PROVISIONAL MARKING GUIDE PHYSICS PAPER 1

P510/1 WAKISSHA JOINT MOCK EXAMINATIONS

AUGUST 2024

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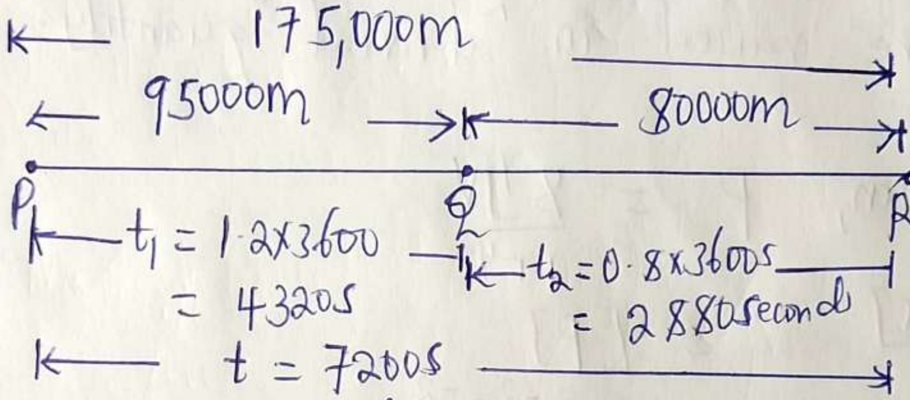
No	MARKING POINT	MARKS
1	(a)(i) Dimensions of a physical quantity is the way by which the physical quantity is related to the fundamental quantities of mass, length and time	1
	Alternatively Dimensions of a physical quantity are powers to which the fundamental quantities of mass, length and time ~~are~~ raised in derived quantity.	
	(a)(ii) Given, $P = \frac{8\eta V}{\pi r^4}$	3
	$[LHS] = [P] = ML^{-2}T^{-2}$	
	$[RHS] = \frac{[\eta][V]}{[r]^4} = \frac{ML^{-1}T^{-1} \cdot L^{3}T^{-1}}{L^4} = ML^{-2}T^{-2}$	
	Since $[LHS] = [RHS]$, the equation $P = \frac{8\eta V}{\pi r^4}$ is dimensionally consistent.	

b)(i) - A body continues in its state of rest or of uniform motion in a straight line unless an external force acts on it.

- The rate of change of momentum of a body is directly proportional to the applied force and the change takes place in the direction of the force.

- For every action, there is always equal and opposite reaction

b(ii)



Using; $S = ut + \frac{1}{2}at^2$

For motion PQ

$$95000 = 4320u + \frac{4320^2}{2}a$$

$$\Rightarrow 95000 = 4320u + 9331,200a \quad \text{—— ①}$$

For motion PR;

$$175,000 = 7200u + \frac{7200^2}{2}a$$

$$\Rightarrow 175,000 = 7200u + 25,920,000a \quad \text{—— ②}$$

4320 Eqn ② − 7200 Eqn ① gives;

$$72,000,000 = 4.4789776 \times 10^{10} a$$

$$\Rightarrow a = 0.00160751$$

From Eqn ①, $u = 18.5185$

Hence $a = 0.00160751$ and $u = 18.5185$

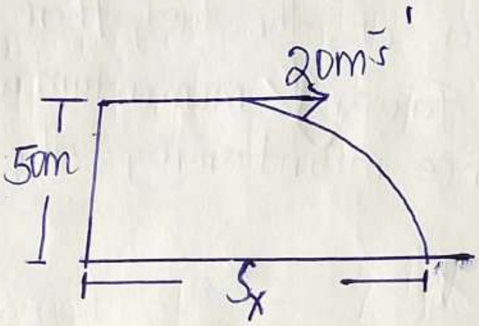
C(i) Time of flight is the time taken by the projectile to move from the point of projection to a point on the plane through the point of projection where the projectile lands.

1

C(ii) Range is the horizontal distance between the point of projection and a point on the plane through the point of projection where the projectile lands.

1

d)



$u_x = 20ms^{-1}$

$u_y = 0ms^{-1}$

$S_y = 50m$

i) Using $S = ut + \frac{1}{2}at^2 \uparrow$

$$50 = 0(t) + \frac{9.81t^2}{2}$$

2

$$t = 3.193 \text{ Seconds}$$

It takes 3.193 seconds to reach ground

ii) Using $S = ut + \frac{1}{2}at^2 \rightarrow$

$$S_x = 20 \times 3.193 + 0$$

2

$$S_x = 63.86m$$

iii) Using $V_y = u_y + at$

$$V_y = 0 + (9.81 \times 3.193)$$

$$V_y = 31.323ms^{-1}$$

3

The velocity is $31.323ms^{-1}$ vertically downwards

20 marks

2 a(i) For a system of colliding objects, their total momentum in a given direction remains constant provided no external force acts on them 1

a ii) Fuel is burst in a Combustion chamber and exhaust gases are expelled at high velocity. This causes a large backward momentum. From the principle of Conservation of linear momentum, an equal forward momentum is gained by the rocket. Due to continuous combustion of the fuel, there is a large change in the forward momentum which leads to the thrust, hence maintaining the rocket in motion. 3

b) By Conservation of momentum,

$$m_b u_b + m_w u_w = (m_b + m_w)V$$

$$\frac{40}{1000} u_b + 0 = \left(\frac{40+960}{1000}\right)V$$

$$u_b = \left(\frac{1000}{40}\right)V$$

$$u_b = 25V \quad \text{—— ① where}$$

V is the common velocity of wood and bullet just after collision.

Initial kinetic energy of wood and bullet = Elastic potential energy gained by spring + work done against friction.

$$\frac{1}{2} \times 1 \times V^2 = \frac{1}{2} \times 50 \times \frac{4.5}{100} + \mu R d$$

$$\frac{V^2}{2} = 1.125 + 0.2 \times 1 \times 9.81 \times \frac{4.5}{100}$$

$$V = 1.558 \, ms^{-1}$$

From ①, $u_b = 25 \times 1.558 = 38.95 ms^{-1}$

Initial speed of the bullet is $38.95 ms^{-1}$ 4

C (i) Laws of Solid friction;

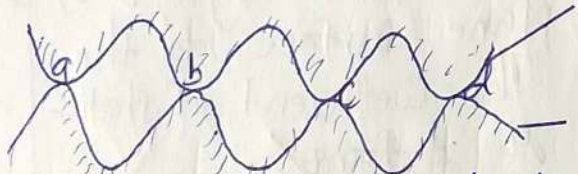
1. The frictional force between two surfaces opposes their relative motion.

2. The frictional force is independent of the area of contact of the given surfaces provided the normal reaction is constant.

3. The limiting frictional force is proportional to the normal reaction for the case of static friction. The frictional force is proportional to the normal reaction for the case of kinetic friction and is independent of the relative velocity of the surfaces.

Molecular theory explanation of the laws

When two surfaces are put together, the actual area of contact is less than the apparent area of contact.

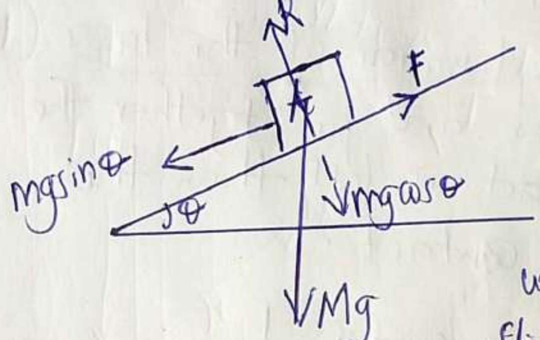


At points of contact like a, b, c, small cold welded joints are formed by the strong adhesive forces between molecules in the two surfaces. These joints have to be broken before one surface can move over the other, this accounts for law 1.

The actual area of contact is proportional with the normal reaction. The frictional force which is determined by the actual area of contact is thus proportional to the normal reaction. This accounts for law 3.

