P510/1 PHYSICS
MARKING GUIDE

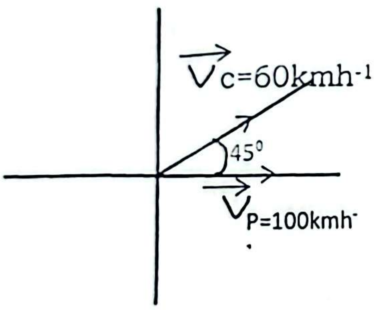
1(a) (i). For 2 bodies A and B =, relative velocity is the velocity that object A would appear to have to an observer moving with B. (1)

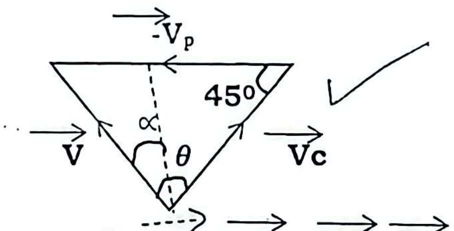
Or.

Velocity which body A would have in a frame of reference in which body B is at rest.

Or.

Velocity of a body as seen by an observer from another body.





Let $_c\vec{V}_p = \vec{V} = \vec{V_c} - \vec{V_p}$

OR.

cosine rule.

$V^2 = 60^2 + 100^2 - 2 \times 60 \times 100 \cos 45$

$V = 71.5 kmh^{-1}$

$$\vec{V_p} = \begin{pmatrix} 60\cos 45^\circ \\ 60 \sin 45^\circ \end{pmatrix} \quad \vec{V_c} = \begin{pmatrix} 100 \\ 0 \end{pmatrix}$$

Sine rule

$\frac{\sin\theta}{100} = \frac{\sin 45}{v} \Rightarrow \sin\theta \, \frac{100 \sin 45}{71.5}$

$\theta = 81.5^0$

$\alpha = 36.5^0$

$$_c\vec{V}_p = \vec{V_p} - \vec{V_c} = \begin{pmatrix} -100 + 30\sqrt{2} \\ 30\sqrt{2} \end{pmatrix}$$

$$|_c\vec{V}_p| = \sqrt{(-100+30\sqrt{2})^2 + (30\sqrt{2})^2}$$

$= 71.5 kmh^{-1}$

OR $19.86 ms^{-1}$

04

Direction:

N 36.5° Nor

W 53.5° N.

(b) (i). Work done by the force is independent of the path between the two points.

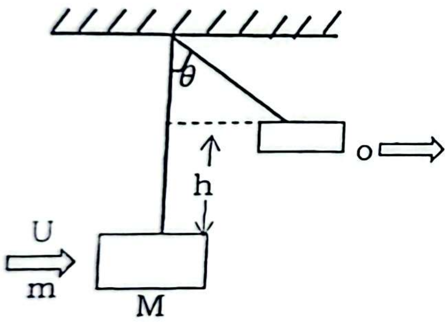
- Mechanical energy is conserved.

(any two)

- Work done by force to move body in closed path is Zero. (02)

(ii). For work to be done, the applied force must be in the same direction as the objects motion. However, centripetal force is perpendicular (orthogonal) to an objects motion, hence No work done. (02)

(c).



$U = 500ms^{-1}$

Let V_1 = velocity of block just after collision

V_2 = velocity of bullet just after collision.

<u>Block:</u> $\frac{1}{2}MV_1^2 = Mgh$

$V1 = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 0.1} = 1.401ms^{-1}$ (04)

Momentum.

$mu + 0 = MV_1 + mV_2$

$0.01 \times 500 = 2 \times 1.401 + 0.01V_2$

$V_2 = 219.8\ ms^{-1}$

(ii). $h = L(1-\cos\theta)$

$0.1 = 5(1-\cos\theta)$

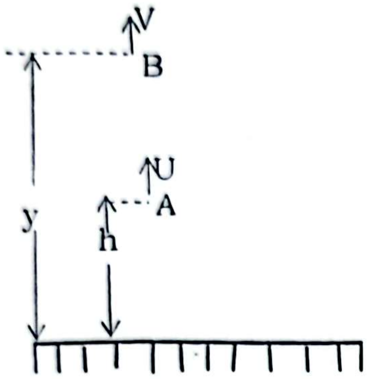
$\cos\theta = 0.98$

02

$\theta = 11.5^0$

(d) (i). It states that the sum of Kinetic energy and potential energy is a constant in the absence of dissipative forces. 01

(ii).



<u>At A</u>

$K.e = \frac{1}{2} mu^2$

$p.e = mgh$

$m.e = k.e + p.e$

$= \frac{1}{2}mu^2 + mgh.$

<u>At B</u>

$V^2 = U^2 + 2as, \quad s = y\text{-}h$

$V^2 = U^2 - 2g\,(y\text{-}h)$

$k.e = \frac{1}{2}mv^2 = \frac{1}{2}m\,[\,U^2 - 2g(y\text{-}h)]$ 04

$= \frac{1}{2}mu^2 + mgh\text{-}mgy$

$p.e = mgy$

$m.e = \frac{1}{2}mu^2 - mgy + mgh + mgy$

$= \frac{1}{2}mu^2 + mgh.$

Since $m.e_A = m.e_B$, principle proved.

2(a) (i). S.h.m – This is a periodic motion whose acceleration is directly proportional to the displacement from a fixed point and is directed towards that point. (01)

(ii). R.D – This is ratio of mass of a substance to the mass of an equal volume of water. (01)

(b). The solid is suspended from a spring balance and its weight in air, W_a is noted /obtained.

A sinker is attached to the solid and the two completely immersed in water and the weight of the solid and sinker in water, W_1 is noted.

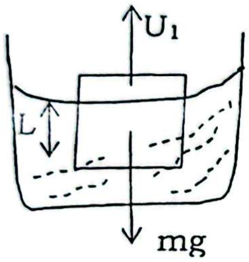
The solid is then detached from the sinker and the weight of the sinker in water W_2 is obtained.

04

The weight of the solid, $W_3 = W_1 - W_2$

Relative density = $\frac{W_a}{W_a - W_3}$

(c).



$60\% = \frac{density\ of\ block}{density\ of\ liquid} = \frac{\rho_b}{\cancel{800}\ 8200}$

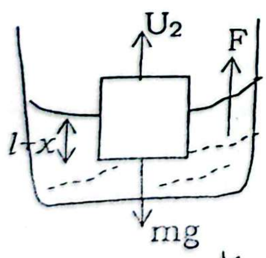
$\rho_b = \cancel{480kgm^{-3}}$ 4920 kgm^{-3}

U_1 = weight of liquid displaced = $V\rho_l g = Al\rho_l g$

U1 = mg = weight of block.

$\Rightarrow mg = Al\rho_L g$............(i)

When slightly displaced.



