



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.

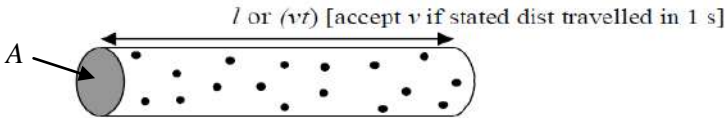
WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

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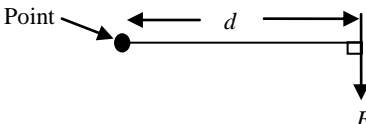
PH1

Question			Marking details	Marks Available
1	(a)	(i)	Horizontal velocity = $\frac{1.20}{0.60} = 2[.0 \text{ m s}^{-1}]$	1
		(ii)	$0 = u^2 - 2 \times 9.81 \times 0.44$ [correct substitution into $v^2 = u^2 + 2ax$] (1) $u = 2.94 [\text{m s}^{-1}]$ (1) or $0 = u - 9.81 \times 0.30$ [correct substitution into $v = u + at$] (1) $u = 2.94 [\text{m s}^{-1}]$ (1) [Other solutions possible]	2
	(b)	(i)	$R = (4 + 8.64)^{1/2}$ (1) [ecf from (a)(i) and/or (a)(ii)] $R = 3.56 [\text{m s}^{-1}]$ (1)	2
		(ii)	$\theta = 55.8^\circ$ ecf	1
	(c)	(i)	<u>Force of gravity on earth due to grasshopper</u>	1
	(ii)	$F = 3 \times 10^{-5} \times 9.81 = 2.9 \times 10^{-4} [\text{N}]$ Accept 0.3 m[N]	1	
	(d)	←	1	
Question 1 Total				[9]
2	(a)		$V \text{ A}^{-1}$ and $W \text{ A}^{-2}$ 2 × (1)	2
	(b)	(i)	$V = 0.01 \times 450 = 4.5 [\text{V}]$	1
		(ii)	$12 \text{ V} - 4.5 \text{ V}$ [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) $R_{\text{variable resistor}} = 4500 [\Omega]$ (1) Alternative solution to (iii) and (iv) I through 900 Ω = $\frac{7.5}{900} = 0.0083 [\text{A}]$ (1) I through variable resistor = 0.0017 [A] (1) $R_{\text{variable resistor}} = \frac{7.5}{0.0017} = 4500 [\Omega]$ (1) Use of resistors in parallel formula to find total parallel resistance = 750 [Ω] (1)	2	

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

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)	$\text{Power} = \frac{1.8}{60} = 0.03 \text{ [W]} (1)$ $R = \frac{0.03(\text{ecf})}{1.6^2} = 0.0117 \text{ [\Omega]} (1)$ <p>Alternative solution possible for the first 2 marks using $V = \frac{W}{Q}$ and</p> $R = \frac{V}{I}$ $\rho = \frac{0.0117 \times 2 \times 10^{-6}}{0.4} (1) \text{ [ecf on R]}$ $= 5.9 \times 10^{-8} \text{ [\Omega m]} (1)$	4
	(b)	(i)	 <p>[NB free electrons not required to be labelled]</p> <p>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)</p> <p>Volume defined either from diagram [e.g. A and l labelled as shown] or in body of derivation [e.g. $\text{vol} = Al$] and n identified correctly – for the first mark</p>	4
		(ii)	$1.6 = 6.4 \times 10^{28} \times 2 \times 10^{-6} \times v \times 1.6 \times 10^{-19} (1: \text{substitution})$ $v = 7.8 \times 10^{-5} \text{ [m s}^{-1}\text{]} (1)$	2
		(iii)	(I) less than 1.6 A identified/circled (1) (II) the same as identified/circled (1) (III) 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		

Question			Marking details	Marks Available
5	(a)	(i)	power = $\frac{\text{work done or energy transferred}}{\text{time}}$ [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] $E_k = \frac{1}{2} (70)(35)^2$ (1) [= 42 875 J] $E_{\text{lost}} = 147 641 - 42 875$ (1) [= 104 766] (ecf on both E_p and E_k) $F = \frac{104766}{1600} = 65.5$ [N] (1) (ecf on E_{lost})	4
		(ii)	Alternative solution: using $v^2 = u^2 + 2ax$ $P = \frac{104766}{46}$ ecf (1) = 2277 J s ⁻¹ or W (1) UNIT mark	2
			Question 5 total	[9]
6	(a)		 <p style="text-align: right;">(1)</p>	2
	(b)	(i)	$(F \sin 40^\circ)(1) \times 0.4$ (1) = $((12 \times 0.9) + (22 \times 1.8))$ (1) $F = 196$ [N] shown	3
		(ii)	(I) Vertical component of force in strut = 126 [N] (1) Accept 128 [N] or 129 [N] if $F = 200$ N is used. (II) Vertical downward arrow shown at hinge. (1) (III) 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
	(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] $F_{\text{drag}} = 82$ [kN] (1)	2
	Question 7 Total			

