GCE MARKING SCHEME

PHYSICS
AS/Advanced

SUMMER 2015

INTRODUCTION

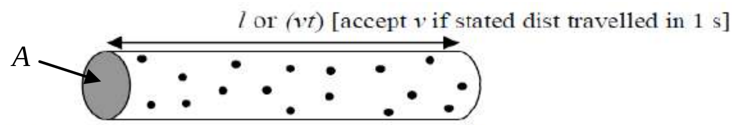
The marking schemes which follow were those used by WJEC for the Summer 2015 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

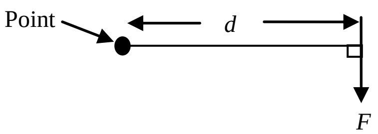
WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

Question			Marking details	Marks Available
1	*(a)*	(i)	Horizontal velocity = $\frac{1.20}{0.60}$ = 2[.0 m s^{-1}]	1
		(ii)	0 = u^2 – 2 × 9.81 × 0.44 [correct substitution into $v^2 = u^2 + 2ax$] (1) u = 2.94 [m s^{-1}] (1) **or** 0 = u – 9.81 × 0.30 [correct substitution into $v = u + at$] (1) u = 2.94 [m s^{-1}] (1) **[Other solutions possible]**	2
	(b)	(i)	$R = (4 + 8.64)^{1/2}$ (1) [**ecf** from (*a*)(i) and/or (*a*)(ii)] R = 3.56 [m s^{-1}] (1)	2
		(ii)	θ = 55.8° **ecf**	1
	(c)	(i)	<u>Force of gravity on earth due to grasshopper</u>	1
		(ii)	$F = 3 \times 10^{-5} \times 9.81 = 2.9 \times 10^{-4}$ [N] Accept 0.3 m[N]	1
	(d)		←	1
			Question 1 Total	**[9]**
2	*(a)*		V A^{-1} and W A^{-2} 2 × (1)	2
	(b)	(i)	V = 0.01 × 450 = 4.5 [V]	1
		(ii)	12 V – 4.5 V [**ecf**] = 7.5 [V]	1
		(iii)	$R = \frac{7.5}{0.01}$ (1 for correct use of 7.5 or **ecf**) = 750 [Ω] (1) **or correct alternative**	2
		(iv)	$\frac{1}{750} = \frac{1}{900} + \frac{1}{R}$ (1) (substitution) $R_{\text{variable resistor}}$ = 4 500 [Ω] (1) **Alternative solution to (iii) and (iv)** I through 900 Ω = $\frac{7.5}{900}$ = 0.0083 [A] (1) I through variable resistor = 0.0017 [A] (1) $R_{\text{variable resistor}} = \frac{7.5}{0.0017}$ = 4 500 [Ω] (1) Use of resistors in parallel formula to find total parallel resistance = 750 [Ω] (1)	2

Question				Marking details	Marks Available
	(c)			[No mark for stating circuit resistance decreases] Current in circuit increases (1) [accept explanation based on potential divider. Hence pd across 450 Ω increases (1) Hence pd across 900 Ω decreases (1**) this mark can't be awarded unless it is correctly substantiated** **Alternative solutions:** Resistance of parallel combination decreases (1) pd across parallel combination decreases (1) pd across 900 Ω decreases (1) OR current through the variable resistor increases (1) current through the 900 Ω decreases (1) pd across the 900 Ω decreases (1)	3
				Question 2 total	**[11]**

Question				Marking details	Marks Available
3	*(a)*	(i)		[Free] electrons forced to move by applied pd (Need a reference to drift velocity or electron flow but does not need to be explicitly stated) (1) They collide with atoms/nuclei/ions/lattice of the wire (1) don't accept particles or molecules	2
		(ii)		Power = $\frac{1.8}{60}$ = 0.03 [W] (1) $R = \frac{0.03(\text{ecf})}{1.6^2}$ = 0.0117 [Ω] (1) **Alternative solution possible** for the first 2 marks using $V = \frac{W}{Q}$ and $R = \frac{V}{I}$ $\rho = \frac{0.0117 \text{x} 2 \text{x} 10^{-6}}{0.4}$ (1) [**ecf** on *R*] = 5.9×10^{-8} [Ω m] (1)	4
	(b)	(i)		 [NB free electrons not required to be labelled] Number of free electrons = *nAvt* [**or** *nAl*] (1) Total change = *nAvte* [**or** *nAle*] (1) $I = \frac{nAvte}{t}$ with cancelling shown [or $\frac{nAle}{t}$, where $\frac{l}{t} = v$ shown] (1) Volume defined either from diagram [e.g. *A* and *l* labelled as shown] or in body of derivation [e.g. vol = *Al*] and *n* identified correctly– **for the first mark**	4
		(ii)		$1.6 = 6.4 \times 10^{28} \times 2 \times 10^{-6} \times v \times 1.6 \times 10^{-19}$ (1: substitution) $v = 7.8 \times 10^{-5}$ [m s^{-1}] (1)	2
		(iii)	(I) (II) (III)	**less than 1.6 A** identified/circled (1) **the same as** identified/circled (1) **half** identified/circled (1)	3
				Question 3 Total	**[15]**

Question			Marking details	Marks Available
4	*(a)*	(i)	Water bath or method of heating shown. Wire [coiled or uncoiled] shown (1). Voltmeter and ammeter and power supply correctly connected **or** ohmmeter only shown (1) Thermometer clearly identifiable. (1) Subtract 1 mark for poorly drawn diagrams. Method of cooling water to 0 °C not credited here.	3
		(ii)	<u>Method</u> of cooling water to 0 °C (1) [Can be credited from (i)] Resistance values taken [or V and I values taken and R calculated](1) ..at different temperatures [minimum 5 implied or implication that a number of temperatures considered] (1) Method to reduce experimental error/ ensure accuracy e.g. water stirred/ resistance of leads/heat slowly/remove heat to allow temperature to settle (1) Accept repeat the experiment again or obtain readings whilst cooling down or using a digital thermometer. Don't accept just repeat readings. Graph of R vs θ drawn (1)	5
	(b)	(i)	[-163 °C] is the temperature at which <u>a sudden decrease in resistance</u> occurs and the metal [alloy] (1) ...becomes a <u>superconductor</u> or resistance becomes zero (1)	2
		(ii)	<u>Liquid nitrogen</u> [Accept liquid helium, liquid oxygen, liquid hydrogen]	1
			Question 4 Total	**[11]**

Question				Marking details	Marks Available
5	*(a)*	(i)		$\text{power} = \dfrac{\text{work done or energy transferred}}{\text{time}}$ [Accept rate of doing work/ rate of energy transfer]	1
		(ii)		$\text{kg m s}^{-2} \times \text{m} \times \text{s}^{-1}$ (1) [Evidence of full correct methodology] $\text{kg m}^2\text{ s}^{-3}$ (1)	2
	(b)	(i)		$E_p = 70 \times 9.81 \times 215$ (1) [= 147 641 J] $E_k = ½ (70)(35)^2$ (1) [= 42 875 J] $E_{\text{lost}} = 147\,641 - 42\,875$ (1) [= 104 766](**ecf** on both E_p and E_k) $F = \dfrac{104766}{1600} = 65.5$ [N] (1) (**ecf** on E_{lost}) **Alternative solution:** using $v^2 = u^2 + 2ax$	4
		(ii)		$P = \dfrac{104766}{46}$ **ecf** (1) $= 2\,277\ \text{J s}^{-1}$ or W (1) **UNIT mark**	2
				Question 5 total	**[9]**
6	*(a)*			 (1) Moment = Fd (1) [award only if clear diagram shown] / if no right angle in diagram then **perpendicular** must be included in definition	2
	(b)	(i)		(F (sin 40°)(1) × 0.4) (1) = ((12 × 0.9) + (22 × 1.8)) (1) F = 196 [N] shown	3
		(ii)	(I) (II) (III)	Vertical component of force in strut = 126 [N] (1) Accept 128 [N] or 129 [N] if F = 200 N is used. Vertical **downward** arrow shown at hinge. (1) Vertical force on bar due to hinge = 92 [N] (1) **ecf**	3
				Question 6 Total	**[8]**

Question				Marking details	Marks Available
7	*(a)*	(i)		[Vector] distance between two locations measured along the shortest path joining them.	1
		(ii)	(I)	Time for outward journey = 7.5 hrs **and** homeward journey = 5 hrs calculated (1) Speed = $\frac{600}{12.5}$ (1) = 48 [km h^{-1}](1)	3
			(II)	0 km h^{-1} (1) displacement = 0 stated (1)	2
	(b)	(i)		Suitable tangent drawn (1) = 0.15 (accept range 0.12 to 0.18) (1) $\Sigma F = 1.2 \times 10^6 \times 0.15 = 180$[kN] (1) [**ecf** on gradient value] ΣF range = 144 kN to 216 kN	3
		(ii)		Line (or time axis) labelled at ≥ 92 or 94 seconds	1
		(iii)		Constant speed (1) Driving force balanced [equal to] resistive forces (1) [Do not accept $\Sigma F = 0$]	2
	(c)	(i)	(I)	$F = \frac{Wx}{t}$ and $\frac{x}{t}$ shown to be = v	1
			(II)	v (from graph) = 17.2 m s^{-1} (1) $F = \frac{4.5 \times 10^6}{17.2}$ = 262[kN] (1)	2
		(ii)		180 000 = 262 000 – F_{drag} (1) [**ecf** on both forces] F_{drag} = 82 [kN] (1)	2
				Question 7 Total	**[17]**

