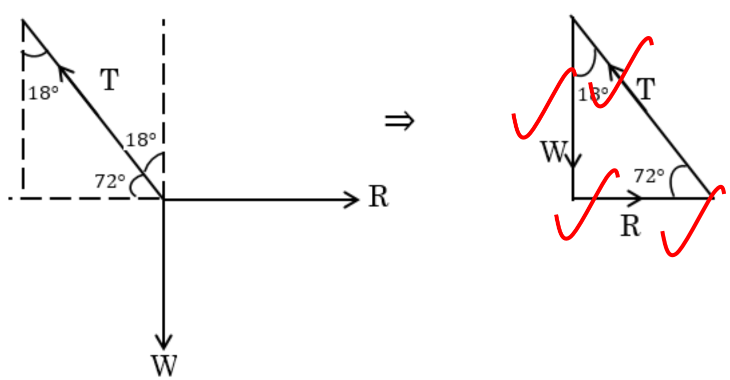
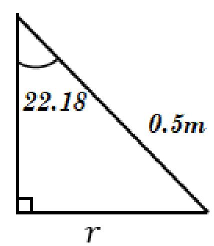
MATIGO EXAMINATIONS BOARD

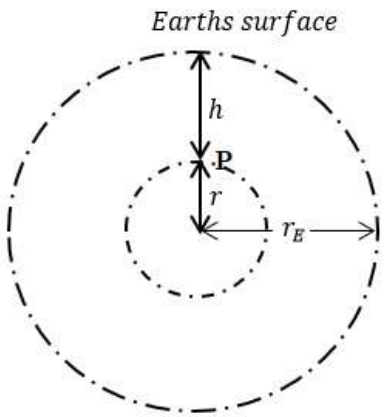
P510/1
PHYSICS
MARKING GUIDE 2023
PAPER 1

Qn	Answer	Marks
1(a)(i)	**Law** of conservation of linear momentum states that for a system of colliding bodies, their total linear momentum remains constant in a given direction provided no external force(s) act on them	01
(ii)	Work energy theorem states that the work done by the net force acting on a body is equal to the change in its kinetic energy.	01
(b)	Elastic collision: is the type of collision in which all kinetic energy and momentum of colliding bodies are conserved. While Inelastic collision: Is the type of collision in which only momentum of colliding bodies is conserved but not kinetic energy.	
(c)		

	(ii) By Lami's theorem $$\frac{\text{T}}{\sin 90°} = \frac{\text{R}}{\text{Sin}(72+90)} = \frac{\text{W}}{\text{Sin}(18+90)}$$ $$\frac{T}{Sin\ 90} = \frac{520}{Sin\ 108}$$ $$T = \frac{520Sin90°}{Sin108°}$$ $$T = 546.8N$$ Alternatively Using a right angled triangle. $$\frac{T}{Sin90°} = \frac{W}{Sin72°} = \frac{R}{Sin18°}$$ $$\frac{T}{Sin90°} = \frac{520}{Sin72}$$ $$T = \frac{520sin90°}{Sin72°}$$ $$T = 546.76N$$ Alternatively $$TCos18° = 520$$ $$T = \frac{520}{cos18}$$ $$T = 546.76N$$	
(iii)	Also $$\frac{R}{Sin18} = \frac{546.8}{Sin90} = \frac{520}{Sin72}$$ $$R = \frac{520Sin18}{Sin72}$$ $$R = 169.0N$$	

	Alternatively $$TCos72 = R$$ $$546.8Cos72 = R$$ $$R = 168.97N$$	
(iv)	Since these forces are coplanar, and the body must stay in mechanical equilibrium, the 3 forces must remain proportional to each other. Hence an increase in the angle at constant weight must cause an increase in the tension.	
(d)(i)	$$Tsin\theta = \frac{mv^2}{r}$$ $$Tcos\theta = mg$$ $$tan\theta = \frac{v^2}{rg}$$ $$tan\theta = \frac{(2)^2}{1 \times 9.81}$$ $$\theta = 22.18°$$  $$sin22.18 = \frac{r}{0.5}$$ $$r = 0.5sin22.18$$ $$r = 0.189$$ $$v^2 = rgtan\theta$$ $$v = \sqrt{rgtan\theta}$$	

	$v = \sqrt{0.189 \times 9.81 tan22.18}$ $v = 0.869ms^{-1}$ *or* $0.87ms^{-1}$	
(ii)	$T = \frac{2\pi r}{v}$ $T = \frac{2 \times 3.14 \times 0.189}{0.869} = 1.37s$	
2(a)	Newton's law of gravitation states that the force of attraction between two bodies in the universe is directly proportional to the product of their masses and inversely proportional to the square of distance between them. Hence From $F = \frac{Gm_1m_2}{r^2}$ $G = \frac{Fr^2}{m_1m_2}$ $[\mathrm{G}] = \frac{[\mathrm{F}][r^2]}{[m_1m_2]}$ $[\mathrm{G}] = \frac{\mathrm{MLT^{-2}L^2}}{\mathrm{M^2}}$ $[\mathrm{G}] = \mathrm{M^{-1}L^3T^{-2}}$	
(b)	Relationship between acceleration due to gravity g and mean distance from centre of earth (i) Inside he earth ⇒ Consider the earth to be a uniform sphere of uniform density for a body at a point h metre from, the surface of earth measured towards the centre of the earth (inside the earth)	



