MARKING GUIDE
PHYSICS PAPER ONE
P510/1 (A-LEVEL)
2022
UTEC

1 a)(i) Rate of change of velocity time. 01

(ii) Let V be velocity gained after time t.

Acceleration = $\frac{\text{Change in Velocity}}{\text{Time taken}}$

$a = \frac{V-0}{t}$, $u=0$

$V = at$ —— (i)

Distance Covered = Average Velocity x Time

$S = \frac{(0+V)}{2}xt$

$S = \frac{1}{2}Vt$ —— (ii)

Substituting (i) in (ii)

$S = \frac{1}{2}x at x t$

$S = \frac{1}{2}at^2$.

04

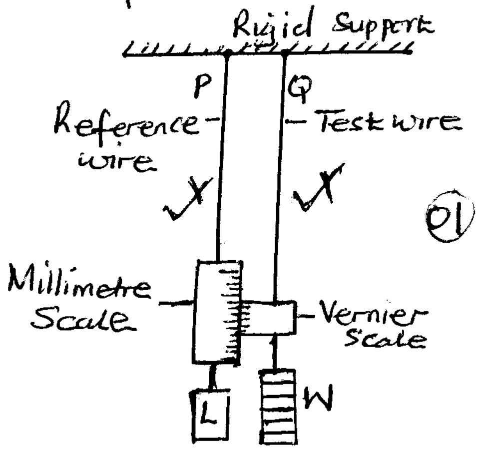
(b) (i) Gradual increase in strain when a material is subjected to a stress for a long time. 01

OR: when a stretching force is applied to a material for a long time.

Give in case of this

(ii) Ability (property) of a material to be pressed/hammered/rolled and forged into useful shapes. 01

(c)



01

- Two identical wires P and Q suspended from the same rigid support.
- Wire P carries a millimetre scale and a load L is suspended on it to make it taut (straight and free of kinks) while wire Q carries a vernier scale.
- Length l of the test wire Q is measured from the rigid support to the vernier and recorded.
- Diameter of the test wire is measured at different points using a micrometer screw gauge, average value d obtained and cross-section area calculated from $A = \frac{\pi d^2}{4}$ and recorded.
- With no weight suspended on wire Q, initial reading x_0 of vernier and scale is read and recorded.
- A small weight W is then suspended on wire Q and new reading x read and recorded ~~and~~ extension is calculated from $e = x - x_0$ and recorded in metres.
- Weight is removed and the reading taken again to ensure that elastic limit is not exceeded.
- Experiment is repeated for increasing weights W and readings taken both when the wire is loaded and when the weight is removed and values of e recorded.
- A graph of values of W is plotted against values of e.

05

- Slope S of the graph is obtained and the ratio of tensile stress to tensile strain (Young's modulus) of the wire is calculated from

$$Y = \frac{Sl}{A} \;\Big|\; E = \frac{Sl}{A}$$ ✓ 06

d)(i) - Length of the wire ✓ 01
- Diameter of the wire ✓ (Any two)
- Extension
- Weights.

(ii) - Two identical wires suspended from same rigid support ✓
- Wire must be thin ✓ 01 (Any two)
- Wire must be long enough
- Wire must be free of kinks

(e)

$d = 0.4cm = 0.004m$

$l = 20cm = 0.20m$

$\alpha = 4.0 \times 10^{-3} K^{-1}$

$\Delta\theta = 35°C - 20°C = 15°C \equiv (15K)$

(i) $e = \alpha l \Delta\theta$ ✓

$= 4.0 \times 10^{-3} \times 0.20 \times 15$ ✓

$= 0.012m$ ✓ 02

(ii) Energy developed in the steel wire $= \frac{EAe^2}{2l}$ ✓

Volume of the wire $= Al$ ✓

Energy density $= \frac{\text{Energy developed}}{\text{Volume}}$

$= \frac{EAe^2}{2l} / Al$

$= \frac{1}{2} E\left(\frac{e}{l}\right)^2$ ✓

$= \frac{1}{2} \times 1.9 \times 10^{11} \times \left(\frac{0.012}{0.2}\right)^2$ ✓

$= \frac{1}{2} \times 1.9 \times 10^{11} \times (0.06)^2$ ✓

$= 3.42 \times 10^{8} Jm^{-3}$ 03

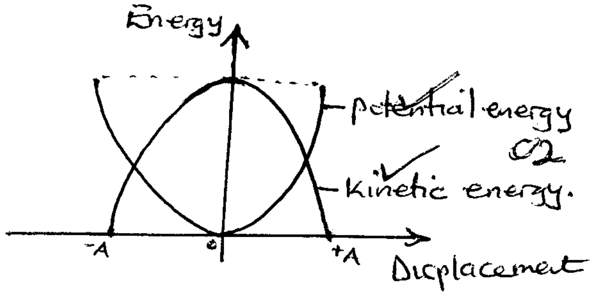
Total = 20mks

2. a) (i) Periodic motion whose acceleration is directly proportional to the displacement from a fixed point and is directed towards the same point. ✓ 01

(ii) - Motion of car engine pistons ✓
- Car shock absorbers ✓ 01 (Any two)
- Operation of pendulum clocks
- Strings of musical instruments (guitars)
- Diving boards.

b) (i) - Motion is periodic ✓
- Acceleration is directly proportional to displacement from a fixed point
- Acceleration is directed towards the fixed point ✓ 02
- Mechanical energy is conserved. ✓

(ii)



(c) (i) Let $K_1 = K$, $K_2 = 2K$.