F = restoring force

= $-[U_2 - mg]$

$U2 = A\,(l + x)\,\rho_l\,g$, F = ma

$F = A\,(l + x)\,\rho_l\,g - mg$

$= -[Al\rho_l g + A\,x\rho_L g - Al\rho_l g]$

$ma = -A\rho_L x$

$a = -\left(\frac{A\rho_L g}{m}\right)x$ since $a \propto x$, *its simple harmonic*

in form $a = -w^2x$.

$m = \rho_b V_b = \overset{4920}{\cancel{480}} \times 4.5 \times 10^{-4} = \overset{2.214\,kg}{\cancel{\mathbf{0.216kg}}}$.

07

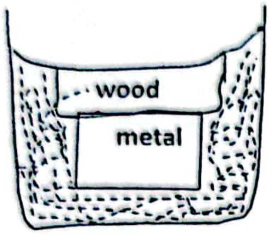
$W^2 = \frac{A \rho_L g}{m} = \frac{6 \times 10^{-3} \times 8200 \times 9.81}{\cancel{0.216}\ 2.214}$

$W = \overset{14.765\ rads^{-1}}{\cancel{14.948}}$ rads.

$f = \frac{w}{2\pi} = \frac{14.948}{2 \times 3.14} = \cancel{\mathbf{2.38HZ.}}$

2.35HZ.

(ii)



Let V = volume of metal.

Mass of liquid displaced = mass of (wood + metal)

Volume of (wood + metal) ρ_l = mass of (wood + metal)

04

$(4.5 \times 10^{-4} + V)\ 1200 = \overset{2.214}{\cancel{0.216}} + 7200\ V.$

$0.54 + 1200V = \overset{2.214}{\cancel{0.216}} + 7200V.$

$\overset{-1.674}{\cancel{0.324}} = 6000V.$ $-0.000279\,m^3$ OR $-2.79 \times 10^{-4}\,m^3$.

V = ~~0.000054m³ OR 5.4 x 10⁻⁵m³~~

3(a). Viscosity – Resistance to motion between two fluid layers. 01

Or

Frictional force that opposes relative motion between different fluid layers.

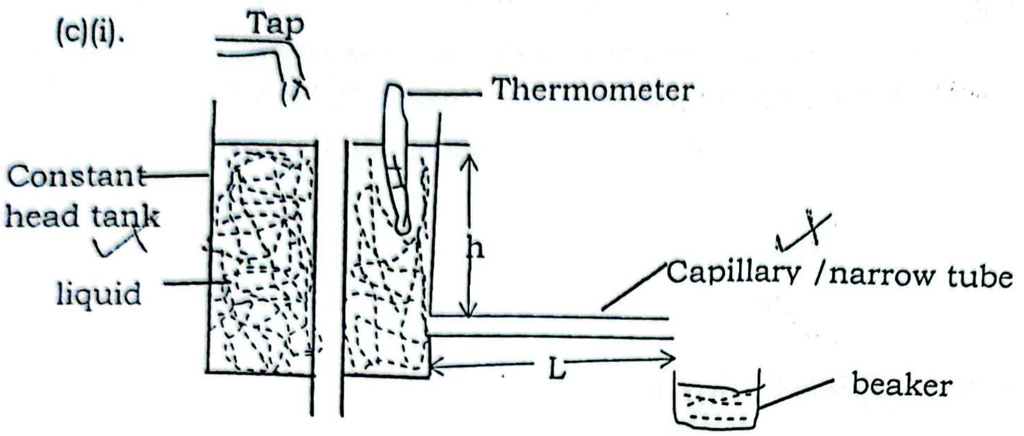
Fluidity – Ability of a fluid to flow easily with minimum resistance. 01

(b) (i). Increase in pressure reduces molecular separation, the intermolecular forces of attraction becomes significant and increases, hence viscosity increases in liquids. 02

(ii). $\eta = \frac{f}{A\frac{dv}{dx}} \Rightarrow dx = \frac{\eta A dv}{f}, A = L \times L = 0.1 \times 0.1 = 0.01m^2$ 03

$= \frac{1.002 \times 10^{-3} \times 0.01 \times 0.1}{0.002} = 5.01 \times 10^{-4} m$

(c)(i).



01

- The temperature, θ_1 of the liquid is measured and recorded.
- The liquid of known density ρ is made to flow at a constant rate through a capillary tube of known length, **L**.
- Volume of liquid, V collected in known time, **t**, is measured and recorded.
- Volume per second, V/t is calculated.
- The procedure is repeated for different values of **h** by adjusting the tube / pipe.
- A graph of v/t against h is plotted.
- Slope, s_1 is calculated (found)
- Radius, **r**, of the tube is found using a travelling microscope.
- Coefficient of viscosity, $\eta_1 = \frac{\pi r^4 \rho g}{8 s_1 l}$ ....(i)
- The liquid is heated to temperature θ_2 and the experiment is repeated.
- Another graph of v/t against h is plotted on the same axes.
- New slope s_2 is found.
- $\eta_2 = \frac{\pi r^4 \rho g}{8 s_2 l}$ .... (ii)

  $(i) \div$ (ii)
- $\frac{\eta_1}{\eta_2} = \frac{s_2}{s_1}$ since $s_2 > s_1 \Rightarrow \eta_1 > \eta_2$

05

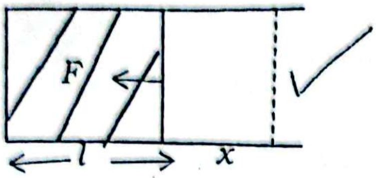
(ii).

- The temperature of the liquid must be kept constant in each experiment.
- The liquid must flow continuously at a constant rate.

01

- The radius of the tube must be accurately found since a single error in it results into a 4 – times error in the value of η.

(d) (i).



F – surface tensional force

Work done = Fx

$= \gamma Lx \times 2 = \gamma(2lx)$

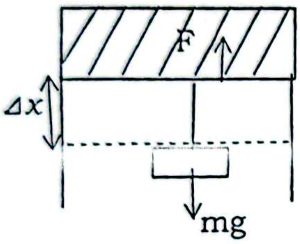
$= \gamma A$

03

If A = 1m², work done = surface tension (γ)

(ii). So that the intermolecular forces are very weak and hence the paint and lubricating oil can spread over large areas easily and faster. 01

(iii).



F – surface tensional force mg
mg = weight

Mechanical work done = work done by surface tension forces.

$(mg - F)\,\Delta x = \gamma L.\Delta x \times 2.$

$Mg - \gamma L.2 = \gamma L.2$

$Mg = 4\gamma L.$

$M = \frac{4\gamma L}{g}$

02

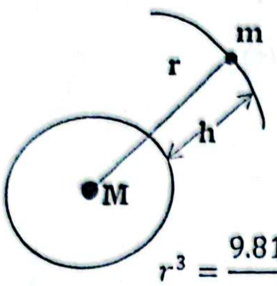
4(a). 1st: All planets describe ellipses about the sun as one focus.

2nd: The imaginary line joining the sun and the planet moving sweeps out equal areas in equal time intervals.

3rd: The square of periodic time of revolution of the planet about the sun is directly proportional to the cube of the mean distance from it.

03

b).



