03. (a) (i) Factors affecting surface tension

- Presence of impurities
- Temperature
- Nature of the liquid
- Oxidation.

any two @ 0.0½ mark

(ii) Practical Examples of adhesive and cohesive forces

- Glue sticking to paper
- Water droplets on glass
- paint adhering to a wall.

any two @ 0.0½ mark

(iii). From

$$\text{Total Pressure} = \text{Atmospheric pressure} + \frac{2\gamma}{R}$$ (01 mark)

$$= 1.013 \times 10^5 + \frac{2 \times 0.072}{0.1 \times 10^{-3}}$$

$$= 1.013 \times 10^5 + 1.440$$ (01 mark)

$$= 102,740 \text{ Pa.}$$

∴ Pressure inside air bubble $= 102,740$ Pa (01 mark)

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3. (b) (i) Water, because water is less compressible than air, then has greater elasticity. (02 marks)

(ii)

Given $\alpha = 18 \times 10^{-6}$

$A = 1\,cm^2$

From linear expansivity

$$\alpha = \frac{\Delta L}{L\Delta\theta}$$ (00½ mark)

$$\Delta L = e = \alpha L \Delta\theta \quad \text{— (i)}$$

from young's modulus

$$e = \frac{FL}{AY} \quad \text{— (ii)}$$ (00½ mark)

equate (i) and (ii)

$$\alpha L \Delta\theta = \frac{FL}{AY}$$

$$F = AY\Delta\theta\alpha$$

$$F = 1\times10^{-4} \times 2\times10^{11} \times 100 \times 18 \times 10^{-6}$$

$$F = 36000N$$ (00½ mark)

but $e = \alpha L \Delta\theta$

$$e = 18\times10^{-6} \times 100 \times 1$$

$$e = 1.8 \times 10^{-4}m.$$ (00½ mark)

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

$$= \frac{1}{2} \times 36000 \times 1.8 \times 10^{-4}$$

$$= 0.324\,J.$$

∴ strain energy, $U = 0.324J.$ (01 mark)

(iii) Bulk modulus, $K = \frac{V\Delta P}{\Delta V}$ (01 mark)

change in volume, $\Delta V = -\frac{\Delta P}{K} \times V$

$$= -\frac{2\times10^8}{8\times10^9} \times V = -\frac{V}{40}$$

new volume of Lead, $V' = V + \Delta V = V - \frac{V}{40} = \frac{39}{40}V$

(01 mark)

3 (b) (iii)

If ρ' kg/m³ is the new density of Lead, then it's mass is given by:-

$$= V'\rho' = \frac{39}{40} V\rho' \text{ kg}$$ (01 mark)

Since the mass is a constant quantity, then,

$$\frac{39}{40} V\rho' = V \times 11.4 \times 10^3$$ (01 mark)

$$\rho' = \frac{40}{39} \times 11.4 \times 10^3$$

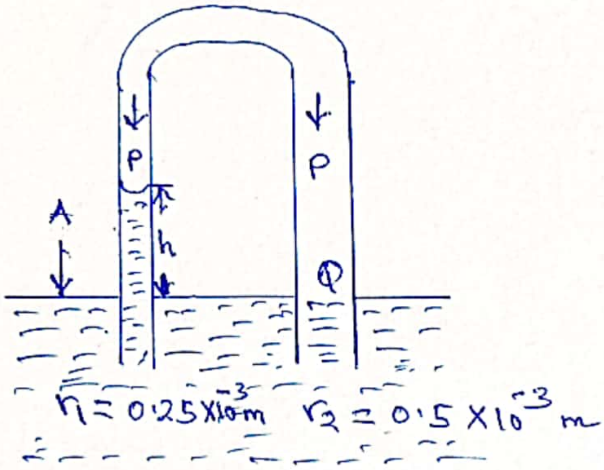
$$\rho' = 11.69 \times 10^3 \text{ kg/m}^3$$

∴ The density of Lead, $\rho' = 11.69 \times 10^3 \text{ kg/m}^3$ (01 mark)

(c)(i) The liquid will rise upto the top of the capillary tube but will not overflow. The radius of curvature of the liquid meniscus increases and the meniscus becomes more and more flat. The liquid can not emerge as a fountain from the upper end of the tube.