- If K_o is the combined force constant, then:

$$\frac{1}{K_o} = \frac{1}{K_1} + \frac{1}{K_2}$$ ✓

$$\frac{1}{K_o} = \frac{K_1 + K_2}{K_1 K_2}$$

$$K_o = \frac{K_1 K_2}{K_1 + K_2}$$ ✓

$$= \frac{K \times 2K}{K + 2K}$$

$$= \frac{2K^2}{3K}$$ ✓

$$K_o = \frac{2K}{3}$$

- If applied horizontal force F on the mass produces a ~~total~~ extension x in both springs, then

$$F \propto x$$
$$F = K_o x$$
$$F = \frac{2K}{3}x$$

- When the force is removed, (mass released), it executes s.h.m of acceleration $a\,ms^{-2}$

$$-F = ma$$
$$-\frac{2K}{3}x = ma$$
$$a = -\frac{2K}{3m}x$$

- Comparing with $a = -\omega^2 x$

$$\omega^2 = \frac{2K}{3M}$$
$$(2\pi f)^2 = \frac{2K}{3M}$$
$$f^2 = \frac{2K}{4\pi^2 \times 3M}$$
$$f = \frac{1}{2\pi}\sqrt{\frac{2K}{3M}}$$

05

(ii) $$K_o = \frac{K_1K_2}{K_1+K_2}$$
$$= \frac{80\times100}{80+100}$$
$$= \frac{800\cancel{0}}{18\cancel{0}}$$
$$= \frac{400}{9}$$

Energy developed $= \frac{1}{2}Fx$

$$F = K_o x$$
$$x = \frac{F}{K_o} = \frac{4}{400/9}$$
$$= \frac{4\times9}{400}$$
$$x = 0.09m$$

Energy developed $= \frac{1}{2}\times4\times0.09$

$$= 0.18J.$$

03

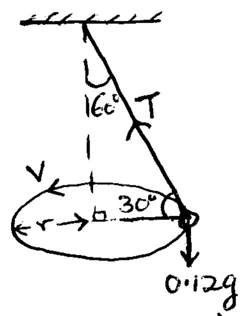
(d) (i) - Centripetal force (Friction force) produces a moment of force on the bodaboda cyclist about the centre of gravity away from the centre of the level circular track then the bodaboda cyclist leans through an angle from the vertical towards the centre of the circular track so that the normal reaction provides a moment of force to the cyclist about the centre of gravity towards the centre of the circular track to counter-balance the moment of the centripetal force to keep the cyclist safe during motion and negotiate the circular track safely.

03

(ii) $T = \frac{\pi}{2}$ seconds

angle $30°$ (To horizontal), $\theta = 60°$ to the vertical

$m = 120g = 0.12kg$



- If V is speed round the circle, then

$$V^2 = rg\tan\theta$$
$$(r\omega)^2 = rg\tan\theta$$
$$\left(\frac{r\times2\pi}{T}\right)^2 = rg\tan\theta$$
$$\frac{4\pi^2r^{\cancel{2}}}{T^2} = \cancel{r}g\tan\theta$$

$$\frac{4\pi^2}{T^2}r = g\tan\theta$$

$$r = \frac{T^2 g\tan\theta}{4\pi^2}$$

$$= \frac{(\frac{\pi}{2})^2 \times 9.81 \times \tan 60^\circ}{4\pi^2}$$

$$= \frac{9.81 \times \tan 60^\circ}{16}$$

$$r = \underline{\underline{1.062\,m.}}$$

03

Total = 20mks

3. a) (i) Friction force acting per unit cross-section area of a pipe on a liquid when flowing in a region of unit velocity gradient. 01

(ii) - radius of the pipe 01
- Coefficient of viscosity of the fluid (Any two)
- pressure gradient

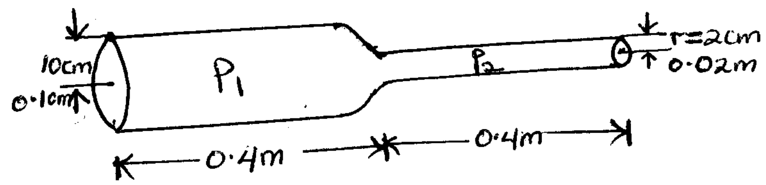
b) (i)

steady flow	turbulent flow
- All particles of the flowing fluid equidistant from the axis of flow have the same velocity and flow parallel to each other (same direction)	- All particles of the flowing fluid equidistant from the axis of flow have different velocities and flow in different directions.

03

(ii) Let P_1 = Pressure difference across the wide pipe

P_2 = pressure difference across the narrow pipe.



$$P_1 + P_2 = 5.2 \times 10^3$$

$$P_1 + P_2 = 5200 \text{ ——— (i)}$$

Volume flow per second $\frac{V}{t} = \frac{\pi r^4 P}{8\eta L}$.

But volume flow per second is the same through both pipes.

$$\frac{\pi \times (0.10)^4 \times P_1}{8 \times 9.0 \times 10^{-3} \times 0.4} = \frac{\pi (0.02)^4 \times P_2}{8 \times 9.0 \times 10^{-3} \times 0.4}$$

$$(0.10)^4 \times P_1 = (0.02)^4 P_2$$

$$0.0001 P_1 = 1.6 \times 10^{-7} P_2$$

$$P_2 = 625 P_1 \text{ ——— (ii)}$$

Substituting (ii) in (i)

$$P_1 + 625 P_1 = 5200$$

$$626 P_1 = 5200$$

$$P_1 = 8.307 \text{ pa}$$

$$P_2 = 625 \times 8.307$$

$$= 5191.875 \text{ pa}.$$

$$\frac{V}{t} = \frac{\pi \times (0.1)^4 \times 8.307}{8 \times 9.0 \times 10^{-3} \times 0.4}$$

$$\frac{V}{t} = 0.091\, m^3 s^{-1}$$

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

$$\rho = \frac{m}{V}$$

$$m = \rho V$$

$$\frac{m}{t} = \rho \times \frac{V}{t}$$

$$= 1000 \times 0.091$$

$$= 91\, kg s^{-1}$$

07

c) (i) – For streamline flow / steady flow / Uniform flow / orderly flow of a non-viscous Incompressible liquid (fluid), the sum of pressure at any part plus K.E per unit volume plus P.E per unit volume is always a Constant. ✓ 01

OR For streamline flow,

$P + \frac{1}{2}\rho v^2 + \rho g h = \text{Constant}$

if a liquid is non-viscous and Incompressible.

