Mark Scheme (Results)

Summer 2024

Pearson Edexcel Advanced Level
In Physics (9PH0)
Paper 03: Advanced Physics III

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Summer 2024
Question Paper Log Number P74470A
Publications Code 9PH0_03_2406_MS

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Question Number	Acceptable Answer		Additional Guidance	Mark
1(a)	• Positions of mass holder not recorded • Data not recorded to the same sf/dp	(1) (1)	Accept reference to not all raw data being recorded/shown	2
1(b)	**MAX 3 from:** • Read the metre rule at eye level (to avoid parallax) • Bring the metre rule closer (to avoid parallax) • Use set square to read position of bottom of mass holder • Use plumb line to check that metre rule is vertical • Record positions of mass holder when loading and unloading and calculate mean value	 (1) (1) (1) (1) (1)	A labelled diagram could score MP3 and MP4 Accept valid alternatives to set square e.g. reference to marker on mass holder **or** add marker to line and position metre rule underneath line Accept valid alternatives to plumb line Accept repeat readings of position and calculate a mean	3
1(c)(i)	• The value of stress at which the fishing line starts to deform permanently/plastically **Or** the value of stress at which the fishing line continues to extend with no additional force	(1)	Accept point / strain for "value of stress" Accept line doesn't return to original length when force is removed	1
1(c)(ii)	• Use of $\varepsilon = \frac{\Delta x}{x}$ • (Maximum) extension (before yielding) is 8 cm, so line doesn't yield **Or** strain (at max extension) = 0.036, so line doesn't yield	(1) (1)	Example of calculation $\Delta x = 0.04 \times 2.0\ \text{m} = 0.08\ \text{m}$	2

(Total for Question 1 = 8 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
2(a)(i)	• Use of $V = \pi r^2 t$ **(1)** • Use of half resolution to calculate % uncertainty in d **(1)** • % uncertainty in area = 2 × (% uncertainty in d) **(1)** • Calculation of % uncertainty in t **(1)** • % uncertainty in t added to % uncertainty in area **(1)** • $V = 5.94 \times 10^{-7}\text{m}^3$ **(1)** • $\%\ U = 0.4\ \%$ **(1)**	Allow MP4 for use of full resolution if MP2 was withheld for not using half resolution Example of calculation $V = \pi\left(\frac{22.16 \times 10^{-3}\text{m}}{2}\right)^2 \times 1.54 \times 10^{-3}\text{m}$ $\therefore V = 5.94 \times 10^{-7}\text{m}^3$ $\%\ U = \left(2 \times \frac{0.005\ \text{mm}}{22.16\ \text{mm}} + \frac{0.005\ \text{mm}}{1.54\ \text{mm}}\right) \times 100\%$ $\%\ U = 0.36\ \%$	**7**

2(a)(ii)	**EITHER** • Use of $\rho = \frac{m}{V}$ (allow use of V from (a)(i)) **(1)** • Calculation of % U in ρ • Max density = 1.9×10^4 kg m^{-3} (ecf from (a)(i)) • 1.9×10^4 kg m^{-3} < 1.93×10^4 kg m^{-3} so coin not pure gold **(1)** **Or** comparison of calculated value of max density with density of gold and consistent conclusion **(1)** **OR** • Use of $\rho = \frac{m}{V}$ to calculate mass of pure gold coin **(1)** • Mass of pure gold coin = 11.5 g (ecf from (a)(i)) **(1)** • Use of half resolution to calculate max mass of coin being tested **(1)** • 11.25 g < 11.5 g, so coin is not pure gold **Or** comparison of maximum value of mass of coin with mass pure gold coin and consistent conclusion. **(1)** **OR** • Use of $\rho = \frac{m}{V}$ to calculate volume of a pure gold coin with mass 11.2g **(1)** • Use of half resolution to calculate % U in mass (0.05/11.2 × 100% = 0.44 %), and hence calculated volume **(1)** • Find the *smallest* volume possible within uncertainty from part (i) **(1)** • 5.83 x 10^{-7} m^3 < 5.91 x 10^{-7} m^3 , so coin not pure gold **Or** comparison of minimum value of volume of coin from part i with maximum volume of pure gold coin and consistent conclusion. **(1)**	For MP2, allow use of resolution if use of half resolution has already been penalised in (a)(i) Allow a conclusion that states the values are similar so it might be gold MP4, allow "density of pure gold" for 1.93×10^4 kg m^{-3} For MP3, allow use of resolution if use of half resolution has already been penalised in (a)(i) MP4: allow "density of pure gold" for 1.93×10^4 kg m^{-3} <u>Example of calculation</u> $\rho = \frac{m}{V} = \frac{11.2 \times 10^{-3}\text{kg}}{5.94 \times 10^{-7}\text{m}^3} = 1.89 \times 10^4$ kg m^{-3} $\%\ U = \frac{0.05\ g}{11.2\ g} \times 100\% + 0.36\% = 0.81\ \%$ $\therefore$ range $= \pm 1.89 \times 10^4$ kg $\times 0.008 = \pm 152$ kg m^{-3} $\therefore$ max density $= 18900 + 150 = 19050$ kg m^{-3}	**4**

