



National
Qualifications
2017

2017 Physics
Higher
Finalised Marking Instructions

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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 the paper. These principles must be read in conjunction with the detailed marking instructions, which identify the key features required in candidate responses.

- (a) Marks for each candidate response must always be assigned in line with these general marking principles and the detailed marking instructions for this assessment.
- (b) Marking should always be positive. This means that, for each candidate response, marks are accumulated for the demonstration of relevant skills, knowledge and understanding: they are not deducted from a maximum on the basis of errors or omissions.
- (c) If a specific candidate response does not seem to be covered by either the principles or detailed marking instructions, and you are uncertain how to assess it, you must seek guidance from your team leader.
- (d) There are no half marks awarded.
- (e) Where a wrong answer to part of a question is carried forward and the wrong answer is then used correctly in the following part, the candidate should be given credit for the subsequent part or 'follow on'.
- (f) Unless a numerical question specifically requires evidence of working to be shown, full marks should be awarded for a correct final answer (including units if required) on its own.
- (g) Credit should be given 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).
- (h) Marks are provided for knowledge of relevant formulae alone. When a candidate writes down several formulae and does not select the correct one to continue with, for example by substituting values, no mark can be awarded.
- (i) Marks should be awarded 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.
- (j) No marks should be awarded if a 'magic triangle' (eg ) is the only statement in a candidate's response. To gain the mark, the correct relationship must be stated eg $V = IR$ or $R = \frac{V}{I}$, etc.
- (k) In rounding to an expected number of significant figures, the mark can be awarded for answers which have up to two figures more or one figure less than the number in the data with the fewest significant figures.
- (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, the mark should not be awarded. Two specific examples of this would be when the candidate uses a term that might be interpreted as 'reflection', 'refraction' or 'diffraction' (eg 'defraction') or one that might be interpreted as either 'fission' or 'fusion' (eg 'fussion').
- (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 be rewarded for the breadth and/or depth of their conceptual understanding.

(n) Marking in calculations

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 + Comment

- | | | |
|-----|--|---|
| 1. | $V = IR$
$7.5 = 1.5R$
$R = 5.0 \Omega$ | 1 mark: formula
1 mark: substitution
1 mark: correct answer |
| 2. | 5.0Ω | 3 marks: correct answer |
| 3. | 5.0 | 2 marks: unit missing |
| 4. | 4.0Ω | 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: formula only |
| 8. | $R = \frac{V}{I} = _ \Omega$ | 1 mark: formula only |
| 9. | $R = \frac{V}{I} = \frac{7.5}{1.5} = _ \Omega$ | 2 marks: formula & subs, no final answer |
| 10. | $R = \frac{V}{I} = \frac{7.5}{1.5} = 4.0$ | 2 marks: formula & subs, wrong answer |
| 11. | $R = \frac{V}{I} = \frac{1.5}{7.5} = 5.0 \Omega$ | 1 mark: formula but wrong substitution |
| 12. | $R = \frac{V}{I} = \frac{75}{1.5} = 5.0 \Omega$ | 1 mark: formula but wrong substitution |
| 13. | $R = \frac{I}{V} = \frac{1.5}{7.5} = 5.0 \Omega$ | 0 marks: wrong formula |
| 14. | $V = IR$
$7.5 = 1.5 \times R$
$R = 0.2 \Omega$ | 2 marks: formula & subs, arithmetic error |
| 15. | $V = IR$
$R = \frac{I}{V} = \frac{1.5}{7.5} = 0.2 \Omega$ | 1 mark: formula correct but wrong rearrangement of symbols |

Marking instructions for each question

Section 1

Question	Answer	Max mark
1.	A	1
2.	B	1
3.	C	1
4.	B	1
5.	B	1
6.	C	1
7.	D	1
8.	A	1
9.	D	1
10.	B	1
11.	E	1
12.	E	1
13.	D	1
14.	D	1
15.	A	1
16.	A	1
17.	B	1
18.	E	1
19.	E	1
20.	A	1

