P510/1
PHYSICS
(Theory)
Paper 1
Nov./Dec. 2020
2½ hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS
(Theory)
Paper 1
2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

Answer **five** *questions, including at least* **one**, *but* **not** *more than* **two** *from each of the sections;* **A**, **B** *and* **C**.
Any additional question(s) answered will **not** *be marked.*
Non-programmable scientific calculators may be used.
Assume where necessary:

Acceleration due to gravity, g	$= 9.81\ ms^{-2}$.
Electron charge, e	$= 1.6 \times 10^{-19}$ C.
Electron mass	$= 9.11 \times 10^{-31}$ kg.
Mass of the earth	$= 5.97 \times 10^{24}$ kg.
Plank's constant, h	$= 6.6 \times 10^{-34}$ Js.
Stefan's Boltzmann's constant, σ	$= 5.67 \times 10^{-8}\ Wm^{-2} K^{-4}$.
Radius of the Earth	$= 6.4 \times 10^{6}$ m.
Radius of the Sun	$= 7 \times 10^{8}$ m.
Radius of earth's orbit about the sun	$= 1.5 \times 10^{11}$m.
Speed of light in a vacuum, c	$= 3.0 \times 10^{8}\ ms^{-1}$.
Thermal conductivity of copper	$= 390\ Wm^{-1} K^{-1}$.
Thermal conductivity of aluminium	$= 210\ Wm^{-1}K^{-1}$.
Specific heat capacity of water	$= 4200\ J\ Kg^{-1} K^{-1}$.
Universal gravitational constant, G	$= 6.67 \times 10^{-11}\ Nm^{2} kg^{-2}$.
Avogadro's number, N_A	$= 6.02 \times 10^{23}\ mol^{-1}$.
Surface tension of water	$= 7.0 \times 10^{-2}\ Nm^{-1}$.
Density of water	$= 1000\ kgm^{-3}$.
Gas constant, R	$= 8.31\ Jmol^{-1}K^{-1}$.
Charge to mass ratio, e/m	$= 1.8 \times 10^{11}\ Ckg^{-1}$.
The constant $\frac{1}{4\pi\varepsilon_0}$	$= 9.0 \times 10^{9}\ F^{-1}m$.
Faraday constant, F	$= 9.65 \times 10^{4}\ Cmol^{-1}$.

If the weight of the drum is 500 N and its volume is 25 m^3, calculate the;

(i) pressure on the drum due to the sea water. *(02 marks)*
(ii) tension in the cable assuming it is vertical. *(03 marks)*

SECTION B

5. (a) Define the following:

(i) Tripple point of water. *(01 mark)*
(ii) Absolute zero temperature. *(01 mark)*

(b) Explain why tripple point of water is taken as a standard in modern thermometry instead of ice and steam points. *(04 marks)*

(c) (i) What is a **thermometric property**? *(01 mark)*
(ii) State **three** qualities of a good thermometric property. *(03 marks)*

(d) (i) A constant volume thermometer was used to measure temperature when the atmospheric pressure was 760 mmHg. The following values were obtained.

	Length of Mercury in closed limb (mmHg)	**Length of Mercury in open limb (mmHg**
Bulb in ice	140	130
Bulb in steam	140	330
Bulb at room temperature	140	170

Calculate the room temperature. *(05 marks)*

(ii) List **two** advantages of the constant volume gas thermometer over the mercury in glass thermometer. *(02 marks)*

(e) Explain what happens when the temperature of a fixed mass of ice is raised from 0 °C to 10 °C. *(03 marks)*

6. (a) Define **specific heat capacity**. *(01 mark)*

(b) Describe, stating the assumptions made, an electrical method for the determination of the specific heat capacity of a metal. *(08 marks)*

(c) In an experiment to determine specific heat capacity of a liquid using the continuous flow calorimeter;

(i) the readings are taken when the apparatus has attained a steady state. Explain the meaning of a steady state. *(02 marks)*
(ii) Explain why two sets of readings are taken. *(01 mark)*

3. (a) (i) Define **centripetal acceleration**. *(01 mark)*

(ii) Show that the force F on a body of mass M moving in a circle of radius r with constant speed V is given by $F = \frac{MV^2}{r}$. *(05 marks)*

(iii) Derive the condition for a car to move round a banked circular track without slipping. *(04 marks)*

(b) Describe how a helical spring may be used to dertermine the acceleration due to gravity. *(05 marks)*

(c) A particle moving with simple harmonic motion, has a speed of $8.0\ ms^{-1}$ and an acceleration of $12\ ms^{-2}$ when it is 3.0 m from its equilibirum position. Find the;

(i) amplitude of motion. *(03 marks)*

(ii) maximum acceleration. *(02 marks)*

4. (a) Define the following:

(i) Pressure. *(01 mark)*

(ii) Relative density. *(01 mark)*

(b) (i) State Archimedes Principle. *(01 mark)*

(ii) Describe an experiment to determine the relative density of a liquid. *(04 marks)*

(c) (i) Derive the expression for Bernoulli's equation. *(05 marks)*

(ii) Explain why a person standing by the road side may be pulled towards the road when a very fast moving bus passes by. *(03 marks)*

(d) A water tight drum tied to a cable anchored on the sea-bed floats 500 m beneath the sea surface as shown in figure **1**.

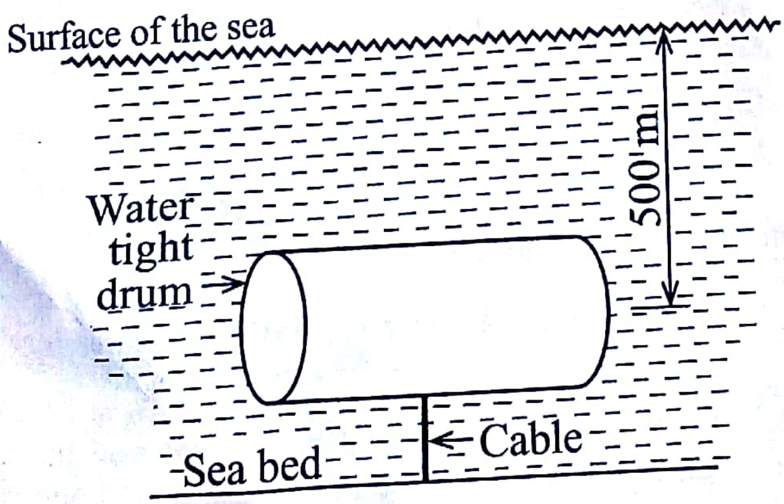

Fig. 1

Turn Over

If the weight of the drum is 500 N and its volume is 25 m^3, calculate the;

(i) pressure on the drum due to the sea water. *(02 marks)*

(ii) tension in the cable assuming it is vertical. *(03 marks)*

SECTION B

5. (a) Define the following:

(i) Tripple point of water. *(01 mark)*

(ii) Absolute zero temperature. *(01 mark)*

(b) Explain why tripple point of water is taken as a standard in modern thermometry instead of ice and steam points. *(04 marks)*

(c) (i) What is a **thermometric property**? *(01 mark)*

(ii) State **three** qualities of a good thermometric property. *(03 marks)*

(d) (i) A constant volume thermometer was used to measure temperature when the atmospheric pressure was 760 mmHg. The following values were obtained.

