

Markscheme

May 2018

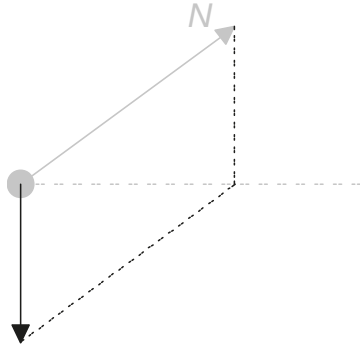
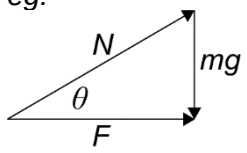
Physics

Higher level

Paper 2

18 pages

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Question			Answers	Notes	Total
1.	a	i	towards the centre «of the circle» / horizontally to the right ✓	<i>Do not accept towards the centre of the bowl</i>	1
1.	a	ii	downward vertical arrow of any length ✓ arrow of correct length ✓	<i>Judge the length of the vertical arrow by eye. The construction lines are not required. A label is not required</i> eg: 	2
1.	a	iii	ALTERNATIVE 1 $F = N \cos \theta$ ✓ $mg = N \sin \theta$ ✓ dividing/substituting to get result ✓ ALTERNATIVE 2 right angle triangle drawn with F , N and W/mg labelled ✓ angle correctly labelled and arrows on forces in correct directions ✓ correct use of trigonometry leading to the required relationship ✓	eg:  $\tan \theta = \frac{O}{A} = \frac{mg}{F}$ $F = \frac{mg}{\tan \theta}$	3

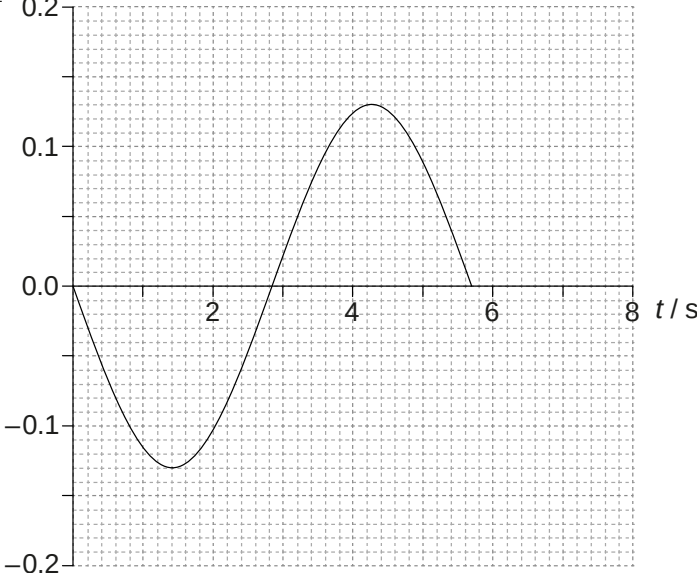
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(Question 1 continued)

Question			Answers	Notes	Total
1.	b		$\frac{mg}{\tan \theta} = m \frac{v^2}{r} \checkmark$ $r = R \cos \theta \checkmark$ $v = \sqrt{\frac{gR \cos^2 \theta}{\sin \theta}} / \sqrt{\frac{gR \cos \theta}{\tan \theta}} / \sqrt{\frac{9.81 \times 8.0 \cos 22}{\tan 22}} \checkmark$ $v = 13.4 / 13 \text{ «ms}^{-1}\text{»} \checkmark$	Award [4] for a bald correct answer Award [3] for an answer of 13.9/14 «ms⁻¹». MP2 omitted	4
1.	c		there is no force to balance the weight/N is horizontal $\checkmark$ so no / it is not possible $\checkmark$	Must see correct justification to award MP2	2

(continued...)

(Question 1 continued)

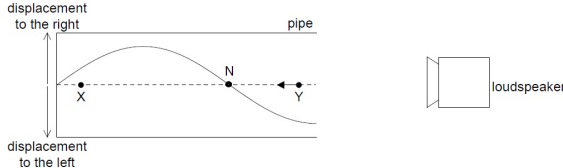
Question			Answers	Notes	Total
1.	d	i	the «restoring» force/acceleration is proportional to displacement ✓	<i>Direction is not required</i>	1
1.	d	ii	$\omega = \left\langle \sqrt{\frac{g}{R}} \right\rangle = \sqrt{\frac{9.81}{8.0}} \left\langle = 1.107 \text{ s}^{-1} \right\rangle \checkmark$ $T = \left\langle \frac{2\pi}{\omega} = \frac{2\pi}{1.107} \right\rangle = 5.7 \text{ «s» } \checkmark$	<i>Allow use of $g = 9.8$ or 10</i> <i>Award [0] for a substitution into $T = 2\pi \sqrt{\frac{l}{g}}$</i>	2
1.	d	iii	sine graph ✓ correct amplitude «0.13 m s ⁻¹ » ✓ correct period and only 1 period shown ✓	<i>Accept $\pm$ sine for shape of the graph. Accept 5.7 s or 6.0 s for the correct period.</i> <i>Amplitude should be correct to $\pm \frac{1}{2}$ square for MP2</i> eg: $v / \text{m s}^{-1}$ 	3