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

$$r3 = \frac{GMT^2}{4\pi^2} \; or \; \frac{g r_e^2 T^2}{4\pi^2}$$

$$r^3 = \frac{9.81 \times (6.4 \times 10^6)^2 \times (94 \times 60)^2}{4 \times (3.14)^2}$$

$r = 6.87 \times 10^6$m. 04

$h = r - r_e = 6.87 \times 10^6 - 6.4 \times 10^6$

$= 4.7 \times 10^6$m or 4.69×10^6m.

(ii). $V = \sqrt{\frac{GM}{r}}$ or $V = \sqrt{\frac{g r_e^2}{r}}$ 02

$= \sqrt{\frac{9.81 \times (6.4 \times 10^6)^2}{4.7 \times 10^6}}$

$= 9.25 \times 10^3 ms^{-1}$

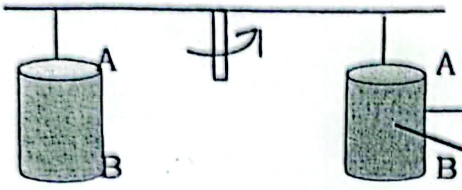
(c) (i). At takeoff, a lift force (F) acts on the wing of air craft due to Bernoulli's principle. By banking the wing, the horizontal component (F sinθ) of lift force provides the necessary centripetal force towards the center of the circle and therefore it is able to describe a circular path. 02

(ii). $\tan\theta = \frac{v^2}{rg}$ 02

$= \frac{(650)^2}{80,000 \times 9.81}$

$\theta = 28.3^0$

4(d). Centrifuge: This is a device that separates liquids of different densities or solids suspended in liquids.



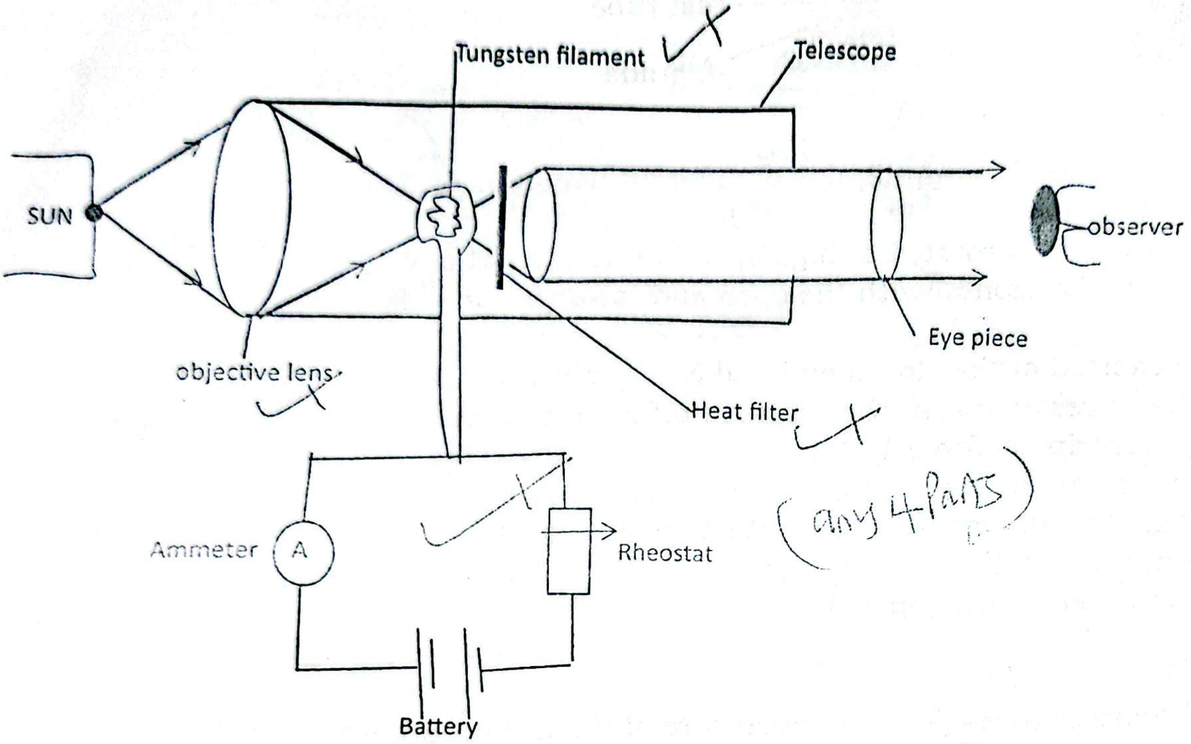
- The vertical tubes contain liquids of different densities or solids suspended in liquids.
- When the system is rotated at high speed in horizontal circle, the tubes become horizontal with the open end towards the axis of rotation.
- The force exerted at the closed end makes the pressure at B to become greater than pressure at A. the pressure difference provides the necessary centripetal force.
- This force causes the less dense matter to move inwards and the more dense is thrown out wards to the bottom of the tube.
- On stopping the rotation the tubes return to the vertical position with less dense matter on the top.

04

5(a) (i). Neutral temperature – is the temperature of the hot junction of the thermocouple at which the e.m.f of the thermocouple is maximum when the cold junction is maintained at a stable temperature of 0°C. 01

(ii). The variation of e.m.f with temperature is small near the neutral temperature and the thermometer is insensitive (not sensitive) in this region. 02

or It is un desirable to use thermocouple for temperature close neutral temperature because further increase in the temperature reverses the direction of the emf.



(any 4 parts) 02

- The sun is focused by the objective lens so that its image lies in the same plane as the filament.
- Light from the sun and the filament is viewed through the eye piece as it passes the filter.
- The rheostat is adjusted until when the image of the sun cannot be distinguished from that of the filament. Appear of the same color. / disappear.
- At this point, the temperature of the sun will be equal to that of the filament and its read on the ammeter calibrated in Kelvin.

03

(ii).

- Temperature of the surroundings may affect the reading of the pyrometer.
- Its not highly accurate.
- It requires a lot of skills and care is required in calibrating the pyrometer.
- Very expensive.

(any two) 01

(c). Rate of heat loss by water and calorimeter in both cases is the same.

$$\frac{(m_w c_w + m_c c_c)\Delta\theta}{t_1} = \frac{(m_w^1 c_w + m_c c_c)\Delta\theta}{t_2}$$

$$\frac{(0.04 \times 4200 + m_c c_c)10}{15} = \frac{(0.1 \times 4200 + m_c c_c)10}{33}$$ 03

$$m_c c_c = heat\ capacity\ of\ calorimetre = 42JK^{-1}$$

(d) (i). Melting point – This is constant temperature at which a substance changes from solid state to liquid state. 01

OR

This is temperature at which the solid and liquid states of a pure substance can exist in equilibrium.

(ii). When a solid is melting after supply of heat, intermolecular forces of attraction weakens and there is increase in molecular separation, increase in potential energy between molecules, regular/orderly pattern collapses to irregular/disorderly pattern when in liquid state.