2(b)	**MAX 4** • Measure thickness of a stack of coins **Or** measure the mass of a stack of coins • (Uncertainty remains the same, so) % U is reduced [MP2 dependent on MP1 • Determine diameter/mass/thickness by repeating measurement and calculating a mean • This reduces the effect of random errors • Check and correct for zero error on calipers or balance • This reduced the effect of systematic error	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	MP1 accept measuring a number of coins side by side MP1 accept using a balance with a higher resolution MP2 as this would reduce the uncertainty MP4 dependent on MP3 MP6 dependent on MP5	**4**

(Total for Question 2 = 15 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*3</td>
<td>This question assesses a student's ability to show a coherent and logical structured answer with linkage and fully-sustained reasoning.

Indicative content:

IC1 Before closing S2, bulb 1 and bulb 2 have the same p.d./current so both bulbs have equal brightness

IC2 Closing switch S2 allows current to flow in bulb 3 Or Closing switch S2 places the same p.d. across bulb 3 as bulb 1.

IC3 Bulb 1 and bulb 3 are in parallel, so the resistance of the combination decreases

IC4 The p.d. across bulb 1 (and bulb 3) decreases Or The p.d. across bulb 2 increases

IC5 The current in circuit/bulb 2 increases so the brightness/power of bulb 2 increases Or current in bulb 1 decreases so the brightness/ power of bulb 1 decreases Or $P = \frac{V^2}{R}$, so power of bulb 2 increases [power of bulb 1 decreases]

IC6 (When S2 closed) bulb 1 is not as bright as bulb 2.</td>
<td>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.
The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>

<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>

Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning

<table>
<tr><th>IC points</th><th>IC mark</th><th>Max linkage mark</th><th>Max final mark</th></tr>
<tr><td>6</td><td>4</td><td>2</td><td>6</td></tr>
<tr><td>5</td><td>3</td><td>2</td><td>5</td></tr>
<tr><td>4</td><td>3</td><td>1</td><td>4</td></tr>
<tr><td>3</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>2</td><td>2</td><td>0</td><td>2</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>
</td>
<td>6</td>
</tr>
</table>

(Total for Question 3 = 6 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
4(a)	• Use of $V = \frac{4}{3}\pi r^3$ **(1)** • Use of $pV = NkT$ **(1)** • Temperature conversion to kelvin **(1)** • Use of $m = \frac{N}{6.02\times10^{23}} \times 4.00 \times 10^{-3}$ kg **(1)** • $m = 9.46 \times 10^{-3}$ kg **(1)**	Allow MP2 if temperature not converted to K Example of calculation $V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi \times (4.36 \times 10^{-2}\ m)^3 = 3.47 \times 10^{-4}\ m^3$ $N = \frac{pV}{kT} = \frac{1.65 \times 10^7 \text{ Pa} \times 3.47 \times 10^{-4} \text{ m}^3}{1.38 \times 10^{-23} \text{ J K}^{-1} \times (18.5 + 273) \text{ K}}$ $\therefore N = 1.42 \times 10^{24}$ $m = \frac{1.42 \times 10^{24}}{6.02 \times 10^{23}} \times 4.00 \times 10^{-3} \text{ kg} = 9.46 \times 10^{-3} \text{ kg}$	**5**
4(b)	• Upthrust on canister equals weight of air/fluid displaced. **(1)** • Volume of canister stays constant, so upthrust on canister remains constant (and student X is incorrect) **(1)** • Mass of helium gas (in canister) decreases **(1)** • Hence the weight will decrease (as helium is released) and student Y is correct **(1)**		**4**