	Length of Mercury in closed limb (mmHg)	**Length of Mercury in open limb (mmHg**
Bulb in ice	140	130
Bulb in steam	140	330
Bulb at room temperature	140	170

Calculate the room temperature. *(05 marks)*

(ii) List **two** advantages of the constant volume gas thermometer over the mercury in glass thermometer. *(02 marks)*

(e) Explain what happens when the temperature of a fixed mass of ice is raised from 0 °C to 10 °C. *(03 marks)*

6. (a) Define **specific heat capacity**. *(01 mark)*

(b) Describe, stating the assumptions made, an electrical method for the determination of the specific heat capacity of a metal. *(08 marks)*

(c) In an experiment to determine specific heat capacity of a liquid using the continuous flow calorimeter;

(i) the readings are taken when the apparatus has attained a steady state. Explain the meaning of a steady state. *(02 marks)*

(ii) Explain why two sets of readings are taken. *(01 mark)*

(d) When water is passed through a continuous flow calorimeter at the rate of 100 g min^{-1}, the temperature rises from 16 °C to 20 °C, when the p.d across the heater is 20 V and the current is 1.5 A. When another liquid at 16 °C is passed through the calorimeter at the rate of 120 g min^{-1}, the same temperature change is obtained at a p.d of 13 V and current 1.2 A. Calculate the specific heat capacity of the liquid. *(04 marks)*

(e) (i) Define **latent heat.** *(01 mark)*

(ii) Explain why latent heat of vaporisation is always greater than that of fusion. *(03 marks)*

7. (a) (i) Explain how a thermocouple is used to measure temperature on a celsius scale. *(05 marks)*

(ii) State **two** advantages of a thermocouple. *(01 mark)*

(b) (i) Two cylindrical bodies *A* and *B* are made of the same material but the length of *A* is twice that of *B* and the cross sectional area of *B* is a third that of *A*. If the ends of *A* and *B* are subjected to the same temperature difference, find the ratio of the rate of heat flow through *A* to the rate of heat flow through *B*. *(03 marks)*

(ii) In the determination of thermal conductivity of copper, when water flows round the cool end of a copper rod at a rate of 600 cm^3 per minute, its temperature increases by 3.3 °C. The temperatures at two points, a distance 5.2 cm apart, along the copper rod are 70 °C and 30 °C respectively. Find the thermal conductivity of copper if the radius of the rod is 1.2 cm. *(04 marks)*

(c) Describe an experiment to measure thermal conductivity of cork. *(07 marks)*

SECTION C

8. (a) What is meant by the following as applied to radioactivity?

(i) Activity. *(01 mark)*

(ii) Decay constant. *(01 mark)*

(b) (i) Explain briefly, why radioactivity is referred to as random and spontaneous. *(02 marks)*

(ii) The half life of $^{230}_{92}Th$ is 2.4×10^{11} s. Find the number of disintegrations per second that occur in 1 g of $^{230}_{92}Th$. *(03 marks)*

(c) (i) Describe, with the aid of a labelled diagram, how the Wilson cloud chamber can be used to detect ionising radiation. *(06 marks)*

Turn Over

(ii) Explain the difference in the patterns of the tracks seen in the chamber when $\alpha-$ and $\beta-$ particles are present in the chamber. (02 marks)

(d) (i) What is meant by **mass defect**? (01 mark)

(ii) Calculate, in MeV, the energy released when helium nucleons are produced by fusing two neutrons and two protons. (04 marks)

Mass of a proton = 1.00759 u.
Mass of a neutron = 1.00898 u.
Mass of helium = 4.00277 u.
1 u = 931 MeV.

9. (a) (i) What is meant by a **p-n junction** as applied to semiconductors? (01 mark)

(ii) Explain the term **doping** as appllied to a p-n junction diode. (03 marks)

(b) (i) Explain, with the aid of a labelled diagram, the I-V characteristic of a junction diode. (03 marks)

(ii) Describe how full wave rectification can be achieved using a bridge rectifier. (04 marks)

(c) The input resistance of a certain n-p-n transistor in the common emitter connection is 3 kΩ. The small current amplification transfer ratio is 100. The internal resistance of the emitter-base junction is negligible and the load resistor is 6 kΩ. Find the voltage gain. (04 marks)

(d) (i) Explain the mechanism of the thermionic emission. (03 marks)

(ii) The gain control of a Cathode Ray Oscilloscope (C.R.O) is set at 0.5 Vcm^{-1}, and an alternating voltage produces a vertical line of length 2.0 cm with the time base off. Find the root mean square value of the potential difference. (02 marks)

10. (a) Define **specific charge** of a positive ion and state its unit. (02 marks)

(b) With the aid of a labelled diagram, describe how Bainbridge spectrometer can be used to determine the specific charge of positive ions. (06 marks)

(c) A beam of positive ions accelerated through a potential difference of 2,000 V enters a region of a uniform magnetic flux density **B**. The ions describe a cricular path of radius 3.2 cm while in the field. If the specific charge of the ions is 8.5×10^{7} C kg^{-1}, derive an expression for the charge to mass ratio of the ions and use it to calculate the value of **B**. (05 marks)

(d) State the use of each of the following features of Cathode Ray Oscilloscope (C.R.O):

(i) Anode system. *(01 mark)*

(ii) Y-plates. *(01 mark)*

(iii) The grid. *(01 mark)*

(e) An electron with energy 5 kV moves in the direction of an electric field of intensity $1.6 \times 10^4\ Vm^{-1}$. What distance will the electron move before coming to rest? *(04 marks)*

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Qn 1.

