National
Qualifications
2018

2018 Physics

National 5

Finalised Marking Instructions

General marking principles for National 5 Physics

This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in this paper. These principles must be read in conjunction with the detailed marking instructions, which identify the key features required in candidate responses.

(a) Marks for each candidate response must **always** be assigned in line with these general marking principles and the detailed marking instructions for this assessment.

(b) Marking should always be positive. This means that, for each candidate response, marks are accumulated for the demonstration of relevant skills, knowledge and understanding: they are not deducted from a maximum on the basis of errors or omissions.

(c) If a specific candidate response does not seem to be covered by either the principles or detailed marking instructions, and you are uncertain how to assess it, you should seek guidance from your team leader.

(d) There are **no half marks** awarded.

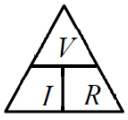
(e) Where a wrong answer to part of a question is carried forward and the wrong answer is then used correctly in the following part, give the candidate credit for the subsequent part or 'follow-on'.

(f) Award marks for non-standard symbols where the symbols are defined and the relationship is correct, or where the substitution shows that the relationship used is correct. This must be clear and unambiguous.

(g) Award full marks for a correct final answer (including units if required) on its own, unless a numerical question specifically requires evidence of working to be shown, eg in a 'show' question.

(h) Give credit where a diagram or sketch conveys correctly the response required by the question. It will usually require clear and correct labels (or the use of standard symbols).

(i) Marks are allocated for knowledge of relevant relationships alone. Do not award a mark when a candidate writes down several relationships and does not select the correct one to continue with, for example by substituting values.

(j) Do not award marks if a 'magic triangle', eg , 

is the only statement in a candidate's response. To gain the mark, the correct relationship must be stated eg $V = IR$ or $R = \frac{V}{I}$, etc.

(k) In rounding to an expected number of significant figures, award the mark for correct answers which have up to two figures more or one figure less than the number in the data with the fewest significant figures.

(Note: the use of a recurrence dot, eg $0 \cdot \dot{6}$, or a vulgar fraction, would imply an infinite number of significant figures and would therefore not be acceptable.)

(l) The incorrect spelling of technical terms should usually be ignored and candidates should be awarded the relevant mark, provided that answers can be interpreted and understood without any doubt as to the meaning.
Where there is ambiguity, do not award the mark. Two specific examples of this would be when the candidate uses a term:

- that might be interpreted as *reflection*, *refraction* or *diffraction*, eg 'defraction'
- that might be interpreted as either *fission* or *fusion*, eg 'fussion'

The spelling of these words is similar, but the words have totally different meanings. If the spelling (or handwriting) in an answer makes it difficult for you to interpret a candidate's intention, then do not award the mark.

(m) Marks are awarded only for a valid response to the question asked. For example, in response to questions that ask candidates to:

- **identify**, **name**, **give**, or **state**, they need only name or present in brief form.
- **describe**, they must provide a statement or structure of characteristics and/or features.
- **explain**, they must relate cause and effect and/or make relationships between things clear.
- **determine** or **calculate**, they must determine a number from given facts, figures or information.
- **estimate**, they must determine an approximate value for something.
- **justify**, they must give reasons to support their suggestions or conclusions, eg this might be by identifying an appropriate relationship and the effect of changing variables.
- **show that**, they must use physics (and mathematics) to prove something, eg a given value. All steps, including the stated answer, must be shown.
- **predict**, they must suggest what may happen based on available information.
- **suggest**, they must apply their knowledge and understanding of physics to a new situation. A number of responses are acceptable: marks will be awarded for any suggestions that are supported by knowledge and understanding of physics.
- **use your knowledge of physics to comment on**, they must apply their skills, knowledge and understanding to respond appropriately to the problem/situation presented, for example by making a statement of principle(s) involved and/or a relationship or equation, and applying these to respond to the problem/situation. They will gain credit for the breadth and/or depth of their conceptual understanding.

Common issues with candidate responses

When marking National 5 Physics, there are some common issues which arise when considering candidates' answers.

There is often a range of acceptable responses which would sensibly answer a particular question. However, it is often difficult to anticipate all correct or partially correct responses to questions.

The detailed marking instructions contain ideal answers, and examples of other acceptable answers which offer guidance for interpreting candidates' responses. They may also contain advice on answers which are **not** acceptable, or only attract partial marks.

