PROVISIONAL MARKING GUIDE PHYSICS PAPER 1
P510/1 UNNASE MOCK EXAMINATIONS
AUGUST 2023

No.	MARKING POINT	Mks

1 **(a)** **(i)** Newton's law of gravitation states that every object in the universe attracts every other object with a force which is directly proportional to the product of their masses and inversely proportional to the square of their distance apart. **1**

(ii) Because of a very small value of the gravitational constant G, the gravitational force between bodies of ordinary mass is extremely small. Hence their acceleration is too small to cause any noticeable motion. The only attraction that we notice is the acceleration due to gravity because the earth is very massive. **3**

(b) **(i)** From $\frac{GM_e m}{r^2} = m\omega^2 r$ and $r = R_e + h$

$$GM_e = \omega^2 (R_e + h)^3$$

But $GM_e = \mathrm{g}{R_e}^2$ and $\omega = \frac{2\pi}{T}$

$$\Rightarrow \mathrm{g}{R_e}^2 = \left(\frac{2\pi}{T}\right)^2 (R_e + h)^3$$

$$T^2 = \frac{4\pi^2}{\mathrm{g}{R_e}^2}(R_e + h)^3$$

Since $\pi^2 \approx \mathrm{g}$ it implies $\frac{\pi^2}{\mathrm{g}} \approx 1$

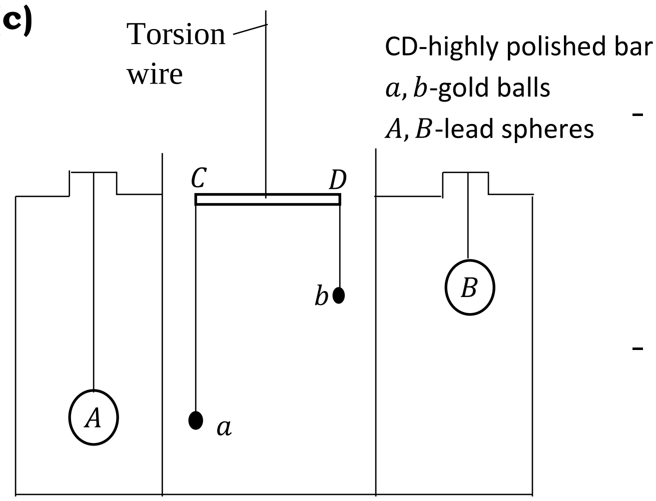
$$\therefore T^2 = \frac{4}{{R_e}^2}(R_e + h)^3$$

$$\boldsymbol{T = \frac{2}{R_e}(R_e + h)^{\frac{3}{2}}}$$

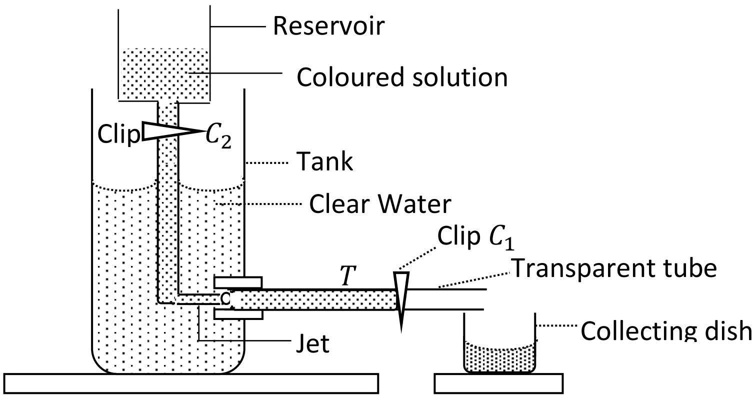
5

(ii) $k.e = \frac{GM_e m}{2r} = \frac{\mathrm{g}{R_e}^2 m}{2(R_e + h)} = \frac{9.81 \times (6.4\times10^6)^2 \times 500}{2(6.4\times10^6 + 3.6\times10^7)} = 2.37 \times 10^9 \mathrm{J}$ **5**

(c)



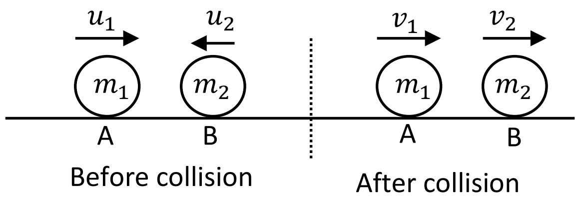
- Two identical solid spheres a, b each of mass, m are suspended using long and short quartz strings from a highly polished bar CD of length l.
- Two identical large spheres A and B each of mass M are brought in positions near a and b respectively.
- Distance d between A and a or B and b is measured and deflection θ of the bar CD is measured using lamp and scale method.
- Universal gravitational constant is calculated from $G = \frac{c\theta d^2}{mMl}$ where c is torque in torsion wire per unit radian of twist **6**