(continued...)

(Question 1 continued)

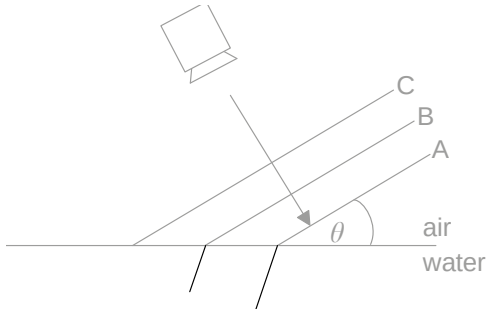
Question			Answers	Notes	Total
1.	e		speed before collision $v = \sqrt{2gR} = 12.5 \text{ ms}^{-1}$ ✓ «from conservation of momentum» common speed after collision is $\frac{1}{2}$ initial speed «$v_c = \frac{12.5}{2} = 6.25 \text{ ms}^{-1}$» ✓ $h = \frac{v_c^2}{2g} = \frac{6.25^2}{2 \times 9.81} = 2.0 \text{ m}$ ✓	Allow 12.5 from incorrect use of kinematics equations Award [3] for a bald correct answer Award [0] for $mg(8) = 2mgh$ leading to $h = 4 \text{ m}$ if done in one step. Allow ECF from MP1 Allow ECF from MP2	3

Question			Answers	Notes	Total
2.	a	i	a gas in which there are no intermolecular forces OR a gas that obeys the ideal gas law/all gas laws at all pressures, volumes and temperatures OR molecules have zero PE/only KE ✓	Accept atoms/particles.	1
2.	a	ii	$N = \left\langle \frac{pV}{kT} = \frac{5.3 \times 10^5 \times 2.1 \times 10^{-4}}{1.38 \times 10^{-23} \times 310} \right\rangle 2.6 \times 10^{22} \checkmark$		1
2.	a	iii	«For one atom $U = \frac{3}{2}kT$» $\frac{3}{2} \times 1.38 \times 10^{-23} \times 310 / 6.4 \times 10^{-21}$ «J» ✓ $U = \left\langle 2.6 \times 10^{22} \times \frac{3}{2} \times 1.38 \times 10^{-23} \times 310 \right\rangle 170$ «J» ✓	Allow ECF from (a)(ii) Award [2] for a bald correct answer Allow use of $U = \frac{3}{2}pV$	2
2.	b	i	$p_2 = \left\langle 5.3 \times 10^5 \times \frac{2.1 \times 10^{-4}}{6.8 \times 10^{-4}} \right\rangle 1.6 \times 10^5$ «Pa» ✓		1
2.	b	ii	«volume has increased and» average velocity/KE remains unchanged ✓ «so» molecules collide with the walls less frequently/longer time between collisions with the walls ✓ «hence» rate of change of momentum at wall has decreased ✓ «and so pressure has decreased»	The idea of average must be included Decrease in number of collisions is not sufficient for MP2. Time must be included. Accept atoms/particles.	2 max

