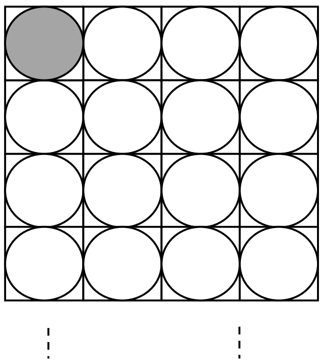
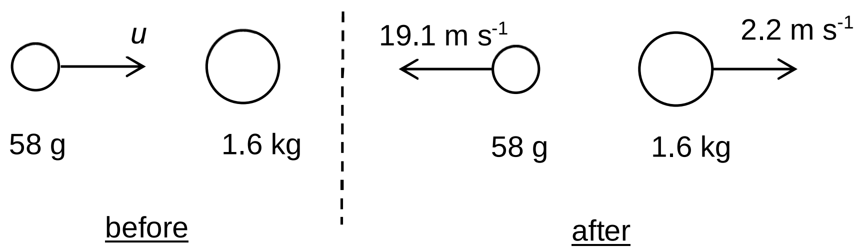
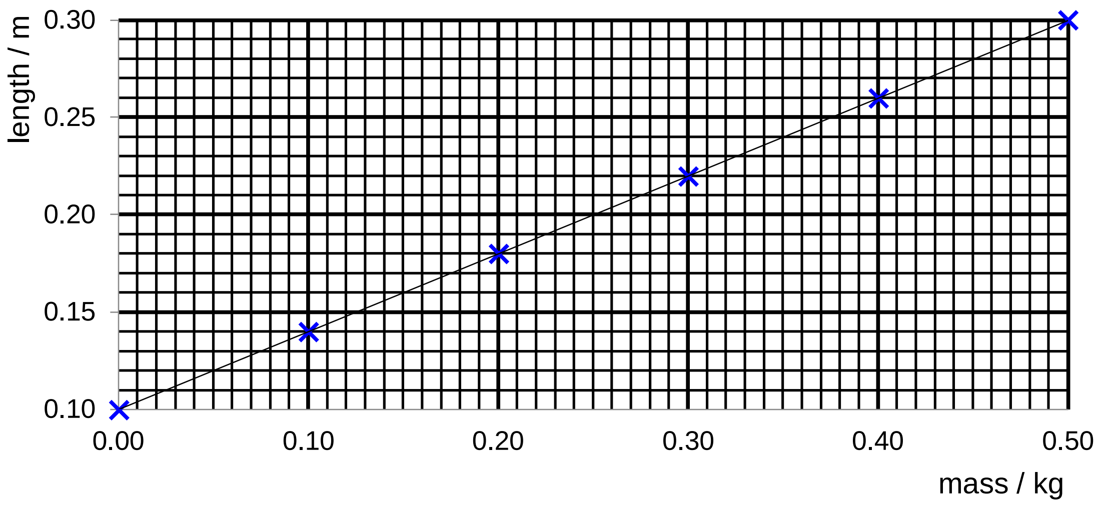
2023 Preliminary Examination H1 Physics Paper 2 Suggested Solution

Qn 1	**Answer**	**Marks**
(a)(i)	Actual dimensions of 330 ml soft drink can radius r = 3.2 cm, height h= 12.2 cm (*the volume of the can is greater than the 330 ml of soft drink contained*) Acceptable range $3.5\text{ cm} \geq r \geq 2.5\text{ cm}$, $14\text{ cm} \geq h \geq 10\text{ cm}$ Volume of a can, $V = \pi r^2 \times h$ Acceptable range for volume of can, $\left(550 \geq V \geq 196\right)$ cm^3 Accept if student quotes 330 cm^3	A1
(a) (ii)	Consider cans as being blocks of dimensions 2r x 2r x h. These blocks are stacked in the crate	
	 No of blocks in 1 m^3, $N = \dfrac{1}{2r \times 2r \times h}$ Empty space per block, $V_{empty} = V_{block} - V_{can} = 2r \times 2r \times h - \pi \times r \times r \times h = \left(4-\pi\right)r^2 h$ Total empty space in crate $= N \times V_{empty} = \dfrac{1}{4r^2 h} \times \left(4-\pi\right)r^2 h = \dfrac{\left(4-\pi\right)}{4} \times 1 = 0.21\text{ m}^3$ (*independent of can dimensions*)	**M1** **M1** **A1**