2	**(a) (i)** Upthrust is the upward force exerted by a fluid on a body placed in a fluid. **(ii)** $Upthrust, U = weight\ of\ the\ fluid\ displaced = mg = V\rho g$ $Resultant\ force = W - U = W - V\rho g$ But $V = \frac{W}{\sigma g}$; **hence**, $Resultant\ force = W - \frac{W}{\sigma g}\rho g = W - \frac{W}{\sigma}\rho = W\left(1 - \frac{\rho}{\sigma}\right)$	1 4
	(b) $Mass\ of\ water\ displaced, M_w = total\ mass\ of\ metal\ and\ wax$ $M_w = 2.6 \times 10^{-2} + 1.0 \times 10^{-4} = 2.61 \times 10^{-2}$ kg Also, $volume\ of\ metal\ and\ wax = volume\ of\ water\ displaced = \frac{M_w}{\rho_w}$ $V = \frac{2.61 \times 10^{-2}}{1000} = 2.61 \times 10^{-5}\ m^3$ Therefore, $volume\ of\ metal\ alone = 2.61 \times 10^{-5} - \frac{1.0\times10^{-4}}{200}$ $= 2.56 \times 10^{-5}\ m^3$ $Density\ of\ the\ metal = \frac{2.6 \times 10^{-2}}{2.56 \times 10^{-5}} = 1.02 \times 10^3 \text{kg}m^{-3}$	4
	(c) (i) A fluid element is a molecule (the smallest volume) of a fluid which follows the flow. **(ii)**  - A reservoir containing coloured water has a jet ending in a horizontal transparent tube. - The flow of the liquid is controlled by clip C_1. - The flow rate is slowly increased while observing T. - Its observed that at low velocities, a coloured stream of water flows along the middle of T; this is laminar flow. - As the flow rate is increased, a stage is reached when the colouring in T begins to spread out and fill the whole of the tube T; this is the onset of turbulent flow.	1 5
	(d) (i) In liquids, molecules are <u>fairly apart but still closer</u>. So, increasing temperature <u>increases the molecular separation</u> which <u>weakens molecular bonds</u> hence <u>lowering viscosity</u>. **(ii)** From force, $\boldsymbol{F} \propto \frac{\mathbf{1}}{\boldsymbol{r}}$; for blowing a balloon at the start radius r is <u>very small</u>, therefore a <u>big force is required</u>. As the balloon grows, <u>radius r increases</u> therefore <u>force also reduces</u>. Hence a big force is needed to grow a blowing balloon.	2 3

3 **(a)** **(i)** Linear momentum is the product of mass of a body and the velocity it moves with in a straight line. **1**

(ii) impulse is the product of force and time for which it acts. **1**

(b)



From principle of conservation of momentum

$$m_1u_1 + m_2(-u_2) = m_1v_1 + m_2v_2$$
$$m_1u_1 - m_2u_2 = m_1v_1 + m_2v_2$$
$$m_1(u_1 - v_1) = m_2(u_2 + v_2)$$
$$\frac{m_1}{m_2} = \frac{(u_2 + v_2)}{(u_1 - v_1)} \dots\dots\dots\dots..(i)$$

From energy

$$\frac{1}{2}m_1{u_1}^2 + \frac{1}{2}m_2{u_2}^2 = \frac{1}{2}m_1{v_1}^2 + \frac{1}{2}m_2{v_2}^2$$
$$m_1({u_1}^2 - {v_1}^2) = m_2({v_2}^2 - {u_2}^2)$$
$$\frac{m_1}{m_2} = \frac{{v_2}^2 - {u_2}^2}{{u_1}^2 - {v_1}^2} = \frac{(v_2 + u_2)(v_2 - u_2)}{(u_1 + v_1)(u_1 - v_1)} \dots\dots\dots\dots..(ii)$$

Equate equation (i) to (ii) **6**

$$\frac{(u_2 + v_2)}{(u_1 - v_1)} = \frac{(v_2 + u_2)(v_2 - u_2)}{(u_1 + v_1)(u_1 - v_1)}$$
$$u_1 + v_1 = v_2 - u_2$$

(c) In order to jump, the player must push himself against the floor. In doing so, the earth recoils as the player moves up. The momentum imparted to the earth is equal and opposite to that imparted to the player. However, because the earth is so much heavier than the player its recoil velocity is so small to be noticed. Nevertheless, the total momentum is conserved. **5**

(d) Horizontally; $8 \times 30 + 5(-50) = 8(15\cos 30°) + 5(-V\cos\theta)$

$$-10 = 103.923 - 5V\cos\theta$$
$$V\cos\theta = 22.785 \dots\dots\dots\dots\dots.(1)$$

Vertically; $0 = 5(V\sin\theta) + 8(-15\sin 30°)$

$$V\sin\theta = 12 \dots\dots\dots\dots\dots.(2)$$

Equation (2)÷ (1); $\tan\theta = \frac{12}{22.785}$; $\theta = 27.77°$

From Equation (2); $V = \frac{22.785}{\cos 27.77°} = 25.75\ ms^{-1}$ **5**

Deduction

k.e before collision $= \frac{1}{2}m_1{u_1}^2 + \frac{1}{2}m_2{u_2}^2$

$$k.e = \frac{1}{2} \times 8(30)^2 + \frac{1}{2} \times 5(50)^2 = 9850\text{ J}$$ **2**

k.e after collision $= \frac{1}{2} \times 8 \times (15)^2 + \frac{1}{2} \times 5(25.75)^2 = 2557.66$ J

collision is perfectly inelastic since there is a loss in kinetic energy.