However, the average kinetic energy remains constant since kinetic energy is directly proportional to temperature, temperature remains constant until the process is complete. 03

(iii). Heat supplied = pt.

$Pt = m_w c_w \theta + m_k c_k \theta + m l_v$

$2000 \times 13 \times 60 = 1 \times 4200 \times 80 + 400 \times 80 + 0.5L_v$ 04

$1{,}560{,}000 \quad = 336000 + 32000 + 0.5L_v$

$L_v \quad = 2.384 \times 10^6\ Jkg^{-1}$

6(a) (i). Dalton's law: The total pressure of a mixture of gases that do not react chemically is equal to the sum of the partial pressure of the component gases of the mixture. 01

(ii).

$P = \frac{1}{3}\rho\overline{C^2}$

$= \frac{1}{3}\frac{M}{V}\overline{C^2} = \frac{1}{3}N\frac{m}{V}\overline{C^2}$

PV = $^2/_3 N\left(\frac{1}{2}m\overline{C^2}\right)$ but $\frac{1}{2}m\overline{C^2} = \frac{3}{2}KT$

$= \frac{2}{3}N\ ^3/_2 KT = NKT$

PV = NKT.

Consider two gases.

1st: $P_1V = N_1KT$ ....(i)

2nd: $P_2V = N_2KT$ ....(ii)

When mixed (i) + (ii)

$(P_1 + P_2)V = (N_1 + N_2)KT$

Let $N = N_1 + N_2$

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

$(P_1 + P_2)V = PV$

: $P = P_1 + P_2$

05

(b). Smoke is confined in a glass cell (smoke cell) and light is made incident on it.

The inside of the cell is viewed through a microscope.

Smoke particles are seen as white specks in continuous random motion.

Some thing must be knocking the smoke particles and this something is the molecules of matter/air.

04

(c).

IL = 1×10^{-3} m^3

P = hρg = 0.8 x 13600 x 9.81

1.07×10^5

$PV = nRT$, $n = \frac{PV}{RT}$

Number of moles = $2 \times \frac{PV}{RT} = \frac{0.80 \times 13600 \times 9.81}{8.31 \times 300} \times 2 \times 1 \times 10^{-3}$

= 0.0856

m = n x R.m.m

5

03

$= 0.0856 \times 4 = 0.3424g$

$= 3.424 \times 10^{-4} kg$

(ii). Total number of moles before = total number of moles after.

$0.0856 = \frac{PV}{R}\left(\frac{1}{T_1} + \frac{1}{T_2}\right)$

03

$= \frac{P \times 10^{-3}}{8.31}\left(\frac{1}{273} + \frac{1}{373}\right) =$

(2A)

P $= 1.12 \times 10^5$ pa.

or 83.94 cmHg

d(i). This is the Kinetic energy of the gas molecules. 01

(ii). $T_1 V_1^{\gamma - 1} = T_2 V_2^{\gamma - 1}$

$T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma - 1} = 293\left(\frac{V}{\frac{1}{2}V}\right)^{0.4} = 386.62K$

$\Delta T = T_2 - T_1 = 386.62 - 293 = 93.62$

$Cp - Cv = R, \gamma = \frac{C_p}{C_v}, C_p = \gamma C_v$

$\gamma C_v - C_v = R$

$C_v = \frac{R}{\gamma - 1}, \quad n = \frac{m}{R.m.m} = \frac{1}{2} = 0.5$

$\Delta U = nC_V \Delta T$ 03

$= 0.5 \times \frac{8.31}{1.4-1} \times 93.62$

$= 972.48$ J

7(a) (i). Temperature gradient – This is the difference in temperature across the ends of a 1m length of the conductor. 01

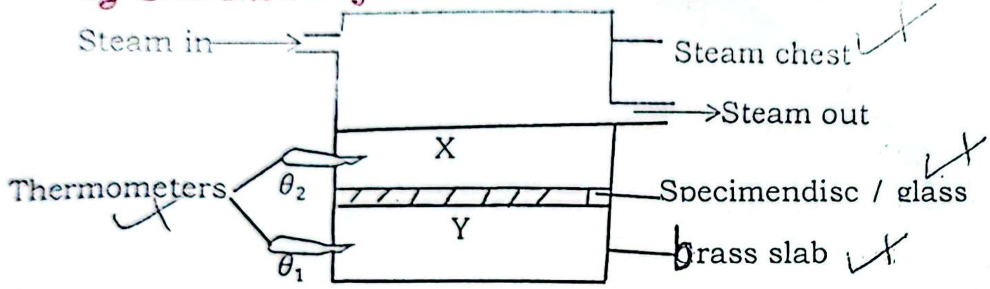
OR Ratio of temperature difference to the distance between two points

(ii). Radiative equilibrium – This is the condition where the total thermal radiation leaving an object is equal to the total thermal radiation entering it. 01

b(i). As the temperature increases, the relative intensity emitted for each wave length increases but the increase is more rapid for shorter wave lengths than longer wave lengths.

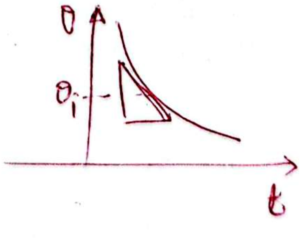
The wave length emitted with maximum intensity, λ max [which determines colour of the hot body] shifts to shorter wave lengths. The body changes its appearance from its normal colour (λ max in infrared region) to red-hot (λmax in the red region) ~~to white – hot (λmax in the red region)~~ to white – hot (λmax, in the middle of the visible spectrum) and eventually to blue – hot (λmax in the blue region). 03

(ii) Above the fire, heat transfer is by both radiation and convection. This creates rapid upward flow of hot air increasing temperature. In the sides, heat transfer is by convection only. Thus more hot above than in the sides.



02

- The material is cut into a thin disc with large diameter.
- Thickness L and diameter d are measured and recorded.
- Cross – sectional area A = $\frac{\pi d^2}{4}$ is calculated.
- The specimen is put between thick base, X of steam chest and brass, slab Y of known mass, m and S.h.c, c
- The specimen is heated by passing steam into the steam chest until a steady state is reached.
- Temperatures, θ_1 *and* θ_2 are noted. 05
- specimen disc is removed and X put into direct contact with Y.
- Y is heated until its temperature is about 10°C above θ_1
- The steam chest is removed and specimen is put back on top of Y.
- The temperatures of Y are noted at suitable time intervals until its temperature has fallen below θ_1.
- A graph of temperature against time is plotted.
- Slope ,s is calculated at θ_1.



$$K = \frac{mcs}{A\left(\frac{\theta_2 - \theta_1}{c}\right)}$$

(ii). Temperatures are read at steady state only.

There is no heat loss through the sides. 01

(d). Let θ = operating temperature.

