Pearson Edexcel

Mark Scheme (Results)

June 2019

Pearson Edexcel Advanced Level

In Physics (9PH0)

Paper 03 Advanced Physics III

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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.

Physics Specific Marking Guidance

Underlying principle
The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

1. Mark scheme format

1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the MS has specified specific words that must be present. Such words will be indicated by underlining e.g. 'resonance'

1.2 Bold lower case will be used for emphasis e.g. '**and**' when two pieces of information are needed for 1 mark.

1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".

1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. Unit error penalties

2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.

2.2 This does not apply in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.

2.3 The mark will not be awarded for the same missing or incorrect unit only once within one clip in epen.

2.4 Occasionally, it may be decided not to insist on a unit e.g the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.

2.5 The mark scheme will indicate if no unit error is to be applied by means of [no ue].

3. Significant figures

3.1 Use of too many significant figures in the theory questions will not be prevent a mark being awarded if the answer given rounds to the answer in the MS.

3.2 Too few significant figures will mean that the final mark cannot be awarded in 'show that' questions where one more significant figure than the value in the question is needed for the candidate to demonstrate the validity of the given answer.

3.3 The use of one significant figure might be inappropriate in the context of the question e.g. reading a value off a graph. If this is the case, there will be a clear indication in the MS.

3.4 The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will mean that one mark will not be awarded. (but not more than once per clip).
Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

3.5 In questions assessing practical skills, a specific number of significant figures will be required e.g. determining a constant from the gradient of a graph or in uncertainty calculations. The MS will clearly identify the number of significant figures required.

4. Calculations

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks. then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 'use of' the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 recall of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

5. Graphs

5.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

5.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

5.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

5.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.
- For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Acceptable Answer	Additional Guidance	Mark
1(a)	• Systematic (error) **(1)**		**1**
1(b)	• (Take readings at) different places/positions **(1)** • (Take readings at) different orientations/angles **(1)** • Calculate a mean/average value **(1)**		**3**
1(c)	• There will be variations in positioning the (jaws of the) micrometer. **Or** There will be variations in the length of the tube (at different points around the circumference of the tube) **(1)**	(Accept any reasonable practical physics alternative)	**1**

(Total for Question 1 = 5 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
2(a)	• Series circuit including power supply, heater and ammeter. **(1)** • Voltmeter connected in parallel with heater **(1)**		**2**
2(b)(i)	• Change in temperature and corresponding time **(1)** • Use of $P = \Delta E/\Delta t$ and $\Delta E = mc\Delta\theta$ **(1)** • $c = 950\ \text{J kg}^{-1}\ \text{K}^{-1}$ **(1)**	Example of calculation: $\frac{\Delta\theta}{\Delta t} = \frac{(36 - 16)\ \text{K}}{(500 - 0)\ \text{s}} = 0.04\ \text{K s}^{-1}$ $37.5\ \text{W} = 0.986\ \text{kg} \times c \times 0.04\ \text{K s}^{-1}$ $c = 951\ \text{J kg}^{-1}\ \text{K}^{-1}$	**3**
2(b)(ii)	An explanation that makes reference to the following points: • In 240 s the temperature of the block rose by only 9.6 °C **Or** It took 250 s for the temperature of the block to rise by 10 °C. **(1)** • Hence there must have been energy transfer to the surroundings (by heating) **(1)**	For MP1 accept 9.5 °C Accept it took 10 s longer For MP2 accept energy dissipated to the surroundings	**2**

(Total for Question 2 = 7 marks)

