2008 Physics

Advanced Higher

Finalised Marking Instructions

Detailed Marking Instructions – AH Physics 2008

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) Negative marks or marks to be subtracted should not be shown. An inverted vee may be used instead.

   (c) 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.)

   (d) 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.

   (e) Fractional marks, if awarded to individual questions, should be recorded in the grid, but the total script mark must be rounded up to the next whole number when transferred to the box at the top of the script.

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.)
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

3. **Marking Symbols which may <u>not</u> be used.**

"WP"	–	Marks not awarded because an apparently correct answer was due to the use of "wrong physics".
"ARITH"	–	Candidate has made an arithmetic mistake. **(Can indicate by line through number).**
"SIG FIGS or SF"	–	Candidate has made a mistake in the number of significant figures for a final answer. **(Can be indicated by a line through additional figures).**

4. **General Instructions (Refer to National Qualifications 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.

(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 higher and one lower.

Max ½ mark deduction per question. Max 2½ deduction from question paper.

(m) Squaring Error

$E_K = \frac{1}{2} mv^2 = \frac{1}{2} \times 4 \times 2^2 = 4J$ (-½, ARITH)

$E_K = \frac{1}{2} mv^2 = \frac{1}{2} \times 4 \times 2 = 4J$ (½, 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 7·5=1·5R R=5·0Ω	(½) (½) (1)	Ideal Answer
2.	5·0Ω	(2) Correct Answer	GMI 1
3.	5·0	(1½) Unit missing	GMI 2(a)
4.	4·0Ω	(0) No evidence/Wrong Answer	GMI 1
5.	_____Ω	(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.	$R=\frac{V}{I}=$_____Ω	(½) Formula only	GMI 4 and 1
9.	$R=\frac{V}{I}=\frac{7{\cdot}5}{1{\cdot}5}=$_____Ω	(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 7·5=1·5 x R R=0·2Ω	(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	$9{\cdot}8\ ms^{-2}$	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	$m_\propto$	$6{\cdot}645 \times 10^{-27}kg$
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	$6{\cdot}67 \times 10^{-11}m^3kg^{-1}s^{-2}$	Planck's constant	h	$6{\cdot}63 \times 10^{-34}Js$
Speed of light in vacuum	c	$3{\cdot}0 \times 10^{8}ms^{-1}$	Permittivity of free space	ε_0	$8{\cdot}85 \times 10^{-12}Fm^{-1}$
Speed of sound in air	v	$3{\cdot}4 \times 10^{2}ms^{-1}$	Permeability of free space	μ_0	$4\pi \times 10^{-7}Hm^{-1}$

Refractive Indices

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

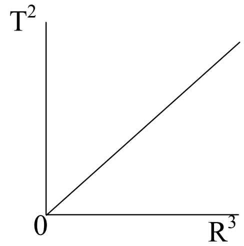
Substance	*Density/ kg m^{-3}*	*Melting Point/K*	*Boiling Point/K*	*Specific Heat Capacity/ $Jkg^{-1} K^{-1}$*	*Specific Latent Heat of Fusion/ Jkg^{-1}*	*Specific latent Heat of Vaporisation/ Jkg^{-1}*
Aluminium	$2·70 \times 10^{3}$	933	2623	$9·02 \times 10^{2}$	$3·95 \times 10^{5}$	….
Copper	$8·96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

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

2008 AH Physics			
Sample answer and mark allocation	**Notes**	**Margin**	
1. (a) (i) $\alpha = \frac{\omega - \omega_0}{t}$ (½) $= \frac{1200 - 0}{4}$ (½) $= 300 \text{ rad s}^{-2}$ (1)		2	12
(ii) $\tau = I\alpha$ (½) $= 5{\cdot}1 \times 10^{-4} \times 300$ (½) $= 0{\cdot}15 \text{ Nm}$ (1)		2	
(iii) $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$ (½) $= 0 + 0{\cdot}5 \times 300 \times 4^2$ (½) $= 2400$ (rad) (½) revolutions $= \frac{2400}{2\pi}$ (½) $= 380$ (1)	If use $s = ut + \frac{1}{2} at^2$ (0) (ie uses standard symbols for linear motion) Could also use $\omega^2 = \omega_o^2 + 2\alpha\theta$	3	
(b) (i) $F = m\omega^2 r$ (½) $= 5{\cdot}3 \times 10^{-6} \times (1200)^2 \times (85 \times 10^{-3})$ (½) $= 0{\cdot}65 \text{ N}$ (1)		2	
(ii) (the force from) the glass/(end of) tube (1)	Friction 0 Any argument around 'centrifugal' 0	1	