Give in case of this

where P = Pressure at any part in the pipe of flow

$\frac{1}{2}\rho v^2$ = K.e per unit volume

$\rho g h$ = P.E per unit volume.

(ii) – Narrow section (part) of a pipe where velocity of flow is high. 01

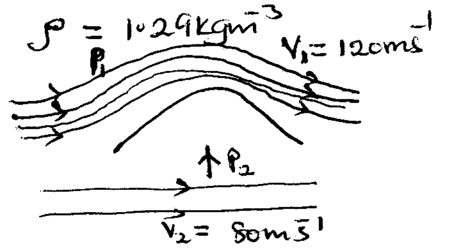
(iii) – Velocity of flow is inversely proportional to radius of the pipe (Cross-section area of the pipe). Thus closing off part of the tap reduces cross-section area leading to high velocity of flow and low pressure ✓ 02

d) $A = 4.0 \times 10^4 cm^2$

$= 4.0 \times 10^4 \times 10^{-4}$

$= 4 m^2$.

$\rho = 1.29 kgm^{-3}$



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

$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$

$P_2 - P_1 = \frac{1}{2}\rho (v_1^2 - v_2^2)$

$P_2 - P_1 = P$ (resultant pressure)

$P = \frac{1}{2} \times 1.29 (120^2 - 80^2)$ ✓

$P = 5160 pa$ ✓

force $F = P \times A$

$= 5160 \times 4$ ✓

$= 20640 N.$ 04

Total = 20mks

4 a) (i) – Space body of small mass moving round a space body of big mass. ✓ 01

(ii) – An orbit where a satellite is observed to be stationary (at rest) from one point on the Earth's surface if its period of rotation round the Earth is equal to that of the ~~Earth~~ round its axis which is 24hrs. 01

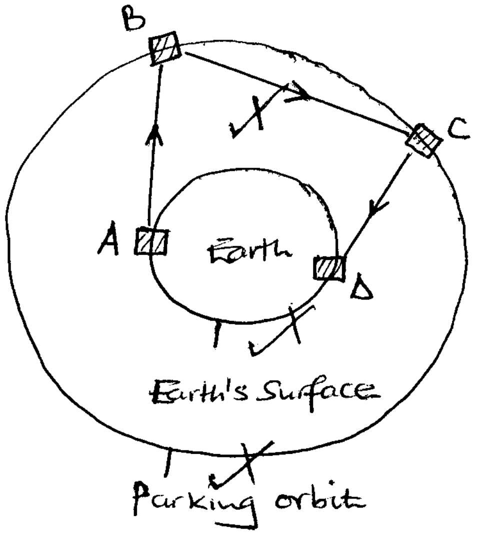
(b) – planets describe ellipses round the Sun as a single focus. ✓

– The imaginary line joining the planet to the Sun sweeps out equal areas in equal time intervals. ✓

– The squares of the periods of revolution of planets round the Sun are directly proportional to the cubes of their mean separation distance from the Sun. ✓ 03

Comment
- The satellite is not in a parking orbit. 01/05

c) (i)



- Satellite A on the Earth's Surface sends Communication signals to satellite B in the parking orbit. Satellite B then sends the signals to satellite C also in the parking orbit and finally C sends the signals to satellite Δ on the Earth's Surface and Communication is Completed. 03

(ii) $h = 42227 km$
$= 42227000 m.$
$r_e = 6.4 \times 10^6 m$

$r = r_e + h$
$= 6.4 \times 10^6 + 42227000$
$= 48627000$
$= 4.8627 \times 10^7 m.$

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

$$T^2 = \frac{4\pi^2 \times (4.8627 \times 10^7)^3}{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}$$

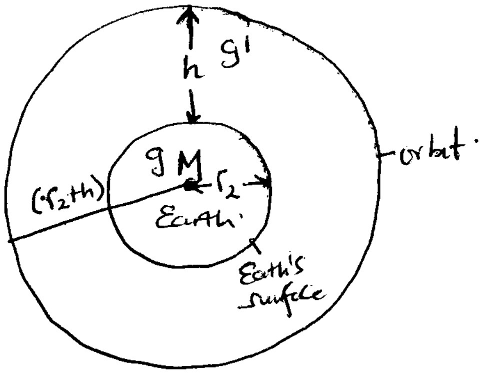
$$T^2 = 1.14 \times 10^{10}$$

$T = 106769.202863$ seconds

$$= \frac{106769.202863}{3600}$$

$T = 30$ hours (Approx)

(d)



- On the Earth's surface, acceleration due to gravity is g

$GM = g r_2^2$ ——— (i)

where M is Mass of the Earth.

- At a height h above the Earth's Surface, $g' = \frac{1}{9} \times g = g/9$

$GM = g'(r_2+h)^2$

$GM = \frac{g(r_2+h)^2}{9}$ ——— (ii)

(i) = (ii)

$$g r_2^2 = \frac{g(r+h)^2}{9}$$

$$9 r_2^2 = (r_2+h)^2$$

$$\sqrt{9 r_2^2} = \sqrt{(r_2+h)^2}$$

$$3 r_2 = r_2 + h$$

$$h = 2 r_2 .$$ 04

d) – Friction between the surface of the satellite and air molecules forces the satellite to reduce radius of orbit. Mechanical energy and potential energy of the satellite reduce while its kinetic energy increases. The satellite speeds up leading to heat generation all over its surface and it can eventually burn out if no precautions are taken. 03

Total = 20mks

5 a) (i) A fraction $\frac{1}{273.16}$ of the tripple point of water. 01

(ii) – The value of X is determined at tripple point (t_r) and recorded as X_{tr}.

