

Physics B (Advancing Physics)

Advanced GCE

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

Mark Scheme for January 2013

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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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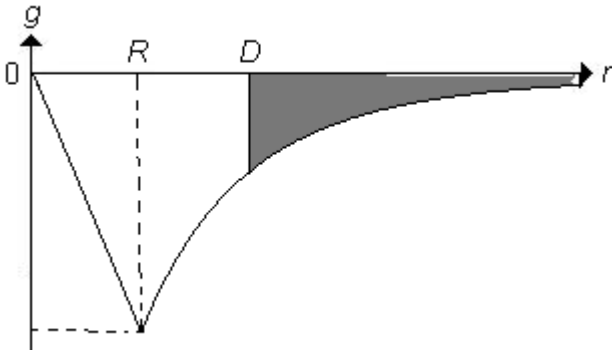
Annotations

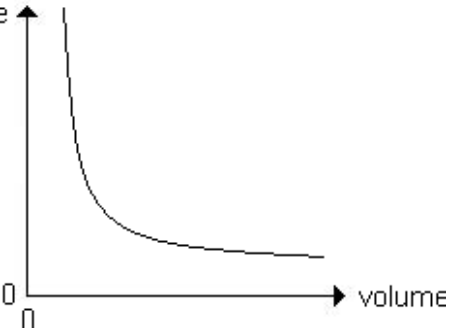
Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response
	Arithmetic error
	Wrong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

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

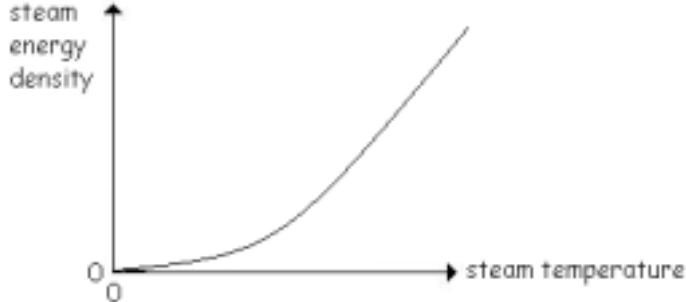
Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential 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; $\lambda = 0.69 / 1.8 \times 10^6 = 3.8(2) \times 10^{-7} \text{ s}^{-1}$ OR correct values of A , A_0 and t (in s) from graph; e.g. $\lambda = \frac{\ln A_0 - \ln A}{t} = \frac{1.69}{50 \times 8.6 \times 10^4} = 3.9 \times 10^{-7} \text{ s}^{-1}$	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 $4.0 \times 10^{-7} \text{ s}^{-1}$, 22 days gives $3.7 \times 10^{-7} \text{ s}^{-1}$ look for correct powers of ten for A , A_0 ecf on incorrect values from graph for [1] accept from $3.7 \times 10^{-7} \text{ s}^{-1}$ to $4.0 \times 10^{-7} \text{ s}^{-1}$ for second method
4		The capacitor gains $180 \mu\text{J}$ of energy after 10s. The voltage across the capacitor is 3.0 V after 10s. The current in the resistor is a constant $60 \mu\text{A}$ 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]

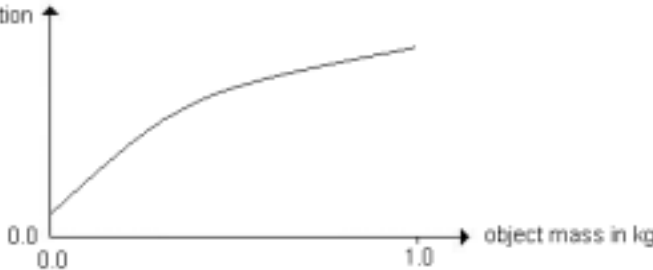
Question		Answer	Marks	Guidance			
5	(a)	EITHER use of area under graph; $0.5 \times 6.0 \times 21 \times 10^{-3} = 6.3 \times 10^{-2} \text{ J};$ OR $k = \frac{F}{x} = 2.86 \times 10^2 \text{ N m}^{-1};$ $E = \frac{1}{2} kx^2 = 6.3 \times 10^{-2} \text{ J};$	1 1	63 J earns [1] for either method accept $6.0 \times 21 \times 10^{-3} = 1.3 \times 10^{-1} \text{ J}$ 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. <table border="1" data-bbox="1064 1173 1164 1375"><tr><td></td></tr><tr><td></td></tr><tr><td>✓</td></tr></table>			✓	1	
✓							

Question			Answer	Marks	Guidance
7	(a)		$T = 273 + 36 = 309 \text{ K};$ $p = \frac{nRT}{V} = 2.2 \times 10^5 \text{ Pa};$	1 1	ecf incorrect T e.g. $T = 36 \text{ K}$ gives $2.5 \times 10^4 / 2.6 \times 10^4 \text{ Pa}$ [1]
	(b)		pressure 	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)		$4.1 \times 10^2 \text{ J kg}^{-1} \text{ K}^{-1}$	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)		$3.0 = \frac{1}{\sqrt{1 - \frac{v^2}{(3.0 \times 10^8)^2}}};$ $v = 2.8(3) \times 10^8 \text{ m s}^{-1};$	2	substitution [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 $g = \frac{GM}{r^2}$; $M = 5.99 \times 10^{24}$ kg	1 1	accept 6.0×10^{24} kg, reject 6×10^{24} kg
	(c)	(i)	centripetal force = gravitational force; ~~mass~~ $\times$ acceleration = ~~mass~~ $\times$ 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); $v = 1.0(3) \times 10^3 \text{ m s}^{-1}$	1 1 1	ignore calculation based on e.g. 28 day period ecf use of $g = 9.8 \text{ m s}^{-2}$ gives $6.1 \times 10^4 \text{ m s}^{-1}$ for [1] accept $1 \times 10^3 \text{ m s}^{-1}$
	(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 3 rd 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 collision 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)	$6.6 \times 10^7 \text{ J m}^{-3}$	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 $F = dp/dt$; $2.6 \times 10^3 \text{ m s}^{-1}$;	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 $m = \frac{2kT^2}{4\pi^2} = 3.0 \times 10^{-1} \text{ kg}$, (so mass of tray is 0.06 kg);	1 1	not just quoting formula, must attempt to rearrange or substitute to earn the mark $k = 2.3 \text{ N m}^{-1}$ gives 0.15 kg for [1] $m = 0.15 \times 2 = 0.30 \text{ kg}$ earns [0], the x2 must be linked with value of k to earn the mark
	(c)	period of oscillation 	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	

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