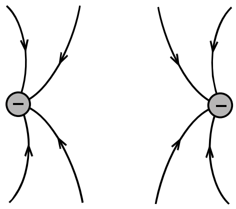
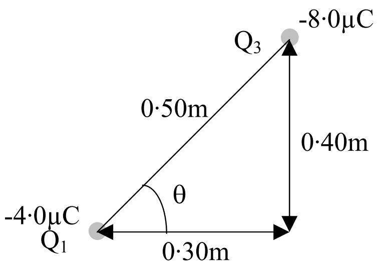
Sample answer and mark allocation			Notes	Margin	
(c)	increase	(1)	If I decreases then (0)		
	r increases (unless accompanied by wrong physics)	(1)	Must state I increases before second mark becomes available	2	

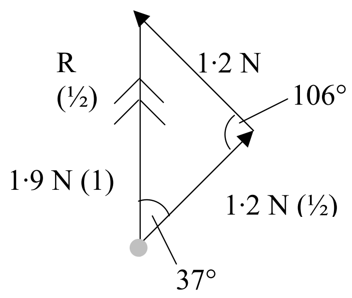
Sample answer and mark allocation	Notes	Margin	
2. (a) $(m)g = \frac{GM(m)}{R^2}$ (1) $R^2 = \frac{6\cdot 67\times10^{-11}\times 6\cdot 4\times10^{23}}{3\cdot 7}$ (½) $= 1\cdot 15\times10^{13}$ $R = \sqrt{1\cdot 15\times10^{13}}$ (½) $= 3\cdot 4\times10^{6}$ m (3400 km)	This mark is for equating 2 correct expressions. If not present (0) for question. Substitution ½ is for the square root	2	11
(b) (i) $\frac{GMm}{R^2} = m\omega^2 R$ (½) (½) $\frac{GM}{R^2} = \omega^2 R$ (½) $\omega^2 = \frac{GM}{R^3}$ (½) $\left(\omega = \sqrt{\frac{GM}{R^3}}\right)$	**OR** $\frac{GMm}{R^2} = \frac{mv^2}{R}$ (½)+(½) for cancelling m for rearranging these two operations can be done in one step	2	
(ii) $\omega = \sqrt{\frac{GM}{R^3}}$ $= \sqrt{\frac{6\cdot 67\times10^{-11}\times 6\cdot 4\times10^{23}}{(3\cdot 4\times10^{6}+1\cdot 7\times10^{7})^3}}$ (½) (½) $= \sqrt{5\times10^{-9}}$ $= 7\cdot 1\times10^{-5}$ rads^{-1} (1)	for $6\cdot 67\times10^{-11}$ for adding (independent) If 9.3 x 10^{-5} then only data (½) available	2	
(iii) $T = \frac{2\pi}{\omega}$ (½) $= \frac{2\times 3\cdot 14}{7\cdot 1\times10^{-5}}$ (½) $= 8\cdot 9\times10^{4}$ s (1)	Ok to use radius of planet if using $v = r\omega$ and $T = \frac{2\pi r}{v}$ need both for (½) Care with rounding. (or 24·6 h)	2	

