

# **2016 Physics**

# Higher

# **Finalised Marking Instructions**

 $\ensuremath{\mathbb{C}}$  Scottish Qualifications Authority 2016

The information in this publication may be reproduced to support SQA qualifications only on a non-commercial basis. If it is to be used for any other purposes written permission must be obtained from SQA's NQ Assessment team.

Where the publication includes materials from sources other than SQA (secondary copyright), this material should only be reproduced for the purposes of examination or assessment. If it needs to be reproduced for any other purpose it is the centre's responsibility to obtain the necessary copyright clearance. SQA's NQ Assessment team may be able to direct you to the secondary sources.

These Marking Instructions have been prepared by Examination Teams for use by SQA Appointed Markers when marking External Course Assessments. This publication must not be reproduced for commercial or trade purposes.



#### 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 <u>always</u> 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.
- (I) 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.	5.0 Ω	3 marks: correct answer				
3.	5.0	2 marks: unit missing				
4.	$4 \cdot 0 \ \Omega$	0 marks: no evidence, wrong answer				
5.	Ω	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: formula only				
8.	$R = \frac{V}{I} = \_ \Omega$	1 mark: formula only				
9.	$R = \frac{V}{I} = \frac{7 \cdot 5}{1 \cdot 5} = \_ \Omega$	2 marks: formula & subs, no final answer				
10.	$R = \frac{V}{I} = \frac{7 \cdot 5}{1 \cdot 5} = 4 \cdot 0$	2 marks: formula & subs, wrong answer				
11.	$R = \frac{V}{I} = \frac{1 \cdot 5}{7 \cdot 5} = 5 \cdot 0 \ \Omega$	1 mark: formula but wrong substitution				
12.	$R = \frac{V}{I} = \frac{75}{1 \cdot 5} = 5 \cdot 0 \ \Omega$	1 mark: formula but wrong substitution				
13.	$R = \frac{I}{V} = \frac{1 \cdot 5}{7 \cdot 5} = 5 \cdot 0 \ \Omega$	0 marks: wrong formula				
14.	V=IR 7.5 = 1.5 × R $R = 0.2 \Omega$	2 marks: formula & subs, arithmetic error				
15.	V=IR					
	$R = \frac{I}{V} = \frac{1 \cdot 5}{7 \cdot 5} = 0 \cdot 2 \ \Omega$	1 mark: formula correct but wrong rearrangement of symbols				

## Marking Instructions for each question

### Section 1

Question	Answer	Max Mark
1.	В	1
2.	А	1
3.	С	1
4.	С	1
5.	С	1
6.	В	1
7.	С	1
8.	А	1
9.	E	1
10.	D	1
11.	D	1
12.	А	1
13.	С	1
14.	E	1
15.	С	1
16.	В	1
17.	D	1
18.	D	1
19.	E	1
20.	В	1

### Section 2

Question			Answer		Max Mark	Additional Guidance
1.	(a)	(i)	$u_{\rm v} = 9.1 \sin 24^{\circ}$ $u_{\rm v} = 3.7 \text{ m s}^{-1}$	(1)	1	Sig figs: Accept 4, 3·70, 3·701 OR Accept m/s
		(ii)	$u_{\rm h} = 9 \cdot 1 \cos 24^{\circ}$ $u_{\rm h} = 8 \cdot 3 \text{ m s}^{-1}$	(1)	1	Sig figs: Accept 8, 8·31, 8·313
	(b)		v = u + at $0 = 3 \cdot 7 + (-9 \cdot 8)t$ $t = 0 \cdot 378 (s)$ (total) $t = 0 \cdot 378 \times 2$ (total) $t = 0 \cdot 76 s$ <b>OR</b> v = u + at $-3 \cdot 7 = 3 \cdot 7 + (-9 \cdot 8) \times t$ (total) $t = 0 \cdot 76 s$	<ul> <li>(1)</li> <li>(1)</li> <li>(1)</li> <li>(1)</li> </ul>	2	SHOW question. Sign convention must be correct. Accept $0 = 3 \cdot 7 - 9 \cdot 8t$ If final line not shown then a maximum of 1 mark can be awarded. Guidance on alternatives $s = ut + \frac{1}{2}at^2$ (1) $0 = 3 \cdot 7t + \frac{1}{2}(-9 \cdot 8)t^2$ (1) (total) t = 0.76 s
	(c)		$s = v_h \times t$ $s = 8 \cdot 3 \times 0 \cdot 76$ $s = 6 \cdot 3 m$	<ul><li>(1)</li><li>(1)</li><li>(1)</li></ul>	3	Or consistent with (a)(ii) Sig figs: Accept 6, 6.31, 6.308 Accept $s = \frac{1}{2}(u+v)t$ Accept $s = ut + \frac{1}{2}at^2$ Accept $s = ut$ $v_h = 8.31 \text{ m s}^{-1}$ gives $s = 6.32 \text{ m is}$ acceptable
	(d)		Smaller displacement curve with decreasing gradient	(1) (1)	2	Ignore any change in time Any part of the curve drawn above the original line - award 0 marks These marks are independent.