$$\Rightarrow$$

$$\mathrm{M}_g = \frac{\mathrm{GM_E m}}{r_\mathrm{E}^2}$$

$$\mathrm{M}_E = \frac{r_E^2 g}{\mathrm{G}} \ldots\ldots\ldots\ldots\ldots.(i)$$

$\Rightarrow$ At point P, at a radius r, effective mass M_E so

$$\mathrm{M_E^I g^I} = \frac{\mathrm{GM_E^I M}}{r^2}$$

$$m = \frac{r^2 g^I}{r^2} \ldots\ldots\ldots\ldots\ldots\ldots.(ii)$$

Dividing (ii) by (i)

$$\frac{m}{\mathrm{M}_E} = \frac{r^2 g^I}{r_E^2 g}$$

$$\frac{g^I}{g} = \frac{r}{r_E}$$

$$\therefore\ g^I = \frac{gr}{r_E}$$

Alternatively

On earth's surface

$$mg = \frac{GM_e m}{r_e^2},$$

$$M_e = \frac{gr_2^2}{G}$$

$$mg^l = \frac{GM_e{}^l m}{r^2}$$

$$M_e^l = \frac{g^l r^2}{G}$$

$$mass = v \times \rho$$

$$M_e = \frac{4}{3}\pi r_e^3 \rho$$

$$M_e^l = \frac{4}{3}\pi r^3 \rho$$

$$\frac{M_e^l}{M_e} = \frac{\frac{4}{3}\pi r^3 \rho}{\frac{4}{3}\pi r_e^3 \rho} = \frac{\frac{g^l r^2}{G}}{\frac{g r_e^2}{\mathrm{G}}}$$

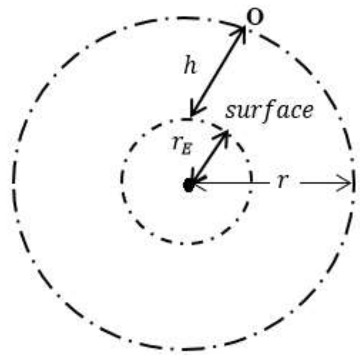
$$\left(\frac{r}{r_e}\right)^3 = \frac{g^l}{g}\left(\frac{r}{r_e}\right)^2$$

$$\frac{r}{r_e} = \frac{g^l}{g}$$

$$g^l = \frac{gr}{r_e}$$

Hence $g^I \propto r$ *for a point inside the earth*

(ii) Outside



For an object of mass m placed at a height h above the surface of earth where acceleration due to gravity is g^I

$$mg^I = \frac{GM_E m}{r^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

$$but\ gr_E^2 = GM_E \ldots\ldots\ldots\ldots\ldots\ldots.. (ii)$$

Dividing (i) by (ii)

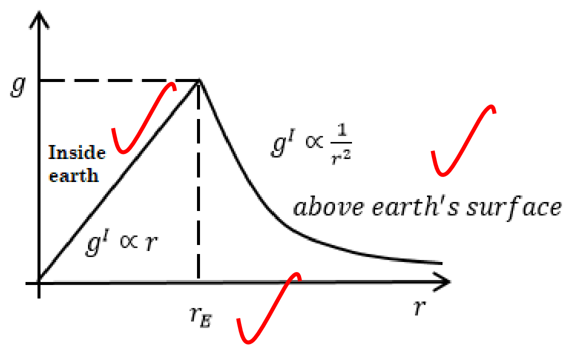
$$\frac{g^I}{g} = \frac{r_E^2}{r^2}$$

$$g^I = \frac{g r_E^2}{r^2}$$

Since r_E and g are constants

$$g^I \propto \frac{1}{r^2}$$

(iii)

		
(c)(i)	Escape velocity. Is the minimum velocity with which a body is projected from the earth's surface so it escape from earth's gravitational pull never to return.	
(ii)	$$W_m = \frac{1}{6}W_E$$ $$mg^I = \frac{1}{6}mg, \quad g^I = \frac{1}{6}g$$ $$V = \sqrt{2g^I r_m}$$ $$Kinetic\ lost = PE\ gained$$ $$1/_2\, mv^2 = 0 - -\frac{GMM_m}{r_m}$$ $$V_{esc} = \sqrt{\frac{2GM_m}{r_m}}$$ $$V_{esc} = \sqrt{\frac{2 \times 9.8 \times 1.75 \times 10^6}{6}}$$ $$V_{esc} = 8730.9ms^{-1}$$	
(d)	Gravitational force of attraction between two bodies of ordinary mass is not noticeable because;	

	• Of its relatively weak strength compared to other forces and our typical distances from large masses like those of planets. • Of the very small value of the gravitational constant G, So the gravitational force between bodies of ordinary mass is extremely small.	
3(a)	S.H.C is the periodic motion of a body whose acceleration is directly proportional to the displacement from a fixed point and is directed towards the fixed point.	
(b)(i)	For $l_1 = 0.4m\ l_2 = 0.6m$ $T = 2\pi\sqrt{\frac{l}{g}}$ $they\ will\ be\ in\ step\ again\ after\ a\ time$ $T = \left(\frac{T_1 \times T_2}{T_2 - T_1}\right)$ $T_1 = 2\pi\sqrt{\frac{0.4}{9.81}}$ $T_1 = 2\pi\sqrt{0.041}s$ $T_2 = 2\pi\sqrt{\frac{0.6}{9.81}}$ $T_2 = 2\pi\sqrt{0.061}s$ $T = \frac{(2\pi\sqrt{0.041})(2\pi\sqrt{0.061})}{(2\pi\sqrt{0.061} - 2\pi\sqrt{0.041})}$ $T = \frac{4\pi^2\sqrt{0.002501}}{2\pi(0.044)}$ $T = 2\pi(1.126)$ $T = 7.074s$	
b(ii)	To find frequencies and oscillations $T_1 = 2\pi\sqrt{\frac{l}{g}}$	

