P510/1
Physics
Paper 1
July - August 2023
2 ½ Hours

UGANDA MUSLIM TEACHERS' ASSOCIATION

UMTA JOINT MOCK EXAMINATIONS - 2023

UGANDA ADVANCED CERTIFICATE OF EDUCATION

Physics

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.*

Assume where necessary

Universal gravitational constant, G	=	$6.67 \times 10^{-11}\ Nm^3\ Kg^{-2}$
Stefan's — Boltzmann's constant, σ	=	$5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$
Speed of light in vacuum, C	=	$3.0 \times 10^8 ms^{-1}$
Specific heat capacity of water	=	$4200 Jkg^{-1}k^{-1}$
Radius of earth	=	$6.4 \times 10^6 m$
Radius of sun	=	$7 \times 10^8 m$
Radius of earth's orbit about the sun	=	$1.5 \times 10^{11} m$
Planck's constant, h	=	$6.6 \times 10^{-34} Js$
Gas constant, R	=	$8.31\ Jmol^{-1}K^{-1}$
Electron mass	=	$9.11 \times 10^{-31}\ Kg$
Electron charge, e	=	$1.6 \times 10^{-19} C$
Density of water	=	$1000\ Kgm^{-3}$
Density of Mercury	=	$13600\ Kg\ m^{-3}$
Specific latent heat of vaporization of water	=	$2.26 \times 10^6 JKg^{-1}$
Viscosity of air	=	$1.8 \times 10^{-5} Ns^{-1}m^{-1}$
Avogadro's number, NA	=	$6.02 \times 10^{23}\ mol^{-1}$
Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Mass of sun	=	$2.0 \times 10^{30} Kg$
Mass of earth	=	$6.0 \times 10^{24} Kg$
Temperature of sun	=	$6000K$
Specific latent heat of fusion of ice	=	$3.4 \times 10^5 JKg^{-1}$
Thermal conductivity of brick	=	$8.0 \times 10^{-1} Wm^{-1}K^{-1}$
Thermal conductivity of air	=	$2.4 \times 10^{-2} Wm^{-1}K^{-1}$
Density of Oil	=	$900 Kgm^{-3}$

SECTION A

1. (a) (i) State the principle of conservation of Mechanical energy (1 mark)

(ii) Give two types of forces in which the principle in a (i) is obeyed. (1 mark)

(b) A particle is thrown vertically upwards with speed **U** from the top of a tower of height, **H**. The time taken by the particle to hit the ground is n-times that taken to reach the highest point of its path.

(i) Sketch its displacement -time and velocity -time graphs for the particle. (2marks)

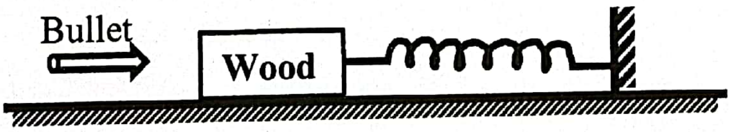
(ii) Show that: $2gH = n(n-2)u^2$. (4 marks)

(c) (i) Use molecular theory to explain the origin of frictional force between two surfaces in contact (3 marks)

(ii) Describe an experiment to determine the coefficient of kinetic friction.

(4 marks)

(d) A bullet of mass 20g is fired at close range into a wooden block of mass 980g connected to a spring of force constant $150Nm^{-1}$ fixed at one end and resting on a rough horizontal surface of coefficient of friction 0.37. After collision, the bullet gets embedded into the wood and the spring is compressed through a distance of 2.4cm. Calculate the initial speed of the bullet before impact with the block (5 marks)



2. (a)(i) What is meant by

(i) an incompressible fluid? (1 mark)

(ii) Pressure energy? (1 mark)

(b) Explain why velocity of a liquid at a wide part of a tube is less than that at a narrow part. (2marks)

(c) (i) State the law of floatation (1 mark)

(ii) Show that the weight of fluid displaced by an object is equal to the up thrust on the object. (4 marks)

(iii) A 500kg wooden block is floating with 0.25 of its volume above the water level, what is the volume of a metal of density $9.0 \times 10^2\ Kgm^{-3}$ which must be attached to the under side of the block to completely submerge it. (5 marks)

(d) Describe, stating the necessary precautions an experiment to measure the coefficient of viscosity of engine oil (6 marks)

3. (a) (i) What is meant by a parking orbit? (1 mark)

(ii) Calculate the height above the earth's surface for a parking orbit. (4 marks)

(b) (i) With aid of a diagram, describe a laboratory method of determining the universal gravitational constant,G (6 marks)

(ii) State any precautions taken in b(i) above (1 mark)

(c) State the conditions for mechanical equilibrium of a system of coplanar forces. (2 marks)

(d) A uniform ladder of mass 40kg and length 5.0m rests with its upper end against a smooth vertical wall and with its lower end at 3.0m from the wall on a rough ground. Find the

(i) Least coefficient of friction between the ladder and the ground. (3 marks)

(ii) Force exerted at the bottom of the ladder. (3 marks)

4. (a) (i) What is meant by surface tension and angle of contact? (2 marks)

(ii) With aid of a diagram, describe the capillary rise method of determining surface tension of water (5 marks)

(b) A U-tube is made up of capillary tubes of diameters 1.0mm and 3.2mm respectively. The tube is held vertically and partially filled with a liquid of surface tension $0.075Nm^{-1}$ and zero angle of contact. If the difference in the levels of the meniscus is 1.25cm, Calculate the density of the liquid. (4 marks)

(c) (i) Explain why the free surface of a liquid under no external forces is spherical. (3 marks)

(ii) An air bubble of diameter 10.0mm is formed at a depth of 50.0cm inside a container of soap solution of relative density 1.20. By what amount is the pressure inside the bubble greater than the atmospheric pressure? (3 marks)

(d) If number of little droplets of water of surface tension **Y**, all of the same radius, **r** combine to form a single drop of radius, **R**, show that the energy released is

$$4\pi R^3\, \gamma \left(\frac{1}{r}-\frac{1}{R}\right)$$ (3 marks)

SECTION B

5. (a) What is meant by

(i) triple point of water? (1 mark)

(ii) Cooling correction? (1 mark)

(b) Explain clearly the steps taken to determine the cooling correction when measuring the specific heat capacity of a poor conductor of heat by the method of mixtures (6 marks)

(c) 10g of dry steam is added to a copper calorimeter of heat capacity $80Jk^{-1}$ containing 50g of ice and 120g of water at 0°C .Calculate the final temperature after all the ice has melted. (5 marks)

(ii) Explain why systems based on circulation of steam are more efficient in warming a room than those based on circulation of boiling water. (2 marks)

(d) (i) Give two advantages of gas thermometers over those of mercury thermometers. (2 marks)

(ii) The resistance of a platinum thermometer is 1.510Ω at ice point, 2.160Ω at steam point and 1.878Ω at 50°C on the gas scale. What is the difference between the values of the latter temperature on the two scales. (3 marks)

6. (a) (i) What is meant by kinetic theory of gases? (1 mark)

(ii) Use the kinetic theory expression of pressure of an ideal gas to deduce Dalton's law of partial pressures. (4 marks)

(b) Explain why;

(i) the behaviour of real gases at very low pressures approximates to that of an Ideal gas. (2 marks)

(ii) air pressure inside a car tyre increases during driving (3 marks)

(c) (i) With aid of a diagram, describe an experiment to determine the temperature dependance of saturated vapour pressure of water. (6 marks)

(ii) A mixture of air and saturated alcohol vapour in presence of liquid alcohol exerts a pressure of 128mmHg at 20°C.When the mixture is heated at constant volume to the boiling point of alcohol at 78°C at standard pressure, the pressure becomes 860mmHg.Find the saturation vapour pressure of alcohol at 20°C. (4 marks)

7. .(a) Define the terms;

(i) Coefficient of the thermal conductivity (1 mark)

(ii) heat current (1 mark)

(b) (i) State Wien's displacement law (1 mark)

(ii) Explain why there is the word displacement in Wien's displacement law (2 marks)