(i). $R_\theta = \frac{V}{I} = \frac{240}{0.5} = 480\ \Omega$

$R_\theta = R_O\,(1 + \alpha\,\theta)$

$R_{20} = R_O\,(1 + 20\,\alpha) = 50\Omega$

$R_\theta = R_O\,(1 + \alpha\,\theta) = 480\Omega$ 03

$$\frac{R_{20}}{R_\theta} = \frac{R_0(1 + 20\,\alpha)}{R_0(1+\alpha\,\theta)} = \frac{50}{480}$$

$$\frac{1 + 20 \times 5 \times 10^{-3}}{1 + 5 \times 10^{-3}\theta} = \frac{50}{480}$$

$\theta = 1912^0C = 1912 + 273 = 2185K$

(ii). $P = A\sigma T^4$, $P = IV = 240 \times 0.5 = 120W$. 02

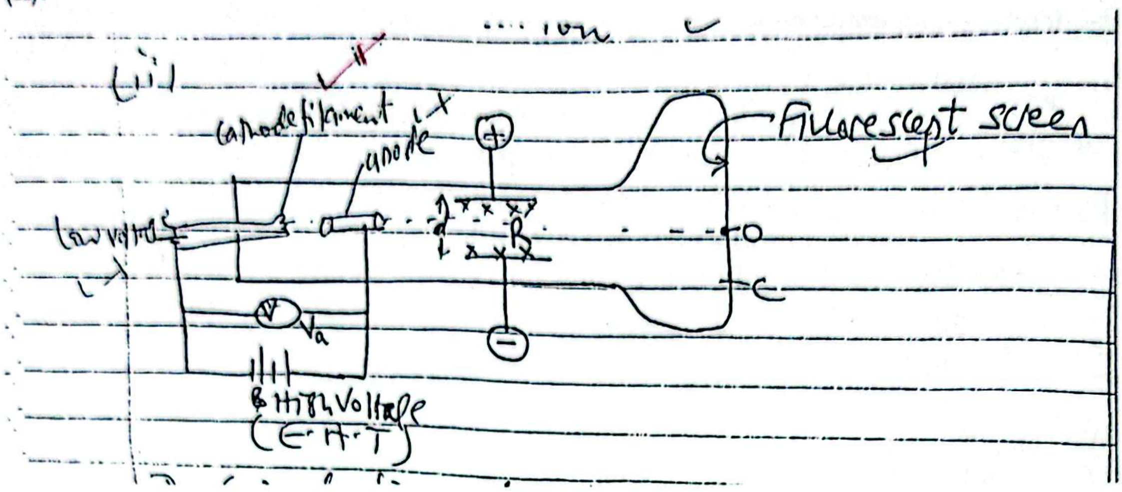
$$\sigma = \frac{P}{AT^4} = \frac{120}{0.9 \times 10^{-4} \times (2185)^4}$$

$= 5.85 \times 10^{-8}\ w_m^{-2}K^{-4}$

SECTION C

8(a) (i). Specific charge – is the ratio of charge to mass of an ion. 01

(ii).



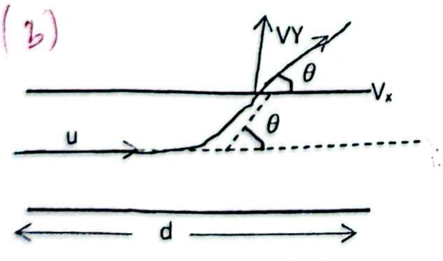
02

- The cathode filament is heated by low voltage and it emits electrons by thermionic emission.
- The anode accelerates the emitted electrons to a high velocity.
- Without electric and magnetic fields at R, the electrons strike point O on the screen.
- Position O is noted.
- The magnetic field of known flux density, B is applied at R to deflect the electron beam to position C.
- The electric field is also simultaneously applied to R and adjusted until the beam goes back to O.
- The p.d across the plates, V plate separation, d and accelerating voltage, V_a are noted.

04

Specific charge = $e/m = \frac{V^2}{2V_a d^2 B^2}$

(b)



Work done = kinetic energy gained

$VQ = \frac{1}{2} mu^2$

$2VQ = mu^2$...............(i)

$V = u + at$

$QE = ma$

$a = \frac{QE}{m}$

$\tan\theta = \frac{V_y}{u}$

$\tan\theta = \frac{EQd}{mu^2}$

$\rightarrow d = ut \Rightarrow t = d/u$

$v_x = u, v_y = at = \frac{EQt}{m} = \frac{EQd}{mu}$

$$\tan\theta = \frac{v_y}{v_x} = \frac{EQd}{mu^2} \ldots\ldots\ldots (ii)$$

Put (i) in (ii)

04

$$\Rightarrow \tan\theta = \frac{EQd}{2VQ} = \frac{Ed}{2v}$$

$$\tan\theta = \frac{Ed}{2V}$$

(c). $\frac{mV^2}{r} = BqV$

$B = 1.2T \quad r = 36\times10^{-2}m$

$F_m = F_c$

$BqV = \frac{mv^2}{r}$.

$\frac{rBq}{m} = V$.

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

$K.e = \frac{1}{2}mV^2 = \frac{1}{2}m\left(\frac{rBq}{m}\right)^2 = \frac{r^2B^2q^2}{2m}$

$K.e \propto r^2$

For $\propto, {}^4_2He, q = 2e, m = 4.0026 \times 1.66 \times 10^{-27}kg.$

$K.e = \frac{(0.36)^2\times(1.2)^2\times(2\times1.6\times10^{-19})^2}{2\times4.0026\times1.66\times10^{-27}}$

04

$= 1.438\times10^{-12}J$

$1.438\times10^{-66}J$

1Mev = 1.6 x 10^{-19} x 10^{6} = 1.6 x 10^{-13}J.

$1 MeV = 1.6\times10^{-13}J$

$x = 1.438\times10^{-66}$

$K.e = \frac{1.438\times10^{-12}}{1.6\times10^{-13}} = 8.99MeV.$

$K_e = 8.9875\times10^{-54} MeV$

(d) (i). When bombarded with electron of energy 12.18ev, New energy = 12.18 + -13.69 = -1.51ev. the atom was excited and the electron made a transition to the -1.5lev energy level. 01

- When bombarded with electron of energy 14.0ev, new energy = 14.0 + -13.69 = 0.31ev.

- The atom was ionized and the electron was completely lost. 01

(ii). $\Delta E = \frac{hc}{\lambda} \Rightarrow \lambda\min = \frac{hc}{\Delta E_{max}} = \frac{hc}{E_\infty - E_1}$ 02

$= \frac{6.6\times10^{-34}\times3\times10^{8}}{(0-{-13.69})\times1.6\times10^{-19}}$

= 9.04 x 10^{-8}m

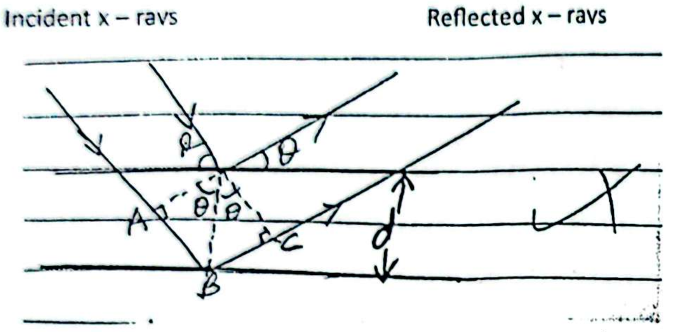
It lies in ultraviolet part of the spectrum

9 (a) (i). Bragg's law states that: when x – rays of wavelength, λ are incident on a crystal of atomic spacing, d, for constructive interference to occur, $2d \sin\theta = n\lambda$.