	$$T_1 = 2\pi\sqrt{\frac{0.4}{9.81}} = 1.264s$$ $$T_2 = 2\pi\sqrt{\frac{0.6}{9.81}} = 1.549s$$ $$Lcm\ of\ periods = 1.264 \times 1.549$$ $$= 7.808s$$ $$In\ this\ time\ pendulum\ 1, Oscillations\ = \frac{7.808}{1.264}$$ $$= 6.17$$ $$\approx 6\ Oscillations$$ $$pendulum\ 2, Oscillations\ = \frac{7.808}{1.549}$$ $$= 5.04$$ $$\approx 5\ Oscillations$$	
3(c)	Applications • Pistons in petrol engine • Pendulum clock • Strings in musical instruments	**01**
3(d)(i)	Hooke's law: The extension of a stretched elastic material is directly proportional to the applied force provided the elastic limit is not exceeded.	**01**
(ii)	$$A = 0.002m^2$$ $$l = 1.5m$$ $$F = 250{,}000N$$ Since the cross-sectional area of the rod is small $(0.002m^2)$,when a large stretching force $(250000N)$is applied the force is distributed over this small cross sectional area. This results into higher stress value since stress = $\frac{force}{cross\ sectional\ area} = \frac{F}{A} = \frac{250{,}000}{0.002} = 125{,}000KNm^{-2}$ As the force applied at the ends of rod is transmitted through it. It thins out x-sectional area/ reduces much further where breaking occurs hence stress increases.	**05**
3(e)(i)	Static friction is a force that opposes the tendency of a body to slide over another and dynamic friction is the force that opposes the relative motion between 2 surfaces which are already.	**02**

<table>
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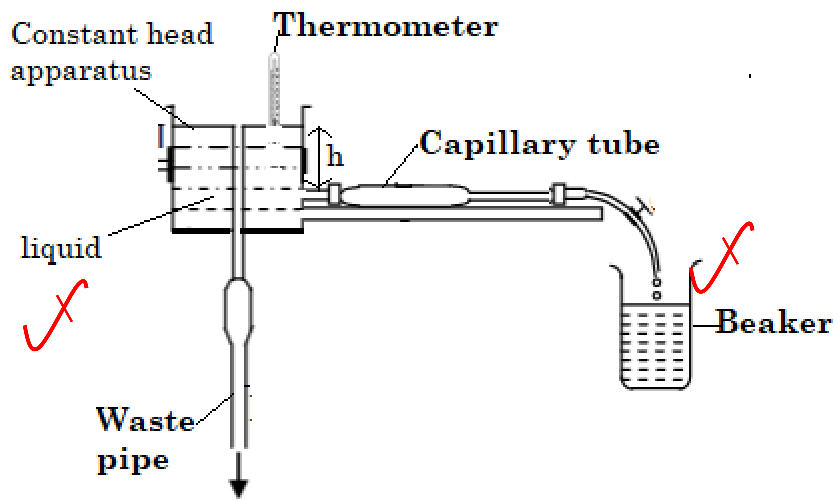
<td>(ii)</td>
<td>


The apparatus is set up as shown above
A constant head, h is measured and recorded
The volume, V of the liquid flowing through the capillary tube in time, t is measured
The procedures are repeated several times by varying h to obtain a set of values for each volume, V and the volume per second, $\frac{V}{t}$is calculated
The length l of the capillary tube is measured and recorded.
the radius r is measured is obtained by measuring the diameter of capillary tube using a travelling microscope.
A graph of $\frac{V}{t}$ against h is obtained.
The slope, S of the graph is obtained.
The coefficient of viscosity η is obtained from

