National Qualifications 2022

2022 Physics

National 5

Finalised Marking Instructions

These marking instructions have been prepared by examination teams for use by SQA appointed markers when marking external course assessments.

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 marking principles, the Physics: general marking principles (GMPs) (http://www.sqa.org.uk/files_ccc/Physicsgeneralmarkingprinciples.pdf) 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 must seek guidance from your team leader.

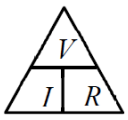
(d) Where a wrong answer to part of a question is carried forward and the wrong answer is then used correctly in the following part, give the candidate credit for the subsequent part or 'follow-on'. (GMP 17)

(e) 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. (GMP 22)

(f) 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. (GMP 1)

(g) 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). (GMP 19)

(h) Marks are allocated for knowledge of relevant formulae alone. Do not award a mark when a candidate writes down several formulae and does not select the correct one to continue with, for example by substituting values. (GMP 3)

(i) 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. (GMP 6)

(k) In rounding to an expected number of significant figures, award the mark for correct answers that have up to two figures more or one figure less than the number in the data with the fewest significant figures. (GMP 10)
(Note: the use of a recurrence dot, eg $0.\dot{6}$, 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. (GMP 25)

(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 or aspect 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 that arise when considering candidates' answers.

There is often a range of acceptable responses that 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 that offer guidance for interpreting candidates' responses. They may also contain advice on answers that are **not** acceptable, or only attract partial marks.

Units

Do not penalise use of upper/lower case when the abbreviated version is given, as long as it can be clearly identified, eg DB, sV, hZ, bq.

However, 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}. (GMP 14)

If d = 4 km and t = 2 minutes

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

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

$$v = 200 \qquad \textbf{(0)}$$

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 incorrect abbreviations in answers to numerical questions.
When the abbreviation can be confused with a different unit then the final mark cannot be awarded, 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^{-1}, m/s	mps, m/s^{-1}
metres per second per second, m s^{-2}, m/s^2	m/s/s, mpsps, m/s^{-2}
joules per kilogram per degree celsius, J kg^{-1} $°C^{-1}$, J/kg °C	J/kg/°C

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 $t = 4 \times 10^5$ s would be correct but $t = 4^5$ s would be treated as an arithmetic error. (GMP 13)

Incorrect answer carried forward (GMP 17)

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 that 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: *240 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 completed correctly.

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 ...'.

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 e.g in a 'show' question.

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

Sometimes, a question requires a calculation that 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 over the page.

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)

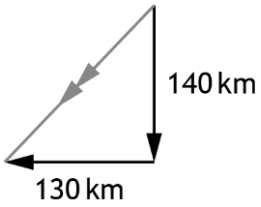
	Example response	Mark and comment
1.	$V = IR$ $7.5 = 1.5R$ $R = 5.0\ \Omega$	1 mark: relationship 1 mark: substitution 1 mark: correct answer
2.	$5.0\ \Omega$	3 marks: correct answer
3.	5.0	2 marks: unit missing
4.	$4.0\ \Omega$	0 marks: no evidence, wrong answer
5.	$\_\_\ \Omega$	0 marks: no working or final answer
6.	$R = \frac{V}{I} = \frac{7.5}{1.5} = 4.0\ \Omega$	2 marks: arithmetic error
7.	$R = \frac{V}{I} = 4.0\ \Omega$	1 mark: relationship only
8.	$R = \frac{V}{I} = \_\_\ \Omega$	1 mark: relationship only
9.	$R = \frac{V}{I} = \frac{7.5}{1.5} = \_\_\ \Omega$	2 marks: relationship and substitution, no final answer
10.	$R = \frac{V}{I} = \frac{7.5}{1.5} = 4.0$	2 marks: relationship and substitution, wrong answer
11.	$R = \frac{V}{I} = \frac{1.5}{7.5} = 5.0\ \Omega$	1 mark: relationship but wrong substitution
12.	$R = \frac{V}{I} = \frac{75}{1.5} = 5.0\ \Omega$	1 mark: relationship but wrong substitution
13.	$R = \frac{I}{V} = \frac{1.5}{7.5} = 5.0\ \Omega$	0 marks: wrong relationship
14.	$V = IR$ $7.5 = 1.5 \times R$ $R = 0.2\ \Omega$	2 marks: relationship and substitution, arithmetic error
15.	$V = IR$ $R = \frac{I}{V} = \frac{1.5}{7.5} = 0.2\ \Omega$	1 mark: relationship correct but wrong rearrangement of symbols

