Oxford Cambridge and RSA

GCE

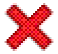
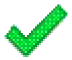
Physics A

Unit **G484**: The Newtonian World

Advanced GCE

Mark Scheme for June 2015

Annotations

Annotation	Meaning
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
BOD	Benefit of doubt given
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.

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Note about significant figures:

If the data given in a question is to 2 sf, then allow to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Guidance.
Penalise a rounding error in the second significant figure once only in the paper.

Question			Answer	Mark	Guidance
1	(a)	(i)	*N* & *W* act on the same body / Newton's 3rd Law forces should act on different bodies *N* & *W* are different types (of force) / are not same type	B1 B1	**Allow:** 3rd law pair to W acts on (centre of)Moon 3rd law pair to N acts on <u>surface</u> of Moon **Allow:** *N* is electromagnetic/electrostatic/electrical/contact *W* is gravitational. **Allow:** Paired forces should be of the same type **Ignore** a general statement of Newton's 2nd or 3rd law
		(ii)	Equal to / same as *W* acting on (the centre of) the Moon	B1	Do not allow 'acts on **surface** of Moon Diagram is not sufficient for this mark
	(b)		Clear use of vertical motion with downward acceleration **and** horizontal motion at constant velocity vertically $0 = (u\sin\theta)t - \frac{1}{2}g_M t^2$ $t = \frac{2u\sin\theta}{g_M}$ horizontaly $x = u\cos\theta \times \frac{(2u\sin\theta)}{g_M}$ $x \propto \frac{u^2}{g_M}$	B1 M1 A1 A0	If sin θ and cos θ are confused allow max 1/3. **Allow:** use of *a* for g_m **Allow:** determination of time to max height using $v=u+at$ Then total time = 2 x time to max height (M1) **Allow** use of 9.81 instead of g_m
			Total	**6**	

Question			Answer	Mark	Guidance
2	(a)	(i)	$m = \dfrac{0.131}{6.02\times10^{23}}$ $m = 2.18\times10^{-25}$ (kg)	A1	
		(ii)	mass of xenon ejected/ s $= m_{Xe} = 2.2\times10^{-25}\times9.5\times10^{18}$ $(= 2.07\times10^{-6})$ $F_{Xe} = \left(m_{Xe}\dfrac{\Delta v}{\Delta t}\right) = 2.2\times10^{-25}\times9.5\times10^{18}\times3.2\times10^{4}$ $(= 0.06627)$ $a_S = \left(\dfrac{F_{Xe}}{m_s}\right) = \dfrac{2.2\times10^{-25}\times9.5\times10^{18}\times3.2\times10^{4}}{5.2\times10^{3}}$ $a_S = 1.3\times10^{-5}$ (m s^{-2})	C1 C1 A1	Possible ECF **Allow:** $5.2\times10^{3}\times\Delta v = 2.07\times10^{-6}\times3.2\times10^{4}$ $\Delta v = 1.3\times10^{-5}$ $a_S = 1.3\times10^{-5}$ (m s^{-2})
		(iii)	Rate of change of **momentum** (of an object) is proportional to the <u>resultant</u> / <u>net</u> (external) force acting upon it. (AW) **OR** statement of law of Conservation **of momentum** in a closed system/no external forces	B1	**Momentum** must be spelled correctly **Allow:** ' equal to' instead of 'proportional to' **Allow:** statement of Newton's 3rd Law provided it is clear the forces act on **different** bodies and **opposite** is spelled correctly
		(iv)	Force (on spacecraft) is constant Mass (of spacecraft) decreases (as xenon is ejected) Acceleration <u>increases</u>	B1 M1 A1	**Not:** Weight (of spacecraft) or 'it is lighter'
	(b)	(i)	Area under graph in range 10.5 to 11.5 (Ns) Area under graph in range 10.8 to 11.2 (Ns) $\Delta v = \dfrac{\text{impulse}}{m} = \dfrac{\text{area}}{m}$ $= \dfrac{11.0}{180}$ $= 6.1\times10^{-2}$ (ms^{-1})	C1 C1 C1 A1	Possible FT for using their area / 180 Use of mass of spacecraft rather than satellite scores 1 out of last 2 marks.
		(ii)	From 0 to 3 (ms) acceleration <u>increases</u> linearly/uniformly/ at constant rate/ at a steady rate. (From 6.5 ms) onwards/later/at end the acceleration <u>decreases</u>	B1 B1	**Allow:** upper limit on time in range 3.0 to 3.5 ms Do not credit use **of 'constantly'** for this mark **Not 'decelerates'**
			Total	**14**	

Question			Answer	Marks	Guidance
3	(a)	(i)	Straight line <u>through</u> the origin Negative gradient and symmetrical about (0,0) by eye.	M1 A1	
		(ii)	Linking gradient to $[2\pi f]^2$. $\text{Frequency} = \dfrac{\sqrt{\text{gradient}}}{2\pi}$	C1 A1	**Allow:** use of a single data point used in $a = (-)[2\pi f]^2 x$ **Note** frequency must be the subject of this equation
	(b)	(i)	$A = \dfrac{v_{\text{max}}}{2\pi f} = \dfrac{0.09}{2\pi \times 8.0}$ $A = 1.8 \times 10^{-3}$ (m)	C1 A1	**Allow:** values for T in range 0.125 to 0.13 s
		(ii)	$a_{\text{max}} = (2\pi f)^2 A$ $a_{\text{max}} = (2\pi \times 8.0)^2 \times 1.8 \times 10^{-3}$ $a_{\text{max}} = 4.5 \quad (\text{m s}^{-2})$	C1 A1	Possible ecf from b(i) **Allow:** Tangent drawn on graph at any $v = 0$ point (C1) calculation of gradient (A1)
	(c)		Curve with same frequency /period max velocities decreasing at **three** successive **positive** peaks	B1 B1	**Allow**: ½ small square error on $v = 0$ points
	(d)		Axes labelled and graph showing correct bell shaped curve (amplitude increases then decreases) <u>Maximum/largest</u> amplitude or energy at f=8 Hz / natural frequency When <u>driving/oscillator's frequency</u> is equal to natural frequency / 8 Hz **resonance** occurs (AW).	B1 B1 B1	**Allow** this mark if curves are drawn asymptotically (to 8 Hz) May be scored on diagram or in text '**resonance**'/ '**resonant**' to be spelled correctly for this mark to be scored.
			Total	**13**	

