2014 Physics

Advanced Higher

Finalised Marking Instructions

Part One: General Marking Principles for Physics – Advanced 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 specific Marking Instructions for each question.

(a) Marks for each candidate response must always be assigned in line with these general marking principles and the specific Marking Instructions for the relevant question. 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/Principal Assessor.

GENERAL MARKING ADVICE: Physics – Advanced Higher

The marking schemes are written to assist in determining the "minimal acceptable answer" rather than listing every possible correct and incorrect answer. The following notes are offered to support Markers in making judgements on candidates' evidence, and apply to marking both end of unit assessments and course assessments.

1. **Numerical Marking**

   (a) The fine divisions of marks shown in the marking scheme may be recorded within the body of the script beside the candidate's answer. If such marks are shown they must total to the mark in the inner margin.

   (b) The number recorded should always be the marks being awarded.
   The number out of which a mark is scored SHOULD NEVER BE SHOWN AS A DENOMINATOR. (½ mark will always mean one half mark and never 1 out of 2.)

   (c) Where square ruled paper is enclosed inside answer books it should be clearly indicated that this item has been considered. Marks awarded should be transferred to the script booklet inner margin and marked G.

   (d) The total for the paper should be rounded up to the nearest whole number.

2. **Other Marking Symbols which may be used**

TICK	–	Correct point as detailed in scheme, includes data entry.
SCORE THROUGH	–	Any part of answer which is wrong. (For a block of wrong answer indicate zero marks.) Excess significant figures.
INVERTED VEE	–	A point omitted which has led to a loss of marks.
WAVY LINE	–	Under an answer worth marks which is wrong only because a wrong answer has been carried forward from a previous part.
"G"	–	Reference to a graph on separate paper. You MUST show a mark on the graph paper and the SAME mark on the script.
"X"	–	Wrong Physics
✳	–	Wrong order of marks

No other annotations are allowed on the scripts.

3. **General Instructions (Refer to National Qualifications Marking Instructions Booklet)**

(a) No marks are allowed for a description of the wrong experiment or one which would not work.
Full marks should be given for information conveyed correctly by a sketch.

(b) Surplus answers: where a number of reasons, examples etc are asked for and a candidate gives more than the required number then wrong answers may be treated as negative and cancel out part of the previous answer.

(c) Full marks should be given for a correct answer to a numerical problem even if the steps are not shown explicitly. The part marks shown in the scheme are for use in marking partially correct answers.

However, when the numerical answer is given or a derivation of a formula is required every step must be shown explicitly.

(d) Where 1 mark is shown for the final answer to a numerical problem ½ mark may be deducted for an incorrect unit.

(e) Where a final answer to a numerical problem is given in the form 3^{-6} instead of 3×10^{-6} then deduct ½ mark.

(f) Deduct ½ mark if an answer is wrong because of an arithmetic slip.

(g) No marks should be awarded in a part question after the application of a wrong physics principle (wrong formula, wrong substitution) **unless specifically allowed for in the marking scheme – eg marks can be awarded for data retrieval.**

(h) In certain situations, a wrong answer to a part of a question can be carried forward within that part of the question. This would incur no further penalty provided that it is used correctly. Such situations are indicated by a horizontal dotted line in the marking instructions.

Wrong answers can always be carried forward to the next part of a question, over a solid line without penalty.

The exceptions to this are:

- where the numerical answer is given
- where the required equation is given.

(i) ½ mark should be awarded for selecting a formula.

(j) Where a triangle type "relationship" is written down and then not used or used incorrectly then any partial ½ mark for a formula should not be awarded.

(k) In numerical calculations, if the correct answer is given then converted wrongly in the last line to another multiple/submultiple of the correct unit then deduct ½ mark.

(l) Significant figures.