Question Number	Acceptable Answer		Additional Guidance	Mark
3(a)	An explanation that makes reference to the following points: • Uncertainty in each reading = 0.05 cm • Uncertainty in *r* is 2 × uncertainty in each reading • Hence percentage uncertainty = 0.8 %	(1) (1) (1)	Example of calculation: $\%\ \text{uncertainty} = \frac{0.1\ \text{cm}}{(17.5\text{-}5.0)\ \text{cm}} \times 100\ \% = 0.8\ \%$ Accept statement that uncertainty in *r* = 0.1 cm for MP2	3
3(b)(i)	• To reduce the effect of random errors	(1)		1
3(b)(ii)	• Use of data to calculate mean value • Use of half range **Or** Use of greatest deviation from mean • % uncertainty in range 5 % to 6% consistent with student's working (1 or 2 SF)	(1) (1) (1)	Example of calculation: $\omega_{av} = \frac{(0.112+0.116+0.118+0.123+0.125)}{5}$ $= 0.119\ \text{rad s}^{-1}$ Half range value $= \frac{0.125\ \text{mm} - 0.112\ \text{mm}}{2} = 0.0065$ $\therefore\ \%\ \text{uncertainty} = \frac{0.0065\ \text{mm}}{0.119\ \text{mm}} \times 100\ \% = 5.5\ \%$ Use of greatest deviation from mean gives 5.9 %	3
3(b)(iii)	• % uncertainty in ω is doubled • Add % uncertainty in *r* • % uncertainty = 11 % to 13% consistent with student's working (2 or 3 SF)(ecf from (b)(ii))	(1) (1) (1)	Don't penalise sf in both (ii) **and** (iii) Example of calculation: % uncertainty = 5% + 5% + 1% = 11%	3
3(c)	An explanation that makes reference to the following points: • The centripetal force is provided by friction • There is a max (frictional) force **Or** (frictional) force is the same when coin starts to slide • $F = m\omega^2 r$ so as *r* increased ω decreased	(1) (1) (1)	For MP3 accept ω^2 for ω	3

(Total for Question 3 = 13 marks)

Question Number	Acceptable Answer		Additional Guidance	Mark
4	• $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$, re-arranged to make $\frac{1}{v}$ the subject	**(1)**	$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $y = mx + c$	
	• Comparison with $y = mx + c$	**(1)**		
	• So intercept equals $1/f$	**(1)**		
	• Use the y intercept to calculate a value for *f*	**(1)**		
	• Comment on the agreement with the initial determination including an appropriate justification	**(1)**		
	OR			
	• Since $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$, when $\frac{1}{u} = 0$, $f = v$	**(1)**		
	• When $\frac{1}{v} = 0$, $f = v$	**(1)**		
	• Use the *y* intercept to calculate a value for *f*	**(1)**		
	• Use the *x* intercept to calculate a value for *f*	**(1)**		
	• Comment on the agreement with the initial determination including an appropriate justification	**(1)**		
	OR			
	• Read a pair of corresponding values from the graph	**(1)**		
	• Use of $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ to calculate a value for *f*	**(1)**		
	• Read a second pair of corresponding values from the graph	**(1)**		
	• Use of $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ to calculate a second value for *f*	**(1)**		
	• Comment on the agreement with the initial determination including an appropriate justification	**(1)**		**5**

(Total for Question 4 = 5 marks)

Question Number	Acceptable Answer		Additional Guidance	Mark
5(a)	• μ read from graph • Use of $I = I_0 e^{-\mu x}$ • I = 1.5 W m^{-2}	(1) (1) (1)	Accept μ in the range 140 (m^{-1}) - 160 (m^{-1}) Accept answers that round to 1.4 W m^{-2} or 1.5 W m^{-2} dependent upon value of μ for MP3 <u>Example of calculation:</u> I=1.8 W m^{-2} × $e^{-150\ \text{m}^{-1} \times 1.4 \times 10^{-3}\ \text{m}}$ = 1.46 W m^{-2}	3
5(b)	• (for deoxygenated blood) μ is greater for red • hence more red is absorbed **Or** intensity is smaller for red **Or** $e^{-\mu x}$ is smaller for red • So I/I_0 is smaller for red [dependent upon MP2]	(1) (1) (1)	Accept values for μ which show $\mu_{red} > \mu_{IR}$ for MP1 Allow numerical substitutions for MP2 and MP3 Accept converse argument leading to same conclusion	3
5(c)	• Use of $\lambda_{max}T$ = 2.898×10^{-3} m K • λ_{max} = 910 nm • Yes, because peak emission occurs at a wavelength close to 950 nm	(1) (1) (1)	Ignore references to the wavelength of red light <u>Example of calculation:</u> $\lambda_{max} = \frac{2.898 \times 10^{-3}\ \text{m K}}{3200\ \text{K}} = 9.06 \times 10^{-7}$ m	3