– The value of X is then determined at unknown but required temperature (T) and recorded as X_T. 02

– Kelvin scale is given by

$$T = \frac{X_T}{X_{tr}} \times 273.16K$$

b) (i) – Should vary linearly and continuously with change in temperature

– Should give one reading at a particular temperature 01 (Any two)

– Should remain constant at constant temperature.

– Should be accurately remeasurable for a wide range of temperatures using simple apparatus.

(ii) – The thermometric property is length l of liquid column in a glass capillary tube.

– The thermometer bulb is inserted in an ice-water mixture (at 0°c) and length of liquid column measured and recorded as l_0.

– The bulb is then inserted in steam from boiling water (100°c) and length of liquid column measured and recorded as l_{100}.

– Finally the thermometer bulb is inserted in a substance of unknown but required temperature (θ°c) and length of liquid column measured and recorded as l_θ

– Since length varies linearly and continuously with change in temperature, then

$$\theta = \frac{l_\theta - l_0}{l_{100} - l_0} \times 100°C. \quad 03$$

c) $R = R_0(4 + \beta t^2)$

At $t = 10°c$, $R = 40\Omega$

$$40 = R_0(4 + \beta \times 10^2)$$

$$40 = R_0(4 + 100\beta) \quad \text{(i)}$$

At $t = 25°c$, $R = 60\Omega$

$$60 = R_0(4 + \beta \times 25^2)$$

$$60 = R_0(4 + 625\beta) \quad \text{(ii)}$$

(i) ÷ (ii)

$$\frac{40}{60} = \frac{R_0(4 + 100\beta)}{R_0(4 + 625\beta)}$$

$$\frac{2}{3} = \frac{4+100\beta}{4+625\beta}$$

$$2(4+625\beta) = 3(4+100\beta)$$

$$8 + 1250\beta = 12 + 300\beta$$

$$1250\beta - 300 = 12 - 8$$

$$950\beta = 4$$

$$\beta = \frac{4}{950} = 4.21\times10^{-3}\,K^{-1}\,(^\circ c^{-1})$$

Substituting β in (i)

$$40 = R_0(4 + 100\times4.21\times10^{-3})$$

$$40 = 4.421R_0$$

$$R_0 = 9.05\,\Omega$$

$$R = 9.05(4 + 4.21\times10^{-3}t^2)$$

At $t = 40^\circ c$

$$R = 9.05(4 + 4.21\times10^{-3}\times40^2)$$

$$= 97.1608$$

$$= 97.16\,\Omega$$

05

d) (i) - placing a copper calorimeter in an Insulator jacket
- polishing / silvering surface walls of the calorimeter (Any two) 01
- placing the copper calorimeter on a wooden block / cotton threads / Insulator ring.
- Surrounding the calorimeter by a vacuum.

(ii) - According to $-\frac{d\theta}{dt} \propto \frac{A}{V}$, the rate of heat loss of a body is inversely proportional to volume of the body. Since mass of the body is directly proportional to volume, rate of heat loss is Inversely proportional to mass of the body, hence the smaller the mass the higher the rate of heat loss (rate of cooling) of a body. 02

e)
$$\begin{pmatrix}\text{Heat carried}\\\text{by steam}\end{pmatrix} + \begin{pmatrix}\text{Heat lost}\\\text{by steam}\\\text{condensing}\\\text{from }100^\circ C\\\text{to }10^\circ c\end{pmatrix} = \begin{pmatrix}\text{Heat}\\\text{needed}\\\text{to melt}\\\text{ice}\end{pmatrix} + \begin{pmatrix}\text{Heat gained}\\\text{by water}\\\text{from melted}\\\text{ice, by water}\\\text{and copper}\\\text{calorimeter}\\\text{raising their}\\\text{temperature}\\\text{from }0^\circ c\text{ to }10^\circ c\end{pmatrix}$$

$$m_sL_v + m_sC_w(100-10) = m_iL_f + (m_iC_w + m_wC_w + C)(10-0)$$

$$m_s\times2.3\times10^6 + m_s\times4200\times90 = 0.15\times3.34\times10^5 + (0.15\times4200 + 0.25\times4200 + 40)(10)$$

$$2678000m_s = 50100 + 17200$$

$$2678000m_s = 67300$$

$$m_s = \frac{67300}{2678000}$$

$$= 0.025\,kg$$

Total mass of water in the calorimeter $= m_s + m_i + m_w$

$$= (0.025 + 0.15 + 0.25)\,kg$$

$$= 0.425\,kg$$

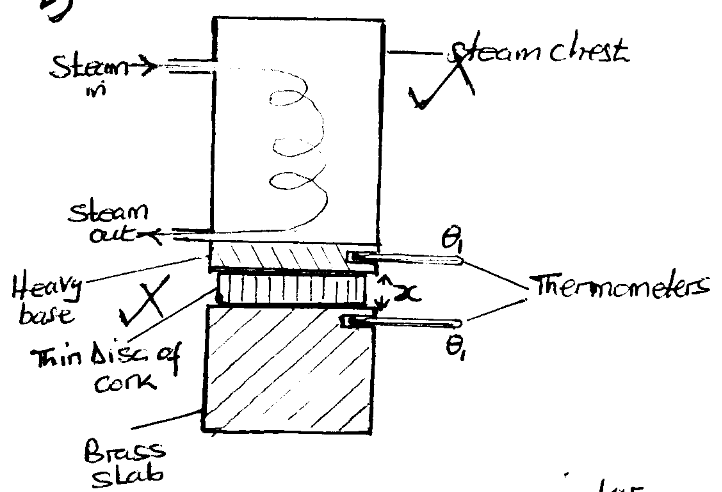
05

Total marks = 20

6 a) (i) Process of heat transfer through a material solid without movement of a solid as a whole. 01