(c) (i) With aid of a diagram. Describe Searle's method of determining thermal conductivity of a material of high conductivity (6 marks)

(ii) Why is the method in C(i) above best suited for a good conductor of heat? (2 marks)

(d) The external walls of a house consist of two layers of brick separated by an air cavity. The outer face of the wall is at a temperature of 20°C while the inside of the house is at 5°C .If the thickness of each brick layer is 10.0cm and of air cavity is 3.0cm

(i) Explain why in steady state, the rate of heat transfer must be the same. (1 mark)

(ii) Calculate the rate of heat flow per square metre through the wall. (6 marks)

SECTION C

8. (a) (i) What are positive rays? (1 mark)

(ii) State two differences between cathode rays and positive rays. (2 marks)

(b) With aid of a diagram, describe Millikan's experiment to determine the value of electronic charge. (6 marks)

(ii) Explain why the size of oil drops must be small in b(i) above (2 marks)

(c) In Millikan's apparatus the horizontal plates are 1.5cm apart. With the electric field switched off, an oil drop is observed to fall with a steady velocity of $2.5 \times 10^{-2}\ cms^{-1}$ .When the field is switched on, the drop just remains stationary when the P.d between the two plates is 1500V.

(i) Calculate the radius of the drop. (3 marks)

(ii) How many electronic charges does it carry? (3 marks)

(iii) If the P.d between the two plates remains unchanged, with what velocity will the drop move when it has collected two more electrons as a result of exposure to ionizing radiation? (3 marks)

9. (a) (i) What is meant by ionization potential? (1mark)

(ii) Explain how line spectra accounts for existence of discrete energy levels in atoms. (3 marks)

(b) The first excitation energy of a hydrogen atom is 10.4eV. Calculate the speed of the slowest electron that can excite a hydrogen atom. (3 marks)

(c) (i) With aid of a diagram, describe how x-rays are produced in an X-ray tube. (5 marks)

(ii) Under what conditions does X-ray diffraction occur? (2 marks)

(d) The closest spacing between planes of atoms in a crystal of NaCl is $2.82A°$ .First order diffraction maxima of a monochromatic beam of X-rays occurs at a glancing angle of $15^0\ 30^1$.

(i) How many orders of diffraction of these X-rays could be observed from these planes. (4 marks)

(ii) Find the density of $NaCl$ if its molecular weight is 59.5 (2 marks)

10. What is meant by

(i) Decay constant (1 mark)

(ii) Background count rate? (1 mark)

(b) (i) Describe the structure and operation of an expansion cloud chamber (5 marks)

(ii) Describe and explain the differences between the tracks formed in the chamber in b (i) above by alpha and beta particles (4 marks)

(c) (i) Explain the application of carbon -14 in carbon dating. (3 marks)

(ii) An element **X** has a stable isotope, 60_X and a radioactive isotope, 59_X of half-life 5.27 years whose atoms are 0.25% of those of the stable isotope. Estimate the rate of decay of 59_X with $5\mu g\ of\ 60_x$ after 10 years. (5marks)

(d) State one industrial use and one health hazard of radioactivity (1 mark)

END

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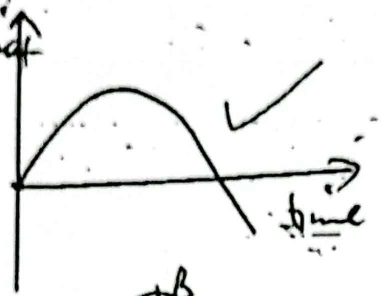
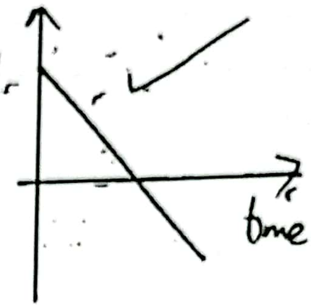
1 a(i) The sum of Kinetic energy and Potential energy is a constant in the absence of dissipative forces. ✓ 1

(ii) - Gravitational force ✓ - Elastic force ✓ (any two) 1
- Electrostatic force - magnetic force

b) (i)





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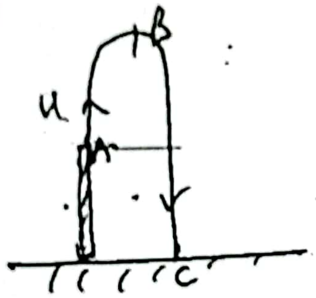
(ii)



AB

$v = u + at$

$0 = u - gt$

$t = \frac{u}{g}$ ✓

ABC

$t = \frac{nu}{g}$ ✓

$s = ut + \frac{1}{2}at^2$ ✓

$\uparrow \; -H = u\left(\frac{nu}{g}\right) - \frac{1}{2}g\left(\frac{nu}{g}\right)^2$ ✓

$= \frac{nu^2}{g} - \frac{gn^2u^2}{2g^2}$

$-2gH = 2nu^2 - n^2u^2$

$2gH = n^2u^2 - 2nu^2$

$2gH = n(n-2)u^2$ ✓

or $v^2 = u^2 + 2as$ ✓

$v = u + at = u - gT$

$= u - g\frac{nu}{g}$

$= u - nu$ ✓

$\downarrow \; (u - nu)^2 = u^2 + 2gH$ ✓

$u^2 - 2nu^2 + n^2u^2 = u^2 + 2gH$ ✓

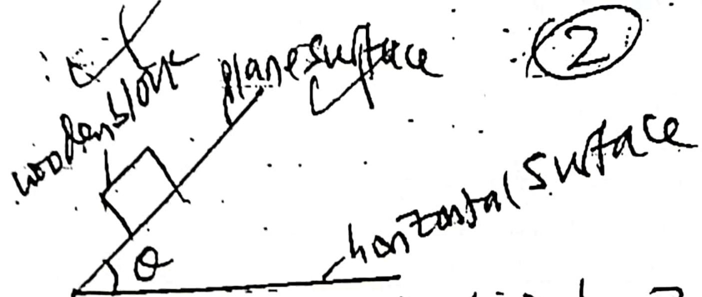
$2gH = n(n-2)u^2$ #

4

c(i) when two surfaces are in contact the molecules or atoms slightly project above the surfaces and a number of welds are formed ✓. Actual area of contact is very small and the pressure at the points of contacts is very high. These welds have to be broken for relative motion to occur, hence the origin of frictional force ✓ 3

(2)

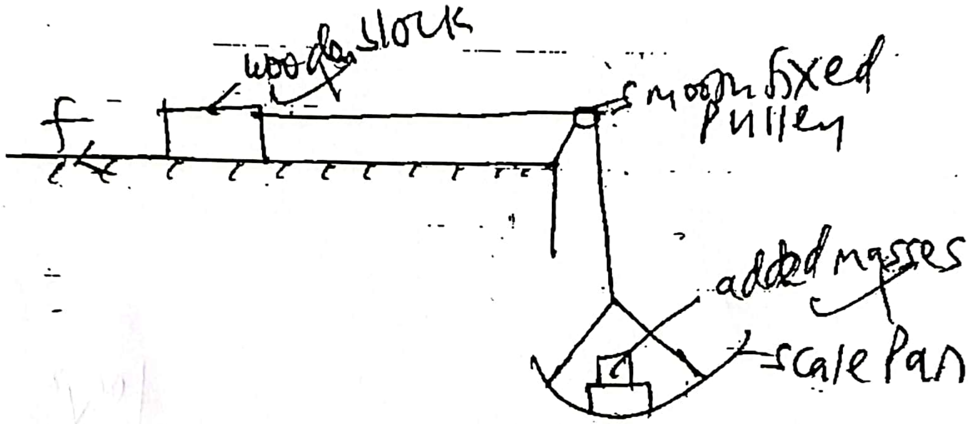
(ii)



The plane surface is put in horizontal position and the block is placed on it.
The plane surface is gradually tilted until the block moves with a steady/uniform/constant velocity
– Angle of tilt θ is measured
$\mu = \tan\theta$