(02 marks)

3. (c) (ii) Consider a U-tube below:



Then from

$$h\rho g = \frac{2T}{r_1} - \frac{2T}{r_2}$$ (0$\frac{1}{2}$ mark)

$$h = \frac{2T}{\rho g}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$ (0$\frac{1}{2}$ mark)

but

$r_1 = 0.25 \times 10^{-3} m$

$r_2 = 0.5 \times 10^{-3} m$

$T = 7.5 \times 10^{-3} Nm^{-1}$

$g = 9.8 m/s^2$

$\rho = 1000 kg/m^3$

$$\therefore h = \frac{2 \times 7.5 \times 10^{-3}}{1000 \times 9.8}\left[\frac{1}{0.25 \times 10^{-3}} - \frac{1}{0.5 \times 10^{-3}}\right]$$

(01 mark)

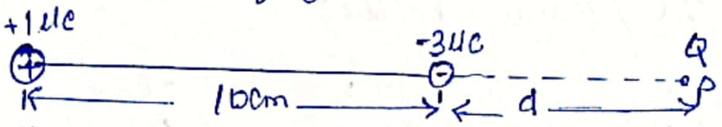
$h = 3.1 \times 10^{-2}$ m.

3 (c)(ii) ∴ The height of water in the other limb, $h = 3.1 \times 10^{-2}$ m. (1 mark)

4 a(i) State that

"The electrostatic force between two point charges is directly proportional to the product of their magnitudes and inversely proportional to the square of the distance between their centres." (01 mark)

ii) Consider the fig bellow



(01 mark)

Let $Q_1 = +1\mu C$

$Q_2 = -3\mu C$

Electostatic force between two charges is given as $F = \frac{KQ_0Q}{r^2}$

Let F_1 be F between Q_1 an Q

$F_1 = \frac{KQ_1Q}{(10+d)^2}$ ---(i) (00½ mark)

F_2 be force between Q_2 and Q

$F_2 = \frac{KQ_2Q}{d^2}$ ---(ii) (00½ mark)

Since at point P No Electrostatic force on charge Q then

$F_1 = F_2$.

$\frac{KQ_1Q}{(10-d)^2} = \frac{KQ_2Q}{d^2}$ (00½ mark)

$\frac{Q_1}{(10-d)^2} = \frac{Q_2}{d^2}$.

$\frac{d^2}{(10-d)^2} = \frac{Q_2}{Q_1}$

$\frac{d}{10-d} = \sqrt{\frac{Q_2}{Q_1}}$ --- (00½ mark)

Solving for d:

$d = -24cm$

The position of third charge will at a distance of 24cm from a point charge of $-3\mu c$.

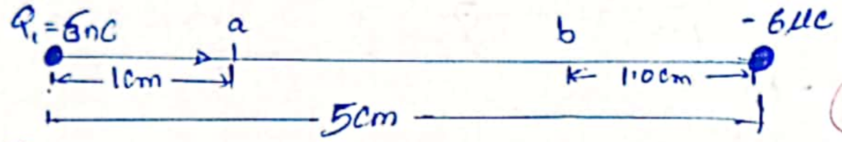
(01 mark)

4b (i) Importance of Equipotential Surface.

i- Help to identify the direction of Electric fields.
ii- Help to identify regions of weak and strong electric field
iii- Showing areas where the potential is constant $\Delta V = 0$

any two @ (1 mark)

ii) Consider the figure bellow



(01 mark)

From the Conservation of charge. Mechanical Energy Hold at position a and b.

$$KE_a + PE_a = KE_b + PE_b.$$

(00½ mark)

as particle starts from rest from $+6\mu C$

Then $KE_a = 0$, $v = 0$.

defn $KE_b = PE_a - PE_b$.

(00½ mark)

$K_b = \frac{1}{2} m V_b^2$.

$KE_b = PE_a - PE_B$

But $PE = Wd = QV$

$KE_b = QV_a - QV_b$.