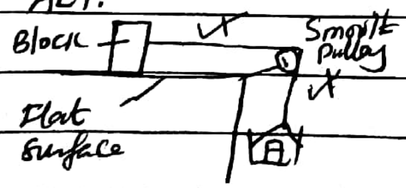
(a) (i) Friction forces opposes attempted relative motion btn two surfaces in contact ✓
- Friction is independent of the area of contact of the surfaces provided normal reaction is constant ✓
- The limiting frictional force is proportional to normal reaction ✓ (3)

(ii) . Surfaces in contact rest on each other's molecular projections ✓ The actual area of contact is very small and this leads to very high pressure ✓ at these pts. These pts form cold 'welded' joints ✓ For the surfaces to move relative to each other, a force must be applied to break the 'welded' joints ✓ (02)

- If norm rxn is kept constant, but the surfaces are made to rest on a smaller area, fewer pts of contact will result ✓ This will cause higher pressure at these pts ✓ hence they tend to flatten out restoring the actual area of contact ✓ to the initial value hence keeping friction constant ✓ (02)
- As normal reaction increases, the pressure at the welded also increases ✓ This causes the points to flatten further / increase in no and the actual area of contact increases ✓ hence an increase in friction ✓

(b) The mass of the block, M is measured and recorded ✓. The block is placed on the horizontal plane surface ✓. The plane surface is gradually tilted until the block just starts to move ✓. The angle, θ btn the plane and the horizontal ground is measured and recorded ✓. Then limiting friction is given ~~by~~ as $Mg\sin\theta$.

ALT.



- Small masses are added onto the scale pan until the block just starts to move ✓
The total mass M of the scale pan and its contents is measured and recorded ✓. Limiting friction is given by Mg ✓ (4)

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c (i) $M_b u_b = (M_b + M_w)V$ ✓ $\Rightarrow 0.05 \times 500 = (3.95 + 0.05)V$ ✓, $V = 6.25\,ms^{-1}$ ✓ (2)

(ii) Friction force, $F = \mu R$ ✓ $= 0.3 \times 4 \times 9.81 = 11.772N$

Deceleration $= F/m = \frac{11.772}{4} = -2.943\,ms^{-1}$ ✓

Velocity of block at the edge of the table; $v^2 = u^2 + 2as$ ✓

$v^2 = 6.25^2 + 2(-2.943) \times 6 = 3.7465$; $V = 1.936\,ms^{-1}$ ✓

Time to hit the ground; $S = ut + \frac{1}{2}at^2$ ✓

$5 = \frac{1}{2} \times 9.81 t^2$ ∴ $t = \sqrt{\frac{10}{9.81}} = 1.01s$ ✓ (5)

Horizontal distance covered $= Vt$ ✓ $= 1.01 \times 1.936$ ✓ $= 1.96m$ ✓

ALT: (work energy theorem)

$Fs = \frac{1}{2}m(v^2 - u^2)$ ✓; $11.77 \times 6 = \frac{1}{2} \times 4(6.25^2 - u^2)$ ✓

$u = 1.936\,ms^{-1}$ ✓

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Qn 2

(a) (i) Stress is force per unit cross sectional area ✓ (1)

(ii) Young's modulus is a ratio of tensile stress to tensile strain (01)

(b) $V = (E/\rho)^{\frac{1}{2}}$, $[V] = LT^{-1}$ ✓; $\left(\frac{[E]}{[\rho]}\right)^{\frac{1}{2}} = \left(\frac{ML^{-1}T^{-2}}{ML^{-3}}\right)^{\frac{1}{2}}$ ✓ ✓ $= LT^{-1}$ ✓ (02)

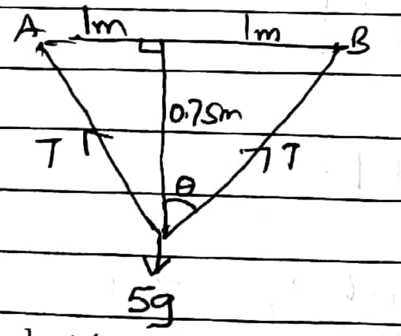
[LHS] = [R.HS] - hence consistent

(c) Av. force $= \frac{0+F}{2} = \frac{1}{2}F$ ✓; Work done $= \frac{1}{2}Fx$ ✓

But $F = kx$ ✓ ∴ $W = \frac{1}{2}kx^2$ ✓ (3)

ALT: $W = \int_0^x F\,dx$ ✓, $F = kx$ ✓ ∴ $W = \int_0^x kx\,dx$ ✓ $= \frac{1}{2}kx^2$ ✓

(d)



$BC^2 = 0.75^2 + 1^2$ ✓ ∴ $BC = 1.25m$ ✓

New length $= AB + BC = 2.50m$

Extension, $e = 2.50 - 2.49$ ✓ $= 0.01m$ ✓

Strain $= e/L$ ✓ $= \frac{0.01}{2.49}$ ✓ $= 0.004016$ ✓

(ii) $Y = \frac{\text{Stress}}{\text{Strain}}$ ✓; Stress $= 2.0 \times 10^{11} \times 0.004016$ ✓ $= 8.03 \times 10^{8}\,Pa$ ✓ (02)

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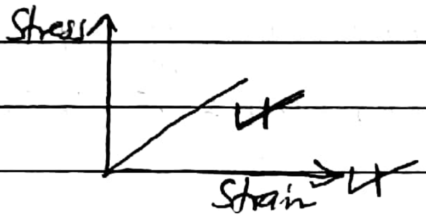
(iii) $2T\cos\theta = 5g$, $\cos\theta = \frac{0.75}{1.25}$ ✓

$T = \frac{5\times9.81\times1.25}{2\times0.75}$ ✓ $= 40.88\ N$ ✓

(4)

Energy stored $= \frac{1}{2}Te$ ✓ $= \frac{1}{2}\times40.88\times0.01$ ✓ $= 0.204\ J$ ✓

(e) 

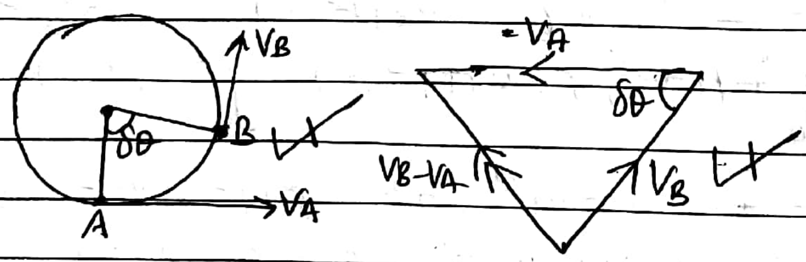
- Glass is brittle and only suffers elastic deformation ✓ (or does not undergo plastic deformation)

- The surface of glass has cracks ✓ in it. A high concentration of stress on a crack makes it to break

Qn 3

(a) (i) It is the rate of change of velocity for a body moving in a circular path ✓

(ii) Consider a body of mass M moving in a circular of radius 'r' with a constant speed, V.



