OCR
RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE

Unit **G484:** The Newtonian World

Mark Scheme for June 2013

Oxford Cambridge and RSA Examinations

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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.

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Annotations

Annotation	Meaning
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	Marks	Guidance
1	(a)	(i)	(Resultant) force (acting on an object) is (directly) proportional to the <u>rate of change of momentum</u> (and occurs in the same direction)(AW)	B1	**Allow:** 'equal' instead of proportional, **Allow:** 'change in momentum <u>divided</u> by time taken' **Not:** a definition involving acceleration **Not:** 'change in momentum **over** time taken' **Not:** an equation unless all terms are defined
		(ii)	$F = \frac{\Delta(mv)}{\Delta t}$ $F = m\frac{\Delta(v)}{\Delta t}$ (if m is constant) $F = ma$ $F = \frac{(mv - mu)}{\Delta t}$ $F = \frac{m(v-u)}{\Delta t}$ (if m is constant) $F = ma$	M1 A1 A0	**Allow:** Any subject. **Not:** $\Delta p/\Delta t$ for M mark **Allow:** $F \propto \frac{(mv - mu)}{\Delta t}$ **Allow:** Use of t for Δt
	(b)	(i)	(Impulse) $F\Delta t$ = area (under graph) **OR Clear** use of ½ x 4 x 20 in $F\Delta t = m\Delta v$ $\Delta v = \frac{40}{2.5}$ $\Delta v = 16 \quad (\text{m s}^{-1})$	C1 C1 A1	**Note:** Area = 40 (N s) **Allow**: any subject
		(ii)	$a = \frac{(v-u)}{t}$ $a = \frac{16}{4}$ $a = 4.0 \quad (\text{m s}^{-2})$	B1	Possible **ecf** from **(b)(i)** **Allow:** mean force <F> = 10 N mean acceleration (= <F>/m) = 10/2.5 = 4.0 (m s^{-2}) **Allow:** a = 4 (m s^{-2}) as answer is exact.
		(iii)	'acceleration **increases** to 2s **and** then **decreases'** Reference to the rate of change of acceleration being constant / linear change in acceleration / acceleration changes at uniform rate in either section.	M1 A1	No credit for any reference to **deceleration.** **Not:** accelerating constantly / uniform acceleration / constant acceleration / increasing rate of change of acceleration
			Total	**9**	

Question			Answer	Marks	Guidance
2	(a)	(i)	Diagram showing **at least 4 radial** lines outside Earth, appearing to meet at centre of Earth (as judged by eye – in a square containing letters **a** and **r** of label) **AND** **at least 4 arrows** directed towards the Earth	B1	**Do not** award this mark if any arrow is in wrong direction. **Allow**: line(s) to continue inside the Earth
		(ii)	Any **two** from the following: • Field lines are **parallel** to each other • Field lines are equally/evenly/uniformly/constantly spaced (AW) • Field lines are **perpendicular / vertical** / **right angles** (to surface of the Earth)	B1 B1	**Note: vertical**, **parallel**, **perpendicular** /**right angles** wherever used to be spelled correctly .
	(b)	(i)	$g = \frac{GM}{R^2}$ $g = \frac{6.67 \times 10^{-11} \times 5.7 \times 10^{26}}{(6 \times 10^7)^2}$ $g = 11 \quad (\text{N kg}^{-1})$	C1 A1	**Note:** Mark is for substitution Answer is 10.6 (N kg^{-1}) to 3 sf Ignore sign
		(ii)1	$\frac{mv^2}{r} = \frac{GMm}{r^2}$ or $v^2 = \frac{GM}{r}$ $v^2 = \frac{6.67 \times 10^{-11} \times 5.7 \times 10^{26}}{5.3 \times 10^8} \quad (= 7.17 \times 10^7)$ $v = 8.5 \times 10^3 \quad (\text{m s}^{-1})$	C1 C1 A1	Allow $T^2 = \left(\frac{4\pi^2}{GM}\right) r^3$ **and** $v = \frac{2\pi r}{T}$ Expected value for T = 3.93 x 10^5 s **Note:** Mark is for substitution Answer is 8470 (m s^{-1}) to 3 sf **Note:** Using • mass of Rhea (2.3 x 10^{21}) gives v = 17 (m s^{-1}) • g from b(i) in $v = \sqrt{gr}$ gives v = 7.5 x 10^4 [correct value of g at Rhea's orbit is 0.135 N kg^{-1}] Both score max 1 mark for use of correct formula
		(ii)2	$E_k = \frac{1}{2} \times 2.3 \times 10^{21} \times 7.17 \times 10^7$ $E_k = 8.2 \times 10^{28}$ (J)	B1	Possible **ecf** for v from **(ii)1** **Note:** Using v = 17 gives E_k = 3.3 x 10^{23} (J) Using v = 7.5 x 10^4 gives E_k = 6.5 x 10^{30} (J) Using b(ii)1 to 2sf gives E_k = 8.3 x 10^{28} (J)
			Total	**9**	