4 (a) (i) A megawatt is the rate of doing work of 1 million joules per second. **1**

(ii) $k.e\ per\ second = \frac{1}{2}\frac{m}{t}u^2$; $\frac{m}{t}$ is mass of air striking the blade per second. $\Rightarrow \frac{m}{t}$ =volume per seconds×density of air.

$$k.e\ per\ second = \frac{1}{2}(\pi r^2 u)\rho \times u^2 = \frac{1}{2}\pi r^2 \rho u^3$$ **3**

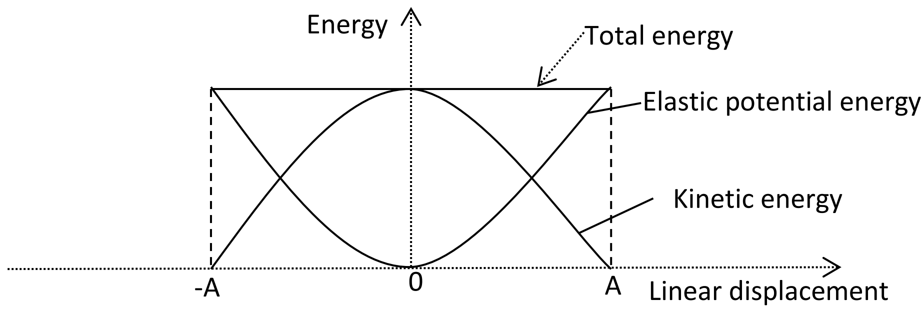
(b) From $F = ma$; $\Rightarrow kx = (\rho A l) \times \frac{v}{t}\ since\ m = \rho \times volume$

$$kx = \rho A v^2\ since\ v = \frac{l}{t}$$

$$v = \sqrt{\frac{kx}{\rho A}} = \sqrt{\frac{512 \times 5 \times 10^{-2}}{1000 \times 4 \times 10^{-4}}} = 8\ ms^{-1}$$ **4**

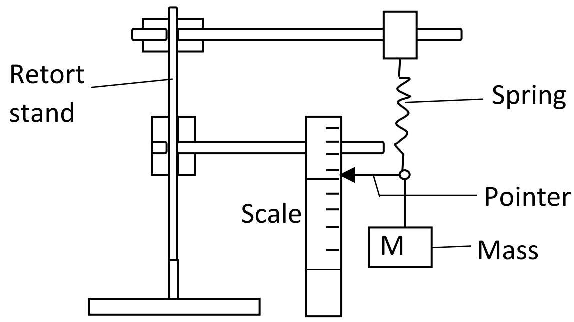
(c) (i)
- Its periodic
- Its acceleration is directed towards a fixed point.
- Its acceleration is directly proportional to the displacement from fixed point.
- Its mechanical energy is conserved. **2**

(ii)



3

(d)



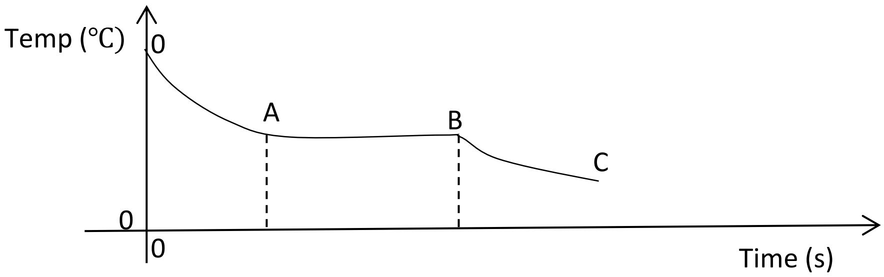
- A spring is clamped on a retort stand.
- A horizontal pin is fixed at the free end of the spring to act as a pointer.
- A vertical metre rule is placed next to the pin and the <u>initial pointer position is noted</u> P_0.
- A known mass M is suspended to the free end of the spring and the <u>new reading of the position of the pointer</u> P_1 is noted.
- The extension, e produced $e = P_1 - P_o$ is found.
- The mass is then <u>slightly</u> displaced vertically downwards and released and <u>time</u> t for n oscillations noted.
- The periodic time T is found.
- Experiment is <u>repeated</u> with different known masses M and results tabulated including <u>values of T^2</u>. **7**
- A graph of T^2 against e is plotted.
- The slope S of the graph is obtained.
- Acceleration due to gravity is calculated from; $g = \frac{4\pi^2}{S}$.

