National
Qualifications
2018

2018 Physics

Higher

Finalised Marking Instructions

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.

(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. $V = IR$ $7{\cdot}5 = 1{\cdot}5R$ $R = 5{\cdot}0\ \Omega$	1 mark: formula 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: 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. $V=IR$ $7{\cdot}5 = 1{\cdot}5 \times R$ $R = 0{\cdot}2\ \Omega$	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	Mark
1.	C	**1**
2.	D	**1**
3.	A	**1**
4.	B	**1**
5.	A	**1**
6.	C	**1**
7.	D	**1**
8.	B	**1**
9.	E	**1**
10.	C	**1**
11.	B	**1**
12.	A	**1**
13.	D	**1**
14.	D	**1**
15.	E	**1**
16.	C	**1**
17.	D	**1**
18.	D	**1**
19.	E	**1**
20.	C	**1**

Section 2

Question			Answer	Max mark	Additional guidance
1.	(a)	(i) (A)	$u_h = 7 \cdot 4 \cos 30$ $u_h = 6 \cdot 4 \text{ m s}^{-1}$ **(1)**	**1**	Accept: 6, 6·41, 6·409
		(i) (B)	$u_v = 7 \cdot 4 \sin 30$ $u_v = 3 \cdot 7 \text{ m s}^{-1}$ **(1)**	**1**	Accept: 4, 3·70, 3·700
		(ii)	$v = u + at$ **(1)** $0 = 3 \cdot 7 + (-9 \cdot 8)t$ **(1)** $t = 0 \cdot 38 \text{ s}$ **(1)**	**3**	**OR** consistent with (a)(i)(B) u and a must have opposite signs Accept: 0·4, 0·378, 0·3776
		(iii)	$s = ut + \frac{1}{2}at^2$ **(1)** $s = (3 \cdot 7 \times 0 \cdot 83) + (0 \cdot 5 \times -9 \cdot 8 \times 0 \cdot 83^2)$ **(1)** $h = 1 \cdot 5 + \left((3 \cdot 7 \times 0 \cdot 83) \times \left(0 \cdot 5 \times -9 \cdot 8 \times 0 \cdot 83^2\right)\right)$ **(1)** $h = 1 \cdot 2 \text{ m}$ **(1)**	**4**	**OR** consistent with (a)(i)(B) and (a)(ii) Accept: 1, 1·20, 1·195 For alternative methods 1 mark for **ALL** relationships 1 mark for **ALL** substitutions 1 mark for addition relative to 1·5m 1 mark for **final answer** $s = \frac{1}{2}(u+v)t$ $s = \frac{1}{2} \times (3 \cdot 7 + 0) \times 0 \cdot 38$ $s = ut + \frac{1}{2}at^2$ $s = (0 \times 0 \cdot 45) + (0 \cdot 5 \times -9 \cdot 8 \times 0 \cdot 45^2)$ $h_{\max} = 1 \cdot 5 + \left(\frac{1}{2} \times (3 \cdot 7 + 0) \times 0 \cdot 38\right)$ $h_{\max} = 2 \cdot 203$ (m) $h = 2 \cdot 203 + (0 \cdot 5 \times -9 \cdot 8 \times 0 \cdot 45^2)$ $h = 1 \cdot 2$ m Accept 1, 1·21, 1·211 for this method.

Question			Answer	Max mark	Additional guidance
1.	(b)		(Initial) vertical/horizontal speed is greater. **(1)** Sponge is higher than the teacher when it has travelled the same horizontal distance. **OR** Sponge has travelled further horizontally when it is at the same height as the teacher. **(1)**	**2**	Look for this statement first – if incorrect or missing then 0 marks.

Question			Answer	Max mark	Additional guidance
2.	(a)	(i)	$W = mg$ **(1)** $W = (5 \cdot 50 + 1 \cdot 25) \times 9 \cdot 8$ **(1)** $W = 66$ N **(1)**	**3**	Accept: 70, 66·2, 66·15 In <u>this</u> question, ignore negative signs in both the substitution and final answer for weight. Do not accept: $F = ma$
	(ii)		$P = \frac{V^2}{R}$ **(1)** $P = \frac{12^2}{9 \cdot 6}$ **(1)** $P = 15$ W **(1)**	**3**	Accept: 20, 15·0, 15·00 For alternative methods 1 mark for **ALL** relationships 1 mark for **ALL** substitutions 1 mark for **final answer**
		(iii)	Drone <u>accelerates upwards</u> **(1)** Upward force is greater than weight **OR** (Upward force remains constant but) weight decreases therefore forces are no longer balanced. **OR** (Upward force remains constant but) weight decreases therefore there is an unbalanced force (upwards). **(1)**	**2**	Look for correct statement of effect first – if incorrect or missing then 0 marks. Accept free-body diagram to aid description of relative size and direction of forces acting on the drone.