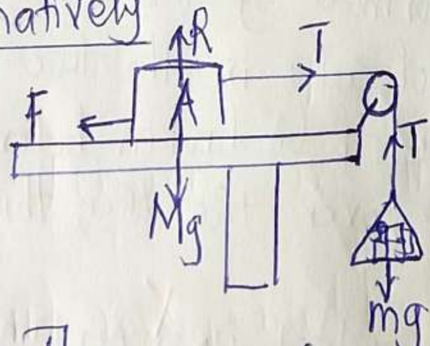
If the apparent area of contact of the body is decreased by turning the body so that it rests on one of the smaller side, the number of contact points is reduced, the body has not altered, Since the weight of the body there is increased pressure at the contact points, and this flattens the bumps so that total contact points and pressure return to their original values; thus although the apparent area of contact has been changed, the actual area of contact has not. This accounts for law 2. 6

Q(ii) Measurement of Coefficient of static friction, μ_s



A block A of mass, m is placed on a rough plane and the plane is tilted until when the block just slides. The angle, θ of inclination of the plane surface to the horizontal is measured. The coefficient of static friction, μ_s is given by $\mu_s = \tan\theta$. 3

Alternatively



Masses are added to the scale pan until the block, A just slides. The total mass, m of the scale pan and its contents is noted. The procedures are repeated for different values of R, by adding known weights to the block. A graph of mg against R (Mg) obtained is plotted. The slope of the graph is obtained and is the coefficient of static friction, μ_s.

2 (d) Because of friction between the tyre and the hard rough surface, the temperature of the tyre and that of air inside the car tyre increases. Since $K.E \propto T$, the kinetic energy of air molecules increases. Since volume of air in the tyre is constant, pressure of the air inside the tyre increases due to increased temperature which may lead the car tyre to burst.

3

20

3

a(i) Elasticity is the ability of a material to regain its original shape or size after being stretched or Compressed.

1

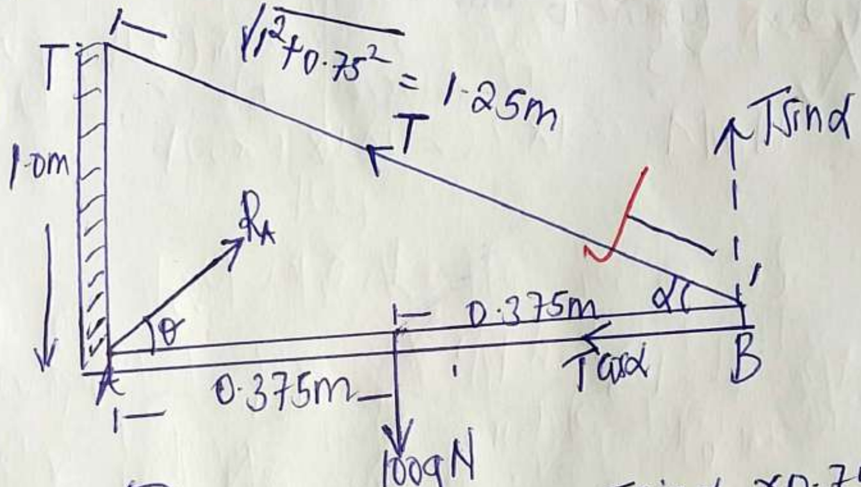
ii) Young's modulus is the ratio of tensile stress to tensile strain.

1

iii) plastic deformation is the permanent deformation or change in shape of a solid body without fracture under the action of a sustained force.

1

b)



i) $\curvearrowleft A$ $100g \times 0.375 = T\sin\alpha \times 0.75$

$100 \times 9.81 \times 0.375 = T \times \frac{1}{1.25} \times 0.75$

$T = 613.125N$

Tension in the wire is 613.125N

3

ii) Young's modulus, $E = \frac{Tl_0}{Ae}$

$= \frac{4Tl_0}{\pi d^2 e}$

$E = \frac{4 \times 613.125 \times 1.23}{\pi \times 0.0008^2 \times (1.25 - 1.23)}$

$E = 7.502 \times 10^{10} Nm^{-2}$

3

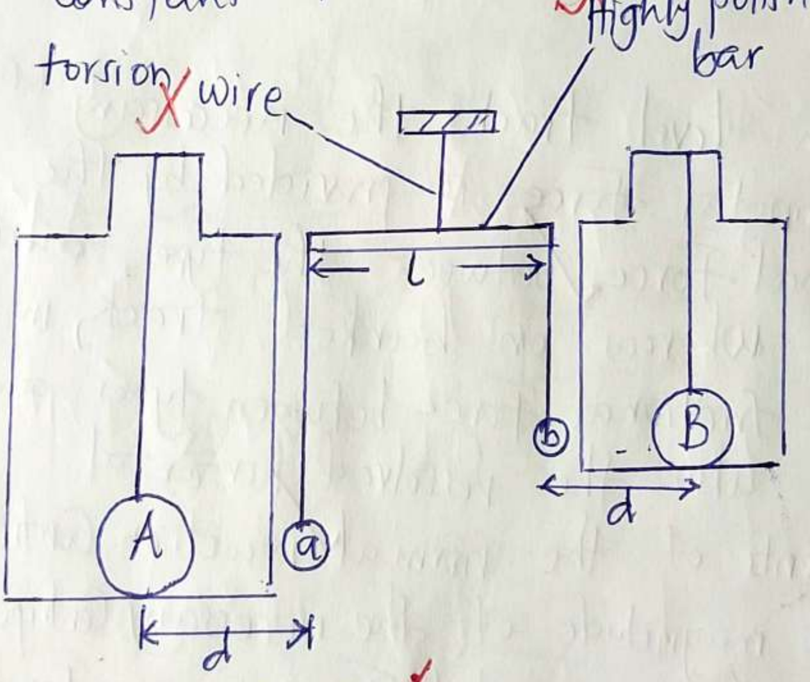
C (i) - Planets revolve in elliptical orbits having the sun at one focus.

- Each planet revolves in such a way that the immaginary line joining it to the sun sweeps out equal areas in equal time intervals.

3

- The squares of the periods of revolution of planets about the sun are directly proportional to the cubes of their mean distance of seperation.

ii) Determination of Universal gravitational Constant G:



2 marks for any 4 correctly labelled parts

a, b - Gold spheres

A, B - Lead spheres.

Two identical small gold spheres a, b each of mass, m are suspended from the ends of a highly polished bar of known length l

The bar is then suspended by a long torsion wire of known torsional constant C

Two identical lead spheres, A and B each of known mass, M are respectively brought near a and b.

- distance d between the spheres is measured.

- Because of the attraction between two spheres near each other, a couple is set up at the ends of the polished bar.

- The bar is deflected through an angle, θ (radians) which is measured by lamp and scale method.

3

- obtain G from $G = \frac{c\theta d^2}{MmL}$

d) On level track the neccessary centripetal force is provided by the frictional force between the tyres and the track. Whereas on banked track, in addition to the frictional force between tyres and track, also the resolved horizontal components of the normal reaction contribute to the magnitude of the necessary centripetal force. Thus centripetal force is greater on banked track hence the car moves faster.

3

20m

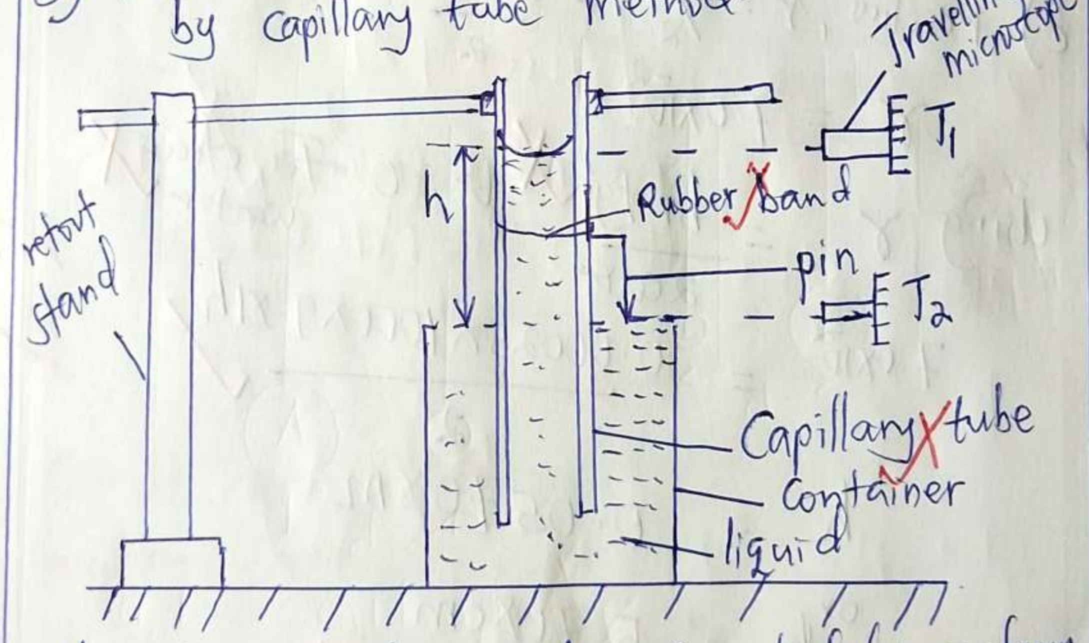
4 a (i) Surface tension is the work done to increase the surface area of a liquid film by $1m^2$ under isothermal conditions

Alternatively

Surface tension is the force per metre length acting at right angles to one side of an immaginary line drawn in the liquid surface.

ii) Angle of contact is the angle between the tangent to the liquid meniscus and the solid surface with which the liquid makes contact and it is measured inside the liquid.

b) Measurement of surface tension of liquid by capillary tube method.