Section 2

Question			Answer	Max mark	Additional guidance
1.	(a)	(i)	The velocity increases by 0.32 ms^{-1} each/per second	1	Accept: Speed increases by ... Rate of change of velocity/speed is ... Train gets faster by ... Velocity/speed changes by ...
		(ii)	$s = ut + \frac{1}{2}at^2$ (1) $s = ((0 \times 25)) + (0.5 \times 0.32 \times 25^2)$ (1) $s = 100 \text{ m}$ (1)	3	Accept: $v = u + at$ $v = (0) + 0.32 \times 25$ $v = 8(\text{ms}^{-1})$ $v^2 = u^2 + 2as$ $8^2 = (0^2) + (2 \times 0.32 \times s)$ $s = 100 \text{ m}$ OR $s = \frac{1}{2}(u + v)t$ or $s = \bar{v} t$ $s = \frac{1}{2}((0) + 8) \times 25$ $s = 100 \text{ m}$ Note: 1 mark for ALL equations 1 mark for ALL substitutions 1 mark for correct answer
	(b)	(i)	$f_o = f_s \left(\frac{v}{v \pm v_s} \right)$ (1) $290 = 270 \left(\frac{340}{340 - v_s} \right)$ (1) $v_s = 23 \text{ ms}^{-1}$ (1)	3	$f_o = f_s \left(\frac{v}{v - v_s} \right)$ is also acceptable Accept 20, 23.4, 23.45
		(ii)	Statement that there are fewer wavefronts per second. OR The wavefronts are further apart OR The wavelength increases OR diagram showing wavefronts closer together ahead of the train and further apart behind it. or any similar response	1	In a diagram, there must be an implication of direction of travel. Do Not Accept Any answer that implies that the frequency/wavelength of the horn itself is changing.

Question			Answer	Max mark	Additional guidance
2.	(a)	(i)	<p>(total momentum before = total momentum after)</p> $m_x u_x + m_y u_y = m_x v_x + m_y v_y \quad (1)$ $(0.180 \times 2.60) + (0.180 \times -1.80)$ $= (0.180 v_x + 0.180 \times 2.38) \quad (1)$ $0.468 - 0.324 = 0.180 v_x + 0.4284$ $v_x = -1.58 \text{ m s}^{-1} \quad (1)$ <p>(Accept '1.58 ms⁻¹ to the left' or an indication of direction eg arrow left)</p>	3	<p>1 mark for equating the momentums before and after. 1 mark for the substitutions. 1 mark for answer including unit.</p> <p>Signs must be consistent.</p> <p>Allow cancellation of masses throughout the relationship.</p> <p>Accept $v_x = -1.58 \text{ ms}^{-1}$ to the left as "loose" use of direction.</p> <p>Sig fig 1.6, 1.580, 1.5800</p>
		(ii)	<p>kinetic energy is lost/greater before the collision than after.</p>	1	<p>Do not accept: E_k before $\neq E_k$ after. E_k is not conserved.</p>
	(b)	(i)	$Ft = mv - mu \quad (1)$ $F \times 0.040 = (0.180 \times 0.84) - (0.180 \times 0) \quad (1)$ $F = 3.8 \text{ N} \quad (1)$	3	<p>Accept:</p> $a = \frac{v-u}{t}$ $a = \frac{0.84(-0)}{0.040}$ $a = 21 \text{ (m s}^{-2}\text{)}$ $F = ma$ $F = 0.180 \times 21$ $F = 3.8 \text{ N}$ <p>Sig figs 4, 3.78, 3.780</p> <p>Note: 1 mark for ALL equations 1 mark for ALL substitutions 1 mark for correct answer</p> <p>Ignore any uncertainty calculations within this question.</p>
		(ii)	$\left(\frac{0.01}{0.84} \times 100 = 1.2 \right)$ $\left(\frac{0.001}{0.180} \times 100 = 0.56 \right)$ $\frac{0.001}{0.040} \times 100 (=2.5) \quad (1)$ <p>(Uncertainty in F is) 2.5% (1)</p>	2	<p>1 mark for correct or implied working for % uncertainty in t.</p> <p>1 mark for indicating 2.5% as the largest.</p> <p>Must have % in final answer - equivalent to 'unit'.</p> <p>Accept: 3%</p>

