OCR
RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE

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

Mark Scheme for June 2011

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 pupils 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.

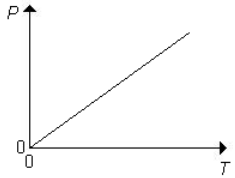
Any enquiries about publications should be addressed to:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

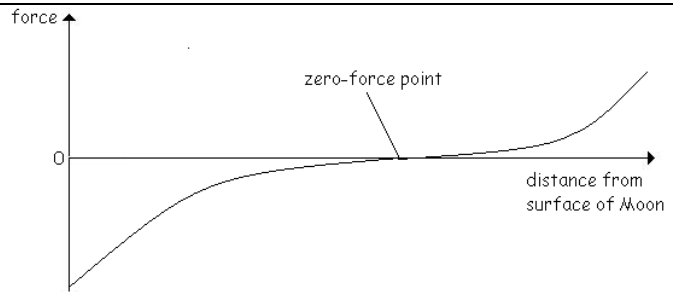
Telephone: 0870 770 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

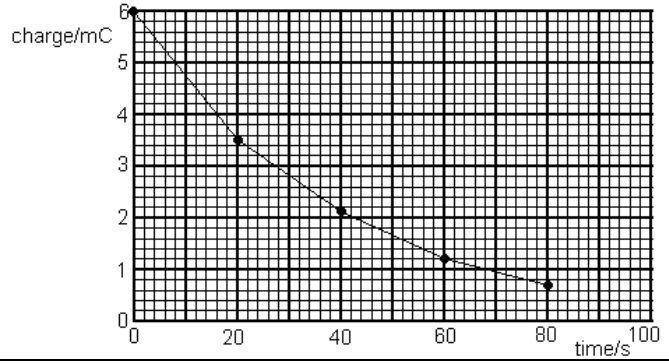
Section A

Question			Expected Answer	Mark	Rationale/Additional Guidance
1	a		N kg^{-1}	1	
	b		J m^{-1}	1	
2	a		$4(.0)\times10^{-19}$	1	**ignore** minus sign
	b		7.5×10^{21}	1	**ecf** incorrect 2a if necessary **look for** at least 2 sig. figs
3				2	correct pattern for [2] one mistake for [1] a mistake is • a tick in the wrong place • a missing tick • an extra tick
4			2.5 × 0.84 (= 2.1); 2.1 / 3.25 = 0.65 m s^{-1};	1 1	**no ecf**
5			lines/equipotentials/surfaces get further apart; (as you go towards the centre)	1	**accept** density of lines decreases
6			$k = \frac{4\pi^2 m}{T^2}$; correct substitution into correct original/transposed formula; $k = 2.8\times10^4$ N m^{-1}	1 1 1	correct transposition of formula [1] correct substitution [1] evaluation [1] **look for** at least 2 sig. figs
7	a		x = **-** 0.1 sin (πt)	1	
	b		0.5 s / 1.5 s / 2.5 s	1	any one for [1] apply list principle
8	a		1.3×10^5 m	1	**look for** at least 2 sig. figs
	b		speed of light towards and away from surface is the same / flight **time** for light is the same in both directions / speed of light in atmosphere almost same as that in free space	1	**look for** wtte **not** just "speed of light is constant" **ignore** references to relativistic effects
	c		pulse-echo time gets shorter (on successive orbits) owtte	1	**accept** echo is blue-shifted / smaller wavelength

Question			Expected Answer	Mark	Rationale/Additional Guidance
9	a		T = 288 K $N = 2.3\times10^{22}$	1 1	ecf: e.g. T = 15 K gives 4.3×10^{23} for [1] **look for** at least 2 sig. figs
	b			1	look for straight line through origin accept freehand lines
			Section A Total	**[20]**	