Question			Answer	Max mark	Additional guidance
2.	(b)		$W = mg$ $W = 3 \cdot 4 \times 9 \cdot 8$ $W = 33 \cdot 32$ (N) **(1)** Each cord supports 33·32/2 = 16·66 (N) **(1)** $F \cos 35 = 16 \cdot 66$ **(1)** $F = 20$ N **(1)**	**4**	Accept: 20·3, 20·34 Accept: $F \sin 55 = 16 \cdot 66$ $F = 20$ N Alternative methods: Each cord supports 3·4/2 = 1·7 (kg) **(1)** $W = mg$ $W = 1 \cdot 7 \times 9 \cdot 8$ $W = 16 \cdot 66$ (N) **(1)** $F \cos 35 = 16 \cdot 66$ **(1)** $F = 20$ N **(1)** **OR** $W = mg$ $W = 3 \cdot 4 \times 9 \cdot 8$ $W = 33 \cdot 32$ (N) **(1)** $F \cos 35 = 33 \cdot 32$ **(1)** Tension in each cord = 40·6762093/2 = 20 N **(1)**

Question			Answer	Max mark	Additional guidance
3.	(a)		(Total momentum before = Total momentum after) $p = mv$ OR **(1)** $(m_x u_x + m_y u_y) = (m_x v_x + m_y v_y)$ $(0 \cdot 75 \times 0 \cdot 50) + (0 \cdot 50 \times -0 \cdot 30) = (0 \cdot 75 \times 0 \cdot 02) + (0 \cdot 50 \mathrm{v}_y)$ **(1)** $v_y = 0 \cdot 42 \text{ m s}^{-1}$	**2**	**"SHOW" question** If sign convention is not applied then max 1 mark for formula.
	(b)		$Ft = mv - mu$ **(1)** $Ft = (0 \cdot 50 \times 0 \cdot 42) - (0 \cdot 50 \times -0 \cdot 30)$ **(1)** $Ft = 0 \cdot 36 \text{ N s}$ **(1)**	**3**	Accept: 0·4 Accept: $\text{Impulse} = mv - mu$ v and u must have opposite sign. Accept: kg m s^{-1}
	(c)		Calculate the <u>total</u> kinetic energy before and (<u>total</u> kinetic energy) after. **(1)** If E_k before is equal to E_k after the collision, is elastic. **OR** If E_k before is greater than E_k after, the collision is inelastic. **(1)**	**2**	Look for a statement relating to calculating/finding the <u>total</u> E_k before and after first, otherwise 0 marks. There must be an indication of total kinetic energy or equivalent term. Accept: If kinetic energy is not the same, collision is inelastic. Can show by calculation but would still require a statement for the second mark. Do not Accept: If kinetic energy is gained, collision is inelastic. If candidate says energy is lost then max 1 mark.

Question			Answer	Max mark	Additional guidance
4.			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**	

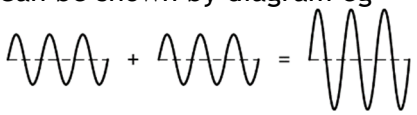
Question			Answer	Max mark	Additional guidance
5.	(a)		Cosmic Microwave Background Radiation **OR** Olber's Paradox **OR** Abundance of Hydrogen and Helium in the Universe	**1**	Present temperature of the universe 2·7K (Blackbody radiation graph) Accept: Abundance of Light elements in the Universe Do not accept: the abbreviation "CMBR" on its own. Do not accept any further evidence based on redshift alone.
	(b)	(i)	$\left(\text{Age} = \frac{1}{H_0}\right)$ $\text{Age} = \frac{1}{2 \cdot 0 \times 10^{-17}}$ **(1)** $\left(\text{Age} = 5 \cdot 0 \times 10^{16}\,(\text{s})\right)$ $\text{Age} = 1 \cdot 6 \times 10^{9}\ (\text{years})$ **(1)**	**2**	Accept: 2, 1·58, 1·584 Accept: 2, 1·59, 1·585 (365 days has been used – this does not need to be shown explicitly.) Years in brackets as question asks for age "in years".

