Pearson Edexcel

Mark Scheme (Results)

November 2021

Pearson Edexcel GCE
In Physics (9PH0)
Paper 3: General and Practical Principles in Physics

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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.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

    i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear

    ii) select and use a form and style of writing appropriate to purpose and to complex subject matter

    iii) organise information clearly and coherently, using specialist vocabulary when appropriate.

Mark scheme notes

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. '<u>resonance</u>'
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.

1. Quality of Written Communication

1.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.
1.2 Usually it is part of a max mark, the final mark not being awarded unless the QoWC condition has been satisfied.

2. Graphs

2.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.
2.2 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.
2.3 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.
2.4 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)	• Use of $F = BIl\sin\theta$ • Use of $F = mg$ • $B = 0.0786$ T	**(1)** **(1)** **(1)**	Example of calculation: $BIl = mg$ $\therefore B = \dfrac{5.65 \times 10^{-3}\text{ kg} \times 9.81\text{ N kg}^{-1}}{4.55\text{ A} \times 15.5 \times 10^{-2}\text{ m}} = 0.07859\ T$	**3**
1(b)	**MAX 3** A comment that makes reference to the following points: • High precision means a small spread of values • High accuracy means close to the true value • The student is actually referring to the resolution of the balance • (The student should have stated) there was a low uncertainty in the value of the force **Or** a high resolution doesn't guarantee accuracy/precision	 **(1)** **(1)** **(1)** **(1)**		**3**

(Total for Question 1 = 6marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
2(a)	• Counting for 1 minute is too short a time **Or** he should count for at least 3 minutes **(1)** • He hasn't recorded the background count rate **(1)** • More than one reading taken and a mean calculated **Or** should have taken more than two readings (to calculate mean) **(1)**	To be marked holistically (with(b))	**3**
2(b)	**MAX 5** An explanation that makes reference to the following points: • The student has calculated the count rate rather than the activity of the source **(1)** • The counts haven't been corrected for background (so there is systematic error in his data) **(1)** • The GM tube is too far away from the source **(1)** • α-radiation won't reach the GM-tube as it only has a short range in air **(1)** • Radiation spreads out from the source, so not all the emitted radiation reaches the GM-tube **(1)** • GM tube won't detect all the gammas which enter it **(1)**	To be marked holistically (with(a))	**5**

(Total for Question 2 = 8 marks)

Question Number	Acceptable Answer		Additional Guidance	Mark
3(a)	• Use of $V = \frac{4}{3}\pi r^3$ • Use of $\rho = \frac{m}{V}$ • $\rho = 2580\ (\text{kg m}^{-3})$	**(1)** **(1)** **(1)**	Example of calculation $V = \frac{4}{3}\pi\left(\frac{5.06 \times 10^{-2}\text{ m}}{2}\right)^3 = 6.78 \times 10^{-5}\text{ m}^3$ $\rho = \frac{0.175\text{ kg}}{6.78 \times 10^{-5}\text{ m}^3} = 2580\text{ kg m}^{-3}$	**3**
3(b)	• Use of half resolution to calculate % uncertainty • % uncertainty in V = 3 × % uncertainty in r • % uncertainty in ρ = (% uncertainty in m + % uncertainty in V) • Use of % uncertainty to calculate upper value of density • Upper value of density 2596 (kg m^{-3}) [2616 (kg m^{-3}) if "show that" value used] • Glass is in the range and Quartz isn't, so it may not be genuine ECF from (a)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	% uncertainty in $r = \frac{0.005\text{ cm}}{5.06\text{ cm}} \times 100\ \% = 0.10\ \%$ % uncertainty in $m = \frac{0.5\text{ g}}{175\text{ g}} \times 100\ \% = 0.29\ \%$ % uncertainty in ρ = (3 × 0.1%) + 0.29% = 0.59% Range = $\pm\frac{0.6}{100} \times 2580\text{ kg m}^{-3} = \pm 15.5\text{ kg m}^{-3}$ Density range = 2565 → 2596 kg m^{-3} Allow use of half resolution in either r or m to calculate minimum V and maximum m and then calculate maximum ρ for MP1 → MP4	**6**

(Total for Question 3 = 9 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>4(a)</td><td>

- decay happens without any external stimulus
Or decay is unaffected by external factors (such as temperature) **(1)**

</td><td>Do not credit references to the randomness of the decay</td><td>1</td></tr>
<tr><td>*4(b)</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 There is a fixed probability (λ) of an individual nucleus undergoing decay (in the next second)