4

OR



Known masses are added to the scale pan and each time a mass is added the block of mass m is given a slight push
This is done until when the block moves with a constant velocity
The mass, M of the scale pan together with added masses (contents) is determined

$$\mu = \frac{M}{m}$$

or $\mu = \dfrac{\text{weight of scale pan with added masses}}{\text{weight of wooden block}}$

4

or can repeat experiment, plot graph of M against m
slope = μ

(3)

1 d) $mu = (M+m)V$ ✓
$0.02u = (0.98+0.02)V$
$u = 50V$ ✓

Elastic Potential energy $= \frac{1}{2}ke^2$ ✓
$= \frac{1}{2} \times 150 \times (0.024)^2 = 0.0432\,J$ ✓

Work done against friction $= fs = \mu mgs$ ✓
$= 0.37 \times 1 \times 9.81 \times 0.024$ ✓
$= 0.0871128\,J$

Kinetic energy lost = elastic p.e + workdone against friction
$\frac{1}{2} \times 1 \times V^2 = 0.0432 + 0.0871128$ 5
$V = 0.5105\,ms^{-1}$ ✓

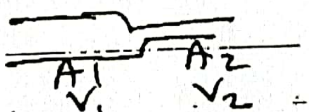
$\therefore u = 50 \times 0.5105 = 25.525\,ms^{-1}$
$\simeq 25.53\,ms^{-1}$ ✓

2. a(i) Incompressible fluid — A fluid whose density does not change when pressure changes. ✓ 1

(ii) Pressure energy: — The energy possessed by a fluid due to its pressure at a point. ✓ 1

OR

— It is work done by a pressure in moving a fluid through a displacement.

b) 

From equation of continuity, $A_1V_1 = A_2V_2$ ✓

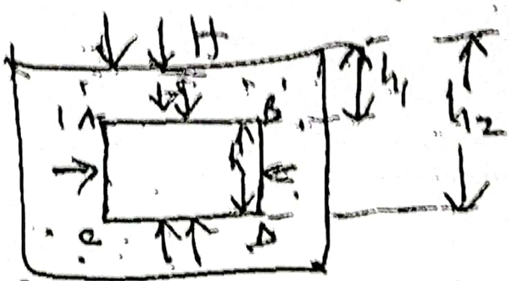
$\Rightarrow \frac{A_1}{A_2} = \frac{V_2}{V_1}$ ✓ Since $A_1 > A_2 \Rightarrow V_2 > V_1$ ✓ 2
or $V_1 < V_2$

$\therefore$ the velocity of liquid at wide part is less than that at narrow part ✓

(4)

(i) A floating body displaces its own weight of the fluid in which it floats.

(ii)



Pressure on face AB, $P_1 = H + h_1\rho g$

Force " " " $F_1 = (H + h_1\rho g)A$

Pressure on face CD, $P_2 = H + h_2\rho g$

Force on " " " $F_2 = (H + h_2\rho g)A$

Net upward force $= F_2 - F_1$

upthrust $= (H + h_2\rho g)A - (H + h_1\rho g)A$

$= (h_2 - h_1)\rho g A$

$= h\rho g A$ ... (i)

Volume ~~Weight~~ of fluid displaced $= hA$

Mass of fluid displaced $= hA\rho$

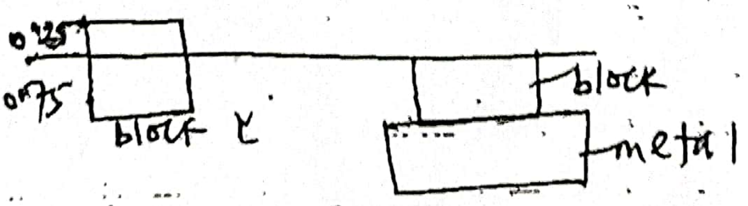
weight of fluid displaced $= hA\rho g$ ... (ii)

from (i) = (ii)

$\Rightarrow$ upthrust = weight of fluid displaced

4

(iii) Initially



Let V_m = Volume of metal

V_w = Volume of water displaced.

V_b = Volume of wooden block

ρ_b = density of wooden block

$$0.75 = \frac{\text{density of block}}{\text{density of water}} = \frac{\rho_b}{1000}$$

$\Rightarrow \rho_b = 750\ Kg\,m^{-3}$ ✓

$$V_b = \frac{M_b}{\rho_b} = \frac{500}{750} = 0.667\ m^3$$ ✓

Later

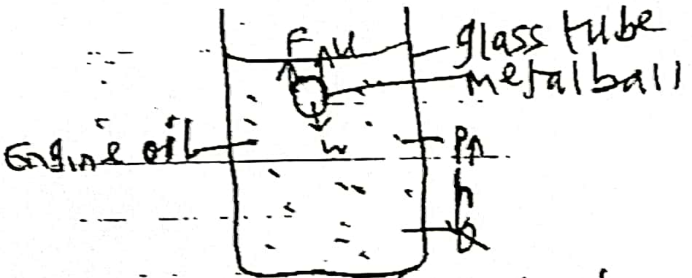
mass of block + mass of metal = mass of water displaced.

$\rho_b V_b + \rho_m V_m = \rho_w V_w = \rho_w (V_b + V_m)$ ✓

$$V_m = \frac{(\rho_b - \rho_w)V_b}{\rho_w - \rho_m} = \frac{(750-1000)\times 0.667}{(1000-900)}$$ ✓

$= -1.6675\ m^3$ ✓ 5

d)



- Engine oil of known density, ρ is put in a glass tube
- Two reference marks P and Q are marked on the glass tube, distance, h between P and Q is measured ✓
- Diameter of ball bearing is measured and its radius, r is determined. ✓
- Metal ball bearing of known density, σ is dropped into oil ✓
- Time taken for the ball to fall from P to Q is measured ✓

terminal velocity, $V_o = h/t$ ✓

- Experiment is repeated with different metal ball bearings of different radii.
- Plot a graph of V_o against r^2 ✓
- Calculate the slope, s ✓

$$\eta = \frac{2g(\sigma-\rho)}{9S}$$ ⑥

5

Precautions

- Glass tube should be wide compared to the size/diameter of the ball bearing. any one 1
- Temperature should be constant.

3. a(i) Parking orbit – Path in space of a satellite which makes it appear to be stationary relative to an observer at a point ~~on~~ on the earth. 1

(ii) $\frac{GMm}{r^2} = \frac{mv^2}{r}$ but $v = \omega r = \frac{2\pi r}{T}$, $T = 24h$

$$\frac{GM}{r} = \frac{4\pi^2 r^2}{T^2}$$

$$r = \sqrt[3]{\frac{GMT^2}{4\pi^2}} \text{ or } r = \sqrt[3]{\frac{gR_e^2 T^2}{4\pi^2}}$$

4

$$= \sqrt[3]{\frac{9.81 \times (6.4 \times 10^6)^2 \times (24 \times 3600)^2}{4 \times (3.14)^2}}$$

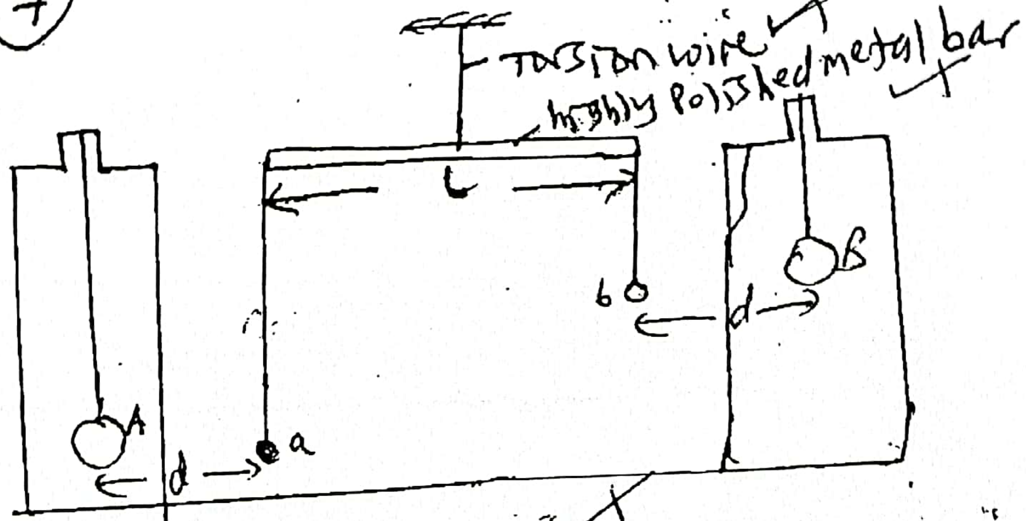
$r = 4.24 \times 10^7 m$

$h = r - r_e = 4.24 \times 10^7 - 6.4 \times 10^6$

$= 3.6 \times 10^7$ m

(7)

3b(i)



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 metal bar of known length, L

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

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

– distance, d between spheres is measured

– because of attraction of the 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) is measured by lamp and scale method.