PH2

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) $v = 500 \text{ mm s}^{-1}$ or 0.5 m s^{-1} or $T = 0.03 \text{ s}$. Accept without units. (1) Attempted use of $f = \frac{v}{\lambda}$ not $c = 3 \times 10^8 \text{ m s}^{-1}$ 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 2 nd mark if also states that dest int at P. For the 3 rd mark it must be carefully explained why destructive interference at P for $\lambda = 15 \text{ mm}$ Alternative solution: Path difference = $7.7 \pm 0.1 \text{ mm}$ (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		
	(b)	II down, up, down half sinusoid: up, down or both (1) $c = 80$ [m s ⁻¹] and $\lambda = 4.8$ [m] or frequency of fundamental = third frequency of 3 rd harmonic or by implication (1) $f = 17$ [Hz] (1)	1 3			
			Question 3 Total	[8]		
4	(a)	(i)	$\sin \theta = 1.331 \sin 40.36^\circ$ or by implication (1) 60° (1) Accept 59.5 °	2		
		(ii)	<i>Not total</i> + 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 $C = 49^\circ$	2		
		(iii)	$v_{\text{violet}} < v_{\text{red}}$ + 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 = $\frac{360}{1.75 \times 10^{-6}}$ [= 2.06 × 10 ⁸ m s ⁻¹] or by implication (1) $n = 1.46$ (1) must be to 3 sig figs	2		
		(ii)	$C = 75^\circ$ or by implication (1) $1.46 \sin 75^\circ = n_{\text{clad}}$ [sin 90°] [Accept 1.5 for 1.46] or by implic (1) $n_{\text{clad}} = 1.41$ [1.45 if n_{core} taken as 1.50] (1) Award 1 mark only for: $1.46 \sin 15^\circ = n_{\text{clad}}$ [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 <i>emitted electron</i> [s]	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) $h = 6.8 [\pm 0.2] \times 10^{-34}$ [J s] (1)	2
		(ii)	II $\phi = 3.1 [\pm 0.1] \times 10^{-19}$ [J] Don't accept a negative ϕ	1
			$\phi_{\text{sodium}} = \phi_{\text{caesium}} + 0.6$ [or 0.7] $\times 10^{-19}$ J or parallel line or use of equation (1) $\phi_{\text{sodium}} = 3.7 [\pm 0.3] \times 10^{-19}$ [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 $[\Delta]E = hf$ 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)	$r = 3.07 \times 10^{10} \text{ m}$ and $L = 1.99 \times 10^{29} \text{ W}$ or by implication (1) $L = \sigma 4\pi r^2 T^4$ (1) Correct algebra including fourth-rooting (1) $T = 4150 \text{ K}$ UNIT mark (1) [Take 5865 K arising from $A = \pi r^2$ as ecf] If only Sun considered $T = 5776 \text{ K}$ award 3 marks only	4	
	(b)	Attempted use of $\lambda_{\text{max}} = 700 - 750 \text{ [nm]}$ in Wien's Law (1) $3867 - 4140 \text{ [K]}$ (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: <ul style="list-style-type: none"> • 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

PHYSICS – PH3

Practical Physics

MARKING

SCHEME

Tests 1 and 2

2015



S15-1323-01D

TEST 1 – MARK SCHEME

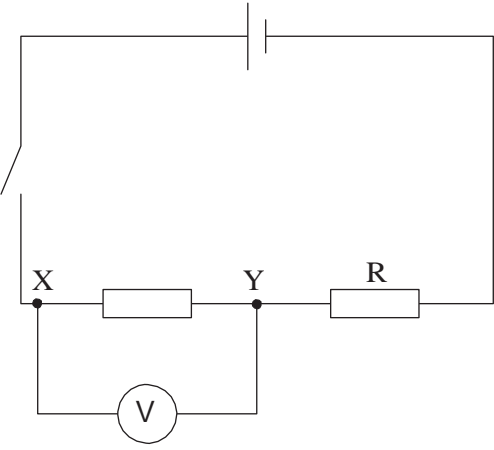
SECTION A

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 = $2 \times$ % 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 50.0cm with $y = 60.0 - (a)$ no unit penalty	1
		(ii)	Attempt to <u>equate</u> 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 $h/\text{mean } H$ or mean $H/\text{mean } h$ 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	1
Question Total			[8]

SECTION B

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

Question		Marking details	Marks Available	
	(f)	(i)	4% of 10.0Ω calculated as 0.4Ω / % 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 $9.6 \Omega - 10.4 \Omega$ (2)	2
		(ii)	Gradient steeper/bigger (1) Intercept stays the same (1)	2
Question Total			[24]	

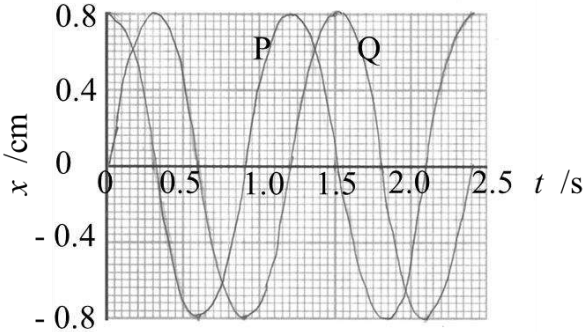
TEST 2 – MARK SCHEME AS TEST 1

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)