Question			Answer	Marks	Guidance
3	(a)		Is in the opposite direction to the displacement Increases as the speed of the object decreases	B1 B1	If more than 2 ticks are given mark all and deduct 1 mark for each error
	(b)	(i)	$f = \frac{1}{T} = \frac{1}{1.2}$ $f = 0.83 \quad (\text{Hz})$	B1	**Allow:** the fraction 5/6 only
		(ii)	$v_{max} = (2\pi f)\ A$ $0.08 = (2\pi \times 0.83)A$ $A = \frac{0.08}{(2\pi \times 0.83)} = 0.015 \quad (\text{m})$	C1 A1	Possible **ecf** from **(b)(i)** **Note:** Mark is for substitution; any subject Answer is 0.0153 (m) to 3 sf
		(iii)	$a_{max} = (2\pi f)^2 A$ $a_{max} = (2\pi \times 0.83)^2 \times 0.015$ $a_{max} = 0.42 \quad (\text{m s}^{-2})$	C1 A1	Possible **ecf** from **(b)(i)** and **(ii)** **Note:** Mark is for substitution **Ignore sign** Expect to see 0.41 if 2 sf values are used **Allow:** tangent used at $v = 0$ (M1) gradient of tangent calculated in range 0.37 to 0.44 ($m\ s^{-2}$) to 2sf (A1). Accept gradient of tangent =0.4 ($m\ s^{-2}$)
	(c)	(i)	Graph(s) tending to single peak with axes labelled in words or appropriate symbols Peak labelled as natural / resonant frequency (of system) or f_o • Resonance occurs when the driving frequency matches natural / resonant frequency (of system) • the amplitude of vibrations / energy (transferred) is then a maximum (AW)	B1 B1 B1 B1	Can be scored even if horizontal axis is not correctly labelled
		(ii)	A valid example of resonance Explanation to include • what does the driving and what is being driven • that this occurs at specific (driver) frequency	B1 B1	**Allow:** Mirror in car, Washing machine, Child on swing, microwave (oven), radio (tuning), Structures (in wind etc) MRI **Not** musical instruments
			Total	**13**	

Question			Answer	Marks	Guidance
4	(a)		Mass of air = 4.5 x 4 x 2.4 x 1.3 (= 56.2) $Q = mc\Delta\theta$ = 56.2 x 990 x (21 – 12) $Q = 5.0 \times 10^5$ (J)	B1 C1 A1	 **Allow:** follow through (FT) for mass of air **Note:** Max 1 mark out of 3 if temperature **rise** is given as 282 K.
	(b)	(i)	$t = \frac{Q}{P} = \frac{5.0 \times 10^5}{2300}$ $t = 220 \quad (s)$	C1 A1	Possible **ecf** from **(a)** Answer is 217 (s) or 218 (s) to 3 sf depending on accuracy of Q used from (a)
		(ii)	$\text{Volume of gas}, V = \frac{5.0 \times 10^5}{39 \times 10^6}$ (= 0.0128 (m^3)) $\text{Mass of gas} = V\rho = 0.0128 \times 0.72$ $\text{Mass} = 9.2 \times 10^{-3} \quad (kg)$	C1 A1	Possible **ecf** from **(a)**
	(c)		Any **two** from the following : • thermal energy/heat is lost through or to walls / ceiling / floor/windows /door of room (AW) • other objects within the room (AW) • warm <u>air</u> may escape from room / cold <u>air</u> or draughts may enter the room	 B1 B1	**Not:** Bald 'Heat lost to surrounding' **Ignore** any references to heater
			Total	**9**	