(Total for Question 5 = 9 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
6(a)(i)	• Use of $F = \frac{GMm}{r^2}$ with $F = \frac{mv^2}{r}$ **(1)** • Correct substitutions to calculate r **(1)** • $h = 5.4 \times 10^5$ m **(1)** **OR** • Use of $g = \frac{GM}{r^2}$ to find value of g at orbit height **(1)** • Use of $a = \frac{v^2}{r}$ with value of g at orbit height **(1)** • $h = 5.4 \times 10^5$ m **(1)**	Example of calculation: $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $r = \frac{GM}{v^2}$ $r = \frac{6.67\times10^{-11}\text{ N m}^2\text{kg}^{-2}\times5.97\times10^{24}\text{ kg}}{(7.59\times10^3\text{ m s}^{-1})^2}$ $r = 6.91\times10^6$ m $\therefore h = (6.91\times10^6 - 6.37\times10^6)\text{ m} = 5.42\times10^5$ m	**3**
6(a)(ii)	• Use of $GPE = \frac{GMm}{r}$ **(1)** • GPE = 5.7×10^{10} J (ecf from (a)(i)) **(1)**	Example of calculation: $GPE = GMm\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$ $\therefore GPE = 6.67\times10^{-11}\text{ Nm}^2\text{kg}^{-2} \times 5.97\times10^{24}\text{ kg} \times 11600\text{ kg}\left(\frac{1}{6.37\times10^6\text{ m}} - \frac{1}{6.91\times10^6\text{ m}}\right)$ $\therefore GPE = 5.67\times10^{10}$ J	**2**

6(a)(iii)	• This would bring the gravitational potential energy closer to zero **(1)** • This would mean that the satellite would orbit at a greater height as $GPE \propto \frac{1}{r}$ **(1)** • To remain in orbit the centripetal acceleration must equal the gravitational field strength at the orbit height **Or** Since gravitational force smaller, $\frac{mv^2}{r}$ would be reduced **(1)** • (Hence) *r* is greater so *v* must be smaller **Or** $v^2 = \frac{GM}{r}$ and satellite would orbit at lower speed **(1)** **OR** • HST will have more kinetic energy at the original orbit height **(1)** • The centripetal force will be too small to keep it in this orbit **(1)** • The satellite would be travelling too fast, so it would move to a higher orbit **(1)** • (Hence) *r* is greater so *v* must be smaller **Or** $v^2 = \frac{GM}{r}$ and satellite would orbit at lower speed **(1)**		4

6(b)	• Stars emitting infra-red radiation can be detected above the atmosphere **Or** Some visible wavelengths emitted by stars reduced to 50% intensity or less by the atmosphere **(1)**	Accept identified wavelength range	**1**
6(c)	• Gradient of graph determined **(1)** • $v = Hd$, so t = 1/H = 1/gradient **(1)** • $t = 4.7 \times 10^{17}$ s **(1)**	Example of calculation: $\text{Gradient} = \dfrac{(44000\text{-}1000)\ \text{km s}^{-1}}{(2.00\text{-}0.00)\times 10^{22}\ \text{km}} = 2.15\times 10^{-18}\text{s}^{-1}$ $t = \dfrac{1}{2.15\times 10^{-18}\text{s}^{-1}} = 4.65\times 10^{17}\text{s}$	**3**

(Total for Question 6 = 13 marks)