$a = \frac{\text{Change in velocity}}{\text{time taken}} = \frac{V_B - V_A}{\delta t}$ ✓

From the diagram above and for a small angle $\delta\theta$ we have $V_B - V_A = V\delta\theta$ ✓, Since $|V_A| = |V_B| = V$

$\therefore a = \frac{V\delta\theta}{\delta t}$ ✓ $= V\omega$, But $\omega = V/r$ ✓

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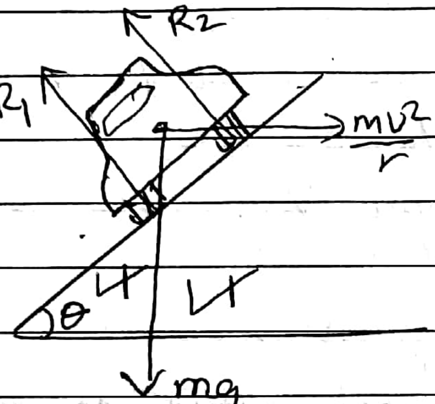
$\Rightarrow a = v.\frac{v}{r} = \frac{v^2}{r}$ ✓✓, Now $F = ma$ ✓✓ $\therefore F = \frac{mv^2}{r}$ ✓ (5)

(iii)



Consider a car of mass m moving with a uniform speed, V round a circular track of radius, r banked at an angle, θ.

$\therefore (R_1 + R_2)\sin\theta = \frac{mv^2}{r}$ ✓ —(1)

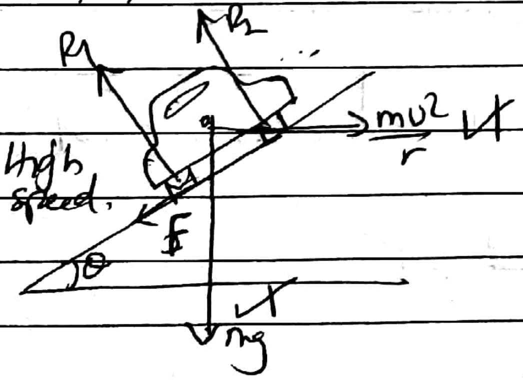
$(R_1 + R_2)\cos\theta = mg$ ✓ —(2)

$\therefore \tan\theta = v^2/rg$ ✓✓ (4)

or $V = (rg\tan\theta)^{\frac{1}{2}}$

And for slipping not to occur, $V < (rg\tan\theta)^{\frac{1}{2}}$ ✓✓

ALT!

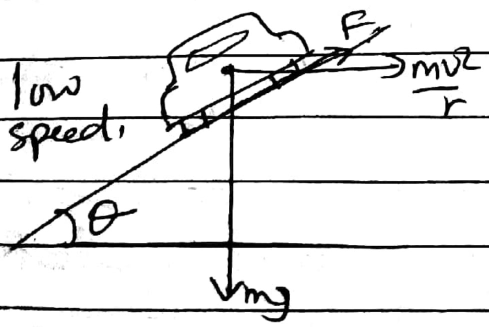


$R\sin\theta + \mu R\cos\theta = \frac{mv^2}{r}$ ✓

$R\cos\theta - \mu R\sin\theta = mg$ ✓

$V_{max} < \left[\frac{rg(\tan\theta + \mu)}{1 - \mu\tan\theta}\right]^{\frac{1}{2}}$ ✓✓ ✓✓ (4)

ALT 2



$R\sin\theta - \mu R\cos\theta = \frac{mv^2}{r}$ ✓

$R\cos\theta + \mu R\sin\theta = mg$ ✓

$V_{min} > \left[\frac{rg(\tan\theta - \mu)}{1 + \mu\tan\theta}\right]^{\frac{1}{2}}$ ✓✓ ✓✓

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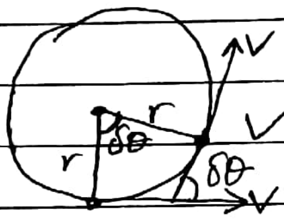
ALT: 3(a)(ii)



$$a_x = \lim_{\delta t \to 0} \frac{V\cos\delta\theta - V}{\delta t} = \lim_{\delta t \to 0} \frac{V(\cos\delta\theta - 1)}{\delta t}$$

as $\delta\theta \to 0$; $(\cos\delta\theta - 1) \to 0$

$\therefore a_x = 0$

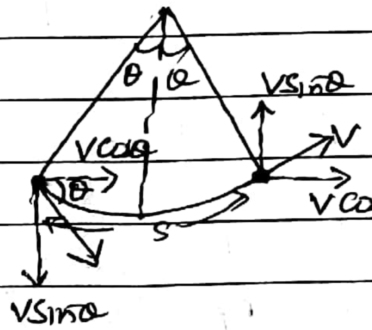
$$a_y = \lim_{\delta t \to 0} \frac{V\sin\delta\theta - 0}{\delta t}$$

as $\delta\theta \to 0$; $\sin\delta\theta \to \delta\theta$.

$a = \frac{V\delta\theta}{\delta t} \Rightarrow a = V\omega$ for small θ, in radians,

but $V = \omega r$ $\therefore$ $a = \frac{V^2}{r}$, $F = ma = \frac{mV^2}{r}$

ALT 3:



$$a_x = \frac{V\cos\theta - V\cos\theta}{t} = 0$$

$$a_y = \frac{V\sin\theta - -V\sin\theta}{t} = \frac{2V\sin\theta}{t}$$

But $t = \frac{2r\theta}{V}$

(4)

$\therefore a_y = \frac{V^2}{r} \cdot \frac{\sin\theta}{\theta}$; $\frac{\sin\theta}{\theta} = 1$ for θ, small in radians.