Units

Do not penalise incorrect spelling of a unit in a **non-numerical** answer which requires a unit to be stated, as long as the unit can be clearly identified, eg

Q State the unit for the activity of a radioactive source.
A *Becquerels*. The answer *beckerels* is acceptable.

Do not penalise use of upper/lower case for **non-numerical** answers when the abbreviated version is given, eg DB, sV, hZ, bq.

However, for **numerical answers**, take care to ensure the unit has the correct prefix, eg for an answer t = 0·005 seconds, t = 5 ms is acceptable but t = 5 Ms is not.

Where a candidate makes multiple unit errors or conversion errors/omissions in any part of a question, penalise once only. For example, when calculating speed from distance and time, and the answer is required to be in m s^{-1}.

If d = 4 km and t = 2 minutes

$$v = \frac{d}{t} \quad (1)$$

$$v = \frac{400}{2} \quad (1)$$

$$v = 200 \quad (0)$$

Although the candidate has made three unit errors, (not correctly converted distance or time and has omitted the final unit), do not award the final mark only.

Some common units often attract wrong abbreviations in answers to numerical questions.
When the abbreviation can be confused with a different unit then apply a unit penalty, eg sec or secs as an abbreviation for seconds is **not** acceptable.

Common units and abbreviations	
Acceptable unit and abbreviation	*unacceptable version*
second, s	sec, secs
hours, h	hr, hrs
ampere, amp, amps, A, a	
metres per second, m/s, m s^{-1}	mps, m/s^{-1}
metres per second per second, m/s^2, m s^{-2}	m/s/s, mpsps, m/s^{-2}

Standard form
Where a candidate fails to express an answer in standard form correctly, treat it as an arithmetic error and do not award the final mark. For example:

For an answer t = 400 000 s, then $t = 4\times10^5$ s would be correct but $t = 4^5$ s would be treated as an arithmetic error.

Incorrect answer carried forward
Do not apply a further penalty where a candidate carries forward an incorrect answer to part of a question, and uses that incorrect answer correctly:

- within that part of the question, eg from (a)(i) to (a)(ii)
- or to the next part of the question, eg from (a) to (b).

Similarly, if a candidate has selected the wrong value in a question which requires a data value, then award full marks in the subsequent answer for a correct response that uses **either** the candidate's wrong value **or** the correct data value. For example:

(a) State the speed of microwaves in air.
Candidate's answer: *340 m s^{-1}*. This answer would attract zero marks.

(b) Calculate the distance travelled by these microwaves in 0·34 seconds.
The candidate may use **either** the value given in part (a) **or** the correct value for the speed, and could gain full marks if correctly completed.

Where an incorrect answer may be carried forward, this is indicated in the additional guidance column of the detailed marking instructions by the comment 'or consistent with part ...'.

Standard three marker
The examples below set out how to apportion marks to answers requiring calculations. These are the 'standard three marker' type of questions.

Award full marks for a correct answer to a numerical question, even if the steps are not shown explicitly, **unless** it specifically requires evidence of working to be shown.

For some questions requiring numerical calculations, there may be alternative methods (eg alternative relationships) which would lead to a correct answer.

Sometimes, a question requires a calculation which does not fit into the 'standard three marker' type of response. In these cases, the detailed marking instructions will contain guidance for marking the question.

When marking partially correct answers, apportion individual marks as shown below.

Example of a 'standard three marker' question
The current in a resistor is 1·5 amperes when the potential difference across it is 7·5 volts. Calculate the resistance of the resistor. (3 marks)

	Candidate answer	**Mark and comment**
1.	$V = IR$ 7·5 = 1·5 × R R = 5·0 Ω	1 mark: relationship 1 mark: substitution 1 mark: correct answer
2.	5·0 Ω	3 marks: correct answer
3.	5·0	2 marks: unit missing

4. $4{\cdot}0\ \Omega$ — 0 marks: no evidence, wrong answer

5. $\_\_\ \Omega$ — 0 marks: no working or final answer

6. $R = \frac{V}{I} = \frac{7{\cdot}5}{1{\cdot}5} = 4{\cdot}0\ \Omega$ — 2 marks: arithmetic error