(ii) A solid is made up of molecules which are closely packed together. When heat is supplied to one end of the solid, molecules gain heat energy and vibrate in their mean position with increased amplitudes. During vibration, molecules collide with their adjacent neighbours and lose some of the heat energy setting them also into vibration and also collide with other molecules. The process continues causing heat transfer from the hot end of the solid to the other. 03

b)



- Cork is designed into a circular disc of thickness x and area $A = \frac{\pi d^2}{4}$, d is its diameter.
- The disc is placed on a brass slab of mass m and specific heat capacity c.
- The disc is then heated from above using steam passed into the steam chest.
- The apparatus is left to run until the thermometers indicate steady temperatures θ_2 and θ_1, noted and recorded.
- At steady state, heat flows through the disc at a uniform rate.

$$\frac{dQ}{dt} = KA\frac{(\theta_2-\theta_1)}{x} \quad \text{(i)},$$

Where, K is the required thermal conductivity
- The disc is then removed and the brass slab is directly heated by the steam chest until its temperature is slightly above θ_1 by about $10^\circ C$.
- The steam chest is removed and the disc is placed back on the brass slab.
- Temperature of the brass slab is recorded in equal time intervals as it loses heat through the disc.
- A graph of values of temperature is plotted against time and the rate of temperature fall $\frac{\Delta\theta}{\Delta t} = S$ is determined by drawing a tangent on the curve at a temperature θ_1
- Rate of heat flow through the disc from the brass slab is

$$\frac{dQ}{dt} = mcS \quad \text{(ii)}$$

- Using equations (i) and (ii), thermal conductivity of cork is calculated from

$$K = \frac{mcS}{A\frac{(\theta_2-\theta_1)}{x}}.$$

06

c) $P = \frac{dQ}{dt} = 100W$

$d = 10.0cm = 0.10m$

$A = \frac{\pi d^2}{4} = \frac{\pi (0.10)^2}{4}$

$= 7.854 \times 10^{-3} m^2$

$x = 2.5cm = 0.025m$

$K = 110 Wm^{-1}K^{-1}$

Let temperature be θ

$\frac{dQ}{dt} = KA(\theta - 55)$

$100 = 110 \times 7.854 \times 10^{-3} \frac{(\theta - 55)}{0.025}$

$2.5 = 0.86394(\theta - 55)$

$2.5 = 0.86394\theta - 47.5167$

$0.86394\theta = 50.0167$

$\theta = \frac{50.0167}{0.86394}$

$\theta = 57.89°C$ 04

d) (i) A body which absorbs all heat radiations of different wave lengths incident on it, reflects and transmits none. 01

(ii) - Sun / Stars 01 (Any two)
- Coil of a cooker / Electric heaters
- Stoves
- Burglar alarms
- filament of a lamp / Incandescent light bulbs

e) $l = 4cm = 0.04m$

$d = 2mm = 0.002m$

$r = \frac{d}{2} = \frac{0.002}{2} = 0.001m$

$A = 2\pi rl = 2\pi \times 0.001 \times 0.04$

Surface area $= 2.5133 \times 10^{-4} m^2$.

$P = 400W$

Power radiated by a black body

$= \frac{75}{100} \times 400$

$= 300W$.

$300 = A\sigma T^4$

$T^4 = \frac{300}{A\sigma}$

$T^4 = \frac{300}{2.5133 \times 10^{-4} \times 5.67 \times 10^{-8}}$

$T^4 = 2.10520244 \times 10^{13}$

$T = 2142.02K$

$T\lambda_{max} = 2.9 \times 10^{-3}$

$\lambda_{max} = \frac{2.9 \times 10^{-3}}{2142.02}$

$= 1.354 \times 10^{-6} m$.

$= 1.35 \times 10^{-6} m$ 04

Total = 20marks

7 a) (i) Process of change of state of a gas at constant heat / without heat entering or leaving the system.

01

(ii) – Rapid expansion of the gas
– Gas in a thick-walled poorly conductive vessel (Any two)
– No exchange of heat between the system and surrounding.
– Gas vessel fitted with a heavy piston.

b)

State 1		State 2
Pressure = P_0	Adiabatic Expansion	Pressure = P
Volume = V		Volume = $2V$
Temperature = T_1		Temperature = T_2

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

$T_1 V^{\gamma-1} = T_2(2V)^{\gamma-1}$

$T_1 \cancel{V^{\gamma-1}} = T_2 \times 2^{\gamma-1} \times \cancel{V^{\gamma-1}}$

$T_1 = T_2 \times 2^{\gamma-1}$

02

$\frac{T_1}{T_2} = 2^{\gamma-1}$

(ii) Work done during adiabatic expansion from state 1 to state 2 $= \frac{1}{\gamma-1}(P_1V_1 - P_2V_2)$

$= \frac{1}{\gamma-1}(P_0V - P\times 2V)$

$= \frac{V}{\gamma-1}(P_0 - 2P)$

Using $PV^{\gamma} = \text{Constant}$,

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

$P_0V^{\gamma} = P\times(2V)^{\gamma}$

$P_0 \cancel{V^{\gamma}} = P\times 2^{\gamma} \cancel{V^{\gamma}}$

$P_0 = 2^{\gamma}P$

$P = \frac{P_0}{2^{\gamma}}$

Substituting for P.

Work done $= \frac{V}{\gamma-1}\left(P_0 - 2\times\frac{P_0}{2^{\gamma}}\right)$

Work done $= \frac{P_0V}{\gamma-1}\left(1 - \frac{2}{2^{\gamma}}\right)$

Work done $= \frac{P_0V}{\gamma-1}\left(1 - 2^{1-\gamma}\right)$

04

c) (i) A gas has molecules at large separation distances and always in continuous random motion. When temperature of the gas is increased (gas heated), molecules gain thermal energy and their random speeds increase. Increase in molecular speed causes increase ~~of~~ their kinetic energies hence a total increase in kinetic energy of the whole gas.