$\therefore$ $a = \frac{V^2}{r}$, $F = ma$ $\therefore$ $F = \frac{mV^2}{r}$

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Qn 4

(a) (i) Is the force acting normally per $1m^2$ area ✓ (1)

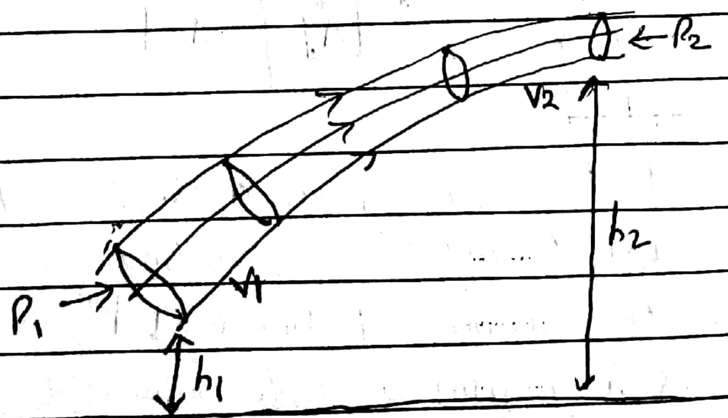
(ii) Relative density is the ratio of mass of a substance to mass of an equal volume of water. ✓ (1)

(b) (i) Archimedes' principle states that when a body is wholly or partially immersed in a fluid, it experiences an upthrust equal to the weight of the fluid displaced ✓ (1)

(ii) An object is weighed in air using a spring balance and its weight W_1 is noted ✓. The object is fully immersed in water and the new reading of the spring balance is noted, W_2 ✓. Upthrust in water $U_1 = W_1 - W_2$ ✓ is calculated. The body is then immersed in a liquid whose relative density is required. New reading W_3 ✓ is noted. Upthrust in liquid $U_2 = W_1 - W_3$ ✓ is calculated

$$R.D = \frac{\text{upthrust in liquid}}{\text{upthrust in water}} = \frac{U_2}{U_1} = \frac{W_1 - W_3}{W_1 - W_2}$$ ✓ (4)

(c)



Work done per unit volume $= \frac{F \times \text{distance}}{vol}$

$$= \frac{PAd}{vol} = P.$$

$$\frac{K.E}{vol} = \frac{1}{2}\frac{mV^2}{vol} = \frac{1}{2}\rho V^2, \quad \frac{P.E}{vol} = \frac{mgh}{vol} = h\rho g.$$

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WD by pressure difference $= \frac{\text{Gain in KE}}{\text{vol}} + \frac{\text{Gain in PE}}{\text{vol}}$

$$P_1 - P_2 = \left(\tfrac{1}{2}\rho V_2^2 - \tfrac{1}{2}\rho V_1^2\right) + \left(h_2\rho g - h_1\rho g\right)$$

$$P_1 + \tfrac{1}{2}\rho V_1^2 + h_1\rho g = P_2 + \tfrac{1}{2}\rho V_2^2 + h_2\rho g$$ (5)

$$\therefore P + \tfrac{1}{2}\rho V^2 + h\rho g = \text{Constant}$$

ALT : Diagram.

$$P_1 A_1 V_1 - P_2 A_2 V_2 = \tfrac{1}{2}\rho A_2 V_2^3 - \tfrac{1}{2}\rho A_1 V_1^3 + A_2 V_2 \rho g h_2 - A_1 V_1 \rho g h_1$$

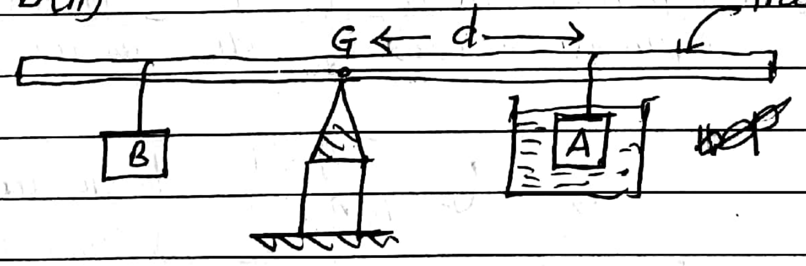
But $A_2 V_2 = A_1 V_1$

$$\therefore P_1 - P_2 = \tfrac{1}{2}\rho V_2^2 - \tfrac{1}{2}\rho V_1^2 + h_2\rho g - h_1\rho g$$ (5)

$$\therefore P_1 + \tfrac{1}{2}\rho V_1^2 + h_1\rho g = P_2 + \tfrac{1}{2}\rho V_2^2 + h_2\rho g$$

$$\therefore P + \tfrac{1}{2}\rho V^2 + h\rho g = \text{Constant}$$

ALT for 4 b(ii)



- A metre rule is balanced horizontally on a knife edge; Balance point, G is noted (marked on metre rule).
- A solid A is hung at a distance d from G.
- A standard mass B is hung from opposite side and its position adjusted until metre rule balances horizontally keep G above knife edge and d constant.
- Distance d_1 of B from G is noted.

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- Procedure is repeated with A in water and distance d_2 of B from G is noted.
- Procedure is repeated with A in liquid under test and distance d_3 of B from G is noted.
- R.D of the liquid is obtained from

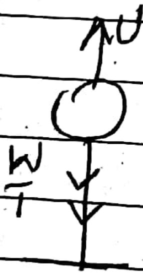
$$R.D = \frac{d_1 - d_3}{d_1 - d_2}.$$

(4)

c (ii) As the bus passes, it makes the air between the man and the bus to move with high velocity. The air behind the man has low velocity. By Bernoulli's principle, there is low pressure between the man and the bus and high pressure behind the man. The pressure difference causes a net force that pushes the man towards the bus. (3)

(d) (i) $P = h\rho g = 500 \times 10^3 \times 9.81 = 4.91 \times 10^6\ Nm^{-2}$ (2)

(ii)



Upthrust U = weight of water displaced

$= V\rho g$

$= 25 \times 10^3 \times 9.81$

$= 245,250$

In equilibrium $U = W + T$ (3)

$245,250 = 500 + T$

$\therefore T = 2.45 \times 10^5 N$

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Qn 5

9 (i) Tripple point of water is the temperature at which pure water, pure water vapour and pure ice are in Equilibrium. 01

(ii) Absolute zero temperature is the temperature at which the K.e of molecules of a substance has ~~least~~ possible value. 01

b) Tripple point is a single temperature and a single pressure. Ice point and steam point vary with pressure and level of impurities 04.

c(i) A physical property of a substance that varies linearly and continuously with temperature. 01

(ii)
- Should vary linearly and continuously with temp.
- A should give a single value for a certain temp
- Vary over a wide temperature range
- Accurately be measurable over a wide range of temp for a simple apparatus.

any 3

d $h_0 = (130-140) = -10$, $h_\theta = (170-140) = 30$, $h_{100} = (330-140) = 190$

$\theta = \left(\frac{h_\theta - h_0}{h_{100} - h_0}\right) \times 100°C = \left(\frac{30 - -10}{190 - -10}\right) \times 100°C = 20°C$ 05.