Question			Marking details	Marks Available
1	*(a)*	(i)	In phase [Accept: in step.]	1
		(ii)	Same amplitude everywhere [Accept: amplitude gets less and less.]	1
	(b)	(i)	v = 500 mm s^{-1} or 0.5 m s^{-1} or T = 0.03 s. Accept without units. (1) Attempted use of $f = \frac{v}{\lambda}$ not $c = 3 \times 10^8$ m s^{-1}) **or** $f = \frac{1}{T}$ **or by implication** (1) 33 [Hz] (1)	3
		(ii)	Working shows crests have moved $\frac{\lambda}{3}$ or 5 mm **or by implic** (1) Positions convincing by eye (1) Accept at 5 mm or third distance between crests. Fewer than 3 lines shown **award 1 mark only**.	2
	(c)	(i)	80 mm, 320 mm and 15 mm correctly put in double slit equation (1) states or implies that first const int is at 60 mm from axis. (1) concludes that there is dest int at P (1) • Give 1 mark if candidate claims first const int at 120 mm, having put in 40 mm instead of 80 mm for slit separation, and another mark if goes on to conclude that neither dest not const at P. • If equation used 'backwards', putting in 30 mm and finding 7.5 mm for λ award 1 mark and 2nd mark if also states that dest int at P. For the 3rd mark it must be carefully explained why destructive interference at P for λ = 15 mm **Alternative solution:** Path difference = 7.7 ± 0.1 mm (1) This is equal to / approximately equal to $\frac{\lambda}{2}$ (1) Hence destructive interference will occur (1)	3
		(ii)	Diffraction is spreading of waves <u>at slits</u> (1) Without which waves wouldn't overlap (or superpose) (1)	2
			Question 1 total	**[12]**

Question			Marking details	Marks Available
2	*(a)*	(i)	λ and *d* correctly inserted (nm is fine) in equation **or by implic** (1) 26° (1) 62° (1)	3
		(ii)	Beams drawn at 0° and at two different angles one side of normal (1) 2 beams either side of normal with some regard for symmetry (1) **ecf** on 1 angle found in (i)	2
	(b)		Only 3 beams emerge (this must be stated in words) [Accept: no second order beams.] (1) First order beams at greater angle to zeroth (a calculation is acceptable) **or** equivalent (1) Reference to colours is irrelevant	2
			Question 2 total	**[7]**

Question				Marking details	Marks Available
3	*(a)*	(i)		1.6 [m]	1
		(ii)		0.4 [m], 1.2 [m], 2.0 [m]	1
		(iii)	I	$t_1 = \frac{T}{4}$ **or** T = 0.02 [s] (1) t_1 = 0.005 s (1) **UNIT mark**	2
			II	down, up, down	1
	(b)			half sinusoid: up, down or both (1) c = 80 [m s^{-1}] **and** λ = 4.8 [m] **or** frequency of fundamental = third frequency of 3rd harmonic **or** by implication (1) f = 17 [Hz] (1)	3
				Question 3 Total	**[8]**
4	*(a)*	(i)		sin θ = 1.331 sin 40.36° **or** by implication (1) 60° (1) Accept 59.5 °	2
		(ii)		*Not* total + attempt at justification even if not worth next mark (1) **For the 2nd mark either:** Light got in at P or gets out at R, so can get out at **Q** [as angles in water the same] **or** 1.331 sin 40.36 reshown to be < 1 **or** C = 49°	2
		(iii)		$v_{violet} < v_{red}$ + attempt at justification even if not worth next mark e.g. violet bends more (1) **For the 2nd mark either:** Violet must have larger n therefore smaller v **or** bending caused by light travelling more slowly in water than in air, so violet must travel most slowly.	2
	(b)	(i)		Speed in glass = $\frac{360}{1.75\text{x}10^{-6}}$ [= 2.06 × 10^8 m s^{-1}] **or** by implication (1) n = 1.46 (1) must be to 3 sig figs	2
		(ii)		C = 75° **or** by implication (1) 1.46 sin 75° = n_{clad} [sin 90°] [Accept 1.5 for 1.46] **or** by implic (1) n_{clad} = 1.41 [1.45 if n_{core} taken as 1.50] (1) **Award 1 mark only for:** 1.46 sin 15° = n_{clad} [sin 90°]	3
		(iii)		Larger angles give longer propagation times. [Accept longer dists.](1) So each pulse spread out over time on arrival **or** each pulse is less spread out if the angles are restricted (1) So pulses might overlap (Accept pulses muddled) **or** overlap/muddling of pulses less likely if angles restricted. (1) **Award 1 mark only** for less multimode dispersion	3
				Question 4 Total	**[14]**

Question				Marking details	Marks Available
5	*(a)*	(i)		[Maximum] kinetic energy *of <u>emitted electron[s</u>*]	1
		(ii)		Photon energy	1
		(iii)		[Minimum] energy needed to release [**or** eject] <u>electron</u> from surface [**or** metal **or** solid]	1
	(b)			$\phi = hf_0$ **or** by implication (1) $f = 3f_0$ (1)	2
	(c)	(i)	I	attempt at gradient calculation even if slips, e.g. in 10^n (1) $h = 6.8$ [± 0.2] × 10^{-34} [J s] (1)	2
			II	$\phi = 3.1$ [± 0.1] × 10^{-19} [J] Don't accept a negative ϕ	1
		(ii)		$\phi_{sodium} = \phi_{caesium} + 0.6$ [or 0.7] × 10^{-19} J **or** parallel line **or** use of equation (1) $\phi_{sodium} = 3.7$ [± 0.3] × 10^{-19} [J] **ecf** (1)	2
				Question 5 Total	**[10]**
6	*(a)*	(i)		$\Delta E = 2.66 - 2.21 \times 10^{-18}$ J [$=0.45 \times 10^{-18}$ J] (1) Use of [Δ]$E = hf$ **and** $f = \frac{c}{\lambda}$ **or** $[\Delta]E = \frac{hc}{\lambda}$ (1) 440 n[m] **No ecf** except on **arithmetical slip** in ΔE (1)	3
		(ii)		$\frac{15\text{mW}}{\Delta E}$ **ecf** [attempted] (1) 3.3×10^{16} [s^{-1}] **ecf** (1)	2
		(iii)		Pumping energy taken as 3.07×10^{-18} J (1) 15 % **Accept** 14 % (1) **ecf** on photon energy	2
	(b)	(i)		Passing photon causes drop from U to L (1) With emission of another photon (1) Don't accept absorption of incident photon and emission of 2. Process happens repeatedly **and** increases photon number (unless already made clear for single event). (1)	3
		(ii)		Stimulated emission events more probable (or equivalent) (1) Absorption events less probable (1)	2
				Question 6 Total	**[12]**

Question			Marking details	Marks Available
7	*(a)*		$r = 3.07 \times 10^{10}$ m **and** $L = 1.99 \times 10^{29}$ W **or** by implication (1) $L = \sigma 4\pi r^2 T^4$ (1) Correct algebra including fourth-rooting (1) T = 4 150 K **UNIT mark** (1) [Take 5 865 K arising from $A = \pi r^2$ as **ecf**] If only Sun considered T = 5 776 K **award 3 marks only**	4
	(b)		Attempted use of λ_{max} = 700 - 750 [nm] in Wien's Law (1) 3 867 – 4 140 [K] (1)	2
	(c)		Black body absorbs all [electromagnetic] radiation (accept light) falling on it. [Accept: Black body emits more radiation per second [or equivalent] [at every wavelength] than any other body at same temperature. **Don't accept** it is a perfect emitter.	1
	(d)		Spectrum peaks in red or equivalent. Accept infra-red. (1) $r = 44.2\ R_\odot$ is sufficient. Must compare with the Sun. (1)	2
			Question 7 Total	**[9]**
8	*(a)*	(i)	A meson is a quark-antiquark combi; (**don't accept** 2 quark combination) a baryon is a 3 quark combi	1
		(ii)	Charge = $+(\frac{2}{3})[e] + (\frac{1}{3})[e] = +1[e]$ **or** equivalent	1
	(b)	(i)	0 = -1 + 1 or equivalent (which does not include 0 = +1 + −1)	1
		(ii)	Weak; suggested by long decay time **or** Weak; indicated by neutrino involvement **or** Weak; indicated by change of quark flavour **Don't accept:** No quark involvement / (only) lepton involvement	1
	(c)	(i)	1 + 2 + 1 = 2 + 2 **or** equivalent (e.g. 1 + 3 = 2 + 2)	1
		(ii)	**2 × (1) from:** • Mesons decay • Strong force is short-range • π^+ and H repel • Large energy needed to regroup groups **For the 3rd mark:** The relevance of one of the above points must be argued	3
			Question 8 Total	**[8]**

GCE AS/A level

1323/01-D

S15-1323-01D

PHYSICS – PH3
Practical Physics
MARKING SCHEME

Tests 1 and 2

2015

TEST 1 – MARK SCHEME

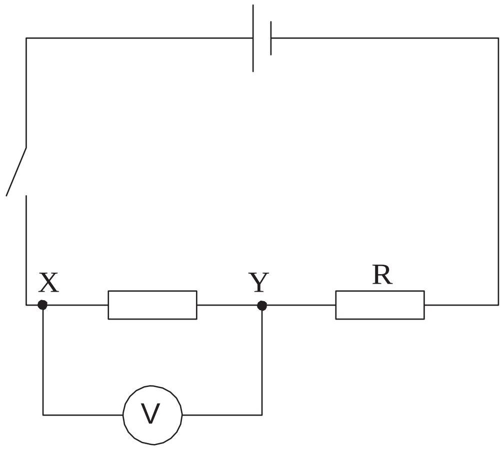
SECTION A

Question			Marking details	Marks Available
A1	*(a)*	(i)	Thickness of 10 coins measured to the nearest mm **and** thickness of one coin calculated correctly with **unit** (accept in range 19 - 22 mm)	1
		(ii)	5% (accept 2.5% if resolution taken as 0.5 mm) **ecf**	1
	(b)		Diameter of 5 to 10 coins measured (1) Diameter correctly identified in the range 25 - 27 mm **with** unit (1) % uncertainty in diameter calculated correctly **ecf** (1)	3
	(c)		Volume calculated correctly with **unit** (1) Total % uncertainty = 2 × % uncertainty in diameter + *(a)*(ii) Then converted correctly to an absolute uncertainty in volume **ecf** No sig fig penalty or unit penalty (1)	2
	(d)		Any number from 45 to 53 **must** be a whole number **no ecf**	1
			Question Total	**[8]**

Question			Marking details	Marks Available
A2	*(a)*		Answer given to nearest mm with **unit**	1
	(b)	(i)	Both answers less than 50.0 cm with y = 60.0 – *(a)* **no unit penalty**	1
		(ii)	Attempt to equate moments e.g. with or without g (1) Mass correctly calculated (1) Correct units g or kg consistent with answer (1)	3
	(c)		Mass of ball bearing = *(c)*–*(b)*(ii) (1) Mass of ball bearing to within 1 g of centre value or 7 g No sig fig penalty (1)	2
	(d)		No the test tube would need to be more than 50.0 cm from the pivot **or** implied that the length of the ruler is not sufficient	1
			Question Total	**[8]**