A clean capillary tube supported by a clamp and retort stand is dipped into a liquid of known density ρ and angle of contact θ

A pin bent at right angles is tied onto the capillary tube and its position is adjusted until its pointed end just touches the horizontal liquid surface

Travelling microscope is focused onto the meniscus, and scale reading, h_1 is noted.

Container is removed and travelling microscope is focused onto the pointed end of the pin and scale reading h_2 is noted.

Capillary rise $h = |h_1 - h_2|$

4

Internal diameter, d of the tube is measured using a travelling microscope, and hence radius $r = d/2$ calculated.

Surface tension, γ is obtained from the expression $\gamma = \frac{hr\rho g}{2\cos\theta}$

c) radius, $r = d/2 = \frac{0.050 \times 10^{-2}}{2} = 0.00025m$

$\gamma = 7.0 \times 10^{-2}$

Using $\gamma = \frac{hr\rho g}{2\cos\theta}$ $\theta = 0$ for clean water

$7.0 \times 10^{-2} = \frac{0.00025 \times 1000 \times 9.81h}{2}$

3

$h = 0.05708m$

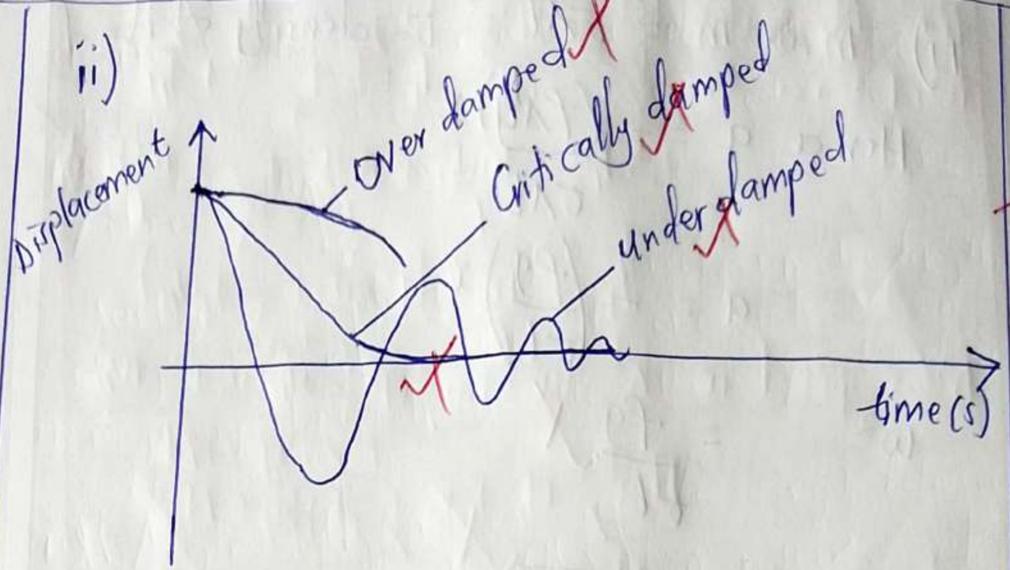
or $h = 5.708cm$

Capillarity rise is $5.708cm$

d(i) Damped oscillations are oscillations that occur in presence of dissipative forces such that the amplitude and energy of oscillation progressively become smaller and eventually the system comes to a stop.

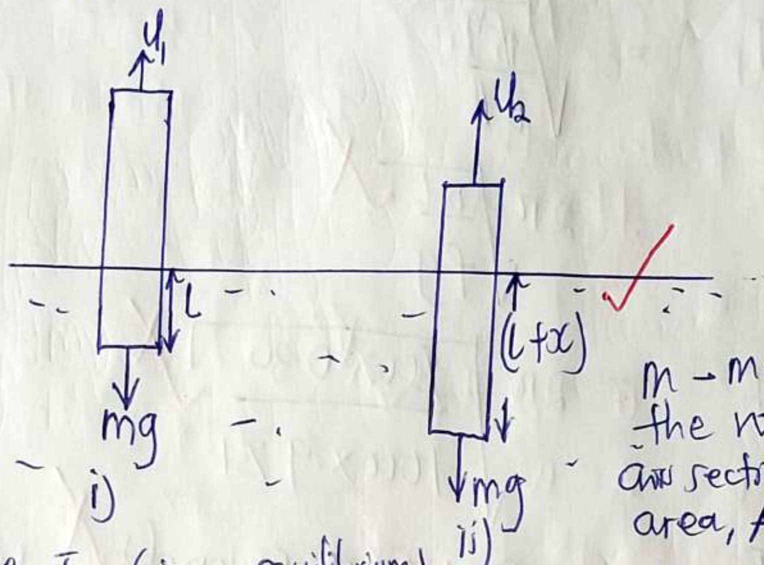
1

ii)



2

e)



m - mass of the rod of cross sectional area, A.

Case I (in equilibrium)

Upthrust $U_1 = mg$

$m_L g = mg$

$\rho A L g = mg$ ——— (1) ρ is the density of liquid.

4

Case II (after displacement through x)

Resultant Force, $F = mg - U_2$

$ma = mg - m_L g$

$ma = mg - \rho A (L+x) g$

$ma = \rho A L g - \rho A L g - \rho A g x$

$a = -\left(\frac{\rho A g}{m}\right) x$ in form of

$a = -\omega^2 x$ hence the rod executes Simple harmonic motion.

ii) mass, $m = \sigma A l$ σ - density of wood

Hence $a = -\frac{(\rho A g)}{\sigma A l} x$

$$a = -\left(\frac{\rho g}{\sigma l}\right) x$$

$$\omega^2 = \frac{\rho g}{\sigma l}$$

$$\frac{2\pi}{T} = \sqrt{\frac{\rho g}{\sigma l}}$$

$$T = 2\pi \sqrt{\frac{\sigma l}{\rho g}}$$

$$T = 2\pi \sqrt{\frac{800 \times 0.30}{1000 \times 9.81}}$$

$$T = 0.1564 \text{ seconds}$$

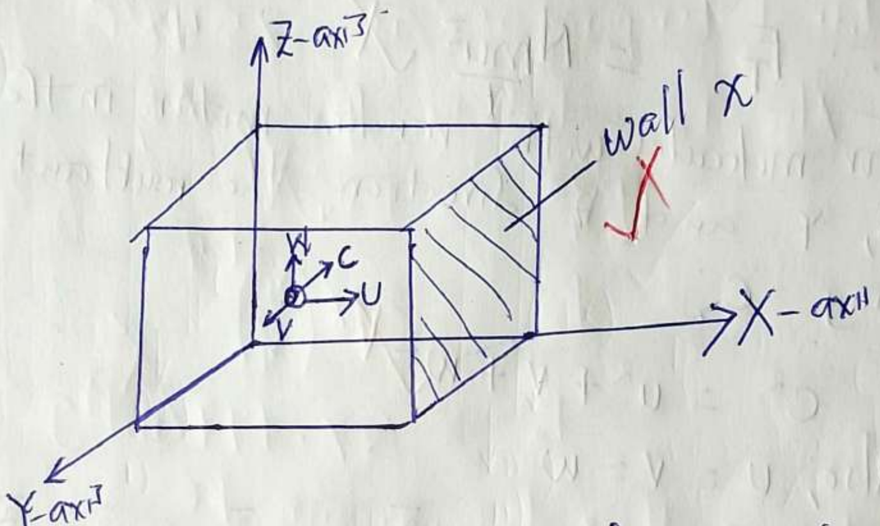
Period of oscillation is 0.1564 seconds.