Sample answer and mark allocation	**Notes**	**Margin**	
(c) (½) $\frac{T^2}{R^3} = 3{\cdot}05 \times 10^{-7}$ (½)			
$\frac{T^2}{R^3} = 3{\cdot}02 \times 10^{-7}$ (½)	Accept 3.0×10^x or if $\frac{R^3}{T^2}$ accept 3.3×10^x		
$\frac{T^2}{R^3} = 3{\cdot}03 \times 10^{-7}$ (½)			
statement $\frac{T^2}{R^3}$ = constant (1)			
<u>or</u> draw graph of 			
plot graph (2)	Must be on graph paper		
statement – straight line through origin (1)	(½) axes (must have correct units plus labels) (½) each point Mark for statement dependent upon correctly drawn graph.	3	

Sample answer and mark allocation	Notes	Margin	
3. (a) (i) acceleration α - displacement (½) + (½) or force α displacement and directed towards a fixed point	Accept F = -kx ½ for proportion ½ for negative/opposite direction restoring force does not imply negative displacement	1	10
(ii) $T = \frac{2\pi}{\omega}$ (½) $= \frac{2 \times 3 \cdot 14}{4 \cdot 3}$ (½) = 1·5 s (or T = 1·46 s) (1)		2	
(b) $v_{max} = \omega\sqrt{A^2 - 0}$ or v = ωA (½) $= 4 \cdot 3 \times 2 \times 10^{-2}$ (½) $= 8 \cdot 6 \times 10^{-2}$ m s^{-1} (1)	Must be equation for v_{max}	2	
(c) $E_{(total)} = \frac{1}{2} m \omega^2 A^2$ (½) $= 0 \cdot 5 \times 5 \times 10^{-2} \times (4 \cdot 3)^2 \times (2 \times 10^{-2})^2$ (½) $= 1 \cdot 8 \times 10^{-4}$ J (1)	$E_k = \frac{1}{2}mv^2$ method acceptable using v_{max} from above accept 1·85 or 1·849 1·9 is possible rounding error	2	
(d) $T = 2\pi\sqrt{\frac{L}{g}}$ $1 \cdot 5 = 2 \times 3 \cdot 14 \times \sqrt{\frac{L}{9 \cdot 8}}$ (½) $5 \cdot 7 \times 10^{-2} = \frac{L}{9 \cdot 8}$ (½) L = 0·56 m (1)	for substitution (accept 0·53 m using T = 1·46s)	2	
(e) **<u>Amplitude</u>** decreases (1)	accept diagram if period constant any mention of "slows down" (0) mention of height (0)	1	

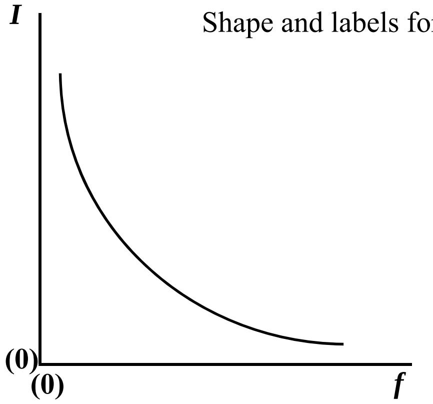
Sample answer and mark allocation	Notes	Margin	
4. (a) Electrons exhibit {diffraction / interference} (1)	Accept Thomson-Reid experiment	1	7
(b) (i) Angular momentum $= \frac{nh}{2\pi}$ (½) $= \frac{2\times 6\cdot 63\times 10^{-34}}{2\times 3\cdot 14}$ (½) $= 2\cdot 1\times 10^{-34}$ kg m^2 s^{-1} (1)	 substitution Accept kg m^2 rad s^{-1}	2	
(ii) $m r v = \frac{nh}{2\pi}$ $m r v = \frac{2h}{2\pi}$ (½) $2\pi r = \frac{2h}{mv}$ (½) $= \frac{2h}{p}$ (½) $= 2\lambda_B$ (½)	 for n = 2 for isolating $2\pi r$ as subject of equation for using mv = p } if $\lambda = \frac{h}{mv}$ (1) for $\lambda_B = \frac{h}{p}$ }	2	
(iii) $2\pi r = 2\lambda_B$ $(2\pi r) = 2\frac{h}{mv}$ $v = \frac{2h}{m(2\pi r)}$ $= \frac{2\times 6\cdot 63\times 10^{-34}}{9\cdot 11\times 10^{-31}\times 1\cdot 3\times 10^{-9}}$ (½) (½) $= 1\cdot 1\times 10^{6}$ m s^{-1} (1)	 for $6\cdot 63\times 10^{-34}$ for $9\cdot 11\times 10^{-31}$	2	