Question			Marking details	Marks Available
A3	*(a)*		At least two readings taken (1) Mean calculated correctly to the nearest cm with **unit** (1) This can be credited from the table	2
	(b)		Headings correct with consistent units H/cm and h/cm and mean (1) Three rows completed and means calculated correctly – no sig fig penalty (1)	2
	(c)		Mean h/mean H or mean H/mean h attempted three times (1) The following marks can't be awarded if the first mark has not been awarded. **Not** directly proportional (1) h/H or H/h is not a constant (1) Accept: directly proportional (1) so h/H or H/h is a constant (1) if consistent with results	3
	(d)		Release mechanism / use of an assistant / larger drop height Don't accept – repeat readings **Question Total**	1 **[8]**

SECTION B

Question			Marking details	Marks Available
B4	*(a)*		 Voltmeter connected in parallel (1) Circuit drawn as shown with all symbols correct (don't allow variable resistor symbol) (1)	2
	(b)		**All** headings and units correct (1) Resistor values **all** quoted to 1 decimal place (including 8.0 Ω) (1) Voltage values all to 2 decimal places (1) $1/R$ **all** calculated correct (1) $1/V$ **all** correct to 2/3 sig figs (1) All 7 resistor combinations totalled correctly (i.e. 2.2, 3.3, 4.7, 5.5, 6.9, 8.0, 10.2) (1)	6
	(c)		Axis labelled with units (**ecf** on incorrect units in table if no units are given in the table there is no ecf here) (1) Sensible scales (over ½ a page used to plot the points, not multiples of 3) and correct axis orientation (1) All points plotted correctly to within ± ½ small square division (1) × 2 (penalise 1 mark for each incorrect plot to a maximum of 2 marks) Good line of best fit consistent with the data (1)	5
	(d)		Intercept correct from graph ± ½ small square tolerance (1) Large triangle used (should occupy at least ½ of the best fit line) [or 2 equivalent suitable points clearly indicated on the graph] (1) Gradient calculated correctly (ignore units and sig figs) (1)	3
	(e)		Intercept = $1/E$ or implied (1) E calculated correctly with <u>unit</u> - V (1) Gradient = R/E or R = gradient × E or implied (1) R calculated correctly with <u>unit</u> - Ω (1)	4

Question			Marking details	Marks Available
	(f)	(i)	4% of 10.0 Ω calculated as 0.4 Ω / % difference for student's value calculated (1) Correct statement e.g. answer not within 4% (1) Award 2 marks for statement that their answer is not within 9.6 Ω - 10.4 Ω (2)	2
		(ii)	Gradient steeper/bigger (1) Intercept stays the same (1)	2
			Question Total	**[24]**

TEST 2 – MARK SCHEME AS TEST 1

Except:

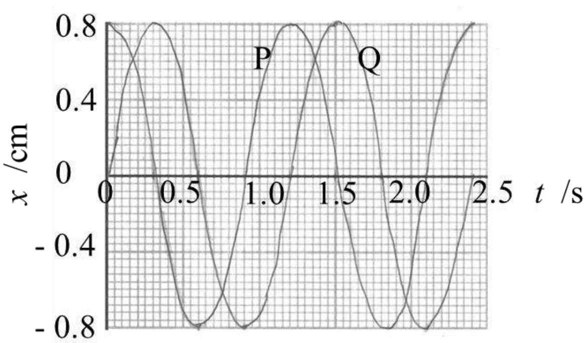
A1 *(a)* (i) Thickness of 10 coins measured to the nearest mm **and** thickness of one coin calculated correctly with **unit** (accept in range 16 - 21 mm)

(b) Diameter correctly identified in the range 23 - 26 mm **with** unit (1)

(d) Any number from 47 to 62 **must** be a whole number **no ecf** (1)

B4 *(b)* 1/R **all** calculated correct and to 2 or 3 sig figs (1)

Question			Marking details	Marks Available
1	*(a)*	(i)	Any 4 from the following (1 mark for each): - the oxygen molecules move at random / in all directions - the molecules strike [the walls of] the container [and rebound] - rate of change of momentum of the molecules when they strike the wall is equal to the <u>force exerted by the wall on the molecules</u> (Newton's second law of motion). - force on the wall is equal and opposite to the force on the molecules (Newton's third law of motion). - pressure is the force per unit area on the walls of the container. **Award a maximum of 2 marks** if no reference made to Newton's laws	4
		(ii)	I. *N*: number of molecules [in the container] (1) II. *m*: mass of <u>one</u> molecule (1) III. $\overline{c^2}$: mean square speed [of the molecules] (1)	3
	(b)	(i)	$n = \frac{pV}{RT} = \frac{(4\times10^5)(0.7)}{(8.31)(288)}$ (substitution (1)) = 117 [mol] (1)	2
		(ii)	$pV = \frac{1}{3}Nm\overline{c^2}$ $\sqrt{\overline{c^2}} = \sqrt{\frac{3pV}{Nm}}$ (rearrange (1)) $\sqrt{\overline{c^2}} = \sqrt{\frac{3pV}{n(32\times10^{-3})}}$ correct incorporation of relative mol. mass (1) $\sqrt{\overline{c^2}} = \sqrt{\frac{3(4\times10^5)(0.7)}{(117)(32\times10^{-3})}} = 473.7$ m s^{-1} (1) **UNIT mark**	3
	(c)		One of the following (or equivalent) …….(1): Volume of molecules not negligible. Force exerted on walls less due to the attraction by other molecules. Intermolecular forces not negligible. Accept: oxygen diatomic / density too high Collisions not elastic PE not zero	1
			Question 1 Total	**[13]**

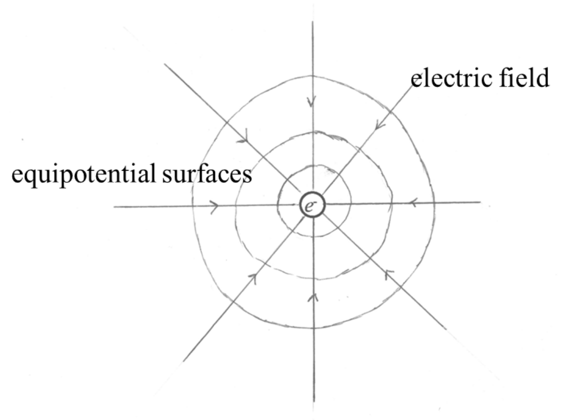
Question			Marking details	Marks Available
2	*(a)*		Acceleration is - [directly] proportional to the displacement [from a fixed point] (1) - directed towards the fixed point (1)	2
	(b)		$T = \frac{24}{20} = 1.2$ [s]	1
	(c)		$\omega = 2\pi f = 2\pi\left(\frac{20}{24}\right)$ (formula and subs. **ecf** from (b)(1)) $= 5.2$ [rad s^{-1}] (1)	2
	(d)		$x = 0.8$ (amplitude (1)) $\sin\left(5.2\ (\omega\,(1))t + \frac{\pi}{2}\text{ (phase (1))}\right)$ cm [or use ω = 5 rad s^{-1} or phase = 90^{o}]	3
	(e)		$0.4 = 0.8\sin\left(5.2t_1 + \frac{\pi}{2}\right)$ $-0.3 = 0.8\ \sin\left(5.2t_2 + \frac{\pi}{2}\right)$ $t_1 = [-]0.201$ [s] (1) $t_2 = [-]0.376$ [s] (1) $\Delta t = t_2 - t_1 = 0.376 - 0.201 = 0.175$ [s] (1) **ecf** from (d) [If using ω = 5 rad s^{-1}, $t_1 = 0.209$ [s] (1) $t_2 = 0.391$ [s] (1) $\Delta t = t_2 - t_1 = 0.391 - 0.209 = 0.182$ [s] (1)]	3
	(f)		 Curve for P (1) Curve for Q relative to P (1) Axes labelled with units and scales (1) **ecf** for *A*, phase and *T*	3
	(g)		$x = 0.8\sin 5.2t$ [cm] (or equivalent) Allow **ecf** if curve in *(f)* is incorrect, but consistent with *(g)*	1
			Question 2 Total	**[15]**

Question			Marking details	Marks Available
3	*(a)*		(see table below)	
			(1 for value of T; 1 for value of U) **ecf** for U if T incorrect	2
	(b)	(i)	Work done by gas A→B = 0	
		(ii)	Work done by gas B→C = -660 [J]	
		(iii)	Work done by gas C→D = 0	
		(iv)	Work done by gas D→A = 768 [J]	
		(v)	Work done by gas A→B→C→D→A (net work done during cycle) = 768 – 660 = 108 [J] **ecf**	
			1 mark each for (ii), (iv) and (v); 1 mark for both (i) and (iii)	4
	(c)		$\Delta U = Q - W$ i.e. application of equation for the first law of thermodynamics (1) C→D $8\,065 - 6\,931 = Q_{\text{CD}} - 0$ $Q_{\text{CD}} = 1\,134$ [J] / 1 135 D→A $9\,217 - 8\,065 = Q_{\text{DA}} - 768$ $Q_{\text{DA}} = 1\,920$ [J] Either of these two lines correct (1) Heat absorbed = 1 134 + 1 920 = 3 054 [J] / 3 055 (1)	3
	(d)		Efficiency $= \frac{108}{3054} \times 100\%$ (substitution (1)) $= 3.54$[%] (1) **ecf** on 108 [If using heat absorbed = 3 000 J; Efficiency = 3.60%]	2
			Question 3 Total	**[11]**

	Temperature T /K	Internal Energy U /J
A	*369.7*	*9 217*
B	*317.7*	*7 920*
C	278.[0]	6 931/ 6 930
D	*323.5*	*8 065*

