

Markscheme

November 2021

Physics

Higher level

Paper 2

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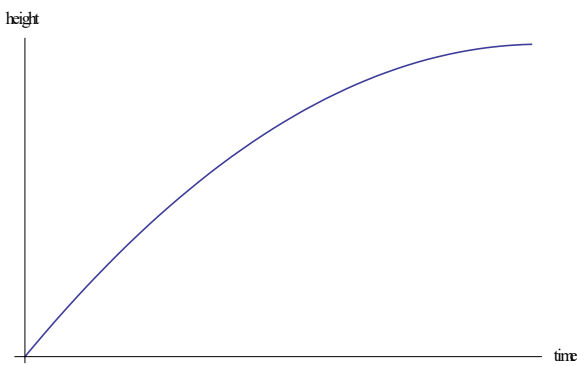
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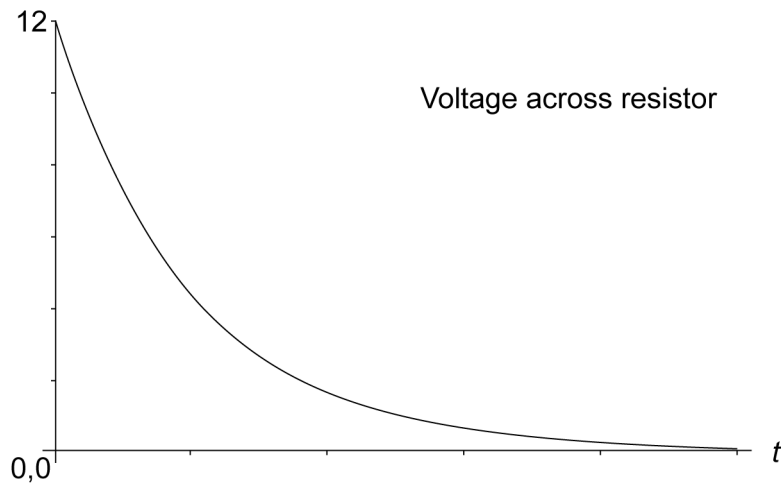
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Question			Answers	Notes	Total
1.	a		$H = \ll \frac{1}{2}gt^2 \Rightarrow 4.9 \ll \text{m} \gg \checkmark$	<p>Accept other methods as area from graph, alternative kinematics equations or conservation of mechanical energy.</p> <p>Award [1] for a bald correct answer in the range 4.9 - 5.1</p> <p>Award [0] if time used is different than 1.0 s</p>	1
	b	i	M at 1.6 s \checkmark		1
	b	ii	$\ll g = \gg 9.80 \ll \text{ms}^{-2} \gg \checkmark$	<p>Accept 9.81, 10 or a plain "g"</p> <p>Ignore sign if provided.</p>	1
	b	iii	 <p>height</p> <p>time</p> <p>concave down parabola as shown «with non-zero initial slope and zero final slope» \checkmark</p>	<p>Award [1] mark if curve starts from a positive time value.</p> <p>Award [0] if the final slope is negative.</p>	1
	c		$\ll \text{loss of KE is } \frac{1}{2} \times 0.25 \times (9.8^2 - 5^2) \Rightarrow 8.9 \ll \text{J} \gg \checkmark$	Award [1] mark for an answer in the range 8.7 - 9.5	1

Question			Answers	Notes	Total
1.	d	i	$\Delta p = 0.250 \times (9.8 + 5.0) \checkmark$ $F_{\text{net}} = \ll \frac{\Delta p}{\Delta t} = \frac{3.7}{0.1} = \gg 37 \ll \text{N} \gg \checkmark$ $N = 37 + 0.250 \times 9.8 = 39.5 \ll \text{N} \gg \checkmark$	Allow ECF for MP2 and MP3	3
	d	ii	there is an external force acting on the ball OR some momentum is transferred to the floor \checkmark	Allow references to impulse instead of force. Do not award references to energy.	1