Data in question is given to 3 significant figures.
Correct final answer is 8·16J.
Final answer 8·2J <u>or</u> 8·158J <u>or</u> 8·1576J – No penalty.
Final answer 8J <u>or</u> 8·15761J – Deduct ½ mark.
Candidates should be penalised for a final answer that includes:

- three or more figures too many
  or
- two or more figures too few. **ie accept two more and one fewer.**

(m) Squaring Error

$E_K = \frac{1}{2} mv^2 = \frac{1}{2} \times 4 \times 2^2 = 4\text{J}$ **Award 1½** Arith error

$E_K = \frac{1}{2} mv^2 = \frac{1}{2} \times 4 \times 2 = 4\text{J}$ **Award ½ for formula.** Incorrect substitution.

The General Marking Instructions booklet should be brought to the markers' meeting.

Physics − Marking Issues

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.

	Answers	Mark + comment	Issue
1.	$V=IR$ $7{\cdot}5=1{\cdot}5R$ $R=5{\cdot}0\Omega$	(½) (½) (1)	Ideal Answer
2.	$5{\cdot}0\Omega$	(2) Correct Answer	GMI 1
3.	5·0	(1½) Unit missing	GMI 2(a)
4.	$4{\cdot}0\Omega$	(0) No evidence/Wrong Answer	GMI 1
5.	$\_\_\_\_\_\Omega$	(0) No final answer	GMI 1
6.	$R=\frac{V}{I}=\frac{7{\cdot}5}{1{\cdot}5}=4{\cdot}0\,\Omega$	(1½) Arithmetic error	GMI 7
7.	$R=\frac{V}{I}=4{\cdot}0\,\Omega$	(½) Formula only	GMI 4 and 1
8.	$R=\frac{V}{I}=\_\_\_\_\_\,\Omega$	(½) Formula only	GMI 4 and 1
9.	$R=\frac{V}{I}=\frac{7{\cdot}5}{1{\cdot}5}=\_\_\_\_\_\,\Omega$	(1) Formula + subs/No final answer	GMI 4 and 1
10.	$R=\frac{V}{I}=\frac{7{\cdot}5}{1{\cdot}5}=4{\cdot}0$	(1) Formula + substitution	GMI 2(a) and 7
11.	$R=\frac{V}{I}=\frac{1{\cdot}5}{7{\cdot}5}=5{\cdot}0\,\Omega$	(½) Formula but wrong substitution	GMI 5
12.	$R=\frac{V}{I}=\frac{75}{1{\cdot}5}=5{\cdot}0\,\Omega$	(½) Formula but wrong substitution	GMI 5
13.	$R=\frac{I}{V}=\frac{7{\cdot}5}{1{\cdot}5}=5{\cdot}0\,\Omega$	(0) Wrong formula	GMI 5
14.	$V=IR \quad 7{\cdot}5=1{\cdot}5\times R$ $R=0{\cdot}2\,\Omega$	(1½) Arithmetic error	GMI 7
15.	$V=IR$ $R=\frac{I}{V}=\frac{1{\cdot}5}{7{\cdot}5}=0{\cdot}2\,\Omega$	(½) Formula only	GMI 20

DATA SHEET

COMMON PHYSICAL QUANTITIES

Quantity	*Symbol*	*Value*	*Quantity*	*Symbol*	*Value*
Gravitational acceleration on Earth	g	$9{\cdot}8\ \text{ms}^{-2}$	Mass of electron	m_e	$9{\cdot}11 \times 10^{-31}$ kg
Radius of Earth	R_E	$6{\cdot}4 \times 10^{6}$ m	Charge on electron	e	$-1{\cdot}60 \times 10^{-19}$ C
Mass of Earth	M_E	$6{\cdot}0 \times 10^{24}$ kg	Mass of neutron	m_n	$1{\cdot}675 \times 10^{-27}$ kg
Mass of Moon	M_M	$7{\cdot}3 \times 10^{22}$ kg	Mass of proton	m_p	$1{\cdot}673 \times 10^{-27}$ kg
Radius of Moon	R_M	$1{\cdot}7 \times 10^{6}$ m	Mass of alpha particle	m_α	$6{\cdot}645 \times 10^{-27}$ kg
Mean Radius of Moon Orbit		$3{\cdot}84 \times 10^{8}$ m	Charge on alpha particle		$3{\cdot}20 \times 10^{-19}$ C
Universal constant of gravitation	G	$6{\cdot}67 \times 10^{-11}\ \text{m}^3\,\text{kg}^{-1}\,\text{s}^{-2}$	Planck's constant	h	$6{\cdot}63 \times 10^{-34}$ Js
Speed of light in vacuum	c	$3{\cdot}0 \times 10^{8}\ \text{ms}^{-1}$	Permittivity of free space	ε_0	$8{\cdot}85 \times 10^{-12}\ \text{Fm}^{-1}$
Speed of sound in air	v	$3{\cdot}4 \times 10^{2}\ \text{ms}^{-1}$	Permeability of free space	μ_0	$4\pi \times 10^{-7}\ \text{Hm}^{-1}$