7. $R = \frac{V}{I} = 4{\cdot}0\ \Omega$ — 1 mark: relationship only

8. $R = \frac{V}{I} = \_\_\ \Omega$ — 1 mark: relationship only

9. $R = \frac{V}{I} = \frac{7{\cdot}5}{1{\cdot}5} = \_\_\ \Omega$ — 2 marks: relationship and substitution, no final answer

10. $R = \frac{V}{I} = \frac{7{\cdot}5}{1{\cdot}5} = 4{\cdot}0$ — 2 marks: relationship and substitution, wrong answer

11. $R = \frac{V}{I} = \frac{1{\cdot}5}{7{\cdot}5} = 5{\cdot}0\ \Omega$ — 1 mark: relationship but wrong substitution

12. $R = \frac{V}{I} = \frac{75}{1{\cdot}5} = 5{\cdot}0\ \Omega$ — 1 mark: relationship but wrong substitution

13. $R = \frac{I}{V} = \frac{7{\cdot}5}{1{\cdot}5} = 5{\cdot}0\ \Omega$ — 0 marks: wrong relationship

14. $V = IR$
$7{\cdot}5 = 1{\cdot}5 \times R$
$R = 0{\cdot}2\ \Omega$ — 2 marks: relationship and substitution, arithmetic error

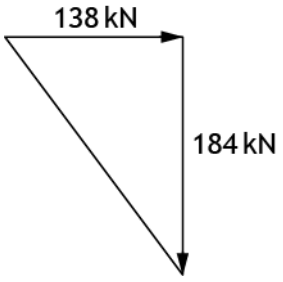
15. $V = IR$
$R = \frac{I}{V} = \frac{1{\cdot}5}{7{\cdot}5} = 0{\cdot}2\ \Omega$ — 1 mark: relationship only, wrong rearrangement of symbols

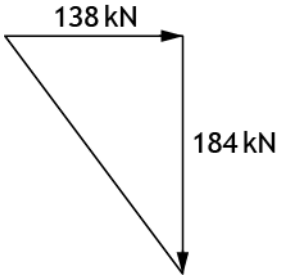
Marking instructions for each question

Section 1

Question	Answer	Mark
1.	E	**1**
2.	D	**1**
3.	E	**1**
4.	C	**1**
5.	A	**1**
6.	C	**1**
7.	D	**1**
8.	A	**1**
9.	D	**1**
10.	C	**1**
11.	E	**1**
12.	D	**1**
13.	A	**1**
14.	C	**1**
15.	B	**1**
16.	C	**1**
17.	C	**1**
18.	B	**1**
19.	E	**1**
20.	B	**1**
21.	A	**1**
22.	C	**1**
23.	A	**1**
24.	B	**1**
25.	B	**1**

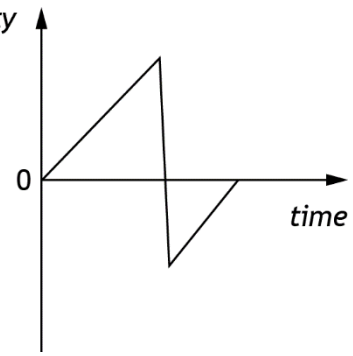
Section 2

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i) (A)	**Using scale diagram:**  Vectors to scale **(1)** Resultant = 230 kN (allow ±10 kN) **(1)** **Using Pythagoras:** Resultant^2 = 184^2 + 138^2 **(1)** Resultant = 230 kN **(1)**	**2**	Regardless of method, if a candidate shows a vector diagram (or a representation of a vector diagram eg a triangle with no arrows) and the vectors have been added incorrectly, eg head-to-head then MAX (1). Ignore any direction stated in the final answer in this part. Can obtain first mark for scale diagram method from suitable diagram in part (a) (i) (B) if not drawn in this part.