03

(ii) - Negligible intermolecular forces
- Volume of gas molecules is negligible compared to volume of gas container
- Molecules make perfectly elastic collisions.
- Duration of collision is negligible compared to time between collision of gas molecules.

02

d) (i) $p = \frac{1}{3}\rho\bar{c^2}$

$\rho = \frac{M}{V} = \frac{\text{Mass of the gas}}{\text{Volume of the gas}}$

$\rho = \frac{Nm}{V}$, N = Number of molecules. m = mass of a molecule.

$p = \frac{Nm\bar{c^2}}{3V}$

$3pV = Nm\bar{c^2}$

$\frac{1}{2} \times 3pV = \frac{1}{2} \times Nm\bar{c^2}$

$\frac{3}{2}pV = N\left(\frac{1}{2}m\bar{c^2}\right)$

$K \cdot E_{molecule} = \frac{1}{2}m\bar{c^2} = \frac{3}{2}K_BT$

$K_B = \frac{R}{N_A}$ is Boltzmann Constant

$\frac{3}{2}pV = N \times \frac{3}{2}K_BT$

$pV = NK_BT$

- For a gas of pressure P_1, Volume V_1 having N molecules at a temperature T_1,

$P_1V_1 = N_1K_BT_1$

- For another gas of pressure P_2, Volume V_2 having N_2 molecules at a temperature T_2,

$P_2V_2 = N_2K_BT_2$.

- But according to Avogadro's Hypothesis,

$P_1 = P_2 = P$, $V_1 = V_2 = V$ and $T_1 = T_2 = T$

$PV = N_1K_BT$ —— (i)

$PV = N_2K_BT$ —— (ii)

(i) = (ii)

$N_1K_BT = N_2K_BT$

$N_1 = N_2$.

04

(ii) $m = 40g = 4.0 \times 10^{-2}kg$

$V = 2 \times 10^{-3}m^3$.

$\rho = \frac{m}{V} = \frac{4.0 \times 10^{-2}}{2 \times 10^{-3}}$

$= 20kgm^{-3}$

$T = 0°c = 273K$

$pV = RT$

$p = \frac{RT}{V} = \frac{8.31 \times 273}{2 \times 10^{-3}}$

$= 1134315Pa$.

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

$\bar{c^2} = \frac{3P}{\rho} = \frac{3 \times 1134315}{20} = 170147.25$

Root mean square speed $= \sqrt{\bar{c^2}} = \sqrt{170147.25}$

$= 412.49 ms^{-1}$

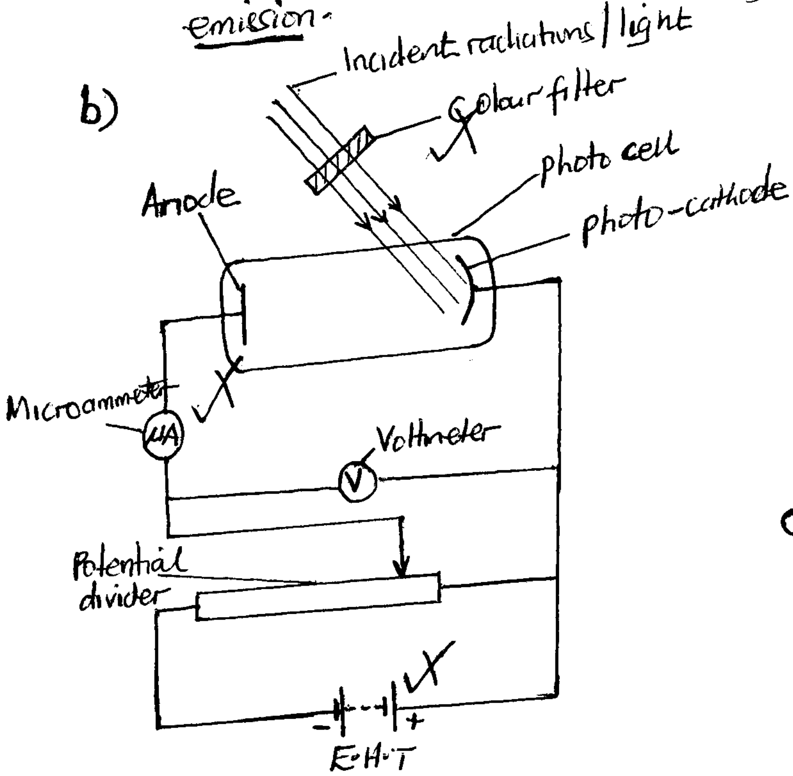
03

Total = 20 marks

8 a) (i) Process by which electrons are emitted from a metal plate when light/radiation of high enough energy is incident on it/falls on it. 01

(ii) Electrons exist in the metal surface together with positive ions under attraction. When light (radiation) of high enough energy falls on the metal surface, electrons break away from the attraction of positive ions, become free and mobile. Kinetic energy of the electrons in the metal surface increases and those with maximum kinetic energy escape from the metal surface hence photo electric emission. 03

b)



- The anode is made negative with respect to the cathode.
- Incident radiations are passed through a colour filter so that radiations of known frequency f fall on the photo-cathode.
- The cathode emits photo electrons which are received by the anode and the microammeter gives a deflection.
- The potential divider is varied until the microammeter shows zero deflection and the voltmeter reading V_s is read and recorded.
- The experiment is repeated using different colour filters so that radiations of different frequencies f are directed to fall on the photo cathode and corresponding values of V_s recorded at zero microammeter deflection.
- A graph of values of V_s is plotted against values of f and the intercept f_0 on the horizontal axis (f-axis) read and recorded as the threshold frequency of the photo cathode. 05

c) $\lambda = 4.5 \times 10^{-5}\,cm = 4.5 \times 10^{-7}\,m$.