Question			Answer	Max mark	Additional guidance
3.	(a)	(i)	$v = u + at$ $0 = 5.6 + (-9.8)t$ $t = 0.57 \text{ s}$	1 1 1 3	<p>u and a must have opposite signs</p> <p>Accept $0 = 5.6 - 9.8t$</p> <p>Accept 0.6, 0.571, 0.5714</p> <p>Alternative method: $v^2 = u^2 + 2as$ $0^2 = 5.6^2 + 2 \times (-9.8) \times s$ $s = 1.6 \text{ (m)}$ $s = \frac{1}{2}(u + v)t$ $1.6 = \left(\frac{5.6 + 0}{2}\right)t$ $t = 0.57 \text{ s}$</p> <p>If an alternative method is used, 1 mark for ALL equations 1 mark for ALL substitutions 1 mark for correct answer</p> <p>If candidate answers question in terms of an object falling from the max height and reaching a velocity of 5.6ms^{-1}, then a suitable justification MUST be given to allow access to 2nd and 3rd marks.</p> <p>A negative value for time is wrong physics - max 1 mark.</p>

Question			Answer	Max mark	Additional guidance
3.	(a)	(ii)	$v^2 = u^2 + 2as$ $(-7.7)^2 = 0^2 + 2 \times (-9.8)s$ $s = -3.0 \text{ m}$ (Distance = 3.0 m)	1 1 1	3 v and a must have the same sign and calculated value of s must agree with sign convention used. Accept 3, 3.03, 3.025 Alternative method: $mgh = \frac{1}{2}mv^2$ $gh = \frac{1}{2}v^2$ $9.8 \times h = \frac{1}{2} \times 7.7^2$ $h = 3.0 \text{ m}$ If an alternative method is used, 1 mark for ALL equations 1 mark for ALL substitutions 1 mark for correct answer
		(b)	Starting point greater than 5.6 Final point beyond -7.7 Acceptably parallel line	1 1 1	3 Independent marks Must be <u>one</u> continuous acceptably <u>straight</u> line for third mark.

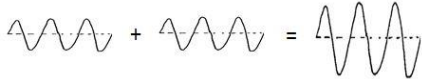
Question	Answer	Max mark	Additional guidance
4.	<p>Demonstrates no understanding 0 marks</p> <p>Demonstrates limited understanding 1 mark</p> <p>Demonstrates reasonable understanding 2 marks</p> <p>Demonstrates good understanding 3 marks</p> <p>This is an open-ended question.</p> <p>1 mark: The student 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.</p> <p>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.</p> <p>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.</p>	3	<p>Open-ended question: a variety of physics arguments can be used to answer this question.</p> <p>Marks are awarded on the basis of whether the answer overall demonstrates “no”, “limited”, “reasonable” or “good” understanding.</p>