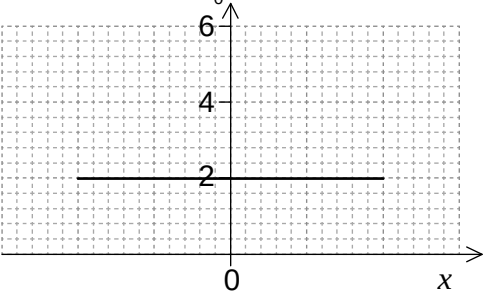
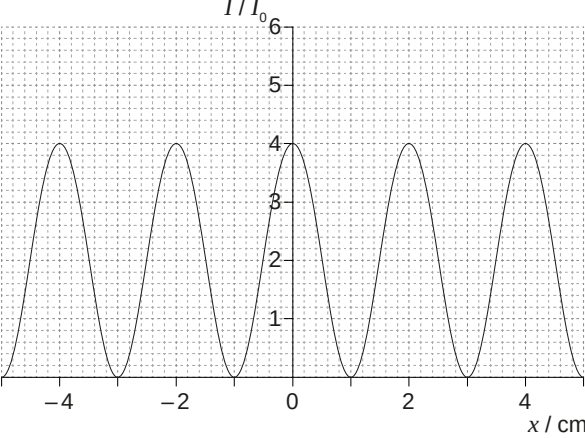
Question			Answers	Notes	Total
3.	a	i	the incident wave «from the speaker» and the reflected wave «from the closed end» superpose/combine/interfere ✓	<i>Allow superimpose/add up Do not allow meet/interact</i>	1
3.	a	ii	Horizontal arrow from X to the right ✓	<i>MP2 is dependent on MP1 Ignore length of arrow</i>	1
3.	a	iii	P at a node ✓		1
3.	a	iv	wavelength is $\lambda = \frac{4 \times 0.30}{3} = 0.40 \text{ «m»}$ ✓ $f = \frac{340}{0.40} = 850 \text{ «Hz»}$ ✓	<i>Award [2] for a bald correct answer</i> <i>Allow ECF from MP1</i>	2

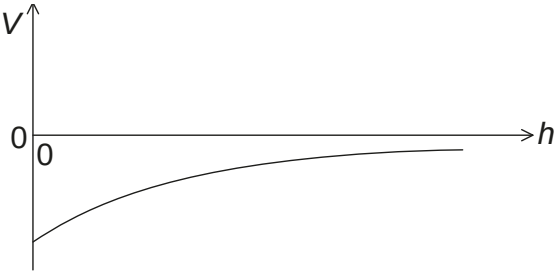
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(Question 3 continued)

Question			Answers	Notes	Total
3.	b	i	$\frac{\sin \theta_c}{340} = \frac{1}{1500} \quad \checkmark$ $\theta_c = 13 \text{ « } ^\circ \text{ » } \quad \checkmark$	Award [2] for a bald correct answer Award [2] for a bald answer of 13.1 Answer must be to 2/3 significant figures to award MP2 Allow 0.23 radians	2
3.	b	ii	correct orientation $\checkmark$ greater separation $\checkmark$	Do not penalize the lengths of A and B in the water Do not penalize a wavefront for C if it is consistent with A and B MP1 must be awarded for MP2 to be awarded eg: 	2

Question			Answers	Notes	Total
4.	a		the work done per unit charge ✓ in moving charge from one terminal of a cell to the other / all the way round the circuit ✓	Award [1] for “energy per unit charge provided by the cell”/“power per unit current” Award [1] for “potential difference across the terminals of the cell when no current is flowing” Do not accept “potential difference across terminals of cell”	2
4.	b	i	the resistance is proportional to length / see 0.35 AND 1«.00»✓ so it equals 0.35×80 ✓ « = 28 Ω »		2
4.	b	ii	current leaving 12 V cell is $\frac{12}{80} = 0.15$ « A » OR $E = \frac{12}{80} \times 28$ ✓ $E = \text{«} 0.15 \times 28 = \text{» } 4.2$ « V » ✓	Award [2] for a bald correct answer Allow a 1sf answer of 4 if it comes from a calculation. Do not allow a bald answer of 4 «V» Allow ECF from incorrect current	2
4.	c		since the current in the cell is still zero there is no potential drop across the internal resistance ✓ and so the length would be the same ✓	OWTTE	2

Question	Answers	Notes	Total
5. a	horizontal straight line through $I = 2$ ✓	eg:  Accept a curve that falls from $I = 2$ as distance increases from centre but not if it falls to zero.	1
5. b	«standard two slit pattern» general shape with a maximum at $x = 0$ ✓ maxima at $4I_0$ ✓ maxima separated by « $\frac{D\lambda}{s} \Rightarrow$ 2.0 cm ✓	Accept single slit modulated pattern provided central maximum is at 4. ie height of peaks decrease as they go away from central maximum. Peaks must be of the same width eg: 	3
5. c	fringe width/separation decreases OR more maxima seen ✓		1

Question			Answers	Notes	Total
6.	a	i	the «gravitational» force per unit mass exerted on a point/small/test mass ✓		1
6.	a	ii	at height h potential is $V = -\frac{GM}{(R+h)}$ ✓ field is $g = \frac{GM}{(R+h)^2}$ ✓ «dividing gives answer»	Do not allow an answer that starts with $g = -\frac{\Delta V}{\Delta r}$ and then cancels the deltas and substitutes $R+h$	2
6.	a	iii	correct shape and sign ✓ non-zero negative vertical intercept ✓	eg: $V \uparrow$ 	2
6.	b		$V = \text{«} -2.2 \times (3.1 \times 10^6 + 2.4 \times 10^7) \text{»} \text{«} - \text{»} 6.0 \times 10^7 \text{ J kg}^{-1}$ ✓	Unit is essential Allow eg MJ kg^{-1} if power of 10 is correct Allow other correct SI units eg $\text{m}^2 \text{s}^{-2}$, Nm kg^{-1}	1

(continued...)