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

2

4

(ii) Precautions:

– Torsion wire should be very sensitive such that big enough deflections are obtained.

– whole setup of apparatus should be small such that it can be screened from air convectional currents.

1

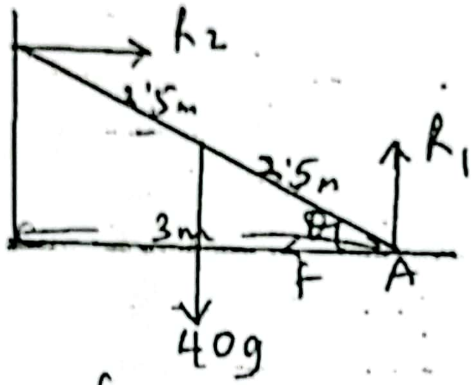
(8)

c) - Resultant force on a body is zero
- Sum of clockwise moments about a point is equal to sum of anticlockwise moments about the same point

or the algebraic sum of moments of the forces about a point is zero.

2

d)



$\cos\theta = 3/5$

$\sin\theta = 4/5$

(i)

$\rightarrow$ $R_2 = f$

$\uparrow$ $R_1 = 40g = 40 \times 9.81 = 392.4N$

moments about A.

$40g \times 2.5\cos\theta = R_2 \times 5\sin\theta$

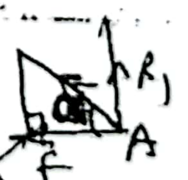
$40g \times 2.5 \times 3/5 = R_2 \times \cancel{5} \times \frac{4}{\cancel{5}}$

$R_2 = f = 147.15N$

$\mu = \frac{f}{R_1} = \frac{147.15}{392.4} = 0.375$

3

(ii) Force at A $= \sqrt{R_1^2 + f^2}$



$= \sqrt{(392.4)^2 + (147.15)^2}$

$= 419.083 N$

3

direction

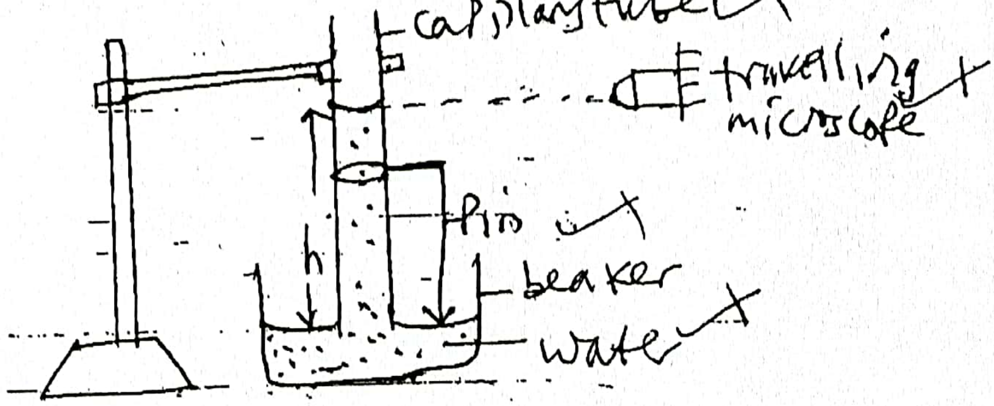
$\tan\alpha = \frac{R_1}{f} = \cancel{147.15} \; \frac{392.4}{147.15}$

69.44° ✗

4(a) Surface tension - The work done to increase the
(i) surface area of a liquid film by $1m^2$ under
Isothermal conditions. 1
OR It is the force per unit length acting on the
surface of liquid at right angles to one
side of an imaginary line drawn in the
liquid surface.

Angle of contact - Angle between the
solid surface and the tangent to the meniscus 1
at point of contact measured through the liquid.

(ii)



2

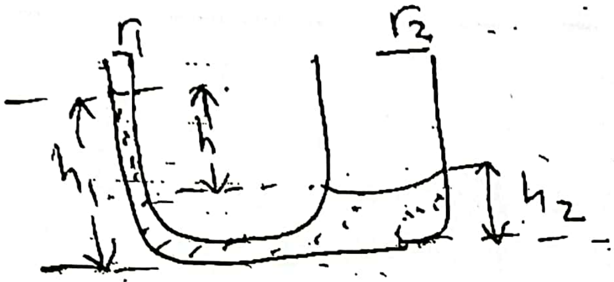
A clean capillary tube supported by a clamp and stand
is dipped into water of known density, ρ and
angle of contact, θ
A pin bent at right angles is tied onto
the capillary tube and its position is adjusted
until its pointed end just touches the
horizontal liquid surface
- travelling microscope is focussed onto the
meniscus and scale reading h_1 is noted.
- Beaker is removed and travelling microscope is 3
focussed onto the pointed end of the pin and
scale reading, h_2 is noted.
- $h = |h_1 - h_2|$

(10)

- Internal diameter of tube is measured using travelling microscope, radius, $r = d/2$

$$\gamma = \frac{hr\rho g}{2\cos\theta}$$

b)



$$h_1 = \frac{2\gamma\cos\theta}{r_1\rho g}, \quad h_2 = \frac{2\gamma\cos\theta}{r_2\rho g}$$

$$h = h_1 - h_2$$

$$= \frac{2\gamma\cos\theta}{\rho g}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$1.25\times10^{-2} = \frac{2\times0.075}{\rho\times9.81}\left(\frac{1}{0.5\times10^{-3}} - \frac{1}{1.6\times10^{-3}}\right)$$

$$\rho = 1681.96\ \mathrm{Kg\,m^{-3}}$$

(OR can use pressure differences)

4

c(i) The free surface of a liquid of a given volume at rest has the minimum number of molecules, tends to have the least potential energy and hence least surface area. For a given volume, a sphere has the least surface area. Hence the free surface of a liquid is spherical 3

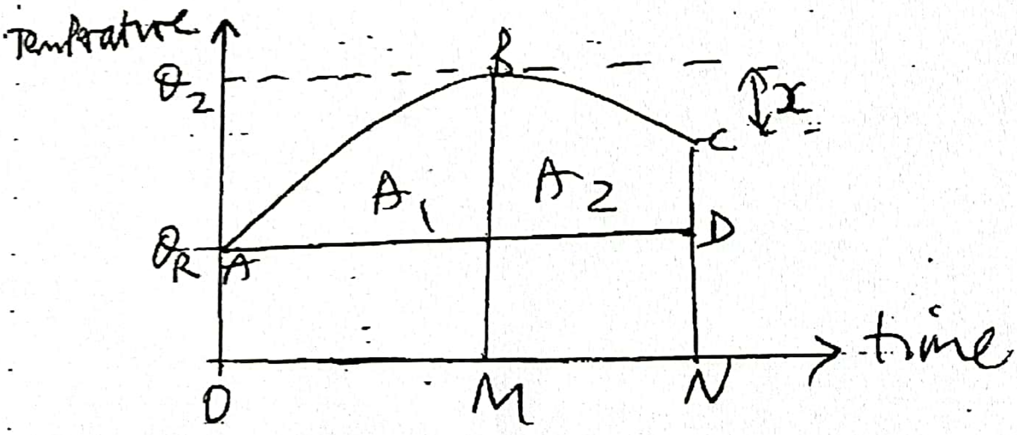
(ii) see back page

SECTION B (11)

5 a) i) Tripple Point of water – Temperature at which pure water, water vapour and pure ice exist in equilibrium. 1

(ii) Cooling Correction – Extra temperature difference/ no of °c added to the observed maximum temperature of the mixture to cater for heat losses during heating / temperature rise. 1

b) Temperature of the surrounding / room temperature, θ_R is recorded / noted
- A solid is heated in boiling water for some time and then quickly transferred into water in a calorimeter and stop clock started immediately. Water is stirred and temperature recorded after suitable time intervals until temperature of the mixture has fallen by ≃ 1°c below the observed maximum temperature
- Results are tabulated
- A graph of temperature against time is plotted.