Question			Answer	Max mark	Additional guidance
5.	(ii)	(A)	(Student's) value for H_0 is incorrect/too large/not accurate (enough). **OR** Incorrect line (of best fit) drawn. **OR** The (student's) gradient (which is H_0) is too large. **OR** New/more data is available/more accurate. **OR** Not enough data at large distances.	**1**	Accept: H_0 varies/decreases as age of the universe increases Do not accept: H_0 is different
		(B)	The student could draw the (correct) line of best fit. **OR** Student could use a larger sample/all of the 1929 Hubble data.	**1**	Accept: The student could use current data. Do not accept "<u>different</u> line of best fit" alone.
	(c)		Dark energy	**1**	

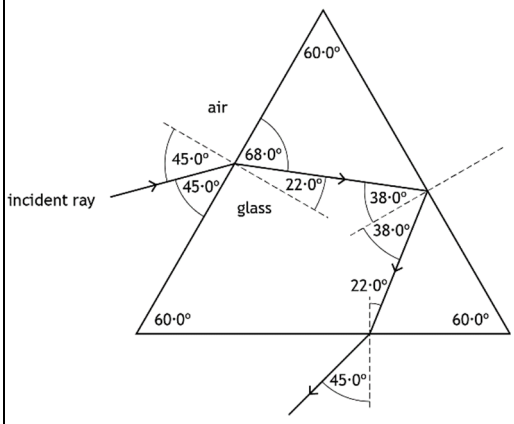
Question			Answer	Max mark	Additional guidance
6.	(a)	(i)	$W = QV$ **(1)** $W = 1{\cdot}60 \times 10^{-19} \times 1600$ **(1)** $W = 2{\cdot}6 \times 10^{-16}\,\text{J}$	**2**	**"SHOW" question**
		(ii)	$E_K = \frac{1}{2}mv^2$ **(1)** $2{\cdot}6 \times 10^{-16} = \frac{1}{2} \times 9{\cdot}11 \times 10^{-31} \times v^2$ **(1)** $v = 2{\cdot}4 \times 10^{7}\,\text{m s}^{-1}$ **(1)**	**3**	Accept: 2, 2·39, 2·389
	(b)		Screen will be brighter/increase glow. **(1)** Electrons will gain more energy/move faster. **OR** Increase in number of electrons <u>per second</u>. **(1)**	**2**	Look for correct statement of effect first – if incorrect or missing then 0 marks. Accept: Circle of brightness on fluorescent screen is reduced. (1) Greater force of attraction on the electrons due to the cross. (1) **OR** Cross on screen is sharper. (1) Greater force of attraction on the electrons due to the cross. (1) 'increase in current' alone is insufficient for the justification. Any correct statement followed by wrong physics, 0 marks. Any correct statement followed by no justification, 0 marks.

Question			Answer	Max mark	Additional guidance
6.	(c)		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**	

Question			Answer	Max mark	Additional guidance
7.	(a)		Frequency of UV/photons/light is not high enough. **OR** Frequency of UV/photons/light is less than threshold frequency. **OR** Energy of photons (of UV light) is not high enough. **OR** Energy of photons (of UV light) is less than work function. **OR** May not be a 'clean plate'.	**1**	Do not accept "gold" for metal plate.
	(b)	(i)	$6{\cdot}94 \times 10^{-19}$ joules of energy is the minimum energy required for (photo) electrons to be emitted/ejected/ photoemission (of electrons).	**1**	Do not accept "to cause photoelectric effect" alone.
		(ii)	No change (to the kinetic energy). **(1)** As the irradiance does not affect the energy of the photons/ $E = hf$ is unchanged. **(1)**	**2**	Look for this first – if incorrect or missing then 0 marks.
	(c)		Lower starting frequency. **(1)** Same gradient. **(1)**	**2**	**Independent marks** Do not accept: Additional line starting at origin.
	(d)		Each photon contains a fixed/discrete amount of energy. **OR** Each photon removes one electron.	**1**	Some indication of quantisation of energy. If light was a wave then the photoelectric effect would occur regardless of the frequency of the light, it would just take longer for electrons to absorb the energy required to be ejected.