REFRACTIVE INDICIES

The refractive indices refer to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

Substance	*Refractive index*	*Substance*	*Refractive index*
Diamond	2·42	Glycerol	1·47
Glass	1·51	Water	1·33
Ice	1·31	Air	1·00
Perspex	1·49	Magnesium Fluoride	1·38

SPECTRAL LINES

Element	*Wavelength*/nm	*Colour*
Hydrogen	656	Red
	486	Blue-green
	434	Blue-violet
	410	Violet
	397	Ultraviolet
	389	Ultraviolet
Sodium	589	Yellow

Element	*Wavelength*/nm	*Colour*
Cadmium	644	Red
	509	Green
	480	Blue

Lasers

Element	*Wavelength*/nm	*Colour*
Carbon dioxide	9550 / 10590	Infrared
Helium-neon	633	Red

PROPERTIES OF SELECTED MATERIALS

Substance	*Density*/ kg m^{-3}	*Melting Point*/K	*Boiling Point*/K	*Specific Heat Capacity*/ J kg^{-1} K^{-1}	*Specific Latent Heat of Fusion*/ J kg^{-1}	*Specific Latent Heat of Vaporisation* /J kg^{-1}
Aluminium	$2{\cdot}70 \times 10^{3}$	933	2623	$9{\cdot}02 \times 10^{2}$	$3{\cdot}95 \times 10^{5}$	….
Copper	$8{\cdot}96 \times 10^{3}$	1357	2853	$3{\cdot}86 \times 10^{2}$	$2{\cdot}05 \times 10^{5}$	….
Glass	$2{\cdot}60 \times 10^{3}$	1400	….	$6{\cdot}70 \times 10^{2}$	….	….
Ice	$9{\cdot}20 \times 10^{2}$	273	….	$2{\cdot}10 \times 10^{3}$	$3{\cdot}34 \times 10^{5}$	….
Gylcerol	$1{\cdot}26 \times 10^{3}$	291	563	$2{\cdot}43 \times 10^{3}$	$1{\cdot}81 \times 10^{5}$	$8{\cdot}30 \times 10^{5}$
Methanol	$7{\cdot}91 \times 10^{2}$	175	338	$2{\cdot}52 \times 10^{3}$	$9{\cdot}9 \times 10^{4}$	$1{\cdot}12 \times 10^{6}$
Sea Water	$1{\cdot}02 \times 10^{3}$	264	377	$3{\cdot}93 \times 10^{3}$	….	….
Water	$1{\cdot}00 \times 10^{3}$	273	373	$4{\cdot}19 \times 10^{3}$	$3{\cdot}34 \times 10^{5}$	$2{\cdot}26 \times 10^{6}$
Air	$1{\cdot}29$	….	….	….	....	….
Hydrogen	$9{\cdot}0 \times 10^{-2}$	14	20	$1{\cdot}43 \times 10^{4}$	....	$4{\cdot}50 \times 10^{5}$
Nitrogen	$1{\cdot}25$	63	77	$1{\cdot}04 \times 10^{3}$	….	$2{\cdot}00 \times 10^{5}$
Oxygen	$1{\cdot}43$	55	90	$9{\cdot}18 \times 10^{2}$	….	$2{\cdot}40 \times 10^{5}$

The gas densities refer to a temperature of 273 K and pressure of $1{\cdot}01 \times 10^{5}$ Pa.