Question			Answer	Max mark	Additional guidance
5.	(a)	(i)	$\left(\frac{3.83 \times 10^{30}}{5.69 \times 10^{27}}\right) = 673$ <p style="text-align: right;">1</p> <p>(Star is) 3 (orders of magnitude) <u>greater</u></p> <p style="text-align: right;">1</p> <p>OR <u>Exoplanet</u> is 3 (orders of magnitude) <u>smaller</u></p>	2	Sig figs: accept 670, 673·1, 673·11 Or $\left(\frac{10^{30}}{10^{27}}\right) = 1000 \text{ or } 10^3$ Or (30-27) = 3 <div style="text-align: right;">1</div> <p>‘3 greater’ on its own is worth 2 marks.</p> <p>Care should be taken where candidates answer by the reciprocal method - 2 marks are still available.</p> $\left(\frac{5.69 \times 10^{27}}{3.83 \times 10^{30}}\right) = 1.49 \times 10^{-3}$ <div style="text-align: right;">1</div> <p>Comparison statement</p> <div style="text-align: right;">1</div> <p>‘Greater’ on its own - 0 marks</p>
		(ii)	$F = G \frac{m_1 m_2}{r^2}$ <p style="text-align: right;">1</p> $F = 6.67 \times 10^{-11} \frac{5.69 \times 10^{27} \times 3.83 \times 10^{30}}{(3.14 \times 10^{11})^2}$ <p style="text-align: right;">1</p> $F = 1.47 \times 10^{25} \text{ N}$ <p style="text-align: right;">1</p>		3
	(b)	(i)	$z = \frac{v}{c}$ <p style="text-align: right;">1</p> $z = \frac{6.60 \times 10^3}{3.00 \times 10^8}$ <p style="text-align: right;">1</p> $z = 2.20 \times 10^{-5}$ <p style="text-align: right;">1</p>	3	Sig figs: Accept 2·2, 2·200, 2·2000
		(ii)	Greater (than)	1	Accept any word synonymous with ‘greater’. Any correct suggestion followed by wrong physics 0 marks.

Question		Answer	Max mark	Additional guidance
7.	(a)	They are composed of other particles/quarks, (fundamental particles are not).	1	Accept they are composite particles.
	(b)	(i) Baryons are (hadrons as they are) composed of (three) <u>quarks</u> . 1 Mesons/some hadrons are made from a quark - anti-quark pair so are not baryons. 1	2	For first mark, a correct statement that baryons consist of quarks. For second mark, a correct statement that there are other hadrons that have a different quark-count from baryons. Accept two quarks in place of quark-anti-quark pair.
		(ii) - 1/3(e)	1	
	(c)	(i) strong (nuclear force)	1	
		(ii) gluon	1	<u>Or</u> consistent with (c)(i). A carry forward mark is only accessible if one of the four fundamental forces is identified in (c)(i).
	(d)	$t' = \frac{t}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$ 1 $t' = \frac{1.5 \times 10^{-10}}{\sqrt{1 - \frac{(0.9c)^2}{c^2}}}$ 1 $t' = 3.4 \times 10^{-10} \text{ s}$ 1	3	Accept: 3, 3.44, 3.441 Accept: $\frac{1.5 \times 10^{-10}}{\sqrt{1 - 0.9^2}}$

Question			Answer	Max mark	Additional guidance
8.	(a)	(i)	W or $E_w = QV$ 1 $= 1.60 \times 10^{-19} \times 2.50 \times 10^3$ 1 $= 4.00 \times 10^{-16} \text{ J}$ 1	3	Suspend significant figure rule and accept $4 \times 10^{-16} \text{ J}$. Ignore negative sign for charge.
		(ii)	Particle (always) accelerates in the same direction/forwards OR Force on particle/electron is always in same direction OR Ensure the direction of the electric field is correct when particle/electron passes between (alternate) gaps		
	(b)	(i)	Out of page	1	Do not accept: 'upwards' on its own, OR 'out of the page' with other comments such as 'circular' 'clockwise'.
		(ii)	(Magnetic fields are in) <u>opposite</u> directions 1 (Magnetic field in) S is <u>stronger</u> than (field in) R 1	2	Independent marks Or consistent with (b)(i) for first mark as long as a <u>linear</u> field is described. Accept statement referring to direction of (magnetic field in) S alone ONLY if (b)(i) has been answered. Do not accept: 'different directions' 'force in S is opposite to force in R' alone.
	(c)		$E_k = \frac{1}{2}mv^2$ 1 $4.16 \times 10^{-17} = \frac{1}{2} \times 9.11 \times 10^{-31} \times v^2$ 1 $v = 9.56 \times 10^6 \text{ ms}^{-1}$ 1	3	Accept: 9.6, 9.557, 9.5566