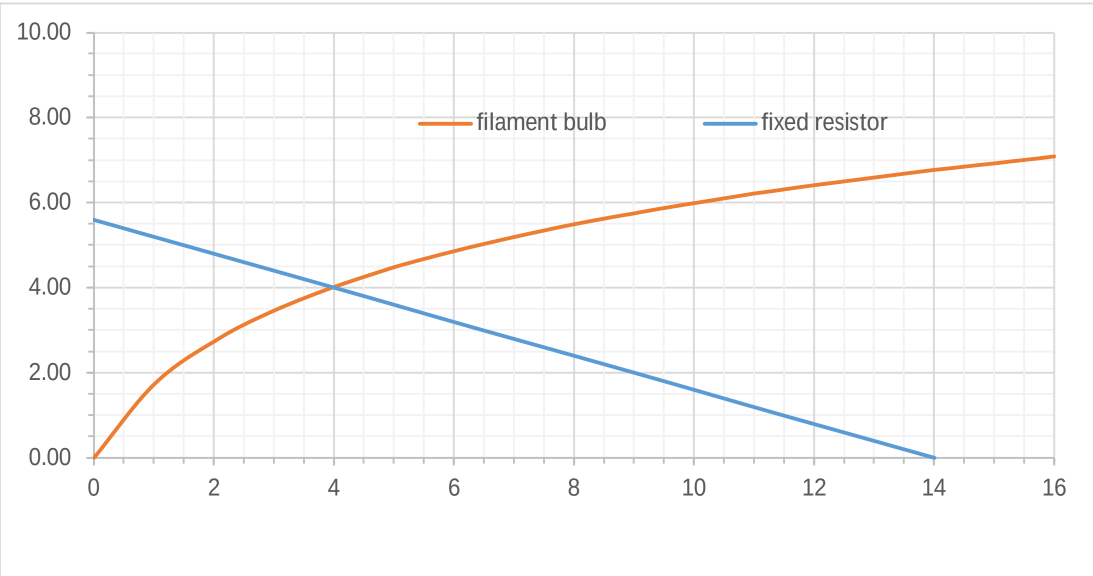
(b)(i)	$v = u + at$ $\dfrac{100 \times 1000}{3600} = 0 + (9)t$ $t = 3.1\text{ s}$	**M1** **A1**
(b)(ii)	time for car to move 2 km = t Using $s = ut + \dfrac{1}{2}at^2$ $\dfrac{1}{2} \times t \times 9t = 2000$ $t = 21.1\text{ s}$ time for jet to move 2 km = t' $\dfrac{1}{2} \times 10 \times 50 + \dfrac{1}{2}\left(50 + 50 + 15(t' - 10)\right) \times (t' - 10) = 2000$ $250 + \dfrac{1}{2}(100 + 15t' - 150)(t' - 10) = 2000$ $15t'^2 - 200t' - 3000 = 0$ $t' = 22.3\text{ s}$ time difference Δt = 1.2 s [A1] Alternatively, time for car to move 2 km = t $s = ut + \dfrac{1}{2}at^2$ $2000 = \dfrac{1}{2}(9)t^2$ [M1] $t = 21.1\text{ s}$ time for jet to move 2 km = t' s_1 distance travelled by jet in first 10 s s_2 distance travelled by jet from 10 s to finish $s_1 = 0 \times 10 + \dfrac{1}{2} \times 5 \times (10)^2 = 250\text{ m}$ $s_2 = 50(t' - 10) + \dfrac{1}{2} \times 15 \times (t' - 10)^2$ $s_1 + s_2 = 2000$ $250 + 50(t' - 10) + \dfrac{1}{2} \times 15 \times (t' - 10)^2 = 2000$ $t' = 22.3\text{ s}$ time difference Δt = 1.2 s [A1]	**M1** **M1** **A1**
	Max Marks	**9**