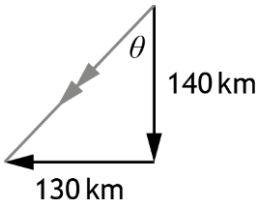
Marking instructions for each question

Section 1

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

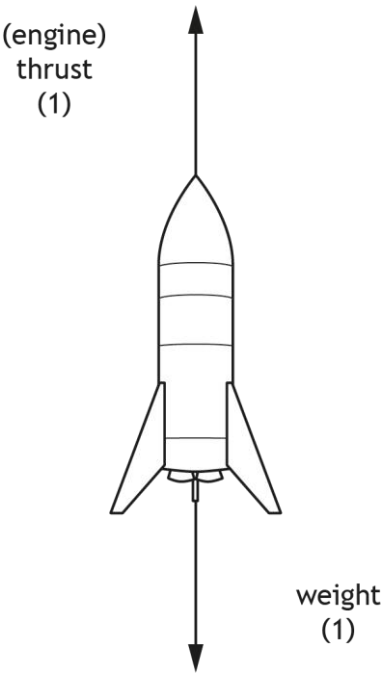
Section 2

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i)	**Using scale diagram:**  Vectors to scale **(1)** Resultant = 190 km (allow ±5 km) **(1)** **Using Pythagoras:** Resultant^2 = $140^2 + 130^2$ **(1)** Resultant = 190 km **(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. Accept: 200 191 191.0

Question			Expected response	Max mark	Additional guidance
1.	(a)	(ii)	**Using scale diagram:**  vectors to scale **(1)** direction = 223 **(1)** (allow ±2° tolerance) **Using trigonometry:** $\tan\theta = \frac{130}{140}$ **(1)** $(\theta = 43°)$ $\text{bearing} = (180 + 43) = 223$ **(1)**	**2**	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 methods:** $\tan\theta = \frac{140}{130}$ (1) $(\theta = 47°)$ $\text{bearing} = (270 - 47) = 223$ (1) Accept: 47° S of W 43° W of S Ignore the degree symbol if direction is stated as a bearing. Can also do with other trig functions, eg $\sin\theta = \frac{130}{190}$ or $\cos\theta = \frac{140}{190}$ Or use of the magnitude of the resultant consistent with (a)(i) Can obtain first mark for scale diagram method from suitable diagram in part (a)(i) if not drawn in this part. However, the candidate must attempt an answer in this part. Ignore any magnitude stated in the final answer in this part. Accept: 220 222.9 222.88 40° W of S 42.9° W of S 42.88° W of S

Question			Expected response	Max mark	Additional guidance
1.	(b)	(i)	$d = \bar{v}t$ **(1)** $190000 = \bar{v} \times (0.50 \times 60 \times 60)$ **(1)** $\bar{v} = 110 \text{ ms}^{-1}$ **(1)**	**3**	Or consistent with (a)(i) Accept $s = \bar{v}t$ provided it is followed by a substitution of the value for distance. Bar not required above *v*. Accept: 380 km h^{-1} Accept: 100 106 105.6
		(ii)	110 m s^{-1} **(1)** At 043 **(1)**	**2**	Or magnitude consistent with (b)(i) and/or direction consistent with (a)(ii). Or calculation using displacement consistent with (a)(i) for magnitude Accept: 43° E of N 47° N of E

Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	Suitable scales, labels, and units **(1)** All points plotted accurately to ±half a division **(1)** Best fit straight line **(1)**	**3**	A non-linear scale on either axis prevents access to any marks. (0) Allow broken axes from origin (with or without symbol), but scale must be linear across data range. Axes can be transposed. A bar chart/histogram can obtain MAX (1) for scales, labels, and units.
		(ii)	0.57 m	**1**	**Must** be consistent with the line the candidate has drawn. If the candidate has used a non-linear scale in (a)(i) this mark cannot be accessed. If the candidate has not shown a line in (a)(i) this mark cannot be accessed. ± half a division tolerance Unit must be stated.
		(iii)	Place carbon paper under landing site **OR** Place sand tray under landing site **OR** Use video analysis	**1**	Any sensible answer that could allow the landing point to be clearly identified, within a school/college setting. Do not accept 'place a ruler/grid' alone.
	(b)	(i)	Any suitable variable	**1**	Apply +/- rule for surplus answers. Do not accept: Release height (of marble) Speed/velocity (of marble)
		(ii)	Description of how independent variable will be changed. **(1)** Indication of how a fair test is achieved. **(1)**	**2**	If candidate has stated speed/velocity in (b)(i) then allow a description of how a variable, other than release height, that affects speed/velocity could be investigated.

Question			Expected response	Max mark	Additional guidance
3.	(a)	(i)	$W = mg$ (1) $W = 1.3 \times 10^6 \times 3.7$ (1) $W = 4.8 \times 10^6$ N (1)	**3**	Accept: 5×10^6 4.81×10^6 4.810×10^6
		(ii)		**2**	(1) for each force correctly labelled with corresponding direction. Accept if arrows do not touch spaceship. Accept: 'rocket thrust' 'force from exhaust gases on rocket' 'force due to gravity' 'gravitational pull' 'pull of gravity' Do not accept: 'upward force' alone 'gravitational field strength' alone 'gravity' alone 'upthrust' Ignore friction/air resistance/drag Ignore horizontal forces Where a candidate has identified more than two vertical forces, apply +/- rule for other vertical forces eg reaction force from ground.
		(iii)	$(F_{un} = \text{engine thrust - weight})$ $F_{un} = 1.2 \times 10^7 - 4.8 \times 10^6$ **(1)** $(F_{un} = 7.2 \times 10^6$ N$)$ $F = ma$ **(1)** $7.2 \times 10^6 = 1.3 \times 10^6 \times a$ **(1)** $a = 5.5$ ms^{-2} **(1)**	**4**	Or consistent with (a)(i) Calculation of unbalanced force may be implied by correct substitution. If no attempt to calculate the unbalanced force, then MAX (1) for the relationship. If clear arithmetic error in calculation of unbalanced force, then MAX (3). Accept: 6 5.54 5.538

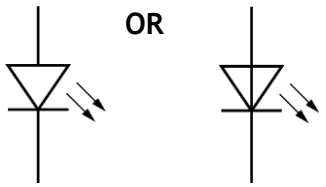
Question			Expected response	Max mark	Additional guidance
3.	(b)		Acceleration increases **(1)** Weight/mass decreases (as fuel is used) **OR** Gravitational field strength decreases **(1)**	**2**	Look for this first, otherwise (0) marks Accept: 'Air resistance' reduces (as altitude increases)

Question			Expected response	Max mark	Additional guidance
4.			**Award 3 marks** where the candidate has demonstrated a good understanding of the physics involved. They show a good comprehension of the physics of the situation and provide 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. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks. **Award 2 marks** where the candidate has demonstrated a reasonable understanding of the physics involved. They make some statement(s) that are relevant to the situation, showing that they have understood the problem. **Award 1 mark** where the candidate has demonstrated a limited understanding of the physics involved. They make some statement(s) that are relevant to the situation, showing that they have understood at least a little of the physics within the problem. **Award 0 marks** where the candidate has not demonstrated an understanding of the physics involved. There is no evidence that they have recognised the area of physics involved, or they have not given any statement of a relevant physics principle. Award this mark also if the candidate merely restates the physics given in the question.	**3**	Candidates may use a variety of physics arguments to answer this question. Award marks based on candidates demonstrating overall good, reasonable, limited, or no understanding.