(ii) Accurate, sensitive, wide range any 2. 02

e) At 0°C, the bonds btn ice molecules are weakened and ice melts. Btn 0°C and 4°C water contracts. Beyond this temperature water ~~Expand~~ Expands. 03

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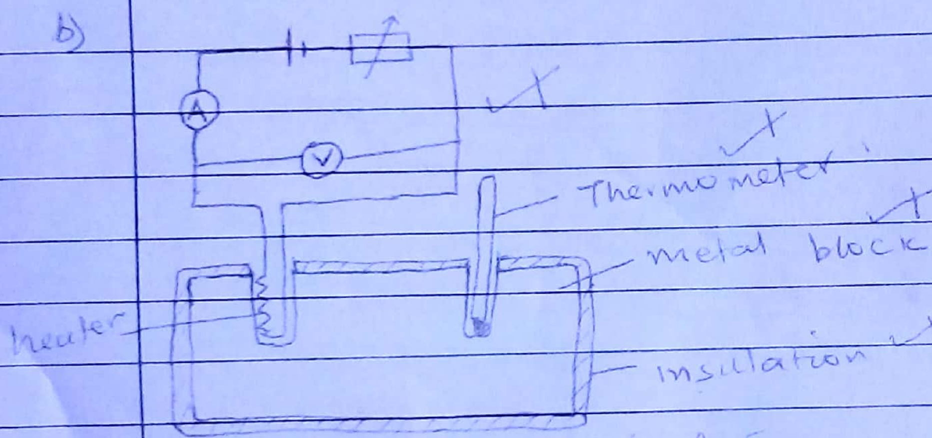
Qn 6.

a) Specific heat capacity is quantity of heat energy required to raise the temperature of 1Kg of a substance by 1K or 1°C

b)



Two holes are drilled in a metal block and its mass, m measured. The initial temperature θ_1 of the block is recorded. The switch is closed and the stop clock started simultaneously. The ammeter and Voltmeter readings I and V respectively are recorded. When the ~~tot~~ temperature has raisen by about 10K the stop clock is stopped and time t, noted. The highest temperature θ_2 is recorded. The specific heat capacity c of the block is obtained from $c = \frac{IVt}{m(\theta_2 - \theta_1)}$

Assumptions

- Heat lost to sorrounding is negligable.
- Thermometer and heater take negligible amount of he[at]
- Block has constant volume

... during which the heat

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its temperature. It's used to mentain its temp.
(condn when inflow temp and out flow temp are constant)
Heat is lose to the sorrounding at a constant rate
(electrical powe supplied = power absorbed by liquid + power lost to s
(ii) Two sets of reading are obtained to account for the heat losses to the sorrounding during steady state.

For water

$$I_1 V_1 = m_1 c_w (\theta_2 - \theta_1) + h$$

$$1.5 \times 20 = \frac{0.1}{60} \times 4200 \times 4 + h \Rightarrow h = 2 J s^{-1}$$

For liquid

$$I_2 V_2 = m_2 c_L (\theta_2 - \theta_1) + h$$

$$1.2 \times 13 = \frac{0.12}{60} \times c_L \times 4 + 2, \quad c_L = 1700 J kg^{-1} K^{-1}$$

e(i) Latent heat is the heat required to change the state of a substance to another state at the same temp.

(ii) In vapourisation heat is required to break the intermolecular attractions between the molecules of the liquid in the surface and bulk of the liquid and also for the vapour to expand and do work against atmospheric pressure whereas in fusion energy is only needed to weaken intermolecular attraction.

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Qn 7.

a(i) - The hot junction of a thermocouple is placed in pure melting ice, the e.m.f, E_0 is noted.
- It is then placed in steam and then in contact with a body of unknown temp, θ
- The e.m.fs E_{100} & E_θ are noted respectively.
- The unknown temp of the body is obtained from $\theta = \frac{E_\theta - E_0}{E_{100} - E_0} \times 100°C$

05

Also accept $\theta = \frac{E_\theta}{E_{100}} \times 100°C$ when $E_0 = 0$

ii) - Can measure temperature at a point.
- It is very sensitive to temp changes
- It is portable.
- Has a wide range of temperatures.

any 2

02

b(i) $l_A = 2l_B \Rightarrow l_B = l_A/2$.

$A_A = A$; $A_B = A/2$.

$\frac{Q}{t} = \frac{KA\Delta T}{l}$ $\left(\frac{Q}{t}\right)_A = \frac{KA\Delta T}{l_A}$, $\left(\frac{Q}{t}\right)_B = \frac{KA/_3 \Delta T}{\frac{1}{2} l_A}$.

$\left(\frac{Q}{t}\right)_B = \frac{2KA\Delta T}{3l_A}$, $\frac{\left(\frac{Q}{t}\right)_A}{\left(\frac{Q}{t}\right)_B} = \frac{KA\Delta T}{l_A} \times \frac{3l_A}{2KA\Delta T} = \frac{3}{2}$

03

Ratio = 3 : 2 OR 1.5

ii) Mass, $m = V\rho = 600 \times 1 = 600g$; $m/t = \frac{600}{1000 \times 60} = 0.01 kg s^{-1}$

$A = 3.14 \times (0.012)^2$

Rate of heat transfer through metal = Rate of heat absorption by water.

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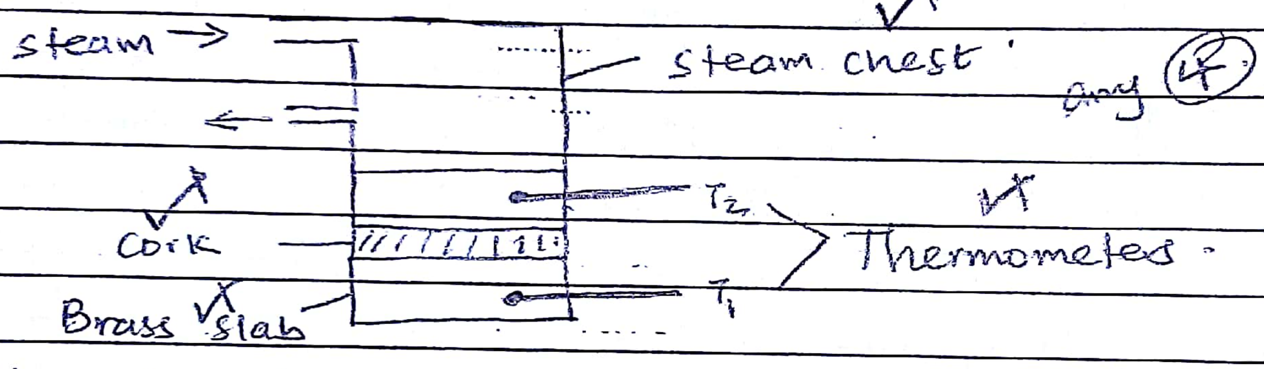
$$\frac{KA(\theta_2-\theta_1)}{l} = \frac{m}{t} C \Delta T$$

$$\frac{K(3.14 \times (0.012)^2)(70-30)}{5.2 \times 10^{-2}} = 0.01 \times 4200 \times 3.3$$ (04)