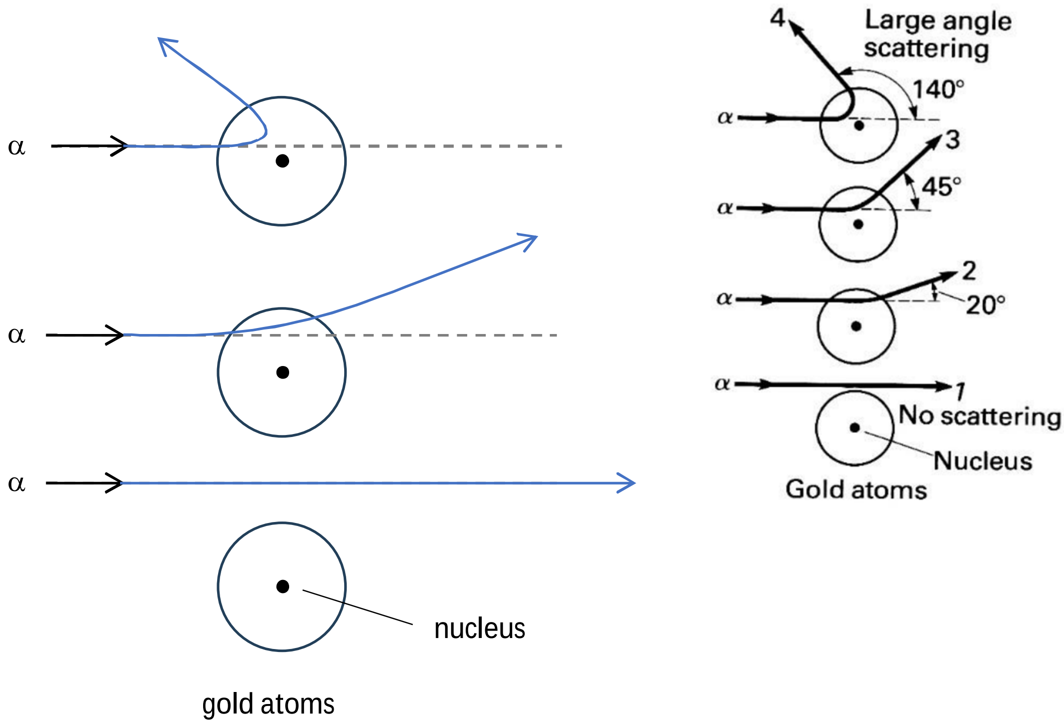
Qn 2	Answer	Marks
(a)	Weight component of the block normal to the slope = 1.6 (9.81) cos 30° = 13.59 N In the normal direction, net force = 0 Normal contact force by the scale on the block = weight component of the block normal to the slope = 13.59 N By Newton's 3rd Law of Motion, Normal contact force by the block on the scale (i.e. this force determine the reading on the scale) is equal and opposite to the normal contact force by the scale on the block. Thus, the reading on the scale = 13.59 / 9.81 = 1.39 or 1.4 kg.	**B1** **B1** **B1** **A1**
(b)(i)	Consider the block: Let the velocity of the block immediately after collision be *v*. By conservation of energy, Loss in KE = Gain in GPE $\frac{1}{2}mv^2 = mgh$ $v = \sqrt{2gh} = \sqrt{0.5g} = 2.2$ m s^{-1}	**B1**
(b)(ii)	By N2L: $\langle F \rangle = \frac{m(v-u)}{\Delta t} = \frac{1.6\left(\sqrt{0.5(9.81)}-0\right)}{0.2}$ $= 17.7$ N	**B1** **A1**
(b)(iii)	 By conservation of linear momentum, $m_{ball}u_{ball} = m_{block}v_{block} + m_{ball}v_{ball}$ $u_{ball} = m_{block}v_{block} / m_{ball} + v_{ball} = \frac{1.6(2.2)}{0.058} - 19.1 = 42$ m s^{-1}	 **B1** **A1**

(c)	Relative speed of approach = 42 m s^{-1} Relative speed of separation $= \sqrt{0.5(9.81)} + 19.1 = 21$ m s^{-1} $\neq$ relative speed of approach Thus, the collision is inelastic. OR Initial KE = ½ (0.058)$(42)^2$ = 51 J Final KE = ½ (0.058)$(19.1)^2$ + ½ (1.6)(0.5 x 9.81) = 14.5 J Since total KE s not conserved, the collision is inelastic.	**B1** **A1**
	Max Marks	**11**

Qn 3	**Answer**	**Marks**
(a)	<table><tr><th>Mass/kg</th><th>Length/m</th></tr><tr><td>0.100</td><td>0.140</td></tr><tr><td>0.200</td><td>0.180</td></tr><tr><td>0.300</td><td>0.220</td></tr><tr><td>0.400</td><td>0.260</td></tr><tr><td>0.500</td><td>0.300</td></tr></table>1 mark for each 2 correct values	**A2**
(b)	Correct plotting of all data – 1 mark	

