

GCE

Physics B (Advancing Physics)

Advanced GCE

Unit G494: Rise and Fall of the Clockwork Universe

Mark Scheme for January 2011

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.

© OCR 2011

Any enquiries about publications should be addressed to:

OCR Publications PO Box 5050 Annesley NOTTINGHAM NG15 0DL

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

Mark Scheme

January 2011

Qu	estic		Marks	Rationale
1	а	kg m s ⁻²	1	
	b	m s ⁻¹	1	
2			1	
3	а	$V = \frac{Q}{C}$	1	not just $Q = CV$
	b	$I = -\frac{dQ}{dt}$	1	
	С	$\frac{V}{R} = -\frac{dQ}{dt} = \frac{Q}{RC}$	1	look for correct substitution for <i>I</i> into answer for (b) (allow ecf) AND correct substitution for <i>V</i> from (a) (allow ecf) accept final incorrect answer which matches incorrect answers to (a) and (b)
4	а	$\frac{1.1 \times 10^{-2}}{2.9 \times 10^{-2}} \times 6.0 \times 10^{23} = 2.28 \times 10^{23} \text{ or } 2.3 \times 10^{23}$	1	2×10 ²³ particles gives 9.7x10 ⁻³ kg for [1]
	b	$\overline{c^2} = \frac{3\rho V}{Nm};$	1	correct substitution into equation for $\overline{c^2}$, perhaps with $m = 1.1 \times 10^{-2}$ kg or 2.9×10^{-2} kg for [1];
		$m_{air} = \frac{2.9 \times 10^{-2}}{6.0 \times 10^{23}} = 4.83 \times 10^{-26} \text{ kg}$ $\overline{c^2} = 2.5 \times 10^5 \text{ m}^2 \text{ s}^{-2}$ $N = 2 \times 10^{23} \text{ gives } 2.9 \times 10^5 \text{ m}^2 \text{ s}^{-2} \text{ for } [2]$	1	correct evaluation of <i>m</i> and $\overline{c^2}$ for [1] $m_{\text{air}} = 2.9 \times 10^{-2}$ kg gives $4.1(7) \times 10^{-19} / 4.7(5) \times 10^{-19}$ m ² s ² for [1] $m_{\text{air}} = 1.1 \times 10^{-2}$ kg gives $1.1 \times 10^{-18} / 1.2(5) \times 10^{-18}$ m ² s ⁻² for [1]
4	C	mean square speed	1	look for a straight line through the origin line does not have to be drawn with a ruler

Question		n Expected Answers	Marks	Rationale
5	а	(shift of) wavelength of (absorption) lines in spectrum of a galaxy	1	accept wavelength / frequency
5	b	(redshift means) universe is expanding / galaxies are moving away from each other / velocity away us increases with increasing distance;	1	
		therefore universe / galaxies / stars were at the same point far enough back in time;	1	not just closer together in the past
6		C	1	
7	а	16(.43)	1	not 20, 115/7
7	b	7.3×10 ⁻⁸ / 7.5×10 ⁻⁸	1	accept 1.1×10^{-7} from $e/kT = 16$ accept full ecf from (a)
7	C		1	accept any clearly unambiguous correct response
8			1	 look for cosine curve of any constant amplitude correct period correct phase amplitude can change by half a square across the graph maxima and minima within the red lines zero crossings within the green lines
9	а	$E = 0.5 \times 4700 \times 10^{-6} \times 20^2 = 0.9(4) \text{ J}$	1	must see calculated value
9	b	40 W	1	

Question		ion	Expected Answers	Marks	
10	a		force proportional to displacement; force and displacement in opposite directions / force always towards equilibrium position;	1	accept force increases with increasing displacement / distance accept acceleration for force throughout not just restoring force or minus sign accept wtte for equilibrium position e.g. centre, midpoint
10	b	i	$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}} = 26(.39)$	1 1	evidence of correct formulae for [1] e.g $T = 2\pi \sqrt{\frac{m}{k}}, f = \frac{1}{T}$ evidence of correct calculation for [1]
10	b	ii	largest amplitude at 26 / 30 Hz / resonant frequency / natural frequency; amplitude decreases with increasing frequency (above resonance);	1	allow ecf from (b)(i) if within 20 Hz to 50 Hz accept small amplitude away from resonance / 26 Hz / 30 Hz ignore sketch graph, award marks for the accompanying words marks are independent, so second mark can be earned if the response doens't mantion resonance.
10	C		any of the following [1] each, maximum [3] air acts like a spring because: • as volume decreases pressure increases • because <i>pV</i> is constant (= <i>NkT</i>) • more collisions as particles pushed together • increased transfer of momentum to cone from particles • force from particle impacts restores cone to equilibrium position any of the following [1] each, maximum [3] effects on the frequency: • total <i>k</i> increases • spring and air act in parallel • frequency of free oscillations increases • because $f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$ or $f \alpha \sqrt{k}$	4	must have correct technical terms throughout for the fourth mark to be awarded. overall mark cannot exceed [4]