5 (a) (i) Melting point is a constant temperature at which a solid changes to a liquid at standard pressure. **1**

(ii) Specific latent heat is the quantity of heat required to change the physical state of a 1 kg mass of a substance from one to another at a constant temperature. **1**

(b) Melting occurs when a substance <u>changes from solid to liquid state</u>. The heat absorbed from its surrounding <u>increases molecular separation</u> due to <u>weakening of the bonds</u> in <u>which p.e of molecules increases</u>, in which molecular bonds weaken to <u>form a liquid</u>. **4**

(c) (i)



1

- OA: the temperature falls as the liquid losses heat to its surroundings.
- AB: the liquid turns to a solid as the temperature remains constant because the would be lost heat to surroundings is compensated by the latent heat extracted from the liquid as it solidifies. **2**
- BC: the temperature of the solid falls as it cools.

(ii) Heat energy lost per second, $mc_l\Delta\theta = ml_f$

$$l_f = 1200 \times \frac{2.9}{60} \times 40 \times 60 = 139200\ \text{Jkg}^{-1}$$

2

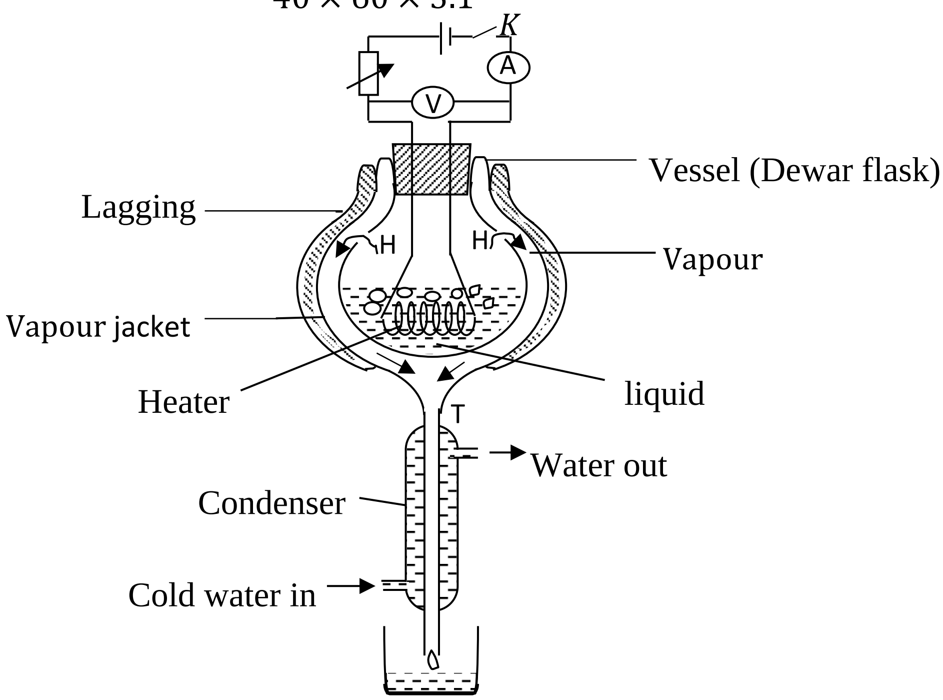
At B: heat absorbed during solidification=heat lost by solid formed

$$ml_f = m_s c_s \Delta\theta$$

$$c_s = \frac{139200 \times 60}{40 \times 60 \times 3.1} = 1122.58\ \text{Jkg}^{-1}\text{K}^{-1}$$

2

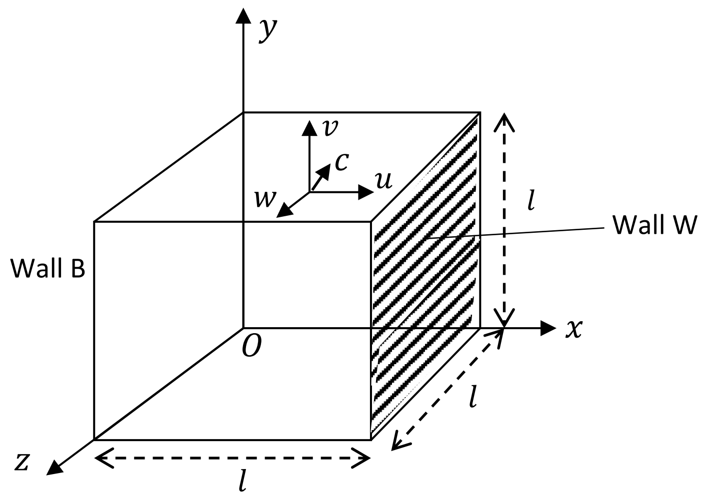
(d)