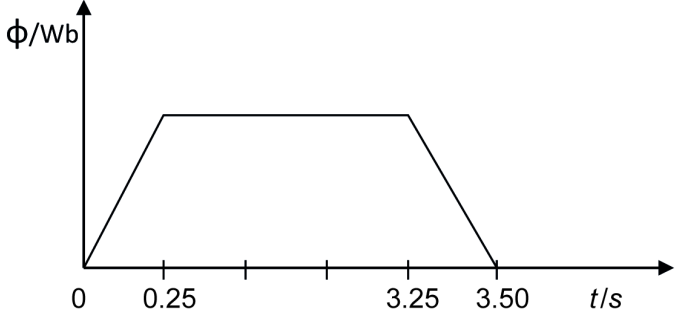
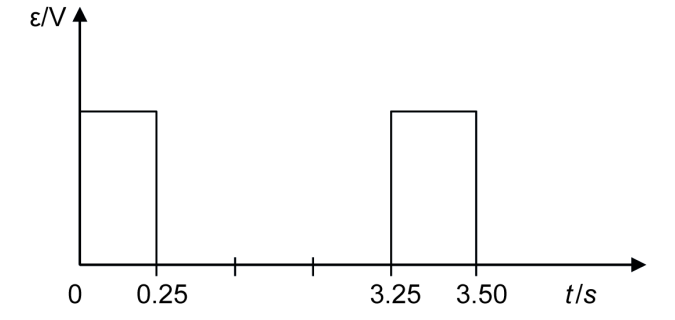
Question			Answers	Notes	Total
2.	a		$T = 4 \times 10^{-3} \text{ «s»}$ or $f = 250 \text{ «Hz»}$ ✓ $\lambda = 340 \times 4.0 \times 10^{-3} = 1.36 \approx 1.4 \text{ «m»}$ ✓	Allow ECF from MP1 . Award [2] for a bald correct answer.	2
	b		$\omega = \text{«}\frac{2\pi}{T} \Rightarrow \frac{2\pi}{4 \times 10^{-3}} \text{ OR } 1.57 \times 10^3 \text{ «s}^{-1}\text{»}$ ✓ $a = \text{«}\omega^2 x_0 = (1.57 \times 10^3)^2 \times 6 \times 10^{-6} = 14.8 \approx \text{» } 15 \text{ «ms}^{-2}\text{»}$ ✓ «opposite to displacement so» to the right ✓		3
	c	i	$\text{«}\pm\text{» } \frac{\pi}{2} / 90^\circ \text{ OR } \frac{3\pi}{2} / 270^\circ$ ✓		1
	c	ii	1.5 «ms» ✓		1
	c	iii	8.0 OR 8.5 «μm» ✓	From the graph on the paper, value is 8.0. From the calculated correct trig functions, value is 8.49	1
	d	i	$L = \text{«}\frac{3}{4} \lambda \Rightarrow 0.90 \text{ «m»}$ ✓		1
	d	ii	to the right ✓ displacement is getting less negative OR change of displacement is positive ✓		2
	d	iii	horizontal line drawn at the equilibrium position ✓		1

Question			Answers	Notes	Total
3.	a	i	<p>«electric field at P from one charge is $\frac{kQ}{r^2} \Rightarrow \frac{8.99 \times 10^9 \times 44 \times 10^{-6}}{0.48^2}$</p> <p>OR</p> <p>$1.7168 \times 10^6 \text{ «NC}^{-1}\text{»} \checkmark$</p> <p>« net field is » $2 \times 1.7168 \times 10^6 \times \cos 30^\circ = 2.97 \times 10^6 \text{ «NC}^{-1}\text{»} \checkmark$</p>		2
	a	ii	directed vertically up «on plane of the page» \checkmark	Allow an arrow pointing up on the diagram.	1
	b	i	force «on q» is proportional to the displacement \checkmark and opposite to the displacement / directed towards equilibrium \checkmark		2
	b	ii	<p>«$a = \frac{F}{m} \Rightarrow \omega^2 x = \frac{115x}{0.25}$» \checkmark</p> <p>$T = \text{«} \frac{2\pi}{\omega} \Rightarrow 0.29 \text{ «s»} \checkmark$</p>	<p>Award [2] marks for a bald correct answer.</p> <p>Allow ECF for MP2</p>	2

Question			Answers	Notes	Total
3.	c	i	decreasing from 12 ✓ correct shape as shown ✓ 	Do not penalize if the graph does not touch the t axis.	2
	c	ii	$\frac{1}{2} = e^{-\frac{5.0}{20 \times 10^6 C}} \checkmark$ $C = 3.6 \times 10^{-7} \text{ «F» } \checkmark$	Award [2] for a bald correct answer.	2

