RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE

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

Mark Scheme for January 2012

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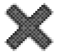
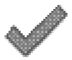
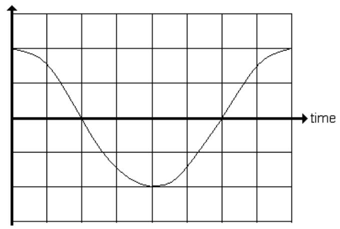
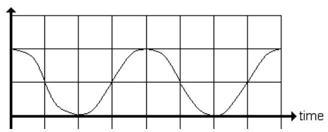
Annotations available in SCORIS

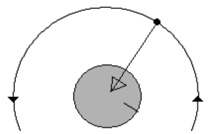
Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response
	Arithmetic error
	Wrong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

Annotations used in detailed mark scheme

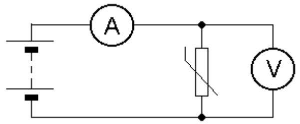
Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential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

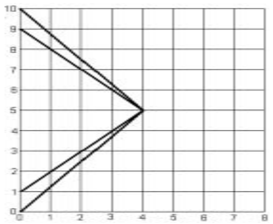
Section A

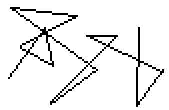
Question			Answer	Marks	Guidance
1	(a)		kg m s^{-1}	1	
	(b)		kg m^2 s^{-2}	1	
2			effect on gas in the box eg • pressure in the box falls (because $p = NkT/V$) • particle density in box falls • fewer particles hitting outside of bag (per second); reason why bag volume increases eg • pressure inside initially greater than outside • more (frequent) collisions from gas inside bag than outside • V rises so that p falls until same as in box; • force pushing bag outwards (from particle collisions) initially greater than force pushing bag inwards	1 1	For a mark to be awarded it must be quite clear which gas they are referring to.
3			 	2	any constant amplitude, across whole time span for both graphs. each correct graph as shown for [1] each **allow** ecf from velocity graph to energy graph if former is incorrect accept full-wave rectified shape instead of correct shape for energy graph overlay provided to show correct phase zero-crossing points, maxima, minimas and amplitudes must be correct within plus or minus half a square

Question			Answer	Marks	Guidance
4	(a)			1	arrow points from satellite to centre of Earth (any length) arrow must touch satellite, but can be from outside arrow tail on or within overlay
	(b)		EITHER force at right angles to velocity / motion OR no distance moved / displacement in direction of force OR no component of force parallel to velocity / motion (ORA)	1	**ignore** references to equipotentials **ignore** work = force $\times$ distance
5			$V_2 = \frac{p_1V_1T_2}{p_2T_1} = \frac{1.0\times10^5 \times 1.4\times10^{-6} \times 320}{5.6\times10^5 \times 280}$; $V_2 = 2.9\times10^{-7}$ m^3	1 1	evidence of use of $\frac{pV}{T} = \text{constant}$ for [1] **reject** $3(.0)\times10^{-7}$ m^3
6	(a)		A	1	
	(b)		C	1	
7	(a)		(red shift different because) one side moves away from us faster than the other side (because of rotation); red shift / wavelength increases for increased (relative) velocity;	1 1	**accept** (red shift different because) one side moves away from us and the other side moves towards us **not** red shift changes as velocity changes **ignore** blue shift **accept** more red shift from side moving away / less red shift from side moving towards
	(b)		makes no difference / light has constant speed (in a vacuum)	1	
8	(a)		$2700 \times 8\times10^{-4} = 2.16$ kg / 2.2 kg	1	
	(b)		temperature difference = 80 K ; $920 \times 2.16 \times 80 = 1.59\times10^5$ J / 1.6×10^5 J	1 1	**accept** 100 - 20 for 80 K 2 kg and 80 K gives 1.47×10^5 J for [2] no ecf on incorrect ΔT (such as 100 or 20)
9			$n = pV/RT$, $n = 2.1\times10^7 \times 2.9\times10^{-2} / 8.3 \times 290 = 253$ mol; mass = $253 \times 4.0\times10^{-3} = 1(.0)$ kg	1 1	**allow** ecf incorrect n in calculating mass for [1]
			Total	**20**	

Question			Answer	Marks	Guidance
10	(a)		$v = 2\pi r/T$	1	**reject** incorrect capitals eg *R, t*
	(b)		$mv^2/r = GMm/r^2$; clear substitution for *v* and manipulation to final formula	1 1	look for evidence of use of both rules for [1] **ignore** minus signs **accept** correct use of $mr\omega^2 = \frac{GMm}{r^2}, \omega = \frac{2\pi}{T}$ etc for [2] no ecf on incorrect (a)
	(c)		$4.2(2)\times10^7$ m	1	**not** 4×10^7 m **accept** $4.2(4)\times10^7$ m
	(d)		$E_g = mV_g$, $V_g = -GM/r$; $E_g = 6.7\times10^{-11} \times 4.7\times10^2 \times 6.0\times10^{24} / 4.2\times10^7$ GPE = -4.5×10^9 J;	 1 2	 evidence use of of both rules for [1] **accept** correct answer without sign for [2] 4×10^7 m gives $-4.7(2)\times10^9$ J for [3] 4×10^7 m gives $4.7(2)\times10^9$ J for [2] **ignore** use of *GPE = mgh* etc
	(e)		KE = $+2.2(6)\times10^9$ J / 2.3×10^9 J; GPE + KE = -2.2×10^9 J	1 1	 **accept** anything from -2.2×10^9 J to -2.5×10^9 J for [2] ecf from incorrect KE or GPE (including sign) eg 4.5×10^{-9} J + 2.3×10^9 J = 6.8×10^9 J 4.7×10^9 J + 2.3×10^9 J = 7.0×10^9 J **accept** correct use of $TE = -\frac{GMm}{2r}$ for [2] final answer must be consistent with answer to (d)
			Total	**9**	