Question			Answer	Max mark	Additional guidance
8.	(a)	(i)	Waves meet in phase. **OR** Crest meets crest. **OR** Trough meets trough. **OR** Path difference = mλ	**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)	$m\lambda = d\sin\theta$ **(1)** $3\times630\times10^{-9} = \frac{1}{250\ 000}\sin\theta$ **(1)** $\theta = 28^{\circ}$ **(1)**	**3**	Accept: 30°, 28·2°, 28·20° Note: d = 4×10^{-6} m Alternative substitution: $m\lambda = d\sin\theta$ **(1)** $3\times630\times10^{-9} = \frac{1\times10^{-3}}{250}\sin\theta$ **(1)** $\theta = 28^{\circ}$ **(1)**
		(iii)	Spots will be further apart. **OR** Angle θ is greater. **(1)** Slit separation d of new grating is smaller than the previous grating. **(1)**	**2**	Look for correct statement of effect first – if incorrect or missing then 0 marks. Accept: fewer/less spots on the screen. Justification can be done by calculation. If calculation is carried out using m = 3, candidate will obtain an invalid answer. This implies fewer/less spots (five) on the screen.
		(iv)	(The waves from the laser have a) constant phase relationship (and have the same frequency, wavelength, and velocity).	**1**	"In phase" is not sufficient.
	(b)		(Polymer) note has vertical and horizontal or crossed lines/grid/grating.	**1**	Accept: crosshatch, mesh Accept: diagram to aid description There are vertical and horizontal spots so there are vertical and horizontal lines or a grid of lines.

Question			Answer	Max mark	Additional guidance
9.	(a)		$n = \frac{\sin\theta_1}{\sin\theta_2}$ **(1)** $n = \frac{\sin 45\cdot 0}{\sin 22\cdot 0}$ **(1)** $n = 1\cdot 89$	**2**	**"SHOW" question** Accept: $\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2}$ **(1)** $\frac{n_2}{1} = \frac{\sin 45\cdot 0}{\sin 22\cdot 0}$ **(1)** $n = 1\cdot 89$
	(b)	(i)	The angle of incidence such that the angle of refraction is 90°.	**1**	Accept a description of the incident ray as an alternative to the word 'incidence'. Do not accept: The minimum angle of incidence that causes total internal reflection.
		(ii)	$\sin\theta_C = \frac{1}{n}$ **(1)** $\sin\theta_C = \frac{1}{1\cdot 89}$ **(1)** $\theta_C = 31\cdot 9^\circ$ **(1)**	**3**	Accept: 32°, 31·94°, 31·945°

Question			Answer	Max mark	Additional guidance
9.	(b)	(iii)	 Total Internal Reflection **(1)** 38° **(1)** Refraction away from the normal on exit **(1)** 22° and 45° **(1)**	**4**	**OR** consistent with part (ii) If arithmetic error for finding one of the angles – maximum 3 marks. First two marks are independent. To access last two marks TIR must be shown. Reflection at any angle Either incidence or reflection angle labelled. Refraction at any angle Both angles required. Notes: Only penalise missing degree unit once in whole question. Decimal points not required Candidate may calculate exit angle, therefore 45·1° is acceptable
	(c)		Less deviation in spectrum position **OR** Less dispersion.	**1**	Accept: Spectrum position higher on screen Smaller spread/width of spectrum Brighter spectrum Do not accept: smaller spectrum alone

Question			Answer	Max mark	Additional guidance
10.	(a)		A (central) positively charged nucleus. (Negatively charged) electrons in (discrete) energy levels/shells (orbiting the nucleus, not radiating energy.) When an electron moves from one state 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/orbit/shell to another.	**2**	Any two correct answers **Independent marks** Accept: A clearly labelled diagram A (central) nucleus containing protons (and neutrons). 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)		$E_2 - E_1 = hf$ **(1)** $-1{\cdot}36\times10^{-19} - (-5{\cdot}45\times10^{-19}) = 6{\cdot}63\times10^{-34}\times f$ **(1)** $f = 6{\cdot}17\times10^{14}$ Hz **(1)**	**3**	Accept: 6·2, 6·169, 6·1689 Accept: $(\Delta)E = hf$ or $E_3 - E_1 = hf$ for formula mark anywhere Accept: $5{\cdot}45\times10^{-19} - 1{\cdot}36\times10^{-19}$ $= 6{\cdot}63\times10^{-34}\times f$ for substitution mark Note: Correct ΔE = 4·09×10^{-19} (J) If $1{\cdot}36\times10^{-19} - 5{\cdot}45\times10^{-19}$ is shown for ΔE, maximum 1 mark for a correct formula.