Question Number	Acceptable Answer		Additional Guidance	Mark
7(a)(i)	An explanation that makes reference to the following points:			
	• Time *n* oscillations and divide by *n*, where *n* is a large number	**(1)**	Where $n \geq 5$	
	• Increasing the time (measured) reduces the uncertainty (in *T*)	**(1)**		
	• Repeat timing and calculate a mean	**(1)**		
	• Use a (fiducial) marker to indicate the reference position	**(1)**		
	• Use equilibrium position as reference position	**(1)**	For equilibrium allow centre/undisplaced	
	• The trolley is moving fastest at this point so the uncertainty in starting/stopping the stopwatch is least	**(1)**		**6**
7(a)(ii)	• Use $\omega = 2\pi/T$ (to calculate a value for ω) **Or** use $\omega = 2\pi f$ with $f = 1/T$	**(1)**		
	• Measure the maximum displacement of the trolley from the equilibrium position (with the metre rule)	**(1)**	For equilibrium allow centre/undisplaced [accept initial displacement for maximum displacement]	
	• Use $v_{max} = \omega A$ (to calculate a value for the maximum velocity of the trolley)	**(1)**		**3**

7(b)	• (The sensor and data logger) eliminates reaction time **Or** data logger will not necessarily record the time with any greater resolution **(1)**		**1**
7(c)	An explanation that makes reference to the following points: • $v_{max} = \omega A$ and ω constant **(1)** • If A doubles, then v_{max} doubles **(1)** • Hence max E_k will quadruple, since $E_k = \frac{1}{2}mv^2$[dependent upon MP2] **(1)** OR • $\Delta E_{el} = \frac{1}{2}F\Delta x$ **and** $\Delta F = k\Delta x$ **(1)** • $\Delta E_{el} \propto (\Delta x)^2$ since k is constant **(1)** • Hence max E_k will quadruple, since max E_k = max ΔE_{el} (dependent upon MP2) **(1)**		**3**

(Total for Question 7 = 13 marks)

Question Number	Acceptable Answer	Additional Guidance	
8(a)	• Use of $s = \frac{(u+v)}{2}.t$ **(1)** • Use of $E_k = \frac{1}{2}mv^2$ **(1)** • Use of $P = \frac{\Delta W}{\Delta t}$ **(1)** • P = 110 W **(1)**	Example of calculation: $32.5\text{ m} = \frac{(u+0)}{2} \times 17.5\text{ s}$ $\therefore u = \frac{32.5\text{ m} \times 2}{17.5\text{ s}} = 3.71\text{ m s}^{-1}$ $P = \frac{\Delta E_k}{\Delta t} = \frac{\frac{1}{2} \times 19.6\text{ kg} \times (3.7\text{ m s}^{-2})^2}{1.25\text{ s}} = 107\text{ W}$	**4**
8(b)	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The table shows how the marks should be awarded for indicative content and lines of reasoning.	(see table below)	

IC points	IC mark	Max linkage mark available	Max final mark
6	4	2	**6**
5	3	2	**5**
4	3	1	**4**
3	2	1	**3**
2	2	0	**2**
1	1	0	**1**
0	0	0	**0**

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkage and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between its points and is unstructured	0

	Indicative content: • (Collision takes place on an ice surface so) there is minimal friction **Or** External forces are negligible • Momentum is conserved in the collision • The momentum of stone A before the collision equals the momentum of (A and) B after the collision • Stone A must be at rest after the collision • All of the kinetic energy of stone A must have been transferred to stone B • Kinetic energy is conserved in an elastic collision		**6**
8(c)	An explanation that makes reference to the following points: • Sweeping the ice smooths out the surface **Or** Sweeping the ice melts the suraface of the ice. **(1)** • So frictional forces are reduced (and the deceleration of the stone is reduced) **(1)**	For MP2 accept references to a lower rate of working against friction **Or** less work done against friction for a given displacement	**2**