	BFL drawn – 1 mark	
(c)	By Hooke's law, $F = kx$ $mg = kx$ $k = \dfrac{mg}{x}$ $= \dfrac{0.100(10)}{0.140 - 0.100} = 25 \text{ N m}^{-1}$	**M1** **A1**
(d)(i)	From Fig. 3.2, Length = 0.240 m Extension = 0.240 – 0.100 = 0.140 m	**A1**
(d)(ii)	$\text{EPE} = \dfrac{1}{2}kx^2 = \dfrac{1}{2}(25)(0.140)^2 = 0.245 \text{ J}$	**M1** **A1**
(e)(i)	Work done to support spring = Loss in EPE + Gain in GPE = -0.245 + mgh = -0.245 + (0.350)(10)(0.140) = 0.245 J	**M1** **A1**
(e)(ii)	By conservation of energy, loss in GPE = gain in EPE $mgx = \dfrac{1}{2}kx^2$ $x = \dfrac{2mg}{k}$ $= \dfrac{2(350 \times 10^{-3})(10)}{25}$ $= 0.28 \text{ m}$	**M1** **A1**
(e)(iii)	Maximum acceleration occurs when the support is just removed i.e. the mass is free falling. Hence maximum acceleration is 10 m s^{-2}.	**A1**
(f)	Line with gentler gradient Same y-intercept at length = 0.10 m Labelled line S (deduct one mark for each missing marking point)	**A2**
	Max Marks	**16**

Qn 4	Answer	Marks
(a)	e.m.f. of **a source** is the **energy converted per unit electric charge *to electrical energy from other forms*** in driving charge round a complete circuit Potential difference ***between two points in a circuit*** is the **energy converted per unit electric charge *from electrical energy to other forms of energy*** when charge moved between the two points.	B1 B1
(b) (i)	In Fig. 5.2, the **<u>ratio of *V/I* decreases as current or voltage increases</u>.** Resistance of thermistor is given by ratio V/I. As current or voltage increases, the thermistor's **<u>resistance decreases with increasing temperature.</u>**	B1 B1
(b)(ii)	From the graph, when current through battery is 8.0 A, 1. the current through the filament bulb = 5.5 A 2. the current through the thermistor = 2.5 A 3. the e.m.f. of the battery = 8.0 V As the thermistor and filament bulb are in parallel, the current through filament bulb and thermistor should add up to 8.0 A. The p.d. across the filament bulb = p.d. across the thermistor = e.m.f. of the battery.	 A1 A1 A1
(c)(i)	 Correct equation ($E - IR = V$) [1] Correct line sketched (line in blue) [1]	
(c)(ii)	1. the current through the filament bulb = 4.0 A 2. the potential difference across the filament bulb = 4.0 V, 3. the potential difference across the resistor = 10.0 V.	A1 A1 A1
	[Total : 12 marks]	

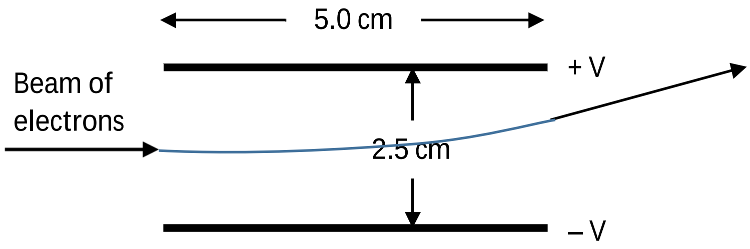
Qn 5	Answer	Marks
(a)		**B3**
(b)(i)	It was observed that most of the α-particles (more than 99%) will pass straight through or emerge scattered over a small angle.	**B1**
	As α-particles are charged (and some α-particles are observed to be scattered / deflected), it shows the existence of a charged nucleus within an atom.	**A1**
	Only a very small fraction of α-particles is observed to be backscattered (i.e. suffer deflections of more than 90°).	**B1**
	This shows that the size of the nucleus is so small that the probability of an α-particle coming close enough to a nucleus to be deflected over a large angle is very low.	**A1**
(c)(i)	The α-particle consists of 2 protons and 2 neutrons.	**A1**
(c)(ii)	Loss of mass, $\Delta m = (4.00260 + 9.01212) - (1.00867 + 12.00000)$ $= 0.00605$ u $= 1.0043 \times 10^{-29}$ kg	**B1**
	Energy equivalence of the loss mass, $E = (\Delta m)c^2$ $= (1.0043 \times 10^{-29})(3.0 \times 10^{8})^2$	**M1**
	$= 9.04 \times 10^{-13}$ J	**A1**
(c)(iii)	Since energy is released after the reaction, the products have a higher total binding energy than the reactants.	**A1**
	[Total : 12 marks]	