Question			Marking details	Marks Available
4	*(a)*	(i)	Application of conservation of momentum (1) $(0.36 + 0.18)v = (0.36 \times 0.40) + \left(0.18 \times (-0.10)\right)$ correct eqn(1) $0.54v = 0.126$ $v = 0.23$ [m s^{-1}] to the right (1) – direction may be by implication	3
		(ii)	Initial KE $= \frac{1}{2}(0.36)(0.4)^2 + \frac{1}{2}(0.18)(-0.10)^2 = 0.0297$ [J] (1) Final KE $= \frac{1}{2}(0.36 + 0.18)(0.23)^2 = 0.0143$ [J] (1) KE lost $= 0.0297 - 0.0143 = 0.0154$ [J] as percentage: $\frac{0.0154}{0.0297} \times 100\% = 51.85$[%] (1)	3
	(b)	(i)	$hf = \frac{hc}{\lambda} = \frac{(6.63\times10^{-34})(3\times10^{8})}{(633\times10^{-9})}\left(\text{subs.}\,(1)\right) = 3.14 \times 10^{-19}$ [J] (1)	2
		(ii)	$N = \frac{(1\times10^{-3})}{(3.14\times10^{-19})}(\text{substitution (1)}) = 3.18 \times 10^{15}$ (1)	2
		(iii)	component of momentum $= \frac{h}{\lambda}\cos 30°$ $= \frac{(6.63\times10^{-34})}{(633\times10^{-9})}\cos 30° = 9.07 \times 10^{-28}$ kg m s^{-1} **or** N s **UNIT mark**	1
		(iv)	$-N\frac{h}{\lambda}\cos30° - \left(N\frac{h}{\lambda}\cos30°\right) = F \times 1$ (application of N 2nd law (1)) $F = -2(3.18 \times 10^{15})(9.07 \times 10^{-28}) = -5.8 \times 10^{-12}$ N Force on photon = 5.8×10^{-12} [N] (1) Allow **ecf** from (*b*) (iii) for the component of momentum	2
			Question 4 Total	**[13]**

Question			Marking details	Marks Available
5	*(a)*		$\omega = \frac{2\pi(1200)}{60}$ (conversion of units (1)) $= 125.7$ [rad s^{-1}] (1) $F = m\omega^2 r = (0.80)(125.7)^2(0.25)$(subs (1)) $= 3160.1$ [N] (1)	4
	(b)	(i)	$R - mg = 3\,160.1$ (1) $R = 3\,160.1 + (0.8)(9.81) = 3\,168$ [N] (1) **ecf** from (a)	
		(ii)	$R + mg = 3\,160.1$ $R = 3\,160.1 - (0.8)(9.81) = 3\,152$ [N] (1) **ecf** from (a)	3
	(c)		Resonance – frequency of rotation matches the natural / resonant frequency of vibration of the saucepan [lid] (1) [When the spin rate decreases,] the frequencies no longer match / so no resonance (1)	2
			Question 5 Total	**[9]**

Question			Marking details	Marks Available
6	*(a)*			
		(i) & (ii)	Correct diagram – 2 or more circles and 3 or more roughly symmetrical lines (1) Correct arrows and labels (1)	2
	(b)		$V = -\frac{1}{4\pi\varepsilon_o}\frac{q}{r} = -\frac{1}{4\pi(8.85\times10^{-12})}\frac{1.60\times10^{-19}}{2.00\times10^{-3}}$ (subs. (1)) $= -7.19\times10^{-7}$ [V] (1)	2
	(c)		Use of W $= q\Delta V$ (1) $= (-1.60\times10^{-19})\left(-1.20\times10^{-6} - (-7.19\times10^{-7})\right)$ $= 7.70\times10^{-26}$[J] (1)	2
	(d)		$F_C = \frac{1}{4\pi\varepsilon_o}\frac{q^2}{r^2} = \frac{1}{4\pi(8.85\times10^{-12})}\frac{(1.60\times10^{-19})^2}{(1.20\times10^{-3})^2}$ $= 1.60\times10^{-22}$ [N] $F_G = G\frac{m^2}{r^2} = (6.67\times10^{-11})\frac{(9.11\times10^{-31})^2}{(1.20\times10^{-3})^2} = 3.84\times10^{-65}$ [N] Both F_C and F_G (1) (or by implication) Gravitational force much less [by factor $\sim \frac{3.84\times10^{-65}}{1.60\times10^{-22}} = 2.40\times10^{-43}$] (or equivalent quantitative comparison or qualitative comparison such as **much** larger, **much** smaller) (1) Electrostatic force repels. Gravitational force attracts. (1) Both need to be mentioned for comparison (or equivalent statement).	3
			Question 6 Total	**[9]**

Question			Marking details	Marks Available
7	*(a)*		$27.3 \times 24 \times 60 \times 60 = 2.36 \times 10^6$ [s] (1) $T = 2\pi\sqrt{\frac{d^3}{G(M_1 + M_2)}}$ $d = \sqrt[3]{\left(\frac{T}{2\pi}\right)^2 G(M_1 + M_2)}$ rearrange (1) $d = \sqrt[3]{\left(\frac{2.36 \times 10^6}{2\pi}\right)^2 (6.67 \times 10^{-11})(6.00 \times 10^{24} + 7.34 \times 10^{22})}$ (accept 7.34×10^{22} ignored in formula) substitution (1) $d = 3.85 \times 10^8$ [m] = 385 000 k[m]	3
	(b)	(i)	$x_{cm} = \frac{M_2}{M_1 + M_2} d$ $= \frac{7.34\times10^{22}}{(6.00\times10^{24}+7.34\times10^{22})} \times 3.85 \times 10^8$ (substitution (1)) $= 4.65 \times 10^6$ [m] (1) (~ 4 650 k[m])	2
		(ii)	The centre of mass is within the Earth **ecf** (~1 710 km below the surface of the Earth)	1
	(c)		$G\frac{M_1}{x^2} = G\frac{M_2}{(d-x)^2}$ (1) – equality of the two fields in terms of *x* $\left(\frac{x}{d-x}\right)^2 = \frac{M_1}{M_2}$ $x = \left(\frac{M_1}{M_2}\right)^{1/2}(d - x)$ $x = \left(\frac{6.00\times10^{24}}{7.34\times10^{22}}\right)^{1/2}(3.85 \times 10^8 - x)$ substitution (1) $x = \left(\frac{(9.04) \times (3.85 \times 10^8)}{10.04}\right)$ rearrange (1) $x = 3.47 \times 10^8$ [m from the Earth] (1)	4
			Question 7 Total	**[10]**

SECTION A

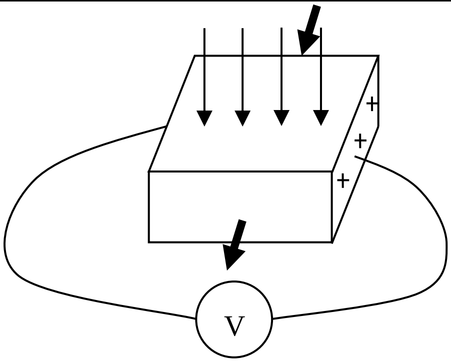
Question			Marking details	Marks Available
1	*(a)*	(i)	84.6×10^{-9} [C] [for 4.7 nF] (1) 73.8×10^{-9} [C][and 73.8 nC or clearly stated same for other 8.2 nF] (1)	2
		(ii)	$E = \frac{1}{2}CV^2$ or other equation used correctly or C total = 8.8 nF (1) Answer = 1.43×10^{-6} [J] **ecf** on Q but not V (1)	2
	(b)	(i)	Points taken from the curve e.g. Q_0 = 85 nC and (50 ms, 6 nC) (or 85 nC/e = 31 nC) (1) Values substituted correctly e.g. $6 = 85e^{-0.05/CR}$ or CR = 18 ms (1) Answer $R = 3.8 \times 10^{6}$ [Ω] (1) **Award 1 mark** for use of $\frac{\Delta Q}{t}$ t **or** 11 MΩ **Alternative:** Tangent (1) Current (1) $R = 3.8 \times 10^{-6}$ [Ω] (1)	3
		(ii)	$I = \frac{V}{R}$ used or tangent drawn at t = 0 (1) Answer = 4.7×10^{-6} [A] **ecf** (1)	2
		(iii)	After 41 ± 1 ms 10% charge left [or 90% discharged] Or other valid method e.g. taking logs and getting time (1) 83×10^{-3} [s] (first step can be implied) **ecf** (1)	2
			Question 1 Total	**[11]**

Question			Marking details	Marks Available
2	*(a)*	(i)	0	1
		(ii)	$\varphi = B \times l^2$(1) Answer = 4.32×10^{-5} [Wb] (1)	2
	(b)		Change in flux or Faraday's law gives emf (1) Complete circuit or accept emf gives current (1) **Award 1 mark only for:** Current due to Faraday's law	2
	(c)		Force / current / emf **opposes the change** (1) Force on PQ opposite to SR **or** the force is clockwise (1)	2
	(d)		$I = \frac{V}{R}$ used (1) $A = \pi\frac{d^2}{4}$ *or* $\pi \times 3^2(\times 10^{-6})$ i.e. πr^2 used (1) $R = \frac{\rho \times l}{A}$ used (1) $V = \frac{\Delta N\phi}{\Delta t}$ used (1) Answer = 0.19 [A] **ecf** on ϕ and πd^2 (1)	5
			Question 2 Total	**[12]**

Question			Marking details	Marks Available
3	*(a)*		Low *A* numbers do fusion (or arrow / label used) (1) High *A* numbers do fission (or arrow / label used) (1) Moving toward high BE/nucleon (around Fe-56) or Fe-56 is the most stable (or low PE/nucleon or accept work done by strong nuclear force) (1) Higher BE/nucleon is more stable (or low PE/nucleon more stable or more work done more stable) (1)	4
	(b)		1.1 ± 0.1 MeV identified from graph for $^{2}_{1}H$ (1) × 2 = 2.2 [MeV] **ecf** (1)	2
	(c)		7.6 ± 0.2, 8.4 ± 0.2, 8.7 ± 0.2 (1) Correct multipliers for each i.e. 235 × 7.6, 137 × 8.4, 96 × 8.7 (1) RHS – LHS or reverse (1) Correct answer e.g. 201 MeV **UNIT mark (**1) [dependent on BE/*A* approximations]	4
			Question 3 Total	**[10]**