$$\eta = \frac{\pi r^4 \rho g}{8Sl}$$
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<td>4(a)(i)</td>
<td>Archimedes principle states that when a body is wholly or partially immersed in a fluid, it experiences an up thrust equal to the weight of the fluid displaced</td>
<td>01</td>
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<td>(ii)</td>
<td>Proof
For a cylindrical rod of cross-sectional area A and height h immersed in a large quantity of fluid of density ρ</td>
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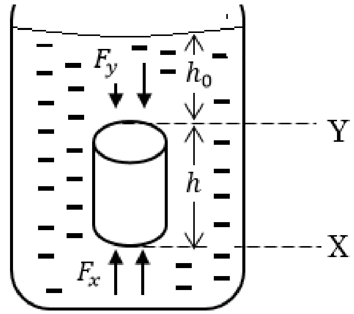
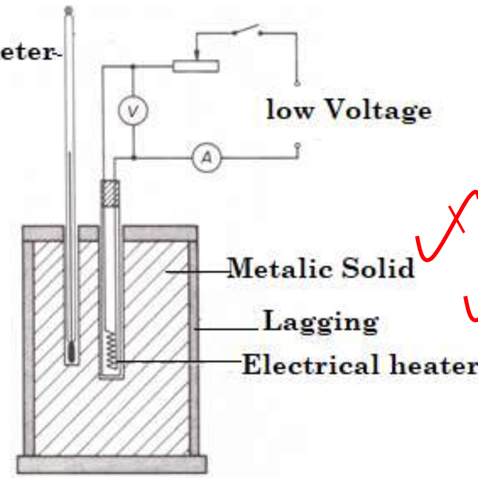
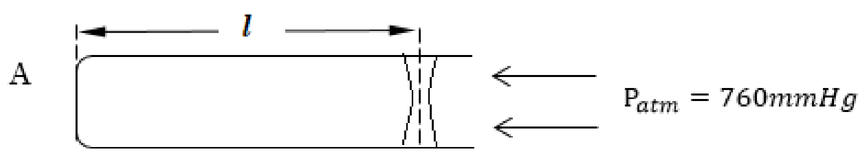
	 $Volume\ of\ displaced\ fluid = Volume\ of\ cylinder$ $\therefore\ V_f = Ah$ $Mass\ of\ displaced\ fluid = \rho V_f$ $\therefore M_f = \rho Ah$ $Weight\ of\ displaced\ fluid = M_f g$ $weight\ of\ fluid\ displaced = \rho Ahg \ldots\ldots\ldots (i)$ $Upthrust = Resultant\ upward\ force\ due\ to\ fluid$ $Upthrust = F_y - F_x$ $But\ P = \frac{F}{A}, F = PA$ $Upthrust = P_y A - P_x A$ $= (h + h_0)\rho g A - h_0 \rho g A$ $= h\rho g A + h_0 \rho g A - h\rho g A$ $Upthrust = h\rho g A \ldots\ldots\ldots\ldots\ldots\ldots. (ii)$ $comparing\ (i) and\ (ii)$ $Upthrust = Weight\ of\ fluid\ displaced$	
b(i)	Law of flotation states that a floating body displaces its own weight of the fluid in which it floats	
(ii)	$V_t = 120ms^{-1}$ $V_b = 115ms^{-1}$ $A = 15m^2$ $\rho_a = 1.28$ $F = ?$ $P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho V_2^2$ $P_2 - P_1 = \frac{1}{2}\rho(V_1^2 - V_2^2)$	

	$P_2 - P_1 = \frac{1}{2} \times 1.28(120^2 - 115^2)$ $Lift\ force, F = (P_2 - P_1)A$ $= \frac{1}{2} \times 1.28(120^2 - 115^2) \times 15$ $= 11280N$	
(d)(i)	Bernoulli's principle. It states that for a non-viscous incompressible fluid flowing steadily, the sum of the pressure plus the potential energy per unit volume plus kinetic energy per unit volume is constant at all points on a stream line.	01
(ii)	Application Bunsen burner: the gas passes through a narrow jet at high speed creating a low pressure region. Atmospheric pressure then pushes air in through the hole towards the region of low pressure and the mixture flows up the tube to burn at the top. Candidate may also explain action of carburetor, spinning ball, Aero lift or suction effect	03
(iii)	Blowing air over it, makes the air on top to move at high speed than the little air that flows beneath the paper. By Bernoulli's principle the pressure below the paper exceeds that on top. This pressure difference produces the resultant force called lift upwards force which keeps it horizontal but above the ground.	O5
	SECTION B	
5(a)(i)	Black body radiation. This is the radiation emitted by black body radiator being a characteristic of its temperature and independent on the nature of its surface.	01
(ii)	$\frac{d\theta}{dt} = -K(\theta - \theta_R)$ $\frac{d\theta}{dt} \Rightarrow Rate\ of\ cooling\ of\ a\ body$ $(\theta - \theta_R) \Rightarrow Excesstemperature\ over\ sounding$ $\theta_R \Rightarrow Sorrounding\ temperature$ $K \Rightarrow constant$	
(b)(i)	$P = 80W$ $\frac{Q}{t} = KA\left(\frac{T_2 - T_1}{l}\right)$ $and\ \frac{Q}{t} = MC(\theta_1 - \theta_2), M = \frac{m}{t}$ $80 = \frac{K(10 \times 10^{-4})(48° - 28°)}{10 \times 10^{-2}}, where\ l = (15 - 5)cm$	03