Que	stion		Answer		Max Mark	Additional Guidance
2.	(a)	(i)	$\overline{d} = \frac{1 \cdot 31 + 1 \cdot 40 + 1 \cdot 38 + 1 \cdot 41 + 1}{5}$ $\overline{d} = 1 \cdot 37 \text{ m}$	·35 (1)	1	Sig figs: Accept 1·4, 1·370
		(ii)	$\Delta \overline{d} = \frac{1 \cdot 41 - 1 \cdot 31}{5}$ $\Delta \overline{d} = 0 \cdot 02 \text{ m}$	(1) (1)	2	Sig figs: Accept $0.020$ Accept $(1.37 \pm 0.02)$ m
	(b)		$\% \Delta m = \frac{0.01}{0.20} \times 100 = 5\%$ $\% \Delta h = \frac{0.0005}{0.40} \times 100 = 1.3\%$ $\% \Delta \overline{d} = \frac{0.02}{1.37} \times 100 = 1.5\%$ Mass (has largest percentage uncertainty).	<ul> <li>(1)</li> <li>(1)</li> <li>(1)</li> </ul>	4	Or consistent with (a)(i) and (a)(ii). Each correct calculation with <u>correct substitution</u> is awarded 1 mark Each calculation is independent but must have all three calculations <u>shown</u> to access the final mark for the conclusion. Accept percentage sign missing. Wrong substitution - maximum of 2 marks. Sig figs: for $\% \Delta m$ Accept 5.0, 5.00 for $\% \Delta h$ Accept 1, 1.25, 1.250 for $\% \Delta d$ Accept 1, 1.46, 1.460
	(c)	(i)	$E_{p} = mgh$ $E_{p} = 0.20 \times 9.8 \times 0.40$ $E_{p} = 0.78 \text{ J}$	(1) (1) (1)	3	Sig figs: Accept 0.8, 0.784 Treat -9.8 as wrong substitution unless h is also negative.

Que	stion		Answer	Max Mark	Additional Guidance
2.	(c)	(ii)	$E_w = Fd$ (1) $0.78 = F \times 1.37$ (1) F = 0.57 N (1)	3	Or consistent with (a)(i) and (c)(i) Sig figs: Accept 0.6, 0.569, 0.5693 Candidates can arrive at this answer by alternative methods eg equating loss in $E_P$ to gain in $E_K$ etc. If alternative methods used, can also accept 0.572, 0.5723 1 for ALL equations 1 for ALL substitutions 1 for correct answer
		(iii)	All $E_{\rho}$ converted to $E_k$ All $E_p$ converted to $E_W$ Air resistance is negligible Ramp is frictionless Bearings in the wheels are frictionless The carpet is horizontal No energy/heat loss <u>on the ramp</u> etc	1	Only one correct statement required Note the ± rule applies Energy is conserved on its own OR No energy/ heat loss on its own – 0 marks