IC2 For a sample with large number of unstable nuclei there is a predictable pattern

IC3 The fraction of nuclei decaying in the next second is equal to the decay constant (λ)

IC4 Hence the number of nuclei decaying (in the next second) depends on the number of (unstable) nuclei
Or activity = λN

IC5 The number of unstable nuclei decreases exponentially (with time)
Or number of (unstable) nuclei $= N_0 e^{-\lambda t}$

IC6 So the rate of decay decreases exponentially (with time)
Or rate of decay = $A_0 e^{-\lambda t}$

</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 4 = 7 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
5(a)(i)	• (±) 0.005 cm **(1)**		**1**
5(a)(ii)	• Use of 2 × uncertainty **(1)** • 0.07 % [1 or 2 sf] ECF answer from (a)(i) **(1)**	Example of calculation % uncertainty in h $= \frac{2 \times 0.005 \text{ cm}}{(27.10 - 12.00 \text{ cm})} \times 100\ \%$ % uncertainty in h = 0.066 %	**2**
5(a)(iii)	**MAX 2** • No units given for 1/*r* in table **(1)** • 1/*r* recorded to more significant figures than *r* **(1)** • *h* recorded to an inconsistent number of decimal places **(1)** • raw data for *h* not shown **(1)**		**2**
5(b)(i)	• Line of best fit drawn **(1)** • Value of 1/*r* calculated **(1)** • *h* = 13.8 cm **(1)**	Example of calulation $\frac{1}{r} = \frac{1}{0.11 \text{ mm}} = 9.1 \text{ mm}^{-1}$	**3**
5(b)(ii)	• There are only 4 points, which isn't enough to form a firm conclusion **(1)** • The range of the points is insufficient to form a firm conclusion (no data between 0.0 and 6.0 on *x*-axis) **(1)** **Either** • $h = \frac{k}{r}$ suggests a straight line through the origin **(1)** • the points plotted do lie in a straight line **(1)** **Or** • $h = \frac{k}{r}$ suggests hr is a constant **(1)** • This is approximately true (k ≈ 1.5) **(1)**	Credit there may be systematic error in *h* causing the points to be displaced	**4**

(Total for Question 5 = 12 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
*6(a)	(see below)	(see below)	6

Acceptable Answer

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 structure and lines of reasoning.

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5–4	3
3–2	2
1	1
0	0

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages 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 points and is unstructured	0

Indicative content:

IC1 The rider experiences a resultant force acting towards the centre (of the circular path)

IC2 This (resultant) force is constant, as the rider has a constant (angular) velocity
Or the weight W is constant

IC3 At the bottom of the circle P and W act in opposite directions, so P must be greater than W

IC4 At the top of the circle P and W act in the same direction, and so P must be less (than at the bottom of the circle)

IC5 P is the weight the rider appears to have

IC6 The rider would feel heavier at the bottom of the circle
Or the rider would feel lighter at the top of the circle

Additional Guidance

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

IC points	IC mark	Max linkage mark	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

Accept "the rider experiences a centripetal force"

6(b)	**MAX 4** • The riders are most at risk of falling out of their seats when they are at the top of the circular path. **(1)** • But, as long as the contact/reaction force from the seat (*P*) is always greater than zero the riders will not fall out of their seats. **(1)** • The faster the ride rotates the larger the value of the contact/reaction force from the seat (*P*) needed to maintain the rider in a circular path **(1)** • So there is a minimum speed for the ride (when it is in vertical mode) **Or** the safety harness will be needed if the ride slows down or stops **(1)** • It is the need for centripetal not centrifugal force that "keeps the riders in their seats" **(1)**	Accept "there is no centrifugal force"	**4**

