Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

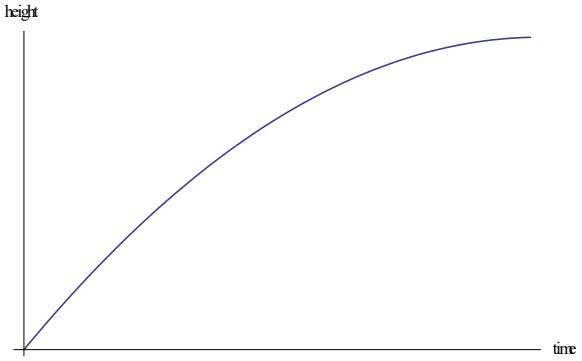
November 2021

Physics

Higher level

Paper 2

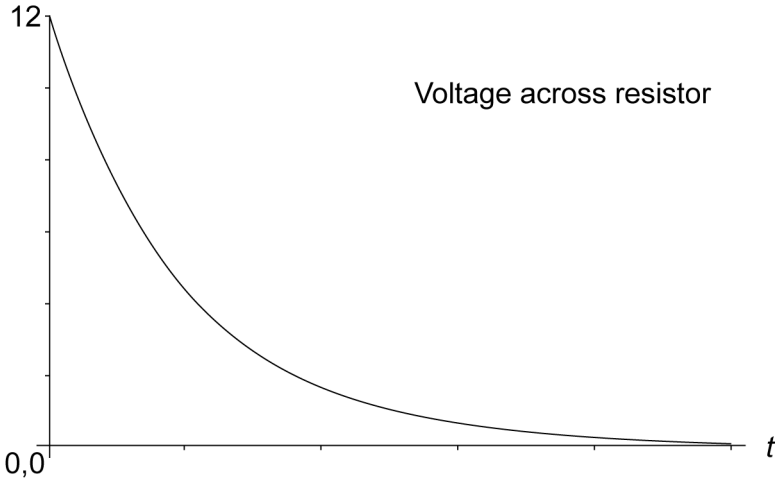
15 pages

Question			Answers	Notes	Total
1.	a		$H = «\frac{1}{2}gt^2 =» 4.9$ «m» ✓	*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**	«g=» 9.80 «ms^{-2}» ✓	*Accept 9.81, 10 or a plain "g"* *Ignore sign if provided.*	**1**
	b	**iii**	 concave down parabola as shown **«**with non-zero initial slope and zero final slope**»** ✓	*Award **[1]** mark if curve starts from a positive time value.* *Award **[0]** if the final slope is negative.*	**1**
	c		**«** loss of KE is $\frac{1}{2} \times 0.25 \times (9.8^2 - 5^2) =» 8.9$ «J» ✓	*Award **[1]** mark for an answer in the range 8.7 - 9.5*	**1**

Question			Answers	Notes	Total
1.	d	i	$\Delta p = 0.250 \times (9.8 + 5.0)$ ✓ $F_{\text{net}} = \text{«}\frac{\Delta p}{\Delta t} = \frac{3.7}{0.1}\text{»} = \text{»}37\ \text{«N»}$ ✓ $N = 37 + 0.250 \times 9.8 = 39.5\text{«N»}$ ✓	*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 ✓	*Allow references to impulse instead of force.* *Do not award references to energy.*	1