Question			Expected response	Max mark	Additional guidance
5.	(a)	(i)	$d = vt$ **(1)** $d = 3.0 \times 10^8$ $\times (860 \times 365.25 \times 24 \times 60 \times 60)$ **(1)** $d = 8.1 \times 10^{18}$ (m) **(1)**	**3**	This is not a Standard Three Marker. Calculation can be carried out in steps, but all steps must be done for the substitution mark to be awarded, eg calculation of distance for one light-year, followed by multiplying this by 860. Unit in final answer not required, but if stated, must be correct. Accept: 8×10^{18} 8.14×10^{18} 8.142×10^{18} Also accept if using 365 days 8.136×10^{18}
		(ii)	$\left(v = \frac{5}{100} \times 3.0 \times 10^8\right)$ $v = 1.5 \times 10^7$ ms^{-1} **(1)**	**1**	
		(iii)	$d = vt$ **(1)** $8.1 \times 10^{18} = 1.5 \times 10^7 \times t$ **(1)** $t = 5.4 \times 10^{11}$ s **(1)**	**3**	Or consistent with (a)(i) and/or (a)(ii) Accept: 5×10^{11} 5.40×10^{11} 5.400×10^{11}
	(b)		Light/EM radiation will take 860 years to reach Earth. **OR** The light/EM radiation from the supernova has not reached Earth yet.	**1**	Or similar Do not accept explanation in terms of distance alone, rather than time, eg 'it is 860 light-years away' Do not award mark if response refers to the time taken for the debris to reach Earth.
	(c)	(i)	line (spectrum)	**1**	Accept: absorption (spectrum)
		(ii)	(Lines in) this spectrum can be matched/compared with (lines in) the spectrum from the element.	**1**	Or similar Accept: Each element has a unique spectrum/pattern of lines

Question			Expected response	Max mark	Additional guidance
6.	(a)		Resistor 1 **(1)** Lower resistance (therefore greater current) **(1)**	**2**	MUST JUSTIFY Resistor correct + justification correct (2) Resistor correct + justification incomplete (1) Resistor correct + justification incorrect (wrong physics) (0) Resistor correct + no justification attempted (0) Incorrect or no resistor stated, regardless of justification (0) Accept justification by appropriate calculation for both resistors.
	(b)		$V_2 = \left(\frac{R_2}{R_1 + R_2}\right) \times V_S$ **(1)** $V_2 = \left(\frac{4.0}{16.0 + 4.0}\right) \times 6.0$ **(1)** $V_2 = 1.2$ V **(1)**	**3**	Accept: 1 1.20 1.200 **Method 2:** $V = IR$ $6.0 = I \times 20.0$ $(I = 0.3$ A) $V = IR$ $V = 0.3 \times 4.0$ $V = 1.2$ V (1) for $V=IR$ (even if only seen once) (1) for all substitutions (1) for final answer including unit **Method 3:** $\frac{V_1}{V_2} = \frac{R_1}{R_2}$ (1) $\frac{V_1}{6.0} = \frac{4.0}{(16.0 + 4.0)}$ (1) $V_1 = 1.2$ V (1)

Question			Expected response	Max mark	Additional guidance
6.	(c)	(i)	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ **(1)** $\frac{1}{R_T} = \frac{1}{4.0} + \frac{1}{16.0}$ **(1)** $R_T = 3.2\ \Omega$ **(1)**	**3**	If wrong equation used eg $R_T = \frac{1}{R_1} + \frac{1}{R_2}$ then (0) marks Accept: 3 3.20 3.200 Accept imprecise working towards a final answer $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{4.0} + \frac{1}{16.0} = 3.2\Omega$ accept
		(ii)	(Reading on ammeter) increases **(1)** Total resistance decreases **(1)**	**2**	Effect must be correct otherwise (0) marks Accept 'current' in place of 'reading on ammeter' Can be justified by a suitable calculation. It must be clear that it is the resistance of the whole circuit that decreases.