Question			Answer	Marks	Guidance
4	(a)		(gravitational) force $\propto \dfrac{\text{[mass 1] [mass 2]}}{\text{[separation (of masses)]}^2}$	B1	**Allow:** equation in symbols if symbols are defined **Allow:** equality **Not** radius
	(b)		Use of $F = \dfrac{GMm}{R^2}$ AND $F = \dfrac{mv^2}{R}$ $v = \dfrac{2\pi R}{T}$ $\dfrac{GM}{R^2} = \dfrac{1}{R}\left(\dfrac{(2\pi R)}{T}\right)^2$ $R^3 = \dfrac{GM}{4\pi^2}T^2 \quad OR \quad R^3 \propto T^2$	B1 B1 B1 A1	**Ignore** signs **Allow:** equation with cancelling shown This mark is for some evidence of substitution and manipulation **Allow:** subject must be either R^3 or T^2 **Allow:** Max 1 mark for bald statement of $R^3 = \dfrac{GM}{4\pi^2}T^2$ without proof
	(c)	(i)	Graph is a straight line / has constant gradient and passes <u>through the origin</u>	B1	
		(ii)	$\text{gradient of graph} = \dfrac{GM}{4\pi^2} = \dfrac{15\times10^{34}}{4.5\times10^{16}} = \left(3.3\times10^{18}\right)$ $M = \dfrac{4\pi^2\times3.3\times10^{18}}{6.67\times10^{-11}}$ $M = 1.97\times10^{30}$ (kg)	C1 C1 A1	**Allow:** ± half small square on reading off points on line **Note** 2 possible POT error in this equation would give max 1 out 3 with FT. **Allow:** use of a point read from straight line substituted into Kepler's equation **Allow:** FT from their gradient value. 2.0 x 10^n where n ≠ 30 scores **max** 2 out of 3 marks
			Total	**9**	

Question			Answer	Marks	Guidance
5	(a)		$E = \dfrac{6.63\times10^{-34}\times3.0\times10^{8}}{1.1\times10^{-6}}$ $E = 1.8\times10^{-19}$ (J)	M1 A0	Values must be substituted Answer to 3sf is 1.81 x 10^{-19} (J)
	(b)		$m = \rho V = 8.1\times10^{-12}\times4.5\times10^{3} = (3.645\times10^{-8})$ Thermal energy gained $= (mc\,\Delta\theta) = 3.645\times10^{-8}\times520\times[1700-20]$ $(= 0.0318)$ $1.81\times10^{-19}\times6.3\times10^{19}\times t = 0.0318$ $t = 2.8\times10^{-3}$ (s)	C1 C1 A1	**Allow**: ecf from (a) and mass of titanium
	(c)		Thermal energy is conducted / transferred to the rest of <u>titanium/metal</u> Photons are reflected / scattered from / not absorbed the titanium surface	B1 B1	**Not:** heat lost to surroundings
	(d)		(Photon) energy is converted into potential energy (rather than kinetic energy) OR Energy is used to change solid to liquid / phase (rather than increase kinetic energy) OR Energy provides (specific) latent heat of fusion (rather than increase kinetic energy)	B1	**Allow:** energy is used to overcome the forces between atoms / breakdown the crystal structure of titanium (rather than increase kinetic energy)
			Total	**7**	

Question			Answer	Marks	Guidance
6	(a)		Idea of extrapolating graph back (to negative temperatures) Volume is zero at absolute zero / negative volumes are impossible	B1 B1	Can be shown on diagram Allow 'negligible volume' rather than zero and use of -273 ºC / 0 K
	(b)	(i)	(Internal energy of a system) is the sum of the random (distribution of) kinetic and potential energies of (all) **atoms/molecules** (in the system)	B1	**Allow :**particles
		(ii)	Any **two** from Comparison of kinetic energies in gas and liquid phases linked to temperature Potential energy of gas phase is greater than PE of liquid phase / energy must be supplied to change liquid into gas phase..	B1 B1	**Allow**: potential energy of gas phase is ('close' to) zero
	(c)	(i)	$p = \frac{nRT}{V} = \frac{45 \times 8.31 \times 293}{1.2 \times 10^{-2}}$ $p = 9.1 \times 10^{6}$ (Pa)	C1 A1	**No credit** If temperature is not converted to kelvin
		(ii)	$n_{He} = \frac{5.0 \times 10^{7} \times 2.0 \times 10^{-3}}{8.31 \times 293} = 41$ $p_{trimix} = \frac{[45 + 41] \times 8.31 \times 293}{[1.2 \times 10^{-2} + 2.0 \times 10^{-3}]}$ $p_{trimix} = 1.5 \times 10^{7}$ (Pa)	C1 C1 A1	**Allow:** ECF if temperature is used in ºC only if penalised in (i) Otherwise max mark allowed is 1 out of 3 for n = 602 mol **Allow:** use of partial pressures
		(iii)	Internal / kinetic energy of molecules decreases (as temperature falls) Hence pressure would decrease	M1 A0	**Allow:** $p \propto T$ if (n and) V constant
			Total	**11**	

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