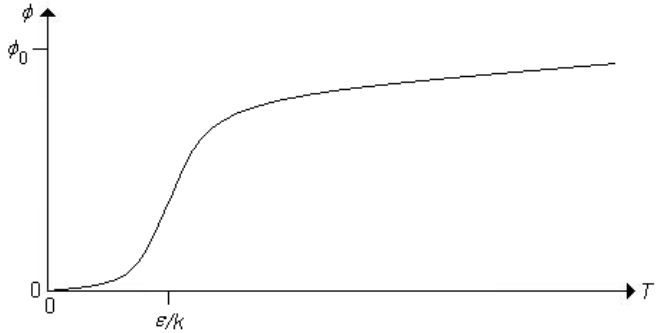
Section B

Question			Expected Answer	Mark	Rationale/Additional Guidance
10	a	i	EITHER $\Delta p = F\Delta t$ = 5.8×10^{6} Ns OR $a = F/m$ = 2.32×10^{4} ms^{-2} THEN $v = p/m$ or at = 2.32×10^{3} m s^{-1}; $E_k = 0.5mv^2$ or $0.5p^2/m$ = 6.728×10^{9} J;	1 1 1	calculation of momentum or acceleration [1] calculation of velocity [1] substitution into KE formula (and evaluation) [1] **ecf** from stage to the next **accept** reverse calculation **accept** 6.728×10^{9} J on its own for [1] **not** 6.73×10^{9}J
	a	ii	$E_p = -\frac{GMm}{r}$ = - $7.29(1)\times10^{9}$ J E_t = 6.73×10^{9} - 7.29×10^{9} = $-5.6(3)\times10^{8}$ J	1 1	calculation of potential energy for [1] – the value must be negative **ecf** incorrect potential <u>energy</u> (not potential)
	b	i	$r = \sqrt{\frac{GMm}{F}}$ or $r^2 = \frac{GMm}{F}$ r = 3.7×10^{7} m	1 1	evidence of correct transposition of formula [1] (r^2 = 1.38×10^{15}) evaluation [1]
		ii		2	correct shape between surface and zero-force point [1] correct shape and sign above zero-force point [1] straight line through both points for [0]
	c		EITHER there is a gravitational force towards the Earth / an attractive gravitational force from the Earth; reduces the deceleration of the object / reduces the decelerating force / does work on the projectile; OR gravitational potential (energy) due to Earth; reduces / lowers GPE of projectile at zero-force point;	2	cause [1] effect [1]
			Total	**[11]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
11	a	i	6(.0) V, 6(.0) mC	1	both for [1]
		ii		2	Ignore point at t = 0. Other four correctly plotted within one square for [2] three or two correctly plotted for [1] **ignore** curve through the points
		iii	EITHER $\ln(\frac{Q}{Q_0}) = -\frac{t}{RC}$ or further rearrangement towards R = ..; substution of any pair of data points and evaluation 3.5 mC gives 37.1 kΩ 2.1 mC gives 38.1 kΩ 1.2 mC gives 37.3 kΩ 0.7 mC gives 37.2 kΩ OR use of gradient of graph or two data points to find current; e.g. $(6.0\times10^{-3} - 3.5\times10^{-3}) / 20 = 1.25\times10^{-4}$ A use of $R = V/I$; e.g. $R = \frac{(6.0+3.5)/2}{1.25\times10^{-4}} = 3.8\times10^{4}\,\Omega$ OR from graph, find time τ for Q to fall to 37% of initial value; use of $\tau = RC$ to find R; OR from graph, find the halving-time $T_{0.5}$;	1 1	method [1] evaluation [1] **accept** reverse calculation into $Q = Q_0e^{-t/RC}$ look for 0.37 × 6.0 = 2.2 mC ...

Question			Expected Answer			Mark	Rationale/Additional Guidance
			use of $T_{0.5} = 0.69RC$ or $\ln 2RC$;				look for $T_{0.5} = 27 \pm 3$ s ...
	b	i	20	3.50	-1.84	2	first value -0.87 correct for [1] remaining three values correct to two sig figs for [1] **no ecf** from incorrect first answer **accept 0.38** in fourth line
			40	1.66	**-0.874 / - 0.87**		
			60	**0.786 / 0.79**	**-0.414 / - 0.42**		
			80	**0.372 / 0.37**			
	b	ii	model assumes constant charge / current / p.d. in time Δt; in practice charge / current / p.d. decreases with time; so calculated ΔQ too large / calculated Q too small;			1 1 1	**accept** constant current / discharge rate in time Δt QWC third mark links model to discrepancy
			Total			**[10]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
12	a	i	arrow to the left, same length	1	arrow can be anywhere on Fig. 12.1
		ii	$\Delta p = mv - (-mv)$ (= $2mv$); total momentum of particle and wall doesn't change;	1 1	justify magnitude for [1] momentum conservation to justify direction for [1] **not** just action and reaction are equal and opposite
		iii	distance travelled between collisions is two diameters AND time between collisions = distance / speed	1	**look for** these two ideas (can be in algebra)
	b	i	$P = \frac{F}{A}$ $F = N \times \frac{mv^2}{2r}$ $P = N \times \frac{mv^2}{2r} \times \frac{1}{2\pi r^2}$ $P = \frac{Nmv^2}{3} \times \frac{3}{4\pi r^3}$ etc.	3	evidence of correct formula for pressure [1] substitution of F (with or without N) and $A = 2\pi r^2$ [1] followed by manipulation to final correct formula [1] Note that if N is inserted into the formulae at the end, without explanation, this loses the 3rd mark. **not** use of $pV = \frac{Nm}{3}\overline{c^2}$
		ii	any three of the following, [1] each: particles can • have different speeds / (kinetic) energy • have different mass • not travel radially (wtte) • interact / collide with each other • have a finite volume • have inelastic collisions (with the walls)	3	**ignore** references to random walks **accept** velocity for speed QWC - third mark can only be earned if all words spelled correctly.
			Total	**[10]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
13	a		EITHER ratio of adjacent values of ϕ constant: 530/920 = 0.58, 920/1500 = 0.61, 1500/2200 = 0.68 OR ratio of adjacent values of ϕ constant: 920/530 = 1.7, 1500/920 = 1.6, 2200/1500 = 1.5 OR difference between adjacent values of lnϕ constant: $\pm$0.55, $\pm$0.49, $\pm$0.38	2	valid test AND condition for exponential variation[1] valid test applied successfully three times [1]
	b	i	(activation) energy to allow a particle to change position within the liquid owtte	1	**not** just activation energy **not** to escape from the liquid **accept** break free (from its neighbours)
		ii	average energy per molecule	1	**accept** particle or atom
		iii		1 1 1	starts at 0 and tending to φ_0 at high T for [1] approx $\varphi_0/3$ at $T = \varepsilon/k$ (use template) for [1] correct shape of curve for [1]
	c		BF / $e^{-\varepsilon/kT}$ increases with increasing temperature; BF is probability that a particle can change position / proportion of particles which can move / fraction of particles which can move;	1 1	**accept** break free (from its neighbours)
			Section B Total	**[9]**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

14 – 19 Qualifications (General)
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