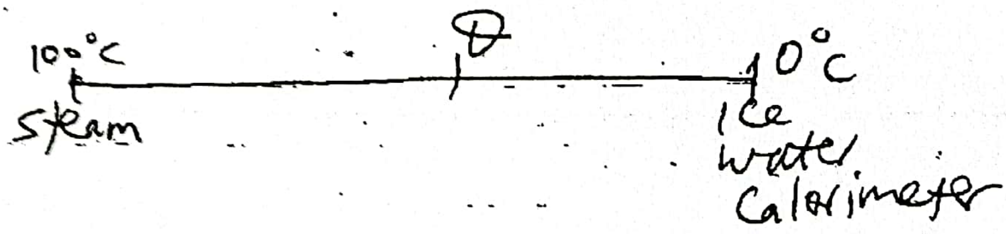
- ~~drawn a vers~~
- A vertical line BM is drawn through the highest temperature θ_2
- Another vertical line CN is drawn such that OM ≃ MN
- A horizontal line AD is drawn through θ_R
- Areas A_1 and A_2 are estimated by counting

squares on the graph.

~~Area~~ value of temperature, x is recorded.

– cooling correction, $\Delta\theta = \frac{A_1}{A_2}x$ 6

c(i)



$m_s L_v + m_s c_w(100-\theta) = m_i L_f + (m_i+m_w)c_w(\theta-0) + m_c c_c(\theta-0)$

$\frac{10}{1000}\times 2.26\times10^6 + \frac{10}{1000}\times 4200(100-\theta) = \frac{50}{1000}\times 3.4\times10^5 \times \frac{170}{1000}\times 4200\,\theta + 80\theta$

$26800 + 42\theta = 17000 + 714\theta + 80\theta$ 5

$\theta = 13.03°C$

(ii) steam contains more heat in form of latent heat than boiling water.
So when steam condenses to form water it gives out 2.26×10^6 J/kg more heat than boiling water at the same temperature. 2
Since steam gives out more heat, it is better than boiling water for heating purposes.

d(i) Gas thermometers are more sensitive than ~~(iii)~~ mercury thermometers
– Gas thermometers are very accurate (2)
– Gas thermometers have a wide range of temperature
(any two)

(15)

5 d(ii) $\theta = \left(\frac{R_{50} - R_0}{R_{100} - R_0}\right) \times 100°c$

$= \left(\frac{1.878 - 1.510}{2.160 - 1.510}\right) \times 100°c$

$= 56.62°c$

Difference in temperature $= 56.62 - 50 = 6.62°c$

3

6 a(i) Kinetic theory of gases – states that gases are made up of small particles called molecules which are held by very weak intermolecular forces of attraction. These molecules are in continuous random motion.

1

(ii) $P = \frac{1}{3}\rho\overline{C^2} = \frac{1}{3}\frac{Nm}{V}\overline{C^2}$

$PV = \frac{2}{3}N(\frac{1}{2}m\overline{c^2})$ where $\frac{1}{2}m\overline{c^2} = \frac{3}{2}K_BT$

Consider two gases

1st: $P_1V = \frac{2}{3}N_1(\frac{1}{2}m_1\overline{c_1^2}) = \frac{2}{3}N_1(\frac{3}{2}K_BT)$

2nd: $P_2V = \frac{2}{3}N_2(\frac{1}{2}m_2\overline{c_2^2}) = \frac{2}{3}N_2(\frac{3}{2}K_BT)$

when mixed

$(P_1+P_2)V = \frac{2}{3}N_1(\frac{1}{2}m_1\overline{c_1^2}) + \frac{2}{3}N_2(\frac{1}{2}m_2\overline{c_2^2})$

$= \frac{2}{3}N_1(\frac{3}{2}K_BT) + \frac{2}{3}N_2(\frac{3}{2}K_BT)$

$= (N_1+N_2)K_BT$

let $N = N_1 + N_2$

$(P_1+P_2)V = NK_BT$ but $PV = NK_BT$

$\Rightarrow (P_1+P_2)V = PV$

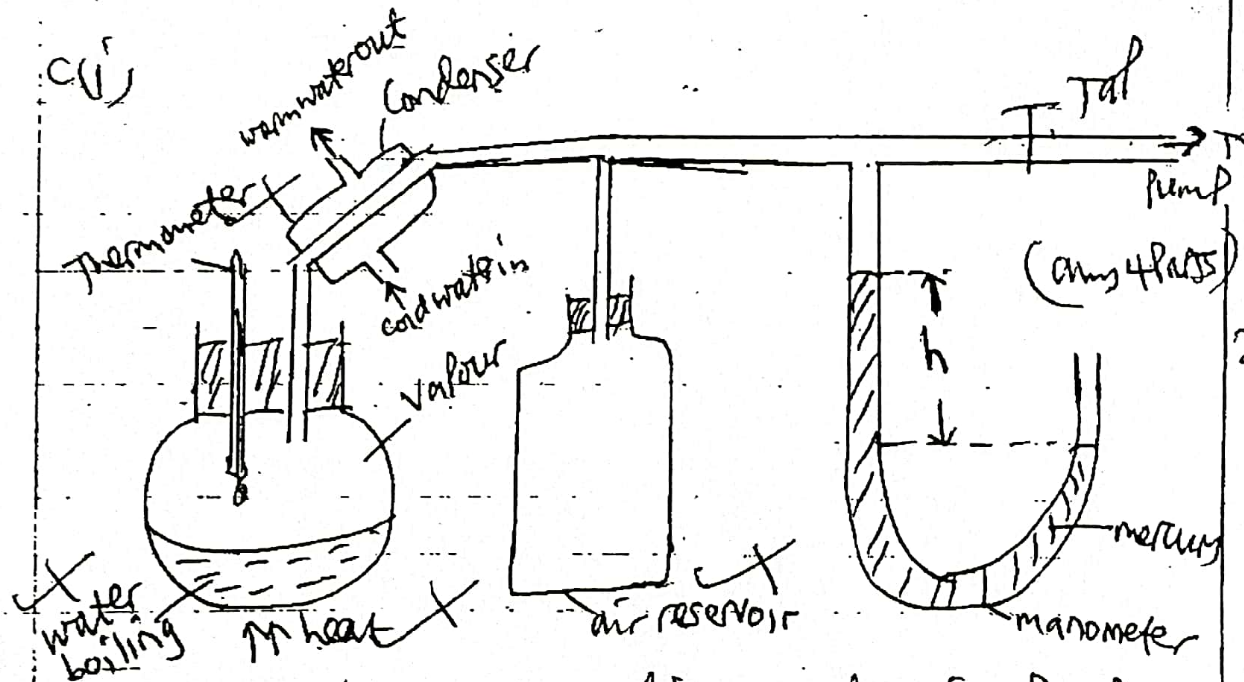
$\therefore P = P_1 + P_2$

4

b (i) ~~For~~ a fixed number of molecules, when pressure is very low, volume increases. The gas molecules will be ~~very~~ few and much further apart. Therefore molecules of a real gas occupy negligible volume compared to that of the container, hence real gas behaves as ideal gas. 2

(ii) During driving, because of friction between the tyre and the road, temperature of the tyre and that of air molecules inside increases. Since $KE \propto T$, kinetic energy of air molecules increases. Since volume of air in tyre is constant, pressure of ~~tyre~~ the air inside the tyre increases due to increase in temperature. 3

c(i)



2

- Pressure above the liquid is varied using a pump when the tap is open.
- Tap is closed and water is heated until 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 buildup.
- Difference in mercury levels, h is measured.
- Atmospheric pressure, H, is measured using barometer.