Question			Answer	Marks	Guidance
11	(a)			2	ammeter in series (before or after thermistor) for [1] voltmeter in parallel (left or right of thermistor) for [1] accept voltmeter in parallel with battery look for correct symbols for each mark circuit must be complete to earn any marks **accept** a switch or (variable) resistor in series
	(b)		$G = 1.4\times10^{-3} / 5.6 = 2.5\times10^{-4}$ S	1	
	(c)	(i)	any **three** of the following, [1] each: • BF gives proportion / probability / fraction of electrons with energy ε / able to move; • BF increases with increasing temperature • average energy per particle increases with increasing temperature • energy exchanged between atoms / electrons at random • electrons more likely to / more electrons obtain energy ε as temperature increases • current is flow of free electrons	3	**not** number of electrons award third mark only if there are no spelling mistakes in specialist words (such as conductance, electron, energy ...).
	(c)	(ii)	substitution to find G_0 eg EITHER $2.5\times10^{-4} = G_0 e^{-\frac{5.0\times10^{-20}}{1.4\times10^{-23}\times300}}$ OR $\ln 2.5\times10^{-4} = \ln G_0 - \frac{5.0\times10^{-20}}{1.4\times10^{-23}\times300}$; evaluation of G_0 = 37 S / elimination of G_0 from simultaneous equations; $G = 37e^{-\frac{5.0\times10^{-20}}{1.4\times10^{-23}\times400}} = 4.9\times10^{-3}$ S;	1 1 1	3×10^{-4}S gives 44 S 44 S gives 5.8×10^{-3} S / 5.9×10^{-3} S no ecf on incorrect value of G_0 **ignore** use of $G_0 = 2.5\times10^{-4}$S or 3×10^{-4}S
			Total	**9**	

Question			Answer	Marks	Guidance
12	(a)		constant speed / velocity / motion (for first 5 years)	1	
	(b)	(i)	light goes 1 light-year in 1 year	1	
		(ii)		2	starts at t = 1.0 s and goes up and right at 45° to meet spacecraft trace, returning at 45° to reach Earth at 9.0 s. **accept** straight lines drawn without a ruler **accept** all lines are drawn at 45° for [1]
	(c)	(i)	overall trip time = 9 - 1 (= 8 yr) ; distance = 8 / 2 (= 4 light-year);	1 1	**accept** correct method (such as $d = ct/2$) with no evaluation for [1]
		(ii)	EITHER pulse delayed by 1 yr then takes 4 yr to get to spaceship; so event time = 4 + 1 (= 5 yr); OR light reaches spaceship halfway through its trip; time when it gets there is EITHER (9+1)/2 OR (9-1)/2 + 1 (= 5 yr);	 1 1	**accept** correct method with no evaluation for [1] **accept** 8/2 + 1, but **not** 4 + 1
		(iii)	EITHER $v = \frac{4(\text{light} - \text{year}) \times 3 \times 10^8}{5(\text{year})} (= 2.4 \times 10^8 \text{ m s}^{-1})$ OR $v = \frac{4 \times 365 \times 24 \times 3600 \times 3 \times 10^8}{5 \times 365 \times 24 \times 3600} (= 2.4 \times 10^8 \text{ m s}^{-1})$	1	**accept** reverse calculation to find distance or time **accept** $v = \frac{4 \times c}{5} (= 2.4 \times 10^8 \text{ m s}^{-1})$ for [1]
	(d)	(i)	$\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = 1.\dot{6} = 1.67 = 1.667$ etc.	1	**not** 1.6, 1.7 **not** 1.666 etc. **not** 5/3
		(ii)	6.0	1	
			Total	**11**	

Question			Answer	Marks	Guidance
13	(a)		T = 273 + 17 = 290 K; $kT = 1.4\times10^{-23} \times 290 = 4.06\times10^{-21}$ J / 4.1×10^{-21} J	1 1	conversion from °C to K for [1] 17 K gives 2.4×10^{-22} J for [1] $E = 3/2\ kT$ gives 6.09×10^{-21} J for [2] allow ecf for incorrect T
	(b)		$m = 0.16 / 6.0\times10^{23} = 2.6(7)\times10^{-25}$ kg; EITHER $E_k = \frac{1}{2}mv^2$, $v = \sqrt{\frac{2E}{m}}$; 1.7×10^2 m s^{-1}; OR $pV = NkT = \frac{Nm\overline{c^2}}{3}, \overline{c^2} = \frac{3kT}{m}$ 2.1×10^2 m s^{-1};	1 1 1	calculation of mass of a single molecule for [1] **allow** ecf on incorrect m, including 0.61 kg **allow** ecf on incorrect E from (a) 5×10^{-21} J gives 1.9×10^2 m s^{-1} 6.09×10^{-21} J gives 2.1×10^2 m s^{-1}; $kT = 5\times10^{-21}$ J gives 2.4×10^2 m s^{-1} by second method
	(c)	(i)	description of random walk eg • path is a string of straight lines with varying length and direction; reasons for random walk • bromine molecules collide with air molecules; • (random) change of direction/velocity on each collision;	1 1 1	**ignore** use of 'random' or 'walk' in description accept a diagram for [1] eg  QWC: third mark only awarded for complete description and explanation
		(ii)	EITHER average speed (and separation) of molecules constant OR average distance between collisions constant; (number of collisions) N proportional to (elapsed time) t; $x \propto \sqrt{N}$ and $N \propto t$, so $x = C\sqrt{t}$;	 1 1 1	award [1] for each clear and correct step in argument,
			Total	**11**	

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