

# Markscheme

November 2021

Physics

Higher level

Paper 2

15 pages

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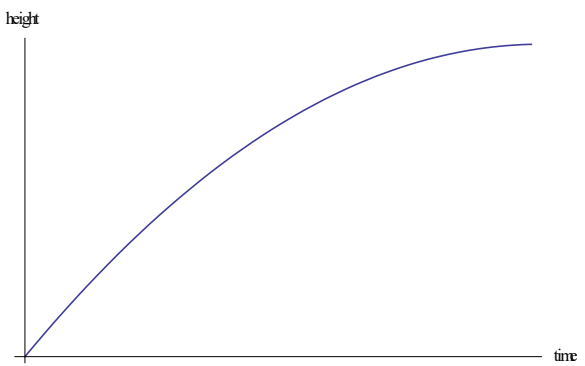
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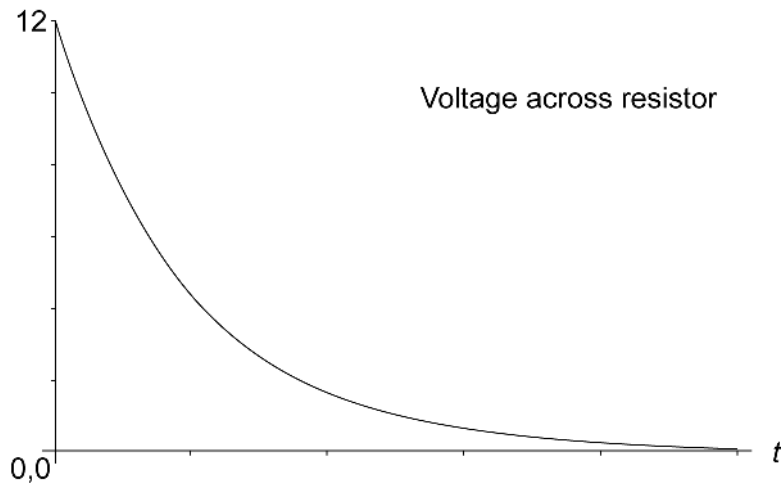
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Question		Answers	Notes	Total	
1.	a	$H = \ll \frac{1}{2}gt^2 \Rightarrow 4.9 \ll \text{m} \gg \checkmark$	Accept other methods as area from graph, alternative kinematics equations or conservation of mechanical energy. Award [1] for a bald correct answer in the range 4.9 - 5.1 Award [0] if time used is different than 1.0 s	1	
	b	i	M at 1.6 s ✓	1	
	b	ii	$\ll g = \gg 9.80 \ll \text{ms}^{-2} \gg \checkmark$	Accept 9.81, 10 or a plain "g" Ignore sign if provided.	1
	b	iii	 <p>height</p> <p>time</p> <p>concave down parabola as shown «with non-zero initial slope and zero final slope» ✓</p>	Award [1] mark if curve starts from a positive time value. Award [0] if the final slope is negative.	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	$\Delta p = 0.250 \times (9.8 + 5.0) \checkmark$  $F_{\text{net}} = \ll \frac{\Delta p}{\Delta t} = \frac{3.7}{0.1} \Rightarrow 37 \text{ «N»} \checkmark$  $N = 37 + 0.250 \times 9.8 = 39.5 \text{ «N»} \checkmark$	Allow <b>ECF</b> for <b>MP2</b> and <b>MP3</b>	3
	d	ii	there is an external force acting on the ball <b>OR</b> 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 <b>ECF</b> from <b>MP1</b> . Award <b>[2]</b> for a bald correct answer.	2	
	b	$\omega = \frac{2\pi}{T} \Rightarrow \frac{2\pi}{4 \times 10^{-3}} \text{ OR } 1.57 \times 10^3 \text{ «s}^{-1}\text{»}$ ✓ $a = \omega^2 x_0 = (1.57 \times 10^3)^2 \times 6 \times 10^{-6} = 14.8 \approx 15 \text{ «ms}^{-2}\text{»}$ ✓ «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	$1.5 \text{ «ms»}$ ✓	1	
	c	iii	$8.0 \text{ OR } 8.5 \text{ «}\mu\text{m»}$ ✓	From the graph on the paper, value is 8.0. From the calculated correct trig functions, value is 8.49	1
	d	i	$L = \frac{3}{4} \lambda \Rightarrow 0.90 \text{ «m»}$ ✓	1	
	d	ii	to the right ✓ displacement is getting less negative <b>OR</b> change of displacement is positive ✓	2	
	d	iii	horizontal line drawn at the equilibrium position ✓	1	