PH4

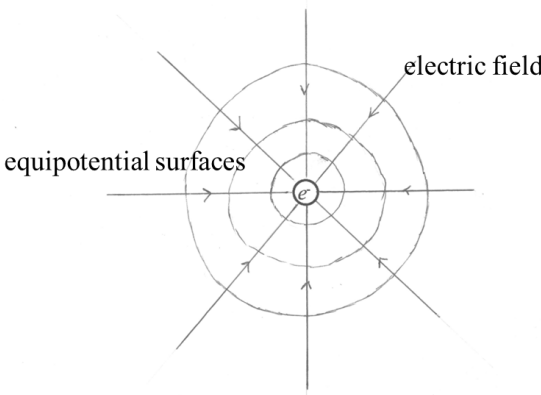
Question		Marking details	Marks Available
1	(a)	(i) Any 4 from the following (1 mark for each): <ul style="list-style-type: none"> - the oxygen molecules move at random / in all directions - the molecules strike [the walls of] the container [and rebound] - rate of change of momentum of the molecules 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) $n = \frac{pV}{RT} = \frac{(4 \times 10^5)(0.7)}{(8.31)(288)}$ (substitution (1)) = 117 [mol] (1)	2
		(ii) $pV = \frac{1}{3} N m \overline{c^2}$ $\sqrt{\overline{c^2}} = \sqrt{\frac{3pV}{Nm}}$ (rearrange (1)) $\sqrt{\overline{c^2}} = \sqrt{\frac{3pV}{n(32 \times 10^{-3})}}$ correct incorporation of relative mol. mass (1) $\sqrt{\overline{c^2}} = \sqrt{\frac{3(4 \times 10^5)(0.7)}{(117)(32 \times 10^{-3})}} = 473.7 \text{ m s}^{-1}$ (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)) $\sin\left(5.2 (\omega(1))t + \frac{\pi}{2}$ (phase (1))) cm [or use $\omega = 5$ rad s ⁻¹ or phase = 90°]	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 $\omega = 5$ 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)		
	(g)	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
	$x = 0.8 \sin 5.2t$ [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)	<table border="1"> <thead> <tr> <th></th> <th>Temperature T /K</th> <th>Internal Energy U /J</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>369.7</td> <td>9217</td> </tr> <tr> <td>B</td> <td>317.7</td> <td>7920</td> </tr> <tr> <td>C</td> <td>278.[0]</td> <td>6931/ 6930</td> </tr> <tr> <td>D</td> <td>323.5</td> <td>8065</td> </tr> </tbody> </table> <p>(1 for value of T; 1 for value of U) ecf for U if T incorrect</p>		Temperature T /K	Internal Energy U /J	A	369.7	9217	B	317.7	7920	C	278.[0]	6931/ 6930	D	323.5	8065	2
		Temperature T /K	Internal Energy U /J															
	A	369.7	9217															
	B	317.7	7920															
	C	278.[0]	6931/ 6930															
D	323.5	8065																
(b)	<p>(i) Work done by gas A→B = 0</p> <p>(ii) Work done by gas B→C = -660 [J]</p> <p>(iii) Work done by gas C→D = 0</p> <p>(iv) Work done by gas D→A = 768 [J]</p> <p>(v) Work done by gas A→B→C→D→A (net work done during cycle) = 768 – 660 = 108 [J] ecf</p> <p>1 mark each for (ii), (iv) and (v); 1 mark for both (i) and (iii)</p>	4																
(c)	<p>$\Delta U = Q - W$ i.e. application of equation for the first law of thermodynamics (1)</p> <p>C→D 8 065 – 6 931 = $Q_{CD} - 0$ $Q_{CD} = 1\ 134$ [J] / 1 135</p> <p>D→A 9 217 – 8 065 = $Q_{DA} - 768$ $Q_{DA} = 1\ 920$ [J]</p> <p>Either of these two lines correct (1)</p> <p>Heat absorbed = 1 134 + 1 920 = 3 054 [J] / 3 055 (1)</p>	3																
(d)	<p>Efficiency = $\frac{108}{3054} \times 100\%$ (substitution (1)) = 3.54[%] (1) ecf on 108</p> <p>[If using heat absorbed = 3 000 J; Efficiency = 3.60%]</p>	2																
		Question 3 Total	[11]															

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

Question		Marking details	Marks Available
5	(a)	$\omega = \frac{2\pi(1200)}{60} \text{ (conversion of units (1))} = 125.7 \text{ [rad s}^{-1}\text{]} \text{ (1)}$ $F = m\omega^2 r = (0.80)(125.7)^2(0.25) \text{ (subs (1))} = 3160.1 \text{ [N]} \text{ (1)}$	4
	(b)	<p>(i) $R - mg = 3160.1 \text{ (1)}$</p> $R = 3160.1 + (0.8)(9.81) = 3168 \text{ [N]} \text{ (1) ecf from (a)}$ <p>(ii) $R + mg = 3160.1$</p> $R = 3160.1 - (0.8)(9.81) = 3152 \text{ [N]} \text{ (1) ecf from (a)}$	3
	(c)	<p>Resonance – frequency of rotation matches the natural / resonant frequency of vibration of the saucepan [lid] (1)</p> <p>[When the spin rate decreases,] the frequencies no longer match / so no resonance (1)</p>	2
		Question 5 Total	[9]