(Total for Question 6 = 10 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
7(a)(i)	• Use of y-sensitivity value **(1)** • $V_0 = 4.0$ V **(1)**	Example of calculation: $V_0 = 2 \times 2.0\ V = 4.0$ V	**2**
7(a)(ii)	• Use of $I = \frac{V}{R}$ **(1)** • Use of $I_{\mathrm{rms}} = \frac{I_0}{\sqrt{2}}$ **Or** use of $V_{\mathrm{rms}} = \frac{V_0}{\sqrt{2}}$ **(1)** • $I_{\mathrm{rms}} = 0.019$ A ECF from(i) **(1)**	Example of calculation $I_0 = \dfrac{4.0\ \mathrm{V}}{150\ \Omega} = 0.0267\ \mathrm{A}$ $I_{\mathrm{rms}} = \dfrac{0.0267\ \mathrm{A}}{\sqrt{2}} = 0.0189\ \mathrm{A}$	**3**
7(a)(iii)	• Use of $R = R_1 + R_2$ **(1)** • Use of $P = I^2R$ (or other valid power equation) **(1)** • $P = 0.096$ W ECF from(i) and (ii) **(1)**	Example of calculation: $R = 150\ \Omega + 120\ \Omega = 270\ \Omega$ $P = I^2R = (0.019\ \mathrm{A})^2 \times 270\ \Omega = 0.0964\ \mathrm{A}$	**3**
7(b)	**MAX 3** • Voltmeter must measure alternating p.d.s **Or** voltmeter would indicate zero for a.c. **(1)** • A.C. voltmeter would give an r.m.s. p.d. directly **(1)** • Voltmeter may draw current and affect the circuit it was connected to **Or** oscilloscope would have little effect on the circuit it was connected to **(1)** • Accuracy would depend upon the calibration of the voltmeter **(1)** • A (digital) voltmeter would give better resolution than measuring trace height on an oscilloscope. **(1)**	Accept "voltmeter reading would change too fast to measure"	**3**

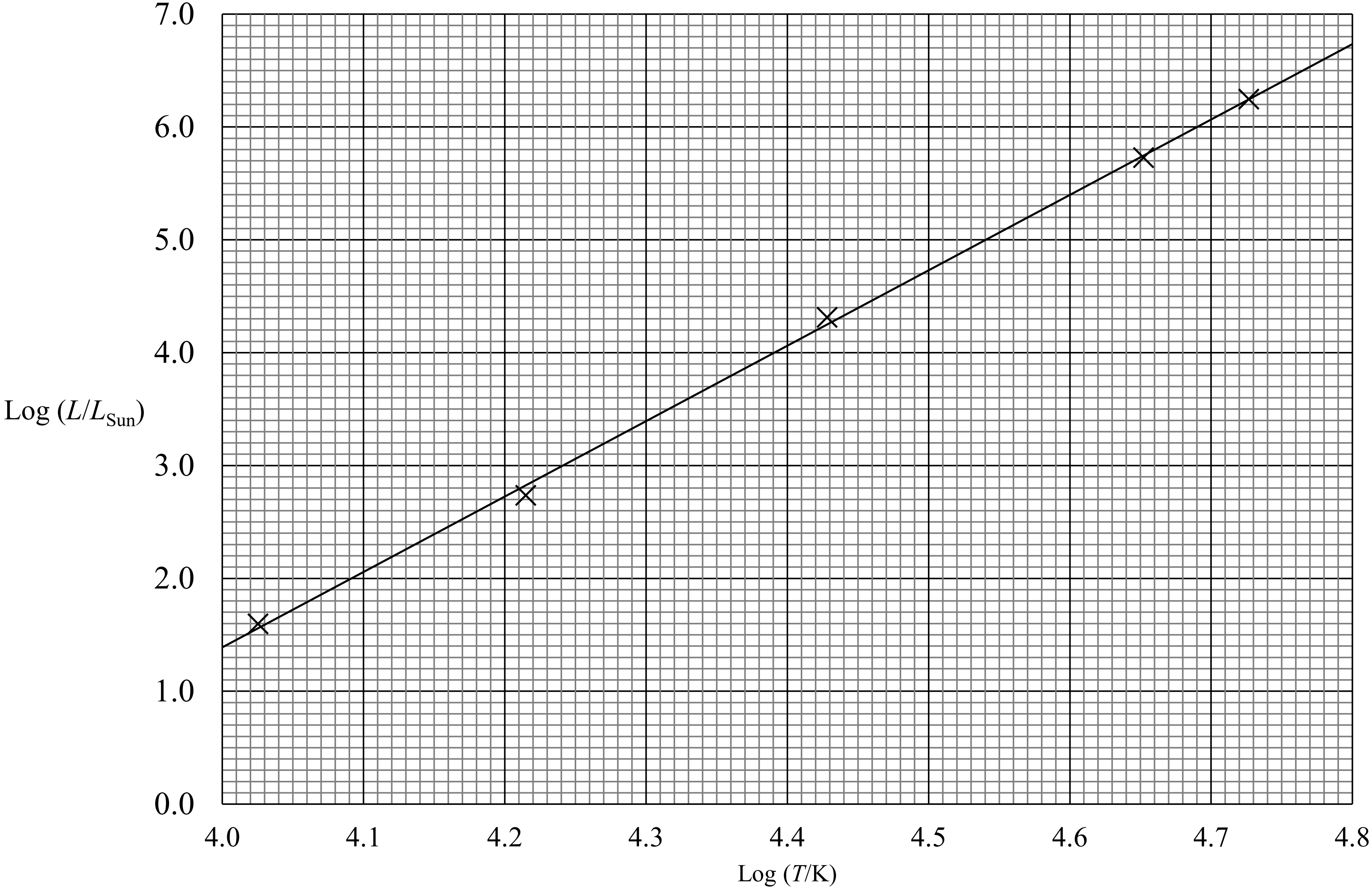
(Total for Question 7 = 11 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
8(a)(i)	• Use of $P = VI$ **(1)** • P = 1900 W (1.9 kW) **(1)**	Example of calculation P=230 V × 8.20 A = 1890 W	**2**
8(a)(ii)	• Use of $\Delta E = mc\Delta\vartheta$ **(1)** • Use of $P = \frac{\Delta E}{\Delta t}$ **(1)** • $\Delta t = 112$ s or 113 s ECF from (a)(i) **(1)**	Example of calculation $\Delta E = 0.655 \text{ kg} \times 4190 \text{ J kg}^{-1}\text{K}^{-1} \times (100 - 22.5)\text{K}$ $\Delta E = 2.13 \times 10^5$ J $\Delta t = \frac{2.13 \times 10^5 \text{J}}{1890 \text{ W}} = 112.5$ s	**3**
8(b)(i)	• After a short time of boiling in the flask, all the apparatus would be at 100 ºC. **Or** so energy is not being used to heat up the flask **Or** so steam won't condense in the flask **(1)**		**1**
8(b)(ii)	• Use of $\Delta E = mL$ **(1)** • Use of $P = \frac{\Delta E}{\Delta t}$ **(1)** • 1720 W (1.72 kW) **(1)**	Example of calculation $\frac{\Delta m}{\Delta t} = \frac{95 \times 10^{-3} \text{ kg}}{125 \text{ s}} = 7.6 \times 10^{-4} \text{ kg s}^{-1}$ $\frac{\Delta E}{\Delta t} = 7.6 \times 10^{-4} \text{ kg s}^{-1} \times 2.26 \times 10^6 \text{J kg}^{-1}$ $P = 1720 \text{ J s}^{-1}$	**3**
8(b)(iii)	• Comparison of answer to (a)(i) with answer to (b)(ii) **(1)** • Not all of the energy from the heater is used to turn water from liquid state into vapour **Or** energy is being used to heat the heat exchanger **Or** not all the steam condenses in the heat exchanger **(1)** • Some energy is transferred to the surroundings **(1)**	e.g. rate at which thermal energy is supplied to the water in the flask is greater than rate at which thermal energy is removed from the water in the heat exchanger. If answer for (b)(ii) is bigger than 2 kW,1 mark for correct comparison can be scored.	**3**
8(c)	• By lagging the flask (to reduce energy transfer to the surroundings) **(1)**		**1**