(Question 6 continued)

Question			Answers	Notes	Total
6.	c		total energy at P = 0 / KE gained = GPE lost ✓ «$\frac{1}{2}mv^2 + mV = 0 \Rightarrow$» $v = \sqrt{-2V}$ ✓ $v = \sqrt{2 \times 6.0 \times 10^7} = 1.1 \times 10^4 \text{ «ms}^{-1}\text{»}$ ✓	Award [3] for a bald correct answer Ignore negative sign errors in the workings Allow ECF from 6(b)	3
6.	d		ALTERNATIVE 1 force on asteroid is «$6.2 \times 10^{12} \times 2.2 =$» $1.4 \times 10^{13} \text{ «N»}$ ✓ «by Newton's third law» this is also the force on the planet ✓ ALTERNATIVE 2 mass of planet = $2.4 \times 10^{25} \text{ «kg»}$ «from $V = -\frac{GM}{(R+h)}$» ✓ force on planet «$= \frac{GMm}{(R+h)^2}$» = $1.4 \times 10^{13} \text{ «N»}$ ✓	MP2 must be explicit	2

Question			Answers	Notes	Total
7.	a	i	Average height = 127 «m» ✓ Specific energy «$\frac{mgh}{m} = gh = 9.81 \times 127$» = $1.2 \times 10^3 \text{ J kg}^{-1}$ ✓	Unit is essential Allow $g = 10$ gives $1.3 \times 10^3 \text{ J kg}^{-1}$ Allow ECF from 110 m ($1.1 \times 10^3 \text{ J kg}^{-1}$) or 144 m ($1.4 \times 10^3 \text{ J kg}^{-1}$)	2
7.	a	ii	mass per second leaving dam is $\frac{1.2 \times 10^5}{60} \times 10^3 = \text{«}2.0 \times 10^6 \text{ kg s}^{-1}\text{»}$ ✓ rate of decrease of GPE is $= 2.0 \times 10^6 \times 9.81 \times 127$ ✓ $= 2.49 \times 10^9 \text{ «W»} / 2.49 \text{ «GW»}$ ✓	Do not award ECF for the use of 110 m or 144 m Allow 2.4 GW if rounded value used from (a)(i) or 2.6 GW if $g = 10$ is used	3
7.	a	iii	efficiency is «$\frac{1.8}{2.5} =$» 0.72 / 72% ✓		1
7.	b		water is pumped back up at times when the demand for/price of electricity is low ✓		1

Question			Answers	Notes	Total
8.	a		$C = \epsilon \frac{A}{d} = 8.8 \times 10^{-12} \times \frac{1.2 \times 10^8}{1600} \checkmark$ $\llcorner C = 6.60 \times 10^{-7} \text{ F} \llcorner$		1
8.	b	i	$V = \frac{Q}{C} = \frac{25}{6.6 \times 10^{-7}} \checkmark$ $V = 3.8 \times 10^7 \text{ «V» } \checkmark$	Award [2] for a bald correct answer	2
8.	b	ii	ALTERNATIVE 1 $E = \frac{1}{2} QV = \frac{1}{2} \times 25 \times 3.8 \times 10^7 \checkmark$ $E = 4.7 \times 10^8 \text{ «J» } \checkmark$ ALTERNATIVE 2 $E = \frac{1}{2} CV^2 = \frac{1}{2} \times 6.60 \times 10^{-7} \times (3.8 \times 10^7)^2 \checkmark$ $E = 4.7 \times 10^8 \text{ «J»} / 4.8 \times 10^8 \text{ «J» if rounded value of V used } \checkmark$	Award [2] for a bald correct answer Allow ECF from (b)(i) Award [2] for a bald correct answer Allow ECF from (b)(i)	2
8.	c	i	$Q = Q_0 e^{-\frac{t}{\tau}} = 25 \times e^{-\frac{18}{32}} \checkmark$ $Q = 14.2 \text{ «C» } \checkmark$ $\text{charge delivered} = Q = 25 - 14.2 = 10.8 \text{ «C» } \checkmark$ $\llcorner \approx -11 \text{ C} \llcorner$	Final answer must be given to at least 3 significant figures	3
8.	c	ii	$I = \frac{\Delta Q}{\Delta t} = \frac{11}{18 \times 10^{-3}} \approx 610 \text{ «A» } \checkmark$	Accept an answer in the range 597 – 611 «A»	1

(continued...)