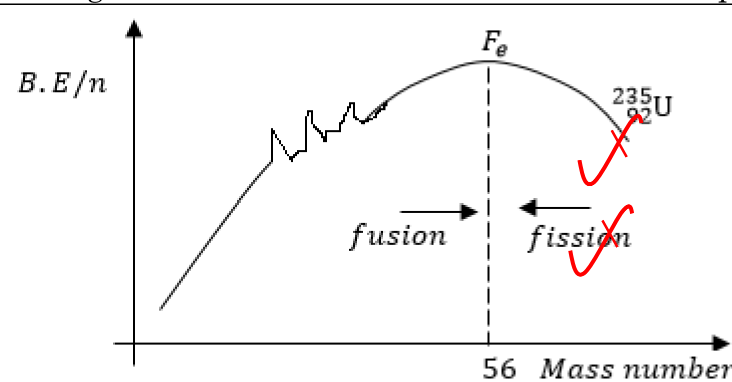
	$K = \frac{80 \times 10^2}{20}$ $K = 400Wm^{-1}K^{-1}$	
(b)(ii)	$\frac{Q}{t} = MC(\Delta\theta)$ $80 = M(4200 \times 5)$ $M = \frac{80}{4200 \times 5} kgs^{-1}$ $M = \frac{80 \times 1000 \times 60}{4200 \times 5}$ $M = 228.57gmin^{-1}$	**03**
b(iii)	$\frac{Q}{t} = KA\left(\frac{T_2 - T_0}{l}\right), l\ is\ entire\ length$ $80 = \frac{400 \times (10 \times 10^{-4})(48 - T_0)}{20 \times 10^{-2}}$ $\frac{80 \times 20 \times 10^{-2}}{400 \times (10 \times 10^{-4})} = 48 - T_0$ $40 = 48 - T_0$ $T_0 = 48 - 40$ $T_0 = 8°C$	**03**
(c)(i)	Specific heat capacity is the quantity of heat required to change the temperature of 1kg mass of a substance by 1°C or $1K$. SI unit Joules per Kilogram per Kelvin ($JKg^{-1}K^{-1}$)	**02**
(c)(ii)	Experiment S.H.C by electrical method	*any four well labelled parts* $@\frac{1}{2} mark$ **06**

	 • A solid metal block is *drilled with 2 holes*, one for the thermometer and the other for an electric heater filled with mercury to increase thermal contact. • The mass, *m, of the block* is found and its initial *temperature θ_1 is recorded*. • A suitable steady current is *switched on* and a stop clock is started simultaneously. • Ammeter and voltmeter *reading I and V* are read and noted. • When the temperature has risen appreciably the current is topped and *the time, t of heating* is noted and also the final *temperature θ_2 is read* and noted. • Assuming no heat loss to the surrounding, heat supplied by the heater = heat gained by the block $$IVt = MC(\theta_2 - \theta_1)$$ • The specific heat capacity, C is given by; $$C = \frac{IVt}{m(\theta_2 - \theta_1)}$$	
6(a)(i)	Thermal conductivity of a material is the rate of heat flow at right angles to the opposite faces of $1m^3$ of a material when temperature difference across the faces in 1K. Accept The rate of heat flow per unit cross sectional area per unit temperature gradient.	01
(ii)	Specific latent heat of vaporization of a substance is the quantity of heat required to change the state of 1kg mass of substance from liquid to vapour state at constant temperature.	01
6(b)	• One must choose a thermometer properly say X	

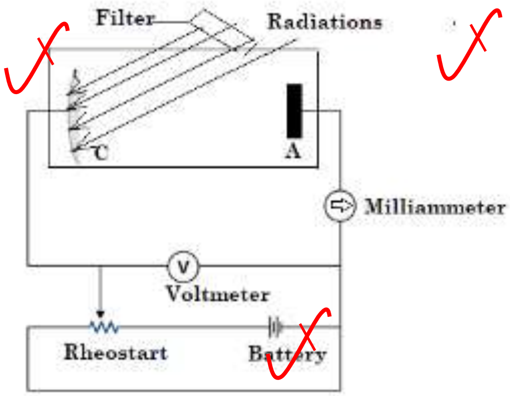
	• Should measure the value of the property at ice point, steam point X_0 and X_{100} respectively • Measure the value of the property at unknown temperature θ suvh as X_θ • The unknown temperature, $\theta = \left(\frac{X_\theta - X_0}{X_{100} - X_0}\right) \times 100°C$	
6(c)(i)	$E = A\theta + B\theta^2$ $2 \mid 4.28 = 100A + 10000B$ $-1 \mid 9.29 = 200A + 40000B$ $0.73 = 20000B$ $A = 0.03915$ $B = 0.0000365$	04
(ii)	$B\theta^2 + A\theta \leq 0.01$ $0.0000365\theta^2 + 0.03915\theta - 0.01 \leq 0$ $Range: -0.51 \leq \theta \leq 0.50$	
(d)	$R_t = (1 + 8000bt - bt^2)$ $At\ t = 0, R_{t=0} = R_0$ $At\ t = 100°C, R_{t=100} = (1 + 800000b - 10000b)R_0$ $At\ t = 400°C, R_{t=400} = (1 + 3200000b - 160000b)R_0$ $\theta = \left(\frac{R_{t=\theta} - R_{t=0}}{R_{t=100} - R_{t=0}}\right) \times 100°C$ $\theta = \left(\frac{[(1 + 3200000b - 160000b) - 1]}{[(1 + 800000b - 10000b) - 1]}\right) \times 100°C$ $\theta = \frac{3040000b \times 100}{790000b}$ $\theta = 384.8°C$	
7(a)(i)	Saturated vapour is the vapour which is dynamic equilibrium with its own liquid while unsaturated vapour is the vapour which is not in dynamic equilibrium with its own liquid.	01
(ii)	 $P_{sv} = 11.2mmHg\ at\ 15°C, l = 10cm$ $P_{sv} = 45.0\ mmHg\ at\ 40°C, l = ?$	05