$\frac{1}{2} m V_b^2 = Q(V_b - V_a)$

(00½ mark)

$$V_b^2 = \sqrt{\frac{2Q(V_a - V_b)}{m}}$$

(00½ mark)

$$V_A = KQ_A\left(\frac{1}{r_a} + \frac{1}{5-r_a}\right) = 9\times10^9 \times 3\times10^{-9}\left(\frac{1}{1\times10^{-2}} + \frac{-1}{4\times10^{-2}}\right)$$

$$V_A = 2025V$$

00½ mark

$$V_b = KQ_B\left(\frac{1}{4\times10^{-2}} - \frac{1}{1\times10^{-2}}\right) = 9\times10^9(3\times10^{-9})\left(\frac{1}{4\times10^{-2}} - \frac{1}{1\times10^{-2}}\right)$$

$$V_b = -2025V$$

(00½ mark)

$$\Delta V = (2025 - -2025)V$$

$$\Delta V = 4050V$$

$$V_b^2 = \frac{2\times 2\times10^{-6} \times 4050}{5.0\times10^{-9}}$$

(01 mark)

$$V = 1800 m/s.$$

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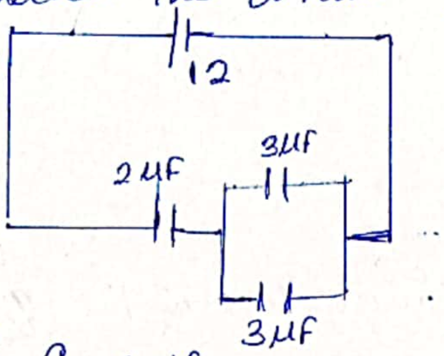
The velocity of the dust particle at b is 1800m/s

4C (ii) Consider the Circuit bellow



Let $C_1 = 2\mu F$
$C_2 = 3\mu F$
$C_3 = 3\mu F$.
$V = 12V$.

Required Total charge through the Circuit

C_2 and C_3 are in parallel

$C_p = C_2 + C_3$
$C_p = 6\mu F$. (00½ mark)

C_1 is in series with C_p.

$C_T = ?$

$\frac{1}{C_T} = \frac{1}{C_p} + \frac{1}{C_1}$

$\frac{1}{C_T} = \frac{1}{6} + \frac{1}{2}$.

$\frac{1}{C_T} = \frac{1+3}{6}$

$C_T = 6/4 \mu F$. ← (00½ mark)

From $Q = CV$

$Q_T = C_T \cdot V$

$Q = (6/4 \times 10^{-6}) \times 12V$

$Q = 1.8 \times 10^{-5} C$. ← (01 mark)

Total charge through the Circuit is $1.8 \times 10^{-5} C$

4C(i)

- Both the dielectric and insulator can not conduct Electricity
- But dielectrics have the property of transmitting electric effects without conducting. (01 mark)

4C (ii) Given

(4C) (ii) $C_1 = 12mF = 12\times10^{-3}F$.

$C_2 = 8mF = 8\times10^{-3}F$

$V_1 = 200V$.

Required to find out the Energy loss in the first capacitor

Before connection C store Energy.

$E_{Before} = E_1 = \frac{1}{2}CV^2$

$E_1 = \frac{1}{2}\times12\times10^{-3}\times(200)^2$

$E_1 = 240J$. (01 mark)

when the capacitor is connected to C_2 the Energy/charge is conserved

So charge before connection = charge after connection

$Q_1 = Q_2$

$Q_1 = C_1V_1$ and $Q_2 = C_1V + C_2V$ (01 mark)

$C_1V = (C_1+C_2)V$

final voltage $V = \frac{C_1V_1}{C_1+C_2}$

$V = \frac{12\times10^{-3}\times200}{8\times10^{-3}+12\times10^{-3}}$

$V = 120V$. ← (01 mark)

Energy lost $\Delta E = E_{befor} - E_{after}$

$\Delta E = E_1 - E_2$

$E_2 = \frac{1}{2}(C_1+C_2)V^2$

$E_2 = \frac{1}{2}(12+8)\times10^{-3}\times(120)^2$

$E_2 = 144J$. (01 mark)

$\Delta E = (240-144)J$

$\Delta E = 96J$ (01 mark)

The required Energy lost is 96J. (20)

Q5. (a) (i) magnetic flux refers to the total number of magnetic field lines passing through a given area while magnetic flux density represents the strength of the magnetic field per unit area. (02 marks)

(ii) Given
Force, $F = 7N$
Current, $I = 40A$
length, $L = 6cm = 6 \times 10^{-2} m$.