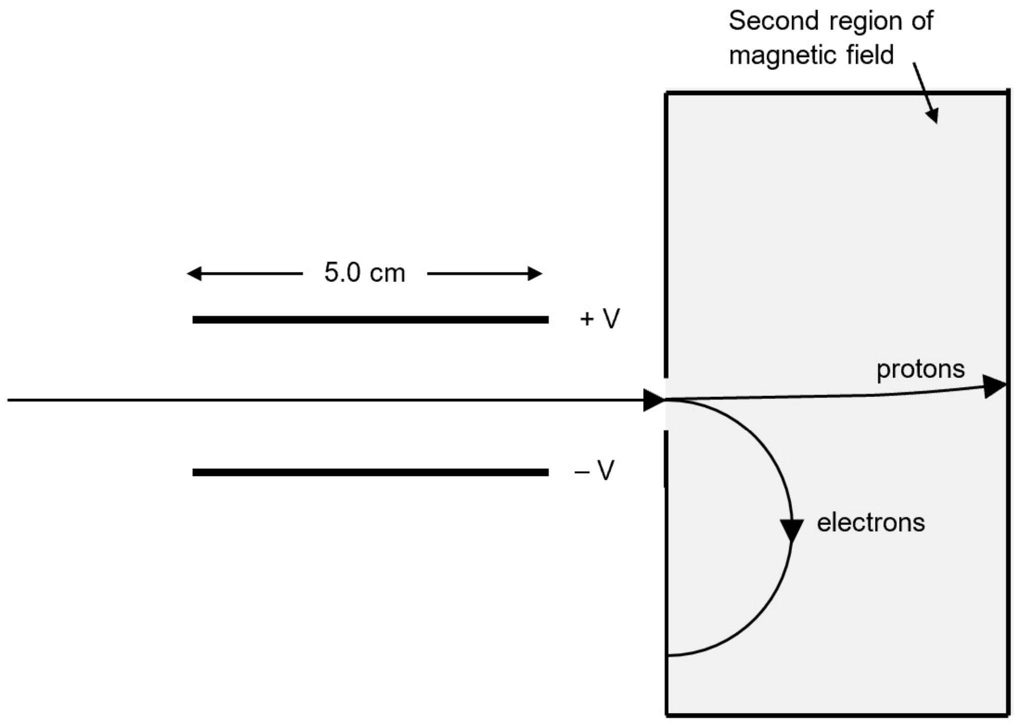
Section B: Answer one question.

Qn 6	Answer	Marks
(a)	The gravitational force F_g between two point masses m_1 and m_2 is directly proportional to the product of the masses and inversely proportional to the square of the distance *r* between them.	 **B1** **B1**
(b)(i)	The weight *mg* of a mass *m* at the surface of the Earth is equal to the gravitational force between the mass *m* and the Earth of mass *M*, when the mass *m* is a distance *R* away from the centre of the Earth, where *R* is the radius of the Earth, $$F_g = G\frac{Mm}{r^2}$$ Hence, the acceleration due to gravity at the Earth's surface is $$g = \frac{F_g}{m} = G\frac{M}{R^2} = \left(6.67\times10^{-11}\right)\frac{\left(5.98\times10^{24}\right)}{\left(6.37\times10^{6}\right)^2} = 9.83 \text{ m s}^{-2}$$	**B1** **M1** **A1**
(b)(ii)	Any two below: It is assumed that the Earth is a perfect sphere. It is assumed that the Earth is not rotating about its axis. It is assumed that the density of Earth is uniform.	**B1** **B1**
(b)(iii)	The Earth is rotating. The Earth is not a perfect sphere; it is flatter at the poles and bulging at the equator. The value is lower in Singapore, as Singapore is farther from the centre of the Earth than 6.37 x 10^6 m and the effect of the Earth's rotation is the largest at the equator.	**B1** **B1** **B1**
(c)(i)	A satellite is geostationary when it is *always positioned over the same geographical spot on Earth*.	**A1**
(c)(ii)	Geostationary satellite rotate in the same direction as the rotation of the Earth, i.e., *from west to east*.	**A1**
(c)(iii)	The gravitational force on the satellite is always directed towards the centre of the Earth and so *any circular orbit must have its centre at the centre of the Earth*. If the orbit is not in the equatorial plane, *the satellite will sometimes be over the northern hemisphere and sometimes over the southern hemisphere*.	**B1** **B1**
(d)(i)	$$g = \left(6.67\times10^{-11}\right)\frac{\left(5.98\times10^{24}\right)}{\left(4.23\times10^{7}\right)^2} = 0.223 \text{ N kg}^{-1}$$	**A1**