(Total for Question 8 = 12 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>9(a)</td><td>An explanation that makes reference to the following points:
• Shows expansion log $v = p \log B + \log k$ (1)
• Compares with $y = mx + c$ and identifies p as the gradient (1)</td><td></td><td>2</td></tr>
<tr><td>9(b)(i)</td><td>• Log values correct and to 3 SF (1)
<table>
<tr><th>Log (v /m s^{-1})</th><th>Log B</th></tr>
<tr><td>0.301</td><td>0.00</td></tr>
<tr><td>1.00</td><td>0.477</td></tr>
<tr><td>1.33</td><td>0.699</td></tr>
<tr><td>1.56</td><td>0.845</td></tr>
<tr><td>1.70</td><td>0.954</td></tr>
<tr><td>1.83</td><td>1.04</td></tr>
</table>
• Labels and unit (1)
• Scales (1)
• Plots (1)
• Line of best fit (1)</td><td>Allow ln v against ln B
<table>
<tr><th>ln (v /m s^{-1})</th><th>ln B</th></tr>
<tr><td>0.693</td><td>0.00</td></tr>
<tr><td>2.30</td><td>1.10</td></tr>
<tr><td>3.07</td><td>1.61</td></tr>
<tr><td>3.58</td><td>1.95</td></tr>
<tr><td>3.92</td><td>2.20</td></tr>
<tr><td>4.22</td><td>2.40</td></tr>
</table>
Check labels on graph axes (not table)
Don't credit difficult scales (e.g. increments of 3, 4, 7)
Check 2 points furthest from the line (within half a square) Don't check points on difficult scales</td><td>5</td></tr>
<tr><td>9(b)(ii)</td><td>• Gradient determined using large triangle - at least half the plotted length (1)
• p = 1.47 to 2/3 SF and no units (1)
• Obtains $k = 2.00$ m s^{-1} (1)</td><td>MP3 answer should round to 2; don't penalise SF</td><td>3</td></tr>
</table>

(Total for Question 9 = 10 marks)

Question Number	Acceptable Answer		Additional Guidance	Mark
10(a)	• Cross sectional area × length used to calculate volume • Use of $E_k = \frac{1}{2}mv^2$ • Energy per unit volume = 1.7×10^8 (J m^{-3})	**(1)** **(1)** **(1)**	<u>Example of calculation:</u> Volume of seatbelt, $V = 0.85 \times 10^{-4}$ $m^2 \times 2$ m $V = 1.7 \times 10–4$ m^3 $E_k = \frac{1}{2} \times 75$ kg $\times (28$ m $s^{-1})^2 = 2.9 \times 10^4$ J $\therefore \frac{E}{V} = \frac{2.9\times10^4 \text{J}}{1.7\times10^{-4} \text{m}^3} = 1.73\times10^8$ J m^{-3}:	**3**
10(b)(i)	• (For linear section of graph) area under graph = $\frac{1}{2}$ stress × strain • Use of stress = F/A and strain = $\Delta x/x$ to show that area = $\frac{1}{2} \times \frac{F}{A} \times \frac{\Delta x}{x} = \frac{F_{av.}\Delta x}{V} = \frac{E}{V}$	**(1)** **(1)**	Candidates who only use the graph to show that the area has units J m^{-3} can score a maximum 1 mark Accept F_{av} for $\frac{1}{2}F$	**2**
10(b)(ii)	• Area under graph up to 0.075 calculated • Energy per unit volume = 7.1×10^5 J m^{-3} • This is much less than the value given in (a), and so belt does not absorb all the KE. **OR** • Graph used to determine stress when strain is 0.075 and $\sigma = \frac{F}{A}$ used to calculate force • $\epsilon = \frac{\Delta x}{x}$ used to calculate extension and $W = \frac{1}{2}F\Delta x$ used to calculate energy • Statement that this energy is much less than the value in (a), and so belt does not absorb all the kinetic energy	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	Example of calculation: When strain is 0.075 Area = $\frac{1}{2}\times19\times10^6 \text{Pa}\times0.075 = 7.13\times10^5$ J m^{-3}	**3**