2

	- Switch K is closed and liquid is heated until it starts to boil. - A stop clock is started and mass m_1 of liquid is collected in time t is noted. - The ammeter and voltmeter readings, I_1 and V_1 are read and noted. $$I_1V_1 = m_1l_v + h$$ where h is heat lost to the surroundings. - Rheostat is adjusted and the new ammeter and voltmeter readings I_2 and V_2 are read and noted. - The new mass m_2 of the collected in the same time t is obtained. $$I_2V_2 = m_2l_v + h$$ - Specific latent heat of evaporation of a liquid l_v is obtained from; $$l_v = \frac{(I_2V_2 - I_1V_1)t}{m_2 - m_1}$$	**5**

6	**(a)(i)** An isothermal change is the change in volume and pressure of a gas at constant temperature. (*accept* compression or expansion) An adiabatic process is a change (expansion or compression) in which there is no heat exchange between the gas and the surrounding.	**1** **1**
	(ii)- Boiling point of water - Melting point of ice	**2**
	(iii) Isothermal - The gas should be sealed in a thin vessel. - The vessel should be highly conducting. - The vessel should be surrounded by a constant temperature bath. - The process should be carried out slowly.	**2**
	Adiabatic - The gas should be sealed in a thick vessel. - The vessel should be poorly conducting. - The process should be carried very rapidly. - There should be no heat exchange between the gas and its surroundings.	**2**
	(b)(i) Dalton's law of partial pressures states that for a mixture of gases which do not interact chemically, their total pressure is the sum of their partial pressures.	**1**
	(ii) Consider a molecule of mass m moving in a cube of length l at a velocity u in direction of x-axis.	



- Change in momentum = $mu - (-mu) = 2mu$
- Rate of change in momentum $= \frac{2mu}{t}$

  But t is time between collisions and $t = \frac{2l}{u}$
- Force on the wall by the molecule $= \frac{2mu}{\frac{2l}{u}} = \frac{mu^2}{l}$
- For N molecules, force F on the wall

$$F = \frac{mu_1^2}{l} + \frac{mu_2^2}{l} + \cdots + \frac{mu_N^2}{l}$$

- Total pressure on wall W, $P = \frac{F}{A} = \frac{mu_1^2}{l^3} + \frac{mu_2^2}{l^3} + \cdots + \frac{mu_N^2}{l^3}$ since $A = l^2$

$$P = \frac{m}{l^3}(u_1^2 + u_2^2 + \cdots + u_N^2) \quad ------(i)$$

Let $\overline{u^2}$ be the mean of the squares of the speeds in the Ox-direction; i.e.

$$\overline{u^2} = \frac{u_1^2 + u_2^2 + \cdots + u_N^2}{N}$$

$$\Longrightarrow u_1^2 + u_2^2 + \cdots + u_N^2 = N\overline{u^2}$$

Therefore, from (i), $P = \frac{mN\overline{u^2}}{l^3}$

- For large number of molecules of varying speed in random motion, the mean square of the component speed in any one of the three axes is the same, $\therefore \overline{u^2} = \overline{v^2} = \overline{w^2}$

  But for each molecule, $c^2 = u^2 + v^2 + w^2$ so the mean square speed $\overline{c^2}$ is given by **6**

$$\overline{c^2} = \overline{u^2} + \overline{v^2} + \overline{w^2}$$

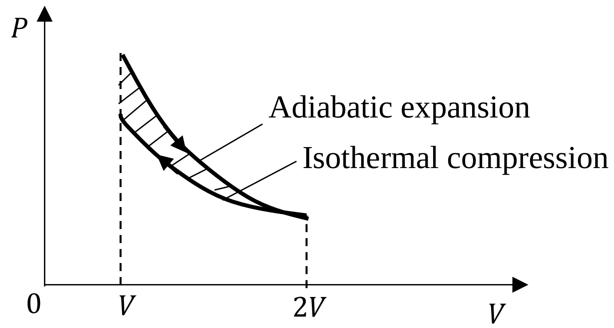
$$\Longrightarrow \overline{c^2} = \overline{u^2} + \overline{u^2} + \overline{u^2} = 3\overline{u^2}$$

$$\therefore \overline{u^2} = \frac{1}{3}\overline{c^2}$$

also $\frac{mN}{l^3} = \rho$ (density of the gas)

- $\therefore \boldsymbol{P = \frac{1}{3}\rho\overline{c^2}}$

(c)(i)



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(ii) $C_v = \frac{5}{2}R$, $C_p = \frac{7}{2}R$, $\gamma = \frac{C_p}{C_v} = 1.4$

$$T_1{V_1}^{\gamma-1} = T_2{V_2}^{\gamma-1}$$

$$(25 + 273)V^{1.4-1} = T_2(2V)^{1.4-1}$$

$$298V^{0.4} = T_2 2^{0.4}V^{0.4}$$

$$\therefore T_2 = 225.8\,K$$

4

7 **(a)**Temperature gradient is the rate of temperature fall per unit length. **1**

(b)(i)

- Conduction of heat in poor conductors is purely through collision of atoms.
- Atoms are heated and vibrate, collide with neighbouring atoms and heat is propagated. **3**
- In metals conduction of heat is by motion of free electrons and vibration of atoms.