Question			Answers	Notes	Total
4.	a	i	the energy needed to «completely» separate the nucleons of a nucleus OR the energy released when a nucleus is assembled from its constituent nucleons ✓	<i>Accept reference to protons and neutrons.</i>	1
	a	ii	curve rising to a maximum between 50 and 100 ✓ curve continued and decreasing ✓	<i>Ignore starting point. Ignore maximum at alpha particle</i>	2
	a	iii	At a point on the peak of their graph ✓		1
	a	iv	beta minus «decay» ✓		1
	b	i	correct mass numbers for uranium (234) and alpha (4)✓ $234 \times 7.600 + 4 \times 7.074 - 238 \times 7.568$ «MeV» ✓ energy released 5.51 «MeV» ✓	<i>Ignore any negative sign.</i>	3
	b	ii	$\ll \frac{KE_{\alpha}}{KE_U} \Rightarrow \frac{\frac{p^2}{2m_{\alpha}}}{\frac{p^2}{2m_U}} \text{ OR } \frac{m_U}{m_{\alpha}} \checkmark$ $\ll \frac{234}{4} \Rightarrow 58.5 \checkmark$	<i>Award [2] marks for a bald correct answer. Accept $\frac{117}{2}$ for MP2.</i>	2

Question			Answers	Notes	Total
4.	c	i	number of nuclei present = $\frac{33 \times 10^3}{238} \times 6.02 \times 10^{23} \llcorner = 8.347 \times 10^{25} \gg \checkmark$ initial activity is $\lambda N_0 = 2.5 \times 10^{-10} \times 8.347 \times 10^{25} \llcorner = 2.08 \times 10^{16} \text{Bq} \gg \checkmark$ power is $2.08 \times 10^{16} \times 5.51 \times 10^6 \times 1.6 \times 10^{-19} \approx 18 \llcorner \text{kW} \gg \checkmark$	Allow a final answer of 20 kW if 6 MeV used. Allow ECF from MP1 and MP2 .	3
	c	ii	available power after time t is $P_0 e^{-\lambda t} \checkmark$ $18 e^{-2.50 \times 10^{-10} \times 2.3 \times 10^8} = 17.0 \llcorner \text{kW} \gg \checkmark$	MP1 may be implicit. Allow ECF from (c)(i) Allow 17.4 kW from unrounded power from (c)(i). Allow 18.8 kW from 6 MeV.	2
	d	i	stays the same \checkmark as energy depends on the frequency of light \checkmark	Allow reference to wavelength for MP2 Award MP2 only to answers stating that KE decreases due to Doppler effect.	2
	d	ii	decreases \checkmark as number of photons incident decreases \checkmark		2

Question			Answers	Notes	Total
5.	a		$\frac{70}{3.5}$ ✓		1
	b	i	 <p>shape as above ✓</p>		1
	b	ii	 <p>shape as above ✓</p>	<p><i>Vertical lines not necessary to score</i></p> <p><i>Allow ECF from (b)(i).</i></p>	1

Question			Answers	Notes	Total
5.	c	i	<p>ALTERNATIVE 1 maximum flux at $\ll 5.0 \times 5.0 \times 10^{-4} \times 85 \times 0.94 \gg = 0.19975 \approx 0.20 \ll \text{Wb} \gg \checkmark$ $\text{emf} = \ll \frac{0.20}{0.25} \Rightarrow 0.80 \ll \text{V} \gg \checkmark$</p> <p>ALTERNATIVE 2 emf induced in one turn $= BvL = 0.94 \times 0.20 \times 0.05 = 0.0094 \ll \text{V} \gg \checkmark$ $\text{emf} = 85 \times 0.0094 = 0.80 \ll \text{V} \gg \checkmark$</p>	<p>Award [2] marks for a bald correct answer</p> <p>Allow ECF from MP1</p>	2
	c	ii	<p>$I = \ll \frac{V}{R} \Rightarrow \frac{0.8}{2.4} \gg \text{ OR } 0.33 \ll \text{A} \gg \checkmark$</p> <p>$F = \ll NBIL = 85 \times 0.94 \times 0.33 \times 0.05 \Rightarrow \gg = 1.3 \ll \text{N} \gg \checkmark$</p>	<p>Allow ECF from (c)(i)</p> <p>Award [2] marks for a bald correct answer</p>	2
	d	i	<p>Energy is being dissipated for 0.50 s \checkmark</p> <p>$E = Fvt = 1.3 \times 0.20 \times 0.50 = \ll 0.13 \text{ J} \gg$</p> <p>OR</p> <p>$E = VIt = 0.80 \times 0.33 \times 0.50 = \ll 0.13 \text{ J} \gg \checkmark$</p>	<p>Allow ECF from (b) and (c).</p> <p>Watch for candidates who do not justify somehow the use of 0.5 s and just divide by 2 their answer.</p>	2
	d	ii	<p>$\Delta T = \frac{0.13}{0.018 \times 385} \checkmark$</p> <p>$\Delta T = 1.9 \times 10^{-2} \ll \text{K} \gg \checkmark$</p>	<p>Allow [2] marks for a bald correct answer.</p> <p>Award [1] for a POT error in MP1</p>	2