Question	Marking details	Marks Available
6	<p>(a)</p> <div style="text-align: center;">  </div> <p>(i) Correct diagram – 2 or more circles and 3 or more roughly & symmetrical lines (1) (ii) Correct arrows and labels (1)</p> <p>(b)</p> $V = -\frac{1}{4\pi\epsilon_0} \frac{q}{r} = -\frac{1}{4\pi(8.85 \times 10^{-12})} \frac{1.60 \times 10^{-19}}{2.00 \times 10^{-3}} \text{ (subs. (1))}$ $= -7.19 \times 10^{-7} \text{ [V] (1)}$ <p>(c)</p> <p>Use of $W = q\Delta V$ (1) $= (-1.60 \times 10^{-19})(-1.20 \times 10^{-6} - (-7.19 \times 10^{-7}))$ $= 7.70 \times 10^{-26} \text{ [J] (1)}$</p> <p>(d)</p> $F_C = \frac{1}{4\pi\epsilon_0} \frac{q^2}{r^2} = \frac{1}{4\pi(8.85 \times 10^{-12})} \frac{(1.60 \times 10^{-19})^2}{(1.20 \times 10^{-3})^2}$ $= 1.60 \times 10^{-22} \text{ [N]}$ $F_G = G \frac{m^2}{r^2} = (6.67 \times 10^{-11}) \frac{(9.11 \times 10^{-31})^2}{(1.20 \times 10^{-3})^2} = 3.84 \times 10^{-65} \text{ [N]}$ <p>Both F_C and F_G (1) (or by implication)</p> <p>Gravitational force much less [by factor $\sim \frac{3.84 \times 10^{-65}}{1.60 \times 10^{-22}} = 2.40 \times 10^{-43}$] (or equivalent quantitative comparison or qualitative comparison such as much larger, much smaller) (1)</p> <p>Electrostatic force repels. Gravitational force attracts. (1) Both need to be mentioned for comparison (or equivalent statement).</p> <p>Question 6 Total</p>	<p>2</p> <p>2</p> <p>2</p> <p>3</p> <p>[9]</p>

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

PH5

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 M Ω	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]

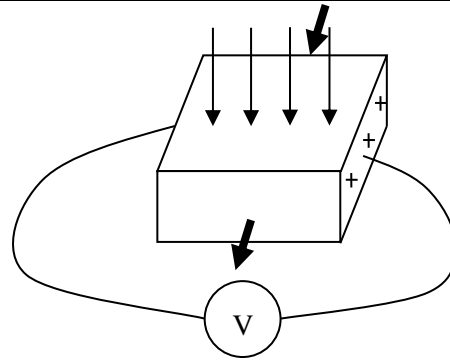
Question		Marking details	Marks Available
2	(a)	(i) 0	1
		(ii) $\varphi = B \times l^2(1)$ Answer = 4.32×10^{-5} [Wb] (1)	2
	(b)	Change in flux or Faraday's law gives emf (1) Complete circuit or accept emf gives current (1) Award 1 mark only for: Current due to Faraday's law	2
	(c)	Force / current / 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) $A = \pi \frac{d^2}{4}$ <i>or</i> $\pi \times 3^2 (\times 10^{-6})$ 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)	<p>Low A numbers do fusion (or arrow / label used) (1)</p> <p>High A numbers do fission (or arrow / label used) (1)</p> <p>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)</p> <p>Higher BE/nucleon is more stable (or low PE/nucleon more stable or more work done more stable) (1)</p>	4
	(b)	<p>1.1 ± 0.1 MeV identified from graph for ${}^2_1\text{H}$ (1)</p> <p>$\times 2 = 2.2$ [MeV] ecf (1)</p>	2
	(c)	<p>$7.6 \pm 0.2, 8.4 \pm 0.2, 8.7 \pm 0.2$ (1)</p> <p>Correct multipliers for each i.e. $235 \times 7.6, 137 \times 8.4, 96 \times 8.7$ (1)</p> <p>RHS – LHS or reverse (1)</p> <p>Correct answer e.g. 201 MeV UNIT mark (1) [dependent on BE/A approximations]</p>	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 of <u>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)	$n = \frac{12\,000}{1.8} (1)$ $B = \mu_0 nI = 0.019 \text{ [T]} (1)$	2
	(b)	(i) <p>Either $Bev = \frac{mv^2}{r}$ or $Bev = m\omega^2 r$ (1)</p> <p>$v = \omega r$ and $\omega = 2\pi f$ quoted (1)</p> <p>Clear algebra (if not immediately understandable then not clear) (1)</p>	3
		(ii) $f = \frac{3.3 \times 6 \times 1.6 \times 10^{-19}}{2\pi \times 12 \times 1.66 \times 10^{-27}} (1)$ <p>Answer = 25.3×10^6 [Hz] (1)</p>	2
		(iii) <p>$6e \times 14.5 \text{ kV} \times 24 [= 2.09 \text{ MeV}] (1)$</p> <p>Conversion to J i.e. look out for $\times 1.6 \times 10^{-19}$ (1)</p> <p>Equating some related energy to $\frac{1}{2}mv^2$ e.g. $\frac{1}{2}mv^2 = 14\,500$ (1)</p> <p>Answer = 5.8×10^6 [m s^{-1}] (1)</p> <p>(ecf on these values only 2.4×10^6 and 4.1×10^6 which correspond to $q = 1e$ and 12 kicks respectively)</p>	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]



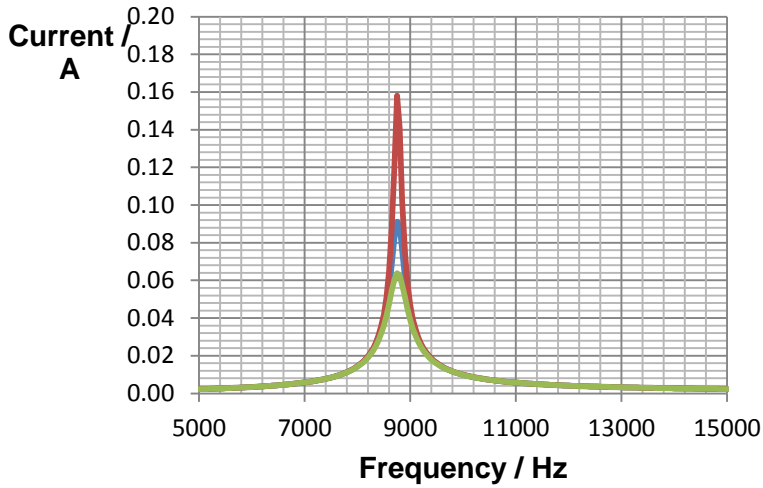
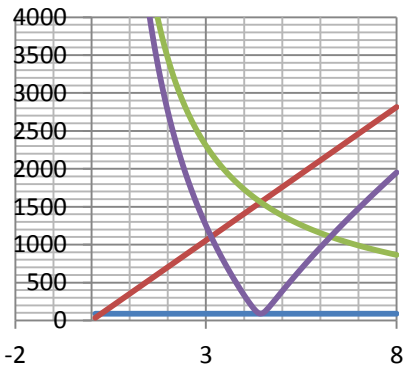
SECTION B

