National
Qualifications
2026

2026 Physics

Higher – Paper 2

Question Paper Finalised Marking Instructions

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

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General marking principles for Physics Higher

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) (Physics: general marking principles - National 3 to Advanced Higher (sqa.org.uk)) 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 candidate answers part of a question incorrectly and carries the incorrect answer forward in the following part, award marks if the incorrect answer has then been used correctly in the subsequent part or 'follow-on'. (GMP 16)

(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 20)

(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) Award marks 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 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. (GMP 1c)

(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, for example $V = IR$ or $R = \frac{V}{I}$. (GMP 2)

(j) In rounding to an expected number of significant figures, award the mark for responses that have up to two figures more or one figure less than the number in the data with the fewest significant figures. (GMP 6)
(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.)

(k) 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 22)

(l) 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. For example 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, for example 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: award marks for any suggestions that are supported by knowledge and understanding of physics.
- **use their 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). Candidates are given credit for the breadth and/or depth of their conceptual understanding.

"Standard three marker"
The examples over the page 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) 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.

Marking in calculations

Example 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

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i) (A)	$(u_h = u\cos\theta)$ $(u_h = 11\cos 34)$ $u_h = 9.1 \text{ ms}^{-1}$	**1**	Accept: 9, 9.12, 9.119
		(i) (B)	$(u_v = u\sin\theta)$ $(u_v = 11\sin 34)$ $u_v = 6.2 \text{ ms}^{-1}$	**1**	Or consistent with (a)(i)(A) if Pythagoras method used. Accept: 6, 6.15, 6.151
		(ii)	$v^2 = u^2 + 2as$ **(1)** $0^2 = 6.2^2 + (2 \times -9.8 \times s)$ **(1)** $h = \left(\frac{-(6.2^2)}{2 \times -9.8}\right) + 1.9$ **(1)** $h = 3.9 \text{ m}$ **(1)**	**4**	Or consistent with (a)(i)(B). Accept: 4, 3.86, 3.861 u and a must have opposite sign otherwise **MAX 1 mark**. Accept use of s for height in this question. Alternative methods, eg using: $v = u + at$ and $s = ut + \frac{1}{2}at^2$ **OR** $E_p = mgh$ and $E_k = \frac{1}{2}mv^2$ **1 mark** for both relationships. **1 mark** for substitutions into both relationships. **1 mark** for calculation to find h. **1 mark** for final answer.
		(iii)	$s = ut + \frac{1}{2}at^2$ **(1)** $-3.9 = 0 + (0.5 \times -9.8 \times t^2)$ **(1)** $t = 0.89 \text{ s}$ **(1)**	**3**	Or consistent with (a)(ii). Accept: 0.9, 0.892, 0.8921 s and a must have same sign otherwise **MAX 1 mark**. Alternative methods: **1 mark** for both relationships. **1 mark** for substitutions into both relationships. **1 mark** for final answer.

Question			Expected response	Max mark	Additional guidance
1.	(a)	(iv)	$d = \overline{v}t$ **(1)** d = 9.1 x 1.52 **(1)** d = 14 m **(1)**	**3**	Or consistent with (a)(i)(A). Accept: 10, 13.8, 13.83 Accept: $d = vt$ **OR** $s = vt$ **OR** $s = \overline{v}t$ **OR** $s = \frac{1}{2}(u + v)t$ **OR** $s = ut + \frac{1}{2}at^2$
	(b)		(The horizontal distance) increases **(1)** because the 'time of flight' is greater. **(1)**	**2**	**MUST JUSTIFY** Accept: the shot is in the air for a longer time Can be justified by calculation.

