RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE

Unit **G494:** Rise and Fall of the Clockwork Universe

Mark Scheme for January 2013

Oxford Cambridge and RSA Examinations

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, OCR Nationals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

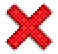
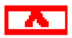
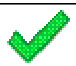
© OCR 2013

Any enquiries about publications should be addressed to:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 770 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

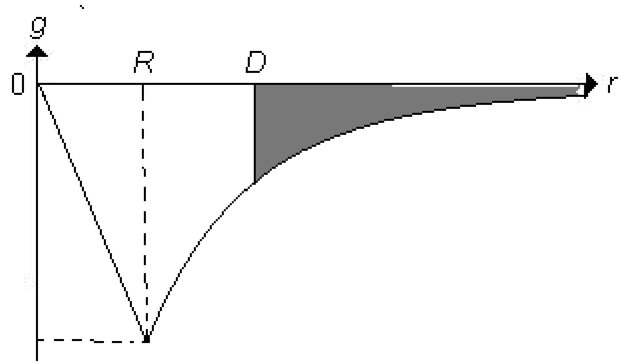
Annotations

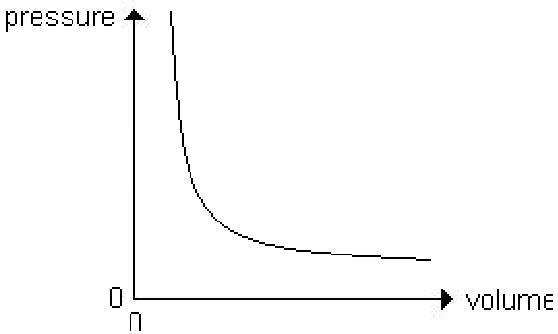
Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response
	Arithmetic error
	Wrong physics or equation

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

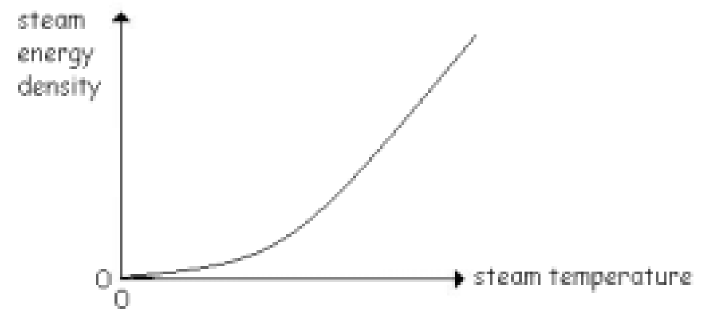
Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential 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

Question			Answer	Marks	Guidance
1	(a)		N m^{-2}	1	
	(b)		N m	1	
2			Some nearby galaxies emit blue-shifted light. [ ] Microwave radiation is detected .... [✓] X-rays from galaxies imply the presence .... [ ] The red-shift of light from most galaxies .... [✓] Most of the visible matter in the Universe ... [ ]	2	correct pattern for [2] one mistake for [1]
3			EITHER half life = 21±1 days = 1.7×10^{6} s to 1.9×10^{6} s; $\lambda = 0.69 / 1.8\times10^{6} = 3.8(2)\times10^{-7}\ \text{s}^{-1}$ OR correct values of A, A_0 and t (in s) from graph; e.g. $\lambda = \dfrac{\ln A_0 - \ln A}{t} = \dfrac{1.69}{50\times8.6\times10^{4}} = 3.9\times10^{-7}\ \text{s}^{-1}$	 1 1	reading of half life in s for [1] evaluation of decay constant for [1] **ecf** on incorrect value of half-life for [1] 20 days gives $4.0\times10^{-7}\ \text{s}^{-1}$, 22 days gives $3.7\times10^{-7}\ \text{s}^{-1}$ **look for** correct powers of ten for A, A_0 **ecf** on incorrect values from graph for [1] **accept** from $3.7\times10^{-7}\ \text{s}^{-1}$ to $4.0\times10^{-7}\ \text{s}^{-1}$ for second method
4			The capacitor gains 180 μJ of energy after 10s. [✓] The voltage across the capacitor is 3.0 V after 10s. [ ] The current in the resistor is a constant 60 μA [ ] The capacitor becomes fully charged after 1.0 s [ ] The charges on the plates are equal and opposite. [✓]	2	correct pattern for [2] one mistake for [1]

