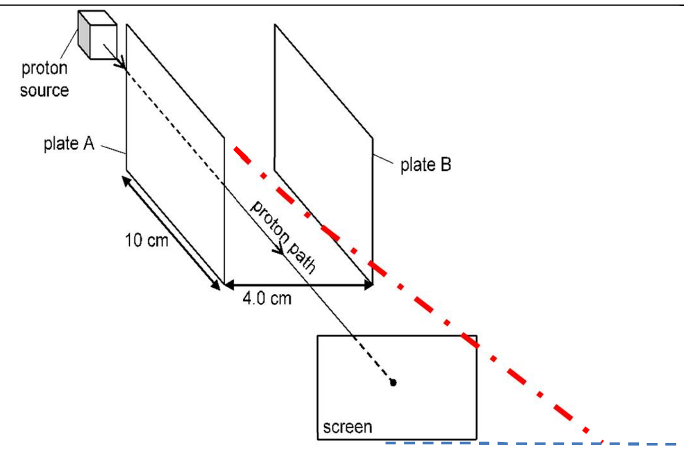
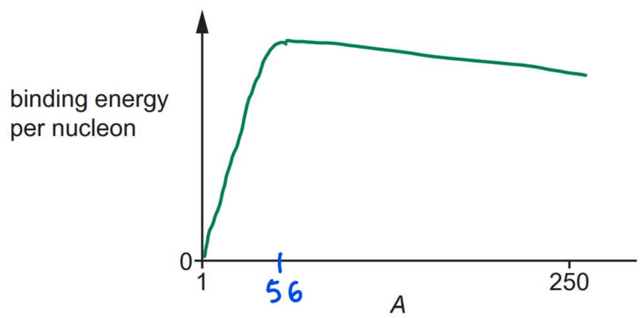
SAJC JC2 H1 Physics **Prelim 2024 Paper 2 Mark Scheme**

	Section A	
1 (a)(i)1	Intercept on graph/ line does not pass through origin	[1]
2	Scatter of readings about best fit line	[1]
(ii)	<u>Correction</u> for zero error (0.05 A) explained Use of V and corrected I values from graph Resistance = V/I = <u>22.2 Ω</u> (e.g. from 4.0 / 0.18, where 0.18 is the corrected I value)	[1] [1] [1]
(b)	$R = V / I$ = 6.8 / 0.64 = 10.625 %R = %V + % I = (0.1/6.8) x 100 + (0.01/0.64) x 100 = 3.033 % ⊗R = 0.0303 x 10.625 = 0.32 Ω = 0.3 Ω (to 1 s.f.) R = <u>10.6 ± 0.3 Ω</u>	[1] [1] [1]
	Total =	**8**
2 (a)	The gravitational force of attraction between two <u>point</u> masses is <u>proportional</u> to the <u>product</u> of their masses and inversely proportional to the <u>square of their separation</u>.	[1]
(b)	At 8200 km from centre of Earth, F = 6.0 N $F = GMm / r^2$ $6.0 = (GM \times 1) / (8200 \times 10^3)^2$ $M_1 = 6.0486 \times 10^{24}$ kg At 16000 km from centre of Earth, F = 1.8 N $F = GMm / r^2$ $1.8 = (GM \times 1) / (16000 \times 10^3)^2$ $M_2 = 6.9085 \times 10^{24}$ kg Average mass M = 6.48×10^{24} kg.	 [1] [1] [1]
	Total =	**4**
3 (a)	time spent between plates: $t = L/v = 10 \times 10^{-2} / 6.5 \times 10^5$ $= 1.54 \times 10^{-7}$ s	[1]
(b)	$F = qE = ma$ $a = \dfrac{qE}{m} = \dfrac{(1.6 \times 10^{-19})(1.25 \times 10^3)}{(1.67 \times 10^{-27})}$ $= 1.20 \times 10^{11}$ m s^{-2}	[1]