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

Question		Marking details	Marks Available
	(f)	$\Delta p = 6.8 \times 10^5 \text{ [Pa]} \text{ (1)}$ $u = \sqrt{\frac{2 \times 6.8 \times 10^5}{1000}} = 36.9 \text{ [m s}^{-1}\text{]} \text{ (1)}$	2
	(g)	<p>mg - weight or gravitational force and $0.0107v^2$ - air resistance / drag accept <u>skin</u> / <u>air</u> friction (1)</p> <p>Weight decreases (1)</p> <p>Air resistance increases (1)</p>	3
	(h)	<p>Squaring equation 6 or rearranging equation 5 (1)</p> <p>Convincing algebra (1)</p>	2
	(i)	<p>I Fast process or no time for heat to flow or equivalent</p> <p>II The gas does <u>work</u> so <u>internal energy</u> decreases</p> <p>Or $\Delta U = -W$</p>	1 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) $= \frac{1}{2\pi\sqrt{0.022 \times 15 \times 10^{-9}}}$ or $f = \frac{1}{2\pi\sqrt{0.022 \times 90 \times 10^{-9}}}$ (1) 8 761 [Hz] and 3 577 [Hz] (1)	3
		(ii) $Q = \frac{2\pi fL}{R}$ 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)	<p>(i)</p>  <p>Shapes similar and asymptotic to original (1)</p> <p>20 Ω with higher peak and 50 Ω with lower (implied if not labelled) (1)</p> <p>20 Ω with peak current of 160 mA (1)</p> <p>50 Ω with peak current of 64 mA (1)</p> <p>(ii)</p> <p>ωL increases (wrt f) or graph (1)</p> <p>$\frac{1}{\omega C}$ decreases (wrt f) (1)</p> <p>low frequency behaviour explained e.g. X_C very large, Z large at low freq (1)</p>  <p>high frequency behaviour explained e.g. X_L very large, Z large at high freq (1)</p> <p>$\omega L - \frac{1}{\omega C} = 0$ at resonance making Z a minimum (1)</p> <p>$I \propto \frac{1}{Z}$ or equivalent equation etc. (1)</p> <p>Question 8 Total</p>	<p>4</p> <p>6</p> <p>[20]</p>

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) $(\frac{1}{2})r_Pv_P\Delta t = (\frac{1}{2})r_Av_A\Delta t$ 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 <i>mechanism</i> • Newton didn't say what <i>caused</i> 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. $\frac{800 \times 10^6}{0.01}$ seen.	1
		(ii)	Area under graph = [$\frac{1}{2} \times 0.01 \times 800 \times 10^6 + \frac{1}{2} \times 0.08 \times 100 \times 10^6 + 0.08 \times 800 \times 10^6$] = 72 [MJ m ⁻³] (1) Volume = $\pi \times (1.25 \times 10^{-3})^2 \times 2.5 = 12.3 \times 10^{-6}$ [m ³] (1) Work done = $72 \times 10^6 \times 12.3 \times 10^{-6} = 884$ [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		

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)	2
		$6.2 \times 10^4 \text{ V}$ (must have valid unit) (1)	
	(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) $v = 0.6 [\text{m s}^{-1}]$ 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)	<p>Any 3 of:</p> <p>More than one isotope of uranium</p> <p>Only U-235 fissile / U-238 unsuitable for fission</p> <p>Need higher concentration of U-235</p> <p>Get rid of U-238 since neutron absorber/'sink'</p>	3
	(b)	<p>More fissile nuclei obtained (1)</p> <p>U-238 captures neutrons or decays to plutonium 239 via beta (1)</p>	2
	(c)	<p>Any 2 of:</p> <p>More easily controllable or no chain reaction</p> <p>Hydrogen & deuterium more plentiful / more easily sourced / can be extracted from sea water</p> <p>No [long term] radioactive products.</p> <p>More energy released per fusion</p>	2
	(d)	<p>(i) Overcome electrostatic repulsion /forces (1)</p> <p>Needs high / enough (K)E (or velocity, speed) of deuterium/tritium (1)</p> <p><u>KE proportional to temperature</u> or only tail end of distribution (1) with high enough energy</p>	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 = $1.35 \times 10^{-6} [\text{kg m}^{-3}] (1)$	3
	(e)	$9 \times 10^{16} (1)$ $\times 2 = 18 \times 10^{16} [\text{J}] (1)$	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)	5
		NOTE: No marks for cheap/expensive - eliminated in stem!!	
		Question 12 Total	[20]