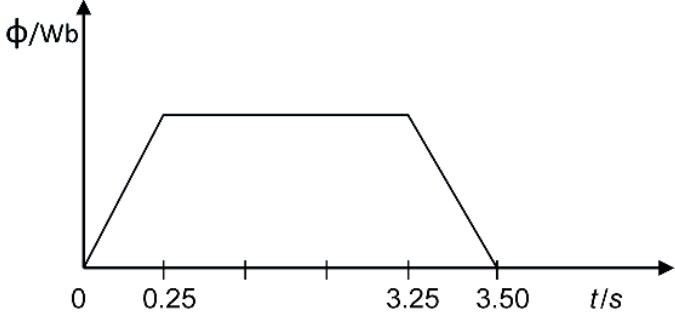
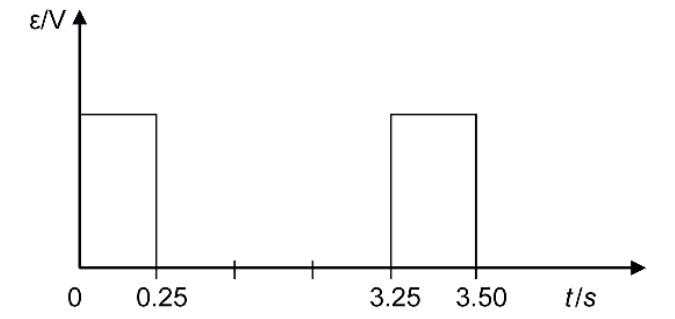
Question			Answers	Notes	Total
3.	a	i	<p>«electric field at P from one charge is <math>\frac{kQ}{r^2} \Rightarrow \frac{8.99 \times 10^9 \times 44 \times 10^{-6}}{0.48^2}</math></p> <p><b>OR</b></p> <p><math>1.7168 \times 10^6 \text{ «NC}^{-1}\text{»} \checkmark</math></p> <p>« net field is » <math>2 \times 1.7168 \times 10^6 \times \cos 30^\circ = 2.97 \times 10^6 \text{ «NC}^{-1}\text{»} \checkmark</math></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>«<math>a = \frac{F}{m} \Rightarrow \omega^2 x = \frac{115x}{0.25}</math>» <math>\checkmark</math></p> <p><math>T = \text{«} \frac{2\pi}{\omega} \Rightarrow 0.29 \text{ «s»} \checkmark</math></p>	<p>Award [2] marks for a bald correct answer.</p> <p>Allow <b>ECF</b> for <b>MP2</b></p>	2