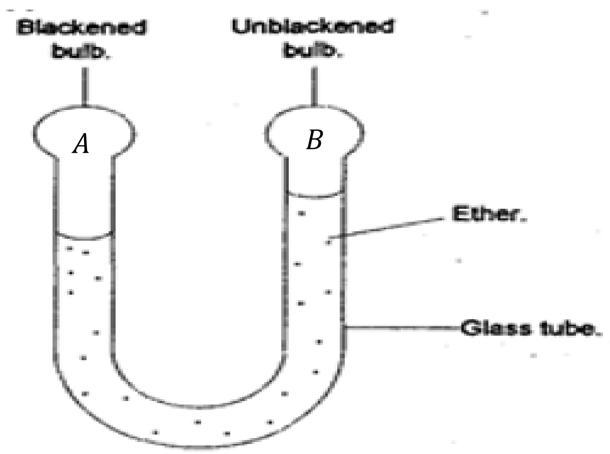
(ii)

- Specimen is well lagged or insulated to prevent lateral heat loss.
- Specimen is made long and given small cross-sectional area so that temperature difference at its ends is sufficiently big enough to measure. If it is thin temperatures at its ends will be equalized within a very short time. **3**

(c)(i)

Prevost's theory of heat exchanges states that when a body is in thermal equilibrium with its surroundings, its rate of emission of radiation to the surroundings is equal to its rate of absorption of the radiation from the surroundings. **1**

(ii)



2

- Infrared radiation is made to fall on the bulbs A and B
- More of the radiation is absorbed by A than B.
- The temperature of air inside A increases making it to expand and hence pressure in A increases which pushes the liquid in it towards B. **4**
- This creates a change in liquid levels in the arms showing the presence of radiation.

(d)

$$\frac{T_{venus}^4}{T_{earth}^4} = \left(\frac{R_{SE}}{R_{SV}}\right)^2$$

$$T_{venus}^4 = \left(\frac{1}{0.72}\right)^2 \times (273 + 15)^4$$

$$T_{venus} = 339.41\ K \quad \boldsymbol{OR}\ 66.41℃$$

6

8 (a)(i)

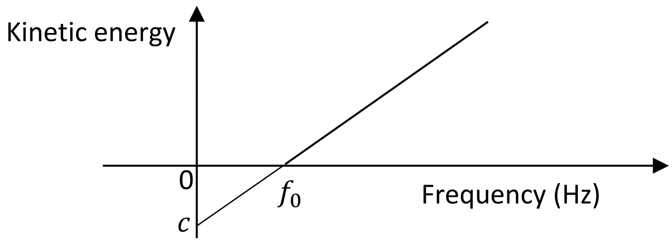
Threshold wavelength is the maximum wavelength beyond which no photoelectric effect occurs. **1**

(ii)

From kinetic energy = $hf - \omega_0$; where ω_0 is work function, which is constant. So, a metal is made up of energy levels in which each electron in that energy level posses different amount of energy.

So, the frequency of incident radiation predicts the amount of energy to be absorbed by electron for it to leave the metal surface. Kinetic energy of the electrons depends on frequency of incident radiation. **3**

(b)(i)



2

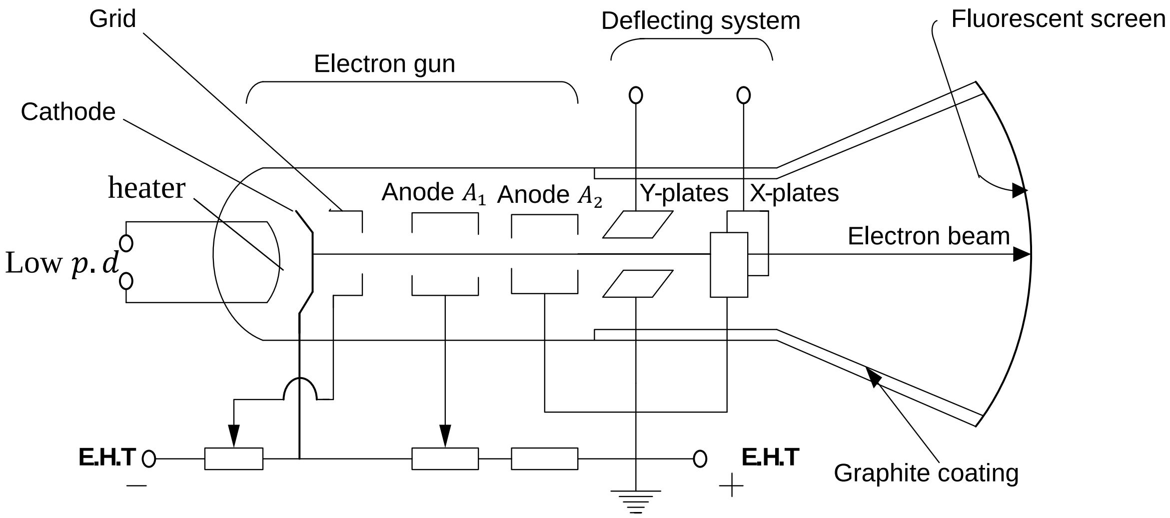
(ii)