2

20 mar

5 a (i) An ideal gas is the gas which has negligible intermolecular forces.

ii) Consider a molecule of gas with N molecules each of mass m approaching wall X of the container of sides of length L, let U, V, and W denote velocities of the molecule in X, Y and Z direction respectively such that their resultant is C.



Change in momentum of molecule after impact with wall X $= mu - (-mu)$

$= 2mu$

Force exerted on wall = Rate of change of momentum

$= \frac{2mu}{t}$

But time taken, $t = \frac{2L}{u}$ (for 1 trip)

Thus Force, $F = \frac{2mu}{(2L/u)}$

$F = \frac{mu^2}{L}$

for N, molecules approaching wall x, the total force exerted, $F_T = F_1 + F_2 + \dots + F_N$

$$F_T = \frac{mu_1^2}{l} + \frac{mu_2^2}{l} + \dots + \frac{mu_N^2}{l}$$

$$F_T = \frac{m}{l}\left(u_1^2 + u_2^2 + \dots + u_N^2\right)$$

Mean speed in x-direction, $\bar{u^2} = \frac{u_1^2 + u_2^2 + \dots + u_N^2}{N}$

Thus, $u_1^2 + u_2^2 + \dots + u_N^2 = N\bar{u^2}$

$$\therefore F_T = \frac{Nm\bar{u^2}}{l}$$

For molecules with random motion in the x, y and z direction, the resultant being c,

$$c^2 = u^2 + v^2 + w^2$$

Also, $u = v = w$

$$\Rightarrow c^2 = 3u^2 \Rightarrow \bar{c^2} = 3\bar{u^2} \Rightarrow \bar{u^2} = \frac{1}{3}\bar{c^2}$$

total force becomes, $F_T = \frac{Nm\bar{c^2}}{3l}$

Pressure exerted, $P = \frac{F_T}{A}$

$$P = \frac{Nm\bar{c^2}}{3l^3}$$

But $Nm = M$ (total mass) and

$l^3 = V$ (volume)

$$P = \frac{1}{3}\left(\frac{M}{V}\right)\bar{c^2}$$

$$P = \frac{1}{3}\rho\bar{c^2}$$

4

Assumptions made in the above derivation

- Intermolecular forces are negligible.
- Collisions are perfectly elastic
- The duration of collision is negligible compared with the time between collisions
- Volume of molecules is negligible compared to the volume of the container

2 marks for any 4

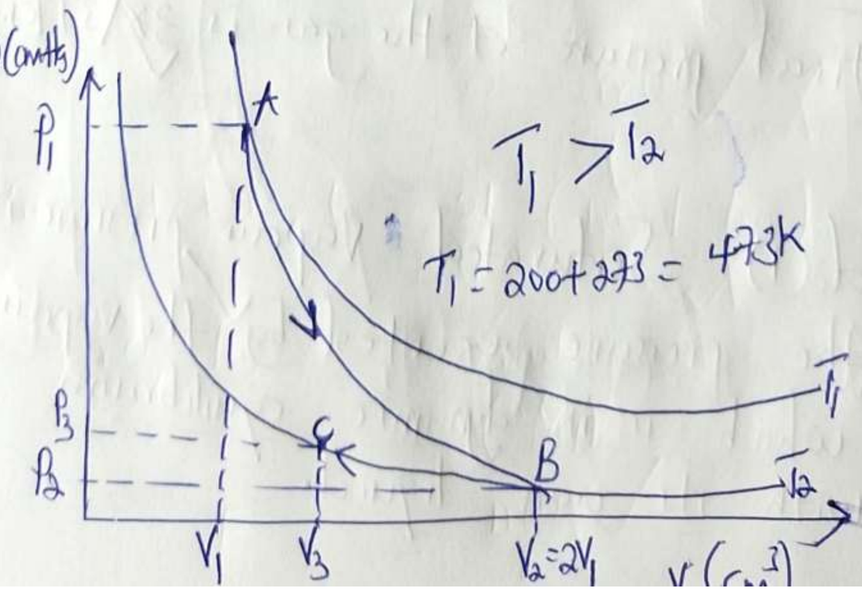
b (i) The intermolecular forces between gas molecules are negligible and hence the gas molecules are free to move in all direction, the movement makes them fill the available space.

2

ii) Increase in temperature of the gas increases the average kinetic energy of the gas molecules, molecules make more frequent collisions with the walls of the container, due to high rate of change of momentum at each collision, force exerted increases and so does the pressure.

2

c)



$T_1 > T_2$

$T_1 = 200+273 = 473K$

For adiabatic expansion, AB,

$$TV^{\gamma-1} = \text{Constant}$$

$$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$$

$$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$T_2 = 473\left(\frac{1}{2}\right)^{0.4}$$

$$T_2 = 358.47K$$

$$= 85.47\,^\circ C$$

Final temperature is 85.47°C

Also For adiabatic process, AB,

$$P_1V_1^{\gamma} = P_2V_2^{\gamma}$$

$$P_2 = 76\left(\frac{V_1}{2V_1}\right)^{1.4}$$

$$P_2 = 28.799\,cmHg$$

3

For isothermal compression BC,

$$P_2V_2 = P_3V_3$$

$$P_3 = \frac{28.799 \times 4000}{3000}$$

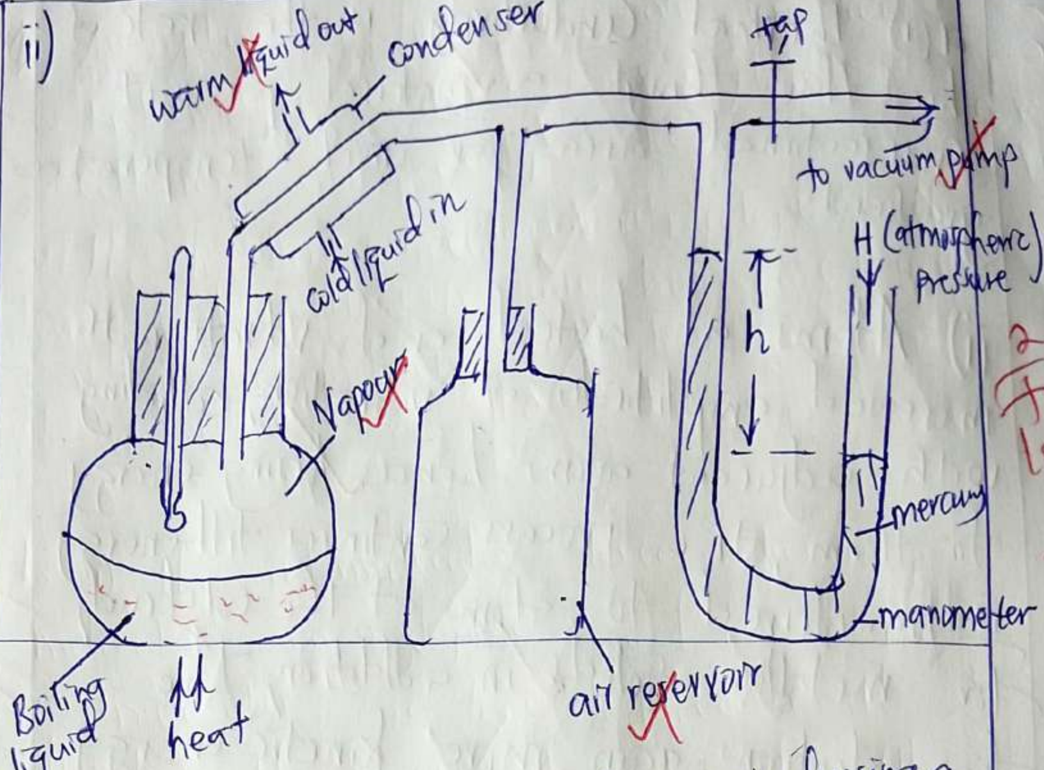
$$P_3 = 38.399\,cmHg$$

Final pressure of the gas is 38.399cmHg

d(i) Saturated vapour pressure is the pressure exerted by the vapour which is in dynamic equilibrium with its own liquid.

1

ii)



2 mrks for 4 labelled Points

- Pressure above the liquid is varied using a vacuum pump when the tap is opened.
- Tap is closed ~~and~~ the liquid is heated till it boils.
- Temperature T of the vapour at boiling point is measured
- Vapour ~~formed~~ is condensed ~~and~~ let to return to the flask to prevent pressure build up.
- Difference in mercury levels h is measured
- Atmospheric pressure H is measured using a barometer

→ SVP = H-hρg where ρ the density of mercury

- The experiment is repeated by varying the pressure above the liquid.
- A graph of SVP ~~against~~ T is plotted and from the graph it shows that SVP increases with increase in temperature.