Question			Expected response	Max mark	Additional guidance
2.	(a)		Measure displacement P to Q (using the metre stick). **(1)** $v = \frac{\text{length of card}}{t}$ **(1)** (Calculate acceleration a using) $v^2 = u^2 + 2as$ **(1)**	**3**	**INDEPENDENT MARKS** Accept: an indication of measurement of distance from start to light gate Do not accept: measure the length of the slope Accept: use $v = \frac{d}{t}$ where d is length of card Do not accept: $v = \frac{d}{t}$ alone Accept: use $v^2 = 2as$ in this question. Accept: graph of v^2 against s, if different values for s mentioned Must be a statement of significance of gradient. Accept: 'ruler' for 'metre stick' If additional apparatus is mentioned then **MAX 2 marks**.
	(b)	(i)	$\left(\frac{13.9+13.1+11.0+12.4}{4}\right)$ $(\bar{t} =) 12.6$ ms	**1**	Accept: 13, 12.60, 12.600
		(ii)	$\left(\Delta R = \frac{R_{\max} - R_{\min}}{n}\right)$ $\Delta\bar{t} = \frac{13.9-11.0}{4}$ **(1)** $\Delta\bar{t} = (\pm)$ 0.7 ms **(1)**	**2**	Accept: 0.73, 0.725 Accept: (12.6 ± 0.7) ms
		(iii)	(Taking more measurements of the time should) reduce the <u>random</u> uncertainty.	**1**	
	(c)		The same as, **(1)** unbalanced force is unchanged. **(1)**	**2**	**MUST JUSTIFY** Accept: the angle/gradient of the slope is the same

Question			Expected response	Max mark	Additional guidance
3.	(a)	(i)	$z = \frac{\lambda_{observed} - \lambda_{rest}}{\lambda_{rest}}$ **(1)** $z = \frac{503\times10^{-9} - 434\times10^{-9}}{434\times10^{-9}}$ **(1)** $z = 0.159$	**2**	**SHOW question.** Accept: $z = \frac{\lambda_o - \lambda_r}{\lambda_r}$ $z = \frac{503 - 434}{434}$
		(ii)	$z = \frac{v}{c}$ **(1)** $0.159 = \frac{v}{3.00\times10^8}$ **(1)** $v = H_0 d$ **(1)** $\left(0.159\times3.00\times10^8\right) = 2.3\times10^{-18}\times d$ **(1)** $d = 2.1\times10^{25}$ m **(1)**	**5**	Accept: 2, 2.07, 2.074 $z = \frac{v}{c}$ anywhere **1 mark** $v = H_0 d$ anywhere **1 mark** Accept: h_0 for H_0 in this relationship, but not h. GMP 20 Alternative method: $zc = H_0 d$ $\left(0.159\times3.00\times10^8\right) = 2.3\times10^{-18}\times d$ $d = 2.1\times10^{25}$ m Equating formula. **(2)** Substitution of z and c. **(1)** Substitution of H_0. **(1)** Final answer. **(1)**
	(b)		$\left(z = \frac{\lambda_{observed} - \lambda_{rest}}{\lambda_{rest}}\right)$ $0.159 = \frac{\lambda_{observed} - 486\times10^{-9}}{486\times10^{-9}}$ **(1)** $\lambda_{observed} = 563\times10^{-9}$(m) **(1)** H$\beta$ **(1)**	**3**	**JUSTIFY by calculation** Look for Hβ first otherwise **0 marks**. Accept: $0.159 = \frac{\lambda_{observed} - 486}{486}$ $\lambda_{observed} = 563$ (nm) Suspend significant figure rule for calculated value of $\lambda_{observed}$ in this question.
	(c)		Hubble-Lemaître (Law)	**1**	Accept: Hubble's (Law) Do not accept: Hubble's constant

Question			Expected response	Max mark	Additional guidance
4.	(a)	(i)	$W = mg$ **(1)** $W = 1400 \times 9.8$ **(1)** $W = 1.4 \times 10^4$ N **(1)**	**3**	Accept: 1, 1.37, 1.372 Accept: 13720 N Accept: $F = mg$ Do not accept: $F = ma$
		(ii)	$F_{vertical} = \frac{1.4\times10^4}{4}$ **(1)** $T\sin 68 = \left(\frac{1.4\times10^4}{4}\right)$ **(1)** $T = 3.8\times10^3$ N **(1)**	**3**	Or consistent with (a)(i). Accept: 4, 3.77, 3.775 **1 mark** for quartering, with the exception of angle, anywhere. **1 mark** for acceptable substitution into trig formula, anywhere. **1 mark** for final answer. Accept: methods using cos22 Do not accept: $F = mg\sin\theta$ **(Max 1 mark** for quartering.)
	(b)		$E_p = mgh$ $E_p = 1400\times9.8\times1.3$ **(1)** $P = \frac{E}{t}$ **(1)** (**for both relationships** anywhere) $P = \frac{1400\times9.8\times1.3}{49}$ **(1)** $P = 360$ W **(1)**	**4**	Accept: 400, 364, 364.0 **1 mark** for both relationships (anywhere). **1 mark** for substitution into 1st relationship. **1 mark** for substitution into 2nd relationship. **1 mark** for final answer. Alternative method: $E_W = Fd$ and $P = \frac{E}{t}$ consistent with (a)(i) or vertical component used in (a)(ii).