- By finding the slope S of the graph and $S = h$ which is the Plank's constant. **2**

(c)(i)

Time base is the circuit connected to the x-plates to sweep the electron beam from left to right. **1**

(ii)

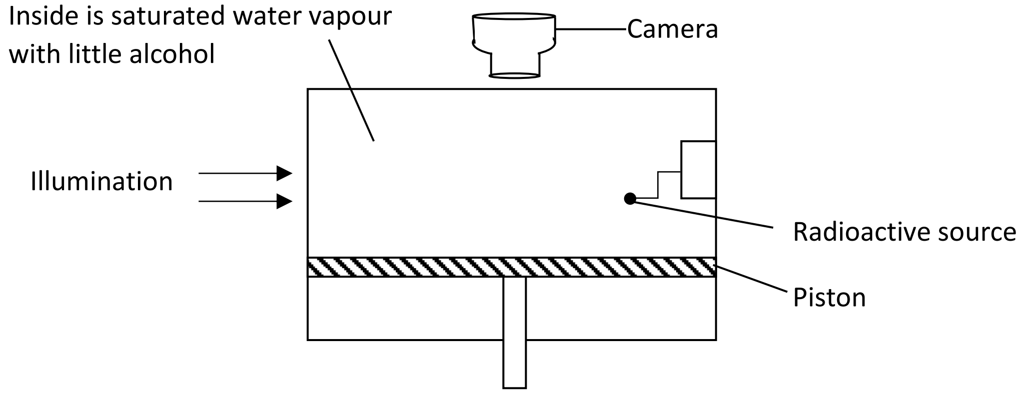


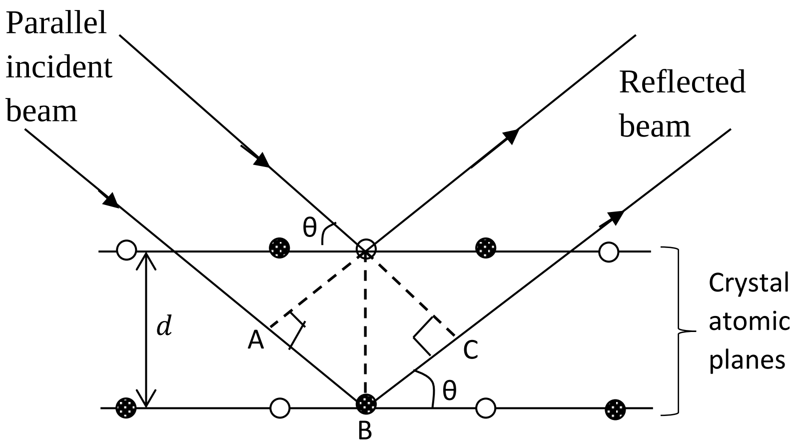
2

- The filament cathode is heated by the low voltage to produce electrons thermionically.
- The electrons are accelerated and shoot through grid and move towards the screen.
- The required wave signal to display is connected to the Y-plates while the time base voltage is connected to the X-plates.
- The Y-plates deflect the electron beam vertically while the X-plates deflect the beam horizontally.
- The required sinusoidal waveform is thus displayed on the fluorescent screen.