(d)(ii)	The gravitational force is providing the centripetal acceleration $F_g = F_c$ $G\dfrac{Mm}{r^2} = m\dfrac{v^2}{r}$ $g = \dfrac{v^2}{r}$ $v = \sqrt{gr} = \sqrt{(0.223)(4.23\times10^7)} = 3070 \text{ m s}^{-1}$	**M1** **B1** **A1**
(d)(iii)	The acceleration of the satellite is equivalent to the gravitational field strength $a = 0.223 \text{ m s}^{-2}$	**M1** **A1**
	[Total : 20 marks]	

Qn 7	Answer	Marks
(a)(i)	An electric field is a region of space where a charge experiences an electric force.	**B1**
(a)(ii)	The electric field strength at a point is the **electric force exerted per unit positive charge at that point**.	**B1**
(b)(i)	$F = eE = (1.6\times10^{-19})(7.5\times10^2)$ $= 1.2\times10^{-16}\ N$	**B1** **A1**
(b)(ii)	Time taken for an electrons to travel 5.0 cm in the horizontal direction, $t = \dfrac{s_x}{u_x} = \dfrac{5.0\times10^{-2}}{4.50\times10^6}$ $= 1.111\times10^{-8} \approx 1.11\times10^{-8}\ s$	**M1** **A1**
(b)(iii)	Acceleration in the vertical direction, $a = \dfrac{F}{m} = \dfrac{1.2\times10^{-16}}{9.11\times10^{-31}} = 1.31723\times10^{14}\ ms^{-2}$ Displacement in vertical-direction during time t, $s = \dfrac{1}{2}at^2 = \dfrac{1}{2}(1.31723\times10^{14})(1.111\times10^{-8})^2 = 0.008129 \approx 0.0081 m$ The electron will not hit any of the plates as the vertical displacement of the electron is less than 0.0125 m when it is travellling between the two parallel plates.	**B1** **M1** **A1**

(b)(iv)	 Parabolic path curves upward inside the plates Straight path outside the plates	**B1** **B1**
(b)(v)	$evB = eE$ $B = \frac{E}{v} = \frac{750}{4.5\times10^{6}}$ $= 1.6667\times10^{-4} \approx 1.67\times10^{-4}\ T$	**M1** **A1**
(c)(i)	The **magnetic force** on the moving electron in the magnetic field **provides for the required centripetal force.** Since the magnetic force acting on the electron is **ALWAYS perpendicular** to it motion (or velocity vector), the path of an electron in the magnetic field is circular.	**B1** **B1**
(c)(ii)	The centripetal force is provided by the magnetic force. $evB = \frac{mv^2}{r}$ $r = \frac{mv^2}{evB} = \frac{mv}{eB} = \frac{(9.11\times10^{-31})(4.50\times10^{6})}{(1.6\times10^{-19})(1.50\times10^{-3})}$ $= 0.0170813 \approx 0.017\ m$	**M1** **A1**
(c)(iii)	$evB = eE$ $v = \frac{E}{B} = \frac{7.50\times10^{2}}{1.6667\times10^{-4}}$ $= 4.49991\times10^{6} \approx 4.50\times10^{6}\ ms^{-1}$	**A1**

(c)(iv)	 **Fig. 9.4** Relative size and circular path (should be semicircle) of electrons in clockwise direction Relative size and curve path of protons in anti-clockwise direction	**B1** **B1**
	[Total : 20 marks]	