GCE A level

1326/01-E

**PHYSICS – PH6
Data Analysis Task
MARKING SCHEME
2015**

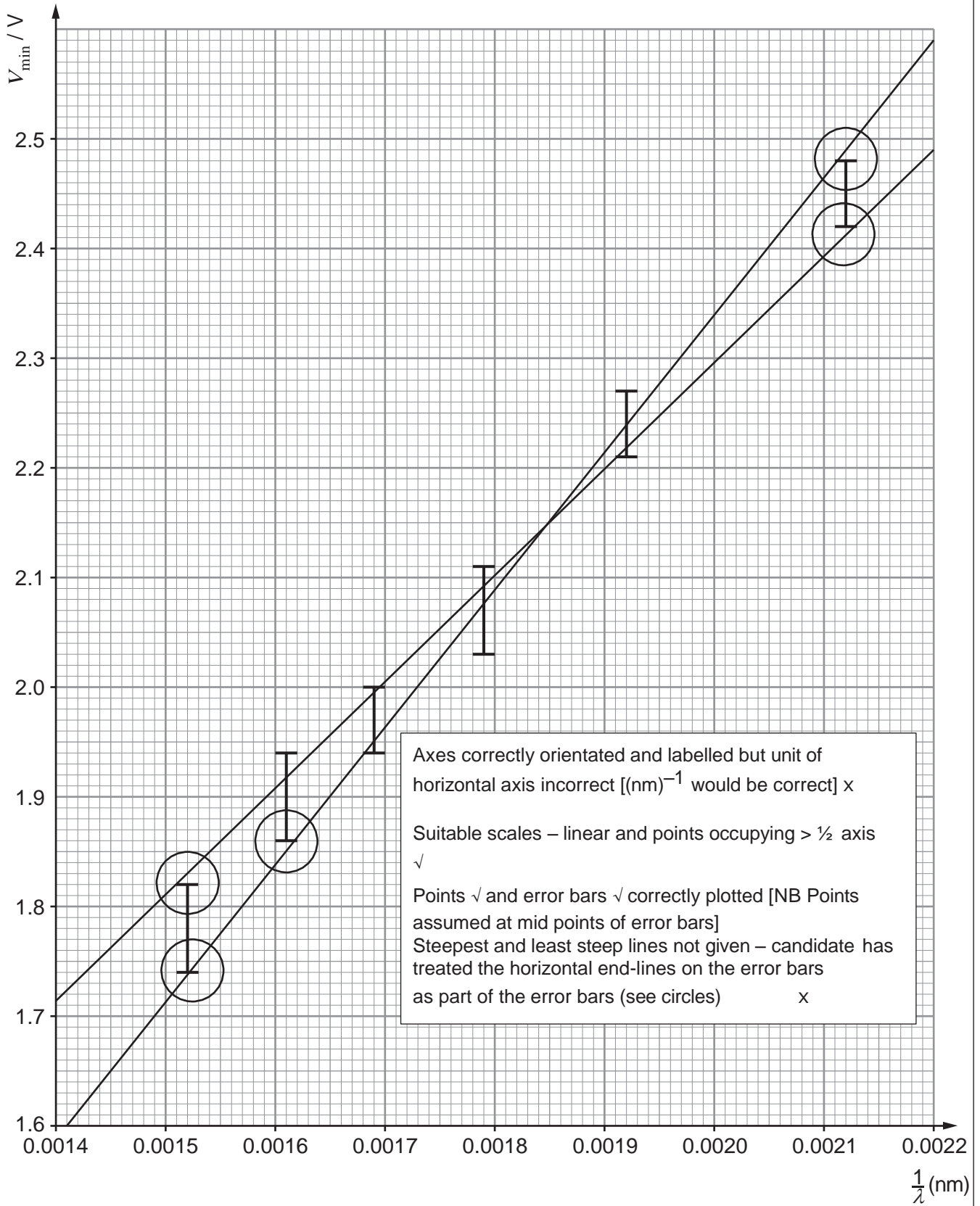


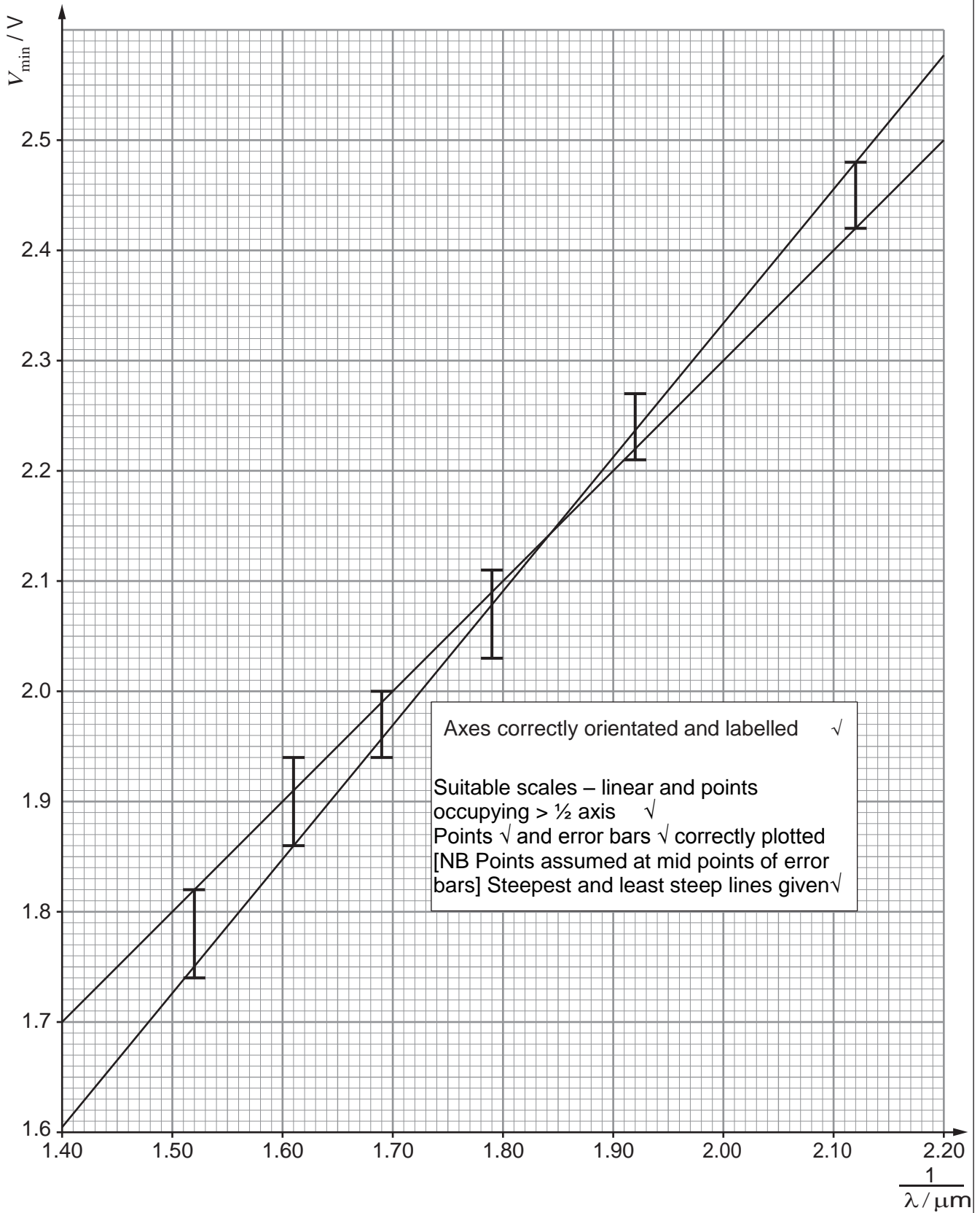
S15-1326-01E

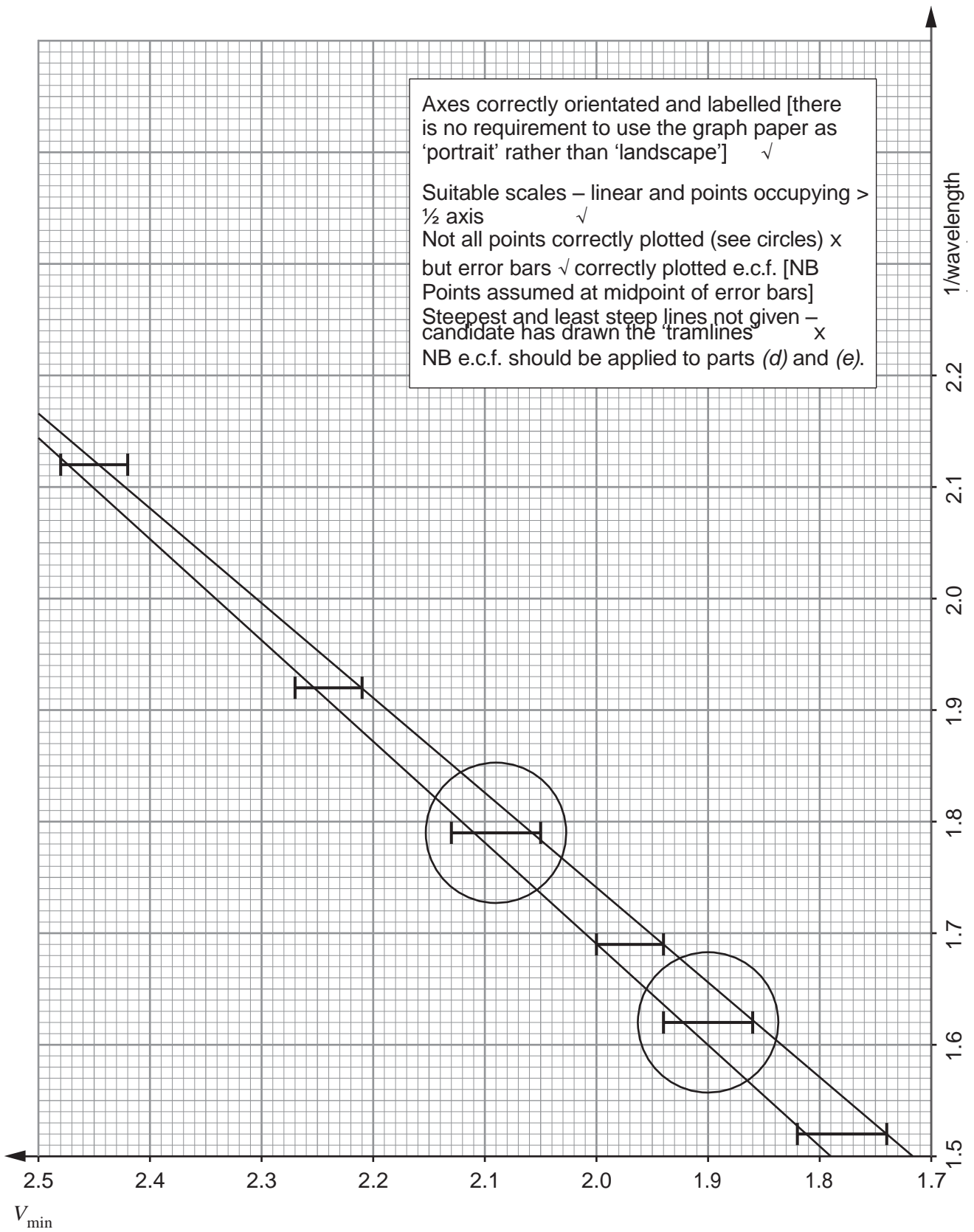
DATA ANALYSIS TASK – Mark Scheme

Question	Marking details	Marks Available																																																				
(a) (b)	<p>Correct circuit diagram including voltmeter, switch and resistor with all the correct symbols given</p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th rowspan="2">Wavelength λ (nm)</th> <th rowspan="2">$\frac{1}{\lambda}$ (μm)⁻¹</th> <th colspan="3">Minimum voltage V_{min} (V)</th> <th rowspan="2">Mean V_{min} (V)</th> <th rowspan="2">Absolute uncertainty V_{min} (V)</th> </tr> <tr> <th>1</th> <th>2</th> <th>3</th> </tr> </thead> <tbody> <tr><td>470</td><td>2.13</td><td>2.48</td><td>2.45</td><td>2.42</td><td>2.45</td><td>0.03</td></tr> <tr><td>520</td><td>1.92</td><td>2.21</td><td>2.25</td><td>2.27</td><td>2.24</td><td>0.03</td></tr> <tr><td>560</td><td>1.79</td><td>2.06</td><td>2.11</td><td>2.03</td><td>2.07</td><td>0.04</td></tr> <tr><td>590</td><td>1.69</td><td>2.00</td><td>1.94</td><td>1.97</td><td>1.97</td><td>0.03</td></tr> <tr><td>620</td><td>1.61</td><td>1.86</td><td>1.89</td><td>1.94</td><td>1.90</td><td>0.04</td></tr> <tr><td>660</td><td>1.52</td><td>1.74</td><td>1.78</td><td>1.82</td><td>1.78</td><td>0.04</td></tr> </tbody> </table>	Wavelength λ (nm)	$\frac{1}{\lambda}$ (μm) ⁻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	1