	$At\ 15°C, P_a + P_{sv} = P_{atm}$ $P_a = P_{atm} - P_{sv}$ $P_a = 760 - 11.2$ $P_a = 748.8 mmHg$ $At\ 40°C, P_a = 760 - 45.0$ $P_a = 715 mmHg$ $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $But\ V = Al$ $\frac{P_1l_1}{T_1} = \frac{P_2l_2}{T_2}$ $\frac{748.8 \times 10}{288} = \frac{715l_2}{313}$ $l_2 = 11.38cm$ $l_2 \approx 11.4cm$	
(c)(i)	Dalton's laws states that the total pressure of a mixture of gases that do not react chemically is the sum of partial pressure of the constituent gases.	01
(ii)	Recall $P = \frac{1}{3}\rho C^{-2}$ $Since\ \rho = \frac{Nm}{v}\ where\ m\ is\ mass\ of\ one\ molecule$ $PV = \frac{1}{3}Nmc^{-2}$ $N = \frac{3PV}{mc^{-2}}$ $If\ the\ gas\ has\ 2\ components\ 1\ \&\ 2$ $N_1 = \frac{3P_1V}{m_1c_1^{-2}}\ and\ N_2 = \frac{3P_2V}{m_2c_2^{-2}}$ $N = N_1 + N_2$ $\frac{3PV}{mc^{-2}} = \frac{3P_1V}{m_1c_1^{-2}} + \frac{3P_2V}{m_2c_2^{-2}}$ $At\ constant\ temperature$ $\frac{1}{2}mc^{-2} = \frac{1}{2}m_1c_1^{-2} = \frac{1}{2}m_2c_2^{-2}$	

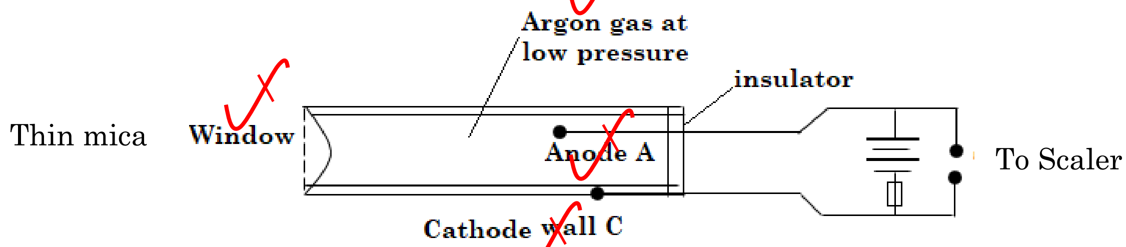
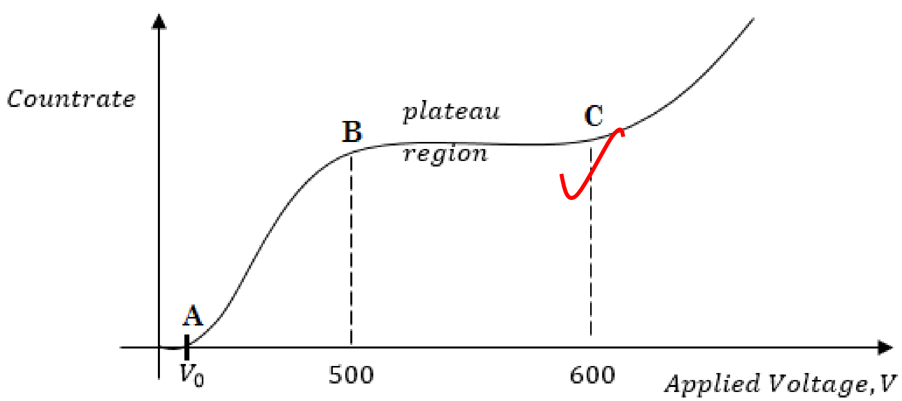
	$Hence\ P = P_1 + P_2$	
(d)	$P_1 = 760mmHg$ $P_2 = (2 \times 760)mmHg$ $V = Constant$ $T_1 = 273K$ $T_2 = ?$ $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $T_2 = \frac{P_2 T_1}{P_1}$ $T_2 = \frac{2 \times 760 \times 273}{760}$ $T_2 = 546K$ $But\ \sqrt{\overline{c^2}} = \sqrt{\frac{3P}{\rho}} \ldots\ldots\ldots\ldots (i)$ $\sqrt{\frac{\overline{c_1^2}}{\overline{c_2^2}}} = \sqrt{\frac{T_1}{T_2}} \ldots\ldots\ldots\ldots\ldots (ii)$ $\sqrt{\frac{\overline{c_1^2}}{\overline{c_2^2}}} = \sqrt{\frac{273}{546}}$ $\sqrt{\frac{\overline{c_1^2}}{\overline{c_2^2}}} = \frac{1}{\sqrt{2}}$ $\sqrt{\frac{\overline{c_1^2}}{\overline{c_2^2}}} = \frac{1}{\sqrt{2}}$ $\overline{C^2} = \sqrt{\frac{3P}{\rho}}\ \ But\ \rho = \frac{P \times R.M.M}{RT}$	