Question			Answer	Max mark	Additional guidance
10.	(c)		$z = \frac{\lambda_o - \lambda_r}{\lambda_r}$ **(1)** $z = \frac{661 - 656}{656}$ **(1)** $\left(z = 7 \cdot 62195122 \times 10^{-3}\right)$ $z = \frac{v}{c}$ **(1)** $7 \cdot 62195122 \times 10^{-3} = \frac{v}{3 \cdot 00 \times 10^8}$ **(1)** $v = 2 \cdot 29 \times 10^6$ m s^{-1} **(1)**	**5**	Accept: 2·3, 2·287, 2·2866 $z = \frac{\lambda_o - \lambda_r}{\lambda_r}$ anywhere, 1 mark $z = \frac{v}{c}$ anywhere, 1 mark Substitution of 3·00×10^8 **(1)** Alternative method: $\frac{v}{c} = \frac{\lambda_o - \lambda_r}{\lambda_r}$ $\frac{v}{3 \cdot 00 \times 10^8} = \frac{661 - 656}{656}$ $v = 2 \cdot 29 \times 10^6$ m s^{-1} Equating formula, **(2)** Substitution of wavelengths, **(1)** Substitution of 3·00×10^8 **(1)** Final answer **(1)**

Question			Answer	Max mark	Additional guidance
11.	(a)		The number of joules/energy gained by/supplied to 1 coulomb (of charge passing through the cell).	**1**	Accept unit charge for 1 coulomb.
	(b)		$\text{gradient} = \dfrac{\left(290\times10^{-3} - 470\times10^{-3}\right)}{\left(105\times10^{-6} - 55\times10^{-6}\right)}$ **(1)** $\text{gradient} = -3600$ **(1)** $(\text{gradient} = -\text{r})$ $r = 3600\ \Omega$ **(1)**	**3**	Accept: 4000 Gradient = r is wrong physics, award 0 marks. subs into gradient formula **(1)** calculating gradient **(1)** Alternative method: $E = V + Ir$ (1) $670\times10^{-3} = 400\times10^{-3} + 75\times10^{-6}r$ (1) $r = 3600\ \Omega$ (1)
	(c)		The electrons do not gain enough energy to move into/towards the conduction band of the p-type.	**1**	Electrons in conduction band (of the n-type) do not gain enough energy to move into/towards the p-type.

Question			Answer	Max mark	Additional guidance
12.	(a)	(i)	$(3 \times 1 \cdot 0 =)\ 3 \cdot 0$ V **(1)**	**1**	Accept: 3, 3·00, 3·000
		(ii)	$f = \frac{1}{T}$ **(1)** $f = \frac{1}{2}$ **(1)** $f = 0 \cdot 5$ Hz **(1)**	**3**	Accept: 0·50, 0·500
		(iii)	The LEDs will light when they are forward biased. **(1)** The change in polarity of voltage changes the biasing. **(1)**	**2**	**Independent marks** LEDs will only conduct in one direction (1) Identifying current/voltage has changed direction (1) Do not accept 'different direction' alone. One LED conducts during one half of the cycle the other LED conducts during the other half of the cycle.
	(b)		$V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_S$ **(1)** $V_2 = \left(\frac{82}{68 + 82}\right) \times 3 \cdot 0$ **(1)** $V_2 = 1 \cdot 64$ (V) $V_{peak} = \sqrt{2} V_{rms}$ **(1)** $1 \cdot 64 = \sqrt{2} V_{rms}$ **(1)** $V_{rms} = 1 \cdot 2$ V **(1)**	**5**	**OR** consistent with (a)(i) Accept: 1, 1·16, 1·160 Alternative Methods: $V_{peak} = \sqrt{2} V_{rms}$ **(1)** $3 \cdot 0 = \sqrt{2} V_{rms}$ **(1)** $V_{rms} = 2 \cdot 12132034$ (V) $V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_S$ **(1)** $V_2 = \left(\frac{82}{68 + 82}\right) \times 2 \cdot 12132034$ **(1)** $V_2 = 1 \cdot 2$ V **(1)**