Part Two: Marking Instructions for each Question

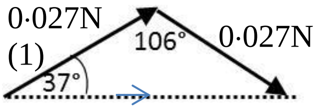
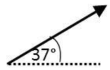
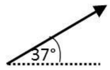
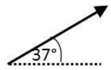
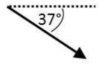
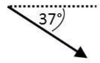
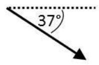
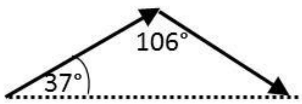
Question			Expected Answer/s	Max Mark	Additional Guidance
1	a	i	$v = r\omega v$ **(½)** $8{\cdot}8 = 7{\cdot}8\ \omega$ **(½)** $\omega = 1{\cdot}1$ rad s^{-1} **(1)**	2	
1	a	ii	$E_{rot} = \frac{1}{2}I\omega^2$ **(½)** $100\times10^6 = \frac{1}{2}\times I\times1{\cdot}1^2$ **(½)** $I = 1{\cdot}7\times10^8\,\mathrm{kg\,m^2}$ **(1)**	2	
1	a	iii	There are no other moving parts in the blade system (e.g. gears).	1	Accept Length of blade is the effective radius **or** blades are rigid/do not bend.
1	b		$\alpha = \frac{\omega - \omega_o}{t}$ **(½)** $\alpha = \frac{1{\cdot}1 - 0}{42}$ **(½)** $= 0{\cdot}026$ $T = I\alpha T$ **(½)** $= 1{\cdot}7\times10^8\times0{\cdot}026$ **(½)** $= 4{\cdot}4\times10^6$ Nm **(1)**	3 **(8)**	

Question			Expected Answer/s	Max Mark	Additional Guidance
2	a		$I = \frac{1}{2}mr^2$ **(½)** $I = \frac{1}{2} \times 0 \cdot 115 \times 0 \cdot 015^2$ **(½)** $I = 1 \cdot 3 \times 10^{-5}\,\text{kg m}^2$ **(1)**	2	
2	b		$\omega = \frac{v}{r}$ **(½)** $\omega = \frac{1 \cdot 60}{0 \cdot 015}$ **(½)** $\omega = 1 \cdot 1 \times 10^2$ (rads^{-1}) **(½)** - - - - - - - - - - - - - - - $mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ (1) $0 \cdot 28 = 0 \cdot 1472 + \frac{1}{2}I\left(1 \cdot 1 \times 10^2\right)^2$ **(½)** **(sub)** $I = \frac{2 \times 0 \cdot 1328}{\left(1 \cdot 1 \times 10^2\right)^2}$ $I = 2 \cdot 2 \times 10^{-5}\,\text{kg m}^2$ (1)	4	
2	c		energy is lost **or** calculation assumes no energy is lost	1 **(7)**	

Question			Expected Answer/s	Max Mark	Additional Guidance
3	**a**	**i**	The (minimum) velocity/speed that a mass must have to escape the gravitational field (of a planet).	**1**	
3	**a**	**ii**	$E_k + E_p = 0$ **(½)** Therefore $\frac{1}{2}mv^2 - \frac{GMm}{r} = 0$ **(1)** $v^2 = \frac{2GM}{r}$ $v = \sqrt{\frac{2GM}{r}}$ **(½)**	**2**	
3	**a**	**iii**	$v = \sqrt{\frac{2GM}{r}}$ **(½)** $v = \sqrt{\frac{2\times6\cdot67\times10^{-11}\times6\cdot0\times10^{24}}{1\cdot7\times6\cdot4\times10^{6}}}$ **(½)** **(1)** $= 8\cdot6 \times 10^3\,\mathrm{m\,s^{-1}}$ **(1)**	**3**	
3	**b**		$\frac{8\cdot6\times10^3}{6} = 1\cdot4\times10^3\,\mathrm{ms^{-1}}$ **(1)** Nitrogen, Oxygen, Methane, Carbon Dioxide could all be found on planet. **(1)**	**2** **(8)**	