Question			Marking details	Marks Available
4	*(a)*		360 ± 10 [minutes]	1
	(b)		No [significant] drop after paper [no α] (1) [Small drop after aluminium] so small amount <u>of γ</u> being absorbed / most γ passes through i.e. could be β but some γ would be absorbed ok **Or** accept drop could be attributable to randomness of decay (1) γ present because something gets through 3 mm Al **or** γ present because **bigger** drop after 10 cm Pb [than 3 mm Al] **or** γ present because <u>only</u> absorbed by the Pb (1)	3
	(c)		Activity = $\frac{450}{0.006}$ = 75 000 (1) Activity = λN or $t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ used (1) $N = 2.34 \times 10^9$ (1) Mass = $99 \times 1.66 \times 10^{-27} \times 2.34 \times 10^9 = 3.84 \times 10^{-16}$ kg **UNIT mark** (1) **ecf** on A and $t_{\frac{1}{2}}$ and N	4
			Question 4 Total	**[8]**

Question			Marking details	Marks Available
5	*(a)*		$n = \frac{12\,000}{1.8}$ (1) $B = \mu_0 n I = 0.019$ [T] (1)	2
	(b)	(i)	Either $Bev = \frac{mv^2}{r}$ *or* $Bev = m\omega^2 r$ (1) $v = \omega r$ *and* $\omega = 2\pi f$ quoted (1) Clear algebra (if not immediately understandable then not clear) (1)	3
		(ii)	$f = \frac{3.3\times 6\times 1.6\times 10^{-19}}{2\pi\times 12\times 1.66\times 10^{-27}}$ (1) Answer = 25.3×10^6 [Hz] (1)	2
		(iii)	$6e \times 14.5$ kV $\times 24$ [= 2.09 MeV] (1) Conversion to J i.e. look out for $\times 1.6 \times 10^{-19}$ (1) Equating some related energy to $\frac{1}{2}mv^2$ e.g. $\frac{1}{2}mv^2$=14 500 (1) Answer = 5.8×10^6 [m s^{-1}] (1) (**ecf** on these values only 2.4×10^6 and 4.1×10^6 which correspond to q =1e and 12 kicks respectively)	4
			Question 5 Total	**[11]**

Question			Marking details	Marks Available
6	*(a)*			
		(i)	+ve correct	1
		(ii)	voltmeter correct	1
	(b)		$V = Ed$ or $V_H = Bvd$ (1) $Bev = eE$ quoted or $d = 5 \times 10^{-3}$ (1) Answer = 6.3×10^{-6} [V] (1)	3
	(c)		Electrons do not move in the direction of the Hall field (or accept in the direction of the Hall voltage)	1
	(d)		Correct use of $I = nAve$ or $n = \frac{BI}{V_H te}$ (or equiv equation) (1) Answer $I = 0.30 \times 10^{-3}$ [A] (1)	2
			Question 6 Total	**[8]**

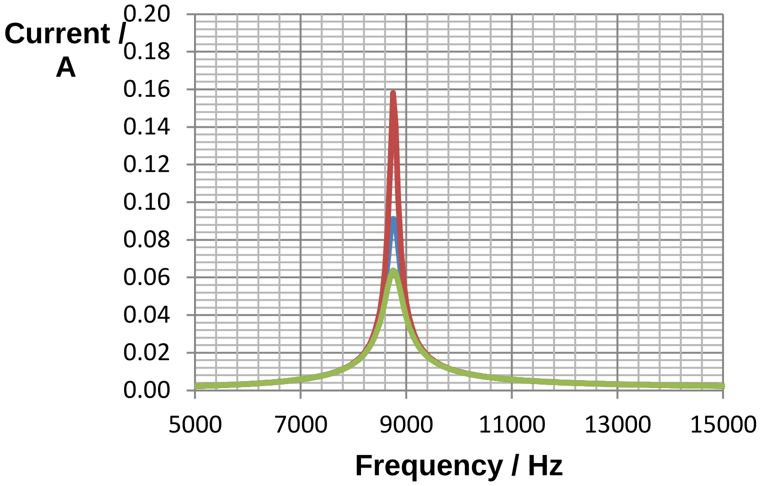
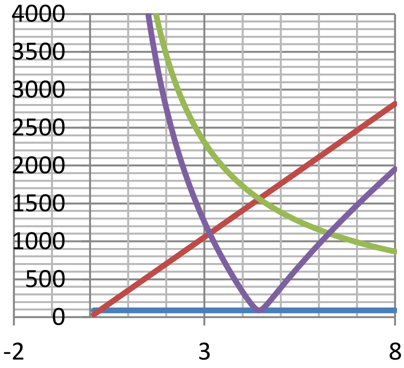
SECTION B

Question			Marking details	Marks Available
7				
	(a)		KE given to water (1) Air resistance (1) **Award 2 marks for:** Water runs out before pressure drops to 1 atm Accept PE given to water [even though water runs out in 1.6 m] Accept viscosity [or friction] of water Accept KE given to bottle [only 1/10th of mass of ball] Don't accept heat or sound	2
	(b)		$v = -20\ln\left(1 - \frac{5.9}{1.5} \times 0.175\right)$ (1) $v = 23.3$ [m s^{-1}] (1)	2
	(c)		kg s^{-1}, m^2, kg m^{-3} and m s^{-1} (0 or 1 unit correct 0 marks) (2 or 3 units correct 1 mark) (All 4 correct 2 marks) If all 4 units correct but algebra is incorrect then deduct 1 mark	2
	(d)		Rearranging i.e. $u = \frac{\Delta m/\Delta t}{\pi r^2 \rho}$ (1) Answer = 25 [m s^{-1}] (1)	2
	(e)		**Any 3 × (1) from:** Rocket equation assumes constant *u* Volume increasing so pressure decreasing Pressure is decreasing so *u* is decreasing Thrust is decreasing	3

Question			Marking details	Marks Available
	(f)		$\Delta p = 6.8 \times 10^5$ [Pa] (1) $u = \sqrt{\frac{2\times6.8\times10^5}{1000}} = 36.9$ [m s^{-1}] (1)	2
	(g)		*mg* - weight or gravitational force **and** $0.0107v^2$ - air resistance / drag accept skin / air friction (1) Weight decreases (1) Air resistance increases (1)	3
	(h)		Squaring equation 6 or rearranging equation 5 (1) Convincing algebra (1)	2
	(i)	I	Fast process or no time for heat to flow or equivalent	1
		II	The gas does work so internal energy decreases **Or** $\Delta U = -W$	1
			Question 7 Total	**[20]**

SECTION C

Question			Marking details	Marks Available
8	*(a)*	(i)	$\omega L = \frac{1}{\omega C}$ *or* $f = \frac{1}{2\pi\sqrt{LC}}$ (1) $= \frac{1}{2\pi\sqrt{0.022\times15\times10^{-9}}}$ or $f = \frac{1}{2\pi\sqrt{0.022\times90\times10^{-9}}}$ (1) 8 761 [Hz] and 3 577 [Hz] (1)	3
		(ii)	$Q = \frac{2\pi f L}{R}$ *or* $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$ (1) Correct matching of *f* and *R* or *R* and *C* (1) 61 (1) 10 (1)	4
	(b)		$Z = \sqrt{\left(\omega L - \frac{1}{\omega C}\right)^2 + R^2}$ used (1) $I = \frac{3.2}{Z}$ i.e. $I = \frac{V}{Z}$ used (1) 1.7 [mA] (1)	3

Question			Marking details	Marks Available
8	*(c)*	(i)	 Shapes similar and asymptotic to original (1) 20 Ω with higher peak and 50 Ω with lower (implied if not labelled) (1) 20 Ω with peak current of 160 mA (1) 50 Ω with peak current of 64 mA (1)	4
		(ii)	ωL increases (wrt f) or graph (1) $\frac{1}{\omega C}$ decreases (wrt f) (1) low frequency behaviour explained e.g. X_C very large, Z large at low freq (1)  high frequency behaviour explained e.g. X_L very large, Z large at high freq (1) $\omega L - \frac{1}{\omega C} = 0$ at resonance making Z a minimum (1) $I \propto \frac{1}{Z}$ or equivalent equation etc. (1)	6
			Question 8 Total	**[20]**

Question			Marking details	Marks Available
9	*(a)*	(i)	Diagram showing either angle (accept θ) or baseline (1) Attempt to use $b = r\theta$ and indication that θ must be in radians, Or attempt to use $b/2 = r \tan(\theta/2)$ or equiv. Or by implication. (1) $r = 1.96 \times 10^6$ [km] or 1.92×10^6 [km] or convincing answer. (1)	3
		(ii)	Showed comet (far) beyond Moon. (1) But according to Aristotle nothing changes beyond Moon [yet comet was new – and went away]. (1)	2
	(b)	(i)	Diagram showing relevant areas (1) r_P, r_A, $v_P\Delta t$, $v_A\Delta t$ marked on diagram or meanings otherwise shown (1) $(\frac{1}{2})r_P v_P \Delta t = (\frac{1}{2})r_A v_A \Delta t$ or equivalent (1)	3
		(ii)	Use of $\frac{v_P}{v_A} = \frac{r_A}{r_P}$ [= 1.10] or by implication (1) 10 % [increase] (1)	2
		(iii)	Explicit use of $\frac{mv^2}{r}$ (1) $\frac{v_P}{v_A} = \frac{r_A}{r_P}$ used convincingly to give $\frac{F_P}{F_A} = \frac{r_A^2}{r_P^2}$ or equiv. (1)	2
	(c)	(i)	Towards S or equivalent	1
		(ii)	Any 3 of ... • Sun at S, planet's path ABCDEF... • If time interval is shrunk, path becomes smooth • Equal areas swept out in equal times • Showed that for an elliptical path ... • ... force had to vary as inverse square of Sun-planet distance	3
		(iii)	Planets swirled in whirlpool (vortex) around the Sun (1) Any 2 of …. (2) • easy to understand • gave a *mechanism* • Newton didn't say what *caused* gravitation Descartes' vortex theory can't be made to account for actual orbits [that is for Kepler's laws] or Newton's theory accounted for so many phenomena so economically [or similar point] (1)	4
			Question 9 Total	**[20]**