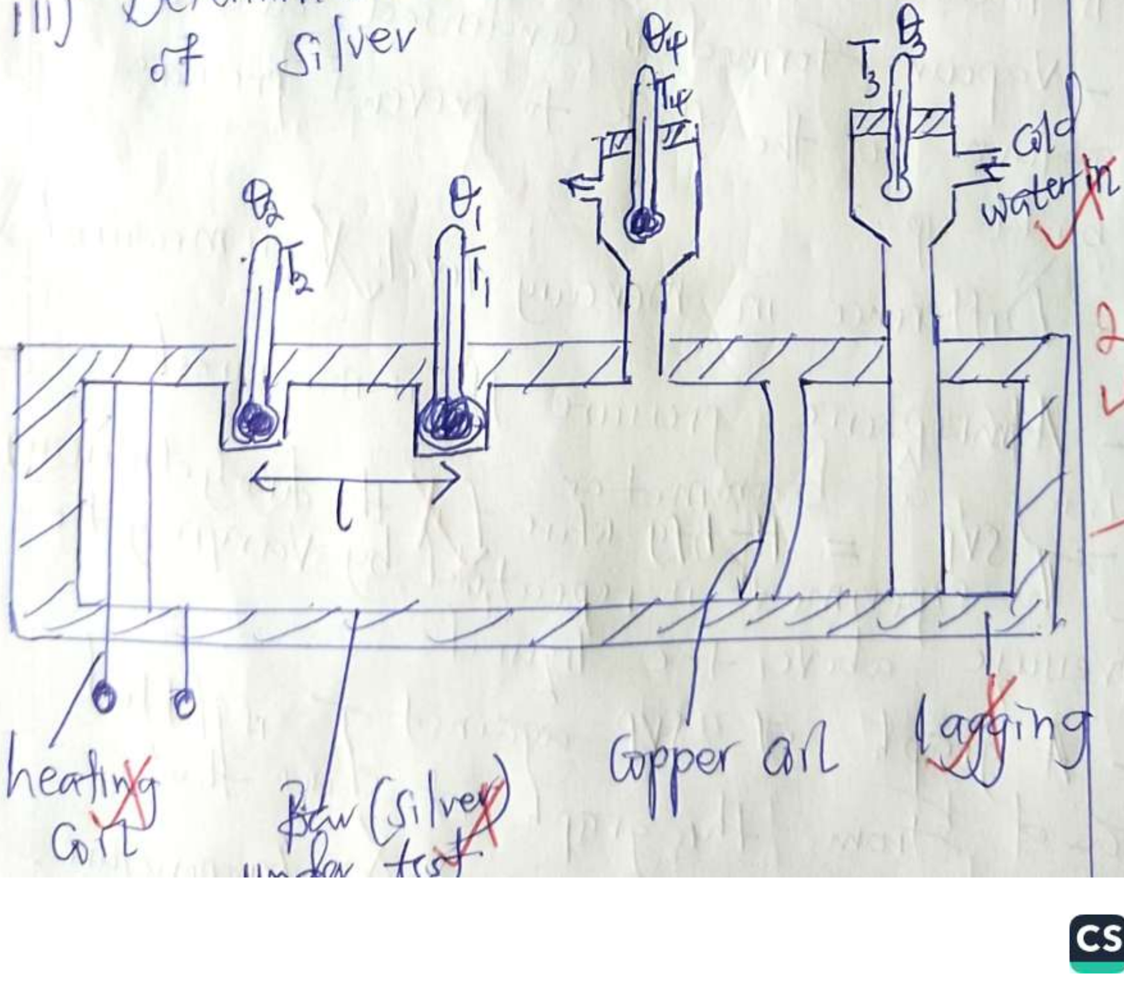
3

20mrks

6 a(i) Thermal Conductivity is the rate of heat flow through a material per unit cross sectional area per unit temperature gradient. 1

ii) Atoms at heated end vibrate with increased amplitudes of vibration, colliding with adjacent atoms hence loosing energy to them, the process continues till energy is transferred to atoms at the cold end, for metallic solids in addition, the free electrons gain more kinetic energy at the heated end and hence drift towards the cold end transferring energy as they make frequent collisions. 3

iii) Determination of thermal Conductivity of silver



2 mrks for 4 labelled parts

- A long bar of silver of cross sectional area, A is used.
- It carries a heater at one end and a copper coil soldered at the other end.
- Two thermometers ~~are~~ inserted in the holes drilled in the bar at a known seperation, L
- The holes are smeared with mercury for good thermal contact.
- Water is allowed to flow through the copper coil ~~and~~ and the heater is switched on.
- When the thermometers read steady temperatures, temperatures, θ_1, θ_2, θ_3 and θ_4 are recorded from thermometers T_1, T_2, T_3 and T_4 respectively.

$$\frac{Q}{t} = \frac{KA(\theta_2-\theta_1)}{L}$$ where K is the thermoconductivity of silver.

The mass, m of water flowing out per second through the coil is determined

$$\frac{Q}{t} = mc(\theta_4-\theta_3)$$ where c is the specific heat capacity of water.

Thus thermal conductivity of silver is got from;

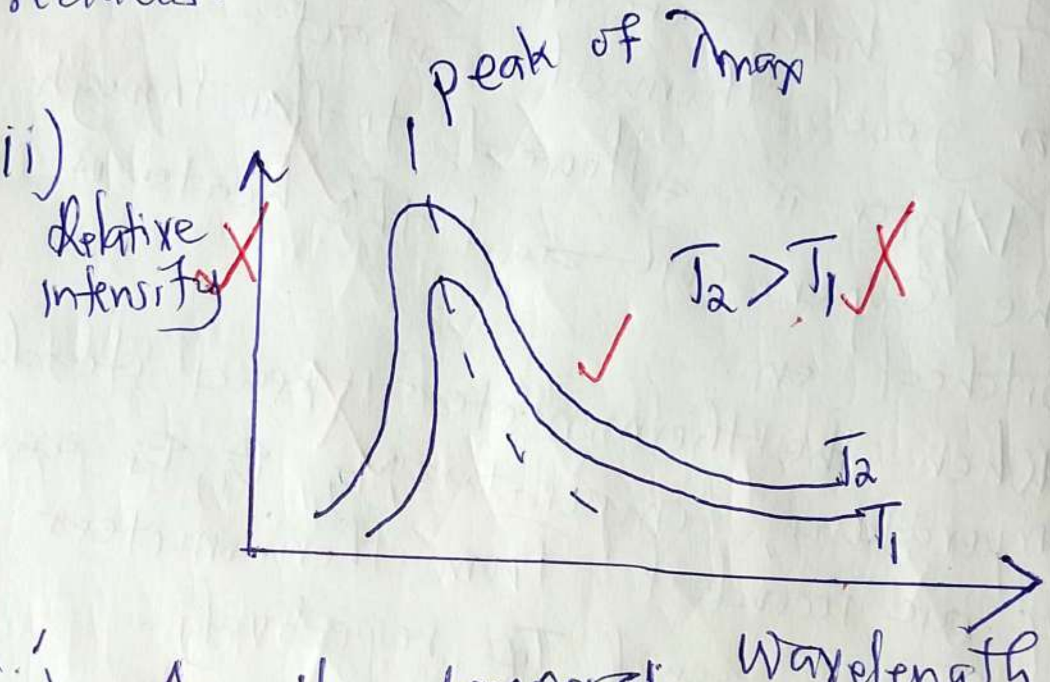
$$K = \frac{mcL(\theta_4-\theta_3)}{A(\theta_2-\theta_1)}$$

4

b(i) A black body ensures that all radiations incident onto it are fully absorbed and none reflected and transmitted, due to continuous absorption of radiations intensity reduces and hence the temperature of the surrounding reduces.

2

ii)



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iii) As the temperature increases, the energy emitted increases but the energy for shorter wavelength increases more rapidly than for longer wavelength.

At each temperature, there is a maximum energy for a particular wavelength and λ_{max} decreases as temperature increases.