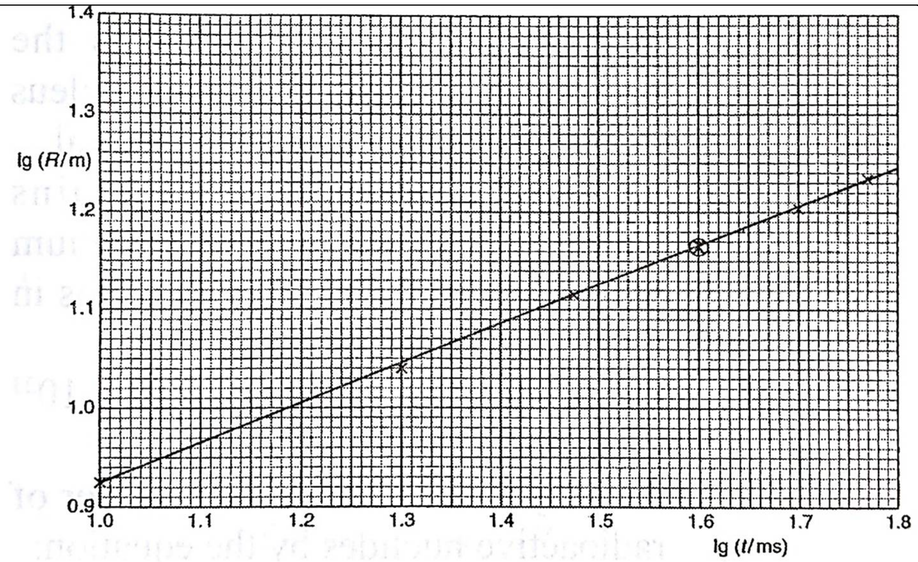
	Direction of acceleration toward the <u>right</u> (lower potential, metal plate B)	[1]
(c)	In the direction from plate A to B, (where there is a constant acceleration due to the uniform e-field), $v_{\perp} = u + at = 0 + at$ = 0 + (1.20 x 10^{11})(1.54 x 10^{-7}) = 18480 = 1.85 x 10^{4} m s^{-1} $\text{speed} = \sqrt{v_{\perp}^2 + v_{\text{initial}}^2}$ = □(18480^2) + (6.5 x 10^5)^2 = 650262 = 6.5 x 10^5	[1] [1], ecf
(d)	**Fig. 6.1 (not to scale)** {no need to draw the red path, for illustration purposes only} (dotted path not required for answer)	[1]
	Total =	**6**
4 (a)(i)	Using <u>Fleming Left hand rule</u>, the magnetic <u>force</u> will <u>always</u> be <u>perpendicular</u> to the direction of the charged particle's <u>velocity</u> The magnetic force <u>provides for the centripetal force</u>.	[1] [1]
(ii)	Negative	[1]
(iii)	Magnetic force provides the centripetal force, Bqv = q = q α (since m, B, v are constants) so = = 2	[1] [1] [1]
(b)(i)	As particle X collides with the gas particles, its magnitude of <u>velocity *v*</u> will gradually <u>decrease</u>. Since *r* = and only *v* is decreasing <u>with *B*, charge *q* and mass *m* constant</u>, So *r* (radius of circular motion), will be <u>decreasing,</u> as depicted by the spiral nature in the diagram.	[1] [1]

