

**GCE**

**Physics A**

Unit **G484**: The Newtonian World

Advanced GCE

**Mark Scheme for June 2015**

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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.

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## Annotations

Annotation	Meaning
	Blank Page – this annotation <b>must</b> 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.
	Benefit of doubt given
	Contradiction
	Incorrect Response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct Response
	Arithmetic error
	Wrong physics or equation

<b>Annotation</b>	<b>Meaning</b>
/	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
<b>IGNORE</b>	Statements which are irrelevant
<b>ALLOW</b>	Answers that can be accepted
( )	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
<b>ecf</b>	Error carried forward
<b>AW</b>	Alternative wording
<b>ORA</b>	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)	<p><math>N</math> &amp; <math>W</math> act on the same body / Newton's 3<sup>rd</sup> Law forces should act on different bodies</p> <p><math>N</math> &amp; <math>W</math> are different types (of force) / are not same type</p>	B1  B1	<p><b>Allow:</b> 3<sup>rd</sup> law pair to <math>W</math> acts on (centre of )Moon 3<sup>rd</sup> law pair to <math>N</math> acts on <u>surface</u> of Moon</p> <p><b>Allow:</b> <math>N</math> is electromagnetic/electrostatic/electrical/contact <math>W</math> is gravitational.</p> <p><b>Allow:</b> Paired forces should be of the same type</p> <p><b>Ignore</b> a general statement of Newton's 2<sup>nd</sup> or 3<sup>rd</sup> law</p>
		(ii)	Equal to / same as $W$ acting on (the centre of) the Moon	B1	Do not allow 'acts on <b>surface</b> of Moon Diagram is not sufficient for this mark
	(b)		<p>Clear use of vertical motion with downward acceleration <b>and</b> horizontal motion at constant velocity</p> <p>vertically <math>0 = (u \sin \theta)t - \frac{1}{2} g_M t^2</math></p> $t = \frac{2u \sin \theta}{g_M}$ <p>horizontally <math>x = u \cos \theta \times \frac{(2u \sin \theta)}{g_M}</math></p> $x \propto \frac{u^2}{g_M}$	B1  M1  A1  A0	<p>If <math>\sin \theta</math> and <math>\cos \theta</math> are confused allow max 1/3.</p> <p><b>Allow:</b> use of <math>a</math> for <math>g_m</math></p> <p><b>Allow:</b> determination of time to max height using <math>v=u + at</math></p> <p>Then total time = 2 x time to max height (M1)</p> <p><b>Allow</b> use of 9.81 instead of <math>g_m</math></p>
<b>Total</b>				<b>6</b>	

Question			Answer	Mark	Guidance
2	(a)	(i)	$m = \frac{0.131}{6.02 \times 10^{23}}$ $m = 2.18 \times 10^{-25} \text{ (kg)}$	A1	
		(ii)	mass of xenonejected/ s = $m_{Xe} = 2.2 \times 10^{-25} \times 9.5 \times 10^{18} (= 2.07 \times 10^{-6})$ $F_{Xe} = \left( m_{Xe} \frac{\Delta v}{\Delta t} \right) = 2.2 \times 10^{-25} \times 9.5 \times 10^{18} \times 3.2 \times 10^4 (= 0.06627)$ $a_S = \left( \frac{F_{Xe}}{m_S} \right) = \frac{2.2 \times 10^{-25} \times 9.5 \times 10^{18} \times 3.2 \times 10^4}{5.2 \times 10^3}$ $a_S = 1.3 \times 10^{-5} \text{ (m s}^{-2}\text{)}$	C1  C1  A1	Possible ECF  <b>Allow:</b> $5.2 \times 10^3 \times \Delta v = 2.07 \times 10^{-6} \times 3.2 \times 10^4$ $\Delta v = 1.3 \times 10^{-5}$ $a_S = 1.3 \times 10^{-5} \text{ (m s}^{-2}\text{)}$
		(iii)	Rate of change of <b>momentum</b> (of an object) is proportional to the <u>resultant / net</u> (external) force acting upon it. (AW)  <b>OR</b> statement of law of Conservation <b>of momentum</b> in a closed system/no external forces	B1	 <b>Momentum</b> must be spelled correctly <b>Allow:</b> 'equal to' instead of 'proportional to' <b>Allow:</b> statement of Newton's 3 <sup>rd</sup> Law provided it is clear the forces act on <b>different</b> bodies and <b>opposite</b> is spelled correctly
		(iv)	Force (on spacecraft) is constant Mass (of spacecraft) decreases (as xenon is ejected) Acceleration <u>increases</u>	B1 M1 A1	<b>Not:</b> 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) $\Delta v = \frac{\text{impulse}}{m} = \frac{\text{area}}{m}$ $= \frac{11.0}{180}$ $= 6.1 \times 10^{-2} \text{ (ms}^{-1}\text{)}$	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	<b>Allow:</b> upper limit on time in range 3.0 to 3.5 ms Do not credit use of ' <b>constantly</b> ' for this mark  <b>Not 'decelerates'</b>
		<b>Total</b>		<b>14</b>	