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i) (B)	**Using scale diagram:**  Angles correct **(1)** direction = 143 **(1)** (allow ±2° tolerance) **Using trigonometry:** $tan\theta = \frac{184}{138}$ **(1)** $(\theta = 53{\cdot}1°)$ direction = 143 **(1)**	**2**	Or use of the magnitude of the resultant consistent with (a)(i) (A) Regardless of method, if a candidate (re)draws a vector diagram (or a representation of a vector diagram eg a triangle with no arrows) in this part and the vectors have been added incorrectly, eg head-to-head then MAX (1). Alternative method: $tan\theta = \frac{138}{184}$ **(1)** $(\theta = 36{\cdot}9°)$ direction = 143 **(1)** Accept: 53° S of E 37° E of S Ignore the degree symbol if direction is stated as a bearing. Can also do with other trig functions, eg $\sin\theta = \frac{184}{230}$ or $\cos\theta = \frac{138}{230}$ Can obtain first mark for scale diagram method from suitable diagram in part (a) (i) (A) if not drawn in this part. Accept: 53° S of E 53·1° S of E 143 53.13° S of E 143·1 53·130° S of E 143·13
		(ii)	$F = ma$ **(1)** $230\,000 = 6{\cdot}8 \times 10^4 \times a$ **(1)** $a = 3{\cdot}4\ m\,s^{-2}$ **(1)**	**3**	Or resultant consistent with (a)(i)(A) Ignore any direction stated. Accept 1-4 sig fig: $3\ m\,s^{-2}$ $3{\cdot}4\ m\,s^{-2}$ $3{\cdot}38\ m\,s^{-2}$ $3{\cdot}382\ m\,s^{-2}$

Question			Expected response	Max mark	Additional guidance
1.	(b)		Mass/weight/(downward) force is less. **(1)** pressure is force/weight per unit area. **(1)**	**2**	Second mark is dependent upon the first. Accept $p = \frac{F}{A}$ for second mark. Accept: 'lighter'

Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	Time for card to cut/pass through light gate X **(1)**	**1**	Do not accept: • 'time from electronic timer' alone • 'time from light gate X' • 'time for trolley to go down ramp' • 'time for trolley to cut beam' – it is the card that cuts the beam Apply +/- rule for surplus answers. However, ignore mention of measurement of 'length of card'.
		(ii)	$v = \frac{length\ of\ card}{time\ for\ card\ to\ cut\ beam}$ **(1)** $v = \frac{0{\cdot}045}{0{\cdot}098}$ **(1)** $v = 0{\cdot}46\ m\,s^{-1}$	**2**	**'Show' question** Must start with the correct relationship or (0). Final answer of $0{\cdot}46\ m\,s^{-1}$, including unit, must be shown, otherwise MAX (1). Accept: $v = \frac{d}{t}$ or $v = \frac{s}{t}$ or $\bar{v} = \frac{d}{t}$ or $\bar{v} = \frac{s}{t}$ if substitutions are correct.
		(iii)	$a = \frac{v\ -\ u}{t}$ **(1)** $a = \frac{0{\cdot}46\ -\ 0{\cdot}32}{0{\cdot}56}$ **(1)** $a = 0{\cdot}25\ m\,s^{-2}$ **(1)**	**3**	Accept: $a = \frac{\Delta v}{t}$ or $v = u + at$ Do not accept: $a = \frac{v}{t}$ or $v = at$ Accept 1-4 sig fig: $0{\cdot}3\ m\,s^{-2}$ $0{\cdot}25\ m\,s^{-2}$ $0{\cdot}250\ m\,s^{-2}$ $0{\cdot}2500\ m\,s^{-2}$
	(b)		$distance = area\ under\ graph$ **(1)** $= \frac{1}{2} \times 2{\cdot}4 \times 0{\cdot}60$ **(1)** $= 0{\cdot}72\ m$ **(1)**	**3**	Accept 1-4 sig fig: 0·7 m 0·72 m 0·720 m 0·7200 m Accept: $s = \bar{v}t$ or $d = \bar{v}t$ $s = vt$ or $d = vt$, provided substitution of average velocity/speed is correct.

Question			Expected response	Max mark	Additional guidance
2.	(c)		 Line with negative gradient to cross time axis to negative value of velocity **(1)** Line with positive gradient to return to intercept time axis **(1)**	**2**	First mark can be awarded for vertical line crossing time axis. Ignore any numerical values. Line should not continue beyond the time when the trolley reaches its maximum height.