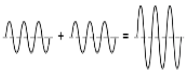
Question			Expected response	Max mark	Additional guidance
4.	(c)		The tension increases. **(1)** The sine of the angle decreases. **OR** Tension is inversely proportional to $\sin\theta$. **OR** The horizontal component/force/ tension increases. **OR** Shown by calculation with smaller angle. **(1)**	**2**	**MUST JUSTIFY** Do not accept: any statement implying that the vertical component decreases Allow for justification using cosine of the complementary angle.

Question			Expected response	Max mark	Additional guidance
5.			**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
6.	(a)	(i)	Uranium	**1**	Accept: U $^{236}_{92}$U If atomic number and mass number are stated, they must be correct.
		(ii)	$E = mc^2$ **(1)** $8.5500\times10^{-13} = m\times\left(3.00\times10^{8}\right)^2$ **(1)** $\left(m_X = m_{Pu} - \left(m_{He} + m_{lost}\right)\right)$ $m_X = 398.626\times10^{-27} - \left(6.6447\times10^{-27} + \frac{8.5500\times10^{-13}}{\left(3.00\times10^{8}\right)^2}\right)$ **(1)** $m_X = 3.919718\times10^{-25}$ kg **(1)**	**4**	$E = mc^2$ anywhere, **1 mark**. Ignore inappropriate reference to mass defect. Suspend significant figure rule for final value of m_X in this question. If finding $E = mc^2$ for each particle, then $E = mc^2$ **(1)** Two substitutions, subtraction, then final substitution **(2)** final answer. **(1)**
	(b)		$W = QV$ **(1)** $7.68\times10^{-13} = Q\times2.40\times10^{3}$ **(1)** $Q = 3.20\times10^{-16}$ C **(1)**	**3**	Accept: 3.2, 3.200, 3.2000
	(c)		Up the page.	**1**	Accept: up/upwards/(towards) top of the page Arrow drawn pointing up the page is acceptable. If upwards arrow is drawn on the original diagram, it must be on the left-hand edge. The path of the particle on its own is not acceptable.
	(d)		A neutron has no charge. **(1)** Only (a moving) charged particle (produces a magnetic field so) experiences a <u>force</u>. **(1)**	**2**	Accept: • a neutron is neutral • a neutron does not have a positive or negative charge Any mention of neutrons being charged award **0 marks**.

Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	6.56×10^{-19} joules of energy is the minimum energy required for electrons to be emitted/ejected.	**1**	Accept: 6.56×10^{-19} joules of energy is the minimum energy required for photoemission (of electrons) Do not accept: 'to cause photoelectric effect' alone Must be some indication of minimum.
		(ii)	$E = hf$ **(1)** $E = 6.63\times10^{-34}\times1.15\times10^{15}$ **(1)** $E = 7.62\times10^{-19}$ J **(1)**	**3**	Accept: 7.6, 7.625, 7.6245
		(iii)	$\left(E_k = hf - hf_0\right)$ $\left(E_k = 7.62\times10^{-19} - 6.56\times10^{-19}\right)$ $E_k = 1.06\times10^{-19}$ J	**1**	Or consistent with (a)(ii). Accept: 1.1, 1.060, 1.0600 $\left(E_k = hf - hf_0\right)$ $\left(E_k = \left(6.63\times10^{-34}\times1.15\times10^{15}\right) - 6.56\times10^{-19}\right)$ $E_k = 1.06\times10^{-19}$ J
		(iv)	$P = \frac{E}{t}$ **(1)** $1.5 = \frac{E}{12}$ **(1)** $\left(N = \frac{E_{total}}{E_{photon}}\right)$ $N = \frac{1.5\times12}{7.62\times10^{-19}}$ **(1)** $N = 2.4\times10^{19}$ **(1)** **OR** $\left(N = \frac{E_{total}}{hf}\right)$ $N = \frac{1.5\times12}{6.63\times10^{-34}\times1.15\times10^{15}}$ **(1)** $\left(N = \frac{1.5\times12}{7.6245\times10^{-19}}\right)$ $N = 2.4\times10^{19}$ **(1)**	**4**	Or consistent with (a)(ii). Accept: 2, 2.36, 2.362 Alternative method: $P = \frac{E_{(photon)}}{t_{(photon)}}$ **(1)** $1.5 = \frac{7.62\times10^{-19}}{t}$ **(1)** $\left(N = \frac{t_{total}}{t_{photon}}\right)$ $N = \frac{12}{\left(\frac{7.62\times10^{-19}}{1.5}\right)}$ **(1)** $N = 2.4\times10^{19}$ **(1)**

