National
Qualifications
2019

2019 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.

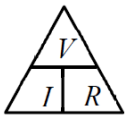
(d) Where a wrong answer to part of a question is carried forward and the wrong answer is then used correctly in the following part, give the candidate credit for the subsequent part or 'follow-on'. (GMP 17)

(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 which 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 $0{\cdot}\dot{6}$, 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 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 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

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

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

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

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 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, 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}
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 $t = 4\times10^5$ 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 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: *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 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 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)

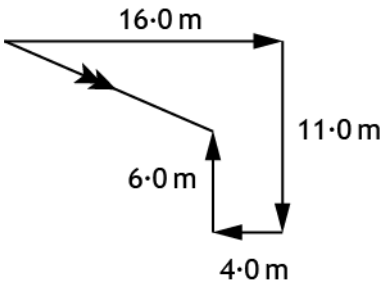
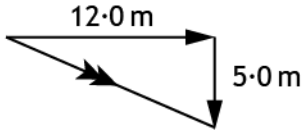
	Candidate answer	Mark and comment
1.	$V=IR$ $7{\cdot}5=1{\cdot}5\times R$ $R=5{\cdot}0\,\Omega$	1 mark: relationship 1 mark: substitution 1 mark: correct answer
2.	$5{\cdot}0\,\Omega$	3 marks: correct answer
3.	$5{\cdot}0$	2 marks: unit missing
4.	$4{\cdot}0\,\Omega$	0 marks: no evidence, wrong answer
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

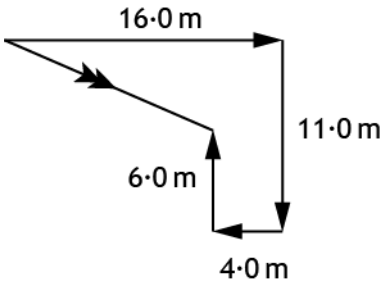
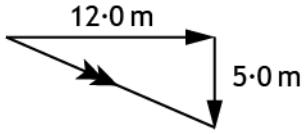
Marking Instructions for each question

Section 1

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

Section 2

Question			Expected response	Max mark	Additional guidance
1	(a)	(i)	Using Pythagoras: Resultant^2 = 12·0^2 + 5·0^2 **(1)** Resultant = 13m **(1)** Using scale diagram:  **or**  Vectors to scale **(1)** Resultant = 13m **(1)** (allow ± 0·5 m tolerance)	**2**	Ignore any direction stated in the final answer in this part. If clear arithmetic error shown in 16 – 4 = 12 or 11 – 6 = 5 then MAX (1) mark for substitution consistent with arithmetic error. No requirement for arrows to be shown on diagram to calculate the magnitude of displacement. Regardless of method, if a candidate shows a vector diagram (or a representation of a vector diagram ie a triangle with no arrows) **and** the vectors have been added incorrectly, eg head-to-head then MAX (1).

Question			Expected response	Max mark	Additional guidance
		(ii)	Using trigonometry: $\tan\theta = \frac{5{\cdot}0}{12{\cdot}0}$ **(1)** $(\theta = 23°)$ direction = 113 **(1)** Using scale diagram:  **or**  Vectors to scale **(1)** Direction = 113 **(1)** (allow ±2° tolerance)	**2**	Or use of resultant value (and appropriate trigonometry) consistent with (a)(i). Accept: 23° South of East 67° East of South Ignore the degree symbol if the direction is stated as a bearing. Can also do using other trig functions, eg $\sin\theta = \frac{5{\cdot}0}{13}$ or $\cos\theta = \frac{12{\cdot}0}{13}$ Regardless of method, if a candidate shows a vector diagram (or a representation of a vector diagram ie a triangle with no arrows) **and** the vectors have been added incorrectly, eg head-to-head then MAX (1). Accept: 20° S of E 110 22·6° S of E 112·6 22·62° S of E 112·62
	(b)		$s = \bar{v}t$ **(1)** $13 = \bar{v} \times 32{\cdot}5$ **(1)** $\bar{v} = 0{\cdot}40\ \text{ms}^{-1}$ at (bearing) 113 **(1)**	**3**	Or consistent with (a)(i) and/or (a)(ii) Accept $d = vt$ provided it is followed by a substitution of the value for displacement. Direction required for final mark. Accept 1-4 sig figs: 0·4 m s^{-1} 0·400 m s^{-1} 0·4000 m s^{-1}