2

C 

$l = 60\times10^{-2} = 0.60m$

$r = \frac{15\times10^{-3}}{2} = 0.0075m$

For black body,

Power $P = \sigma A T^4$

$P = \sigma(2\pi r l)T^4$

$P = 5.67\times10^{-8}(2\pi\times0.60\times0.0075)T^4$

$P = (1.603\times10^{-9})T^4$

But $2KW = \frac{80}{100}$ of P

$2000 = \frac{80}{100}\times(1.603\times10^{-9})T^4$

$T = 1117.48K$

Its temperature is $1117.48K$

ii) By Wien's law,

$T\lambda_{max} = \sigma$

$\lambda_{max} = \frac{2.9\times10^{-3}}{1117.48}$

$\lambda_{max} = 2.595\mu m$

2

2

7 a(i) Kelvin is the fraction $\frac{1}{273.16}$ of the thermodynamic temperature of the tripple point of water. 1

ii) ~~Properties of~~ a good thermometric property

- It should change considerably for a small change in temperature
- It should vary over a wide range of temperature.
- It should vary continuously and linearly with temperature changes.
- Each value of the property should correspond to one and only one value of temperature

2 For four correct 4

b(i) The test junction is placed in a system ~~at~~ tripple point of water.
The thermoelectric emf E_{tr} is recorded
The test junction is now placed in a system at unknown temperature, T.
The thermoelectric emf E_T is recorded
The unknown temperature is obtained
from $T = \frac{E_T}{E_{tr}} \times 273.16K$ 3

ii) $L_0 = 2.0cm$, $L_{100} = 2.7cm$, $L_\theta = 8.4cm$

$$\theta = \frac{L_\theta - L_0}{L_{100} - L_0} \times 100°C$$

$$\theta = \frac{8.4 - 2.0}{2.7 - 2.0} \times 100°C$$

$$\theta = 914.26°C$$

In Kelvin.

$$T = \theta + 273.16$$

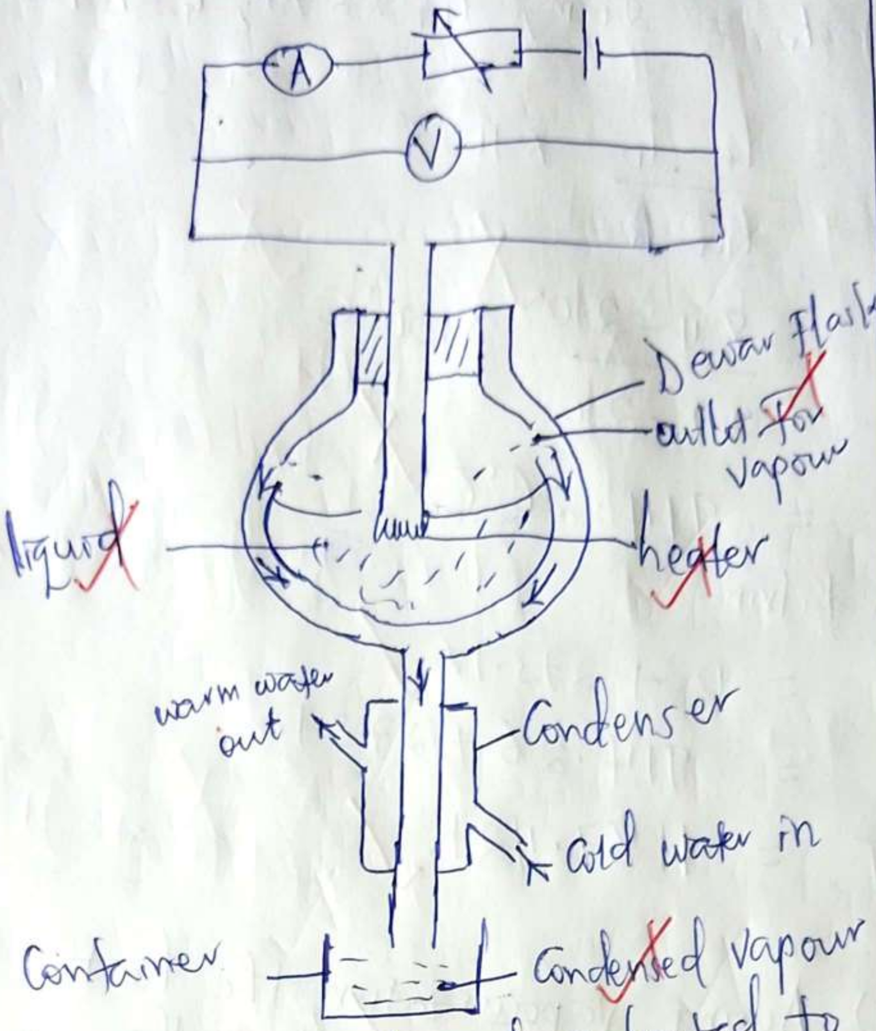
$$T = 914.26 + 273.16$$

$$T = 1187.42K$$

3

C(i) During vapourization, the heat Supplied is used to weaken the intermolecular ~~forces of attraction~~ to enable liquid molecules change into vapour molecules accompanied with much work done during expansion of vapour. ~~For~~ fusion the heat Supplied is used to ~~break~~ weaken intermolecular forces to enable solid molecules appear as liquid molecules accompanied with negligible work done.

2



2 marks for 4 labelled parts.

The specimen liquid is heated to boiling point by the heater as shown above

A stop clock is started and mass, m_1 of liquid collected in a time t is noted

The ammeter reading I_1 and voltimeter reading V_1 are recorded

$I_1V_1t = m_1l_v + h$ where h is the heat lost to sorrounding.

4 marks

The rheostat is adjusted and a new ammeter reading I_2 and voltimeter reading V_2 are recorded.

New mass, m_2 of the liquid collected in the same time, t is obtained

$I_2V_2 = m_2l_v + h$

l_v is obtained from $l_v = \frac{I_2V_2 - I_1V_1}{m_2 - m_1}$

d) Assuming no heat loss to surroundings;
Heat lost by steam = heat gained by ice and calorimeter

$$M_s L_v + M_s C_w (100-10) = M_c C_c (10-0) + M_i L_f + M_i C_w (10-0)$$

$$(2.23\times10^6)M_s + (4200\times90)M_s = \left(\frac{200}{1000}\times3.34\times10^5\right) + \left(\frac{200}{1000}\times4200\times10\right) + 40\times10$$

$$2608000 M_s = 75600$$

$$M_s = 0.02899 kg$$

$$M_s = 28.99 g$$

Total mass of liquid in calorimeter = M_s + Mass of water from ice.

$$= 28.99 + 200$$

$$= 228.99$$

3

20m

8 a(i) Cathode rays are a stream of fast moving electrons 1

X-rays are electromagnetic radiations of very short wavelength produced when fast moving electrons are stopped by a metal target such as tangsten 1

ii) Anode is made from a material such as copper which is a good conductor of heat hence heat generated at anode can easily be led away. On anode there is a tangsten target which has a high melting point hence high temperatures can be withstood before melting can occur 3

b(i) Bragg's Law ~~states~~ that "when a beam of monochromatic X-rays is incident on a set of atomic planes, Constructive interference occurs when the path difference is an integral multiple of the wavelength of the waves". 1

ii) For many orders $\theta = 90^\circ$

iii) Given; $\lambda = 1.10 \times 10^{-10}$ m

$n = 1$

$\theta = 19^\circ$

$M = 75.5 \times 10^{-3}$ kg

75.5g of KCL contain 6.02×10^{23} atoms.