Question			Expected response	Max mark	Additional guidance
7.	(a)		3 A	**1**	
	(b)		$P = \frac{V^2}{R}$ **(1)** $0.35 \times 10^3 = \frac{230^2}{R}$ **(1)** $R = 150\ \Omega$ **(1)**	**3**	Accept: 200 151 151.1 For alternative methods: (1) for all required relationships (1) for all substitutions (1) for final answer including unit
	(c)	(i)	 **OR**	**1**	Must have correct orientation.
		(ii)	Voltage across <u>variable resistor</u> increases **(1)** <u>Transistor</u> switches on **(1)**	**2**	Do not accept 'voltage through the variable resistor' Ignore any stated values of switching voltage.
		(iii)	To adjust/control the moisture level at which the dehumidifier/transistor LED/fan switches on.	**1**	To adjust/control when the dehumidifier/transistor/LED/fan switches on.

Question			Expected response	Max mark	Additional guidance
8.	(a)		$P = IV$ **(1)** $1750 = I \times 230$ **(1)** $I = 7.6$ A **(1)**	**3**	Accept: 8 7.61 7.609
	(b)	(i)	$E_h = cm\Delta T$ **(1)** $126\ 000 = 902 \times 0.650 \times \Delta T$ **(1)** $\Delta T = 215\ (°C)$ **(1)** $(T_{final} = 215 + 22)$ $T_{final} = 237$ °C **(1)**	**4**	If 215 is stated as the final answer it must have the correct unit for the third mark to be awarded. Accept imprecise working towards final answer (eg $\Delta T = 215 + 22 = 237$ °C) ↑ accept Accept: 240 236.9 236.91
		(ii)	Heat (energy) is lost to the surroundings/rest of iron/clothes	**1**	Do not accept 'heat loss' alone – it must be clear where it is going

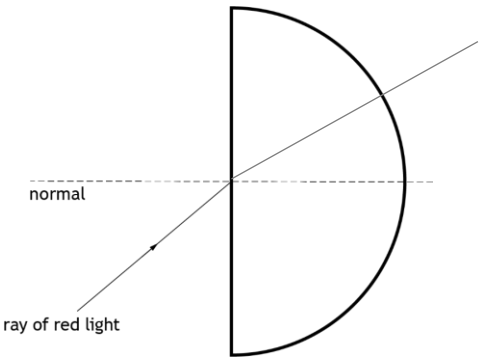
Question			Expected response	Max mark	Additional guidance
9.	(a)		For $\frac{p}{T}$: $\left(\frac{121\times10^3}{323}\right) = 375$ $\left(\frac{124\times10^3}{333}\right) = 372$ $\left(\frac{128\times10^3}{343}\right) = 373$ $\left(\frac{132\times10^3}{353}\right) = 374$ **(2)** For $\frac{T}{p}$: $\left(\frac{323}{121\times10^3}\right) = 0.00267$ $\left(\frac{333}{124\times10^3}\right) = 0.00269$ $\left(\frac{343}{128\times10^3}\right) = 0.00268$ $\left(\frac{353}{132\times10^3}\right) = 0.00267$ Statement of relationship: $\frac{p}{T} = constant$ **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 **Calculations:** First two marks are awarded for the calculations: • All four calculations correct (2) • Three calculations correct (1) • Fewer than three calculations correct (0) Accept 2 - 5 sig figs in all calculated values. Conversion from kPa to Pa not required **Relationship:** Mark for $\frac{p}{T} = constant$ 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 $\frac{pV}{T} = constant$ Do not accept: $\frac{p^1}{T^1} = \frac{p^2}{T^2}$

Question			Expected response	Max mark	Additional guidance
9.	(a)		(continued)		**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 (1) (minimum of three calculations) All calculations correct (1) Relationship stated and supported (1) **Graphical method:** Must be on graph paper for any marks to be awarded. **(1)** suitable scales, labels and units **(1)** all points plotted accurately to ±half a division and line of best fit **(1)** relationship stated
	(b)		Any single value between 138 kPa and 142 kPa inclusive	**1**	Unit required
	(c)		Repeat the experiment **OR** Increase the range (of temperatures) **OR** Take readings at more (different) temperatures within the range **OR** Have more of the flask in the water **OR** Add more water (in the beaker) **OR** Reduce the length/diameter of the connecting tube **OR** Stir the water	**1**	Accept: Place thermometer inside the flask/in the gas. Apply +/- rule for surplus answers. Candidates do not have to use the terms accurate, precise or reliable, but if they do so they must use them correctly. Accept an appropriate use of insulation (eg 'insulate the connecting tube/top of flask'), but not a generic use of insulation.

