OCR
Oxford Cambridge and RSA

GCE

Physics A

Unit **G484**: The Newtonian World

Advanced GCE

Mark Scheme for June 2017

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations

Annotation	Meaning
BOD	Benefit of doubt given
BP	Blank Page
CON	Contradiction
	Incorrect Response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct Response
AE	Arithmetic error
	Wrong physics or equation

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

All questions should be annotated with ticks where marks are allocated; One tick per mark.

Question			Answer	Marks	Guidance
1	a		Energy of ∝ = $5.2 \times 10^6 \times 1.6 \times 10^{-19}$ (= 8.32×10^{-13} (J)) $E = ½ mv^2$ so $v = \sqrt{\frac{2 \times 8.32 \times 10^{-13}}{6.6 \times 10^{-27}}}$ $= 1.6 \times 10^7 \quad (\text{m s}^{-1})$	C1 A1 A0	Must see some working **Allow:** Max 1 mark for 4 x 10^{16} (not converting to J) or 1.6 x 10^4 (not converting MeV to eV) 5.1 x 10^5 (using keV rather than MeV)
	b		Any **three** from • Total **momentum** of system / particles is conserved (as there are no external forces) / Increase in momentum of Sr nucleus equals decrease in momentum of alpha-particle • (Electrostatic) force (of repulsion) acts on (Sr) nucleus • (By Newton's 2nd law Sr) nucleus accelerates (away from alpha particle) • Sr acceleration increases and then decreases (to zero) • Force on Sr nucleus ∝ rate of change of momentum of alpha particle. (AW)	B1 × 3	✎ **momentum** / **accelerate(s)** / **acceleration** must be spelled correctly to score corresponding mark
	c		(Momentum is conserved) $6.6 \times 10^{-27} \times 1.6 \times 10^7 = 1.3 \times 10^{-25} \times V$ $V = 8.1 \times 10^5 \quad (\text{m s}^{-1})$	C1 A1	**Possible ECF from (a)** **Allow** full marks for use of 2 x 10^7 for speed of alpha particle giving V = 1.0 x 10^6 (m s^{-1})
	d		$\Delta(mv) = 2 \times 6.6 \times 10^{-27} \times 1.6 \times 10^7$ (= 2.11×10^{-19}) $F\Delta t = 4.8 \times \Delta t = 2.11 \times 10^{-19}$ $\Delta t = 4.4 \times 10^{-20}$ (s)	C1 A1	**Possible ECF from (a)** **Allow** full marks for use of 2 x 10^7 for speed of alpha particle giving Δt = 5.5 x 10^{-20} (s)
			Total	9	

2	**a**		(Fig. 2.1 shows) *a* and *x* are in opposite directions (Fig. 2.2 shows that magnitude of) *a* is proportional to *x* because graph is a straight line through the origin	**B1** **B1**	**Allow** *a* is towards the equilibrium position Reason must be given
	b		gradient = $\omega^2 = \frac{40}{50\times10^{-3}} = 800$ $T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{800}} = 0.22$ (s)	**C1** **A1**	**Allow** : use of equation and one point from graph **Allow:** Max 1 mark for $T = 7$ (s) (not converting mm to m)
	c	**i**	$[k] = \left[\frac{ma}{x}\right] = \frac{kg\times m\,s^{-2}}{m}$ $[k] = kg\ s^{-2}$	**C1** **A1**	**Allow:** C1 mark for any subject
		ii	$\frac{k}{m}$ is gradient $\frac{k}{m} = 800$ (s^{-2})	**A1**	**Possible ECF from (b)** Ignore sign
	d		• The period / frequency of the oscillations would remain the same • Successive **amplitude(s)** would decrease in magnitude • energy is dissipated as heat / thermal energy / work is done against friction (AW)	**B1** **B1** **B1**	✎ **amplitude** must be spelled correctly to score this mark **Allow:** 1 mark for bald statement that motion would be 'damped harmonic ' or suitable sketch.

2	**e**	**i**	• **C** continues to move in a straight line as the tube rotates (by N1st Law) stretching the spring. • Spring exerts a force on **C** which provides the centripetal acceleration (by Newton's 2nd law) to rotate **C** (in a circle of appropriate radius).	**B1** **B1**	No credit for bald statement of laws. They must be applied to the problem.
		ii	Any **four** from • Measure natural length of spring **OR** Measure mass of **C** with balance/scale(s). • Rotate at <u>constant</u> speed and video apparatus and ruler • Measure *R* from video • Find period *T* from video and speed *v* from $2\pi R/T$ • Measure extension from video **OR** calculate extension, *x*, from *R* and natural length • Use spring constant and $F = kx$ / Hooke's law **OR** substitute *M, v R* into $F = Mv^2/R$ to find force *F*	**B1 x 4**	
		iii1	*FR* / Nm	**B1**	Must have appropriate unit (ignore any prefix)
		iii2	$m = FR / v^2$ [any subject] mass is gradient of graph	**C1** **A1**	**Possible ecf from (iii)1**
			Total	**19**	