(Total for Question 4 = 9 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
5(a)	• Time a number of (complete) oscillations calculate a mean time period **(1)** • This reduces the effect of random error (dependent on MP1) **(1)** • Allow oscillation to settle before starting to time. **(1)** • Use a (fiducial) marker (so easier to see when trolley passes a point) **(1)** • Use the mid-point of the oscillation (for timing), **(1)** • Trolley is travelling fastest at mid-point, so effect of reaction time is reduced. **(1)**	Accept description of how to determine a mean – don't need to see the word "mean" Accept reaction time for random error, also accept reference to reducing percentage uncertainty Accept equilibrium/undisplaced position For MP6 allow use a datalogger to eliminate effect of reaction time [not dependent upon MP5]	**6**
5(b)	• Substitutes into equation for mass on spring to give $T = 2\pi\sqrt{\frac{M+m}{k}}$ **(1)** • $T^2 = \frac{4\pi^2}{k}m + \frac{4\pi^2 M}{k}$ **(1)** • Identify gradient as $4\pi^2/k$ (and calculate a value for k) **(1)** • Identify y-intercept as $4\pi^2 M/k$ (and calculate a value for M) **(1)**		**4**

(Total for Question 5 = 10 marks)

Question Number	Acceptable Answer		Additional Guidance	Mark
6(a)	• There are nodes and antinodes on the plate	**(1)**	Allow "points with minimum/zero amplitude" for "nodes" and "points with maximum amplitude" for "antinodes" Accept "displacement" for "amplitude"	**3**
	• Sand is displaced away from the antinodes	**(1)**		
	• Sand collected/gathers at the nodes	**(1)**		
6(b)	• 1 full cycle read from oscilloscope trace 4.5 → 4.7 div	**(1)**	Example of calculation $T = 4.6 \text{ div} \times 0.5 \text{ ms div}^{-1} = 2.3 \text{ ms}$ $f = \frac{1}{2.3 \times 10^{-3} \text{ s}} = 435 \text{ Hz}$ $v = 435 \text{ s}^{-1} \times 0.32 \text{ m} = 139 \text{ m s}^{-1}$	**5**
	• Converts from div to s	**(1)**		
	• Use of $f = 1/T$	**(1)**		
	• Use of $v = f\lambda$	**(1)**		
	• v = 140 m s^{-1}, which is (much) less than 340 m s^{-1}	**(1)**	Allow "the speed of sound in air" for 340 m s^{-1}	
6(c)	**EITHER**			**3**
	• Plot a graph of L against $1/f$	**(1)**	Allow Plot a graph of L against $1/f$	
	• $L = \lambda/4$	**(1)**		
	• $L = \frac{v}{4f}$, so speed of sound = 4 × gradient	**(1)**	$v = \frac{4}{\text{gradient}}$	
	OR			
	• (Calculate λ using) $\lambda = 4L$	**(1)**		
	• Plot a graph of λ against $1/f$	**(1)**	Allow Plot a graph of f against $1/\lambda$	
	• Speed of sound = gradient	**(1)**		

(Total for Question 6 = 11 marks)