Que	stion	Answer	Max Mark	Additional Guidance
3.	(a)	<u>Total</u> momentum before (a collision) is equal to the <u>total</u> momentum after (a collision) in the absence of external forces (1)	1	Not: TMB = TMA An isolated system is equivalent to the absence of external forces
	(b)	$m_{1}u_{1} + m_{2}u_{2} = (m_{1} + u_{2})v \qquad (1)$ $(0 \cdot 85 \times 0 \cdot 55) + (0 \cdot 25 \times -0 \cdot 3)$ $= (0 \cdot 25 + 0 \cdot 85)v \qquad (1)$ $v = 0 \cdot 36 \text{ m s}^{-1} \qquad (1)$	3	Sign of the answer must be consistent with the substitution of + and – velocities. Sig figs: Accept 0.4, 0.357, 0.3568 If candidate then goes on to state a direction which is not consistent with their substitution then maximum two marks can be awarded. Where candidates calculate the momentum of each trolley individually both before and after, no marks are awarded unless correct addition (including sign convention) and equating takes place.
	(c)	$E_{k} = \frac{1}{2}mv^{2} \text{ ANYWHERE} $ (1) Before $E_{k} = \frac{1}{2}m_{X}v_{X}^{2} + \frac{1}{2}m_{Y}v_{Y}^{2}$ $= (\frac{1}{2} \times 0.85 \times 0.55^{2})$ $+ (\frac{1}{2} \times 0.25 \times 0.3^{2})$ = 0.14  (J) (1) After $E_{k} = \frac{1}{2}mv^{2}$ $= \frac{1}{2} \times 1.1 \times 0.36^{2} = 0.071 \text{ (J)} $ (1) <u>Kinetic</u> energy is lost. (Therefore inelastic.) (1)	4	Or consistent with (b) 1 mark for both substitutions If candidate answers 0.49 in (b), this gives 0.13 J for $E_K$ after. $E_K before \neq E_K after$ is insufficient

Que	stion		Answer	Max Mark	Additional Guidance
4.	(a)		$\begin{array}{c} (0.83 + 1.20) - 1.80 \\ 0.23 \text{ m s}^{-1} \end{array} \tag{1}$	2	
	(b)	(i)	$3 \times 10^8$ m s <sup>-1</sup> or $c$ (1) Speed of light is the same for all observers / all (inertial) frames of reference or equivalent (1)	2	Look for this statement first - if incorrect then 0 marks. $3 \times 10^8$ m s <sup>-1</sup> or c on its own is worth 1 mark If the numerical value for speed is given, then unit is required- otherwise 0 marks Any wrong physics in justification then maximum 1 mark for the statement
		(ii)	$l' = l \sqrt{1 - \left(\frac{v}{c}\right)^2} $ (1) $l = 71 \sqrt{1 - 0 \cdot 8^2} $ (1) l = 43  m (1)	3	Sig figs: Accept 40, 42·6, 42·60
		(iii)	Correct - from the perspective of the stationary observer there will be time dilation Incorrect - from the perspective of the students they are in the same frame of reference as the clock Not possible to say/could be both correct and incorrect - frame of reference has not been defined	1	The response must involve a statement referring to, or implying, a frame of reference
5.	(a)	(i)	$\Delta X = 0.04 \text{ (m)}$ $X = 0.016 \text{ (m s}^{-1})$ (1) $\Delta Y = 0.06 \text{ (m)}$ $Y = 0.024 \text{ (m s}^{-1})$ (1)	2	If values are not entered in the table, then X and Y must be identified <u>and</u> units required.
		(ii)	More distant <u>galaxies</u> are moving <u>away</u> at a greater velocity/ have a greater recessional velocity Or equivalent	1	The (average) speed (of the knots) is (directly) <u>proportional</u> to the distance (from V) Any reference to planets or stars alone - 0 marks
	(b)		$z = \frac{\lambda_{observed} - \lambda_{rest}}{\lambda_{rest}} $ (1) $z = \frac{667 \times 10^{-9} - 656 \times 10^{-9}}{656 \times 10^{-9}} $ (1) z = 0.0168 (1)	3	Sig figs: Accept 0.017, 0.01677, 0.016768 Accept $z = \frac{667 - 656}{656}$