Question			Expected response	Max mark	Additional guidance
1.	(c)		$d = \bar{v}t$ **(1)** $37{\cdot}0 = 1{\cdot}25 \times t$ **(1)** $(t = 29{\cdot}6$ s) difference in time $= (32{\cdot}5 - 29{\cdot}6)$ $= 2{\cdot}9$s **(1)**	**3**	Accept $s = \bar{v}t$ provided it is followed by a substitution of the value for distance. Accept 1-4 sig figs: 3 s 2·90 s 2·900 s
	(d)		(The forces are) equal (in size) and opposite (in direction).	**1**	Accept: '(the forces are) balanced' Do not accept 'lift equals weight' alone.

Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	$a=\frac{v-u}{t}$ **(1)** $a=\frac{20-0}{8}$ **(1)** $a=2{\cdot}5\ \text{ms}^{-2}$	**2**	** SHOW THAT ** Must start with a correct relationship or (0) marks Accept: $a=\frac{\Delta v}{t}$ Do not accept: $a=\frac{v}{t}$ Accept methods starting with: $a=gradient$ or $a=\frac{\Delta y}{\Delta x}$ or $a=\frac{y_2-y_1}{x_2-x_1}$ However substitutions for two points on the line must be shown for the second mark. Accept consistent use of any other values for v, u and t in the first 9·6 s of the graph. Final answer of 2·5 ms^{-2}, including unit, must be shown or MAX (1).
		(ii)	$F=ma$ **(1)** $925=m\times 2{\cdot}5$ **(1)** $m=370\ \text{kg}$ **(1)**	**3**	Must use a value of $2{\cdot}5\ \text{ms}^{-2}$ for acceleration. Accept 1-4 sig figs: 400 kg 370·0 kg
		(iii) (A)	$(F=1200\text{-}925)$ $F=275\ \text{N}$	**1**	Ignore any direction stated. Unit must be stated.
		(B)	streamlined (shape) has wheels aerodynamic	**1**	Or any other suitable response. Apply +/- rule for surplus answers
	(b)		$d=\text{area under graph}$ **(1)** $d=\frac{1}{2}\times 8{\cdot}0\times 20$ **(1)** $d=80\ \text{m}$ **(1)**	**3**	If incorrect substitution then MAX (1) for (implied) relationship. Accept $s=\bar{v}t$ or $d=\bar{v}t$ for relationship mark. Accept $s=vt$ or $d=vt$, provided substitution of average velocity/ speed is correct. Accept 1-4 sig figs: 80·0 m 80·00 m

Question			Expected response	Max mark	Additional guidance
3.			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 student has demonstrated a limited understanding of the physics involved. The student 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 student has demonstrated a reasonable understanding of the physics involved. The student makes some statement(s), which is/are relevant to the situation, showing that the problem is understood. **3 marks:** The maximum available mark would be awarded to a student who has demonstrated a good understanding of the physics involved. The student 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.

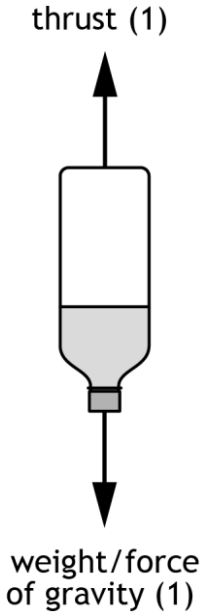
Question			Expected response	Max mark	Additional guidance
4.	(a)		Hydrogen, helium and mercury	**1**	Must have all three.
	(b)	(i)	The distance light travels in one year.	**1**	
		(ii)	$d = vt$ **(1)** $d = 3{\cdot}0 \times 10^8 \times (60 \times 60 \times 24 \times 365{\cdot}25 \times 97)$ **(1)** $d = 9{\cdot}2 \times 10^{17}$ (m) **(1)**	**3**	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 97. Unit in final answer not required, but if stated, must be correct. Accept 1-4 sig fig: 9×10^{17} $9{\cdot}18 \times 10^{17}$ $9{\cdot}183 \times 10^{17}$ Also accept, if using 365 days: $9{\cdot}177 \times 10^{17}$
	(c)	(i)	No atmosphere to absorb light full range of EM waves can be observed can be used in cloudy weather/ daytime no light pollution	**1**	Or other suitable response Do not accept 'closer' but would not negate a correct response. Apply +/- rule for surplus answers
		(ii)	GPS weather forecasting communications scientific discovery	**1**	Or other suitable response Do not accept responses relating to space observation Apply +/- rule for surplus answers