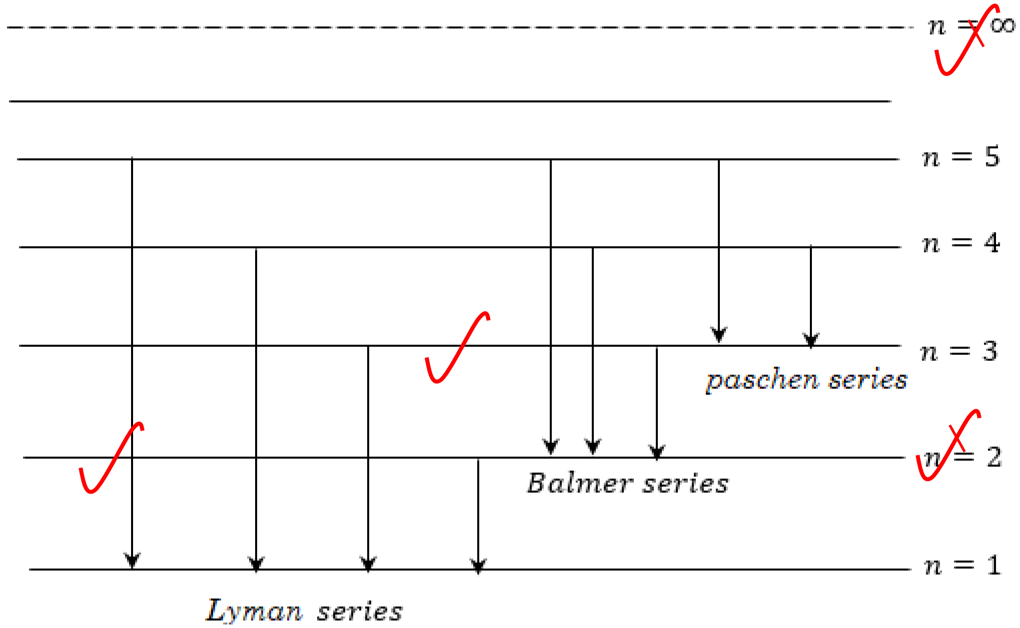
	$= \sqrt{\frac{3P \times RT}{P \times R.m.m}}$ $\overline{C^2} = \sqrt{\frac{3RT}{R.m.m}}$ $\sqrt{\overline{c_1^2}} = \sqrt{\frac{3 \times 8.31 \times 273}{16}}$ $\sqrt{\overline{c_1^2}} = \sqrt{425.4} = 20.62$ $\frac{\sqrt{425.4}}{\sqrt{\overline{c_2^2}}} = \frac{1}{\sqrt{2}}$ $\sqrt{\overline{c_2^2}} = \sqrt{2}\sqrt{425.4}$ $\therefore \sqrt{\overline{c_2^2}} = 29.16ms^{-1}$	
	SECTION C	
8(a)(i)	Nuclear fission is the disintegration of a heavy unstable nucleus into two lighter nuclei. Accompanied by release of energy.	
(ii)	Nuclear fusion is the union of two light nuclei to form a heavier nucleus accompanied by release of energy.	
(b)(i)		

(ii)	**Fission** • If a nucleus of high mass number and of low B.e per nucleon is split into two lighter nuclei, there is an increase in B.e per nucleon. The total mass of lighter nuclei is less than the mass of the heavy nucleus. The mass difference accounts for the energy released, this process is called fission Fusion • If two light nuclei of low binding energy per nucleon are joined to form a heavier nucleus is less than the total mass of the lighter nuclei. The difference in mass accounts for energy released. This process is called fusion.	
(c)(i)	$4 = x + 1$ $x = 3$	01
(ii)	$5 = y + 1$ $y = 4$	01
(iii)	$235 + 1 = z + 92 + 3$ $z = 236 - 95$ $z = 141$	01
(d)(i)	Photo electric emission is the liberation of electrons from a clean metal surface when it's exposed by electromagnetic radiation of short wavelength (of high enough frequency).	01
(ii)	$hf - hf_0 = eV_s = \frac{1}{2}mu^2,\quad Where\ W_0 = hf_0$ $hf - W_0 = eV_s$ $f - frequency\ of\ incident\ radiation$ $h - plank's constant$ $W_0 - work\ function$ $V_s - stopping\ potential$ $e - electronic\ charge$ $hf = w_0 + K.e_{max}$ $K.e_{max} = maximum\ kinetic$ $Energy\ of\ electrons\ emitted$ $w_0 = work\ function$ $f = frequency\ of\ incident$ $Radiation$	02
(iii)	• The anode A is made negative with respect to the cathode and cathode c made positive with respect to the anode. • A beam of radiation of known frequency $f \geq f_0$ is directed on to a photocathode through a colour filter. • The ammeter connected in series with photo current due to emitted electrons • The potential divider is varied (adjusted) until the ammeter registers zero reading, the voltmeter connected across registers the stopping potential V_s. • The procedure is repeated with other frequencies f of the radiation and values of V and F are tabulated in a suitable table. • A graph of V_s against f is plotted. • A straight line graph shows that Einstein's equation is verified	

	• The slope, S is found and plank's constant h is got from $h = es$ where e is the electronic charge. 	
9(a)(i)	Radio isotope refers to radioactive atoms of the same element having the same atomic number (number of protons) but different atomic mass (number of neutrons)	01
(ii)	Radioactive decay is described as spontaneous because no particular pattern is followed and cannot be controlled by both physical and chemical change.	01
(b)	$\frac{dm}{dt} = -\gamma M$ $\int \frac{dM}{M} = -\int \gamma dt$ $\ln M = -\gamma t + c$ $if\ t = 0, M = M_0$ $In\ M_0 = 0 + c$ $\therefore c = lnM_0$ $\ln M = -\gamma t + lnM_0$ $lnM - lnM_0 = -\gamma t$ $ln\left(\frac{M}{M_0}\right) = -\gamma t$ $\frac{M}{M_0} = e^{\gamma t}$	