Question			Answer	Max mark	Additional guidance
12.	(b)		continued		**OR** $V_{peak} = \sqrt{2}V_{rms}$ **(1)** $3 \cdot 0 = \sqrt{2}V_{rms}$ **(1)** $V_{rms} = 2 \cdot 12132034$ (V) $V = IR$ $2 \cdot 12132034 = I \times (68 + 82)$ $I = 0 \cdot 0141421356$ (A) $V = IR$ $V = 0 \cdot 0141421356 \times 82$ $V = 1 \cdot 2$ V $V = IR$ **twice** **(1)** Both substitutions into $V = IR$ **(1)** Final answer **(1)** **OR** $V = IR$ $3 \cdot 0 = I \times (68 + 82)$ $I = 0 \cdot 02$ (A) $V = IR$ $V = 0 \cdot 02 \times 82$ $V = 1 \cdot 64$ (V) $V_{peak} = \sqrt{2}V_{rms}$ **(1)** $1 \cdot 64 = \sqrt{2}V_{rms}$ **(1)** $V_{rms} = 1 \cdot 2$ V $V = IR$ **twice** **(1)** Both substitutions into $V = IR$ **(1)** Final answer **(1)**

Question			Answer	Max mark	Additional guidance
13.	(a)		$p = 1{\cdot}00 \times 10^3 \times 9{\cdot}8 \times 0{\cdot}35$ **(1)** $p = 3{\cdot}4 \times 10^3$ Pa **(1)**	**2**	Accept: 3, 3·43, 3·430
	(b)	(i)	Suitable scales with labels on axes (quantity and units) **(1)** Correct plotting of points **(1)** Appropriate line of best fit **(1)**	**3**	Allow for axes starting at zero or broken axes or at an appropriate value. Accuracy of plotting should be easily checkable with the scale chosen. If the origin is shown the scale must either be continuous or the axis must be 'broken'. Otherwise maximum 2 marks. Do not penalise if the candidate plots h against p.
		(ii)	$m = \frac{y_2 - y_1}{x_2 - x_1}$ $m = \frac{4{\cdot}9 \times 10^3 - 1{\cdot}2 \times 10^3}{0{\cdot}40 - 0{\cdot}10}$ **(1)** = 12 000 (Pa m^{-1}) **(1)**	**2**	**<u>Must</u>** be consistent with graph drawn for (b)(i). Candidates are asked to calculate the gradient of **<u>their graph</u>.** Tolerance required depending upon best fit line drawn by the candidate. Accept: $m = \frac{y_2 - y_1}{x_2 - x_1}$ $m = \frac{4{\cdot}9 - 1{\cdot}2}{0{\cdot}40 - 0{\cdot}10}$ **(1)** = 12 (kPa m^{-1}) **(1)**

Question			Answer	Max mark	Additional guidance
13.		(iii)	*(gradient =* ρg *)* 12 000 = ρg **(1)** ρ = 1·2 × 10^3 kg m^{-3} **(1)**	**2**	**OR** consistent with (b)(ii) If m = 12 in (b)(ii) 12 = ρg **(1)** ρ = 1·2 × 10^3 kg m^{-3} **(1)** If candidate arrives at this answer then they **have** taken into consideration the prefix (kPa). If the candidate has drawn a straight line through the origin (tolerance within ± 1 full division), then any point on the line, within ± ½ division tolerance, can be used to calculate the density using $p = \rho gh$. 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. If the line drawn (or extrapolated line 'created' on Assessor) does NOT pass through the origin within ± 1 full division tolerance, the gradient of the line must be used and not one single point selected, otherwise 0 marks.

Question			Answer	Max mark	Additional guidance
13.		(iii)	continued		If candidate has chosen an appropriate point on their line, 1 mark for correct substitution 1 mark for final answer. If the candidate uses a broken scale on either axis, or does not start their scale at zero, they must use the gradient in their calculation of ρ, otherwise 0 marks. If candidate has plotted h against p, the formula becomes $\rho g = \frac{1}{gradient}$, otherwise 0 marks for the 'gradient' method. The method by selecting a valid point is can still be used, and the criteria above apply.

[END OF MARKING INSTRUCTIONS]