Question			Expected response	Max mark	Additional guidance
5.	(a)	(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). Allow broken axes from origin (with or without symbol)
		(ii)	(Resistance of wire) increases (as the length of wire increases) **(1)** Current decreases (as the length of wire increases). **(1)**	**2**	Effect must be correct, otherwise (0) marks. Can be justified by suitable calculations involving currents from the table/graph.
		(iii)	0·55 A	**1**	**Must** be consistent with candidate's curve or line. Unit required If a candidate has not shown a curve or line in (a)(i) this mark cannot be accessed. If candidate has used a non-linear scale in (a)(i) this mark cannot be accessed.
		(iv)	repeat (and average)	**1**	Accept: • increase the range of lengths • increase the number of different lengths If candidates use the terms 'accurate' and/or 'precise' in their response, they must be used correctly otherwise (0).

Question			Expected response	Max mark	Additional guidance
5.	(b)		(Resistance will be) less (than 5·2 Ω) **(1)** (The wire now has) shorter length (between X and Y) **OR** (Two wires are) connected in parallel **(1)**	**2**	First mark can only be awarded if a 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) If candidate tries to justify this by calculation, then the substitution must be correct (R_1 and R_2 are both equal to 2·6 Ω) or (0) marks.

Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)	Total $R = 180 + 180 + 120$ $(= 480\,\Omega)$ **(1)** $V = IR$ **(1)** $12 = I \times 480$ **(1)** $I = 0{\cdot}025$ A **(1)**	**4**	Calculation of resistance may be implied by correct substitution. If no attempt to calculate the resistance, or incorrect substitution to calculate resistance, then MAX (1) for relationship. If clear arithmetic error is shown in the calculation of total resistance then MAX (3). Accept 1-4 sig figs: 0·03 A 0·025 0 A 0·025 00 A For alternative methods: (1) for all required relationships (1) for all substitutions (1) for final answer including unit
		(ii)	$P = I^2R$ **(1)** $P = 0{\cdot}025^2 \times 120$ **(1)** $P = 0{\cdot}075$ W **(1)**	**3**	Or consistent with (a)(i) Accept 1-4 sig figs: 0·08 W 0·075 0 W 0·075 00 W For alternative methods: (1) for all required relationships (1) for all substitutions (1) for final answer including unit
	(b)	(i)	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ **(1)** $\frac{1}{R_T} = \frac{1}{720} + \frac{1}{720}$ **(1)** $(R_T = 360\,\Omega)$ $R_{total} = 360 + 120$ **(1)** $R_{total} = 480\,\Omega$ **(1)**	**4**	Do not accept wrong relationship eg $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + R_3$ OR $R_T = \frac{1}{R_1} + \frac{1}{R_2}$ (0) marks If arithmetic error in parallel resistance calculation, can still access mark for adding the 120 Ω resistance, ie MAX (3). If a candidate attempts to calculate all three in parallel (0) marks.
		(ii)	(Power will be) the same **(1)** Current (in the 120 Ω resistor) will be the same **(1)**	**2**	or consistent with (a)(ii) and (b)(i) For justification mark accept: voltage across the 120 Ω resistor will be the same.