Question			Expected Answer/s	Max Mark	Additional Guidance
4	**a**		The unbalanced force/ acceleration is proportional to the displacement of the object and act in the opposite direction.	**1**	
4	**b**		0·07 m	**1**	
4	**c**	**i**	$\omega = \frac{\theta}{t}$ **(½)** $\omega = \frac{1500 \times 2\pi}{60}$ $\omega = 157$ (rad s^{-1}) **(½)** -------------------------------- $a = (-)\omega^2 y$ **(½)** $= (-)\ 157^2 \times 0{\cdot}070$ **(½)** $= (-)\ 1{\cdot}7 \times 10^3$ m s^{-2} **(1)**	**3**	
4	**c**	**ii**	$E_k = \frac{1}{2} m\omega^2 \left(A^2 - y^2\right)$ **or** $E_k = \frac{1}{2} m\,\omega^2\, A^2$ **(½)** $= \frac{1}{2} \times 1{\cdot}40 \times 157^2 \times \left(0{\cdot}070^2\right)$ **(½)** $= 85$ J **(1)**	**2** **(7)**	

Question			Expected Answer/s	Max Mark	Additional Guidance
5	a	i	Electrons behave like waves	1	
5	a	ii	Photoelectric effect or Compton scattering Collision and transfer of energy	1	
5	b		$\lambda = \frac{h}{p}$ or $\lambda = \frac{h}{mv}$ **(½)** $\lambda = \frac{6 \cdot 63 \times 10^{-34}}{4 \cdot 4 \times 10^{6} \times 9 \cdot 11 \times 10^{-31}}$ **(½)** $\lambda = 1 \cdot 7 \times 10^{-10}\,\text{m}$ **(1)**	2	
5	c		$\lambda = \frac{h}{p}$ $\lambda = \frac{6 \cdot 63 \times 10^{-34}}{300 \times 0 \cdot 02}$ **(½)** $\lambda = 1 \cdot 1 \times 10^{-34}$ m **(½)** This value is so small (that no diffraction would be seen). **Or** the de Broglie wavelength of the bullet is much smaller than the gap. **(1)**	2	
5	d	i	Electron orbits a nucleus / proton **(1)** Angular momentum quantised **(1)** **or** Certain allowed orbits / discrete energy level	2	
5	d	ii	$\boldsymbol{mvr = \frac{nh}{2\pi}}$ **(½)** $= \frac{3 \times 6 \cdot 63 \times 10^{-34}}{2 \times 3 \cdot 14}$ **(½)** $= 3 \cdot 17 \times 10^{-34}\,\text{kg m}^{2}\,\text{s}^{-1}$ **(1)**	2 **(10)**	Alternative acceptable units • Js • $\text{kg m}^{2}\,\text{rad s}^{-1}$ • $\text{kg m}^{2}\,\text{s}^{-1}\,\text{rad}^{-1}$