(Question 8 continued)

Question			Answers	Notes	Total
8.	d		the base of the thundercloud must be parallel to the Earth surface OR the base of the thundercloud must be flat OR the base of the cloud must be very long «compared with the distance from the surface» ✓		1
9.	a		«most of» the mass of the atom is confined within a very small volume/nucleus ✓ «all» the positive charge is confined within a very small volume/nucleus ✓ electrons orbit the nucleus «in circular orbits» ✓		2 max
9.	b		the electrons accelerate and so radiate energy ✓ they would therefore spiral into the nucleus/atoms would be unstable ✓ electrons have discrete/only certain energy levels ✓ the only orbits where electrons do not radiate are those that satisfy the Bohr condition « $mvr = n \frac{h}{2\pi}$ » ✓		3 max

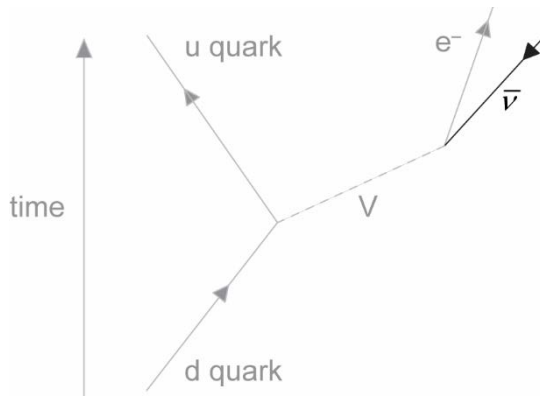
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(Question 9 continued)

Question			Answers	Notes	Total
9.	c	i	$\frac{m_e v^2}{r} = \frac{ke^2}{r^2}$ OR $KE = \frac{1}{2}PE \text{ hence } \frac{1}{2}m_e v^2 = \frac{1}{2} \frac{ke^2}{r} \checkmark$ «solving for v to get answer»	Answer given – look for correct working	1
9.	c	ii	combining $v = \sqrt{\frac{ke^2}{m_e r}}$ with $m_e v r = \frac{h}{2\pi}$ using correct substitution $\checkmark$ «eg $m_e^2 \frac{ke^2}{m_e r} r^2 = \frac{h^2}{4\pi^2}$» correct algebraic manipulation to gain the answer $\checkmark$	Answer given – look for correct working Do not allow a bald statement of the answer for MP2. Some further working eg cancellation of m or r must be shown	2
9.	c	iii	$r = \frac{(6.63 \times 10^{-34})^2}{4\pi^2 \times 8.99 \times 10^9 \times 9.11 \times 10^{-31} \times (1.6 \times 10^{-19})^2}$ $r = 5.3 \times 10^{-11}$ «m» $\checkmark$		1
9.	d	i	the energy released is $3.54 - 0.48 = 3.06$ «MeV» $\checkmark$ this is shared by the electron and the antineutrino $\checkmark$ so the electron's energy varies from 0 to 3.06 «MeV» $\checkmark$		3
9.	d	ii	the palladium nucleus emits the photon when it decays into the ground state «from the excited state» $\checkmark$		1

(continued...)

(Question 9 continued)

Question			Answers	Notes	Total
9.	d	iii	Photon energy $E = 0.48 \times 10^6 \times 1.6 \times 10^{-19} = \text{«}7.68 \times 10^{-14} \text{ J}\text{»} \checkmark$ $\lambda = \text{«} \frac{hc}{E} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{7.68 \times 10^{-14}} = \text{«} 2.6 \times 10^{-12} \text{ «m»} \checkmark$	Award [2] for a bald correct answer Allow ECF from incorrect energy	2
9.	e	i	line <u>with arrow</u> as shown labelled anti-neutrino/$\bar{\nu}$ $\checkmark$	Correct direction of the “arrow” is essential The line drawn must be “upwards” from the vertex in the time direction i.e. above the horizontal eg: 	1
9.	e	ii	$V = W^- \checkmark$		1