Question				Marking details	Marks Available
10	*(a)*	(i)		Strong (covalent) bonds between ions in structure. Accept molecules arranged irregularly or amorphous structure present (1) [No dislocations present] so no slip (accept no movement of dislocations). Accept different sized atoms seize up the structure (1) Do not accept 'untangle'.	2
		(ii)		Scratches (on surface) weaken material or break surface bonds. Scratches have stress concentrations at their tips- can be awarded from diagram. Cracks propagate through material. Correct direction of bending is to open the crack [ANY 2] (credit well annotated diagrams) [Local] stress cannot be relieved by slip / plastic flow/ dislocation movement.	2
		(iii)		Compression (1]) [Do not accept 'stress] More difficult for cracks to develop/ widen/ propagate (1)	2
	(b)	(i)		Gradient shown = 80 GPa e.g. $\frac{800\text{x}10^6}{0.01}$ seen.	1
		(ii)		Area under graph = [½ × 0.01 × 800 × 10^6 + ½ × 0.08 × 100 × 10^6 + 0.08 × 800 × 10^6] = 72 [MJ m^{-3}] (1) Volume = π × $(1.25 \times 10^{-3})^2$ × 2.5 = 12.3 × 10^{-6} [m^3] (1) Work done = 72 × 10^6 × 12.3 × 10^{-6} = 884 [J] (1) (**ecf** on both area and volume).	3
		(iii)		Initial straight line of same gradient. (1) Yield point at 1 000 MPa. (1) Linear plastic region of small slope (accept zero slope) stopping at 5% strain. (1)	3
		(iv)	(I)	Creep: **[Gradual/slow/Over time]** AND **[extension/stretching/deformity or increase in strain]** (1) (under a constant load). Necking: **Localised** (or reference to 'section' or 'region') **thinning** (of structure/material before breaking- accept diagram) (1)	2
			(II)	Same shaped curve but steeper gradient (1) Stopped at 15% and t < 400 hrs (approx.) (1)	2
		(v)		Repeated bending, stretching or hammering of metal alloy (1) Dislocations become tangled / traffic jam effect **or** new dislocations created (1) Stopping each other from moving (or inhibiting plastic deformation or collect at grain boundaries) (1)	3
				Question 10 Total	**[20]**

Question			Marking details	Marks Available
11	*(a)*	(i)	A/B/D	1
		(ii)	C	1
		(iii)	A	1
	(b)		$V = \frac{hc}{e\lambda}$ (must rearrange) (1) 6.2×10^4 V (must have valid unit) (1)	2
	(c)		Reduces scattering/ spreading accept 'ensures (X-rays) are all parallel / perpendicular [to the patient] (1) [leading to] sharper image / better resolution (1)	2
	(d)	(i)	Radio (waves)	1
		(ii)	Cause Hydrogen atoms to resonate (1) Flip alignment producing a magnetic field (1)	2
		(iii)	Not good for dense objects/bone/ Uncomfortable/ Claustrophobic/cannot be used with pacemakers/ expensive	1
	(e)	(i)	Depolarization of ventricles/ repolarisation of atria (1) Contraction of ventricles (1)	2
		(ii)	Repolarization of ventricles (1) Relaxation of ventricles/ ventricles return to normal (1) Do NOT accept ventricles expand	2
	(f)	(i)	Doppler	1
		(ii)	$0.4 \times \frac{1500}{500} = 2v$ (1) $v = 0.6$ [m s^{-1}] allow 1 mark only for 1.2 m s^{-1} (1)	2
	(g)	(i)	Gamma /γ	1
		(ii)	Very expensive/need a cyclotron / particle accelerator Ignore any reference to radiation dose	1
			Question 11 Total	**[20]**

Question			Marking details	Marks Available
12	*(a)*		Any 3 of: More than one isotope of uranium Only U-235 fissile / U-238 unsuitable for fission Need higher concentration of U-235 Get rid of U-238 since neutron absorber/'sink'	3
	(b)		More fissile nuclei obtained (1) U-238 captures neutrons **or** decays to plutonium 239 via beta (1)	2
	(c)		Any 2 of: More easily controllable or no chain reaction Hydrogen & deuterium more plentiful / more easily sourced / can be extracted from sea water No [long term] radioactive products. More energy released per fusion	2
	(d)	(i)	Overcome electrostatic repulsion /forces (1) Needs high / enough (K)E (or velocity, speed) of deuterium/tritium (1) <u>KE proportional to temperature</u> or only tail end of distribution with high enough energy (1)	3

Question			Marking details	Marks Available
		(ii)	$n = or \geq \frac{3.5 \times 10^{28}}{0.9 \times 120000000}$ (1) Multiplying by $2.5 \times 1.67 \times 10^{-27}$ (1) Answer = 1.35×10^{-6} [kg m^{-3}] (1)	3
	(e)		9×10^{16} (1) $\times 2 = 18 \times 10^{16}$ [J] (1)	2
	(f)		Coal **- any 2 of**: acid rain, CO_2, non-renewable, lasts hundreds of years, increase asthma, damage to buildings/trees/etc, global warming (1) Natural gas **- any 2 of:** less acid rain, CO_2, non-renewable lasts tens or hundreds of years, global warming (1) Biomass **- any 2 of:** acid rain, CO_2 neutral (roughly), renewable/lasts millions of years, increase asthma, damage to buildings/trees/etc, (roughly) no global warming, large land area needed (1) Uranium-235 **any 2 of**: no acid rain, no CO_2, lasts thousands of years, no increase asthma, no damage to buildings/trees/etc, (little or) no global warming, leak or explosion risk, disposal of waste, hazardous waste, large energy output per kg of fuel (1) Wind **any 2 of:** no acid rain, no CO_2, renewable/lasts millions of years, no increase asthma, no damage to buildings/trees/etc, no global warming, low power, weather dependent/unreliable, large area (1) (ugly/kills birds/noisy/disrupts TV signals OK but only 1 point max for these) NOTE: No marks for cheap/expensive **-** eliminated in stem!!	5
			Question 12 Total	**[20]**

GCE A level

1326/01-E

S15-1326-01E

PHYSICS – PH6

Data Analysis Task

MARKING SCHEME

2015

1326
01E001

DATA ANALYSIS TASK – Mark Scheme

Question		Marking details	Marks Available
(a)		Correct circuit diagram including voltmeter, switch and resistor with all the correct symbols given	1
(b)		(see table below)	

Wavelength λ (nm)	$\frac{1}{\lambda}$ $(\mu m)^{-1}$	Minimum voltage V_{min} (V)			Mean V_{min} (V)	Absolute uncertainty V_{min} (V)
		1	2	3		
470	2.13	2.48	2.45	2.42	2.45	0.03
520	1.92	2.21	2.25	2.27	2.24	0.03
560	1.79	2.06	2.11	2.03	2.07	0.04
590	1.69	2.00	1.94	1.97	1.97	0.03
620	1.61	1.86	1.89	1.94	1.90	0.04
660	1.52	1.74	1.78	1.82	1.78	0.04

(b)(i) Values of $\frac{1}{\lambda}$ determined correctly to 3 s.f. [accept 2 s.f.] with consistent number of s.f.
e.g. As above or 0.00213, 0.00192, 0.00179 ... [for λ in nm]. (1)
Correct unit for $\frac{1}{\lambda}$ given, correctly expressed. e.g. as above, or expressed as $\frac{1}{\lambda}$ / μm^{-1} [accept (μm^{-1})]. (1)

Alternatively $\frac{1}{\lambda / \text{nm}}$, $\frac{1}{\lambda}$ / nm^{-1}, $\frac{1}{\lambda / 10^{-9}\text{m}}$, $\frac{1}{\lambda}$ / 10^9m^{-1}, $\frac{1}{\lambda}$ / $(10^{-9}\text{m})^{-1}$
$\frac{1}{\lambda / 10^{-6}\text{m}}$, $\frac{1}{\lambda}$ / 10^6m^{-1}, $\frac{1}{\lambda}$ / $(10^{-6}\text{m})^{-1}$ (1)

[Note: the mark given for a correctly expressed unit consistent with the values given.]

Marks available: 2

(b)(ii) Mean values of V_{min} determined correctly [as above] and expressed to 3 s.f. (1)
Uncertainty in V_{min} determined correctly [as above] and expressed to 1 s.f. (1)

Marks available: 2

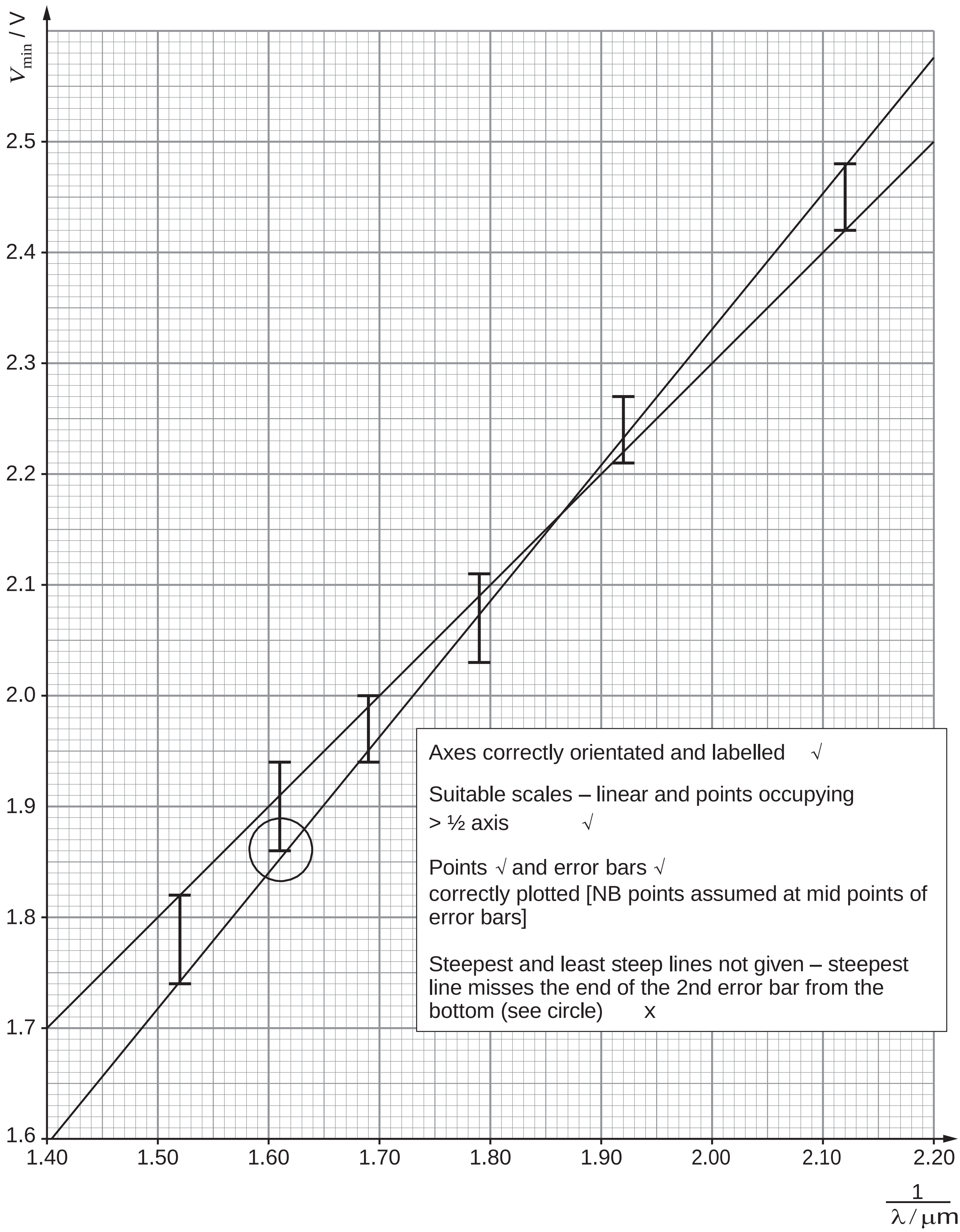
(c) Axes labelled, with units [e.c.f. from table] and correct orientation [i.e. V_{min} on vertical axis] (1)
Suitable scales chosen so that the data points occupy at least ½ of each axis and not involving awkward factors, e.g. 3. (1)
All points plotted correctly to within ± ½ small square division. (1)
All error bars plotted correctly. (1)
Correct steepest and least steep lines consistent with the error bars **ecf** (1) See exemplification graphs on pages 42–45.