(ii)1.	$v = r\omega$, where $\omega =$, $v = r$ $T = 2\pi()$ Using $r =$, $T = 2\pi()$ $T =$	[1] [1]
2.	For the tau particle, $m = 3000(9.11\times10^{-31}) = 2.733 \times 10^{-27}$ kg, $B = 1.0$ T, $q = 1.6 \times 10^{-19}$ C, $T = \ = \ =$ <u>1.07×10^{-7} s</u> (time for 1 complete revolution), which is larger than 2.9×10^{-13} s. It <u>cannot</u> be a tau particle as it <u>does not live long enough</u> to make the orbits shown in Fig. 4.2. (since it would have decayed to something else before it can even make 1 complete revolution!)	[1] [1]
	Total =	**12**
5 (a)(i)	The nucleus (volume) is very <u>small compared to the atom</u>	[1]
(ii)	The nucleus is <u>charged</u> The mass is <u>concentrated</u> in a small region/volume/core/nucleus	[1] [1]
(b)(i)	Nuclear fusion is the process where two <u>light/small</u> nuclei are combined to produce a <u>heavier/larger</u> nucleus with the <u>release of energy</u>.	[1]
(ii)		[1]
(iii)1.	X shown at value of A at <u>56</u> at the <u>peak</u> of graph	[1]
2.	Y shown at value of <u>A close to 1</u>	[1]
***(iv)**	energy from 1 nucleus of Z = $(1.77 \cdot 10^{13}) / (6.02 \cdot 10^{23}) = 2.94 \cdot 10^{-11}$ J {since qn gave “1 mol of Z” releases 1.77×10^{13} J of energy} nucleon number of Z = 93 + 139 + 2 – 1 = 233 From: E released = BE of products (Sr & Xe) – BE of reactants (Z), Thus BE of Z = $[(1.25 + 1.81) \cdot 10^{-10}] - 2.94 \cdot 10^{-11}$ $= 2.77 \cdot 10^{-10}$ J binding energy *per nucleon* $= (2.77 \cdot 10^{-10}) / (233) = 1.189 \times 10^{-12}$ J	[1] [1] [1]

	= 1.189 x 10^{-12} J / (10^{6} x 1.6 x 10^{-19}) MeV = 7.43 MeV	[1]
(c)	Current ratio 2 Y to 1 Zr, so initially there was 3 Y. $$\frac{N}{N_o} = \frac{2}{3} = \left(\frac{1}{2}\right)^{n} = \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$$ $= \left(\frac{1}{2}\right)^{\frac{t}{2.7\,days}}$ n = 0.585 $lg\,\frac{2}{3} = lg\frac{1}{2} \times \frac{t}{t_{1/2}}$ or $t = n \times t_{1/2}$ = 0.585 x 2.7 days t = 1.58 or 1.6 days	[1] [1] [1]
(d)	$$I = \frac{Q}{t} = \frac{Ne}{t} = \frac{(9.8 \times 10^{10})(1.6 \times 10^{-19})}{2 \times 60}$$ = 1.31 x 10^{-10} A = 131 pA (3 sf) (where p = prefix called 'pico' = 10^{-12})	[1] [1]
	Total =	**16**

6 (a)(i)	From 0 ms to 45 ms, the rate of increase of the radius R of fireball decreases with time (since gradient becomes gentler). From 45 ms to 60 ms, the rate of increase is constant (since constant gradient).	[1] [1]
(a)(ii)	With a length and width of 12 m, the fireball will take a maximum of 25 ms to travel from one end of the room to the other (or max of 4.5 ms from the middle of the room to one end) leaving very little time (for the fire-fighter) to react.	[1] [1]
(b)(i)1	When t = 40 ms, lg t = lg 40 = 1.60 When R = 14.6 m, lg R = lg 14.6 = 1.16 (Accept R from 14.4 to 14.6 m) The point is plotted in the graph below (circled).	[1]

(b)(i)2



Correct best fit line drawn [1]
(balance number of points above and below the line)

(b)(ii)

Gradient = (1.245 – 0.925) / (1.80 – 1.00) [1]
= 0.40 [1]

(b)(iii)

From given eqn $R^n = k\,t^m$,
$n \lg R = m \lg t + \lg k$
$\lg R = (m/n) \lg t + (1/n) \lg k$ [1]

Thus gradient = (m/n) = 0.40 (from (b)(ii) value) [1]

The two smallest integers that would give a ratio of 0.40 is n = 5 and m = 2. [1]

(c)