Sample answer and mark allocation	Notes	Margin	
5. (a) (i)  (1)	½ for shape ½ for direction wrong shape (0)	1	7
(ii) $V = \dfrac{Q}{4\pi\varepsilon_0 r}$ (½) $V_X = V_{Q1} + V_{Q2}$ $\therefore V_X = \dfrac{-4\times10^{-6}}{4\times\pi\times8\cdot85\times10^{-12}\times0\cdot3} + \dfrac{-4\times10^{-6}}{4\times\pi\times8\cdot85\times10^{-12}\times0\cdot3}$ (½) $V_X = -2\cdot4\times10^{5}\ \text{V}$ (1)	no negative ½ only for equation as counts as wrong substitution	2	
(b) (i)  $F = \dfrac{Qq}{4\pi\varepsilon_0 r^2}$ (½) (½ substitution) $F = \dfrac{-8\times10^{-6}\times-4\times10^{-6}}{4\times\pi\times8\cdot85\times10^{-12}\times0\cdot5^2} = 1\cdot2N$ (½) (½)	Substitution must contain all numerical values. Must state value of ε_0 (9×10^9 ok) calculation gives 1·15N	2	

Sample answer and mark allocation	Notes	Margin	
(ii) $\theta =$ **<u>37° or 53°</u>** consistent with diagram (½)	Accept 36·9°		
EITHER Scale Diagram 	Can work out by scale diagram and trigonometry Accept 1.15 N (carry forward) (1 for magnitude) (½ for angle/direction)		
OR F = 2 × 1·2 cos 37° = 1·9 N (1) Direction (000°) (independent) (½) North ok	Accept "upwards"	2	

Sample answer and mark allocation	Notes	Margin	
6. (a) (i) gradient $= \frac{y_2 - y_1}{x_2 - x_1}$ (½) gradient $= \frac{3\cdot50 - 1\cdot50}{2\cdot25 - 1\cdot10}$ (½) (gradient $= \frac{2\cdot0}{1\cdot15} = 1\cdot7 \times 10^{-3}\,\mathrm{NA}^{-1}$)	Accept omission of 10^{-3} on top line $\frac{3\cdot50 - 0.45}{2\cdot25 - 0.5}$ is okay Check answer is close to given value	1	8
(ii) $m(\max) = \frac{4\cdot40 - 0}{2\cdot5 - 0\cdot5} = 2\cdot20$ (½) $m(\min) = \frac{3\cdot50 - 0\cdot90}{2\cdot5 - 0\cdot5} = 1\cdot30$ (½) $\Delta m = \frac{m(\max) - m(\min)}{2\sqrt{(n-2)}}$ (½) $= \frac{2\cdot20 - 1\cdot30}{2\sqrt{3}}$ (½) $\Delta \mathrm{m} = 0\cdot26$ Absolute uncertainty is $\pm 0\cdot3 \times 10^{-3}\,\mathrm{NA}^{-1}$ (1)	Look for equation (independent) Accept 0·2 to 0·3. Accept up to 3 sig figs	3	
(iii) $F_w = F = BIl\ (\sin\theta)$ (½) The gradient of the graph is therefore $= \frac{F}{I} = Bl\ (\sin\theta)$ $1\cdot7 \times 10^{-3} = B \times 52 \times 10^{-3} (\times 1)$ (½) $B = \frac{1\cdot7 \times 10^{-3}}{52 \times 10^{-3}} = 3\cdot3 \times 10^{-2}\,T$ (1)	Must use gradient	2	
(b) (i) Systematic uncertainty, calibration or zero error (1)		1	
(ii) One from: • take more readings (to increase n) • increase the range (to narrow parallelogram) • take multiple readings and average.		1	