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(i)	<p>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 $\frac{1}{\lambda} / \mu\text{m}^{-1}$ [accept (μm^{-1})]. (1)</p> <p>Alternatively $\frac{1}{\lambda/\text{nm}}$, $\frac{1}{\lambda} / \text{nm}^{-1}$, $\frac{1}{\lambda/10^{-9}\text{m}}$, $\frac{1}{\lambda} / 10^9\text{m}^{-1}$, $\frac{1}{\lambda} / (10^{-9}\text{m})^{-1}$ $\frac{1}{\lambda/10^{-6}\text{m}}$, $\frac{1}{\lambda} / 10^6\text{m}^{-1}$, $\frac{1}{\lambda} / (10^{-6}\text{m})^{-1}$ (1)</p> <p>[Note: the mark given for a correctly expressed unit consistent with the values given.]</p>	2																																																				
(ii)	<p>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)</p>	2																																																				
(c)	<p>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 $\frac{1}{2}$ of each axis and not involving awkward factors, e.g. 3. (1) All points plotted correctly to within $\pm \frac{1}{2}$ 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.</p>	5																																																				

Question		Marking details	Marks Available
(d)	(i)	<p>There are no marks for the answer yes or no – the marks are for the discussion.</p> <ul style="list-style-type: none"> 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)	<p>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)</p> <p>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)</p> <p>ecf allowed for incorrect max/min lines / ignore errors of powers of 10</p> <p>Example of clear implication [from 3rd graph – on page 44]</p> $\text{Max gradient} = \frac{2.575 - 1.605}{2.20 - 1.40} = 1.213 \text{ [V } \mu\text{m]}$ $\text{Min gradient} = \frac{2.499 - 1.712}{2.20 - 1.40} = 0.984 \text{ [V } \mu\text{m]}$ <p>Note: the values of both gradients are $\sim 1 \times 10^{-6}$ [V m]. If $\frac{1}{\lambda}$ is expressed in nm^{-1} the numerical values of the gradient will be $\sim 1 \times 10^3$</p>	3