Question			Answer	Marks	Guidance
5	(a)		**Kinetic** energy is conserved (when molecule collides) / collision is **elastic** (so velocity after collision is $-v$) Momentum change = $mv - [-mv]$ $= 2mv$	M1 A1 A0	**Note: Kinetic** and **elastic,** wherever used, to be spelled correctly **Allow**: *m[v-(-v)] or –mv – mv* **Allow**: A1 mark if M1 mark has been lost for incorrect spelling
	(b)		Increase in temperature causes an increase in velocity / speed (of molecules) Collisions are more frequent (AW) Greater (rate of) change in momentum (in each collision with the surface) Hence force increases	B1 B1 B1 A0	**Note:** No credit for references to pressure [NAQ]
	(c)	(i)	$\frac{p_2}{T_2} = \frac{p_1}{T_1}$ $p_2 = \frac{2.2 \times 10^5}{(273+18)} \times (273+54)$ $p_2 = 2.5 \times 10^5$ (Pa)	C1 A1	**Note:** Mark is for substitution; any subject No marks if temperatures are not converted to kelvin Answer to 3 sf is 2.47×10^5 (Pa)
		(ii)	Original area $= \frac{W}{p_1} = \frac{1200 \times 9.8}{2.2 \times 10^5}$ $(= 5.35 \times 10^{-2})$ (m^2) Final area $= \frac{W}{p_2} = \frac{1200 \times 9.8}{2.47 \times 10^5}$ $(= 4.77 \times 10^{-2})$ (m^2) Change in area $= (5.35 - 4.77) \times 10^{-2} = 5.8 \times 10^{-3}$ (m^2)	C1 C1 A1	 Possible **ecf** from **(c)(i)** **Allow:** Full credit if 2 sf values are used eg 6.4×10^{-3} (m^2) using $p_2 = 2.5 \times 10^5$
			Total	**10**	

Question			Answer		Marks	Guidance
6	(a)	(i)	For a <u>fixed / constant mass</u> of gas at constant temperature Pressure is inversely proportional to volume / pressure x volume = constant		B1 B1	
		(ii)	Axes labelled *p* and 1/*V* OR *V* and 1/*p*		B1	**No ecf from a(i)** **Note:** Only one tick
	(b)	(i)1	$pV = nRT$ $n = \frac{pV}{RT} = \frac{1.2\times10^{7}\times0.05}{8.31\times(273+21)}$ $n = 250$		C1 A1	**Allow:** use of $pV = NkT$ leading to $N = 1.48\text{x}10^{26}$ (C1) and $n = N/N_A$ giving $n = 250$ (A1) Mark is for substitution; any subject. No credit if 21ºC is used giving $n = 3438$
		(i)2	mass = *n* x 0.029 = 246 x 0.029 = 7.1 kg	mass = *n* x 0.029 = 250 x 0.029 = 7.3 kg	A1	Possible **ecf** from **(b)(i)1** Allow ecf if *n* = 3438 leads to mass = 99.7 kg

Question			Answer	Marks	Guidance
6	(b)	(ii)	$n_{air\ added} = \frac{pV}{RT} = \frac{1.0\times10^5\times1.5}{8.31\times(273+21)}$		Possible **ecf** from **(b)(i)1** or **2**
			$n_{air\ added} = 61.4$	C1	**Allow** follow through for incorrect $n_{air\ added}$ value
			$n_{total} = n_{initial} + n_{air\ added} = 246 + 61.4 \quad (= 307)$	C1	Using n =250 from **b(i)1** leads to $n_{total} = 250 + 61.4 \quad (= 311)$
			$p_{final} = n_{total}\left(\frac{RT}{V}\right) = 307\times\left(\frac{8.31\times(273+21)}{0.050}\right)$	C1	Use of T = 21ºC or V =1.55 is wrong physics so can not score last two marks
			$p_{final} = 1.5\times10^7 \quad (\text{Pa})$	A1	**ALTERNATIVE METHOD** Calculates pressure of air pumped in if it were to occupy a volume equal to cylinder $p_2 = \frac{1\times10^5\times1.5}{0.05}$ (C1) $p_2 = 3.0\times10^6$ (C1) When added to air already in cylinder $p_{final} = p_{original} + p_2$ $p_{final} = 1.2\times10^7 + 3.0\times10^6$ (C1) $p_{final} = 1.5\times10^7$ (Pa) (A1) **SPECIAL CASES** Using alternative method but with final volume taken as 1.5 m³ p_2 = 4.0 x 10^5 (Pa) and final pressure is 5.0 x 10^5 (Pa) Scores 2 marks . No credit if final volume taken as 1.55 m³
			Total	**10**	

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

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