1 molecule (2 atoms) weighs $\left(\frac{75.5 \times 10^{-3}}{6.02 \times 10^{23}}\right)$ kg

1 atom weighs $\frac{1}{2}\left(\frac{75.5 \times 10^{-3}}{6.02 \times 10^{23}}\right)$ kg

Volume of one atom, $V = d^3$

Hence density of KCL, $\rho = \frac{\text{mass}}{\text{Volume}}$

$$\rho = \frac{75.5 \times 10^{-3}}{2 \times 6.02 \times 10^{23} d^3} \quad \text{—(1)}$$

From Bragg's law; $2d\sin\theta = n\lambda$

$$d = \frac{1 \times 1.10 \times 10^{-10}}{2\sin 19^\circ}$$

$$d = 1.6894 \times 10^{-10} m$$

$$\therefore \rho = \frac{75.5 \times 10^{-3}}{2 \times 6.02 \times 10^{23} \times (1.6894 \times 10^{-10})^3}$$

$$\rho = 13006 kgm^{-3}$$

4

<u>Alternatively</u>:

$$d^3 = \frac{M \times 10^{-3}}{2N_A\rho}$$

$$\left(\frac{n\lambda}{2\sin\theta}\right)^3 = \frac{M \times 10^{-3}}{2N_A\rho}$$

$$\rho = \frac{75.5 \times 10^{-3}}{2 \times 6.02 \times 10^{23}} \times \left(\frac{2\sin 19}{1 \times 1.10 \times 10^{-10}}\right)^3$$

$$\rho = 13006 kgm^{-3}$$

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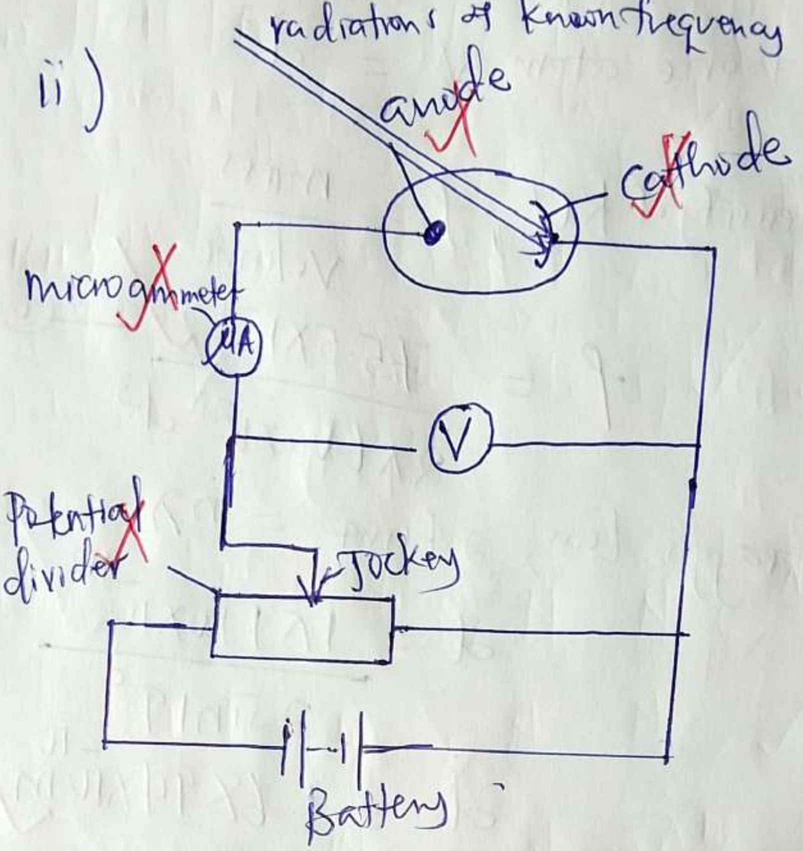
amount of energy required to remove an electron from the bulk of a metal interior to its surface against the attractive force of positive ions. I

ii)



2 mrk For 4 labelled parts

The anode is made more negative with respect to the Cathode.
Radiations of known frequency ($f > f_0$) are made incident on a cathode.
The pd between anode and cathode is varied using a potentio divider until the reading of micro ammeter is zero.
The corresponding voltimeter reading, V_s is taken and is the stopping potential. 2
The procedure is repeated using other radiations of different frequency.
A graph of V_s against f is plotted and slope, S obtained
Plank's Constant is obtained from $h = Se$
where e is the electronic charge.

iii) Case I

$f = 6.0 \times 10^{14} Hz$

$V_s = 0.4V$

$hf = \phi_0 + eV_s$

$6.0 \times 10^{14} h = \phi_0 + 0.4 \times 1.6 \times 10^{-19}$

$6.0 \times 10^{14} h = \phi_0 + 6.4 \times 10^{-20}$ ——— (1)

Case 2

$f = 1.0 \times 10^{15} Hz$

$V_s = 2.2V$

$hf = \phi_0 + eV_s$

$1.0 \times 10^{15} h = \phi_0 + 1.6 \times 10^{-19} \times 2.2$

$1.0 \times 10^{15} h = \phi_0 + 3.52 \times 10^{-19}$ ——— (2)

Eqn (2) $\div$ Eqn (1) gives;

$$\frac{5}{3} = \frac{\phi_0 + 3.52 \times 10^{-19}}{\phi_0 + 6.4 \times 10^{-20}}$$

$(5-3)\phi_0 = 7.36 \times 10^{-19}$

$\phi_0 = 3.68 \times 10^{-19} J$

$\phi_0 = 2.3 eV$

9

a(i) Radioactivity is the spontaneous disintegration of unstable nucleus to attain stable state accampanied with emmission of radiations. 1

Nuclear fission is the splitting of a large unstable nucleus to form two lighter stable nuclei with release of energy. 1

b(i) Half life is the time take for half the number of radioactive atoms initially present in the sample to decay. 1

a(ii) Binding energy of a nucleus is the minimum amount of energy required by a nucleus to split into its constituent nucleons. 1

b(ii) From decay law, $N = N_0 e^{-\lambda t}$

at $t = T_{1/2}$, $N = \frac{N_0}{2}$

$$\Rightarrow \frac{N_0}{2} = N_0 e^{-\lambda T_{1/2}}$$

$$\frac{1}{2} = e^{-\lambda T_{1/2}}$$

$$\ln 2^{-1} = -\lambda T_{1/2} \ln e$$

$$-\ln 2 = -\lambda T_{1/2}$$

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

4

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c) $^{238}_{92}U \longrightarrow {}^{234}_{90}X + {}^{4}_{2}He$

$m_u = m_x + m_\alpha + \Delta m$

$238.12492 = 234.11650U + 4.003870 + \Delta m$

Mass defect, $\Delta m = 0.00455U$ ✓

Energy released $= 0.00455 \times 931 MeV$

$= 4.23605 MeV$

$= 4.23605 \times 10^{6} \times 1.6 \times 10^{-19}$

Total energy, $E = 6.77768 \times 10^{-13} J$ ✓

Power developed $=$ Activity $\times$ total energy

Activity, $A = \lambda N$

238g of U contain 6.02×10^{23} atoms

2g of U contain $\frac{6.02 \times 10^{23}}{238} \times 2$

$N = 5.05888 \times 10^{21}$ atoms ✓

Decay Constant, $\lambda = \frac{\ln 2}{4500 \times 365 \times 24 \times 3600}$

$= 4.884 \times 10^{-12} s^{-1}$ ✓

$A = 4.884 \times 10^{-12} \times 5.05888 \times 10^{21}$

$A = 2.47093 \times 10^{10} Bq$ ✗

Power $= 2.4709 \times 10^{10} \times 6.77768 \times 10^{-13}$

$= 0.0167 W$ ✗

5 mks

d (i) work done by accelerating voltage = K.E gained

$$eV_a = \frac{1}{2}mu_x^2$$

$$u_x = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 1800}{9.11 \times 10^{-31}}}$$

3 marks

$$u_x = 2.515 \times 10^{7} ms^{-1}$$

ii) As electrons move between the plates, they describe a parabolic path. At any time t, the horizontal component of velocity, V_x is constant i.e $V_x = u_x = 2.515 \times 10^{7} ms^{-1}$ because no net force acts in this direction. However the vertical component V_y changes with time because there is a net vertical force, $F = Ee$ and intensity, $E = \frac{V}{d}$ in this direction.

1

iii) $V = \sqrt{V_x^2 + V_y^2}$

but $V_x = u_x = 2.515 \times 10^{7} ms^{-1}$

$$V_y = u_y + at$$

$$= 0 + \left(\frac{Ee}{m}\right)\left(\frac{l}{u_x}\right)$$

$$= \frac{Eel}{mu_x}$$

since $E = V/d$

$$V_y = \frac{Vel}{dmu_x}$$

$$= \frac{90 \times 1.6 \times 10^{-19} \times 0.04}{9.11 \times 10^{-31} \times 0.04 \times 2.515 \times 10^{7}}$$