3	a		$g = \frac{GM}{R^2}$ $\frac{g_{Mars}}{g_{Earth}} = \left(\frac{GM_{Mars}}{R^2_{Mars}}\right)\left(\frac{R^2_{Earth}}{GM_{Earth}}\right) = \left(\frac{1}{(3400)^2}\right)\left(\frac{(6400)^2}{9.3}\right)$ $g_{Mars} = 0.38 \times 9.81$ $g_{Mars} = 3.74 \approx 3.7 \quad (N\,kg^{-1})$	**C1** **A1**	**Allow:** use of recalled mass of Earth (~6 x 10^{24} kg) and G from data tables **OR** calculation of mass of Earth from g = 9.81 m s^{-1} **C1** mark is for substitution into appropriate formula **OR** mass of Mars = 6.45 x 10^{23} (kg) Possible **FT** from their mass of Mars
	b	i	• Vertical acceleration on Mars is less than on Earth (AW) • time of fall on Mars is greater than time of fall on Earth (AW) • horizontal distance travelled will be greater on Mars	**B1** **B1** **A0**	
		ii	• Value of max height will be too small • g /a will reduce as height increases / $g \propto 1/r^2$ / SUVAT equations only apply if a is constant	**B1** **B1**	**Allow** 1 out of 2 marks for 'air resistance will reduce the height'

	c	i1	• orbit must be over equator / equatorial • period must be one Martian day / 8.9 x 10^4 s • direction of rotation must be the same as that of Mars / must travel in orbit parallel to a point on surface of Mars	B1 B1 B1	**Allow** : same <u>angular</u> speed as Mars
		i2	$GM_{Mars} = gR^2 = 3.74 \times (3400 \times 10^3)^2 \quad (= 4.3 \times 10^{13})$ $T^2 = \frac{4\pi^2}{GM_{Mars}} r^3$ $r = \sqrt[3]{\frac{4.3 \times 10^{13} \times (8.9 \times 10^4)^2}{4\pi^2}}$ $r = 2.1 \times 10^7$ (m)	C1 A1	**Possible** ECF for mass of Mars from (a) **Allow: C1** mark for substitution of values into correct equation written with any subject. **Allow:** $r = \sqrt[3]{\frac{6.67 \times 10^{-11} \times 6.45 \times 10^{23} (8.9 \times 10^4)^2}{4\pi^2}}$ $r = 2.1 \times 10^7$ (m)
		ii	$T = \sqrt{\frac{4\pi^2 r^3}{GM_{Mars}}} = \sqrt{\frac{4\pi^2 \times ((3400 + 9000) \times 10^3)^3}{4.3 \times 10^{13}}}$ $T = 4.2 \times 10^4$ (s) $\text{number of images} = \frac{4.2 \times 10^4}{25} = 1700$	C1 C1 A1	**Possible ECF from** their GM_{Mars} in c(i)**2** or mass of Mars from (a) **Allow :** Alternative method using $T^2 \propto r^3$ eg $T = \left(\sqrt{\frac{(12400 \times 10^3)^3}{(2.1 \times 10^7)^3}} \right) \times 8.9 \times 10^4$ = 4.2 x 10^4 (s) **Allow:** 2 out of 3 marks for T = 2.6 x 10^4 (s) leading to approximately 1034 images [uses 9000 km as radius of orbit] **Possible FT** from their value of T
			Total	14	

4	a		charge flowing = $I\Delta t = 45 \times 10^{-3} \times 1.6 = (72 \times 10^{-3}$ C) number of electrons $= \frac{72\times10^{-3}}{1.6\times10^{-19}} = 4.5\times10^{17}$	 A1	
	b		$\lambda = \frac{hc}{eV} = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{1.6\times10^{-19}\times130\times10^{3}}$ $\lambda = 9.6\times10^{-12}$ (m)	C1 A1	
	c		electrical power = IV =130 × 10^3 × 45 × 10^{-3} = 5850 W rate of heat produced = 0.9 x 5850 = 5265 W 5265 = m x 4200 x 10 m = 0.125 (kg s^{-1}) $V = \frac{m}{\rho} = \frac{0.125}{1000} = 1.25\times10^{-4}$ $(m^3\ s^{-1})$	 C1 C1 A1	**Allow:** electrons energy = 4.5 x 10^{17} x 130 x 10^3 in 1.6 s. $\text{power} = \frac{4.5\,x\,10^{17}\,x\,130\,x\,10^{3}\times1.6\times10^{-19}}{1.6} = 5850\ W$ **Allow:** Full marks for correct use of 5 x 10^{17} electrons. Giving V = 1.4 x 10^{-4} ($m^3\ s^{-1}$)
			Total	**6**	

5	a	i	Selection of **two or more** points from the curve and calculation of pV for each point or comparison of values hence pV constant / $p \propto 1/V$ / Boyle's law is obeyed	**M1** **A1**	Ignore units in calculation
		ii	• mass of gas / number of molecules must be constant/fixed • Temperature must be constant	**B1** **B1**	**Allow:** system must be closed
		iii	Straight line graph with positive gradient negative intercept on the mass axis (equal to mass of piston)	**B1** **B1**	
	b	i	$n = \frac{pV}{RT} = \frac{1.0\times10^5 \times (4/3)\pi \times 1.0^3}{8.31\times(273+17)} = (174)$ $mass = 4.0\times10^{-3} \times 174 = 0.70$ (kg)	**C1** **A1**	**Allow:** 1 mark for mass = 5.6 kg [incorrect radius] **Allow:** 1 mark for mass = 12 kg [incorrect T]
		ii	$p_2 = \frac{p_1 V_1 T_2}{V_2 T_1}$ $= \frac{1.0\times10^5 \times 1.0^3 \times 240}{4.5^3 \times 290}$ $p_2 = 9.1\times10^2$ (Pa)	**C1** **A1**	**Allow:** Use of $p = \frac{nRT}{V}$ with their n from **b(i)** **Allow:** 1 mark for p_2 = 2100 (Pa) [incorrect T]
		iii	Use of internal energy $\propto T$ $\frac{\text{internal energy at max height}}{\text{internal energy at ground}} = \frac{240}{290}$ = 0.83	**C1** **A1**	**Not** ratio = 1.9 [incorrect T]
			Total	**12**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

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Head office
Telephone: 01223 552552
Facsimile: 01223 552553