Question			Expected response	Max mark	Additional guidance
9.	(d)		(The increase in temperature) increases the kinetic energy of the gas particles/the particles move faster. **(1)** The particles hit the tyre walls more frequently **OR** The particles hit the tyre walls with greater force. **(1)** Pressure (in the tyre) increases **(1)**	**3**	Accept: 'atoms'/'molecules' in place of 'particles' An incorrect statement about collisions does not allow this mark to be awarded eg 'more frequent and less force' or 'less frequent and more force'. Do not accept: 'particles hit the tyre walls more' alone

Question			Expected response	Max mark	Additional guidance
10.	(a)	(i)	$\left(\lambda = \frac{0.12}{6}\right)$ $\lambda = 0.020$ m **(1)**	**1**	Unit must be stated Accept: 0.02 0.0200 0.02000
		(ii)	$f = \frac{N}{t}$ **(1)** $f = \frac{6}{0.40}$ **(1)** $f = 15$ Hz	**2**	**'Show' question** Must state the correct relationship otherwise (0) marks Final answer of 15 Hz, including unit, must be shown, otherwise MAX (1) **Alternative method 1:** $f = \frac{1}{T}$ **(1)** $f = \frac{1}{(\frac{0.40}{6})}$ **(1)** $f = 15$ Hz For the second mark to be awarded it must be shown how the period is calculated. **Alternative method 2:** $d = vt$ $0.12 = v \times 0.40$ $(v = 0.30 \text{ ms}^{-1})$ $v = f\lambda$ $0.30 = f \times 0.020$ $f = 15$ Hz (1) for both relationships (1) for all substitutions
		(iii)	$v = f\lambda$ **(1)** $v = 15 \times 0.020$ **(1)** $v = 0.30 \text{ ms}^{-1}$ **(1)**	**3**	Or consistent with (a)(i) Accept: 0.3 0.300 0.3000 **Alternative method:** $d = vt$ **(1)** $0.12 = v \times 0.40$ **(1)** $v = 0.30 \text{ ms}^{-1}$ **(1)**

Question			Expected response	Max mark	Additional guidance
10.	(b)		diffraction of waves into right 'shadow' region of the plastic block **(1)** consistent wavelengths before and after plastic block **(1)**	**2**	(0) marks if no evidence of diffraction (ie no curved sections), second mark is dependent on first mark. (0) marks if diagram represents diffraction through a gap (ie curved sections at top) Minimum of two waves for any marks to be awarded.

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	Refraction	**1**	
		(ii)	Correct change in direction on entering block (towards normal) and no change in direction leaving the block **(1)**  	**1**	Arrows not required. Passably straight line. Any change of direction of ray within the block then do not award the mark. Any change of direction of ray after it has left the block then do not award the mark. Do not accept ray in the block drawn along or below the normal.
		(iii)	less	**1**	Accept: 'shorter'
	(b)		$P = \frac{E}{t}$ **(1)** $25 = \frac{42.5 \times 10^{-3}}{t}$ **(1)** $t = 1.7 \times 10^{-3}$ s **(1)**	**3**	Accept: 2×10^{-3} 1.70×10^{-3} 1.700×10^{-3}

Question			Expected response	Max mark	Additional guidance
12.	(a)	(i)	As the distance increases the infrared radiation detected decreases	**1**	Accept: As the distance decreases the infrared radiation detected increases Do not accept: Conclusions that only relate to the relationship between distance and voltage.
		(ii)	Similar shape to original curve **(1)** Line always below original curve **(1)**	**2**	Curve does not need to cover entire range of original curve. Curve can extend beyond the range of the original curve