(15)

- $S.V.P = H - h\rho g$ H measured
  (ρ = density of mercury)
- experiment is repeated by varying pressure above the liquid.
- a graph of S.V.P against T is plotted.
- from the graph S.V.P increases with temperature.

(ii) $T_1 = 20 + 273 = 293K$

$P = 128 mmHg$

$P_s = ?$

$P_a = ?$

$T_2 = 78 + 273 = 351 K$

$P = 860 mmHg$

$P_s = 760 mmHg$

$P = P_a + P_s$

$P_a = 860 - 760$

$= 100 mmHg$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

At boiling point, S.V.P = atmospheric pressure

$$\frac{P_a}{293} = \frac{100}{351} \Rightarrow P_a = 83.48 mmHg$$

$P = P_a + P_s$

$128 = 83.48 + P_s \Rightarrow S.V.P = 44.52 mmHg.$

4

16

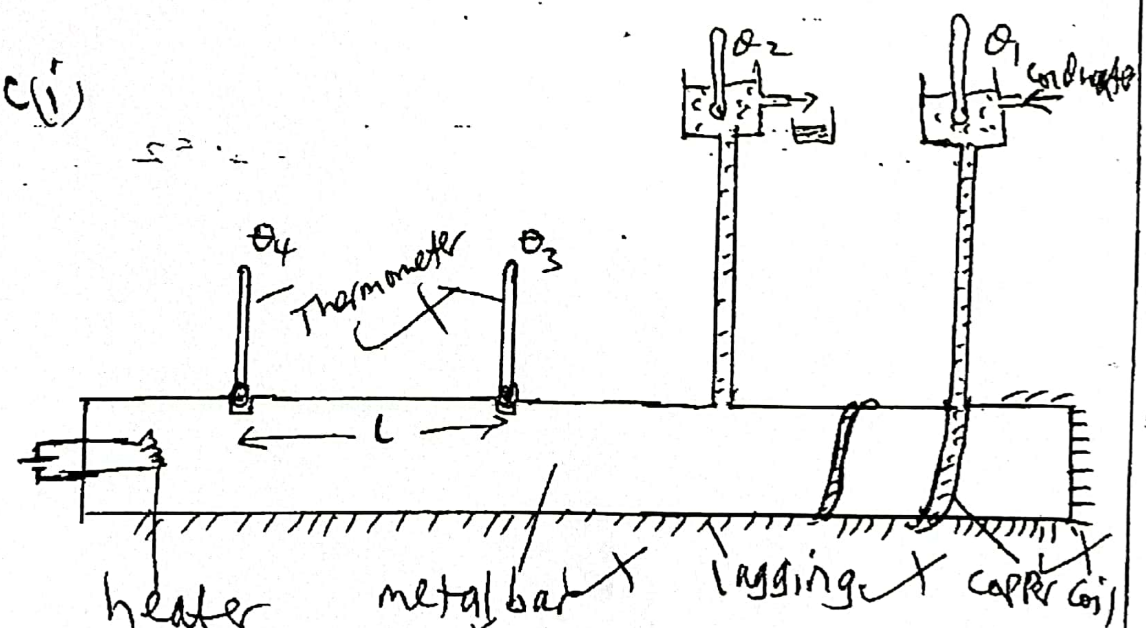
7 a(i) This is the rate of heat flow through a material per unit cross-sectional area per unit temperature gradient. 1

(ii) heat current - This is the rate of heat flow per unit time in a material. 1

b(i) It states that the wavelength corresponding to the maximum intensity is inversely proportional to the absolute temperature of a black body.

(ii) As temperature is increased the wavelength at maximum intensity is displaced towards the shorter wavelength region. Hence the word displacement is used. 2

c(i)



2

- Two holes are drilled in the metal bar at a known distance, l from each other.
- Thermometers are put in the holes which are filled with mercury/oil
- diameter, d of metal bar is measured using micrometer screw gauge, cross-sectional area, $A = \frac{\pi d^2}{4}$

17

is calculated
- one end of the metal bar is heated while the other end is cooled with help of water flowing in copper coil.
- The experiment is left to stand until a steady state is reached.
- Temperatures $\theta_1, \theta_2, \theta_3, \theta_4$ are noted.
- water of known s.h.c, C flowing in copper coil is collected in measured time, t.
- mass per second, m/t is calculated.

$$K = \frac{\frac{m}{t} C(\theta_2 - \theta_1)}{A\left(\frac{\theta_4 - \theta_3}{L}\right)}.$$

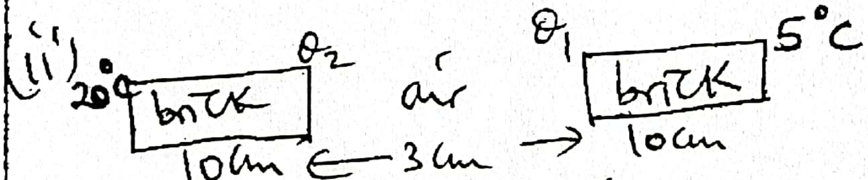
4

(ii) - Rate of heat flow through the conductor is measurable.
- Temperature gradient can be measurably steep.

2

d) (i) Because no heat is lost through the sides or no heat is lost transverse to the direction of heat flow, since it's assumed that the body is perfectly lagged.

(ii)



$$Q/t = KA\frac{\Delta\theta}{L}$$

$$\frac{K_b A(20-\theta_2)}{L_b} = K_a\frac{A(\theta_2-\theta_1)}{L_a} = \frac{K_b A(\theta_1 - 5)}{L_b}$$

$$20 - \theta_2 = \theta_1 - 5$$

$$\theta_1 + \theta_2 = 25 \text{ ---- (i)}$$

(18)

$$\frac{2.4\times10^{-2}(\theta_2-\theta_1)}{3\times10^{-2}} = \frac{8\times10^{-1}(\theta_1-5)}{10\times10^{-2}}$$

$$\theta_2-\theta_1 = 10(\theta_1-5) \quad \text{(ii)}$$

$$\theta_2-\theta_1 = 10\theta_1-50$$

$$\text{(i)}-\text{(ii)}$$

$$2\theta_1 = 75-10\theta_1$$

$$\Rightarrow \theta_1 = 6.25^\circ C, \quad \theta_2 = 18.75^\circ C$$

$$\Rightarrow \frac{Q}{At} = \frac{K_b(20-\theta_2)}{L_b}$$

$$= \frac{8\times10^{-1}(20-18.75)}{0.1}$$

$$= 10\ Wm^{-2}$$

5 a) (i) Positive rays – streams of positive gas ions. 01 1

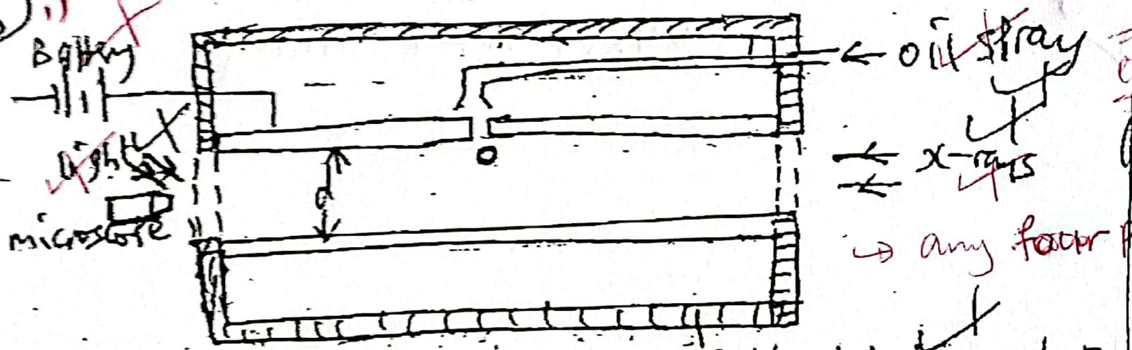
(ii)

Cathode rays	Positive rays (first two)
- Negatively charged	Positively charged
- Travel with same velocity	Exhibit a range of velocities
- Lighter.	heavier
- Deflected more in electric and magnetic fields	Deflected less in electric and magnetic fields
- Produce x-rays when strike hard metal surface	Cannot produce x-rays

02 (2

↳ first two

b) (i)



02 (2)

↳ any four parts

- oil is sprayed through a small hole in the upper metal plate
- oil drops acquire charge by friction or x-rays
- with no p.d, a suitable drop is selected, distance, x it falls in time t is obtained and terminal velocity, $V_0 = \frac{x}{t}$ is calculated.