From $F = IBL\sin\theta$ (01 mark)
but $\theta = 90^{\circ}$ (perpendicular)

$F = IBL$

$B = \frac{F}{IL} = \frac{7}{40 \times 6 \times 10^{-2}}$ (01 mark)

$B = 2.92T$

$\therefore$ magnetic field strength, $B = 2.92T$.
(01 mark)

5. (b) (i) Biot – Savart Law states that " the magnetic field dB produced at a point due to a small current element dl carrying current I is directly proportional to the length of the element dl, the current I, and the sine of the angle between dl and the position vector r to the point, and inversely proportional to the square of the distance r from the element to the point

(01 mark)

ie $dB \propto \frac{I dl \sin\theta}{r^2}$

(ii) From

$$B = \frac{\mu_0 I R^2 N}{2(x^2 + R^2)^{3/2}}$$ (00½ mark)

Let $x = R/2$

$$B = \frac{\mu_0 I R^2 N}{2((R/2)^2 + R^2)^{3/2}}$$ (00½ mark)

5 (b) (ii)

$$B = \frac{\mu_0 I R^2 N}{2\left[\frac{R^2}{4} + R^2\right]^{3/2}}$$

$$B = \frac{\mu_0 I R^2 N}{2\left[\frac{5R^2}{4}\right]^{3/2}}$$ (00½ mark)

$$B = \frac{\mu_0 I R^2 N}{2\left[\frac{5^{3/2}}{4^{3/2}} \cdot R^3\right]}$$

$$B = \frac{\mu_0 I R^2 N}{2\left[\frac{5^{3/2}}{8} \cdot R^3\right]}$$ (00½ mark)

$$B = \frac{\mu_0 I N}{2\left(\frac{5^{3/2}}{8} R\right)}$$

$$B = \frac{\mu_0 I N}{\frac{5^{3/2}}{4} R}$$

$$B = \frac{\mu_0 I N}{2.7951 R}$$

$$B = \frac{0.3578 \mu_0 I N}{R}$$ (00½ mark)

Since we have two coil, the value of B should multiplied by 2. (00½ mark)

$$\therefore B = \left(\frac{0.3578 \mu_0 I N}{R}\right) 2$$

$$\therefore B = 0.72\left(\frac{\mu_0 N I}{R}\right)$$

hence proved!

(01 mark)

5 (c) (i) Factors influencing magnitude of induced e.m.f in electric circuit

- Number of turns in the coil
- Strength of the magnetic field
- The area of the coil
- The rate of change of magnetic flux through the coil.

any three @ $00\frac{1}{2}$ mark.

(ii) Given

$I = 5t^2 + 8t + 4$

$L = 4H$

$t = 3ms = 3 \times 10^{-3}$ sec.

From $E = -L\frac{dI}{dt}$ ($00\frac{1}{2}$ mark)

Where $\frac{dI}{dt} = \frac{d}{dt}(5t^2 + 8t + 4) = 10t + 8$ $00\frac{1}{2}$ mark

Then $|E| = \left|-L\frac{dI}{dt}\right|$

$|E| = 4 \times (10t + 8) = (40t + 32)V$

$\therefore$ magnitude of induced E.m.f $= (40t + 32)V$ (01 mark)

5. (c) (ii) E.m.f at $t = 3\,ms = 3 \times 10^{-3}$ second.

$$|E| = (40t + 32)\,V$$

$$|E| = [(40 \times 3 \times 10^{-3}) + 32]\,V$$ (01 mark)

$$|E| = 32.12\,V.$$

$\therefore$ At $t = 3\,ms$, $|E| = 32.12\,V.$

(01 mark)

(d) (i) - Dynamo theory

The earth's magnetic field is formed in the planet's outer core.

(01 mark)

- Ionisation theory

Earth's rotation in its own axis produces a strong electric current due to ionisation of the outer layers of the earth. This produces magnetism due to the movement of the ions.