Question	Answer	Max Mark	Additional Guidance
6.	Demonstrates no understanding 0 marks Demonstrates limited understanding 1 marks Demonstrates reasonable understanding 2 marks Demonstrates good understanding 3 marks This is an open-ended question. <b>1 mark:</b> 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. <b>2 marks:</b> The student has demonstrated a reasonable understanding of the physics involved. The student make some statement(s) which is/are relevant to the situation, showing that at least a little of the physics within the problem is understood. <b>2 marks:</b> The student makes some statement(s) which is/are relevant to the situation, showing that the problem is understood. <b>3 marks:</b> 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		Answer		Max Mark	Additional Guidance
7.	(a)	W = QV = 1.6×10 <sup>-19</sup> ×2000 = 3.2×10 <sup>-16</sup> J	(1) (1) (1)	3	Sig figs: Accept $3 \times 10^{-16}$ , $3 \cdot 20 \times 10^{-16}$ , $3 \cdot 200 \times 10^{-16}$ , Ignore negative sign for charge.
	(b)	$Q = It$ $= 0.008 \times 60$ $= 0.48 (C)$ $number = \frac{0.48}{1.6 \times 10^{-19}}$ $= 3.0 \times 10^{18}$	(1) (1) (1)	4	Sig figs: Accept $3 \times 10^{18}$ If the response stops at $0.48$ then a correct unit is required. Candidates can arrive at this answer by alternative methods eg P=IV and E=Pt <b>OR</b> Q=It to calculate the time for 1 electron.
	(c)	Straight lines with arrows po downwards.	inting	1	spacing should be approximately equal (ignore end effect) Field lines must start and finish on the plates Lines at right angles to the plates

Que	stion	Answer	Max Mark	Additional Guidance
8.	(a)	mass is converted into energy	1	There must be a link between mass and energy.
				Mass is lost on its own - 0 marks
				Mass defect is wrong physics - 0 marks
				Energy is released or equivalent is not sufficient.
	(b)	$m_{before} = 3.3436 \times 10^{-27} + 5.0083 \times 10^{-27}$	4	$E = mc^2$ anywhere - 1 mark.
		$= 8 \cdot 3519 \times 10^{-27} \text{ (kg)}$ $m_{after} = 6 \cdot 6465 \times 10^{-27} + 1 \cdot 6749 \times 10^{-27}$ $= 8 \cdot 3214 \times 10^{-27} \text{ (kg)}$		If mass before and after not used to 5 significant figures from table then stop marking - maximum 1 mark for formula
		$\Delta m = 3 \cdot 0500 \times 10^{-29}  \text{(kg)} \tag{1}$		Arithmetic mistake can be carried forward
				Truncation error in mass before and/or mass after- maximum 1 mark for formula
		$E = mc^{2} $ (1) = 3.0500 × 10 <sup>-29</sup> × (3.00 × 10 <sup>8</sup> ) <sup>2</sup> (1)		Sig figs: 2·7, 2·745, 2·7450
		$= 2.75 \times 10^{-12} $ J (1)		If finding $E = mc^2$ for each particle, then $E = mc^2$ (1) All substitutions (1) Subtraction (1) Final answer (1)
	(c)	Plasma would cool down if it came too close to the sides (and reaction would stop)	1	(Reaction requires very high temperature), so plasma would melt the sides of the reactor
				OR
				High temperature plasma could damage/ destroy the container
	(d)	Up the page	1	Accept up and upwards
				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

Question		Answer	Max Mark	Additional Guidance
9.	(a)	The waves from the two sources have a constant phase relationship (and have the same frequency, wavelength, and velocity).	1	"In phase" is not sufficient
	(b)	Waves <u>meet</u> in phase OR Crest <u>meets</u> crest OR Trough <u>meets</u> trough OR Path difference = mλ	1	Accept peak for crest Can be shown by diagram eg AAA + AAA = AAA Diagram must imply addition of two waves in phase
	(c)	Path Difference = $m\lambda$ (1) $0.282 - 0.204 = 2 \times \lambda$ (1) $\lambda = 0.0390m$ (1) (39 mm)	3	Sig figs: 0.039 m 0.03900 m 0.039000 m Not: 0.04 m
	(d)	The path difference stays the same <b>OR</b> The path difference is still $2\lambda$ (1) because the wavelength has not changed (1)	2	Look for this statement first - if incorrect then 0 marks. The path difference stays the same <b>OR</b> The path difference is still $2\lambda$ on its own - 1 mark Any wrong physics in justification then maximum 1 mark (for the statement)