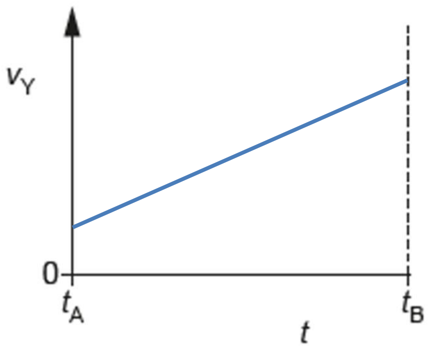
By taking values of R^5/V for the 5 data points at t = 40 ms, c can be shown to be a constant. [2]

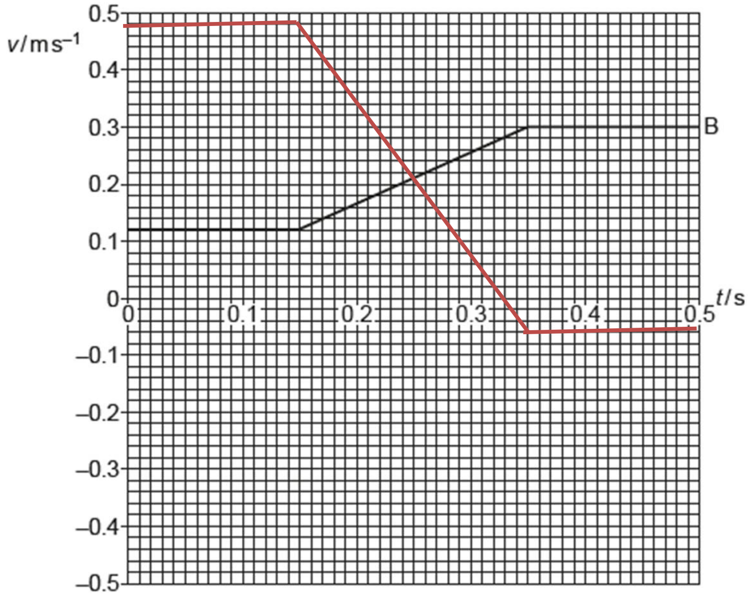
Volume V / m^3	R / m	$c = R^5/V$ c / m^2
12.5×10^{-3}	14.6	5.31×10^7
10.0×10^{-3}	14.0	5.38×10^7
7.5×10^{-3}	13.2	5.34×10^7
5.0×10^{-3}	12.2	5.41×10^7
2.5×10^{-3}	10.6	5.35×10^7

[1]

For all 5 sets of readings, the value of c is approximately the same. Hence, c is constant at t = 40 ms (within limits of experimental error).

Total = 14

	Section B	
7 (a)(i)	$T_y = 4.8 \sin 30^o = 2.4$ N	[1]
(ii)	Taking moments about the hinge, Sum of CW moments = sum of ACW moments (W x 0.60) + (0.30 x 0.80) + (T_y x 1.2) = (8.2 x 0.50) W = <u>1.6 N</u>	 [2] [1]
(iii)	Hor component of hinge force = $T_x = 4.8 \cos 30^o$ = <u>4.2 N</u>	[1]
(iv)	From EPE = ½ Fx 0.32 = ½ (8.2)(x) x = compression = <u>0.078 m</u>	 [1] [1]
(v)1.	Decrease in GPE = mg⊗h = (0.30)(0.090) = <u>0.027 J</u>	 [1]
2.	By COE, Loss in GPE = gain in KE of block 0.027 = (0.044) – KE_A $KE_A = 0.017$ J = ½ mv_A^2 Thus v_A^2 = (0.017 x 2)/ (0.30/9.81) v_A = <u>1.1 m s^{-1}</u> OR $KE_B = 0.044$ J = ½ mv_B^2 = ½ (0.30/9.81) v_B^2 Thus $v_B^2 = 2.88$ From $v^2 = u_A^2 + 2a_y s_y$ $2.88 = u_A^2 + 2\,(9.81)(0.090)$ u_A = speed at A = <u>1.1 m s^{-1}</u>	 [1] [1] [1] [1] [1] [1]
(vi)	Resultant force = gravitational force/ weight is vertical only (Hence no resultant force in horizontal direction)	[1]
(vii)	 Straight line with positive gradient starting from non-zero value of v_Y at time t_A	 [1] [1]
(b)(i)1.	Acceleration = gradient of v-t = (0.30 – 0.12)/ (0.35 – 0.15) = 0.90 m s^{-2}	[1]
2.	By PCLM, $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ (0.25 x 0.48) + (0.75 x 0.12) = (0.25 v) + (0.75 x 0.30) v = (-)0.060 m s^{-1}	 [1] [1]