(01 mark)

5. (d) (ii)

Horizontal Component, $H = 6.2 \times 10^{-4}$ T

Angle of dip $= 40° = I$.

Let Z be the vertical component, then from

$$\tan I = \frac{Z}{H}. \quad (00\tfrac{1}{2} \text{ mark})$$

$$Z = H \tan I$$

$$Z = 6.2 \times 10^{-4} \times \tan 40°$$

$$Z = ~~1.074 \times 10^{-3}~~ \text{ T}$$

5.2×10^{-4} T $(00\tfrac{1}{2}$ mark)

∴ The Vertical Component $Z = 1.074 \times 10^{-3}$ T.

Let the total intensity of the earth's field be B_E.

Then

$$B_E = \frac{H}{\cos I} \quad (00\tfrac{1}{2} \text{ mark})$$

$$B_E = \frac{6.2 \times 10^{-4}}{\cos 40} \quad (00\tfrac{1}{2} \text{ mark})$$

$$B_E = 8.09 \times 10^{-3} \text{ T}.$$

∴ Total intensity, $B_E = 8.1 \times 10^{-3}$ T. $(00\tfrac{1}{2}$ mark)

6\. a (i) X-rays are produced when energetic electrons strike a target such as metal piece (tungsten), when electrons collide with the atom of solid, they loss energy (kinetic energy which is converted into radiant high energy electromagnetic waves (x-rays).

(02 marks)

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

$\lambda_p = \frac{h}{m_p v_p}$ ——— ($00\frac{1}{2}$ mark)

For electron

$\lambda_e = h/m_e v_e$ ——— $00\frac{1}{2}$ mark

to have same wavelength

$\lambda_e = \lambda_p$

$\frac{h}{m_p V_p} = \frac{h}{m_e V_e}$ ——— $00\frac{1}{2}$ mark

$m_p V_p = m_e V_e$

$V_p = \frac{m_e V_e}{m_p}$ ——— $00\frac{1}{2}$ mark

$V_p = \frac{9.1 \times 10^{-31} \times 4.5 \times 10^{6}}{1.67 \times 10^{-27}}$ m/s

$V_p = 2.45 \times 10^{3}$ m/s Required (0.1 mark)

6 b a (i) Wave-particle duality
- Means. The matter posses both wave property and particle property.

A particle posses $E = mc^2$ (Einstein Eqn)

As a wave passes $E = hf$. (Plank).

(01 mark)

6 b (ii)

Given

$V_{s_1} = 3.00V$

$\lambda_1 = 500nm$

$\lambda_2 = 600nm$

V_{s_2}.

from $eV = hf$.

$E_{max} = W_0 + E$ — (00½ mark)

$E_{max} = W_0 + eV_s$.

$hf = hf_0 + eV_s$.

$eV_s = hf - hf_0$.

For λ_1

$eV_{s_1} = hf_1 - hf_0$

$eV_{s_1} = h\frac{c}{\lambda_1} - hf_0$ --- (i) — (00½ mark)

for λ_2 beam

$eV_{s_2} = h\frac{c}{\lambda_2} - hf_0$ — (ii)

Substracting (i) from (ii)

$eV_{s_2} - eV_1 = hc\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right)$ — (00½ mark)

$V_2 - V_1 = \frac{hc}{e}\left(\frac{1}{\lambda_2} - 1/\lambda_1\right)$

$V_2 - V_1 = \frac{hc}{e}\left(\frac{\lambda_2 - \lambda_1}{\lambda_1\lambda_2}\right)$

$V_2 - V_1 = 0.4$

$V_2 = V_1 - 00.4$

$V_2 = 3 - 0.4$

$V_2 = 2.6V$. — (00½ mark)

6 b iii

Given

Power $P = 10 kW = 10 \times 10^3 W$

frequency $f = 6 \times 10^5$ Hz

Let N be No of proton

$E = hf$

$P = \frac{E}{t}$

$P = \frac{hf}{t}$

for N ~~electron~~ no of photon

$P = \frac{Nhf}{t}$ (00 ½ mark)