$P = 20mW = 0.02W$

$$P = nE = \frac{nhc}{\lambda}$$

$$n = \frac{P\lambda}{hc}$$

$$n = \frac{0.02 \times 4.5\times10^{-7}}{6.6\times10^{-34}\times 3.0\times10^{8}}$$

$n = 4.55\times10^{16}$ emitted photo-electrons.

Number of photo-electrons causing current (n') $= \frac{60}{100}\times 4.55\times10^{16}$

$n' = 2.73\times10^{16}$ photo-electrons.

$$n'e = It$$

$$I = \frac{n'e}{t} = \frac{2.73\times10^{16}\times1.6\times10^{-19}}{1}$$

$$\underline{\underline{I = 4.37\times10^{-3}\,A}}$$ 04

d) Accelerating potential energy / work done by the accelerating potential = Kinetic energy of the electron

$$eV = \tfrac{1}{2}mv^2 \text{ ——— (i)}$$

where v is velocity of the electron.

- In the magnetic field, the magnetic force on the electron gives the electron a centripetal force

$$Bev = \frac{mv^2}{r}$$

$$v = \frac{Ber}{m} \text{ ——— (ii)}$$

- substituting (ii) in (i)

$$eV = \tfrac{1}{2}m\left(\frac{Ber}{m}\right)^2$$

$$2\cancel{e}V = \frac{\cancel{m}B^2e^{\cancel{2}}r^2}{m^{\cancel{2}}}$$

$$2V = \frac{B^2er^2}{m}$$

$$\underline{\underline{\frac{e}{m} = \frac{2V}{B^2r^2}}}$$ 03

e) $\rho = 900\,kgm^{-3}$

$r = 1.2\times10^{-6}\,m$

$V = 150V$

$d = 1.5cm = 0.015m$.

Electric force on the oil-drop = Weight of the oil drop.

$$EQ = mg.$$

$$\frac{VQ}{d} = \frac{4}{3}\pi r^3 \rho g$$

$$\frac{Vne}{d} = \frac{4\pi r^3 \rho g}{3}$$

$$n = \frac{4\pi r^3 \rho g d}{3Ve}$$

$$n = \frac{4\pi\times(1.2\times10^{-6})^3\times900\times9.81\times0.015}{3\times150\times1.6\times10^{-19}}$$

$$\underline{\underline{n = 40 \text{ electrons.}}}$$ 04

Total = 20marks

9 a) (i) Energy carried by an electron on an orbit round the nucleus of an atom. 01

(ii) When a radiation is passed through a gas, atoms of the gas gain energy from the radiation. Electrons in the lower energy levels of the atom gain energy and move from lower energy levels to higher energy levels making the atom excited and unstable. Other electrons on higher energy levels then make a transition to occupy the vacant spaces left in the lower energy levels. During transition, electrons emit radiations which form an emission spectra. 03

b) (i)

$$E_n = \frac{-K}{n^2} = \frac{-me^4}{8\varepsilon_0^2 n^2 h^2}$$

$$E_{n_2} = \frac{-me^4}{8\varepsilon_0^2 n_2^2 h^2}$$

$$E_{n_1} = \frac{-me^4}{8\varepsilon_0^2 n_1^2 h^2}$$

- A transition from n_2 to n_1 causes emission of radiations of energy given by:

$$E_{n_2} - E_{n_1} = hf$$

$$\frac{-me^4}{8\varepsilon_0^2 n_2^2 h^2} - \frac{-me^4}{8\varepsilon_0^2 n_1^2 h^2} = hf$$

$$hf = \frac{me^4}{8\varepsilon_0^2 n_1^2 h^2} - \frac{me^4}{8\varepsilon_0^2 n_2^2 h^2}$$

$$hf = \frac{me^4}{8\varepsilon_0^2 h^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$f = \frac{me^4(n_2^2 - n_1^2)}{8\varepsilon_0^2 n_1^2 n_2^2 h^3}$$ 03

(iii) $E_n = \frac{-20}{n^2}\,eV$

$E_5 = \frac{-20eV}{5^2} = -0.8eV = -1.28\times10^{-19}J$

$E_2 = \frac{-20eV}{2^2} = -5.0eV = -8.0\times10^{-19}J$

$E_5 - E_2 = \frac{hc}{\lambda}$

$-1.28\times10^{-19} - 8.0\times10^{-19} = \frac{6.6\times10^{-34}\times3.0\times10^{8}}{\lambda}$

$\lambda = \frac{1.98\times10^{-25}}{6.72\times10^{-19}}$

$\lambda = 2.95\times10^{-7}m.$

Ultra-violet radiations. 04

c) (i) - Most alpha particles pass through the atom undeviated. This is because the biggest percentage of the atom is free space.

- Few alpha particles are deviated through small angles less than 90° (acute angles). This is due to force of repulsion between the nucleus and the positively charged alpha particles.

- Very few alpha particles are deviated through angles greater than 90° (obtuse angles). These tend to move so as to have a head on collision with the tiny nucleus at the centre of the atom.