(Total for Question 8 = 13 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>9(a)(i)</td><td>All the stars are in the main sequence (1)
In an older cluster there would be red giant stars (1)</td><td></td><td>2</td></tr>
<tr><td>9(a)(ii)</td><td>MAX 4
The most massive stars experience much greater gravitational forces (1)
So core temperature and density is greatest (1)
The rate of fusion in the core is greatest
Or the power generated in the core is greatest (1)
The (surface) temperature is greatest (1)
The surface area of these stars is greatest (1)
So according to Stefan’s Law the power radiated from these massive stars is greatest (1)</td><td></td><td>4</td></tr>
<tr><td>9(b)(i)</td><td>An explanation that makes reference to the following points:
Shows expansion $\log L = n \log T + \log k$ (1)
Compares with $y = mx + c$ and states that gradient is n (1)</td><td></td><td>2</td></tr>
<tr><td>9(b)(ii)</td><td>Log values correct and to 2 or 3 d.p. (1)
Graph axes labelled with quantities and units (1)
Scales (1)
Plots (1)
Line of best fit (1)</td><td><table>
<tr><th>Log (L/L_{Sun})</th><th>Log (T/K)</th></tr>
<tr><td>1.597</td><td>4.025</td></tr>
<tr><td>2.736</td><td>4.215</td></tr>
<tr><td>4.314</td><td>4.428</td></tr>
<tr><td>5.728</td><td>4.652</td></tr>
<tr><td>6.248</td><td>4.727</td></tr>
</table></td><td>5</td></tr>
<tr><td>9(b)(iii)</td><td>Determines gradient using large triangle (1)
n = 6.68 to 2 or 3 SF (1)
(accept answers in range 6.6 $\rightarrow$ 6.9)</td><td></td><td>2</td></tr>
</table>