$K = 398.5 \ W m^{-1} K^{-1}$



(02)

The cork is made into a thin wide disc and its diameter, d and thickness, l are measured and recorded. The disc is then put between the brass slab and steam chest. The ~~cork~~ cork and brass surfaces are smeared with vasciline for better thermal contact. Steam is passed through the steam chest until the thermometers T_1 and T_2 show steady values. The temperatures θ_1 and θ_2 are recorded. The specimen is removed and brass slab heated directly to a higher temperature than θ_1. The specimen is replaced and temp of slab is recorded at regular time intervals. A cooling curve is plotted. The slope, s of the curve at θ_1 is obtained

$\Rightarrow \frac{K \cdot A(\theta_2-\theta_1)}{l} = mc \cdot s$, $K = \frac{4lmcs}{\pi d^2(\theta_2-\theta_1)}$

where m = mass of slab
c = s.h.c of brass slab.
$A = \pi d^2$

(05)

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QUESTION 8

a) i) Activity is the number of disintegrations per second of a radioactive sample. ✓ (1)

ii) Decay constant is the fractional number of disintegrations persecond of a radioactive sample. ✓ (1)

b) i) Radioactive decay process is random b'se one can not tell which nucleus is going to disintegrate ✓ next and Spontaneous b'se the rate of decay can not be controlled (speeded up, or slowed down) by physical or chemical change. ✓ (2)

ii) No of disintegrations per second $A = \lambda N$ ✓

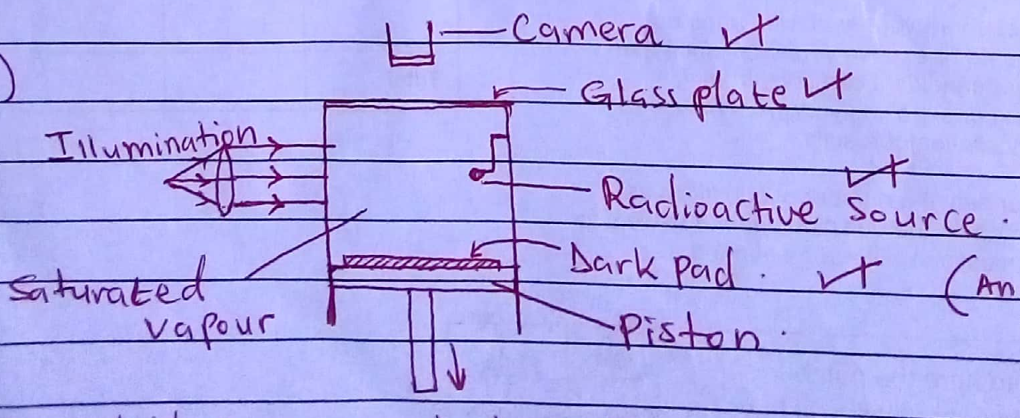
but $\lambda = \frac{0.693}{t_{1/2}} = \left(\frac{0.693}{2.4 \times 10^{11}}\right) s^{-1}$ ✓

Since 230g of Th contains 6.02×10^{23} atoms

1g of Th contains $\frac{6.02 \times 10^{23}}{230}$ atoms ✓

$\Rightarrow A = \left(\frac{0.693}{2.4 \times 10^{11}}\right) \times \left(\frac{6.02 \times 10^{23}}{230}\right)$ ✓ $= 7.559 \times 10^{9} s^{-1}$ ✓ (check with Cal). (3)

c) i)



(Any ~~two~~ 4) (2)

With alcohol on the dark pad, the piston is moved down

L5

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quickly so as to expand the air in the chamber adiabatically and cools. ~~A few~~ After a few expansions the dust particles are all carried away and the ~~free ai~~ dust free air is subjected to controlled adiabatic expansions. The air becomes supersaturated and simultaneously the air is exposed to radiations from the radioactive source. Water droplets immediately collect around the ions produced. The droplets are then illuminated and photographed by the camera. (4)

) α-p'cles produce thick, short and straight tracks compared to the thin longer and tortous tracks produced by β-particles b'se α-p'cles are more massive and slower compared to the β-p'cles which are less massive and therefore easily deflected after collisions with gas molecules. (2)

i) Mass defect is the difference btn the mass of nucleons and mass of nucleus of an atom. (1)

ii) $2\,{}^{1}_{0}n + 2\,{}^{1}_{1}H \longrightarrow {}^{4}_{2}He + \text{Energy}$

$2(1.00898u) + 2(1.00759u) = 4.0027u + \text{Energy}$

$\text{Energy} = 0.03037u$

$= 0.03037 \times 931$

$= 28.27447\ \text{MeV}$ (4)

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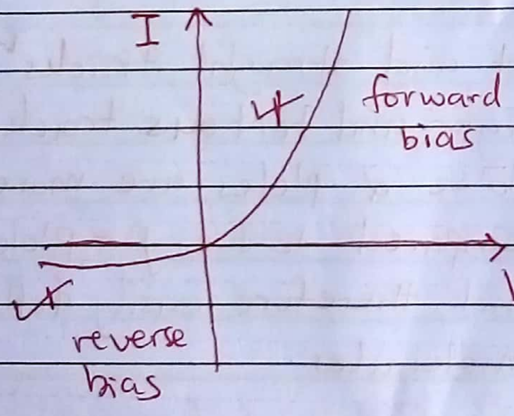
QUESTION 9

a) i) A p-n junction is one formed by melting the boundaries of a p- and n-type semiconductors and joining them ✓ (1)

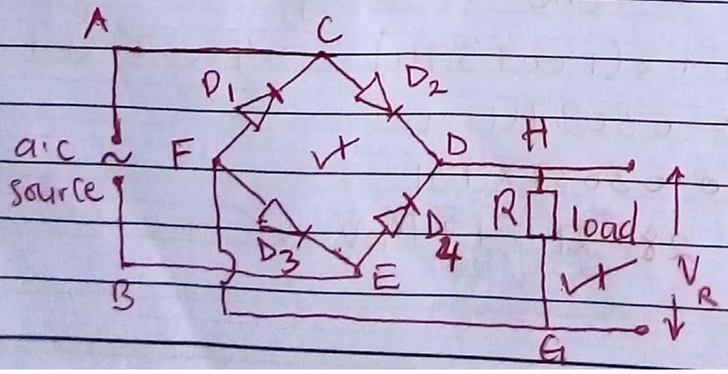
ii) Doping is the introduction of controlled amounts of group V impurities ✓ into one half of group IV semiconductors and group III impurities in the other half ✓ of group IV semiconductor. The first half has electrons ✓ as the majority charge carriers and therefore called the n-type ✓ while the second half has 'holes' ✓ as the majority charge carriers forming the p-type ✓ (3)

b) i)