Conclusion:

An atom consists of a central nucleus where the positive charge and almost all the mass of the atom is concentrated. 04

(ii) Alpha particles have a short range in air so a vacuum is required to enable them move close to the nucleus of the atom with less interference from air molecules. 01

d)

Energy of alpha particle = Kinetic energy = $4.2 \times 10^{6} \times 1.6 \times 10^{-19}$

$$\frac{1}{2}mv^2 = 4.2 \times 1.6 \times 10^{-13}$$

$$mv^2 = 2 \times 4.2 \times 1.6 \times 10^{-13}$$

$$mv^2 = 1.344 \times 10^{-12}$$

$$b_o = 5.4 \times 10^{-12}\text{ cm}$$

$$= 5.4 \times 10^{-14}\text{ m}.$$

$$\frac{1}{4\pi\varepsilon_o} = 9.0 \times 10^{9}$$

$$\frac{1}{\pi\varepsilon_o} = 3.6 \times 10^{10}$$

$$\pi\varepsilon_o = \frac{1}{3.6 \times 10^{10}} = 2.778 \times 10^{-11}$$

$$b_o = \frac{Ze^2}{\pi\varepsilon_o mv^2}$$

$$Z = \frac{\pi\varepsilon_o mv^2 b_o}{e^2}$$

$$Z = \frac{2.778 \times 10^{-11} \times 1.344 \times 10^{-12} \times 5.4 \times 10^{-14}}{(1.6 \times 10^{-19})^2}$$

$$Z = 78.756$$

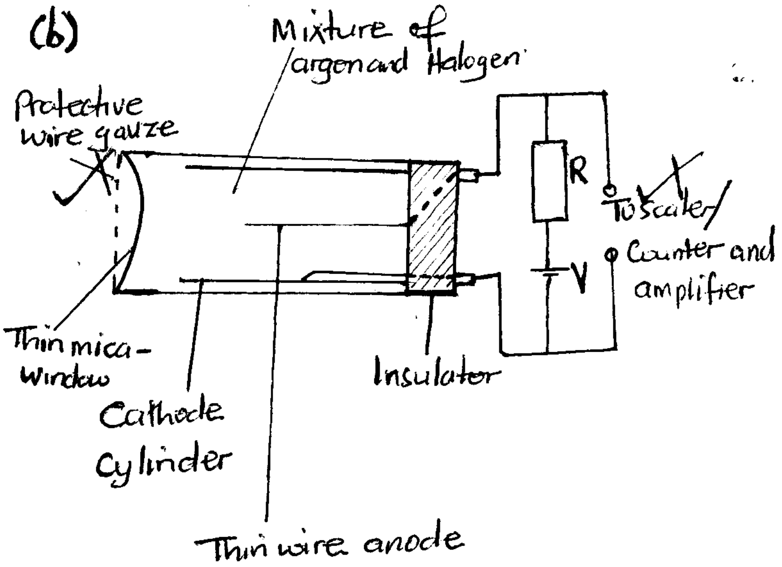
$$Z = 79 \text{ (Approx)}.$$ 04

Total = 20mks.

10a) (i) Number of protons in the nucleus of an atom. ✓01

(ii) Fraction of the number of radioactive atoms of a material disintegrating per second. ✓01

(b)



- Ionising radiations from a source are directed inside the Geiger Muller tube through the thin Mica-window.
- Inside the tube, the radiations Ionise air (gas) molecules to form ion pairs (positive and negative charges).
- Due to the applied p.d V across the tube, the negative charges are attracted to the positive thin wire anode while the positive ions move to the negative charged cathode cylinder.
- The electrons (negative charges) move at high speeds towards the thin wire anode, Collide with air (gas) molecules, Ionise them Leading to formation of more Ion pairs inside the tube.
- The Concentration of ions (charges) on their respective electrodes results into a pulse Ionisation current which flows through a high resistor R and sets up a p.d across it.
- The p.d set up across R is amplified and sent to a Scaler/Counter which registers the passage of ionising radiations inside the GM-tube. 05

c) Total energy of α-ples $= 5Mev$

$$= 5\times10^6 eV$$

$$= 5.0\times10^6 eV$$

Energy required to form one Ion-pair $= 50eV$

Number of ion pairs formed

$$= \frac{5.0\times10^6 eV}{50 eV}$$

$$= 1.0\times10^5 \text{ Ion pairs/ionisations}$$

Number of ionisations per mm in a range of 20mm

$$= \frac{1.0\times10^5 \text{ Ionisations}}{20mm}$$ 03

$$= 5.0\times10^3 \text{ Ionisations per mm.}$$

d) (i) Original mass $M_0 = 1g$.

- At time $t = T_{\frac{1}{2}}$ (Half life),

Mass present $M = \frac{M_0}{2}$

$= \frac{1}{2}g$ ✓✗

- Using the decay law equation:

$M = M_0 e^{-\lambda t}$ ✓

$\frac{1}{2}g = 1g e^{-\lambda T_{\frac{1}{2}}}$ ✓✗

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

$\ln 2^{-1} = \ln e^{-\lambda T_{\frac{1}{2}}}$ ✓✗

$-\ln 2 = -\lambda T_{\frac{1}{2}}$, $\ln e = 1$

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

$T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ ✓✗ 03

$T_{\frac{1}{2}} = \frac{0.693}{\lambda}$

(ii) - Nature of the radioactive sample. ✓

- Number of radioactive atoms present in the sample. ✓ 02

e)

(i) $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{144}_{42}X + ^{84}_{50}Y + 8^{1}_{0}n$ + Energy released ✓ 01

(ii) Total mass on left hand side

$= 233.132u + 1.009u$

$= 234.141u$ ✓✗

Total mass on the right hand side

$= 144.212u + 81.413u + 8(1.009u)$

$= 233.697u$ ✓✗

Mass defect (Δm)

$\Delta m = 234.141u - 233.697u$

$= 0.444u$ ✓✗

Energy of a photon released

$= 0.444 \times 931$ Mev

$= 413.364$ Mev ✓✗

235g $\xrightarrow{\text{Release}}$ 6.02×10^{23} photons of energy ✓✗

1g $\xrightarrow{\text{Releases}}$ $\frac{6.02 \times 10^{23}}{235}$ photons

50g $\xrightarrow{\text{Release}}$ $\frac{6.02 \times 10^{23} \times 50}{235}$ photons ✓✗

$= 1.28 \times 10^{23}$ photons ✓✗

Total energy released by 50g of U-235 ✓✗

$= 1.28 \times 10^{23} \times 413.364$ Mev

$= 5.291 \times 10^{25}$ Mev ✓ 05

Total = 20marks

-END-