(Total for Question 9 = 15 marks)


Log (L/L_{Sun})
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4.0
4.1
4.2
4.3
4.4
4.5
4.6
4.7
4.8
Log (T/K)

Question Number	Acceptable Answer		Additional Guidance	Mark
10(a)(i)	**MAX 4** • It's difficult to measure from the same position on the spring each time • Ruler may move between readings • There may be parallax error in reading positions • The student has only taken one measurement for each added mass • Hence this method would not produce accurate values (dependent upon at least one from MP1 ¬ MP4)	**(1)** **(1)** **(1)** **(1)** **(1)**	Mark (i) and (ii) holistically	**5**
10(a)(ii)	**MAX 5** • Attach a pointer to the bottom of the spring **Or** take measurements from bottom of mass holder • Bring metre rule closer to the spring • Take measurements from the metre rule as masses are added and as masses are removed • Calculate a mean extension for each mass • Method to ensure metre rule is vertical • Method to reduce parallax error	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	Mark (i) and (ii) holistically e.g. use of a set square, lining up against a vertical, use of spirit level e.g. take reading at eye level	**5**
10(b)(i)	• Ignoring mass of holder / spring when determining the oscillating mass	**(1)**		**1**

10(b)(ii)	• Using a data logger (and light gate) would eliminate reaction time **(1)** • So the uncertainty in the measurement (of the time) would be reduced **(1)** • Not easy to measure timings for multiple swings/oscillations with a data logger **(1)**	MP2 (dependent upon MP1	**3**
10(b)(iii)	• Identify gradient as $\frac{4\pi^2}{k}$ **(1)** • Determine gradient of graph **(1)** • k = 17.8 N m^{-1} [17.5 → 18.5] **(1)**	Example of calculation Gradient = 2.21 s^2 kg^{-1} $k = \frac{4\pi^2}{2.21 \text{ s}^2 \text{ kg}^{-1}} = 17.8 \text{ N m}^{-1}$	**3**
10(c)	• Timing a large number of oscillations minimised the percentage uncertainty in the measurement **(1)** • Repeating each timing measurement and calculating a mean minimised the effect of random errors **(1)** • Taking a repeat measurement allowed a check for gross timing errors. **(1)**		**3**

(Total for Question 10 = 20 marks)

Question Number	Acceptable Answer		Additional Guidance	Mark
11(a)	• Use of trigonometry to determine θ • Calculation of both angles • Use of $d\ sin\theta = n\lambda_1$ to calculate d • Use of $d\ sin\theta = n\lambda_2$ with d • $\lambda_2 = 5.3 \times 10^{-7}$ m (530 nm)	**(1)** **(1)** **(1)** **(1)** **(1)**	Example of calculation $\tan\theta = \frac{0.50\text{ m}}{1.45\text{ m}} \therefore \theta = 19.0^{\text{o}}$ $\tan\theta = \frac{0.40\text{ m}}{1.45\text{ m}} \therefore \theta = 15.4^{\text{o}}$ $d = \frac{650 \times 10^{-9}\text{ m}}{\sin 19.0^{o}} = 1.99 \times 10^{-6}\text{ m}$ $\lambda_2 = 1.99 \times 10^{-6}\text{m} \times \sin 15.4^{o} = 5.29 \times 10^{-7}\text{m}$	**5**
11(b)	An explanation that makes reference to the following points: • Measure the distance between the two 1st/2nd order maxima **Or** measure the distance from the 2nd order to the central maximum **Or** increase the distance from the grating to the screen • This increases the distance measured on the screen (and reduce the % uncertainty) MP2 dependent upon MP1	**(1)** **(1)**		**2**
11(c)	An explanation that makes reference to the following points: • Maxima on one side move closer to the central maximum • Maxima on the other side move further away from the central maximum • Intensity of maxima would be different on each side of central maximum	**(1)** **(1)** **(1)**	Allow 1 mark for spacing of maxima on screen will change	**3**

(Total for Question 11 = 10 marks)