Question			Expected response	Max mark	Additional guidance
3.	(a)		$E_k = ½\ mv^2$ **(1)** $E_k = ½ \times 75 \times 8{\cdot}0^2$ **(1)** $E_k = 2400$ J **(1)**	**3**	
	(b)	(i)	$E_p = mgh$ **(1)** $2400 = 75 \times 9{\cdot}8 \times h$ **(1)** $h = 3{\cdot}3$ m **(1)**	**3**	Or consistent with (a) Accept 1-4 sig fig: 3 m 3·27 m 3·265 m
		(ii)	Energy lost (as heat and sound) due to friction/air resistance	**1**	
	(c)	(i)	Curved path	**1**	Do not accept an indication of competitor and bike rising.
		(ii)	$a = \frac{v-u}{t}$ **(1)** $9{\cdot}8 = \frac{v-0}{0{\cdot}40}$ **(1)** $v = 3{\cdot}9$ m s^{-1} **(1)**	**3**	Accept: $a = \frac{\Delta v}{t}$ OR $v = u + at$ Do not accept a response starting with $a = \frac{v}{t}$ OR $v = at$ Accept 1-4 sig figs: 4 m s^{-1} 3·92 m s^{-1} 3·920 m s^{-1}

Question			Expected response	Max mark	Additional guidance
4.	(a)	(i)	$d = (1{\cdot}50 \times 10^{11} \times 1{\cdot}52)$ $= 2{\cdot}28 \times 10^{11}$ (m)	**1**	Unit not required but if stated must be correct. Accept 2-5 sig figs: $2{\cdot}3 \times 10^{11}$ $2{\cdot}280 \times 10^{11}$ $2{\cdot}2800 \times 10^{11}$
		(ii)	$d = vt$ (1) $2{\cdot}28 \times 10^{11} = 3{\cdot}0 \times 10^{8} \times t$ (1) $t = 760$ s (1)	**3**	Or consistent with (a)(i) Accept 1-4 sig figs: 800 s 760·0 s
	(b)	(i)	Solar cells	**1**	Accept: solar panels Radioisotope Thermoelectric Generator (RTG) nuclear reactors or other suitable answer Solar energy/power alone is insufficient. Nuclear energy/power/reactions alone is insufficient. (Rechargeable) batteries/cells alone is insufficient.
		(ii)	Manoeuvring in zero friction environment **OR** Fuel load on take-off **OR** Potential exposure to radiation **OR** Pressure differential **OR** Re-entry through an atmosphere	**1**	Accept any other suitable answer. Do not accept: 'it takes a long time' alone 'cost'

Question			Expected response	Max mark	Additional guidance
5.			Demonstrates no understanding 0 marks Demonstrates limited understanding 1 mark Demonstrates reasonable understanding 2 marks Demonstrates good understanding 3 marks This is an open-ended question. **1 mark:** The candidate has demonstrated a limited understanding of the physics involved. The candidate has made some statement(s) which is/are relevant to the situation, showing that at least a little of the physics within the problem is understood. **2 marks**: The candidate has demonstrated a reasonable understanding of the physics involved. The candidate makes some statement(s) which is/are relevant to the situation, showing that the problem is understood. **3 marks:** Award the maximum available mark to a candidate who has demonstrated a good understanding of the physics involved. The candidate shows a good comprehension of the physics of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. This does not mean the answer has to be what might be termed an 'excellent' answer or a 'complete' one.	**3**	Open-ended question: a variety of physics arguments can be used to answer this question. Marks are awarded on the basis of whether the answer overall demonstrates 'no', 'limited', 'reasonable' or 'good' understanding.

Question			Expected response	Max mark	Additional guidance
6.	(a)		$V_2 = \frac{R_2}{R_1 + R_2} \times V_s$ **(1)** $V_2 = \frac{18}{18 + 2 \cdot 0} \times 4 \cdot 0$ **(1)** $V_2 = 3 \cdot 6$ V **(1)**	**3**	**Method 2:** $V = IR$ $4 \cdot 0 = I \times (18 + 2 \cdot 0)$ $(I = 0 \cdot 2$ A) $V = IR$ $= 0 \cdot 2 \times 18$ $= 3 \cdot 6$ V (1) mark for Ohm's Law (even if only seen once) (1) mark for all substitutions (1) mark for final answer including unit **Method 3:** $\frac{V_1}{V_2} = \frac{R_1}{R_2}$ (1) $\frac{V_1}{4 \cdot 0} = \frac{18}{20}$ (1) $V_1 = 3 \cdot 6$ V (1) Accept 1-4 sig figs: 3·60 V 3·600 V Only accept 4 V if there is clear evidence of working and the final value being rounded to 1 sig fig.
	(b)	(i)	To reduce/limit the current (in the LED)	**1**	Accept: To reduce the voltage **across** the LED OR To protect/prevent damage to the LED