U = upthrust
F = viscous drag
W = weight

$$W = F + U \quad \text{--- (i)}$$
$$W - U = F$$

$$\frac{4}{3}\pi r^3 \sigma g = 6\pi r \eta V_0 + \frac{4}{3}\pi r^3 \rho g$$

$$r = \sqrt{\frac{9V_0\eta}{2g(\sigma-\rho)}}$$

[must define symbols]

04

(20)

- A p.d V is applied across the plates and it is adjusted until the drop becomes stationary
- p.d V, plate seperation d are measured

$E = V/d$ is calculated.

$$W = F_e + U$$

$$\text{or } W - U = F_e \text{ --- (ii)}$$

from (i) and (ii)

$$F_e = F$$

$$EQ = 6\pi r\eta V_0$$

$$Q = \frac{6\pi r\eta V_0}{E}$$

or

$$Q = \frac{\frac{4}{3}\pi r^3 g(\sigma - \rho)}{E}$$

when r is substituted Q can be obtained. The experiment is repeated for several oil drops and the charge on each drop is an integral multiple of electronic charge, e.

max 4

(ii) Small drops can easily acquire terminal velocity before striking the lower plate since seperation of plates is small. 02

2

c)

$$W = F + U$$

$$\frac{4}{3}\pi r^3 \sigma g = 6\pi r\eta V_0 + \frac{4}{3}\pi r^3 \rho g$$

(21)

$V_0 = 2.5 \times 10^{-2}\, cm\,s^{-1}$

$\eta = 1.8 \times 10^{-5}\, N\,s\,m^{-1}$

$$r = \sqrt{\frac{9 V_0 \eta}{2g(\sigma - \rho)}}$$

$$= \sqrt{\frac{9 \times 2.5 \times 10^{-4} \times 1.8 \times 10^{-5}}{2 \times 9.81 (900 - 1.29)}}$$

$$= \cancel{1.512 \times 10^{-6}}\ m$$

$1.514 \times 10^{-6} m$

3

(ii) $E = \frac{V}{d} = \frac{1500}{1.5 \times 10^{-2}} = 1 \times 10^{5}\ V m^{-1}$

F_e U W

$$W = U + EQ$$

$$\frac{4}{3}\pi r^3 \sigma g = \frac{4}{3}\pi r^3 \rho g + EQ$$

$$Q = \frac{\frac{4}{3}\pi r^3 g(\sigma - \rho)}{E}$$

$$= \frac{\frac{4}{3} \times 3.14 \times (1.54 \times 10^{-6})^3 (900 - 1.29) \times 9.81}{1 \times 10^{5}}$$

$$= \cancel{1.37 \times 10^{-19}}\ C$$

1.285×10^{-18}

$1.285 \times 10^{-18} c$

3

$$n = Q/e = \frac{\cancel{1.37 \times 10^{-19}}}{1.6 \times 10^{-19}} = 8 \text{ electrons}$$

1.285×10^{-18}

(iii) $Q = 10e = 10 \times 1.6 \times 10^{-19}\, C = 1.6 \times 10^{-18}\, c$

F_e U W F_V

$$EQ + U = W + F_V$$

$$EQ = (W - U) + F_V$$

22

$EQ = \frac{4}{3}\pi r^3 g(\sigma - \rho) + 6\pi \eta r V$

$1\times10^{5} \times 4.8\times10^{-19} = \frac{4}{3}\times3.14\times(1.52\times10^{-6})^3(900-1.29)\times9.81 + 6\times3.14\times1.52\times10^{-6}\times1.8\times10^{-5}V$

1.6×10^{-13} 1.614 1.54×10^{-6}

$4.8\times10^{-14} = \cancel{1.32\times10^{-14}} + 5.155\times10^{-10}V$

1.30×10^{-13}

$V = 6.75\times10^{-5}\,ms^{-1}$

3

$\cancel{4.8\times10^{-14}} = 1.30\times10^{-13} + 5.155\times10^{-10}V$

$1.6\times10^{-13} = 1.28\times10^{-13} + 5.134\times10^{-10}V$

$V = -1.591\times10^{-4}\,ms^{-1}$

$= 1.59\times10^{-4}\,ms^{-1}$ (falling)

$V = 6.175\times10^{-5}\,ms^{-1}$

03

20

9 a) i) Ionisation Potential – is the Potential difference through which an electron is accelerated from rest in order to ionise a given atom.

01

(ii) When a gas is heated to a high temperature, atoms are excited and electrons jump to a high energy level. When the electrons fall back to a lower energy level to fill vacancy left, electromagnetic radiation is emitted and a line is formed on the spectrum. The lines are separated and discontinous. This gives evidence that energy levels of an atom are seperate / discrete.

3

03

(23)

9 b) Excitation potential, $V = \frac{\text{excitation energy}}{e}$ ✓

$= \frac{10.4eV}{e} = 10.4V$ ✓

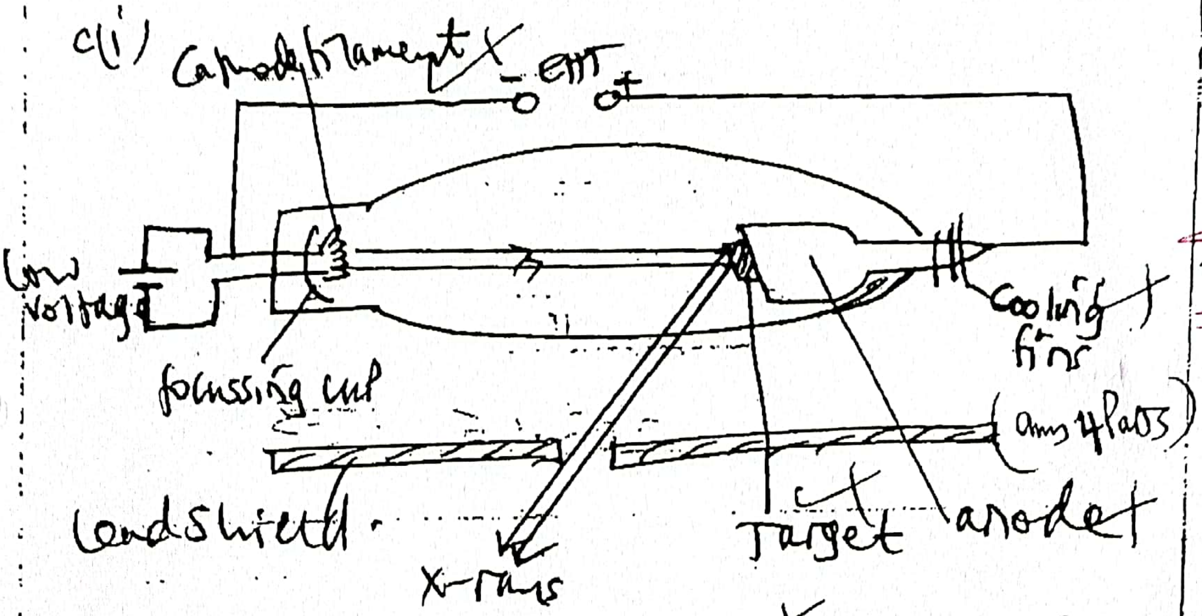
But $\frac{1}{2}mu^2 = eV$ ✓

$u = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 10.4}{9.11 \times 10^{-31}}}$ ✓

$= 1.911 \times 10^6 ms^{-1}$ ✓

3

c(i)



2

- Filament is heated by low voltage and it emits electrons by thermionic emission.
- electrons emitted are accelerated by EHT between cathode and anode. ✓
- On striking the target, most kinetic energy of electrons is lost into heat and the rest into X-rays ✓
- The heat is conducted through the anode and is cooled by cooling fins ✓

3

(ii)
- Incident x-rays must be parallel ✓
- The wavelength ~~must be~~ of the same order as the inter-atomic spacing ✓

02

(24)

d) (i) $2d\sin\theta = n\lambda$

$2\times2.82\times10^{-10}\sin 15.5 = 1\lambda$

$\lambda = 1.507\times10^{-10}\ m$

for maximum order, $\theta = 90^\circ$.