Let n be number of photon emitted per second (00 ½ mark)

$P = nhf$

$n = \frac{P}{hf}$ (00 ½ mark)

$n = \frac{10 \times 10^3}{6.63 \times 10^{-34} \times 6 \times 10^5}$

$n = 2.5 \times 10^{31}$ photons per second (00 ½ mark)

C (i) (i) Laser light is highly coherent - is in phase both in time and space where normal light is incoherent with random phases.

any two (@ 00 ½ mark)

ii Laser light is nearly monochromatic consisting of single wavelength / colour, while normal light contains broad spectrum of wavelength

(iii) Laser light is directional while normal light spread out in all directions

iv) Can achieve high intensities while normal light achieve relative low intensity

6C ii) Given

$n_i = 1^2$

$n_2 = 3$

from

$$E = \frac{13.6Z^2}{n^2}$$ —— (00 $\frac{1}{2}$ mark)

Required ΔE

$\Delta E = E_3 - E_1$

$E_1 = n = 1$

$$E_1 = -\frac{13.6 \times 3^2}{1^2}$$ —— 00 $\frac{1}{2}$ mark

$E_1 = -122.43V$

$$E_3 = -\frac{13.6 \times 3^2}{3^2}$$ —— (00 $\frac{1}{2}$ mark)

$E_3 = -13.6eV$

$\Delta E = (-13.6 - 122.43)eV$

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

$$\lambda = \frac{12375}{(-13.6 - (122.43))eV}$$

$\lambda = 113.74 \mathring{A}$ —— (00 $\frac{1}{2}$ mark)

6 C iii) Soln

from

$$B.E = [Zm_H + (A - Z)m_n - M_{Am}]c^2$$

where Z = atomic number

A = Mass number

M_p = mass of proton

M_n = mass of neutron

$$\Delta m = 95 \times 1.007825 + (244 - 95)1.008665 - 244.064\ldots$$

$$\Delta m = 1.970181 \text{ a.m.u}$$ (00½ mark)

Since 1 a.m.u = 931.5 MeV

$$\therefore B.E = 1.970181 \times 931.5 = 1835.2 \text{ MeV}$$ (00½ mark)

$$\therefore \frac{B.E}{A} = \frac{1835.2 \text{ MeV}}{244} = 7.52 \text{ MeV}$$

$\therefore$ The Binding Energy per nucleon, $\frac{BE}{A} = 7.52$ MeV

(01 mark)

Essential requirements for nuclear power plant in Tanzania

6 (d) (i) Natural uranium enrichment

- it means to reduce 99.3% of $\left({}^{238}_{92}U\right)$ to 96% of $\left({}^{238}_{92}U\right)$ so as to increase the probability of neutrons produced to induce the next fission.

(00½ mark)

(ii) To thermalize high energy fission neutrons using hydron in water in the first loop as a moderator.

(00½ mark)

(iii) To reduce the escape of the neutrons produced from the core reactor by increasing the mass of nuclear fuel used in a reactor.

(00½ mark)

d (ii) From

$$N = N_0 e^{-\lambda t}$$ ← 00½ mark

$$\lambda = \frac{0.693}{T} = \frac{0.693}{2000} = 3.47 \times 10^{-4}$$

$$\lambda t = 3.47 \times 10^{-4} \times 5000 = 1.733$$ (00½ mark)

$$\frac{N}{N_0} = e^{-1.733} = 0.177$$

∴ The fraction remaining after 5000 days is 0.177 ——— (01/2 mark)

6 (d) (ii) Activity, $\frac{dN}{dt} = \lambda N$

$N_0 = 10^{18}$ atoms

$N = 0.177 \times 10^{18}$

$$\lambda = \frac{0.693}{2000 \times 24 \times 3600} = 4.01 \times 10^{-9}$$ (01/2 mark)

$$\frac{dN}{dt} = 4.01 \times 10^{-9} \times 0.177 \times 10^{18}$$ (01/2 mark)

$$\frac{dN}{dt} = 7.1 \times 10^{8}\ Bq$$

∴ Activity of the sample, $\frac{dN}{dt} = 7.1 \times 10^{8}$ Bq. (01 mark)