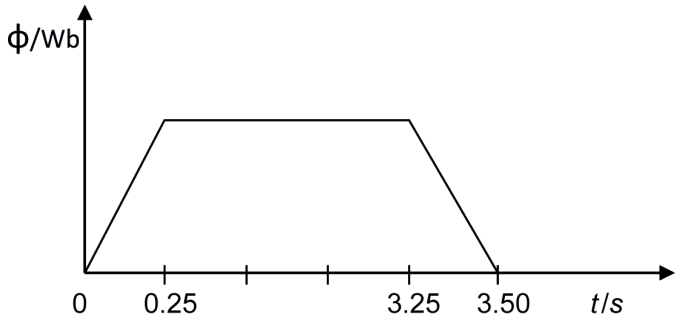
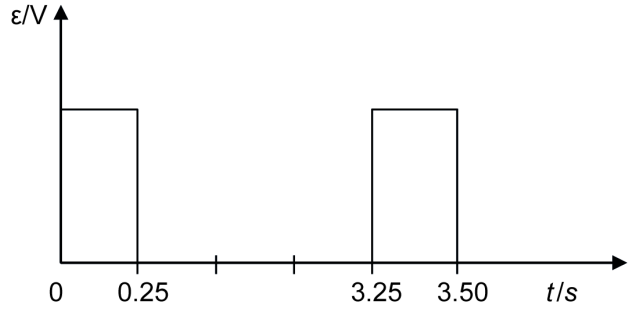
Question			Answers	Notes	Total
2.	a		$T = 4 \times 10^{-3}$ «s» or $f = 250$ «Hz» ✓ $\lambda = 340 \times 4.0 \times 10^{-3} = 1.36 \approx 1.4$ **«**m**»** ✓	*Allow **ECF** from **MP1**.* *Award **[2]** for a bald correct answer.*	**2**
	b		$\varpi = «\frac{2\pi}{T} =» \frac{2\pi}{4 \times 10^{-3}}$ ***OR*** 1.57×10^{3} «s^{-1}» ✓ a = «$\varpi^2 x_0 = (1.57 \times 10^3)^2 \times 6 \times 10^{-6} = 14.8 \approx$» 15 «$ms^{-2}$» ✓ **«**opposite to displacement so**»** to the right ✓		**3**
	c	i	«±» $\frac{\pi}{2}$ / 90° ***OR*** $\frac{3\pi}{2}$ / 270° ✓		**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	$L = «\frac{3}{4}\lambda =»$ 0.90 «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	«electric field at P from one charge is $\frac{kQ}{r^2} =» \frac{8.99 \times 10^9 \times 44 \times 10^{-6}}{0.48^2}$ ***OR*** 1.7168×10^6 «NC^{-1}» ✓ « net field is » $2 \times 1.7168 \times 10^6 \times \cos 30° = 2.97 \times 10^6$ «NC^{-1}» ✓		**2**
	a	**ii**	directed vertically up «on plane of the page» ✓	*Allow an arrow pointing up on the diagram.*	**1**
	b	**i**	force «on *q*» is proportional to the displacement ✓ and opposite to the displacement / directed towards equilibrium ✓		**2**
	b	**ii**	«$a = \frac{F}{m} =» \omega^2 x = \frac{115x}{0.25}$ ✓ $T =$ «$\frac{2\pi}{\omega} =$»0.29 «s» ✓	*Award **[2]** marks for a bald correct answer.* *Allow **ECF** for **MP2***	**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**	$\frac{1}{2} = e^{-\frac{5.0}{20\times10^6 C}}$ ✓ $C = 3.6 \times 10^{-7}$ «F» ✓	*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 ✓	*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	$\left(\frac{KE_\alpha}{KE_U} = \frac{\frac{p^2}{2m_\alpha}}{\frac{p^2}{2m_U}}\right)$ ***OR*** $\frac{m_U}{m_\alpha}$ ✓ $\left(\frac{234}{4} = 58.5\right)$ ✓	*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 $= \frac{33\times10^3}{238}\times 6.02\times10^{23}$ «$= 8.347\times10^{25}$» ✓ initial activity is $\lambda N_0 = 2.5\times10^{-10}\times 8.347\times10^{25}$ «$= 2.08\times10^{16}$ Bq» ✓ power is $2.08\times10^{16}\times5.51\times10^{6}\times1.6\times10^{-19} \approx 18$ «kW» ✓	*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 $P_0e^{-\lambda t}$ ✓ $18e^{-2.50\times10^{-10}\times2.3\times10^{8}} = 17.0$ «kW» ✓	***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 ✓ as energy depends on the frequency of light ✓	*Allow reference to wavelength for* ***MP2*** *Award* ***MP2*** *only to answers stating that KE decreases due to Doppler effect.*	**2**
	d	**ii**	decreases ✓ as number of photons incident decreases ✓		**2**

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

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

Question			Answers	Notes	Total
6.	a	i	incident intensity $\frac{1360}{9.3^2}$ ***OR*** 15.7 ≈ 16**«**W m^{-2}**»** ✓	*Allow the use of 1400 for the solar constant.*	**1**
	a	ii	exposed surface is ¼ of the total surface ✓ absorbed intensity = (1-0.22) × incident intensity ✓ 0.78 × 0.25 × 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		$v = \text{«}\sqrt{\frac{2GM}{R}} = \text{»}\sqrt{\frac{0.025}{0.404}} \times 11.2$ ***OR*** 2.79 **«**km s^{-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 x 24 x 3600 **«**s**»** ✓ $M = \frac{4\pi^2(1.2\times10^9)^3}{6.67\times10^{-11}\times(15.9\times24\times3600)^2} = 5.4\times10^{26}$ **«**kg**»** ✓	*Award* ***[2]*** *marks for a bald correct answer.* *Allow* ***ECF*** *from* ***MP1***	**2**

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

Question			Answers	Notes	Total
7.	a		$Q = \text{«}\frac{VR}{k}\text{=»}\frac{3.4\times10^{5}\times0.48}{8.99\times10^{9}}$ ***OR*** $Q = 18.2$ «μC» ✓		1
	b	i	electrons leave the small sphere «making it positively charged» ✓		1
	b	ii	$k\frac{q_1}{48} = k\frac{q_2}{24} \Rightarrow q_1 = 2q_2$ ✓ $q_1 + q_2 = 18$ ✓ so $q_1 = 12$ «μC», $q_2 = 6.0$ «μC» ✓	*Award **[3]** marks for a bald correct answer.*	3

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