	OR $u_1 - u_2 = v_2 - v_1$ (since elastic collision) $(0.48 - 0.12) = (0.30 - v)$ OR Total KE before = total KE after	
(ii)	 horizontal line from (0, 0.48) to (0.15, 0.48) horizontal line from (0.35, –0.06) to (0.5, –0.06) straight line between (0.15, 0.48) and (0.35, –0.06)	[1] [1] [1]
8 (a)	Ratio of potential difference to current.	[1]
(b)(i)	From $P = V^2/R$ $36 = 12^2/R$ $R = \underline{4.0\ \Omega}$	[1] [1]
(ii)	Straight line from origin then curve (downwards) in correct direction (I-V graph of filament) Line passes through 12 V, 3.0 A (since R = 4 Ω), with vertical axis labelled appropriately {the resistance at 6V is unknown and therefore the curve does not need to pass through any specified point}	[1] [1]
(iii)	From $R = 4.0 = \dfrac{\rho L}{\pi\left(\frac{d}{2}\right)^2} = \dfrac{(4.9\times10^{-7})L}{\pi\left(\frac{0.54/1000}{2}\right)^2}$ $L = \underline{1.87\ \text{m}}$	[1] [1]
(c)(i)	Since resistance is ratio of V/I at a point, and I increases more rapidly than V, Resistance of C decreases	0 or [2]
(ii)	At V = 4 V, current = 2.00 mA Resistance = V/I = 4 / 0.002 = 2000 Ω	[1] [1]

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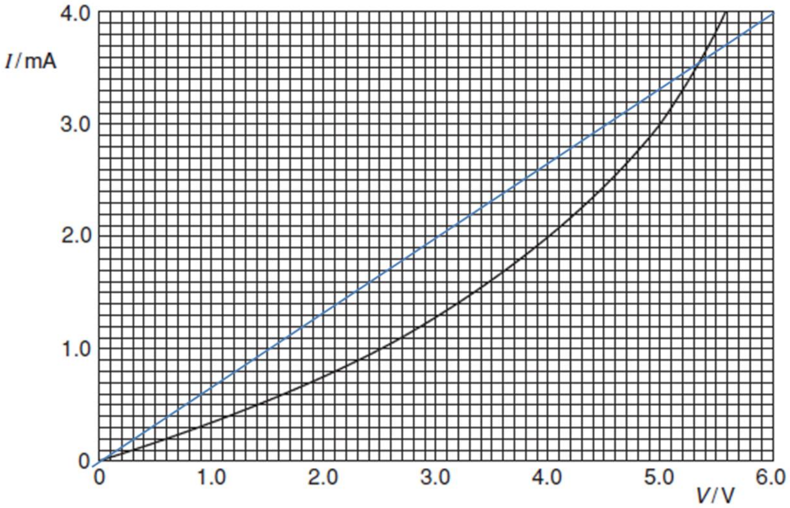
<td>(iii)1.</td>
<td>