Question			Expected response	Max mark	Additional guidance
6.	(b)	(ii)	$V = 3{\cdot}4 - 1{\cdot}6$ **(1)** $(= 1{\cdot}8\ \text{V})$ $V = IR$ **(1)** $1{\cdot}8 = 25 \times 10^{-3} \times R$ **(1)** $R = 72\ \Omega$ **(1)**	**4**	Calculation of voltage across LED may be implied by correct substitution. If no attempt to calculate the voltage across LED, or incorrect substitution to calculate the voltage across LED, then MAX (1) for relationship. If clear arithmetic error in calculation of voltage across LED then MAX (3). Accept 1–4 sig figs: 70 Ω 72·0 Ω 72·00 Ω
	(c)		$Q = It$ **(1)** $= 0{\cdot}135 \times 6{\cdot}0 \times 60 \times 60$ **(1)** $= 2900\ \text{C}$ **(1)**	**3**	Accept 1-4 sig figs: 3000 C 2920 C 2916 C

Question			Expected response	Max mark	Additional guidance
7.			Demonstrates no understanding 0 marks Demonstrates limited understanding 1 mark Demonstrates reasonable understanding 2 marks Demonstrates good understanding 3 marks This is an open-ended question. **1 mark:** The candidate has demonstrated a limited understanding of the physics involved. The candidate has made some statement(s) which is/are relevant to the situation, showing that at least a little of the physics within the problem is understood. **2 marks**: The candidate has demonstrated a reasonable understanding of the physics involved. The candidate makes some statement(s) which is/are relevant to the situation, showing that the problem is understood. **3 marks:** Award the maximum available mark to a candidate who has demonstrated a good understanding of the physics involved. The candidate shows a good comprehension of the physics of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. This does not mean the answer has to be what might be termed an 'excellent' answer or a 'complete' one.	**3**	Open-ended question: a variety of physics arguments can be used to answer this question. Marks are awarded on the basis of whether the answer overall demonstrates 'no', 'limited', 'reasonable' or 'good' understanding.

Question			Expected response	Max mark	Additional guidance
8.	(a)	(i)	$E_h = cm\Delta T$ **(1)** $21\ 600 = c \times 0{\cdot}50 \times (24-16)$ **(1)** $c = 5\ 400\ \text{J kg}^{-1}\ ^\circ\text{C}^{-1}$ **(1)**	**3**	Calculation of temperature change may be implied by correct substitution. If no attempt to calculate the temperature change, or incorrect substitution to calculate the temperature change, then MAX (1) for relationship. If clear arithmetic error in calculation of temperature change then MAX (2). Accept 1–4 sig figs: 5 000 J kg^{-1} $^\circ C^{-1}$
		(ii)	Heat (energy) is lost to the surroundings/to air. OR some of the heat (energy) is used to heat up the heater/beaker.	**1**	Accept: not all the heat (energy) is transferred into the water. Do not accept: 'heat loss' alone – it must be clear where it is going.
	(b)		$P = IV$ **(1)** $= 4{\cdot}0 \times 12$ $= 48\ (\text{W})$ $P = \frac{E}{t}$ **(1)** $48 = \frac{21600}{t}$ **(1)** $t = 450\ \text{s}$ **(1)**	**4**	(1) each relationship (1) for all substitutions (1) final answer and unit Alternative method: $E = ItV$ (1)+(1) $21\ 600 = 4{\cdot}0 \times t \times 12$ (1) $t = 450\ \text{s}$ (1) Accept 1–4 sig figs: 500 s 450·0 s
	(c)		(Measure the) mass of water evaporated. **(1)** (Measure the) energy supplied. **(1)** $E_h = ml$ **(1)**	**3**	Independent marks Accept: 'loss in mass' 'difference in mass' Do not accept: 'reading on joulemeter' alone Do not accept: answers that involve using additional apparatus to measure the energy (eg stopclocks, ammeters and voltmeters).