Question			Expected Answer/s	Max Mark	Additional Guidance
6	**a**	**i**	$F_{PA} = \dfrac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$ **(½)** $= \dfrac{(4\cdot0\times10^{-9})\times(2\cdot6\times10^{-9})}{4\pi\times8\cdot85\times10^{-12}\times(2\cdot5\times10^{-3})^2}$ **(½)** $= 0\cdot015$ N **(1)** ($1\cdot5 \times 10^{-2}$ N)	**2**	
6	**a**	**ii**	(F_{RA}) = (−) 0·012 (N) **(½)** (F_{SA}) = (−) 0·015 (N) **(½)** F (due to P&S) = 2 × 0·015 cos 37 = 0·024N (to right) **(½)** F (due to Q&R) = 2 × 0·012 cos 37 = 0·019N (to right) (½) Combined force = 0·024 + 0·019 = 0·043 N to right **(1)** ($4\cdot3 \times 10^{-2}$ N to right) 0·027N (1)  0·027N (1) 0·043N (1)	**3**	F_{QA} = 0·012 N  F_{SA} = 0·015 N  (½) Combine = 0·027 N  (½) F_{PA} = 0·015 N  F_{RA} = 0·012 N  (½) Combine = 0·027 N  (½)  $a^2 = b^2 + c^2 - 2bc \cos A$ $a^2 = (0\cdot027)^2 + (0\cdot027)^2 - (2 \times 0\cdot027 \times 0\cdot027 \cos 106^o)$ a = 0·043 N to right or (scale) drawing (1) Also accept sine rule (-½) if direction not given

Question			Expected Answer/s	Max Mark	Additional Guidance
6	b		$V = \dfrac{Q}{4\pi\varepsilon_0 r}$ **(½)** $-37 = \dfrac{-2\cdot 6\times 10^{-9}}{4\pi\times 8\cdot 85\times 10^{-12} r}$ **(½)** $r = 0\cdot 63$ m **(1)**	**2**	
6	b	ii	The work done (energy) used would be the same **or** The charge is in a conservative field, the path taken between two points does not affect the work done (energy used).	**1** **(8)**	

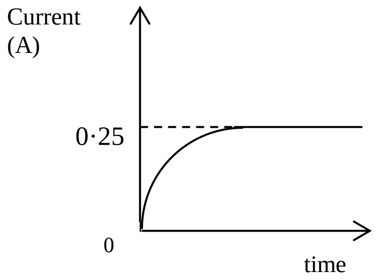
Question			Expected Answer/s	Max Mark	Additional Guidance
7	a	i	$qV = \frac{1}{2}mv^2$ **(1)** $\frac{q}{m} = \frac{v^2}{2V}$.		(-½) if no final answer given
7	a	ii	**(A)** $\frac{q}{m} = \frac{v^2}{2V}$ $\frac{\left(2 \cdot 92\times10^7\right)^2}{2\times2480} = 1 \cdot 72\times10^{11}\,\text{Ckg}^{-1}$ $\frac{\left(2 \cdot 73\times10^7\right)^2}{2\times2150} = 1 \cdot 73\times10^{11}\,\text{Ckg}^{-1}$ $\frac{\left(2 \cdot 61\times10^7\right)^2}{2\times2000} = 1 \cdot 70\times10^{11}\,\text{Ckg}^{-1}$ $\frac{\left(2 \cdot 47\times10^7\right)^2}{2\times1750} = 1 \cdot 74\times10^{11}\,\text{Ckg}^{-1}$ $\frac{\left(2 \cdot 26\times10^7\right)^2}{2\times1560} = 1 \cdot 64\times10^{11}\,\text{Ckg}^{-1}$	2	
7	a	ii	**(B)** $\frac{1 \cdot 72 + 1 \cdot 73 + 1 \cdot 70 + 1 \cdot 74 + 1 \cdot 64}{5} = 1 \cdot 71\times10^{11}\,\text{Ckg}^{-1}$	1	
7	a	ii	**(C)** Drawing a graph of v^2 *vs* $2V$ **(1)** and calculating the gradient = $\frac{q}{m}$ **(1)**	2	Draw graph of v^2 against V **(1)** calculating the gradient as = $\frac{2q}{m}$ **(1)**