Qu	Question		Expected Answers	Marks	Rationale
11	а		energy Kinetic gravitational potential	4	 one mark for each point, maximum [4]: KE rises from A to D with correct shape KE drops suddenly at D to constant value from D to F GPE drops from A to D with correct shape total energy constant from A to D (by eye) GPE constant from D to F KE is -0.5 GPE (and constant) from D to F use the overlay to help you make judgements vertical part of overlay must pass though D
11		i	$\Delta p = 1.2 \times 10^{3} \times 1.8 \times 10^{3} - 9.5 \times 10^{2} \times 1.5 \times 10^{3}$ $\Delta p = 7.35 \times 10^{5} \text{ Ns}$ $m_{\text{gas}} = 2.5 \times 10^{2} \text{ kg}$ $v = 7.35 \times 10^{5} / 2.5 \times 10^{2} \text{ kg} = 2.9 \times 10^{3} \text{ m s}^{-1}$ $\frac{mv^{2}}{r} = \frac{GMm}{r^{2}}$ cancellation and rearrangement as required	1 1 1 1	correct value of Δp for [1] correct m_{gas} for [1] ecf incorrect Δp , m_{gas} for ecf must have calculated a change of momentum not just separate statement of both forces working to final formula must be clear ignore minus signs
11	С	ii	$r = 1.9(36) \times 10^7 \text{ m}$	1	must have correct rounding to earn mark, but not 2×10^7

Mark Scheme

Qu	Question		Expected Answers	Marks	Rationale
12	а		T = 273 + 20 = 293 K	1	
			$N = \frac{pV}{kT} = 3.17 \times 10^{27} \text{ accept } 3.2 \times 10^{27}$	1	ecf incorrect T: e.g. $T = 20$ K gives 4.6×10^{28} for [1]
12	b		energy per particle $\approx kT$ $\Delta E = 3.2 \times 10^{27} \times 1.4 \times 10^{-23} \times (20 - 5) = 6.7 \times 10^5 \text{ J}$	1	accept anything from kT to 3kT
			$\Delta E = 3.2 \times 10^{-1} \times 1.4 \times 10^{-1} \times (20^{-5}) = 6.7 \times 10^{-5} \text{ J}$ $P = 6.7 \times 10^{5} \text{ / } 3600 = 187 \text{ W or } 190 \text{ W}$	1	3×10 ²⁷ particles gives 175 W 3.17×10 ²⁷ particles gives 185 W
12	С		EITHER particles have more energy / move faster; particles collide more (often) / greater impact force; particles get further apart / occupy a larger volume; reducing density; OR	1 1 1 1	accept increased rate of change of momentum at impact
			assuming ideal gas behaviour; V increase as T increases (at constant p, N); so same number of particles occupy larger volume; reducing density; OR		accept $pV = NkT$ instead of ideal gas behaviour accept volume increases as particle energy increases accept same mass instead of number of particles
			$p = \frac{1}{3}\rho \overline{c^2}$ for ideal gas;		
			particles have more energy;		
			<i>c</i> ² increases with increasing energy; (<i>p</i> constant) so density reduces		

G494

Qu	Question		Expected Answers	Marks	Rationale
13	а	i	probability of decay; of a single nucleon in one second;	1 1	accept proportion of nucleons [1] which decay per second [1] accept muon / electron / particle / nucleus / atom for nucleon accept rate of decay as decays per second
13	а	ii	$0.693/1.5 \times 10^{-6} = 4.6(2) \times 10^5 \text{ s}^{-1}$	1	
13	b	i	three half-lives to reduce to one eighth; $t = 3 \times 1.5 \times 10^{-6} = 4.5 \times 10^{-6} \text{ s};$ $s = 4.5 \times 10^{-6} \times 3.0 \times 10^{8} = 1.35 \times 10^{3} \text{ m};$	1 1 1	accept use of $N = N_0 e^{-\lambda t}$ to find t accept working backwards e.g.: 1.4 km gives 4.67×10^{-6} s [1] $e^{-\lambda t} = 0.116$ [1] 1/0.116 = 8.6 [1] 1.4 km gives 3.11 half-lives for [3]
13	b	ii		1	correct shape (falling with decreasing gradient all the way from 0.0 to 1.4 km) for [1] passing through points for [1] (by eye) use overlay for guidance
13	b	iii	$\gamma = 4/1.35 = 2.96 / 3.0;$ time dilation occurs / muon time runs slower than laboratory time / effective half-life longer for muons / effective half-life now 4.4 µs; γ formula to find $v = 2.8 \times 10^8$ m s ⁻¹ / $v/c = 0.94(1);$	1 1 1	1.4 km gives γ = 2.86 / 2.9

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