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	All four substitutions for $\frac{p}{T}$ OR $\frac{T}{p}$ **(1)** All values calculated correctly **(1)** For $\frac{p}{T}$: $\frac{101\times10^3}{293} = 345$ $\frac{107\times10^3}{313} = 342$ $\frac{116\times10^3}{333} = 348$ $\frac{122\times10^3}{353} = 346$ For $\frac{T}{p}$: $\frac{293}{101\times10^3} = 0{\cdot}00290$ $\frac{313}{107\times10^3} = 0{\cdot}00293$ $\frac{333}{116\times10^3} = 0{\cdot}00287$ $\frac{353}{122\times10^3} = 0{\cdot}00289$ Statement of: $\frac{p}{T} = constant$ OR $\frac{T}{p} = constant$ OR $\frac{p_1}{T_1} = \frac{p_2}{T_2}$ OR p is (directly) proportional to T (in kelvin) **(1)**	**3**	If only 1 or 0 sets of data used (0) for entire question Substitutions may be implied by all four calculated values. For the second mark, values must be calculated correctly for all substitutions shown by the candidate (minimum of using at least two sets of data). Accept 2-5 sig figs in all calculated values. Conversion from kPa to Pa not required. Mark for $\frac{p}{T} = \text{constant}$ can only be accessed if the candidate has completed calculations using a minimum of two sets of data, however the relationship must be supported by all the candidate's calculated values. Do not accept $\frac{pV}{T} = constant$ **Graphical method:** Must be on graph paper for any marks to be awarded suitable scales, labels and units (1) all points plotted accurately to ±half a division and line of best fit (1) relationship stated (1)

Question			Expected response	Max mark	Additional guidance
					Alternative method: If candidate uses $\frac{p_1}{T_1} = \frac{p_2}{T_2}$ to verify values of pressures or temperatures in the table then they must make it clear that the calculated value is approximately the same as the value in the table for any marks to be awarded. Thereafter: All four sets of data linked (minimum of three calculations) (1) All calculations correct (1) Relationship stated and supported (1)
9.	(a)	(ii)	(The increase in temperature) increases the kinetic energy of the gas particles/the particles move faster. **(1)** The particles hit the container/walls more frequently. **(1)** The particles hit the container/walls with greater force. **(1)**	**3**	Independent marks Accept: 'atoms'/'molecules' in place of 'particles' Do not accept: 'particles hit the container/walls more' alone
		(iii)	Any single value between 83 kPa and 89 kPa inclusive	**1**	Unit must be stated Excessive sig figs should be ignored.
	(b)		Have more of the flask under the water, **(1)** so that the gas is at the same temperature/evenly heated **(1)** **OR** Reduce the length/diameter/volume of the connecting tube **(1)** so that the gas is at the same temperature/evenly heated **(1)**	**2**	Accept: Place the temperature sensor in the flask (1) So that the temperature of the gas is being measured (1) Accept: 'so that all the gas is being heated' Do not accept: 'repeat measurements' – it is an improvement to the set up that is required

Question			Expected response	Max mark	Additional guidance
10.	(a)		$d = vt$ **(1)** $d = 3{\cdot}0 \times 10^{8} \times 2{\cdot}1 \times 10^{-8}$ **(1)** $d = 6{\cdot}3$ m **(1)**	**3**	Accept 1-4 sig figs: 6 m 6·30 m 6·300 m
	(b)	(i)	(Particle) vibrations/oscillations are in the same direction as the energy transfer. **OR** (Particle) vibrations/oscillations are in the same direction as the wave is travelling.	**1**	Accept: 'particles move forward and backward/to and fro' to indicate a vibration. Do not accept: 'particles move in the same direction...'.
		(ii)	$(\lambda = \frac{0{\cdot}272}{4})$ $\lambda = 0{\cdot}068$ m **(1)**	**1**	Unit must be stated.
		(iii)	$v = f\lambda$ **(1)** $340 = f \times 0{\cdot}068$ **(1)** $f = 5000$ Hz **(1)**	**3**	Or consistent with (b)(ii) Accept 1-4 sig figs