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

Question			Answers	Notes	Total
4.	a	i	the energy needed to «completely» separate the nucleons of a nucleus <b>OR</b> the energy released when a nucleus is assembled from its constituent nucleons ✓	Accept reference to protons and neutrons.	1
	a	ii	curve rising to a maximum between 50 and 100 ✓  curve continued and decreasing ✓	Ignore starting point. Ignore maximum at alpha particle	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» ✓	Ignore any negative sign.	3
	b	ii	$\ll \frac{KE_{\alpha}}{KE_U} \Rightarrow \frac{\frac{p^2}{2m_{\alpha}}}{\frac{p^2}{2m_U}} \text{ OR } \frac{m_U}{m_{\alpha}} \checkmark$  $\ll \frac{234}{4} \Rightarrow 58.5 \checkmark$	Award [2] marks for a bald correct answer.  Accept $\frac{117}{2}$ for MP2.	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 <b>ECF</b> from <b>MP1</b> and <b>MP2</b> .	3
	c	ii	available power after time $t$ is $P_0 e^{-\lambda t} \checkmark$ $18 e^{-2.50 \times 10^{-10} \times 2.3 \times 10^8} = 17.0 \llcorner \text{kW} \gg \checkmark$	<b>MP1</b> may be implicit. Allow <b>ECF</b> 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 <b>MP2</b> Award <b>MP2</b> 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><b>ALTERNATIVE 1</b>                      maximum flux at <math>\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</math>  <math display="block">\text{emf} = \ll \frac{0.20}{0.25} \Rightarrow 0.80 \ll \text{V} \gg \checkmark</math></p> <p><b>ALTERNATIVE 2</b>                      emf induced in one turn <math>= BvL = 0.94 \times 0.20 \times 0.05 = 0.0094 \ll \text{V} \gg \checkmark</math>  <math display="block">\text{emf} = 85 \times 0.0094 = 0.80 \ll \text{V} \gg \checkmark</math></p>	<p>Award [2] marks for a bald correct answer</p> <p>Allow ECF from MP1</p>	2
	c	ii	<p><math display="block">I = \ll \frac{V}{R} \Rightarrow \frac{0.8}{2.4} \gg \text{ OR } 0.33 \ll \text{A} \gg \checkmark</math></p> <p><math display="block">F = \ll NBIL = 85 \times 0.94 \times 0.33 \times 0.05 \Rightarrow \gg = 1.3 \ll \text{N} \gg \checkmark</math></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 <math>\checkmark</math></p> <p><math display="block">E = Fvt = 1.3 \times 0.20 \times 0.50 = \ll 0.13 \text{ J} \gg</math></p> <p><b>OR</b></p> <p><math display="block">E = VIt = 0.80 \times 0.33 \times 0.50 = \ll 0.13 \text{ J} \gg \checkmark</math></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><math display="block">\Delta T = \frac{0.13}{0.018 \times 385} \checkmark</math></p> <p><math display="block">\Delta T = 1.9 \times 10^{-2} \ll \text{K} \gg \checkmark</math></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 $\frac{1360}{9.3^2}$ <b>OR</b> $15.7 \approx 16$ «W m <sup>-2</sup> » ✓	Allow the use of 1400 for the solar constant.	1
	a	ii	exposed surface is $\frac{1}{4}$ of the total surface ✓ absorbed intensity = $(1-0.22) \times$ incident intensity ✓ $0.78 \times 0.25 \times 15.7$ <b>OR</b> $3.07$ «W m <sup>-2</sup> » ✓	Allow 3.06 from rounding and 3.12 if they use $16 \text{ Wm}^{-2}$	3
	a	iii	$\sigma T^4 = 3.07$ <b>OR</b> $T = 86$ «K» ✓		1
	b		$v = \sqrt{\frac{2GM}{R}} \Rightarrow \sqrt{\frac{0.025}{0.404}} \times 11.2$ <b>OR</b> $2.79$ «kms <sup>-1</sup> » ✓		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 <b>MP1</b>	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 <b>[2]</b> marks for a bald correct answer. Allow <b>ECF</b> from <b>MP1</b>	2

Question			Answers	Notes	Total
6.	d	i	$m = \frac{28 \times 10^{-3}}{6.02 \times 10^{23}}$ <p><b>OR</b></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>Award <b>[2]</b> marks for a bald correct answer.</p> <p>Allow 282 from a rounded mass.</p>	2
	e		no, molecular speeds much less than escape speed $\checkmark$	Allow <b>ECF</b> from incorrect <b>(d)(ii)</b>	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><b>OR</b></p> $Q = 18.2 \text{ «}\mu\text{C}\text{» } \checkmark$		<b>1</b>
	b	i	electrons leave the small sphere «making it positively charged» $\checkmark$		<b>1</b>
	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 <math>q_1 = 12 \text{ «}\mu\text{C}\text{»}</math>, <math>q_2 = 6.0 \text{ «}\mu\text{C}\text{» } \checkmark</math></p>	<i>Award [3] marks for a bald correct answer.</i>	<b>3</b>

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