Where n – order of diffraction.

θ – *glancing angle*

(ii)



with a diagram

Constructive interference occurs when path difference = $\cap\lambda$

Path difference = AB + BC

Where AB = d sin θ, BC = d sinθ

$2\,d\sin\theta = \cap\lambda$

$$\Rightarrow \sin\theta = \frac{\cap\lambda}{2d} \text{ but } -1 \le \sin\theta \le 1$$

$$\Rightarrow \frac{\cap\lambda}{2d} \le 1 \Rightarrow \cap\lambda \le 2d$$

03

(b) (i). I = $\cap$e.

$$\cap = \frac{I}{e} = \frac{20\times10^{-3}}{1.6\times10^{-19}} = 1.25 \times 10^{17} s^{-1}$$

02

(ii). For maximum order, sinθ = 1.

$2d\sin\theta = \cap\lambda$

$$\cap_{max} = \frac{2d}{\lambda} \text{ but } hf_{max} = eV$$

$f = \frac{c}{\lambda}$

$\frac{hc}{\lambda_{min}} = eV$

$$h\frac{c}{\lambda_{min}} = eV$$

$$\Rightarrow \lambda_{min} = \frac{hc}{eV}$$

$$n_{max} = \frac{2deV}{hc}$$

$$= \frac{2\times1.5\times10^{-10}\times1.6\times10^{-19}\times100\times1000}{6.6\times10^{-34}\times3\times10^{8}}$$

= 24

0

(c). Increase in filament current increases the temperature of the filament. Many electrons gain enough thermal energy and overcome attraction force due to positive charges / ions and escape.

The rate of production of electrons, increases and the number of electrons reaching the target per second increases.

Many x – ray photons are emitted and intensity increases.

2 C

(d). Work function. This is minimum energy required to liberate the loosely bound electrons from the metal surface.

01

OR

This is minimum energy that has to be given to an electron to release it from the metal surface.

(ii). W_o = 1.9eV = 1.9x 1.6 x 10^{-19} = 3.04 x 10^{-19}J.

$hf = KE + W_o$.

$\frac{hc}{\lambda} = eV_s + W_o$.

$$\frac{hc}{\lambda} = K.e_{max} + W_o$$

$$\frac{hc}{\lambda} = eV_s + W_o$$

03

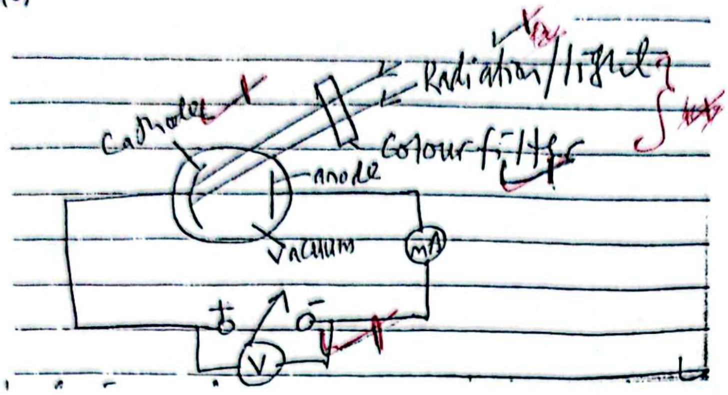
$$\frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{4.5 \times 10^{-7}} = 1.6 \times 10^{-19}V_S + 3.04 \times 10^{-19}$$

4.4 x 10^{-19} = (V_s + 1.9) 1.6 x 10^{-19}

3

V_s = 0.85V

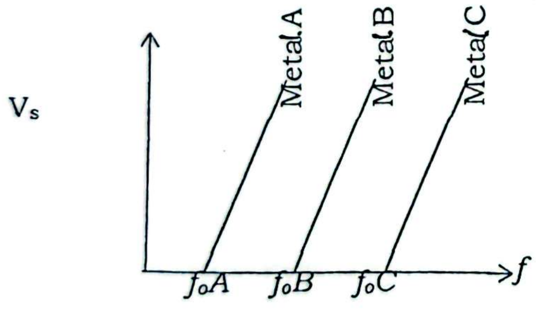
(e)



02

- The cathode is made positive relative to the anode.
- A radiation / light of known frequency, $f > f_0$) ~~f~~ is made to pass through the filter and incident on the cathode of the photo cell.
- The p.d across the anode and cathode is varied until the photo current is zero (mA reads zero).
- The p.d at this point is measured by the voltmeter and recorded as stopping potential, V_s.
- The experiment is repeated using cathodes of different metals.
- A graph of V_s against f is plotted for different cathodes.
- Graphs with different f – axis intercept are obtained.
- Each metal has its own threshold frequency (f_0).
-

04



10(a) (i). Mass detect – This is the difference between the mass of nucleons that make up the nucleus and the mass of the nucleus. 01

- Radioactive tracer – This is a radio isotope used in chemical, biological and industrial processes by detecting particles emitted in radioactive decay of the isotope. 01

(ii). To detect leaks in underground pipes carrying water/petroleum products.

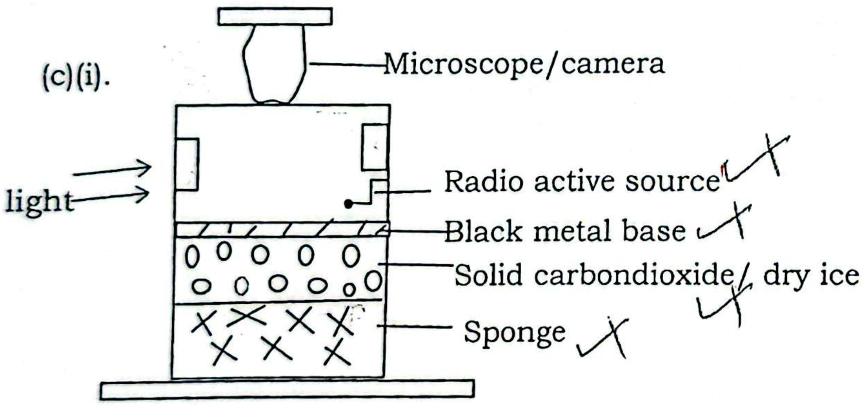
- To determine rate of wear of piston rings in car engines.
- To determine rate of wear of car tyres.
- Used for automatic control of the thickness of paper/plastics/metal sheets during manufacture.

(b) (i). $^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

(ii). Carbon – 14 is radioactive with known half life, $t_{\frac{1}{2}}$. It is absorbed by plants during photosynthesis. When plants die, C – 14 starts to decay. The activity, A_o of living plants is measured. The activity A of dead plants is also measured.