Question			Expected response	Max mark	Additional guidance
7.	(b)		(Rate of fall) increases. **(1)** More photons incident per second (on the bare aluminium). **OR** More electrons released/leave per second. **(1)**	**2**	**JUSTIFY** Accept: (tinsel falls) quicker/faster Accept: rate of photons incident/ electrons released increases Any indication of irradiance changing, **maximum 1 mark**.
	(c)	(i)	(A semiconductor that has specific) impurities added.	**1**	Must be an indication of impurities being added, eg contains other elements/atoms.
		(ii)	(Voltage applied causes) electrons to move from the conduction band of the n-type (semiconductor) towards the conduction band of the p-type (semiconductor). **(1)** Electrons 'fall' from the conduction band into the valence band (on either side of the junction). **(1)** Photons are emitted. **(1)**	**3**	Ignore any reference to initial movement of electrons from the valence band of the n-type to the conduction band of the n-type. To access 1st mark, the direction the electrons move must be clear. To access 2nd mark, valence and conduction bands must be included in the answer. Bands must be named correctly, eg do not accept 'valency' or 'conductive'. Final mark is dependent upon having at least one of the first two statements. Any answer using recombination of holes and electrons **on its own**, with no reference to band theory, is worth **0 marks**.

Question			Expected response	Max mark	Additional guidance
8.	(a)	(i)	Waves meet in phase. **OR** Crest meets crest. **OR** Trough meets trough. **OR** $path\ difference = m\lambda$	**1**	Accept: peak for crest Can be shown by diagram eg  Diagram must imply addition of two waves in phase. Do not accept: 'join' or 'merge' alone
		(ii)	The path difference (at the central maximum) for each wavelength is zero.	**1**	Accept: path difference is the same for all wavelengths Accept: frequency/colour for wavelength, for this question The path difference is zero, on its own, **0 marks**.
		(iii)	$d\sin\theta = m\lambda$ **(1)** $3.33\times10^{-6}\times\sin 24.0 = 2\times\lambda$ **(1)** $\lambda = 6.77\times10^{-7}$ m **(1)**	**3**	Accept: 6.8, 6.772, 6.7722
	(b)	(i)	Plot a graph of λ against sin θ. **(1)** Calculate gradient of the line. **(1)**	**2**	Accept: gradient of graph is d **2nd mark** conditional on first mark. Accept reciprocal method: Plot a graph of sin θ against λ **(1)** Calculate inverse of gradient of graph. **(1)** Do not accept: calculating d for each angle of θ and averaging (as this is an example of invalid averaging)
		(ii)	$\left(\text{number of lines} = \frac{1\times10^{-3}}{1.6\times10^{-6}}\right)$ $(\text{number of lines} =) 625$	**1**	Accept: 630 Accept: mm^{-1} as unit

Question			Expected response	Max mark	Additional guidance
9.	(a)		A (central) positively charged nucleus. (Negatively charged) electron(s) in (discrete) energy levels (orbiting the nucleus, not radiating energy.) When an electron moves from one energy level to another, the energy lost or gained is done so only in very specific amounts of energy. Each line in a spectrum is produced when an electron moves from one energy level to another.	**2**	Any two correct answers. **INDEPENDENT MARKS**. GMP 21 (+/- rule) applies. Accept: A (central) nucleus containing a proton (and neutrons) Do not accept: protons Accept: 'in orbits', 'in shells', or 'in states' for 'in energy levels' Some implication of more than one. Do not accept: 'bands' for 'energy levels' Some indication of quantisation of energy. Do not accept: • atom is mainly empty space • nucleus is small compared to size of the atom • any statement referring to photons and photon frequency is a consequence, not a feature
	(b)	(i)	21.8×10^{-19} J	**1**	Do not accept: -21.8×10^{-19} J
		(ii)	$E_2 - E_1 = hf$ **(1)** $-0.871\times10^{-19} - \left(-21.8\times10^{-19}\right) = 6.63\times10^{-34}\times f$ **(1)** $f = 3.16\times10^{15}$ Hz **(1)**	**3**	Accept: 3.2, 3.157, 3.1567 Accept: $E_4 - E_0 = hf$ Do not accept: $E_0 - E_4 = hf$ Accept: $21.8\times10^{-19} - 0.871\times10^{-19} = 6.63\times10^{-34}\times f$ for substitution mark. Accept: $(\Delta)E = hf$ If $0.871\times10^{-19} - 21.8\times10^{-19}$ is shown for ΔE, **maximum 1 mark** for correct relationship.