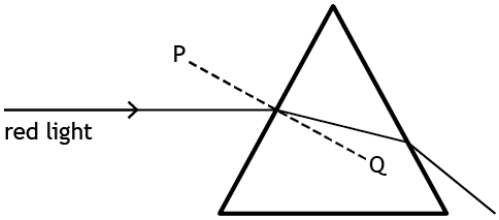
Question			Expected response	Max mark	Additional guidance
7.	(a)		$P=\frac{E}{t}$ **(1)** $3500=\frac{E}{26}$ **(1)** $E=91000\ \text{J}$	**2**	** SHOW THAT ** Must start with a correct relationship or (0) marks Final answer of 91 000 J or its numerical equivalent, including unit, must be shown, otherwise a maximum of (1) can be awarded.
	(b)	(i)	$E_h = cm\Delta T$ **(1)** $= 4180\times 0\times 250\times 80\times 0$ **(1)** $= 83\,600\ \text{J}$ **(1)**	**3**	Accept 2–5 sig figs: 84 000 J
		(ii)	$E_h = 91000 - 83\,600$ **(1)** $(=7400\ \text{J})$ $E_h = ml$ **(1)** $7400 = m\times 22\times 6\times 10^5$ **(1)** $m = 0\times 0033\ \text{kg}$ **(1)**	**4**	Or consistent with (b)(i) Calculation of energy difference may be implied by correct substitution. If no attempt to calculate the energy difference, or incorrect substitution to calculate energy difference, then MAX (1) for relationship. If clear arithmetic error is shown in calculation of energy difference then MAX (3). accept: 1–4 sig figs: 0·003 kg 0·003 27 kg 0·003 274 kg
		(iii)	Heat (energy) lost to the surroundings. **OR** Some of the heat (energy) is used to heat the dispenser.	**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.

Question			Expected response	Max mark	Additional guidance
8.	(a)			**2**	Independent marks. Name **and** direction required for each mark. Accept: 'force of water on air in bottle' 'force of water on rocket' Do not accept: 'upward force' alone 'lift (force)' 'upthrust' Accept: 'gravitational pull' 'pull of gravity' Do not accept: 'gravity' alone Apply +/- rule for surplus incorrect forces acting on the bottle for each of the independent marks.
	(b)		$p = \frac{F}{A}$ **(1)** $1{\cdot}74 \times 10^{5} = \frac{F}{4{\cdot}50 \times 10^{-3}}$ **(1)** $F = 783\ \text{N}$ **(1)**	**3**	Accept 2-5 sig figs: 780 N 783·0 N 783·00 N

Question			Expected response	Max mark	Additional guidance
8.	(c)	(i)	New volume of air $=$ $7{\cdot}5\times10^{-4}+1{\cdot}2\times10^{-4}$ **(1)** $\left(8{\cdot}7\times10^{-4}\,\text{m}^3\right)$ $p_1V_1 = p_2V_2$ **(1)** $1{\cdot}74\times10^{5}\times7{\cdot}5\times10^{-4} = p_2\times8{\cdot}7\times10^{-4}$ **(1)** $p_2 = 1{\cdot}5\times10^{5}\ \text{Pa}$ **(1)**	**4**	Calculation of new volume of air may be implied by correct substitution. If no attempt to calculate the new volume, or incorrect substitution to calculate new volume of air, then MAX (1) for relationship. If clear arithmetic error is shown in calculation of new volume of air then MAX (3). Accept 1-4 sig figs: 2×10^{5} Pa $1{\cdot}50\times10^{5}$ Pa $1{\cdot}500\times10^{5}$ Pa Accept $\frac{p_1V_1}{T_1}=\frac{p_2V_2}{T_2}$ or $\frac{pV}{T}=$constant
		(ii)	(individual) particles collide with container/walls less frequently (than before) **(1)** (overall) force (on walls) is less **(1)** pressure decreases **(1)**	**3**	Independent marks. However, if the candidate indicates that individual collisions have less/more force or the particles move slower/faster, then do not award the first mark. Accept 'atoms'/'molecules' in place of 'particles'.

Question			Expected response	Max mark	Additional guidance
9.	(a)		$v = f\ \lambda$ **(1)** $3{\cdot}0\times10^{8} = 153\times10^{6}\times\lambda$ **(1)** $\lambda = 2{\cdot}0\,\text{m}$ **(1)**	**3**	Accept 1-4 sig figs: 2 m 1·96 m 1·961 m
	(b)		The speed of light is (much) greater than the speed of sound. **(1)** The sound takes more time to travel (the 100 m). **(1)**	**2**	Do not accept 'different speeds' alone for first mark. Must make clear which arrives first for the second mark. Any statement that sound travels faster than light (0) marks, otherwise treat as independent marks.
	(c)	(i)	$E_k = \frac{1}{2}mv^2$ **(1)** $4{\cdot}5\times10^{5} = 0{\cdot}5\times25000\times v^2$ **(1)** $v = 6{\cdot}0\,\text{ms}^{-1}$ **(1)**	**3**	Accept 1-4 sig figs: 6 ms^{-1} 6·00 ms^{-1} 6·000 ms^{-1}
		(ii)	<u>energy</u> is lost (as heat and sound) due to friction/air resistance	**1**	