Question			Answers	Notes	Total
6.	a	i	incident intensity $\frac{1360}{9.3^2}$ OR $15.7 \approx 16$ «W m ⁻² » ✓	Allow the use of 1400 for the solar constant.	1
	a	ii	exposed surface is $\frac{1}{4}$ of the total surface ✓ absorbed intensity = (1-0.22) × incident intensity ✓ $0.78 \times 0.25 \times 15.7$ OR 3.07 «W m ⁻² » ✓	Allow 3.06 from rounding and 3.12 if they use 16 Wm ⁻²	3
	a	iii	$\sigma T^4 = 3.07$ OR $T = 86$ «K» ✓		1
	b		$v = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{0.025}{0.404}} \times 11.2$ OR 2.79 «kms ⁻¹ » ✓		1
	c	i	correct equating of gravitational force / acceleration to centripetal force / acceleration ✓ correct rearrangement to reach the expression given ✓	Allow use of $\sqrt{\frac{GM}{R}} = \frac{2\pi R}{T}$ for MP1	2
	c	ii	$T = 15.9 \times 24 \times 3600$ «s» ✓ $M = \frac{4\pi^2(1.2 \times 10^9)^3}{6.67 \times 10^{-11} \times (15.9 \times 24 \times 3600)^2} = 5.4 \times 10^{26}$ «kg» ✓	Award [2] marks for a bald correct answer. Allow ECF from MP1	2

Question			Answers	Notes	Total
6.	d	i	$m = \frac{28 \times 10^{-3}}{6.02 \times 10^{23}}$ <p>OR</p> $4.65 \times 10^{-26} \text{ «kg» } \checkmark$		1
	d	ii	$\left\langle \frac{1}{2}mv^2 \right\rangle = \frac{3}{2}kT \Rightarrow v = \sqrt{\frac{3kT}{m}} \checkmark$ $v = \left\langle \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 90}{4.651 \times 10^{-26}}} \right\rangle \Rightarrow 283 \approx 300 \text{ «ms}^{-1}\text{» } \checkmark$	<p><i>Award [2] marks for a bald correct answer.</i></p> <p><i>Allow 282 from a rounded mass.</i></p>	2
	e		no, molecular speeds much less than escape speed \checkmark	<i>Allow ECF from incorrect (d)(ii)</i>	1

Question			Answers	Notes	Total
7.	a		$Q = \left\langle \frac{VR}{k} \Rightarrow \frac{3.4 \times 10^5 \times 0.48}{8.99 \times 10^9} \right\rangle$ <p>OR</p> $Q = 18.2 \text{ «}\mu\text{C}\text{» } \checkmark$		1
	b	i	electrons leave the small sphere «making it positively charged» \checkmark		1
	b	ii	$k \frac{q_1}{48} = k \frac{q_2}{24} \Rightarrow q_1 = 2q_2 \checkmark$ $q_1 + q_2 = 18 \checkmark$ <p>so $q_1 = 12 \text{ «}\mu\text{C}\text{»}, q_2 = 6.0 \text{ «}\mu\text{C}\text{» } \checkmark$</p>	<i>Award [3] marks for a bald correct answer.</i>	3

Question			Answers	Notes	Total
8.	a		the change in the observed frequency ✓ when there is relative motion between the source and the observer ✓	<i>Do not award MP1 if they refer to wavelength.</i>	2
	b		use of $2\pi f A$ ✓ maximum speed is $2\pi \times 39 \times 0.080 = 19.6 \text{ «ms}^{-1}\text{»}$ ✓	<i>Award [2] for a bald correct answer.</i>	2
	c		frequency at plate $2400 \times \frac{340 + 19.6}{340} \text{ «} = 2538\text{Hz}\text{»}$ at source $2538 \times \frac{340}{340 - 19.6} = 2694 \approx 2700 \text{ «Hz»}$ ✓	<i>Award [2] marks for a bald correct answer.</i> <i>Award [1] mark when the effect is only applied once.</i>	2
	d	i	stays the same ✓		1
	d	ii	decreases ✓		1
	d	iii	decreases ✓		1