The age t of dead plant is deduced from $A = A_o\, e^{-\lambda t}$ where $\lambda = \frac{0.693}{t_{1/2}}$.

(c)(i).



- Air in the chamber is saturated with alcohol vapour.
- The top of the chamber is at room temperature while the metal base is at very low temperature (Ω-80°C) by help of solid carbondioxide, this creates a temperature gradient.
- Due to temperature gradient, alcohol vapour steadily diffuses from top to bottom where it becomes supersaturated.
- When radioactive source is introduced, radiation ionizes air molecules, ions formed diffuse to the bottom where they act as condensation centres.

- Supersaturated vapour condenses on ions formed forming tracks/trails/paths. ✓ 04
- Such tracks appear white on an black background. ✓
- The length/thickness/nature of tracks show the extent of ionization. ✓

(c) (i). If the source is for alpha particle.

- ✓ thick tracks are formed because they cause intense ionization. ✓
- ✓ Straight tracks are formed because they are massive. ✓
- ✓ Tracks are of the same length because they are emitted with same speed/kinetic energy. ✓ 03

For beta particles.

- ✓ Thin tracks are formed because they cause less ionization. ✓
- ✓ Tracks are not straight because they are light. ✓
- ✓ Tracks are of varying length because they are emitted with varying speed/kinetic energy. ✓

(d). $A = 1000 - 300 = 700\ hr^{-1}$ ✓

$Ao = 1600 - 300 = 1300\ hr^{-1}$ ✓

$A = Ao\ e^{-\lambda t}$ ✓

$\frac{A}{A_o} = e^{-\lambda t}$ or $\frac{A_o}{A} = e^{\lambda t}$ 04

$\text{In}\ \frac{A_o}{A} = \lambda t$

$\text{In}\left(\frac{1300}{700}\right) = \frac{0.693}{5700}\ t$ ✓

t = 5091.66 years. ✓

 ~0.619039208

P510/1
Physics
Paper 1
July - August
2024
2 ½ Hours

UGANDA MUSLIM TEACHERS' ASSOCIATION

UMTA JOINT MOCK EXAMINATIONS - 2024

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:

- *Acceleration due to gravity, g* $= 9.81ms^{-2}$
- *Electron charge, ℓ* $= 1.6x10^{-19}c.$
- *Electron mass* $= 9.11x10^{31}kg.$
- *Mass of earth* $= 5.97x10^{24}kg.$
- *Plank's constant h* $= 6.6x10^{-34}Js$
- *Stefan's – Boltzmann's constant σ* $= 5.67x10^{-8}Wm^{-2}K^{-4}$
- *Radius of earth* $= 6.4x10^{6}m.$
- *Speed of light in vacuum, **C*** $= 3.0x10^{8}m.$
- *Universal gravitational constant **G*** $= 6.67x10^{-11}Nm^{2}kg^{-2}$
- *Specific heat capacity of water* $= 4200Jkg^{-1}K^{-1}$
- *Density of water* $= 1000kgm^{-3}$
- *Gas constant, **R*** $= 8.31Jmol^{-1}k^{-1}$
- *Avogadro's number N_A* $= 6.02x10^{23}mol^{-1}$
- *Specific latent heat of vaporization of water* $= 2.26x10^{6}Jkg^{-1}$
- *Radius of earth's orbit about the sun* $= 1.5x10^{11}m.$

Ho

1. a) (i) What is meant by relative velocity? (01 mark)

(ii) A passenger on a train which is travelling due east at $100kmh^{-1}$ observes a car which is travelling North-East at $60kmh^{-1}$. Calculate the velocity of the car relative to the observer on the train. (04 marks)

b) (i) State the conditions for a force to be conservative. (02 marks)

(ii) Explain why centripetal force does no work. (02 marks)

c) A bullet of mass 10g and travelling at a speed of $500ms^{-1}$ strikes a block of mass 2kg which is suspended by a string of length 5.0m. The centre of gravity of the block is found to rise a vertical distance of 10.0cm.

(i) What is the speed of bullet after it emerges from the block? (04 marks)

(ii) Calculate the maximum inclination of the string to the vertical. (02 marks)

d) (i) State the principle of conservation of mechanical energy. (01 mark)

(ii) Prove the principle in **(i)** above for a body projected from a point vertically upwards. (04 marks)

2. a) Define the following.

(i) Simple harmonic motion. (01mark)

(ii) Relative density. (01 mark)

b) Describe an experiment to determine relative density of an irregular solid which floats in water. (04 marks)

c). A rectangular block of wood of volume $4.5x10^{-4}m^3$ floats in a liquid of density $8.2x10^3km^{-3}$ with only 60% of its volume immersed. The area of cross-section of the block is $6.0x10^{-3}m^{2}$.

(i) The block is given a small vertical displacement and then released. Show that it executes simple harmonic motion and find its frequency. (07 marks)

(ii) The block is now placed in another liquid of density $1200kgm^{-3}$, find the volume of metal of density $7.2 \times 10^3\ kgm^{-3}$, that should be added to the block in order for the block to just float totally immersed in this liquid. (04 marks)

3. a) Distinguish between Viscosity and Fluidity. (02 marks)

b) (i) Explain the effect of increasing pressure on the Viscosity of a liquid. (02 marks)

(ii) A square plate of side 0.1m moves in water parallel to another similar plate at $0.1ms^{-1}$. If the viscous force is 0.002 N and coefficient of viscosity of water is **$1.002\times10^{-3}Nsm^{-2}$**, find the distance between the plates at constant temperature.

(04 marks)

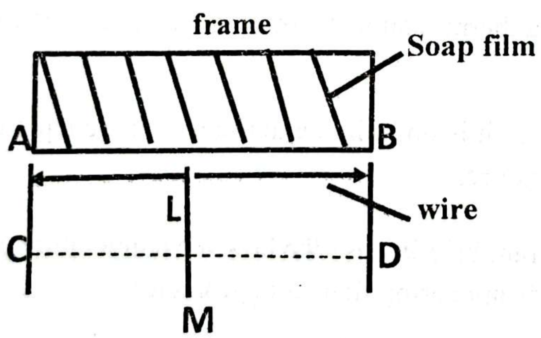
c) (i) Describe the experiment to compare the viscosity of a less viscous liquid at **two** different temperatures. (05 marks)

(ii). State one precaution that must be taken in the above experiment to ensure accurate results. (01 mark)

d) (i) Show that surface tension is equal to the work done in increasing the surface area of a liquid by $1m^2$ under isothermal conditions. (03 marks)

(ii) Explain why paints and lubricating oils should have low surface tension. (01 mark)

(iii)



A small mass, M on a light string is fixed on a thin wire of length, L enclosing a soap film. The wire moves from position **AB** to **CD.** The system is in equilibrium when the wire is at **CD.** If γ is the surface tension soap solution and temperature remains constant, show that;

$$M = \frac{4\gamma L}{g}$$

4. a) State Keplers laws of planetory motion. (03 marks)

b) A small artificial earth satellite revolves in an equatorial orbit with a period of 94 minutes. Calculate the;

(i) Height of the satellite above the earth's surface. (04 marks)

(ii) Velocity of the satellite in the orbit (02 marks)

c) An air craft moving in a horizontal plane at a constant speed of $650ms^{-1}$, makes a turn with a radius of 80km at an angle of tilt, θ to the vertical.