Question Number	Acceptable Answer		Additional Guidance	Mark
7(a)	• Top line correct • Bottom line correct	(1) (1)	$^{220}_{86}\text{Rn} \rightarrow {}^{216}_{84}\text{Po} + {}^{4}_{2}\alpha$	2
7(b)	• Radon gas can be breathed in and can cause damage to living cells **Or** Once radon is inside the body the alpha particles/radiation can cause damage to living cells • Because alpha (particles) highly ionising	(1) (1)	Accept the idea of damage e.g. causing mutations/cancer etc. Must have stated that this happens inside the body	2
7(c)(i)	• The alpha particles ionise the air (inside the chamber) • This produces (moving) electrons inside the chamber	(1) (1)	If no other marks scored, allow MAX 1 for alpha particles are charged and attracted to (negative) electrode and current produced	2
7(c)(ii)	• Use of $\lambda = \frac{ln2}{t_{1/2}}$ • Use of $A = A_0 e^{-\lambda t}$ • % activity remaining = 0.4 % (<1%), so claim is correct **Or** time to decay to 1% = 370 s (<450 s), so claim is correct	(1) (1) (1)	Allow application of constant ratio rule Example of calculation $\lambda = \frac{\ln 2}{55.6\ \text{s}} = 0.0125\ \text{s}^{-1}$ $\%\ \text{activity remaining} = 100\text{e}^{-0.0125\ \text{s}^{-1} \times 450\ \text{s}} = 0.37$	3

(Total for Question 7 = 9 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*8(a)</td>
<td>This question assesses a student's ability to show a coherent and logical structured answer with linkage and fully-sustained reasoning.

Indicative content:
IC1 Elastic P.E. (of the spring) is transferred to K.E. of the modelling clay

IC2 Clay has momentum before hitting the bob

IC3 Momentum is conserved when clay hits the bob

IC4 K.E. is transferred from the clay to the bob

IC5 Collision is inelastic
Or K.E. is not conserved
Or In the collision (some) energy is transferred to thermal energy

IC6 At the maximum height/displacement of the bob all the K.E. (after the collision) has been transferred to gravitational P.E.</td>
<td>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.
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<tr><td>3</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>2</td><td>2</td><td>0</td><td>2</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>
(Accept responses in terms of energy stores model)</td>
<td>6</td>
</tr>
</table>

8(b)(i)	• Use of $T = 2\pi\sqrt{\frac{l}{g}}$ **(1)** • Time to reach maximum height = $T/4$ **(1)** • Time to reach maximum height = 0.56 (s) **(1)**	Example of calculation $T = 2\pi\sqrt{\frac{1.25\text{ m}}{9.81\text{ m s}^{-2}}} = 2.24\text{ s}$ $t = \frac{T}{4} = \frac{2.24\text{ s}}{4} = 0.56\text{ s}$	**3**
8(b)(ii)	• Use of $T = 2\pi\sqrt{\frac{m}{k}}$ **(1)** • m = 0.015 kg (ecf from (b)(i)) **(1)** [show that value gives 0.018 kg]	Example of calculation $2.24\text{ s} = 2\pi\sqrt{\frac{m}{0.12\text{ N m}^{-1}}}$ $\therefore m = \left(\frac{2.24\text{ s}}{2\pi}\right)^2 \times 0.12\text{ N m}^{-1} = 0.0153\text{ kg}$	**2**

(Total for Question 8 = 11 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
9(a)(i)	**MAX 3** • Intensity of light varies as an inverse square law **Or** reference to $I = \frac{P}{4\pi d^2}$ **(1)** • the light intensity would not increase uniformly (decreasing the distance as suggested) **(1)** • The student should decrease the distance at decreasing intervals **(1)** • The student should use a greater range (of distances, as lamp is not a point source of light) **(1)**		**3**
9(a)(ii)	An explanation that makes reference to the following points: **EITHER** • Carry out experiment under subdued lighting **(1)** • As the ambient lighting will increase the ammeter reading [dependent upon MP1] **(1)** **OR** • Take readings at eye level **(1)** • As this will reduce parallax error [dependent upon MP3] **(1)** **OR** • Take multiple readings of intensity and calculate a mean **(1)** • As this will reduce the effect of <u>random</u> error [dependent upon MP5] **(1)**	Allow: Keep the intensity of the lamp constant **Or** Keep angle of lamp constant As this would change the ammeter reading [dependent upon MP1	**2**