Sample answer and mark allocation	Notes	Margin	
7. (a) (i) A changing/increasing current (½) in the inductor generates a back emf. (½)	Accept a changing magnetic field generates a back emf	1	13
(ii) $I = \frac{V}{R}$ (½) $I = \frac{12}{15}$ (½) $I = 0 \cdot 80$ A (1)		2	
(iii) $E = \frac{1}{2}LI^2$ (½) $E = \frac{1}{2} \times 0 \cdot 80 \times 0 \cdot 80^2$ (½) $E = 0 \cdot 26$ J (1)		2	
(iv) $V = IR = 0 \cdot 12 \times 15$ $V = 1{\cdot}8$(V) (½) Back emf, E is emf across the inductor = (–)10·2(V) (½) $E = -L\frac{dI}{dt}$ (½) $\frac{dI}{dt} = \frac{E}{-L} = \frac{-10 \cdot 2}{-0 \cdot 8} = 13\ \text{A s}^{-1}$ (1) (½) for substitution	(independent) (independent) Accept 12·8, 12·75	3	

Sample answer and mark allocation	Notes	Margin
(b) (i) Maximum current unchanged		1
(ii) The time delay is decreased or the time to reach maximum current is reduced (1), because the inductance is decreased (by removing the iron core).(1) OR back emf is reduced (1)	Time delay increased (0) First mark independent	2
(iii) I is the same (½) but L is smaller (½).		1
(c)  Shape and labels for 1 mark		1

Sample answer and mark allocation	Notes	Margin	
8. (a) (i) $F_{(E)} = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2} = \frac{1\cdot6\times10^{-19}\times1\cdot6\times10^{-19}}{4\times\pi\times8\cdot85\times10^{-12}(22\times10^{-6})^2} = 4\cdot8\times10^{-19}\,(N)$ (½ for equation), (½ for substitution), (½ for answer) (1½) $F_{(G)} = \frac{Gm_1m_2}{r^2} = \frac{6\cdot67\times10^{-11}\times1\cdot673\times10^{-27}\times1\cdot673\times10^{-27}}{(22\times10^{-6})^2}$ $F_G = 3\cdot9\times10^{-55}\,(N)$ (½ for equation), (½ for substitution), (½ for answer) (1½) $F_G(10^{-55}\,N) << F_E(10^{-19}\,N)$ (1)	No marks for units If F_E or F_G is incorrect due to wrong physics then cannot award final mark. Must show that $F_G << F_E$	4	13
(ii) Strong force only acts at a range of approx. 10^{-14} m. OR The distance between these 2 protons is too large.		1	
(b) $E_K = E_P$ $\therefore \frac{1}{2}mv^2 = \frac{Qq}{4\pi\varepsilon_0 r_c}$ (½) (½) (½) $v^2 = \frac{2Qq}{4\pi\varepsilon_0 m r_c}$ (½) $v = \sqrt{\frac{Qq}{2\pi\varepsilon_0 m r_c}}$	(½) for equating depends on both expressions being correct	2	