Question			Expected Answer/s	Max Mark	Additional Guidance
7	b	i	$QV = \frac{1}{2}mv^2$ **(½)** $1\cdot60\times10^{-19}\times2\cdot08\times10^{3} = \frac{1}{2}\times9\cdot11\times10^{-31}v^2$ **(½)** $v = 2\cdot70 \times 10^{7}$ ms^{-1}	1	(−½) if no final answer given or wrong final answer
7	b	ii	$t = \frac{d}{v}$ $t = \frac{85\cdot0\times10^{-3}}{2\cdot70\times10^{7}}$ $t = 3\cdot15 \times 10^{-9}$ (s) **(½)** QE = ma **(½)** $E = \frac{1900}{0\cdot105} = 1\cdot8\times10^{4}$ **(½)** $1\cdot60\times10^{-19}\times\frac{1900}{0\cdot105} = 9\cdot11\times10^{-31}a$ a = $3\cdot18 \times 10^{15}$ (m s^{-2}) **(½)** $s = ut + \frac{1}{2}at^2$ $s = 0 + \frac{1}{2}\times 3\cdot18\times 10^{15}\left(3\cdot15\times 10^{-9}\right)^2$ s = 0·0157 m **(1)**	3	
7	b	iii	Lower than x /vertical displacement reduces **(1)** Increased horizontal velocity **(½)** Time between plates reduced **(½)**	2 **(12)**	

Question			Expected Answer/s	Max Mark	Additional Guidance
8	**a**	**i**	$qvB = \dfrac{mv^2}{r}$ **(1)** $r = \dfrac{mv}{qB}$	**1**	(− ½) if no final answer given
8	**a**	**ii**	$r = \dfrac{mv}{qB}$ $r = \dfrac{0 \cdot 5}{2}$ $= 0 \cdot 25\ \text{m}$ **(½)** $0 \cdot 25 = \dfrac{3 \cdot 343 \times 10^{-27} \times 2 \cdot 4 \times 10^{7}}{1 \cdot 60 \times 10^{-19} \times B}$ **(½)** $B = 2 \cdot 0\ \text{T}$ **(1)**	**2**	

Question			Expected Answer/s	Max Mark	Additional Guidance
8	**a**	**iii**	$T = \dfrac{2\pi r}{v}$ **(½)** $T = \dfrac{2\pi \times 0 \cdot 25}{2 \cdot 4 \times 10^{7}}$ **(½)** $T = 6 \cdot 5 \times 10^{-8}$ s **(1)** $6 \cdot 6 \times 10^{-8}$ s (½) for last line, wrong rounding using this method.	**2**	$T = \dfrac{2\pi m}{qB}$ acceptable
8	**b**	**i**	Accept any of the following • Period independent of velocity. • Radius and vertical velocity reduce (in proportion) or both reduce • Angular velocity is constant • The magnetic induction has not changed **(1)**	**1**	$T = \dfrac{2\pi r}{v \sin\theta}$ $r = \dfrac{mv \sin\theta}{qB}$ so $T = \dfrac{2\pi mv \sin\theta}{qBv \sin\theta}$ $T = \dfrac{2\pi m}{qB}$
8	**b**	**ii**	$v_h = v\cos\theta$ **(½)** $v_h = 2 \cdot 4 \times 10^{7} \cos 40$ $v_h = 1 \cdot 84 \times 10^{7}\,\mathrm{m\,s^{-1}}$ **(½)** *pitch* = $v \times t$ *pitch* = $1 \cdot 84 \times 10^{7} \times 6 \cdot 5 \times 10^{-8}$ **(½)** *pitch* = 1·2 m **(½)**	**2** **(8)**	

Question			Expected Answer/s	Max Mark	Additional Guidance
9	**a**	**i**	Out of page **(1)**	**1**	
9	**a**	**ii**	To ensure that the accelerating potential is in the correct direction for the particle's motion. **(1)** Direction of force acting on charges reversed.	**1**	
9	**b**	**i**	$E_k = \frac{1}{2}mv^2$ **(½)** $\frac{1}{2}\times 1\cdot 673\times 10^{-27}\times\left(3\cdot 0\times 10^{7}\right)^2$ **(½)** $= 7\cdot 5 \times 10^{-13}$ J **(½)** $Number\ of\ gap\ transits = \frac{7\cdot 5\times 10^{-13}}{1\cdot 5\times 10^{-14}} = 50$ **(½)**	**2**	
9	**b**	**ii**	Their mass will increase (become relativistic) **(1)** A greater centripetal force will be required **(1)** **or** To keep the radius of orbit within the dimensions of the cyclotron $\left(qvB = \frac{mv^2}{r}\right)$	**2**	Must have increasing mass before second mark awarded. $f = \frac{qB}{2\pi m}$ To maintain a constant frequency, as their mass increases
9	**c**	**i**	A has no charge **(1)** B & C have different charge to mass ratios **or** B and C have opposite charges **(1)**	**2**	
9	**c**	**ii**	The particles are losing energy **or** speed **or** momentum is decreasing	**1** **(9)**	