$n = \frac{2d}{\lambda} = \frac{2\times2.82\times10^{-10}}{1.507\times10^{-10}} = 3.74$

$n_{max} = 4$

04

(ii) $\rho = \frac{M}{2d^3N_A}$

$= \frac{59.5\times10^{-3}}{2\times(2.82\times10^{-10})^3\times6.02\times10^{23}}$

$= 2203.65\ Kg\,m^{-3}$

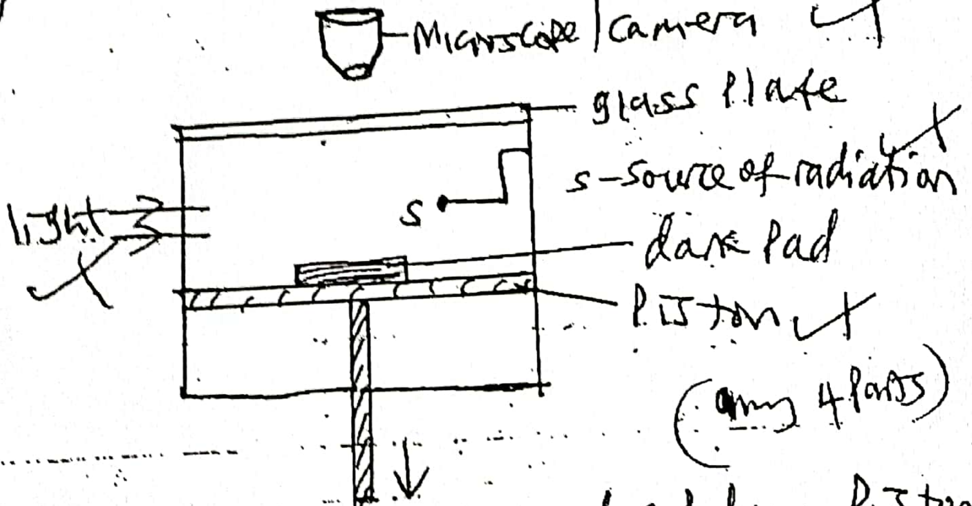
02

(25)

0 a(i) Decay constant – Fractional number of atoms disintegrating per second. 01
or Ratio of activity to the number of radio active atoms in a sample.
or Fractional number of atoms which decay per second.

(ii) Background countrate –
This is activity detected by GM tube in the absence of the radio active source. 01

b(i)



(any 4 parts) 02

– Liquid alcohol is placed on a dark pad on a piston. when the piston is moved down quickly, air undergoes an adiabatic expansion and it cools
– Dust particles are carried away after a few expansions by drops of water falling on them after vapour condensation.
– Dust free air is now subjected to ~~ionizing radiation~~ to controlled expansion making alcohol vapour supersaturated
– air is now subjected to ionizing radiation from source S, ionization of air occurs, vapour condenses and water droplets collect as ions produced. 03
– water droplets reflect light and can be photographed.

... the action of frictional force

(26)

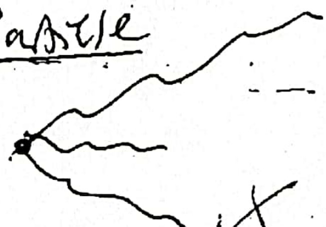
Thickness and length of the paths/traces/trails indicate the extent of ionization and type of ionizing radiation.

(ii) α-Particle.

- Tracks are thick because they have high ionizing power
- Tracks are straight because α-particles are massive (heavy) ∴ cannot be deflected from their paths.
- Tracks are of the same length because they are produced from the source with same speed/energy.

any two 02

β-Particle



- Tracks are thin because they cause less ionization (low ionizing power)
- Tracks are not straight because they are light and can easily be knocked off from their paths
- Tracks have different lengths because they leave the source with different speed/energy.

any two 02

c (i) Plants take in CO_2 which contains radioactive carbon-14 during photosynthesis. When the plant dies, no more CO_2 is taken in and the number of atoms of carbon-14 decreases.

The activity of C-14 in the dead sample, A is obtained and the activity, A_0 in the living sample of C-14 is also obtained.

Since the half life of C-14 is ≃ 5600–5700 years, using $A = A_0 e^{-\lambda t}$ the apparent age, t can be obtained.

03

10 c(ii)

60 g of ^{60}X contains 6.02×10^{23} atoms

5×10^{-6} g ... ... $\frac{6.02 \times 10^{23}}{60} \times 5 \times 10^{-6}$

$= 5.017 \times 10^{16}$

Number of ^{59}X atoms $= \frac{0.25}{100} \times 5.017 \times 10^{16}$

$N = 1.254 \times 10^{14}$ atoms

$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{5.27} = 0.1315\ yr^{-1}$

5

$A = \lambda N$

$= \frac{0.693}{5.27} \times 1.254 \times 10^{14} = 1.649 \times 10^{13}\ yr^{-1}$

after 10 yrs

$A = A_0 e^{-\lambda t}$

$= 1.649 \times 10^{13}\ e^{-\frac{0.693}{5.27} \times 10}$

$= 4.427 \times 10^{12}\ yr^{-1}$

20

END

VB

(d) Industrial use – determine thickness of paper/ironsheets/plastics
– detect leakages in underground pipes carrying oil/water
– determine rate of wear of metals/tyres

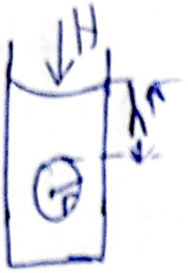
01/2

Health hazard – Can cause Cancer
– Cause deformation of offsprings / genetic damage
– Can damages skin / skin burns / eyes sight
– Can cause sterility (barrenness)

01/2

[illegible]

4 c(ii)



6 copies.

external pressure, $P_1 = H + h\rho g$

let Inside pressure be P_2

$P_2 - P_1 = \frac{2\gamma}{r}$ (γ = surface tension of soap but not given)

$P_2 - (H + h\rho g) = \frac{2\gamma}{r}$

$P_2 - H = \frac{2\gamma}{r} + h\rho g$

$= \frac{2\gamma}{5\times10^{-3}} + 0.5\times1200\times9.81 = 400\gamma + 5886$.

3

(d) let n = number of droplets formed.

using volume conservation.

$\frac{4}{3}\pi r^3 n = \frac{4}{3}\pi R^3 \Rightarrow n = \frac{R^3}{r^3}$

Initial energy = surface area × surface tension

$= 4\pi r^2 n\gamma = 4\pi r^2 \frac{R^3}{r^3} n\gamma = 4\pi \frac{R^3}{r}\gamma$

final energy $= 4\pi R^2\gamma$

Energy released = change in energy

= Initial energy − final energy

$= 4\pi \frac{R^3}{r}\gamma - 4\pi R^2\gamma$

$= \frac{4\pi R^3\gamma}{r} - \frac{4\pi R^3\gamma}{R}$

$= 4\pi R^3\gamma\left(\frac{1}{r} - \frac{1}{R}\right)$ #

(3)