OCR
RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE

Unit **G484:** The Newtonian World

Mark Scheme for January 2013

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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
	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

The abbreviations, annotations and conventions used in the detailed Mark Scheme are:

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

Note about significant figures:

If the data given in a question is to 2 sf, then allow answers to 2 or more sf.
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 Column.

CATEGORISATION OF MARKS

The mark scheme 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.

Question			Answer	Marks	Guidance
1	(a)		Rate of change of momentum (of a body) is proportional / equal to the (net) force (acting on it) and takes place in the direction of that force.	M1 A1	**Allow:** Force = change in momentum / time (taken) ✎ **Note: momentum** must be spelled correctly to score the mark. **Allow** this mark if the M1 mark is lost for spelling error
	(b)	(i)	(3 x 5) – (7 x 2) = 10v v = (15 – 14)/10 = 0.10 (m s^{-1}) to the right (AW)	C1 M1 A1	Signs must be correct for the mark to be scored **Allow** 1 sf answer **Not** forwards/towards **B** but **allow** correct arrow → or east
		(ii)	Impulse = 3(0.1 – 5) (= - 14.7) = (-)15 (Ns) to the left (AW)	M1 A1	**Allow:** ecf from (b)(i) **Ignore** sign **Not** backwards/towards **A** but **allow** correct arrow ← or west
		(iii)	(Newton's 3rd law says) Force on B (due to A) is equal and opposite to force on A (due to B) time (of contact) / t is same for both **AND** Impulse = Ft impulse on A is equal and opposite to impulse on B	M1 A1 A0	**Allow**: use of minus sign to indicate 'opposite' **Not**: Action and reaction are equal and opposite.
			Total	**9**	

Question			Answer	Marks	Guidance
2	(a)	(i)	$g = \frac{v^2}{r}$ or $v^2 = \frac{GM}{r}$ $v = \sqrt{gr}$ $v = \sqrt{7.7 \times 7.2 \times 10^6}$ $v = 7400$ (m s^{-1})	C1 C1 A1	Correct formula in any form **Allow:** use of *a* for *g* Mark is for substitution (**Note** Mass of Earth is 6.0 x 10^{24} kg) **Any use of r = 800 km is WP scores 0/3** **Note:** Answer to 3 sf is 7450 (m s^{-1})
		(ii)	$T = \frac{2\pi r}{v}$ $T = \frac{2\pi \times 7.2 \times 10^6}{7450}$ = 6100 (s) OR $T^2 = \frac{4\pi^2 r^3}{GM}$ $T^2 = \frac{4\pi^2 (7.2 \times 10^6)^3}{6.67 \times 10^{-11} \times 6 \times 10^{24}}$ T = 6100 (s)	C1 A1	**Allow:** possible ecf for *v* from (a)(i) **No ecf** for use of r = 6.4 x 10^6 again or use of r = 800 km Both score 0/2 **Note:** Answer to 3 sf using v = 7400 is 6110 (s) Answer to 3 sf using v = 7450 is 6070 (s)
	(b)	(i)	Number of orbits = $\frac{24 \times 3600}{6080}$ (= 14.2) ≈ 14	B1	**Allow** any correct method **Allow** ora **No ecf** from a(ii)
		(ii)	Circumference = $2\pi r$ $\frac{\text{equatorial circumference}}{\text{width of photograph}} = \frac{2\pi \times 6400}{3000} = 13.4$ (But each orbit crosses the equator twice hence) number of orbits = 6.7 This is fewer than 14 orbits so whole of Earth's surface can be photographed (AW)	C1 C1 A1 A0	**Allow**: Circumference = $2\pi r$ (C1) length of equator covered per orbit = 2π x 6.4 x 10^3/14 (C1) (= 2872) (But each orbit crosses the equator twice hence) min width to be photographed = ½ x 2872 = 1400 km (A1) < 3000 km so all of Earth's surface can be photographed in one day (A0)

Question			Answer	Marks	Guidance
	(c)		suitable example: eg weather / spy / surveying / mapping / GPS	B1	**Ignore** TV / radio / communications
			Total	**10**	

Question			Answer	Marks	Guidance
3	(a)		Force is proportional to the product of the masses and inversely proportional to the square of their separation (AW)	B1	**Allow:** $F = \frac{GmM}{r^2}$ with **all** symbols defined.
	(b)	(i)	$mg = \frac{GmM_J}{r^2}$ $M_J \left(= \frac{g r^2}{G} \right) = \frac{7.5 \times (1.3 \times 10^8)^2}{6.67 \times 10^{-11}}$ M_J = 1.9 x 10^{27} (kg)	C1 C1 A1	**Allow:** formula with m cancelled **Allow:** use of $T^2 = \frac{4\pi^2 r^3}{GM_J} \Rightarrow M_J = \frac{4\pi^2 (1.3 \times 10^8)^3}{6.67 \times 10^{-11} \times (7.2 \times 60^2)^2}$ **Note:** mark is for substitution with any subject
		(ii)	$\frac{g_M}{g_A} = \frac{r_A^2}{r_M^2}$ $\frac{g_M}{7.5} = \frac{(1.3 \times 10^8)^2}{(2.4 \times 10^{10})^2}$ g_M = 2.2 x 10^{-4} (N kg^{-1})	C1 A1	**Allow:** use of $g = \frac{GM_J}{r^2}$ with possible ecf for M_J from (b)(i) $g_M = \frac{(6.67 \times 10^{-11}) \times (1.9 \times 10^{27})}{(2.4 \times 10^{10})^2}$ **Note:** mark is for substitution g_M = 2.2 x 10^{-4} (N kg^{-1})
		(iii)	$T^2 \propto r^3$ OR T^2/r^3 = constant (= $4\pi^2/GM_J$) $\frac{T_M^2}{7.2^2} = \frac{(2.4 \times 10^{10})^3}{(1.3 \times 10^8)^3}$ T_M = 1.8 x10^4 (hours)	C1 C1 A1	**Allow:** possible ecf for M_J from b(i) **Allow:** use of other **c**orrect formulae **Note:** mark is for substitution **Note** using times in seconds gives T_M = 6.49 x10^7 (s) scores 2 marks
			Total	**9**	