(i) Explain why the aircraft has to bank its wings in order to move in a circular path. (02 marks)

(ii) Find the value of θ. (02 marks)

d) Describe the principle of operation of a centrifuge. (04 marks)

SECTION B

5. a) (i) With reference to a thermocouple thermometer, what is meant by neutral temperature? (01 mark)

(ii) Briefly explain why it is undesirable to use a thermocouple for temperatures close to the neutral temperature. (02 marks)

b) (i) With aid of a diagram briefly describe how the temperature of the surface of the sun is measured using a disappearing filament pyrometer. (05 marks)

(ii) State **two** disadvantages of the pyrometer in **(i)** above. (01 mark)

c) A calorimeter containing first 40g and then later 100g of water is heated and suspended in the same constant temperature enclosure. It is found that the times taken to cool from 50°C to 40°C in the two cases are 15 minutes and 33 minutes respectively. Calculate the heat capacity of the calorimeter. (03 marks)

d) (i) Define melting point. (01 mark)

(ii) Explain briefly why melting point occurs at a constant temperature. (03 marks)

(iii) A shiny kettle with a 2.0 KW heating element has a heat capacity of $400 JK^{-1}$. A 1.00kg of water at 20° C is placed in the kettle. The kettle is then switched on and 0.5kg of water remain after 13 minutes. Calculate the value of the specific latent heat of vaporization of water. (04 marks)

6. a) (i) State Dalton's law of partial pressures. (01 mark)

(ii) Use the kinetic theory expression of pressure of an ideal gas to deduce Dalton's law. (05 marks)

b) Describe an experiment to verify the kinetic theory of matter. (04 marks)

c) Two identical vessels each of capacity 1.0 liter are connected by a tube of negligible volume. Together they contain helium gas at a pressure of 80cmHg and temperature 27°C. If **one** vessel is cooled to 0^0 C and the other heated to 100°C, assuming that the heat capacity of each vessel is unchanged. Calculate the;

(i) mass of helium gas in the vessels. (03 marks)

(ii) pressure developed in the apparatus. (03 marks)

(molar mass of helium = $4 gmol^{-1}$)

d) (i) What is meant by internal energy of an ideal gas? (01 mark)

(ii) A mass of **1g** of hydrogen at 20°C and 1×10^5Pa has its volume halved by an adiabatic change. Calculate the change in the internal energy of the gas.

(ratio of the principal specific heats of hydrogen = 1.40)

(molar mass of hydrogen = $2 gmol^{-1}$). (03 marks)

7. a) Define the following.

(i) Temperature gradient. (01 mark)

(ii) Radiative equilibrium. (01 mark)

b) (i) As a metal is heated it appears to change colour. Describe and account for this effect. (03 marks)

(ii) Explain why its much hotter above the fire than by its sides. (02 marks)

c) (i) Describe with aid of a diagram a method of determining the thermal conductivity of glass. (07 marks)

(ii) State **two** advantages of the method used in **(i)** above. (01 mark)

d) A tungsten filament lamp of effective radiating surface area $0.90cm^2$ radiates as a black body. It has a resistance of 50Ω at 20^0C. At an operating voltage of 240V, the current through the lamp is 0.5A. If the temperature coefficient of resistance is $5.0x10^{-3}K^{-1}$.

(i) Find the temperature at the above operating voltage. (03 marks)

(ii) Calculate the value of Stefan's constant. (02 marks)

SECTION C

8 a) (i) Define specific charge. (01 mark)

(ii) With aid of diagram describe an experiment to determine the specific charge of an electron by J.J Thomson's method. (06 marks)

b) Show that the angle, θ of deflection of charge **Q** with mass, **m** accelerated by a p.d, **V** in an electric field of field strength, **E** between the plates of length, **d** is given by;

$$\tan \theta = \frac{Ed}{2V}.$$ (04 marks)

c) A uniform magnetic field of flux density **1.2T** is applied to a cloud chamber. Alpha particles emitted from a radioactive source in the chamber describe a circular path of radius 36.0cm. Find the energy in **Mev** with which the alpha particles are emitted. Mass of alpha particles = 4.0026U. (04 marks)

d) The energy levels of hydrogen are -13.69ev, -3.39eV, -1.51eV, -0.85eV.

(i) What is likely to happen in an unexcited state when bombarded with an electron energy 12.18ev, 14.0ev. (02 marks)

(ii) Calculate the shortest wave length of the hydrogen spectrum and state the region of the spectrum in which it lies. (03 marks)

9 a) (i) State Bragg's law of X-ray diffraction.

(ii) A beam of X-rays of wavelength, λ is incident on a set of atomic planes of separation, **d.** Show that for diffraction to occur, $n\lambda \leq 2d$, where **n** is the order of diffraction. (04 marks)

b) An X-ray tube operating a100KV and 20m A produces x-rays of shortest wave length. The x-rays are incident on a quartz fibre of atomic spacing 1.5×10^{-10}m. Find the;

(i) number of electrons incident on the target per second. (02 marks)

(ii) maximum possible order with these x-rays. (02 marks)

c) Explain how the increase of filament current leads to increase of intensity of x-ray? (02 marks)

d) (i) What is meant by work function of a metal? (01 mark)

(ii) The surface of a metal of work function 1.9ev used in a photo cell is illuminated by violet light of wave length 4.5×10^{-7}m. Calculate the stopping voltage for the photo cell. (03 marks)

e) Describe an experiment to show that for every metal, there is a particular frequency of the incident radiation below which no emission of electrons occurs irrespective of the intensity of that radiation. (05 marks)

10 a) (i) What is meant by the terms mass defect and radioactive tracer? (02 marks)

(ii) State **one** industrial use of radioactive tracers. (01 mark)

b) Carbon -14, ${}^{14}_{6}C$ decays by emission of beta particles.

(i) Write an equation for the decay. (01 mark)

(ii) Explain how Carbon-14 is used in Carbon dating. (03 marks)

c) (i) Describe the structure and action of a diffusion cloud chamber. (06 marks)

(ii) Explain how the cloud chamber observations can be used to ascertain whether the source is an $\propto$ – particle or β – particle emitter. (03 marks)

d) A **G-M** tube counter is used to measure the age of a piece of wood. A sample containing 1.00g of carbon taken from the wood is placed in the detecting tube and the count rate recorded was 1000 counts per hour. The background count rate at the time was 300 counts per hour. When living material containing 1.00g of Carbon was placed in the tube, the count rate was 1600 counts per hour. If the half-life of Carbon -14 is 5700 years, Calculate the age of the wood. (04 marks)

END