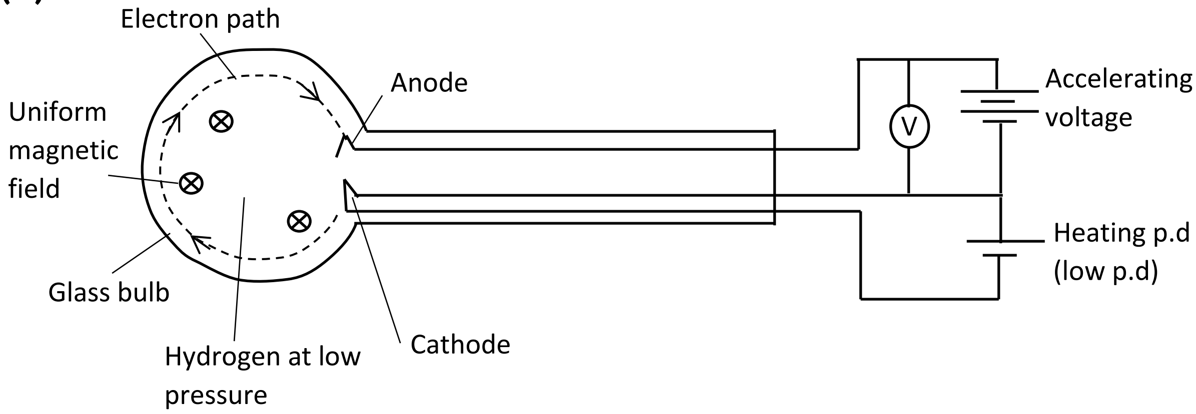
4

	(e) From $V_{rms} = \frac{V_0}{\sqrt{2}}$ $\therefore Peak\ voltage, V_0 = V_{rms}\sqrt{2} = 50\sqrt{2} = 70.71V$ Peak-to-peak voltage= $70.71 \times 2 = 141.42\ V$ If 10 V is represented by 1 cm, then 141.42 V will be represented by $\frac{141.42}{10} = 14.142$ cm Therefore, peak-to-peak height = 14.142 cm Time occupied by 1 cycle (period), $T = \frac{1}{f} = \frac{1}{50} = 0.02\ s$ Time occupied by n cycles in 40 cm length is; $t = 40\ cm \times 10\ \text{ms cm}^{-1} = 400\ \text{ms} = 400 \times 10^{-3} s$ Thus, number of cycles, $n = \frac{t}{T} = \frac{400\times10^{-3}}{0.02} = 20$ cycles	**5**

9	**(a)(i)** Dead time is the time taken by the positive ions to move far enough away from the anode for the electric field there to return to a level which is large enough for an avalanche to start.	**2**
	(ii) Recovery time is the time which elapses while argon ions are being neutralized by the quenching agent.	**1**
	(b) (i) 	**2**
	- When the piston is moved down quickly the air in the chamber undergoes adiabatic expansion and cools. - The dust nuclei are all carried away after a few expansions by drops forming on them. - And then dust free air in the chamber is subjected to controlled adiabatic expansions and the air becomes super saturated. And simultaneously the air is exposed to radiations from the radioactive source. - Water droplets immediately collect around ions produced forming tracks. - The droplets are then illuminated and photographed by the camera.	**4**
	(ii) - From $p = \frac{1}{3}\rho \overline{c^2}$, $P \propto \rho$; decrease in pressure decreases the density of air there. - From $\rho = \frac{m}{V}$, implies that volume of air in the chamber increases. - Since $V = Al$; hence the length of the tracks increases.	**3**
	(c)(i) Number of disintegrations per second within the source$= \frac{dN}{dt} = \frac{4\pi r^2}{A} C$ $$\frac{dN}{dt} = \frac{4\pi(10)^2}{4} \times \frac{4.8 \times 10^4}{60} = 2.5133 \times 10^5 \text{ s}^{-1}$$	**4**
	(ii) From $A = \lambda N$ and $\lambda = \frac{\ln 2}{T}$ $$\Rightarrow T = \frac{\ln 2}{A} N = \frac{\ln 2}{2.5133 \times 10^5} \times 5.2 \times 10^{15} = 1.43 \times 10^{10} \text{ s}$$	**4**

10	**(a)(i)** Transistor is a device used for controlling current or voltage flow in addition amplifying and generating electrical signals and acting as a switch.	**1**
	(ii) - When a semi-conductor is doped with group 3 impurities, p-type is formed in which holes are majority charge carriers. - And when doped with group 5 impurities, n-type is formed in which electrons are majority charge carriers.	**3**
	(b)(i) Bragg's law states that, for constructive interference of diffracted X-rays to occur, their path difference is an integral multiple of their wavelength.	**1**
	(ii) - Wavelength of X-rays should be of the same order as the interplanar spacing. - Parallel beam of X-rays should be incident on planes.	**2**
	(iii) 	**1**
	- For constructive interference the path difference between the X-rays reflected from consecutive planes is equal to integral multiple of their wavelength. - $\overline{AB} + \overline{BC} = n\lambda$ But $\overline{AB} = \overline{BC} = d\sin\theta$ - $d\sin\theta + d\sin\theta = n\lambda$ - $2d\sin\theta = n\lambda$	**3**
	(c)(i) • Electrical energy→kinetic energy→heat energy +X-rays	**2**
	(ii) - By increasing the p.d across the tube, the energy of the electrons moving towards the target is increased, making much high energy available for production of X-rays, thus X-rays of high quality are produced.	**2**

(d)



1

- Electrons are emitted thermionically from the cathode and accelerated to the anode.
- Electrons collide with hydrogen atoms causing the atoms to emit light revealing a circular path of electrons caused by uniform magnetic field of flux density B.
- The radius r of the circular path is measured using a plane mirror.
- Centripetal force=magnetic force

$$\frac{mu^2}{r} = Beu \qquad \Longrightarrow u = \frac{Ber}{m}$$

But $k.e\ of\ electron = \frac{1}{2}mu^2 = \frac{1}{2}m\left(\frac{Ber}{m}\right)^2 = \frac{B^2e^2r^2}{2m}$

Also, $k.e\ of\ electron = eV$; where V is accelerating p.d

$$\Longrightarrow eV = \frac{B^2e^2r^2}{2m}$$

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

4

END