$$= 6.285 \times 10^{5} ms^{-1}$$

$$\therefore V = \sqrt{(6.285 \times 10^{5})^2 + (2.515 \times 10^{7})^2}$$

$$V = 2.516 \times 10^{7} ms^{-1}$$

Electron emerge out at speed of

$2.516 \times 10^{7} ms^{-1}$

3

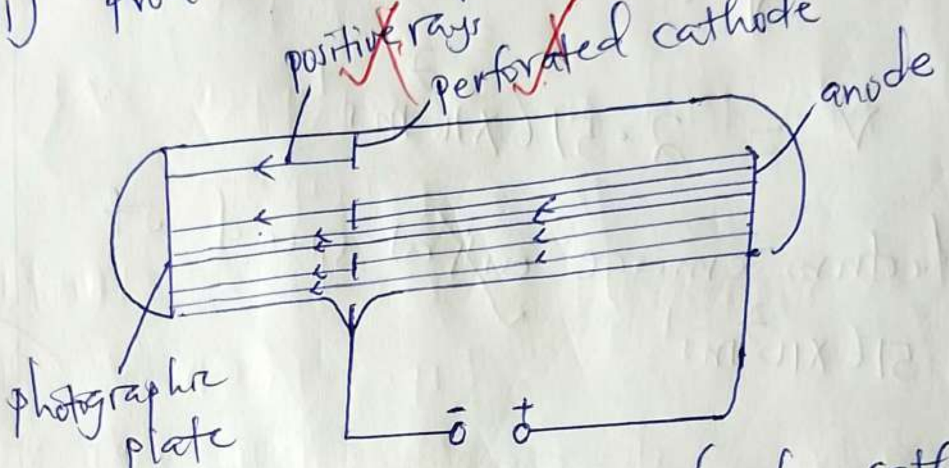
Zom

10

a (i) Positive rays are streams of positively charged particles that pass through a perforated cathode produced when cathode rays in a discharge tube collide with gaseous atoms and strip off some electrons from the atoms.

1

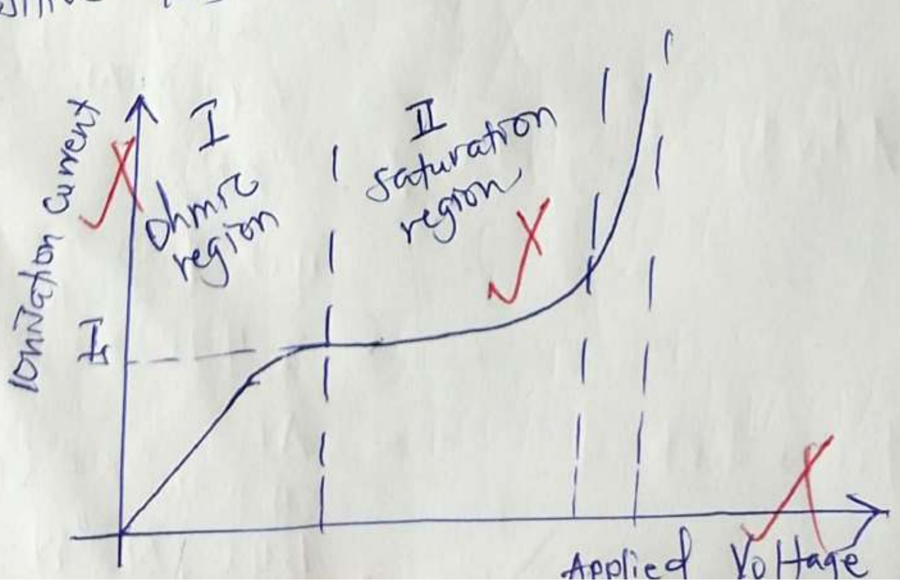
ii) Production of positive rays



3

Positive rays are produced when cathode rays in a discharge tube collide with gaseous atoms and dislodge some electrons from them, The positive ions formed are accelerated to the cathode and these streams of positive ions constitute positive rays.

b)



2

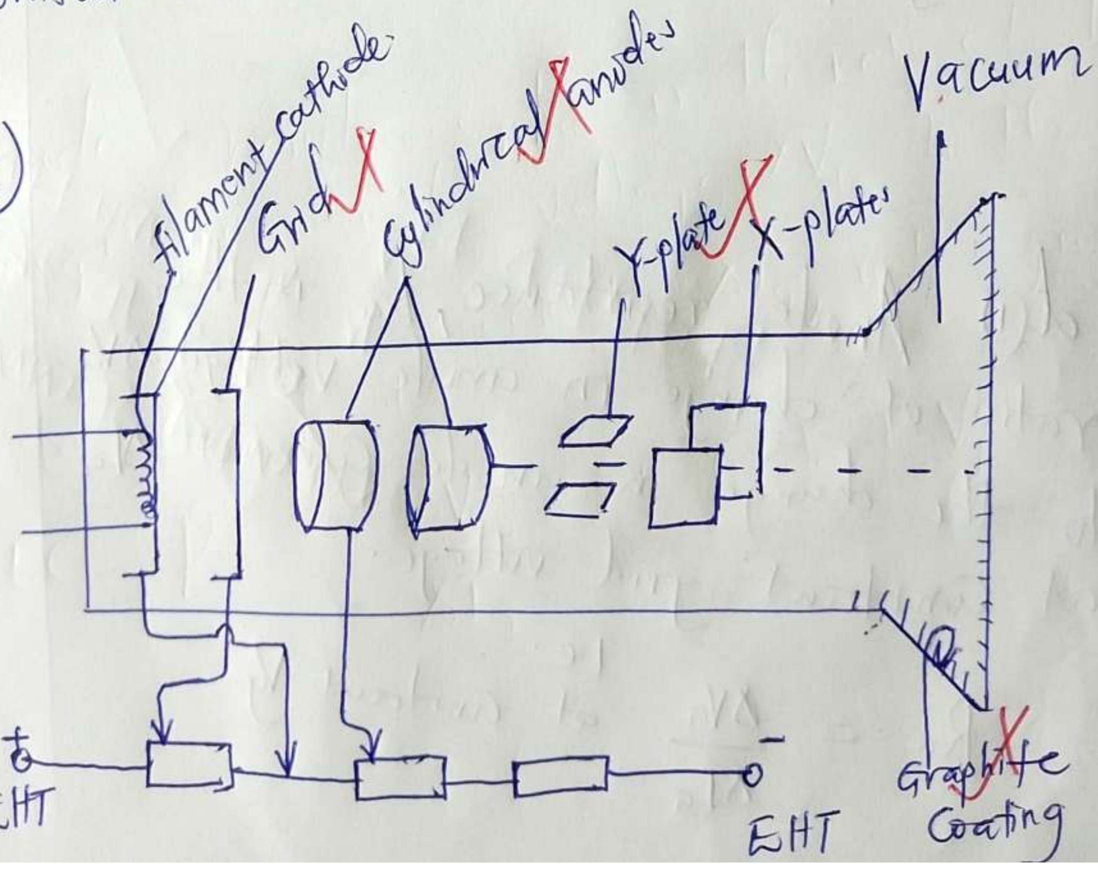
In region I (Ohmic region), the applied Voltage is low, the positive ions and electrons produced by Collisions of Cathode rays with the neutral gas atoms have a high chance of recombining since their velocity is low. The current produced is proportional to the applied Voltage.

In region II (Saturation region), All ions pairs produced per second travel and reach the respective electrodes. This results in constant current (saturation current) $I_s = ne$

3

Beyond saturation region, the electrons produced by ionisation of neutral gas atoms acquire sufficient energy to cause ionisation themselves due to large applied voltages. This results into ~~tar~~ rapid multiplication of ions in the tube ~~and~~ hence the rise in the ionisation current.

c)



2 mks for 4 labelled parts

- The Cathode emits electrons thermionically
- Grid Controls the number of electrons passing through the anode to screen thereby controlling the brightness of the spot on screen.
- Anodes accelerate the electrons along the tube and focuses the electron beam into a small spot on the screen.
- Y-plates deflect the electron beam vertically.
- X-plates deflect the electron beam horizontally.
- Fluorescent screen is where a spot is formed by it emitting light when energetic electrons bombard it.
- Graphite Coating shields the electron beam from external electric fields by providing equipotential surface.

4

d(i) Anode resistance, R_a is the ratio of change in anode voltage, ΔV_a to the change in anode current ΔI_a at constant grid voltage.

1

i.e.

$$R_a = \frac{\Delta V_a}{\Delta I_a} \text{ at constant } V_g$$

d(ii) Data given;

mutual conductance, $g_m = 5m\Omega V^{-1} = 5\times10^{-3}\,\Omega V^{-1}$

anode resistance, $R_a = 20000\,\Omega$

Load resistance, $R_L = 10000\,\Omega$

Voltage Gain, $G = \dfrac{\mu R_L}{R_a + R_L}$

But amplification factor, $\mu = R_a \times g_m$

$= 20000 \times 5\times10^{-3}$

$= 100$

Thus, $G = \dfrac{100 \times 10000}{20000 + 10000}$

Voltage Gain, $G = 33.33$

END

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