9(b)	An explanation that makes reference to the following points: • <u>Photons</u> incident upon LDR promoted electrons into conduction band **Or** <u>photons</u> incident upon LDR released conduction electrons **(1)** • Number of free electrons (per unit volume) increases **(1)** • Current $I = nqvA$ so the current increases **Or** $I \propto n$ so the current increases **(1)**	If no other marks scored, allow MAX 1 for resistance decreases and so current increases. Accept "charge carriers" for "free electrons"	**3**

(Total for Question 9 = 8 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
10(a)	• Use of $a = (-)\omega^2 x$ **(1)** • Use of $v = \omega A \sin \omega t$ **(1)** • v_{max} = 0.44 m s^{-1}, so it is safe to oscillate at this amplitude **(1)**	No need to see 0.44 m s^{-1} < 0.5 m s^{-1}, as conclusion includes credit for the correct value of v. Example of calculation $\omega = \sqrt{\frac{20.0 \text{ cm s}^{-2}}{5.0 \text{ cm}}} = 2.0 \text{ s}^{-1}$ $v_{max} = 2.0 \text{ s}^{-1} \times 0.22 \text{ m} = 0.44 \text{ m s}^{-1}$	**3**
10(b)	An explanation that makes reference to the following points: • The (pushing) frequency must match the natural frequency **(1)** • The time period of oscillation increases, as $T = 2\pi\sqrt{\frac{m}{k}}$ **(1)** • So the frequency of pushing must decrease [dependent upon MP2] **(1)**		**3**

(Total for Question 10 = 6 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
11(a)	An explanation that makes reference to the following points: • When S is at end X, V is zero **Or** When S is at end Y, V equals supply (terminal) p.d. **(1)** • The resistance (between X and S) is proportional to the length XS **Or** As S is moved towards Y the supply p.d. is divided in proportion to the resistance to the left and right of S **(1)** • V increases as the slider moves from X to Y **(1)**	If both versions of MP1 given, then give MP3 too.	**3**
11(b)	An explanation that makes reference to the following points: • (As V increases) I increases, so the temperature of the filament increases **(1)** • So the resistance of the filament increases (so the increase in current per unit increase in p.d. decreases) **(1)**	Allow filament heats up for "temperature of filament increases"	**2**
11(c)(i)	An explanation that makes reference to the following points: • Shows expansion $\log(T) = \mathrm{b}\log V + \log a$ **(1)** • Compares with $y = mx + c$ and states/indicates that the gradient is b (which is a constant) **(1)**		**2**

<table>
<tr>
<td>11(c)(ii)</td>
<td>
• Log values correct and to 2 or 3 decimal places (1)
[Allow either a consistent number of d.p. or s.f. in values for logV]

• Labels and unit (1)
[check correct representation of units on graph]

• Scales (1)
[Must not be an awkward scale, points must be spread over at least half the graph grid]

• Plots (1)
[check the 2 points furthest from the line, if all points on line check any 2 points]