Straight line from origin
That passes through (6.0 V, 4.0 mA) (allow ½ square tolerance), since resistance of R is 1500 Ω
</td>
<td>[1]
[1]</td>
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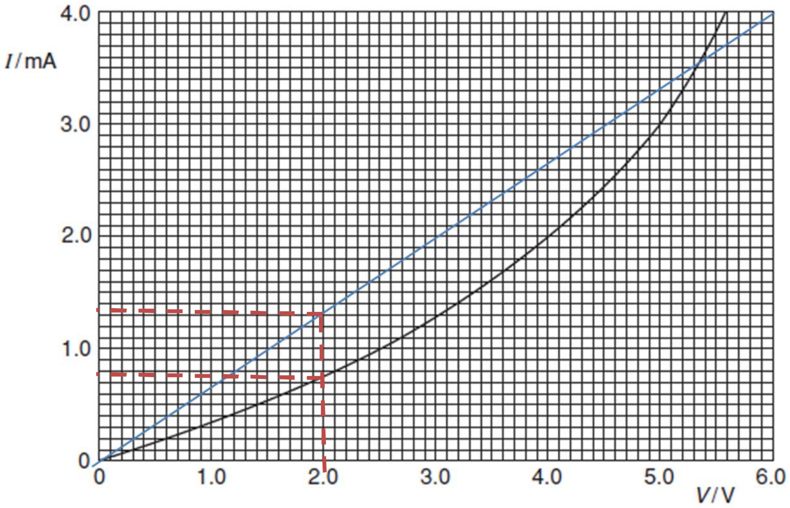
<tr>
<td>2.</td>
<td>


At terminal p.d. of 2.0 V, p.d. across C and R each is also 2.0 V,
Hence using the graph above, at V = 2.0 V,
Currents in C and R are <u>0.75 mA and 1.3 mA</u> individually.

So, Current in battery = 0.75 + 1.3 = <u>2.05 mA</u>
</td>
<td>[1]

[1]</td>
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<tr>
<td>3.</td>
<td>
From E = Ir + IR,
$2.02 = (2.05 \times 10^{-3})(r) + 2$ (since IR = p.d. across R = 2 V)
r = <u>9.76 Ω</u>
</td>
<td>[1]
[1]</td>
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<tr>
<td>(iv)</td>
<td>
Since C & R are now in series,
there is <u>same current</u> in C & R

From Fig. 8.2,
we see that <u>p.d. across C is larger</u> than that across R

Since power = IV, power (or rate of dissipation of thermal energy) is therefore <u>greater in C</u> (allow $P = I^2R$ or V^2/R)
</td>
<td>[1]

[1]

[1]</td>
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	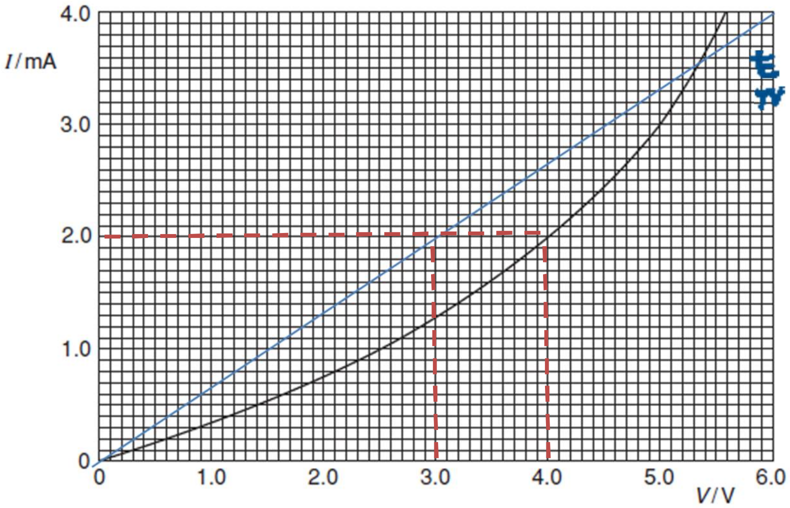 (graph above not required but is to illustrate only)	
	Total =	**20**

End of mark scheme