Question		Answer		Max Mark	Additional Guidance
10.	(a)	$n = \sin i / \sin r$	(1)	3	Sig figs:
		= sin36/sin18	(1)		Accept 2, 1.90, 1.902
		= 1.9	(1)		
	(b)	$\sin\theta_{\rm C} = 1/n$	(1)	3	Or consistent with 10(a).
		= 1/1.9	(1)		
		= 0.5263			
		$\theta_{\rm C} = 32^{\circ}$	(1)		
	(c)	Completed diagram, showing light emerging (approximately) parallel to the incident ray		1	The normal is not required

Question	Answer	Max Mark	Additional Guidance
11.	Demonstrates no understanding 0 marks Demonstrates limited understanding 1 marks Demonstrates reasonable Understanding 2 marks Demonstrates good understanding 3 marks This is an open-ended question. <b>1 mark:</b> 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. <b>2 marks:</b> The student has demonstrated a reasonable understanding of the physics involved. The student make some statement(s) which is/are relevant to the situation, showing that the problem is understood. <b>3 marks:</b> 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			Answer		Max Mark	Additional Guidance
12.	(a)	(i)	$V = IR$ $V = 1 \cdot 80 (4 \cdot 8 + 0 \cdot 10)$	(1) (1)	4	lost volts = Ir $lost volts = 1 \cdot 80 \times 0 \cdot 10$ $lost volts = 0 \cdot 18 V$
			V = 8.82 (V) Voltmeter reading (= $12.8 - 8.8$	(1) 2)		V = IR $V = 1 \cdot 80 \times 4 \cdot 8$ $V = 8 \cdot 64 V$
			$= 4 \cdot 0 V$	(1)		$V = 12 \cdot 8 - 0 \cdot 18 - 8 \cdot 64$ $V = 4 \cdot 0 V$
						OR
						$E = V + Ir 12 \cdot 8 = V + (1 \cdot 80 \times 0 \cdot 10) V = 12 \cdot 62 V$
						V = IR $V = 1 \cdot 80 \times 4 \cdot 8$ $V = 8 \cdot 64 V$
						$V = 12 \cdot 62 - 8 \cdot 64$ $V = 4 \cdot 0 V$
						1 for all equations 1 for all substitutions 1 for all correct intermediate values 1 for final answer
						Sig figs: Accept 4, 3·98, 3·980
		(ii)	(Reading on voltmeter)/(voltage across lamp) decreases	e (1)	3	Look for this statement first - if incorrect then 0 marks.
			(total) resistance decreases/ current increases.	(1)		'Reading on voltmeter decreases' on its own is worth 1 mark
			lost volts increases/ $V_{\rm tpd}$ decreases/p.d. across $4.8~\Omega$ increases/share of p.d. across			Any wrong physics in justification then maximum 1 mark for the statement
			parallel branch decreases	(1)		Last 2 marks are independent of each other
						Can be justified by calculation $(R_{lamp} \text{ is } 2 \cdot 2 \Omega, I = 2 \cdot 1 \text{ A, gives})$ $V = 2 \cdot 3 \text{ V}$