When the p-n junction diode is connected in the forward bias ✓ there is a large flow of electrons ✓ and hence high current. In the reverse bias, ✓ there is a small current due to minority charge carriers flow ✓ (3)

(ii)



(1)

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During the half cycles when A is positive relative to B, diodes D_2 and D_3 are forward biased and conduct and current flows through the load R in the direction H to G. Diodes D_1 and D_4 are reverse biased and do not conduct. During the half cycles when B is at positive potential relative to A diodes D_1 and D_4 are forward biased and conduct and current flows through R in the direction H to G. Diodes D_2 and D_3 donot conduct. (3)

c) Voltage gain $\mu = \frac{\Delta V_o}{\Delta V_i} = \beta \frac{R_L}{R_i + R_s}$

$= \frac{6\times10^3}{3\times10^3 + 0} \times 100$

$= 200$ (4)

d) i) Metals contain free electrons when a metal is heated to a high temp, electrons gain k.E. Those electrons whose energy is sufficient to overcome the attractive forces of the positive nuclei leave the surface of the metal implying thermionic emission (3)

ii) $V_o = \frac{0.5 \times 2}{2} = 0.5V$

$V_{rms} = \frac{V_o}{\sqrt{2}} = \frac{0.5}{\sqrt{2}} = 0.354V$ (2)

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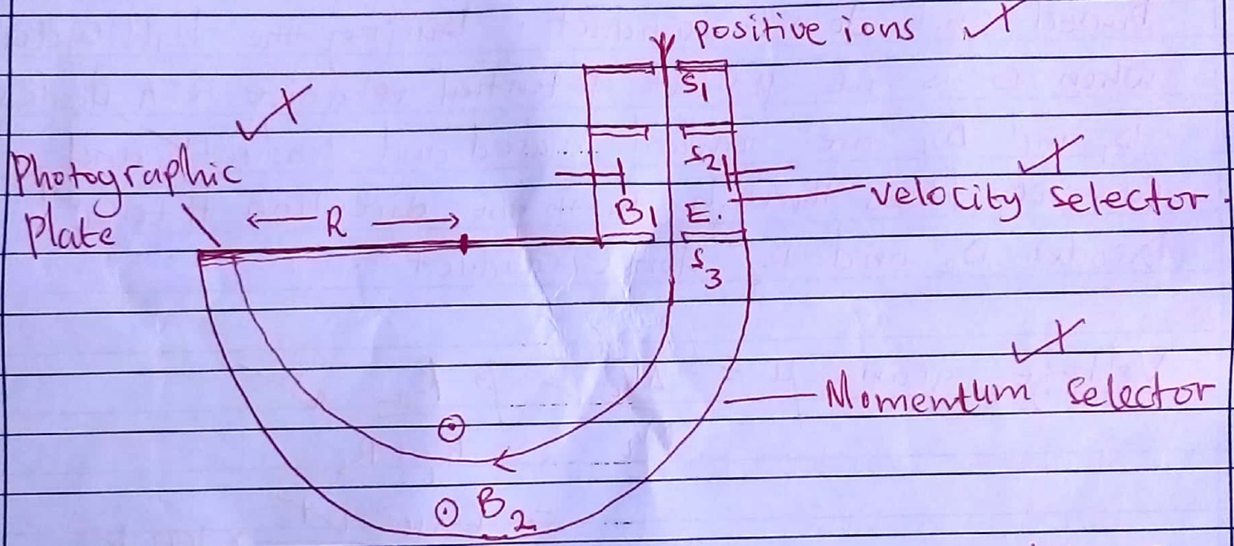
QUESTION 10

a) Specific charge of an ion is the ratio of charge of an ion to the mass of the ion. Its units are Ckg^{-1} (1) (1)

b)



(2)

Positive ions enter the chamber through slits S_1 and S_2. They are then acted on by crossed magnetic and electric fields of flux density B_1 and intensity E. $EQ = B_1 Q v \Rightarrow v = \frac{E}{B_1}$ where Q is charge of ions and v their velocity.

Only ions with velocity $v = E/B_1$ pass through the velocity ~~sect~~ selector undeflected and enter the momentum selector where a magnetic field of flux density B_2 is applied. They describe a circular path of radius R and strike the photographic plate. $B_2 Q v = \frac{mv^2}{R}$ where m is the mass of the ion.

$$\frac{Q}{m} = \frac{v}{B_2 R} \Rightarrow \frac{Q}{m} = \frac{E}{B_1 B_2 R}$$

(4)

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c) $Vq = \frac{1}{2}mu^2 \Rightarrow \quad q/m = \frac{1}{2}u^2/V$

$Bqu = \frac{mu^2}{r} \quad u^2 = \frac{q^2B^2r^2}{m^2}$

$q/m = \frac{1}{2}\frac{q^2B^2r^2}{m^2V} \quad \therefore \frac{q}{m} = \frac{2V}{B^2r^2}$

$8.5\times10^7 = \frac{2\times2000}{B^2\times0.032^2} \Rightarrow \cancel{B^2 =}$

$B = 0.214T$ (5)

d) i) Anode system accelerates and focuses electrons. (1)

ii) Y-plates deflect the electrons vertically. (1)

iii) Grid controls the number of electrons striking the screen per second, hence controls the brightness of the image on the screen. (1)

e) $\frac{1}{2}mu^2 = 5\times10^3\times1.6\times10^{-19}$ $\quad u^2 = \frac{2\times5\times10^3\times1.6\times10^{-19}}{9.11\times10^{-31}}$

$= 2\times8.782\times10^{14}$

$a = -\frac{Ee}{m} = \frac{-1.6\times10^4\times1.6\times10^{-19}}{9.11\times10^{-31}} = -2.810\times10^{15}$

$v^2 = u^2 + 2as \Rightarrow 0 = 2\times8.782\times10^{14} - 2\times2.810\times10^{15}\times s$

$s = 0.3125m$ (4)

Other alternatives may involve
$\Rightarrow$ 5×10^3 J as energy or 5eV as the energy.