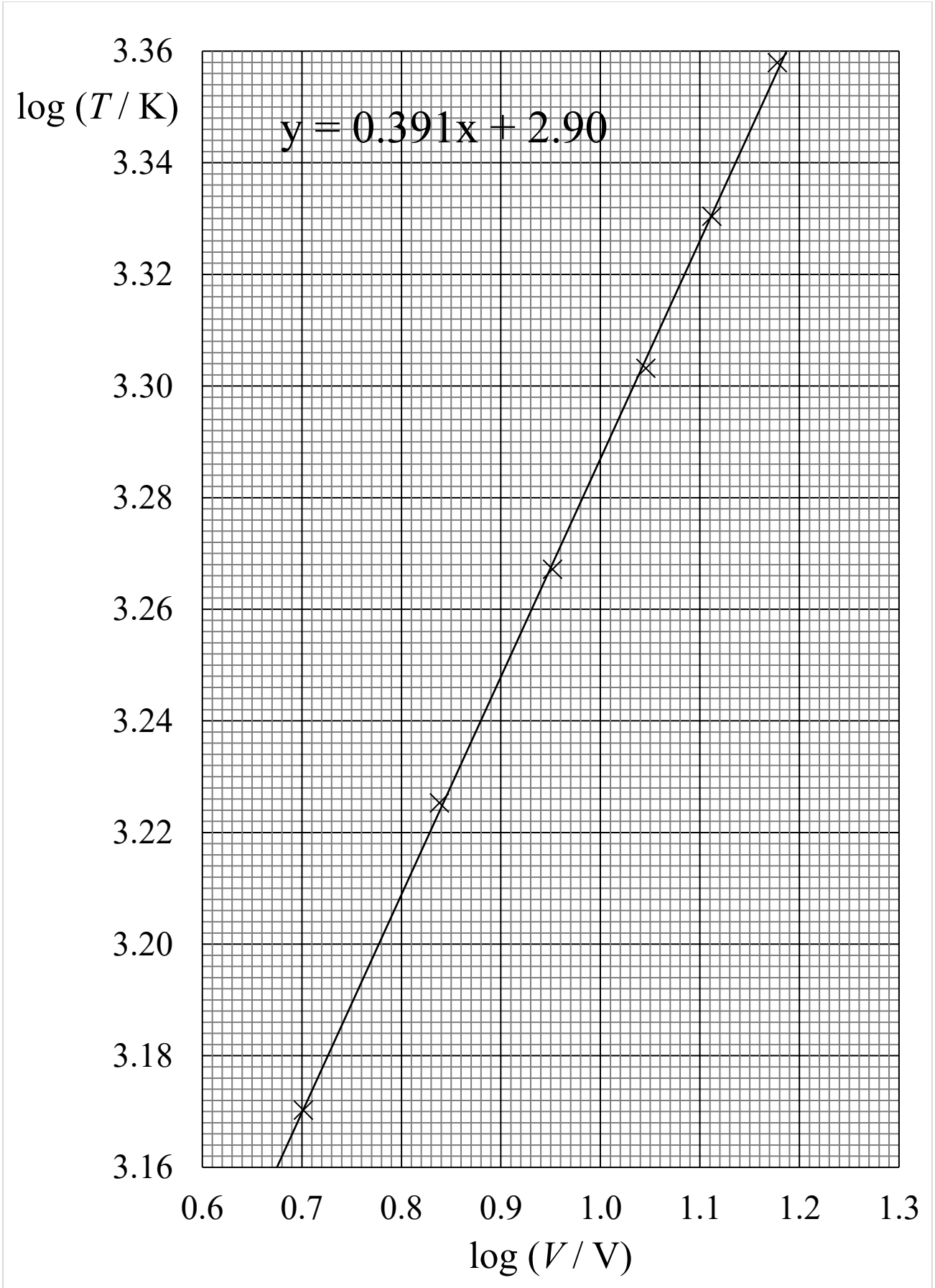
• Line of best fit (1)
[If not all points on line, look for balanced spread of points above and below line]
</td>
<td>
<table>
<tr><th>V / V</th><th>T / K</th><th>log (V / V)</th><th>log (T / K)</th></tr>
<tr><td>5.03</td><td>1480</td><td>0.702</td><td>3.170</td></tr>
<tr><td>6.89</td><td>1680</td><td>0.838</td><td>3.225</td></tr>
<tr><td>8.95</td><td>1850</td><td>0.952</td><td>3.267</td></tr>
<tr><td>11.11</td><td>2010</td><td>1.046</td><td>3.303</td></tr>
<tr><td>12.94</td><td>2140</td><td>1.112</td><td>3.330</td></tr>
<tr><td>15.06</td><td>2280</td><td>1.178</td><td>3.358</td></tr>
</table>

<table>
<tr><th>V / V</th><th>T / K</th><th>ln (V / V)</th><th>ln (T / K)</th></tr>
<tr><td>5.03</td><td>1480</td><td>1.615</td><td>7.300</td></tr>
<tr><td>6.89</td><td>1680</td><td>1.930</td><td>7.427</td></tr>
<tr><td>8.95</td><td>1850</td><td>2.192</td><td>7.523</td></tr>
<tr><td>11.11</td><td>2010</td><td>2.408</td><td>7.606</td></tr>
<tr><td>12.94</td><td>2140</td><td>2.560</td><td>7.669</td></tr>
<tr><td>15.06</td><td>2280</td><td>2.712</td><td>7.732</td></tr>
</table>
</td>
<td>5</td>
</tr>
<tr>
<td>11(c)(iii)</td>
<td>
• Gradient determined using large triangle (1)