Question			Answer	Max Mark	Additional Guidance
12.	(b)	(i)		3	Look for reference to either conduction or valence band first. Otherwise 0 marks.
					Bands must be named correctly in first two marking point eg not valency and not conductive
					Any answer using recombination of holes and electrons <b>on its</b> <b>own</b> , with no reference to band theory, is worth 0 marks.
			(Voltage applied causes) <u>electrons</u> to move towards <u>conduction band</u> of p-type/ away from n-type (towards the junction) (1)		Must be directional
			Electrons move/ drop from conduction band to valence band (1)		Any wrong physics eg holes move up (from valence band to conduction band)- 0 marks
			Photon emitted (when electron drops) (1)		This mark is dependent upon having at least one of the first two statements
		(ii) (A)	$E = hf$ $3 \cdot 03 \times 10^{-19} = 6 \cdot 63 \times 10^{-34} \times f$ $f = 4 \cdot 57 \times 10^{14} \text{ (Hz)}$ $v = f\lambda \text{ (1) for both equations}$ $3 \times 10^8 = 4 \cdot 57 \times 10^{14} \times \lambda$ $\lambda = 6 \cdot 56 \times 10^{-7} \text{ m}$ (1)	4	Alternative: $E = \frac{hc}{\lambda}$ (1) Correct substitution (2) (1 for <i>E</i> and <i>h</i> ; 1 for <i>c</i> ) Final value of $\lambda$ (1) Sig figs: Accept $6 \cdot 6 \times 10^{-7}$ , $6 \cdot 564 \times 10^{-7}$ , $6 \cdot 5644 \times 10^{-7}$
		(ii) (B)	Red (1)	1	or consistent with (A) If wavelength stated in this part, then colour must be consistent with this value

Question			Answer	Max Mark	Additional Guidance
13.	(a)	(i)	12 V	1	Accept 12.0 V
		(ii)	$E = \frac{1}{2} C V^{2}$ (1) $E = \frac{1}{2} \times 150 \times 10^{-3} \times 12^{2}$ (1) E = 11 J (1)	3	Or consistent with a(i) Sig figs: 10 J 10·8 J 10·80 J $Q = CV$ and $E = \frac{1}{2}QV$ OR $Q = CV$ and $E = \frac{1}{2}\frac{Q^2}{C}$ (1) Both substitutions (1) Final answer (1)
	(b)		$(R_{\rm T} = 56 + 19 = 75 \ (\Omega))$ $I = \frac{V}{R} \qquad (1)$ $I = \frac{12}{75} \qquad (1)$ $I = 0.16 \ A \qquad (1)$	3	Or consistent with a(i) Candidates can arrive at this answer by alternative methods. Sig figs: 0·2 A 0·160 A 0·1600 A
	(c)		(Lamp stays lit for a) shorter time (1) (as smaller capacitance results in) less energy stored / less charge stored (1)	2	Look for this first Must provide relevant justification which is not wrong physics. If wrong physics - 0 marks. <i>E</i> is less because $E = \frac{1}{2} C V^2$ is acceptable. If candidate says the current stays the same, they must identify it is the <u>initial</u> current.

Question			Answer	Max Mark	Additional Guidance
14.	(a)		$f = \frac{1}{2L} \sqrt{\frac{T}{\mu}}$ $= \frac{1}{2 \times 0.550} \sqrt{\frac{49 \cdot 0}{4 \cdot 00 \times 10^{-4}}}  (1)$ $= 318 \text{ Hz} \qquad (1)$	2	Substitution (1) Answer (1) Sig figs: Accept 320, 318·2, 318·18
	(b)	(i)	Suitable scales with labels on axes (quantity and units)(1)[Allow for axes starting at zero or broken axes or an appropriate value]Points plotted correctly(1)Best-fit straight line(1)	3	If the origin is shown the scale must either be continuous or the axis must be 'broken'. Otherwise maximum 2 marks. If an invalid scale is used on either axis eg values from the table are used as the scale points - 0 marks Do not penalise if candidates plot $\sqrt{T}$ against $f$ Graphs of $T$ and $f$ are incorrect for (b)(i) - 0 marks, but can still gain marks for b(ii).
		(ii)	230 Hz	1	Must be consistent with the candidate's graph in (b)(i) $(\sqrt{22} = 4.7 \text{ gives}) 230 \text{ Hz}$ Correct value of $\sqrt{T}$ must be used If f against T is drawn in b(i), then this mark can still be accessed. If values from table are used as the scale points - 0 marks

## [END OF MARKING INSTRUCTIONS]