	(iii)	<p>Mean gradient calculated correctly [the expected answer from examples in (ii) is $\sim 1.10 \times 10^{-6}$] allow ecf from (ii). (1)</p> <p>Absolute uncertainty calculated (1) [can be inferred from correct value of percentage uncertainty] [the expected answer is 0.1×10^{-6}]</p> <p>Percentage uncertainty calculated correctly (1) [expected answer from examples in (ii) is $\sim 10\%$] ecf Allow 1 or 2 sig figs</p>	3
	(iv)	<p>h calculated correctly with a valid unit [expected value $5.9(4) \times 10^{-34}$ J s] using the gradient (1) no sig fig penalty</p> <p>Absolute uncertainty calculated correctly [expected value $\sim 0.7 \times 10^{-34}$ J s] and written with the value of h, e.g. $(5.9 \pm 0.7) \times 10^{-34}$ [J s] or $(5.94 \pm 0.66) 10^{-34}$ [J s] ecf (1)</p>	2
	(v)	<p>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)</p> <p>Note: the reasoning must be valid and clearly expressed.</p> <p>Percentage difference between the given value of h and the result in (iv) calculated correctly [expected answer $\sim 11\%$] or 5% of the given value of h calculated [0.3×10^{-34} J s] (1)</p>	2
(e)	(i)	$V_{\text{min}} = 1.11 \text{ V}$ 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]







EXPERIMENTAL TASK - MARK SCHEME

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) <i>All of the above points cannot be awarded from the table they must be stated in the plan.</i>	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 $\pm \frac{1}{2}$ 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: <ul style="list-style-type: none"> • 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) Question total	3
Question total		[25]



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