Question			Expected response	Max mark	Additional guidance
12	(b)		**Award 3 marks** where the candidate has demonstrated a good understanding of the physics involved. They show a good comprehension of the physics of the situation and provide 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. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks. **Award 2 marks** where the candidate has demonstrated a reasonable understanding of the physics involved. They make some statement(s) that are relevant to the situation, showing that they have understood the problem. **Award 1 mark** where the candidate has demonstrated a limited understanding of the physics involved. They make some statement(s) that are relevant to the situation, showing that they have understood at least a little of the physics within the problem. **Award 0 marks** where the candidate has not demonstrated an understanding of the physics involved. There is no evidence that they have recognised the area of physics involved, or they have not given any statement of a relevant physics principle. Award this mark also if the candidate merely restates the physics given in the question.	**3**	Candidates may use a variety of physics arguments to answer this question. Award marks based on candidates demonstrating overall good, reasonable, limited, or no understanding

Question			Expected response	Max mark	Additional guidance
13.	(a)		Alpha is (more easily) absorbed by air/smoke/detector **OR** Alpha has a short(er) range in air **(1)** Alpha is the most ionising **(1)**	**2**	Accept converse statements about why beta and gamma are not suitable. Apply +/- rule for surplus answers
	(b)	(i)	Z	**1**	Accept: Z clearly identified
		(ii)	The half-life of the sources are too short **(1)** The smoke detectors would only work for a short time/need to be replaced frequently/would not last 10 years. **(1)**	**2**	
	(c)		$H = Dw_r$ **(1)** $H = 4.5\times10^{-6}\times20$ **(1)** $(H = 9.0\times10^{-5}$ Sv$)$ $H = 9.0\times10^{-5}\times8$ **(1)** $H = 7.2\times10^{-4}$ Sv **(1)**	**4**	**Alternative method:** $D = 4.5\times10^{-6}\times8$ **(1)** $(D = 3.6\times10^{-5}$ Gy$)$ $H = Dw_r$ **(1)** $H = 3.6\times10^{-5}\times20$ **(1)** $H = 7.2\times10^{-4}$ Sv **(1)** Accept: 7×10^{-4} 7.20×10^{-4} 7.200×10^{-4}

Question			Expected response	Max mark	Additional guidance
14.	(a)		(Nuclear fission is when a large) <u>nucleus</u> (of an atom) splits (into two or more smaller nuclei).	**1**	Do not accept: atom alone
	(b)	(i)	$P = \frac{E}{t}$ **(1)** $150\times10^{6} = \frac{E}{60\times60}$ **(1)** $(E = 5.4\times10^{11}\ \text{J})$ $\text{number of fissions} = \frac{5.4\times10^{11}}{2.9\times10^{-11}}$ **(1)** $= 1.9\times10^{22}$ **(1)**	**4**	Accept: 2×10^{22} 1.86×10^{22} 1.862×10^{22} Calculation of power of one decay over an hour is wrong physics, MAX (1) for relationship. **Alternative method 1:** $P = \frac{E}{t}$ **(1)** $150\times10^{6} = \frac{2.9\times10^{-11}}{t}$ **(1)** $(t = 1.93\times10^{-19})$ $\text{number of fissions} = \frac{60\times60}{1.93\times10^{-19}}$ **(1)** $= 1.9\times10^{22}$ **(1)** **Alternative method 2:** $\text{fissions per second} = \frac{150\times10^{6}}{2.9\times10^{-11}}$ **(1)** $= 5.17\times10^{18}$ **(1)** $\text{total fissions} = 5.17\times10^{18}\times60\times60$ **(1)** $= 1.9\times10^{22}$ **(1)**
		(ii)	Any one of: Requires high temperatures Difficult to control/contain plasma Requires strong magnetic fields	**1**	Or any other suitable statements relating to difficulties in sustaining reactions. Accept: 'Requires high pressure' 'Difficult to control/contain energy/heat produced' Answers in terms of cost alone are insufficient. Apply +/- rule for surplus answers.

[END OF MARKING INSTRUCTIONS]