Question			Expected response	Max mark	Additional guidance
10.	(a)	(i)	(Absolute refractive index of a medium is the) ratio of the speed of light in a vacuum to the speed of light in a medium.	**1**	Accept: • 'air' for 'vacuum' • 'material' for 'medium' $n = \frac{v_{vacuum}}{v_{medium}}$ $n = \frac{c}{v_{medium}}$ Do not accept: ratio of the speed of light in a medium to the speed of light in a vacuum
		(ii)	$n = \frac{\sin\theta_1}{\sin\theta_2}$ **(1)** $n = \frac{\sin 30.0}{\sin 21.0}$ **(1)** $n = 1.40$ **(1)**	**3**	Accept: 1.4, 1.395, 1.3952
		(iii)	$v = f\lambda$ **(1)** $3.00 \times 10^8 = f \times 532 \times 10^{-9}$ **(1)** $f = 5.64 \times 10^{14}$ Hz **(1)**	**3**	Accept: 5.6, 5.639, 5.6391 $v = f\lambda$ anywhere **1 mark** Alternative method: Use v and λ inside the glass. $n = \frac{v_1}{v_2}$ **AND** $n = \frac{\lambda_1}{\lambda_2}$ **THEN** $v = f\lambda$ Alternative method: **1 mark** for $v = f\lambda$ anywhere. **1 mark** for substitutions into all relationships. **1 mark** for final answer.
	(b)		(Point) R **(1)** The (absolute) refractive index (of the prism) for red light is less (than the absolute refractive index of the prism for green light) **(1)** (as) red light has a lower frequency (than green light). **(1)**	**3**	Accept: smaller, lower etc Do not accept: wavelength alone

Question			Expected response	Max mark	Additional guidance
11.			**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
12.	(a)		The energy gained by/supplied to 1 coulomb (of charge passing through the supply).	**1**	Accept: • 'number of joules' for energy • 'unit charge' for 1 coulomb • across the supply • battery
	(b)	(i)	any single value from 1.46 to 1.48 V	**1**	
		(ii)	$\left(m = \frac{y_2 - y_1}{x_2 - x_1}\right)$ $m = \frac{1.24 - 1.36}{0.40 - 0.19}$ **(1)** $m = -0.57$ **(1)** $(m = -r)$ $r = 0.57\ \Omega$ **(1)**	**3**	Accept: 1 to 4 significant figures Gradient = r is wrong physics, award **0 marks**. Substitution of any valid pair of points into gradient relationship **(1)** accept any point on a correctly extrapolated line eg (0.00,1.47). Calculated value of gradient. **(1)** If relationship to calculate gradient is stated incorrectly **0 marks,** eg $\frac{y^2 - y^1}{x^2 - x^1}$ Alternative method: For example: $E = V + Ir$ **(1)** $1.47 = 1.36 + 0.19r$ **(1)** $r = 0.58\ \Omega$ **(1)** If using this method, must use data from the line. **OR** Value of E consistent with (b)(i).