Question			Expected response	Max mark	Additional guidance
11.	(a)		Any one of: • photodiode • phototransistor • thermistor • LDR • thermocouple • thermopile • CCD.	**1**	Do not accept: • skin • (infrared) camera • (thermal imaging) camera • photographic film • thermogram • (black bulb) thermometer • thermochromic film. Apply +/- rule for surplus answers.
	(b)		$N = 54$ **(1)** $f = \frac{N}{t}$ **(1)** $f = \frac{54}{60}$ **(1)** $f = 0 \cdot 90$ Hz	**3**	**'Show' question** Must state the correct relationship or MAX (1) for identifying $N = 54$. Final answer of 0·90 Hz or 0·9 Hz, including unit, must be shown, otherwise MAX (2). **Alternative method:** Marks can only be awarded for this method if substitution for calculation of the period is shown. $T = \frac{60}{54} (= 1 \cdot 11)$ **(1)** $f = \frac{1}{T}$ **(1)** $f = \frac{1}{1 \cdot 11}$ **(1)** $f = 0 \cdot 90$ Hz For alternative methods calculating N or t, there must be a final statement to show the calculated value of N or t is the same as the value stated in the question.
	(c)	(i) (A)	Normal drawn and labelled	**1**	Must be 'passably' perpendicular and straight and must appear in both materials. Does not need to be dashed Accept: 'N', 'n' or 'A' as label

Question			Expected response	Max mark	Additional guidance
11.	(c)	(i) (B)	Both angles indicated and labelled	**1**	Accept: i and r I and R θ_i and θ_r If normal has been incorrectly drawn, then this mark is still accessible, provided angles are indicated to the normal within each material and labelled.
		(ii)	(Wavelength in water is) greater (than in glass). **(1)** Speed of light (in water) is greater (than in glass). **(1)**	**2**	First mark can only be awarded if justification is attempted Effect correct + justification correct (2) Effect correct + justification incomplete (1) Effect correct + justification incorrect (wrong physics) (0) Effect correct + no justification attempted (0) Incorrect or no effect stated regardless of justification (0) Accept: 'refractive index in water is less than glass' 'water is less optically dense than glass' for justification The effect can be justified by appropriate calculations.

Question			Expected response	Max mark	Additional guidance
12.	(a)		Fast/high-energy electron	**1**	Accept: 'an electron from the nucleus' Do not accept: 'electron' alone
	(b)		Activity of tritium source is less/ fewer beta particles emitted per second. **(1)** Less light produced **(1)**	**2**	Independent marks Accept: 'activity will have halved'. Do not accept: 'radioactivity' in place of activity.
	(c)	(i)	$D = \frac{E}{m}$ **(1)** $0 \cdot 40 \times 10^{-3} = \frac{E}{85}$ **(1)** $E = 0 \cdot 034\,\text{J}$ **(1)**	**3**	Accept 1-4 sig figs: 0·03 J 0·0340 J 0·03400 J
		(ii)	$H = Dw_r$ **(1)** $= 0 \cdot 40 \times 10^{-3} \times 1$ **(1)** $= 4 \cdot 0 \times 10^{-4}\,\text{Sv}$ **(1)**	**3**	Accept 1–4 sig figs: 4×10^{-4} Sv $4{\cdot}00 \times 10^{-4}$ Sv $4{\cdot}000 \times 10^{-4}$ Sv

Question			Expected response	Max mark	Additional guidance
13.	(a)	(i)	The counter reading will include the source and background count. **OR** Background will need to be subtracted. **OR** To measure/determine the count rate due to the source.	**1**	
		(ii)	Any suitable source	**1**	Apply +/- rule for surplus answers. Do not accept: Cosmic Microwave Background Radiation.
	(b)	(i)	Suitable scales, labels and units **(1)** All points plotted accurately to ±half a division **(1)** Best fit curve **(1)**	**3**	A non-linear scale on either axis prevents access to any marks. (0) No marks for a bar graph (0) Axes can be transposed
		(ii)	30 minutes	**1**	Or consistent with best fit curve from (b)(i) Or consistent with best fit line or dot-to-dot line ±Half a division tolerance Unit must be stated.
	(c)	(i)	Reduce the distance (between the detector and the source). **(1)** Alpha is absorbed by a few cm of air/range in air is a few cm. **OR** Alpha has a shorter range (than gamma). **(1)**	**2**	Suggestion must be correct, otherwise (0 marks). Accept: 'move the source closer (to the detector)'. Do not accept: 'alpha is weaker/gamma is stronger'.
		(ii)	$A = \frac{N}{t}$ **(1)** $520 = \frac{N}{15}$ **(1)** $N = 7800$ **(1)**	**3**	No unit required but if wrong unit stated MAX (2). Accept 1–4 sig figs: 8000

[END OF MARKING INSTRUCTIONS]