• $b = 0.38 \rightarrow 0.40$ (2 or 3 sf) (1)
</td>
<td>
<u>Example of calculation</u>

$\text{gradient} = \dfrac{3.32 - 3.18}{1.09 - 0.73} = 0.389$
</td>
<td>2</td>
</tr>
</table>

(Total for Question 11 = 14 marks)


y = 0.391x + 2.90
log (T / K)
3.36
3.34
3.32
3.30
3.28
3.26
3.24
3.22
3.20
3.18
3.16
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
log (V / V)

Question Number	Acceptable Answer	Additional Guidance	Mark
12(a)(i)	**EITHER** • Calculation of mean t **(1)** • Use of $s = ut$ **(1)** • Use of $v = \frac{2r^2 g(\rho_B - \rho_C)}{9\eta}$ **(1)** • Cocoa content = 30% **Or** viscosity at 35% = 4.5 (Pa s) **(1)** • Conclusion consistent with their graph value **(1)** **OR** • Viscosity at 35% = 4.5 (Pa s) **(1)** • Use of $v = \frac{2r^2 g(\rho_B - \rho_C)}{9\eta}$ **(1)** • Use of $s = ut$ to calculate time to fall T_{fall} **(1)** • Calculation of mean t **(1)** • Conclusion consistent with calculated value of T_{fall} **(1)**	Example of calculation $t = \frac{(9.6 + 9.9 + 9.6)\ \text{s}}{3} = 9.7\ \text{s}$ $v = \frac{0.225\ \text{m}}{9.7\ \text{s}} = 0.0232\ \text{m s}^{-1}$ $\eta = \frac{2 \times (4.25 \times 10^{-3}\ \text{m})^2 \times 9.81\ \text{m s}^{-2} \times (7750 - 1330)\ \text{kg m}^{-3}}{9 \times 0.0232\ \text{m s}^{-1}}$ η = 10.9 Pa s, so cocoa content is 30% (from graph) Cocoa content is 30% so not consistent **Or** viscosity value is 4.5 Pa s so not consistent Time taken would be 4.0 s so not consistent with mean time	**5**

(Total for Question 12 = 13 marks)

12(a)(ii)	An explanation that makes reference to the following points: **EITHER** • The temperature may not have been constant **(1)** • So the viscosity value would have varied **(1)** **OR** • There may have been reaction time error **Or** There may have been parallax error in reading the distance fallen by the ball **(1)** • So the velocity of the ball may have been inaccurate **(1)** **OR** • There may have been an extra drag force **(1)** • So terminal velocity would have been reduced **(1)**	If no other marks scored then allow MAX 1 for reference to ball not falling at terminal velocity Allow a reference to eddies **Or** turbulent flow	**2**
12(b)	• Use of $\Delta E = mc\Delta\theta$ **(1)** • Use of $\Delta E = mL$ **(1)** • $\Delta E_{\text{total}} = \Delta E_c + \Delta E_L$ **(1)** • Conversion between kcal and J **(1)** • Use of 15% to give 2.2×10^5J **(1)** **Or** energy required = 1% • Conclusion consistent with comparison of calculated values of energy released and 15% of required energy. **(1)**	<u>Example of calculation</u> $\Delta E = 0.065\ \text{kg} \times 3900\ \text{J kg}^{-1}\ \text{K}^{-1} \times (32 - 15)\ \text{K} = 4.31 \times 10^3\ \text{J}$ $\Delta E = 0.065\ \text{kg} \times 1.50 \times 10^5\ \text{J kg}^{-1} = 9.75 \times 10^3\ \text{J}$ Energy to melt chocolate $= (4.31 \times 10^3 + 9.75 \times 10^3)$ J $= 1.41 \times 10^4$ J Energy released from chocolate = 345 × 4200 J $= 1.45 \times 10^6$ J 15% of energy released = $0.15 \times 1.45 \times 10^6$ J = 2.17×10^5J So energy required to melt chocolate is much less than 15% of energy released.	**6**

Total for Paper = 120 marks

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