Question			Expected response	Max mark	Additional guidance
12.	(c)		$E = V + Ir$ **(1)** $1.47 = 0 + I \times 0.57$ **(1)** $I = 2.6$ A **(1)**	**3**	Must be consistent with (b)(i) and (b)(ii). Accept: 1 to 4 significant figures Alternative methods: $I = \frac{E}{r}$ **(1)** $I = \frac{1.47}{0.57}$ **(1)** $I = 2.6$ A **(1)** **OR** $E = IR + Ir$ **(1)** $1.47 = 0 + I \times 0.57$ **(1)** $I = 2.6$ A **(1)** $V = IR$ on its own **0 marks** Accept: $V = IR$ $1.47 = I$ x 0.57 $I = 2.6$ A
	(d)		The line drawn can be extrapolated to intercept the y-axis lower than the original intercept. **(1)** Passably straight line of steeper gradient. **(1)**	**2**	**INDEPENDENT MARKS**

Question			Expected response	Max mark	Additional guidance
13.	(a)		$V = IR$ **(1)** $V = 16 \times 10^{-3} \times 220$ **(1)** $V_C = 11 - \left(16 \times 10^{-3} \times 220\right)$ **(1)** $V_C = 7.5$ V **(1)**	**4**	Accept: 7, 7.48, 7.480
	(b)		$E = \frac{1}{2}CV^2$ **(1)** $E = 0.5 \times 27 \times 10^{-6} \times 11^2$ **(1)** $E = 1.6 \times 10^{-3}$ J **(1)**	**3**	Accept: 2, 1.63, 1.634 Alternative methods: eg $C = \frac{Q}{V}$ $27 \times 10^{-6} = \frac{Q}{11}$ $E = \frac{1}{2}QV$ $E = 0.5 \times \left(27 \times 10^{-6} \times 11\right) \times 11$ $E = 1.6 \times 10^{-3}$ J Alternative methods: **1 mark** for both relationships. **1 mark** for substitutions into both relationships. **1 mark** for final answer.
	(c)		Greater than. **(1)** Initial/average current is less. **(1)** (Final charge stays the same).	**2**	**JUSTIFY** Do not accept: current is less on its own

Question			Expected response	Max mark	Additional guidance
14.	(a)	(i)	Axes appropriately labelled (quantity and units), and axes linearly scaled. **(1)** Data points plotted accurately. **(1)** Appropriate line of best-fit. **(1)**	**3**	Allow for axes starting at zero or broken axes or an appropriate value. If the origin is shown the scale must either be continuous, or the axis must be 'broken'. Otherwise, **maximum 2 marks**. If non-linear scale is used over the range of the data on either axis eg values from the table are used as the scale points, **0 marks**. Do not penalise if candidates plot h_d against h_r. Accuracy of plotting should be easily checkable with the scale chosen. An appropriate scale to allow the accuracy of plotting to be checked must be linear over the range of the data.

Question			Expected response		Max mark	Additional guidance
14.	(a)	(ii)	Choosing 2 points on their line Calculate gradient	**(1)** **(1)**	**2**	Accept: 1 to 5 significant figures **Must** be consistent with graph drawn for (a)(i). Candidates are asked to calculate the gradient of **their line of best fit**. If relationship to calculate gradient is stated incorrectly (0) marks, eg. $\frac{y^2 - y^1}{x^2 - x^1}$ Judgement required depending upon line of best fit drawn by the candidate. If candidates use values from the table, these points must lie on **their line**. Any unit given in the final answer is incorrect. If candidate has a non-linear scale over the range of the values used in the substitution, 0 marks. If candidate has drawn a 'dot to dot' graph or no line, 0 marks. If the candidate has drawn a straight line through the origin, then any point on the line can be used to calculate the gradient. If candidate has plotted h_d against h_r, then marks can still be awarded.

Question			Expected response	Max mark	Additional guidance
14.	(a)	(iii)	$\left(e^2 = gradient\right)$ $e^2 = 0.509$ **(1)** $e = 0.713$ **(1)** Acceptable significant figure range must be consistent with values used.	**2**	**Must be** consistent with (a)(ii). **Must** substitute the gradient of **their line of best fit**, and not a single data point. If a single data point is substituted into the calculation, award **0 marks**. If candidate has plotted h_d against h_r, then the formula becomes $\left(e^2 = \frac{1}{gradient}\right)$
	(b)		$\left(h_r = e^2 h_d\right)$ $h_r = 0.723^2 \times 2.250$ **(1)** $h_r = 1.18$ m **(1)** Acceptable significant figure range must be consistent with values used.	**2**	**Must be** consistent with a(ii) or a(iii). Method consistent with a(ii) $\left(h_r = gradient \times h_d\right)$ $h_r = 0.509 \times 2.250$ **(1)** $h_r = 1.15$ m **(1)**

[END OF MARKING INSTRUCTIONS]