Sample answer and mark allocation	Notes	Margin
(c) (i) $v = \sqrt{\dfrac{qQ}{2\pi\varepsilon_0 m r_c}}$ (½) (½) substitution $9 \cdot 63 \times 10^6 = \sqrt{\dfrac{2 \times 1 \cdot 6 \times 10^{-19} \times Q}{2 \times \pi \times 8 \cdot 85 \times 10^{-12} \times 6 \cdot 645 \times 10^{-27} \times 1 \cdot 12 \times 10^{-13}}}$ (½) (½) $\therefore 9 \cdot 27 \times 10^{13} = \dfrac{2 \times 1 \cdot 6 \times 10^{-19} \times Q}{2 \times \pi \times 8 \cdot 85 \times 10^{-12} \times 6 \cdot 645 \times 10^{-27} \times 1 \cdot 12 \times 10^{-13}}$ $Q = \dfrac{9 \cdot 27 \times 10^{13} \times 2 \times \pi \times 8 \cdot 85 \times 10^{-12} \times 6 \cdot 645 \times 10^{-27} \times 1 \cdot 12 \times 10^{-13}}{2 \times 1 \cdot 6 \times 10^{-19}}$ $Q = 1 \cdot 2 \times 10^{-17}\,C$ (1)	3 × (½) data marks	3
(ii) Number of protons in the nucleus is given by: $N = \dfrac{Q}{e}$ (½) (½) $\dfrac{1 \cdot 2 \times 10^{-17}}{1 \cdot 6 \times 10^{-19}} = 75$ (1) (1 for value of Q, ½ for formula, ½ for answer)	Accept 75·5 (rounds to 76) Allow rounding up or down regardless of the figure in the first decimal place	2
(iii) It is a Rhenium nucleus (atomic number 75) (1) Must be consistent with part (ii)	Accept osmium if 76 above	1

Sample answer and mark allocation					Notes	Margin	
9	(a)	(i)	frequency increased (with moving observer) Driver passing through more (than 1250) wavefronts in <u>1 second</u>	(1) (1)		2	6
		(ii)	$f = f_s \left(\frac{v + vo}{v} \right)$ $= 1250 \left(\frac{340 + 25 \cdot 0}{340} \right)$ = 1342 = 1340 Hz	(½) (½) (1)	1341is incorrect rounding	2	

Sample answer and mark allocation			Notes	Margin	
(b)	moving away	(1)			
	wavelength increased OR frequency decreased	(1)	Second mark only available if "moving away" is present.	2	

Sample answer and mark allocation					**Notes**	**Margin**	
10	(a)	(i)	Polarised light: (The electric field vector of) the wave **oscillates** or **vibrates** in one **plane**.		One direction (0) Accept diagrammatical explanations – use of double arrowhead okay	1	7
		(ii)	$\mu = \frac{\sin i}{\sin r}$	(½)	for formula		
			$\mu = \frac{\sin 34 \cdot 0}{\sin 48 \cdot 0} = \frac{0 \cdot 559}{0 \cdot 743} = 0 \cdot 752$	(½)	for substitution		
			OR				
			$\mu = \frac{1}{n}$	(½)	for formula		
			$\mu = \frac{1}{1 \cdot 33} = 0 \cdot 752$	(½)	for substitution	1	
		(iii)	$\mu = \tan i_p$				
			$\mu = 0 \cdot 752 = \tan i_p$	(½)			
			$i_p = \tan^{-1} 0 \cdot 752 = 36 \cdot 9°$	(½)	must include unit Accept 36·94°	1	

Sample answer and mark allocation		Notes	Margin	
(b) $\mu_{violet} = 0 \cdot 745 = \tan i_{pviolet}$	(½)			
$i_{pviolet} = \tan^{-1} 0 \cdot 745 = 36 \cdot 7°$	(½)	36.6 is incorrect rounding		
Difference $= 36 \cdot 9 - 36 \cdot 7 = 0 \cdot 2°$	(1)	Accept 0.2 to 0.3 must have unit	2	
(c) Intensity changes (1) In a cyclic fashion (1)		Colours disappear at different angles (1)	2	

Sample answer and mark allocation					Notes	Margin	
11.	(a)	Division of wavefront		(1)		1	6
	(b)	$\Delta x = \frac{\lambda D}{d}$ $d = \frac{\lambda D}{\Delta x}$ $= \frac{633\times10^{-9}\times3\cdot50}{7\cdot2\times10^{-3}}$ $= 3\cdot1\times10^{-4}\,\text{m}$		(½) (½) (1)		2	
	(c)	(i)	increased Δx Smaller **<u>%</u>** uncertainty in d or Δx	(1) (1)		2	
		(ii)	Fainter fringes OR broader fringes OR Not all fringes seen, screen not big enough	(1)	Distorted (0)	1	

[END OF MARKING INSTRUCTIONS]