Question			Expected Answer/s	Max Mark	Additional Guidance
10	**a**		$I = \frac{V}{R}$ $I = \frac{12}{48}$ $I = 0{\cdot}25$ (A) **(½)**  **(1) for shape (½) labels**	**2**	
10	**b**		$E = -L\frac{dI}{dt}$ **(½)** $-12 = -4{\cdot}0\frac{dI}{dt}$ **(½)** $\frac{dI}{dt} = 3{\cdot}0\,\text{As}^{-1}$ **(1)**	**2**	
10	**c**		X_L /(inductive reactance) increases **Or** back emf **increases** **(½)** Therefore current decreases (impedance increases) **(½)**	**1** **(5)**	

Question			Expected Answer/s	Max Mark	Additional Guidance
11	a		Coloured fringes are produced by **interference (1)** Reference to **different colours produced by** • angle of viewing • thickness of film • optical path difference **(1)**	2	
11	b		$d = \dfrac{\lambda}{4n}$ **(½)** $d = \dfrac{555\times10^{-9}}{4\times1\cdot38}$ **(½)** $= 1\cdot01 \times 10^{-7}$ m **(1)**	2	
11	c		Wavelengths in the middle of the visible spectrum not reflected or destructively interfere. **(1)** Red and blue reflected / combined to (form purple). **(1)**	2 **(6)**	

Question			Expected Answer/s	Max Mark	Additional Guidance
12	a		Division of wavefront	1	
12	b	i	$\Delta x = \frac{\lambda D}{d}$ **(½)** $\Delta x = \frac{510\times10^{-9}\times2\cdot5}{3\cdot0\times10^{-4}}$ **(½)** $\Delta x = 4\cdot3\times10^{-3}\,\text{m}$ **(1)**	2	
12	b	ii	% Uncertainty in λ = $\frac{2\times100}{510} = 0\cdot40\%$ **(½)** % Uncertainty in D = $\frac{0\cdot05\times100}{2\cdot5} = 2\%$ **(½)** % Uncertainty in d = $\frac{0\cdot00001\times100}{0\cdot0003} = 3\cdot3\%$ **(½)** % Uncertainty in $\Delta x = \sqrt{2^2 + 3\cdot3^2} = 3\cdot9\%$ **(½)** Absolute uncertainty in $\Delta x = 3\cdot9\%\times4\cdot3\times10^{-3}$ $= 1\cdot7 \times 10^{-4}\,\text{m}$ **(1)**	3	
12	b	iii	Slit separation **(½)** Highest **percentage** uncertainty **(½)**	1 **(7)**	

Question			Expected Answer/s	Max Mark	Additional Guidance
13	**a**	**i**	The tablet emits plane polarised light.	**1**	
13	**a**	**ii**	The brightness would gradually reduce from a maximum at 0 degrees to no intensity at 90 degrees. **(1)** It would then gradually increase in intensity from 90 degrees to 180 where it would again be at a maximum. **(1)**	**2**	
13	**b**		$\tan\theta_1 = n$ θ_1 = *Brewsters angle* **(½)** $\tan\theta_1 = 1{\cdot}33$ **(½)** $\theta_1 = 53{\cdot}1^{o}$ **(½)** $\theta = 90 - 53{\cdot}1 = 36{\cdot}9^{o}$ **(½)**	**2** **(5)**	

[END OF MARKING INSTRUCTIONS]