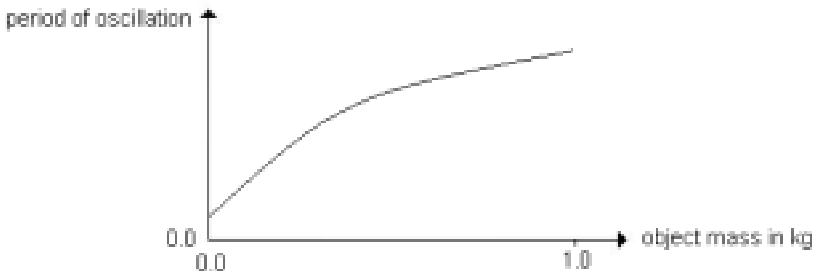
Question			Answer	Marks	Guidance
5	(a)		EITHER use of area under graph; $0.5\times6.0\times21\times10^{-3} = 6.3\times10^{-2}$ J; OR $k = \frac{F}{x} = 2.86\times10^{2}$ N m^{-1}; $E = \frac{1}{2}kx^{2} = 6.3\times10^{-2}$ J;	 1 1	63 J earns [1] for either method **accept** $6.0\times21\times10^{-3} = 1.3\times10^{-1}$ J for [1] **accept** ecf on incorrect computed value of *k*
	(b)		Force not proportional to displacement / extension	1	**accept** spring doesn't obey Hooke's Law **accept** spring goes past its elastic limit **accept** friction / air resistance damps the system **accept** energy lost due to friction / air resistance **ignore** graph not a straight line **ignore** acceleration not proportional to displacement
6	(a)			1	look for any unambiguous indication of correct area
	(b)		The field strength can never be zero.. [ ] The field changes direction at the surface of the sphere. [ ] The field direction is always towards the centre of the sphere. [✓]	1	

Question			Answer	Marks	Guidance
7	(a)		$T = 273 + 36 = 309$ K; $p = \dfrac{nRT}{V} = 2.2{\times}10^5$ Pa;	1 1	**ecf** incorrect T e.g. $T = 36$ K gives $2.5{\times}10^4$ / $2.6{\times}10^4$ Pa [1]
	(b)			2	correct shape for [1] not touching the axes **and** gradient ≤ 0 throughout for [1] **reject** curve which moves away from either axis at their end
8	(a)		$4.1{\times}10^2$ J kg^{-1} K^{-1}	1	**accept** 410
	(b)		some energy required to raise temperature of heater / thermometer (so less transferred to the block)	1	**ignore** effect on value of *c* **ignore** energy loss to the surroundings
9	(a)		3.0	1	**accept** 3
	(b)		$3.0 = \dfrac{1}{\sqrt{1 - \dfrac{v^2}{(3.0\times10^8)^2}}}$; $v = 2.8(3){\times}10^8$ m s^{-1};	2	substition [1], evaluation [1] **accept** substitution of incorrect value of $\gamma = 0.33$ for [1] **ecf** value of incorrect value of γ greater than 1 for [2]
			Total	**22**	

Question			Answer	Marks	Guidance
10	**(a)**		radial lines with arrows to centre of Earth; only four at 90 degrees to each other (by eye)	1 1	arrows do not have to touch surface of Earth, but some of the arrow must be outside shaded region **accept** straight lines drawn by hand
	(b)		substitution into $g = \frac{GM}{r^2}$; $M = 5.99\times10^{24}$ kg	1 1	**accept** 6.0×10^{24} kg, **reject** 6×10^{24} kg
	(c)	**(i)**	centripetal force = gravitational force; ~~mass~~ × acceleration = ~~mass~~ × field strength;	1 1	**accept** $\frac{mv^2}{r} = \frac{GMm}{r^2}$ (or $= mg$) **accept** $\frac{v^2}{r} = \frac{GM}{r^2} \therefore a = g$ where a and g are defined
		(ii)	use of $(g =)\frac{v^2}{r} = \frac{GM}{r^2}$; substitution (even after incorrect rearrangement); $v = 1.0(3)\times10^3$ m s^{-1}	1 1 1	**ignore** calculation based on e.g. 28 day period **ecf** use of g = 9.8 m s^{-2} gives 6.1×10^4 m s^{-1} for [1] **accept** 1×10^3 m s^{-1}
	(d)		(reflect) pulse of (light / radio / microwave) radiation from Moon; measure pulse-echo time; orbit radius = $\frac{\text{pulse} - \text{echo time}}{2} \times \text{speed of light}$;	3	**accept** radar pulse **look for** reflect a pulse, not just a wave **accept** time for wave to return **ignore** references to Earth radius correction QWC: award 3rd mark for clear statement of calculation (**accept** symbol equation e.g 2d = ct with definition of d and t)
			Total	**12**	