Question			Answer	Marks	Guidance
4	(a)		Obtain a set of readings for: mass *m*, time period AND calculate frequency using *f* = 1/*T*. Plot graphs of *f* against 1/*m* AND *f* against 1/√*m* The graph which is a straight line through the origin provides the correct relationship Reference to one method of improving reliability eg counting more than 5 oscillations to find *T* or *f* taking repeat measurements of *T* or *f* (and average values) time oscillations from equilibrium position	B1 B1 B1 B1	**Not** number of oscillations in a set time **Allow:** product method using two or more points (B1) Select the relation which gives a constant product (B1) **Allow:** plot ln *f* against ln *m* (B1) gradient= -1 then $f \propto 1/m$ **or** gradient= -0.5 then $f \propto 1/\sqrt{m}$ (B1)
	(b)	(i)	$v_{max} = 2\pi f A = 2\pi\left(\frac{1}{1.2}\right)\times 36\times 10^{-3}$ $v_{max} = \frac{3\pi}{50} \quad (= 0.188)$ $KE_{max} = \frac{1}{2}\times 0.4\times\left(\frac{3\pi}{50}\right)^2$ $KE_{max} = 7.1\times 10^{-3}$ (J)	C1 C1 A1	**Note:** mark is for substitution
		(ii)	$a_{max} = (2\pi f)^2 A = \left[2\pi\left(\frac{1}{1.2}\right)\right]^2 \times 36\times 10^{-3}$ $a_{max} = 0.99$ (ms^{-2})	C1 A1	**Note:** mark is for correct substitution

Question			Answer	Marks	Guidance
	(c)		**Reference to** : kinetic energy (of masses and spring), gravitational potential energy (of mass and spring), elastic (potential) energy / strain energy of spring KE: zero (at lowest point), increasing to max at equilibrium point, decreasing to zero (at highest point) GPE: increases (as masses rise from lowest to highest point) (clearly worded ora)(AW) strain / elastic energy: decreases (as masses rise from lowest to highest point) (clearly worded ora) (AW)	B1 B1 B1 B1	**Note:** mark to be awarded only if **all** 3 forms are quoted ✎ **Note: potential** must be spelled correctly throughout to score this mark
			Total	**13**	

Question			Answer	Marks	Guidance
5	(a)	(i)	*n* = number of moles (in sample) **AND** *N* = number of atoms / molecules (in sample)	B1	**Note: both** definitions are required **Not:** particles / Avogadro's constant
		(ii)	*n* or *N* **AND** T is constant (and R and k are constants) for a fixed mass (of gas), pV = constant / $p \propto 1/V$	M1 A1	*nRT* or *NkT* is constant is **not** sufficient
		(iii)	Shows that $Nm^{-2} \times m^3 = Nm$	B1	**Allow:** Use of base units for **both** *pV* **and** work done
	(b)	(i)	Calculates $p \times (1/V)^{-1}$ at **two** points on the graph values are the same pV = constant / $p \propto 1/V$ / nRT = constant	M1 A1	Expected values for pV are 7500 (Nm) or 0.075 ($\times 10^{-5}$)for most points **Allow:** Correct calculation of gradient (M1) Calculates intercept = 0 hence graph is through the origin and pV = constant / $p \propto 1/V$ (A1)
		(ii)	Number of moles in 0.050 kg = 0.05/0.016 (= 3.125) $T = \frac{pV}{nR} = \frac{7500}{3.125 \times 8.31}$ $= 289$ (K) $T = 16$ (ºC)	C1 C1 A1	 **Allow:** possible ecf from (b)(i) or error in *n* but apply POT error for use of $pV = 0.075$ leading to $T = 2.9 \times 10^{-3}$ K **Note:** Mark is for correct conversion of their *T* (K) value **Note**: Allow full range of marks for other sensible alternative approaches e.g. use of a molecular mass of 0.032 kg/mol giving a temperature of 305°C
			Total	**9**	

Question			Answer	Marks	Guidance
6	(a)	(i)	vibrate (about their 'fixed' positions)	B1	**Allow:** molecules vibrate
		(ii)	greater amplitude / greater frequency (of vibration)	B1	**Not:** faster / more / bigger /more vigorous (vibrations)
		(iii)	**Either** internal energy increases **Or** potential energy (of molecules) increases and the kinetic energy remains constant temperature remains constant	B1 B1	
	(b)	(i)	$P\,t = m\,c\,\Delta\theta$ 48 x 720 = 0.98 x c x (54 - 18) + 0.027 x 850 x (38-18) c = 970 (J kg^{-1} K^{-1})	C1 C1 C1 A1	**Note:** mark is for correct substitution for total energy input **and** heat gained by **metal** **Note:** mark is for adding a correct substitution for heat gained by insulation into this equation **Note:** answer to 3 sf = 967 Calculation of c = 980 ignoring energy used to heat insulation scores 2 marks
		(ii)	Without the insulation there will be **more** heat lost to the surroundings / air (AW) final temperature will be **lower** **OR** a **lower** temperature rise **OR** more energy will be required to give the **same** temperature rise / final temperature **AND** hence c is **higher** than that calculated in (i)	M1 A1	**Not:** lost to wires / data logger
			Total	**10**	

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