Question			Answer	Max mark	Additional guidance
9.	(a)		(Two) small nuclei combine to form a larger nucleus	1	<p>Accept: 'light' and 'heavy'. Accept: 'fuse', 'join'</p> <p>Do not accept: Atoms/molecules/particles/ isotopes/elements.</p> <p>Do not accept: 'react' in place of 'combine' or equivalent of 'combining'.</p>
	(b)	(i)	(Some) mass (is lost and) <u>converted</u> to energy	1	<p>There must be an indication of mass being converted (or an equivalent term) to energy e.g. transformed, becomes, changed to etc...</p> <p>Do not accept: transferred...</p> <p>Mass is lost on its own - 0 marks. Mass defect is wrong physics - 0 marks.</p>

Question		Answer	Max mark	Additional guidance
10.	(a)	<p>Waves <u>meet</u> in phase</p> <p>OR Crest <u>meets</u> crest</p> <p>OR Trough <u>meets</u> trough</p> <p>OR Path difference = $m\lambda$</p>	1	<p>Accept 'peak' for 'crest'. Can be shown by diagram:</p>  <p>Do not accept 'join' or 'merge' alone.</p>
	(b)	<p>(i) statement that $\lambda = \text{gradient}$ or link λ to the gradient 1</p> <p>subs to calculate gradient 1</p> <p>$\lambda = 4.8 \times 10^{-7} \text{m}$ 1</p>	3	<p>Acceptable range using the 'gradient' method, 4.7 to $5.0 \times 10^{-7} \text{m}$, but intermediate steps still need to be checked.</p> <p>If any of the plotted points on the graph ('x') are used, then maximum 1 for formula.</p> <p>$m\lambda = d \sin \theta$ 1</p> <p>Accept : $\lambda = d \sin \theta$ in this case</p> <p>Subs of values <u>from line</u> 1</p> <p>$\lambda = 4.8 \times 10^{-7} \text{m}$ 1</p>
		<p>(ii) ($d = 2 \times 10^{-6}$ gives:)</p> <p>$\frac{1}{d} = 0.50 \times 10^6$ 1</p> <p>$\sin \theta = 0.24$ from graph 1</p> <p>$\theta = 14^\circ$ 1</p>	3	<p>Sig figs: Accept 10, 13.9, 13.89</p> <p>Alternative method -</p> <p>$m\lambda = d \sin \theta$ 1</p> <p>Accept: $\lambda = d \sin \theta$ in this case</p> <p>$1 \times 4.8 \times 10^{-7} = 2.0 \times 10^{-6} \times \sin \theta$ 1</p> <p>$\theta = 14^\circ$ 1</p> <p>Or consistent with (b)(i).</p>
	(c)	<p>Any two correct answers from:</p> <p>Repeat measurements</p> <p>Use additional gratings</p> <p>Move screen further away</p> <p>Use second order maxima to determine θ</p> <p>Measure angle from first order to first order</p>	2	<p>Independent marks</p> <p>For the first point opposite, it must be clear that the candidate is implying that the measurements are being repeated.</p> <p>Do not accept: 'repeat the experiment' 'different sizes of slits/gratings' 'darkened room'</p> <p>Any <u>additional</u> improvements stated (beyond two) that <u>reduce reliability</u>, then \pm rule applies.</p>

Question	Answer	Max mark	Additional guidance
11.	<p>Demonstrates no understanding 0 marks</p> <p>Demonstrates limited understanding 1 mark</p> <p>Demonstrates reasonable understanding 2 marks</p> <p>Demonstrates good understanding 3 marks</p> <p>This is an open-ended question.</p> <p>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.</p> <p>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.</p> <p>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.</p>	3	<p>Open-ended question: a variety of physics arguments can be used to answer this question.</p> <p>Marks are awarded on the basis of whether the answer overall demonstrates “no”, “limited”, “reasonable” or “good” understanding.</p>