Question			Expected response	Max mark	Additional guidance
10.	(a)		electromagnetic (spectrum/waves/radiation)	**1**	Accept: EM (spectrum/waves/radiation)
	(b)		(The frequency of infrared is) less/lower (than the frequency of gamma rays).	**1**	Accept: (The frequency of) gamma (rays) is higher (than the frequency of infrared).
	(c)	(i) (A)	(black-bulb) thermometer	**1**	
		(i) (B)	radioactive waste	**1**	
		(ii)	Treating skin conditions/jaundice Checking security markings on banknotes Produces vitamin D Disinfection of hospital instruments To 'cure' or harden composite material for fillings or nail gel/polish Tanning/Sun-beds	**1**	Any other sensible suggestion Apply +/- rule for surplus answers

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	 correct change in direction on entering block **(1)** correct change in direction leaving the block **(1)**	**2**	Independent marks. Normal not required for ray leaving block. If drawn can be ignored in this part. Arrows not required. Any change of direction of ray within the block then do not award the first mark. Any change of direction of ray after it has left the block then do not award the second mark. Do not accept ray in the block drawn along or below the normal for the first mark.
		(ii)	(the) normal	**1**	
		(iii)	angle of incidence labelled correctly.	**1**	If the angle of incidence is marked on the emergent ray then a second correctly drawn normal is required.
	(b)		(wavelength is the) same **(1)** the blocks are made of the same material. **(1)**	**2**	Effect must be correct otherwise (0) marks. Accept: the blocks have the same optical density the blocks have the same refractive index same amount of refraction takes place the light travels at the same speed in both blocks

Question			Expected response	Max mark	Additional guidance
12.	(a)		Measure the count in a set time **(1)** Repeat at (regular) intervals **(1)** (Measure and) subtract background (count) **(1)**	**3**	Independent marks Do not accept 'activity' as an alternative to counts in a set time (do not award first mark). Description must refer to the apparatus shown. If a candidate response makes reference to using a ratemeter, then MAX (2) marks. (First mark cannot be awarded.)
	(b)		Carry out experiment over a longer time period.	**1**	
	(c)	(i)	$D=\frac{E}{m}$ **(1)** $D=\frac{1{\cdot}2\times10^{-6}}{80{\cdot}0}$ **(1)** $D=1{\cdot}5\times10^{-8}$ Gy **(1)**	**3**	Accept 1-4 sig figs: 2×10^{-8} Gy $1{\cdot}50\times10^{-8}$ Gy $1{\cdot}500\times10^{-8}$ Gy
		(ii)	$H=Dw_R$ **(1)** $4{\cdot}5\times10^{-8}=1{\cdot}5\times10^{-8}\times w_R$ **(1)** $w_R=3$ **(1)**	**3**	or consistent with (c)(i) Ignore any identification of a type of radiation.
	(d)		(Photographic) <u>film</u> blackened/ darkened/fogged **(1)** (Film behind) different windows affected by different types of radiation **(1)**	**2**	Independent marks Accept: (Photographic) <u>film</u> changes colour For the second mark accept an indication of the absorption/ penetration of radiations by the materials in the windows, however any incorrect statement about the absorption/penetration of a type of radiation means this mark cannot be awarded.

Question			Expected response	Max mark	Additional guidance
13.			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 student has demonstrated a limited understanding of the physics involved. The student 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 student has demonstrated a reasonable understanding of the physics involved. The student makes some statement(s), which is/are relevant to the situation, showing that the problem is understood. **3 marks:** The maximum available mark would be awarded to a student who has demonstrated a good understanding of the physics involved. The student 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.

[END OF MARKING INSTRUCTIONS]