Marks available: 5

Question		Marking details	Marks Available
(d)	(i)	There are no marks for the answer yes or no – the marks are for the discussion. • Data points are consistent with a straight line / best fit line with a positive gradient [which is consistent with the equation] (1) • The [straight] line of best fit goes through all the error bars (1) • But [without calculation] we cannot determine if the data are consistent with an intercept = 0 [so we cannot be sure that the data are consistent with the equation] [or equiv.] (1)	3
	(ii)	Large triangle used (should be close to the extremities of the line of best fit) or 2 equivalent suitable points clearly indicated on the graph or clearly implied by the calculation [see below] (1) Both gradients of the graph calculated correctly. Data points used must be on the line graph N.B. no sig fig or unit penalty (1 + 1) **ecf** allowed for incorrect max/min lines / ignore errors of powers of 10 Example of clear implication [from 3rd graph – on page 44] Max gradient = $\dfrac{2.575 - 1.605}{2.20 - 1.40}$ = 1.213 [V μm] Min gradient = $\dfrac{2.499 - 1.712}{2.20 - 1.40}$ = 0.984 [V μm] Note: the values of both gradients are ~ 1×10^{-6} [V m]. If $\frac{1}{\lambda}$ is expressed in nm^{-1} the numerical values of the gradient will be ~ 1×10^{3}	3
	(iii)	Mean gradient calculated correctly [the expected answer from examples in (ii) is ~ 1.10×10^{-6}] allow **ecf** from (ii). (1) Absolute uncertainty calculated (1) [can be inferred from correct value of percentage uncertainty] [the expected answer is 0.1×10^{-6}] Percentage uncertainty calculated correctly (1) [expected answer from examples in (ii) is ~ 10%] **ecf** Allow 1 or 2 sig figs	3
	(iv)	h calculated **correctly** with a valid unit [expected value 5.9(4) × 10^{-34} J s] using the gradient (1) no sig fig penalty Absolute uncertainty calculated correctly [expected value ~ 0.7×10^{-34} J s] and written with the value of h, e.g. (5.9 ± 0.7) × 10^{-34} [J s] or (5.94 ± 0.66) 10^{-34} [J s] **ecf** (1)	2
	(v)	Comment on accuracy of result [e.g. the calculated value of h is more than 5% away from the accepted value so the value is not accurate] (1) Note: the reasoning must be valid and clearly expressed. Percentage difference between the given value of h and the result in (iv) calculated correctly [expected answer ~11%] **or** 5% of the given value of h calculated [0.3×10^{-34} J s] (1)	2
(e)	(i)	V_{min} = 1.11 V or 1.1 V	1
	(ii)	The value of wavelength is in the infra-red part of the spectrum [or equiv, e.g. wavelength longer than the visible region of spectrum].	1
		Question Total	**[25]**

1326 01E003

Examiner only



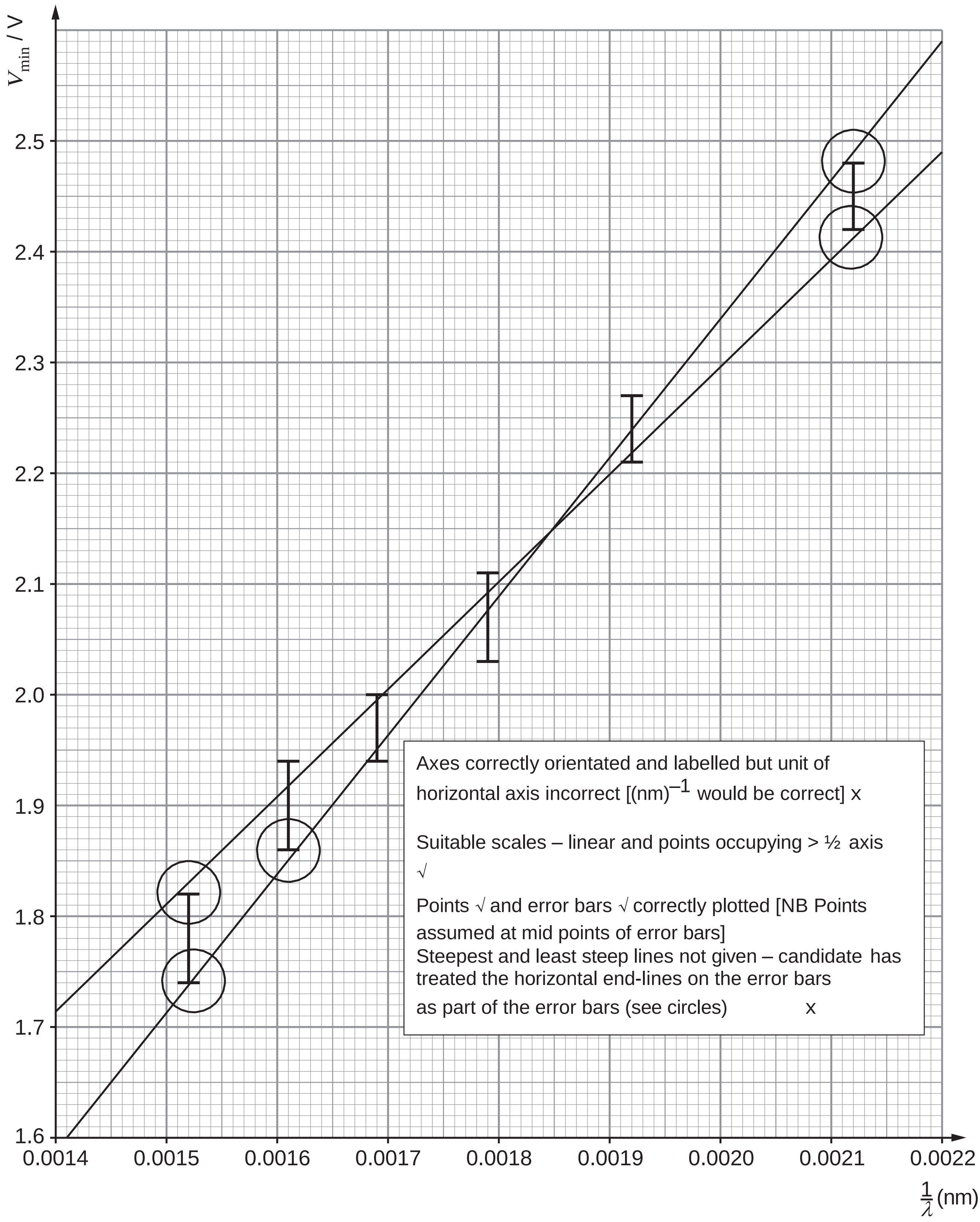
Axes correctly orientated and labelled √

Suitable scales – linear and points occupying > ½ axis √

Points √ and error bars √ correctly plotted [NB points assumed at mid points of error bars]

Steepest and least steep lines not given – steepest line misses the end of the 2nd error bar from the bottom (see circle) x