Question		Answer	Max mark	Additional guidance	
12.	(a)	1.5 J (of energy) is <u>supplied to/gained by</u> each coulomb (of charge passing through the cell).	1	Accept 'given to'... Accept 'battery'/'source'.	
	(b)	(i)	lost volts = Ir 1 lost volts = $64 \times 10^{-3} \times (2 \times 2.7)$ 1 lost volts = 0.35 V	2	“SHOW” question. Must start with a correct formula. Accept $V = IR$ Accept 5.4 as substitution for 'r' Accept working out lost volts for one cell, then doubling.
		(ii)	$V = 2.7 V$	1	Must use 0.35 V Do not accept 3V on its own, but if 3V is clearly shown as a rounded value - 1 mark.
		(iii)	$P = IV$ 1 $P = 64 \times 10^{-3} \times 2.7$ 1 $P = 0.17 W$ 1	3	Or consistent with (b)(ii) Sig figs: Accept 0.2, 0.173, 0.1728

Question		Answer	Max mark	Additional guidance
12.	(c)	$V = E - Ir$ $V = 6.0 - (26 \times 10^{-3} \times (4 \times 2.7))$ 1 $V = 5.7192 (V)$ $R = \frac{V_R}{I}$ (both formulae) 1 $R = \frac{5.7192 - 3.6}{26 \times 10^{-3}}$ 1 $R = 82 \Omega$ 1	4	1 mark for quoting <u>both</u> formulae - explicitly or implied. Sig figs: Accept 80, 81.5, 81.51 Alternative methods: $R_T = \frac{V}{I}$ $R_T = \frac{6.0}{26 \times 10^{-3}} = 230.8(\Omega)$ $R_{LED} = \frac{V}{I}$ $R_{LED} = \frac{3.6}{26 \times 10^{-3}} = 138.5(\Omega)$ $R = 230.8 - (138.5 + 10.8)$ $R = 82 \Omega$ $V = Ir$ $V = 26 \times 10^{-3} \times (2.7 \times 4)$ $V = 0.2808 (V)$ $V_R = 6.0 - 3.6 - 0.2808$ $V_R = 2.1192 (V)$ $R = \frac{V_R}{I}$ $R = \frac{2.1192}{26 \times 10^{-3}}$ $R = 82 \Omega$ 1 mark for <u>all</u> formulae 1 mark for <u>all</u> substitutions 1 mark for <u>all</u> correct intermediate values 1 mark for final answer

Question		Answer	Max mark	Additional guidance
13.	(a)	$V = IR$ 1 $12 = I \times 6800$ 1 $I = 1.8 \times 10^{-3} A$ 1	3	Sig figs: Accept 2, 1.76, 1.765
	(b)	The (circuit/total) resistance is less 1 <u>Initial</u> charging current is greater 1	2	Independent marks. Accept: <u>Average</u> current is greater OR The current <u>at any given time</u> is greater. 'Current greater' on its own is not sufficient for 2 nd mark.
14.	(a)	Photovoltaic (effect)	1	
	(b)	(i) $I = 35 \text{ mA}$ (from graph) 1 $P = IV$ 1 ($P = 0.035 \times 2.1$) $P = 0.074 \text{ W}$ 1	3	$P = IV$ anywhere, 1 mark. Sig figs: Accept 0.07, 0.0735 Accept a value for I between 34.5 and 35 mA inclusive. $I = 34.5 \text{ mA}$ gives $P = 0.073 \text{ W}$ Sig figs for above: Accept 0.07, 0.0725, 0.07245
		(ii) Greater number of <u>photons</u> (strike the solar cell) <u>per second</u>	1	The answer has to imply a 'rate'. Any correct statement followed by wrong physics, 0 marks.