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 $[2\pi f]^2$ . Frequency = $\frac{\sqrt{\text{gradient}}}{2\pi}$	C1  A1	<b>Allow:</b> use of a single data point used in $a = (-)[2\pi f]^2 x$ <b>Note</b> frequency must be the subject of this equation
	(b)	(i)	$A = \frac{v_{\max}}{2\pi f} = \frac{0.09}{2\pi \times 8.0}$ $A = 1.8 \times 10^{-3} \text{ (m)}$	C1  A1	<b>Allow:</b> values for $T$ in range 0.125 to 0.13 s
		(ii)	$a_{\max} = (2\pi f)^2 A$ $a_{\max} = (2\pi \times 8.0)^2 \times 1.8 \times 10^{-3}$ $a_{\max} = 4.5 \text{ (ms}^{-2}\text{)}$	C1 A1	Possible ecf from b(i) <b>Allow:</b> Tangent drawn on graph at any $v = 0$ point (C1) calculation of gradient (A1)
	(c)		Curve with same frequency /period  max velocities decreasing at <b>three</b> successive <b>positive</b> peaks	B1  B1	<b>Allow:</b> 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 $f=8 \text{ Hz}$ / natural frequency  When <u>driving/oscillator's</u> frequency is equal to natural frequency / 8 Hz <b>resonance</b> occurs (AW).	B1  B1  B1	<b>Allow</b> this mark if curves are drawn asymptotically (to 8 Hz)  May be scored on diagram or in text   <b>'resonance'</b> / <b>'resonant'</b> to be spelled correctly for this mark to be scored.
<b>Total</b>				<b>13</b>	



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

Question		Answer	Marks	Guidance
5	(a)	$E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{1.1 \times 10^{-6}}$ $E = 1.8 \times 10^{-19} \text{ (J)}$	M1 A0	Values must be substituted Answer to 3sf is $1.81 \times 10^{-19}$ (J)
	(b)	$m = \rho V = 8.1 \times 10^{-12} \times 4.5 \times 10^3 = (3.645 \times 10^{-8})$ $\text{Thermal energy gained} = (mc \Delta\theta) = 3.645 \times 10^{-8} \times 520 \times [1700 - 20] \quad (= 0.0318)$ $1.81 \times 10^{-19} \times 6.3 \times 10^{19} \times t = 0.0318$ $t = 2.8 \times 10^{-3} \text{ (s)}$	C1 C1 A1	<b>Allow:</b> ecf from (a) and mass of titanium
	(c)	<p>Thermal energy is conducted / transferred to the rest of <u>titanium/metal</u></p> <p>Photons are reflected / scattered from / not absorbed the titanium surface</p>	B1 B1	<b>Not:</b> heat lost to surroundings
	(d)	<p>(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)</p>	B1	<b>Allow:</b> energy is used to overcome the forces between atoms / breakdown the crystal structure of titanium (rather than increase kinetic energy)
<b>Total</b>			<b>7</b>	

Question		Answer	Marks	Guidance
6	(a)	Idea of extrapolating graph back (to negative temperatures) <u>Volume is zero</u> at absolute zero / <u>negative volumes</u> are impossible	B1 B1	Can be shown on diagram Allow 'negligible <u>volume</u> ' rather than zero and use of -273 °C / 0 K
	(b)	(i)		
		(i)	B1	<b>Allow</b> :particles
		(ii)	B1 B1	<b>Allow</b> : potential energy of gas phase is ('close' to) zero
		Any <b>two</b> 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..		
	(c)	(i)	C1 A1	<b>No credit</b> If temperature is not converted to kelvin
		(ii)	C1 C1 A1	<b>Allow</b> : ECF if temperature is used in °C only if penalised in (i) Otherwise max mark allowed is 1 out of 3 for $n = 602$ mol  <b>Allow</b> : use of partial pressures
		(iii)	M1 A0	<b>Allow</b> : $p \propto T$ if (n and) <u>V constant</u>
		<b>Total</b>	<b>11</b>	

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