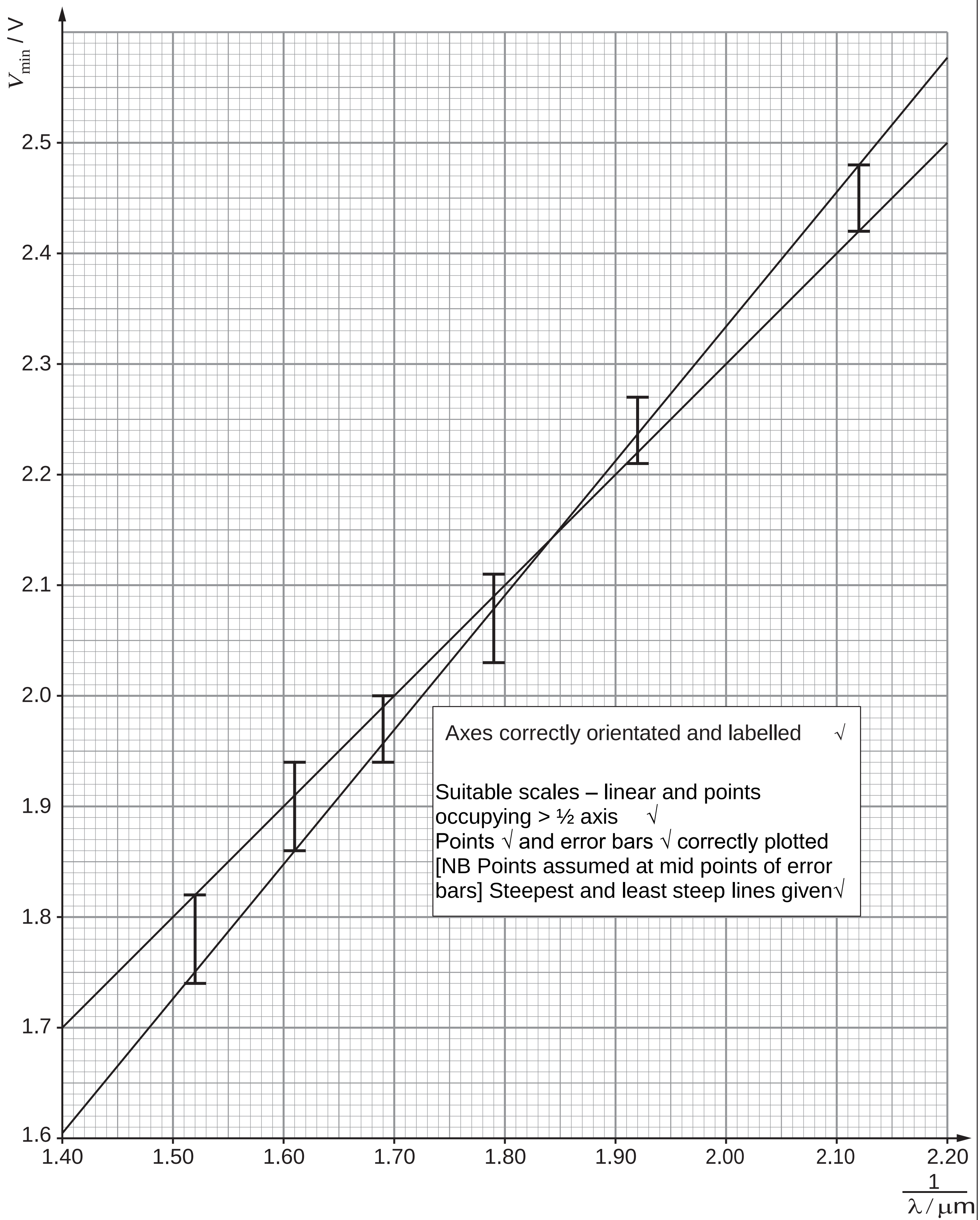
Examiner only



Axes correctly orientated and labelled but unit of horizontal axis incorrect [$(nm)^{-1}$ would be correct] x

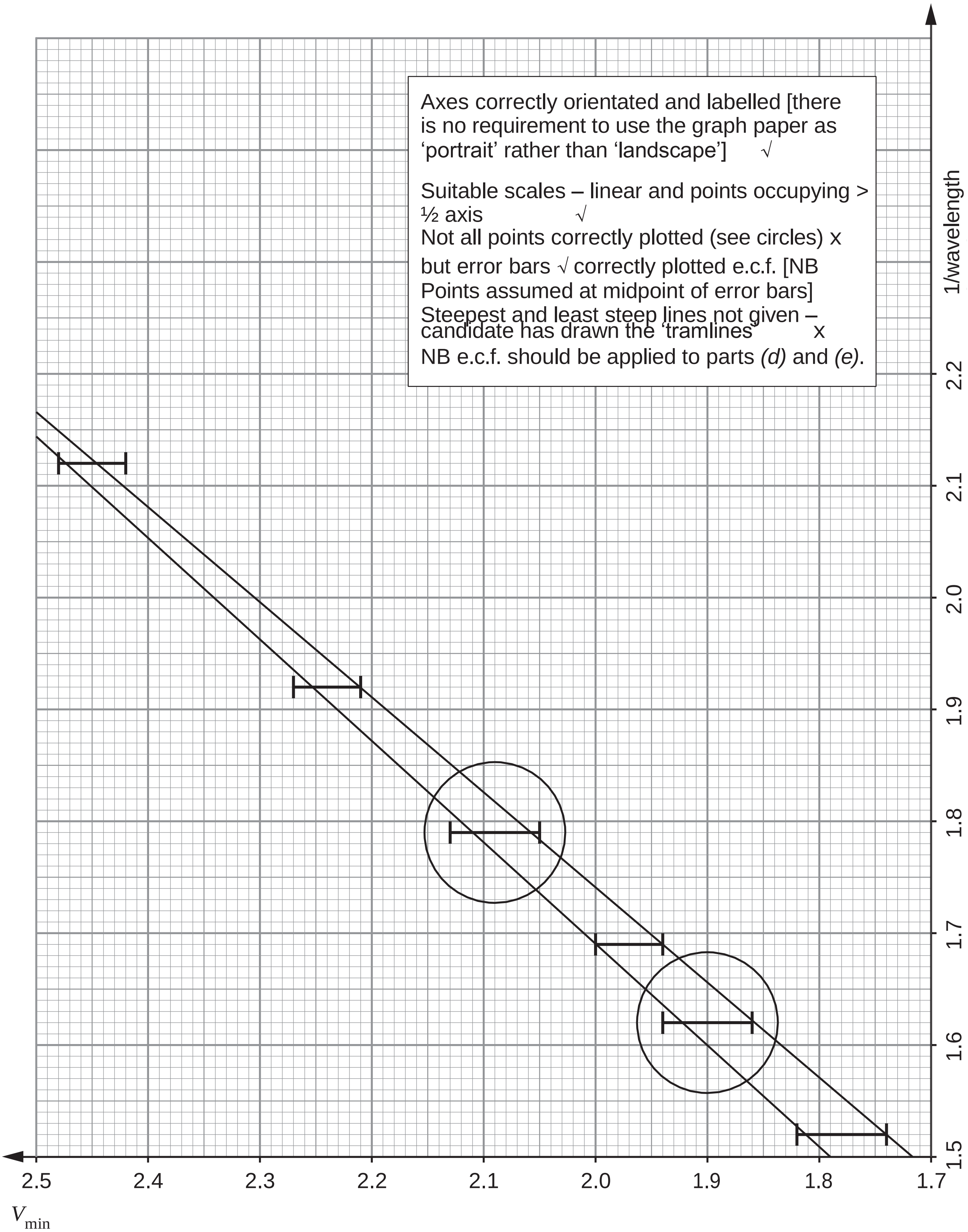
Suitable scales – linear and points occupying > ½ axis √

Points √ and error bars √ correctly plotted [NB Points assumed at mid points of error bars]
Steepest and least steep lines not given – candidate has treated the horizontal end-lines on the error bars as part of the error bars (see circles) x



V_{min} / V
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.40
1.50
1.60
1.70
1.80
1.90
2.00
2.10
2.20
$\frac{1}{\lambda / \mu m}$
Axes correctly orientated and labelled √
Suitable scales – linear and points occupying > ½ axis √
Points √ and error bars √ correctly plotted
[NB Points assumed at mid points of error bars] Steepest and least steep lines given√

Examiner only



Axes correctly orientated and labelled [there is no requirement to use the graph paper as 'portrait' rather than 'landscape'] √

Suitable scales – linear and points occupying > ½ axis √

Not all points correctly plotted (see circles) x but error bars √ correctly plotted e.c.f. [NB Points assumed at midpoint of error bars]

Steepest and least steep lines not given – candidate has drawn the 'tramlines' x

NB e.c.f. should be applied to parts *(d)* and *(e)*.

Question			Marking details	Marks Available
1	*(a)*	(i)	Equation re-arranged as $\ln H = -\lambda t + \ln H_0$ (1) Graph of $\ln H$ on the y-axis and t on the x-axis stated to be plotted or explicit comparison with $y = mx + c$ (1) ***Remember not to award the marks if the information sheet was issued.***	2
		(ii)	Range of heights / times used and stated e.g. start at 70 cm and measure time every 10 cm to a height of 30 cm or every 10 s until a reasonable drop in height occurs(1) Readings taken at eye level **or** equivalent (1) Repeat readings taken (1) *All of the above points cannot be awarded from the table they must be stated in the plan.*	3
	(b)		Single clear main table: with titles and units on all columns (1) (N.B. log values should have no unit e.g. $\ln H$ or $\ln (H/\text{cm})$ are acceptable but $\ln H$ (cm) or $\ln H$ (m) are not acceptable) Repeat readings included and all mean values calculated correctly (1) All $\ln H$ values correct (1) All data given to consistent sig figs (1) Resolution of stopwatch and metre ruler given correctly as 1 s and 1 mm / 1 cm [accept 0.5 mm / cm] (1)	5
	(c)		Graph of $\ln H$ against t plotted with axes labelled and correct units given on axes (1) Allow **ecf** from table and *(a)*(i) Suitable scale chosen so that all data points occupy at least half of each axis and not involving awkward factors e.g. 3 (1) All points plotted correctly to within ± ½ small square division (1) Appropriate line / curve of best fit consistent with the data (1)	4
	(d)		Large triangle used (should be close to the extremities of the line of best fit) or 2 equivalent suitable points clearly indicated on the graph (1) Gradient of the graph calculated correctly. Data points used must be on the line of best fit graph N.B. no sig fig or unit penalty. Ignore negative sign(1)	2
	(e)	(i)	Gradient = λ (can be implied) **and** correct unit given s^{-1} Allow ecf. No sig fig penalty. Ignore negative sign.	1
		(ii)	Any relevant factor e.g. degree of turn on the tap / different solution / diameter of nozzle / angle of burette. Don't accept: area / volume of burette / gravity or g	1
	(f)		**Any 3 × (1) from:** • Graph has <u>negative</u> gradient • Positive intercept or suitable alternative • Straight line or slightly curved • All points lie close to the line N.B. Yes/No – scores 0 mark	3
	(g)	(i)	Correct calculation for half-life with unit. No sig fig penalty. Ignore negative sign.	1
		(ii)	Correct interpretation of half-life e.g. time taken from ln 32 to ln 16(1) The value of $T_{\frac{1}{2}}$ correctly determined from the graph (1) Comment on accuracy; allow **ecf** for incorrect interpretation of $T_{\frac{1}{2}}$ and from part *(g)*(i) (1)	3
			Question total	**[25]**

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