Question		Answer	Max mark	Additional guidance
15.	(a)	$R = \frac{\rho L}{A}$ $R = \frac{2.8 \times 10^{-8} \times 0.82}{4.0 \times 10^{-6}} \quad 1$ $R = 5.7 \times 10^{-3} \Omega \quad 1$	2	Sig figs: Accept 6×10^{-3} , 5.74×10^{-3} , 5.740×10^{-3}
	(b)	(i) <p>Suitable scales with labels on axes (quantity and unit) 1 [Allow for axes starting at zero or broken axes or starting at an appropriate value]</p> <p>Correct plotting of points 1</p> <p>Best fit line 1</p>	3	<p>The scale must correctly extend over the range of the points plotted.</p> <p>The resistance scale must include ($\times 10^{-3}$) or show correct converted values, otherwise maximum 2 marks.</p> <p>If an invalid scale is used on either axis eg values for resistance from the table are used as major grid line values - 0 marks.</p> <p>Accuracy of plotting should be easily checkable with scale chosen.</p> <p>If the origin on an axis is shown, the scale must either be continuous or the axis must be 'broken'. Otherwise maximum 2 marks.</p> <p>Do not penalise if candidates plot L against R.</p>

Question			Answer	Max mark	Additional guidance
15.	(b)	(ii)	Choosing 2 points on <u>their</u> line 1 Calculate gradient : accept value between 3.7×10^{-3} and $4.0 \times 10^{-3} (\Omega m^{-1})$ 1 (min 1 sig fig, max 4 sig figs)	2	<p>Must be consistent with graph drawn for (b)(i). Candidates are asked to calculate the gradient of their graph.</p> <p>Calculated value must be consistent with the points selected.</p> <p>Data points $x=3.0$ and 3.5 give an acceptable gradient of 4.0×10^{-3}.</p> <p>If the scale points <u>do not</u> lie on the line drawn outwith $\pm \frac{1}{2}$ box tolerance, the scale points cannot be used to calculate the gradient.</p> <p>If $(\times 10^{-3})$ is not included in the final answer, maximum 1 mark unless this being omitted is consistent with the graph drawn in (b)(i).</p> <p>Unit is not required, but must be correct if stated and be consistent with graph drawn, otherwise maximum 1 mark.</p>

Question			Answer	Max mark	Additional guidance
15.	(b)	(iii)	$\rho = \text{gradient} \times A$ 1 $\rho = 3.7 \times 10^{-3} \times 4.52 \times 10^{-6}$ 1 $\rho = 1.7 \times 10^{-8} \Omega \text{m}$ 1	3	<p>Or consistent with (b)(ii).</p> <p>$\text{gradient} = 3.7 \times 10^{-3}$ leads to $\rho = 1.672 \times 10^{-8} \Omega \text{m}$ $\text{gradient} = 4.0 \times 10^{-3}$ leads to $\rho = 1.808 \times 10^{-8} \Omega \text{m}$</p> <p>If the candidate has drawn a straight line <u>through the origin</u> (tolerance within ± 1 full box), then any point <u>on the line</u> can be used to calculate the resistivity.</p> <p>If the candidate has used a point on their line and uses continuous scales from zero, but has not extended their line back through the origin, then use the ruler tool to confirm that their line passes through the origin within tolerance.</p> <p>If the line drawn (or extrapolated line 'created' on Assessor) does NOT pass through the origin within ± 1 full box tolerance, the gradient of the line must be used and not one single point selected, otherwise 0 marks.</p> <p>If candidate has chosen an appropriate point on their line, 1 mark for selection of point 1 mark for correct substitution 1 mark for final answer.</p> <p>If $(\times 10^{-3})$ is missing from substitution, then maximum 1 mark if not corrected in the unit given with the final answer.</p> <p>If the candidate uses a broken scale on either axis, or does not start their scale at zero, they <u>must</u> use the gradient in their calculation of ρ, otherwise 0 marks.</p> <p>If candidate has plotted L against R, the formula becomes $\rho = \frac{1}{\text{gradient}} \times A,$ otherwise 0 marks.</p>

[END OF MARKING INSTRUCTIONS]