Question			Answer	Marks	Guidance
11	(a)	(i)	any two of the following, for [1] each: • $e^{-\varepsilon/kT}$ is Boltzmann factor • BF is the chance / probability / proportion / fraction of particles in liquid getting extra energy (ε) • through (random) collisions with other particles (and be able to leave the liquid)	2	BF in words or algebra **accept** particles able to leave liquid / become steam
		(ii)	use of ideal gas equation e.g. $N = \frac{pV}{kT}$ or $p = \frac{NkT}{V}$ substitute into $N \propto e^{-\varepsilon/kT}$ and manipulate to final formula;	1 1	**accept** use of $pV = nRT$ and $N = nN_A$ **reject** use of $N = e^{-\varepsilon/kT}$ **ignore** disappearance of constants e.g. V and k **accept** constant C absorbing other constants without becoming e.g. C'
	(b)		any three of the following, for [1] each: • (frequent) collisions with other particles • energy transfer at each collision • energy change at each collison is random • average energy of a particle (over time) is constant	3	QWC: award third mark if a clear explanation is provided **accept** kT as average energy of particle
	(c)	(i)	6.6×10^{7} J m^{-3}	1	
		(ii)		1	starts off at origin and gradient increases with increasing temperature (then becomes constant) **reject** straight line through origin
			Total	**9**	

Question			Answer	Marks	Guidance
12	**(a)**	**(i)**	any three of the following, [1] each: • total momentum of rocket + fuel is constant; • fuel gains downwards momentum; • so rocket gains upwards momentum; • so (upwards) momentum of rocket increases with time;	3	**not just** momentum is conserved **ignore** references to action or reaction forces
		(ii)	use of $F = dp/dt$; 2.6×10^{3} m s $^{-1}$;	1 1	
		(iii)	gradient of graph is acceleration; so acceleration increases with increasing time; because rocket mass/weight decreases as fuel ejected;	1 1 1	**accept** *g* decreases with increasing height **ignore** references to air resistance, thrust**,** gravitational force
	(b)		EITHER particles bouncing off top of chamber exert upwards force; particles don't bounce off bottom so no downwards force; OR particles bouncing off top of chamber transfer upwards momentum to it; particles don't bounce off bottom so no downwards momentum transfer to chamber;	1 1	**accept** escaping instead of not bouncing **ignore** action and reaction forces or bulk properties of gas
			Total	**10**	

Question			Answer	Marks	Guidance
13	(a)		$T_L = -k(e+x)$ and $T_R = k(e - x)$; $F = T_R + T_L = -2kx$; use of $F = ma$ and $F = -2kx$ to obtain final formula;	1 1 1	**accept** correct magnitudes of both tensions **look for** correct addition / subtraction of tensions
	(b)		EITHER use of $T = 2\pi\sqrt{\frac{m}{k}}$; OR use of $f = \frac{1}{T}, \omega = 2\pi f = \sqrt{\frac{k}{m}}$; THEN $m = \frac{2kT^2}{4\pi^2} = 3.0\times10^{-1}$ kg, (so mass of tray is 0.06 kg);	1 1	not just quoting formula, must attempt to rearrange or substitute to earn the mark $k = 2.3$ N m^{-1} gives 0.15 kg for [1] $m = 0.15 \times 2 = 0.30$ kg earns [0], the x2 must be linked with value of k to earn the mark
	(c)			2	any two of these features, for [1] each • gradient positive • and decreasing from left to right • finite period for mass of zero
			Total	**7**	

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

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; 1 Hills Road, Cambridge, CB1 2EU
Registered Company Number: 3484466
OCR is an exempt Charity

OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553

© OCR 2012