(Total for Question 10 = 8 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
11(a)(i)	**MAX 3** • There is an inconsistent number of decimal places **(1)** • No evidence of repeats **(1)** • Range is too small **(1)** • Not enough readings between 24 ^{o}C and 60 ^{o}C **(1)** • Four (pairs of) readings are not enough **(1)**		**3**
11(a)(ii)	An explanation that makes reference to the following points: • The (trapped) air may not have been at the temperature of the water **(1)** • Because water temperature may not be uniform **Or** because transfer of thermal energy through the glass takes time **(1)** • The volume of the (trapped) air column may not be proportional to the length of the column **(1)** • Because the bore of the glass tube may not have been uniform **(1)** • The temperature / length may be read incorrectly **(1)** • Because there may be a parallax error when reading the temperature or length of the trapped air column **(1)**	Mark any two pairs	**4**

11(a)(iii)	**Any two from:** • Stir water in beaker **(1)** • Use digital thermometer **Or** temp sensor & data logger **(1)** • Put thermometer close to tube **(1)** • Let tube reach thermal equilibrium before taking readings **(1)** • Use thermostatically controlled water bath **(1)** • Take reading in line with scale **(1)**		**2**
11(b)(i)	An explanation that makes reference to the following points: • The intercept represents the temperature of the air at which the volume occupied would be zero **(1)** • This is the absolute zero (of temperature) **(1)** • Absolute zero is the lowest attainable temperature **Or** absolute zero is the temperature at which the atoms/molecules of the gas have zero kinetic energy **(1)**	For MP3 accept atoms/molecules stop moving	**3**
11(b)(ii)	**MAX 4** **Resolution:** • It is correct that uncertainties would be reduced by using high resolution instruments **(1)** • But the instruments are not high resolution **(1)** • There could be a systematic error (in the measurements) **(1)** **Graph:** • The points do not lie on a perfect straight line **Or** the true relationship may not linear **(1)** • Temperature intercept may not be accurate **Or** there may be extrapolation errors **(1)** • More points are needed **Or** a wider range is needed **(1)**		**4**

(Total for Question 11 = 16 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>12(a)</td><td>• Speed of impact is the same for both spheres (1)
• mass of sphere ∝ (diameter)^3 (1)
• $E_k = \frac{1}{2}mv^2$ so factor = 8 (1)
OR
• Final $E_k = \Delta E_{grav}$ (1)
• mass of sphere ∝ (diameter)^3 (1)
• $\Delta E_{grav} = mg\Delta h$, so factor = 8 (1)</td><td>For MP2 accept radius instead of diameter

A bald correct answer scores MP3 only

Example of calculation:
$\frac{m_2}{m_1} = \left(\frac{4\text{ cm}}{2\text{ cm}}\right)^3 = 8$
$\frac{E_{k2}}{E_{k1}} = \frac{m_2}{m_1} = 8$</td><td>3</td></tr>
<tr><td>*12(b)</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.
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<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>
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<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 linkage 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 its points and is unstructured</td><td>0</td></tr>
</table></td><td></td></tr>
</table>

	Indicative content: • The table shows that increasing the drop height does increase the crater diameter • Increasing the drop height increases the impact velocity/E_k • Because there is a greater acceleration time **Or** because there is a greater transfer of GPE to KE • The table does not show that increasing the sphere diameter (always) increases the crater diameter • For smaller spheres (from 2 to 4 cm), increasing sphere diameter does increase crater diameter **Or** for bigger spheres (from 4 to 6 cm), increasing the sphere diameter has little effect on crater diameter • More data is needed for firmer conclusions	For IC3 accept reference to an appropriate equation For IC5 accept "no effect" or "inconsistent effect" for "little effect"	**6**

(Total for Question 12 = 9 marks)