	$M = M_0 e^{-\gamma t}$	
(c)(i)	$t_{\frac{1}{2}} = 80years$ The statement means that the sample of the radioactive element takes 80years to reduce (decay) to half of its original value.	01
(ii)	$At\ t_{\frac{1}{2}}, M = \frac{1}{2}M_0$ $ln\left(\frac{\frac{1}{2}M_0}{M_0}\right) = \gamma t_{\frac{1}{2}}$ $\frac{ln2}{\gamma} = t_{\frac{1}{2}}$ *where γ is decay constant*	
(iii)	$t_{\frac{1}{2}} = 29200$ $A = \frac{20}{100}A_0, t = ?$ $A = A_0 e^{-\gamma t}$ $\frac{ln5}{\gamma} = t$ $But\ t_{\frac{1}{2}} = \frac{ln2}{\gamma}$ $\gamma = \frac{ln2}{29200}$ $T = \frac{ln5}{\left(\frac{ln2}{29200}\right)}$ $T = \left(\frac{ln5}{ln2}\right)(29200)$ $T = 67800.3\ days$ $\frac{20A_0}{100} = A_0 e^{-\lambda t}$ $\frac{1}{5} = e^{-\lambda t}$ $ln\frac{1}{5} = -\lambda t$ $ln5 = \lambda t$ $t = \frac{ln5}{\lambda}$	
(d)(i)	• When ionizing radiation enters the G.M tube either through the window or cylindrical cathode walls, argon atoms are ionised • The electrons move very fast to the anode ad the positive ions drift to the cathode. • When the electrons reach the anode, a discharge occurs and a current flows in the external circuit.	

	• A potential difference is obtained across a large resistance R which is amplified and passed to a scaler/counter. • The magnitude of the pulse registered gives the extent to which ionisation occurred. • When positive ions reach and bombard the cathode walls, secondary ionisation occurs, the resulting electrons would interfere with first current, to prevent this second avalanche, a halogen gas such as bromine is mixed with the argon gas to form a quenching agent.  	
(ii)	 A p.dV_0, no count rate recorded at all since the amount of electron amplification is not enough to give pulses of sufficient magnitude to be detected. Between A and B the magnitude of pulse developed in the tube depends on initial ionisation which in turn depends on the energy of the incident ionizing particles. Only some of the freed electrons give pulse of sufficient magnitude to be recorded but their number increases with applied voltage, count rate increases.	03

	Between B and C the count rate is almost constant. A full avalanche is obtained along the entire length of the anode and all particles whatever their energy produce detectable pulses. Beyond C, the count rate increase rapidly with voltage due to incomplete quenching. One incident ionizing particle may start a whole train of pulses.	
10(a)	Bohr model is one with a small centrally positive nucleus with electrons revolving around it only in certain allowed circular orbits and while in these orbits they do not emit radiations. Electromagnetic radiations are emitted when an electron makes a transition between two orbits	03
(b)		
(c)	Show that $r = \frac{n^2 h^2 \varepsilon_0}{\pi m e^2}$ $For\ circular\ motion, \frac{mV^2}{r} = \frac{e^2}{4\pi\varepsilon_0 r^2}$ $mV^2 = \frac{e^2}{4\pi\varepsilon_0 r}$ $\frac{1}{2}mV^2 = \frac{e^2}{8\pi\varepsilon_0 r}$ $KE = \frac{e^2}{8\pi\varepsilon_0 r} \dots \dots \dots \dots \dots (i)$	

	From Bohrs assumptions $$mVr = \frac{nh}{2\pi}$$ $$m^2V^2r^2 = \frac{n^2h^2}{4\pi^2}$$ $$mV^2 = \frac{n^2h^2}{4\pi^2mr^2}$$ $$\frac{1}{2}mV^2 = \frac{n^2h^2}{8\pi^2mr^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (ii)$$ $$K.E = \frac{n^2h^2}{8\pi^2mr^2}$$ Comparing (i) and (ii) $$\frac{e^2}{8\pi\varepsilon_0 r} = \frac{n^2h^2}{8\pi^2mr^2}$$ $$r = \frac{n^2h^2\varepsilon_0}{\pi me^2}$$ As required	
(d)(i)	Electron Volt. Is the kinetic energy gained by electron in being accelerated through a potential difference of one Volt. Or Minimum amount of energy required to accelerate an electron through a p.d of 1V	
(ii)	Energy of an electron at rest outside the atom is taken as zero (eV) and work has to be done to remove the electron to infinity since its bound to the nucleus.	
(iii)	Transition A not mentioned in question. $$E_B - E_A = \frac{hC}{\lambda}$$ $$(-1.50 - -3.40) \times 1.6 \times 10^{-19} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{\lambda}$$ $$\lambda = 6.51 \times 10^{-7}m$$ *Visible region*	
(iv)	For ionisation	

	$Ionisation\ energy = K.E = (0 - -13.6) \times 1.6 \times 10^{-19}$ $K.E = 2.176 \times 10^{-18} J$ $\frac{1}{2} mV^2 = 2.176 \times 10^{-18}$ $V = \sqrt{\frac{2 \times 2.176 \times 10^{-18}}{9.11 \times 10^{-31}}}$ $V = \sqrt{4.78 \times 10^{13}}$ $V = 6.91 \times 10^6 ms^{-1}$	

END