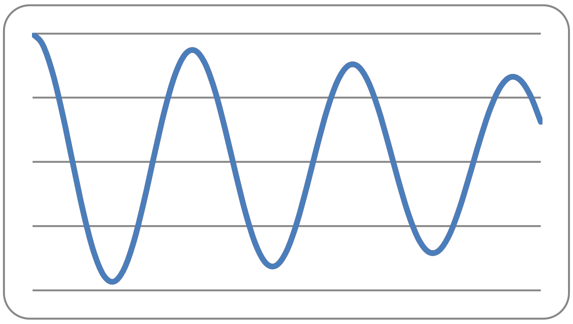
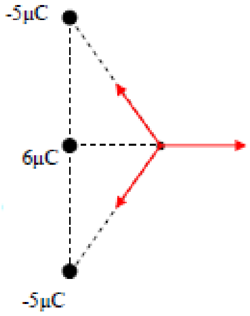
GCE Physics - PH4

January 2013 - Markscheme

Question			Marking details	Marks Available
1	*(a)*	(i)	$T = \frac{1}{f} = 1.6$ **or** $\omega^2 = \frac{k}{m}$ (1) algebra i.e. $m = \frac{T^2 k}{4\pi^2}$ **or** $\omega = 2\pi f$ (1) $m = \frac{1.6^2 \times 2640}{4\pi^2}$ (1) = [171 kg]	[3]
		(ii)	$\frac{1}{2}mv^2 = 2150$ (1) v = 5.01 [m s^{-1}] (1) **ecf** on m	[2]
		(iii)	2.15 [kJ] (1) conservation of energy stated or implied / **all** KE transferred to PE (1) (accept energy cannot be created or destroyed)	[2]
		(iv)	$v = \omega A$ (1) or suitable alternative A = 1.28 [m] (1) **ecf**	[2]
		(v)	$x = \pm A\sin(2\pi ft)$ (1) For 1st mark ω must be substituted. $a = -\omega^2 x$ used **(1)** 13.9 [m s^{-2}] (1) **ecf**	[3]
	(b)		Resonance / maximum amplitude (1) since natural frequency / $\frac{1}{0.625} = 1.6$ (1)	[2]

Question			**Marking details**	**Marks Available**
	(c)		Basic shape (decreasing to 1.4 m with a cos or –cos shape) (1) period = 1.6 s (accept 1.5 – 1.7 s) (1) period constant (1) 	[3]
			Question 1 total	**[17]**
2	*(a)*		$\frac{1}{2}m\overline{c^2}$ **KE of a particle**/atom/molecule	[1]
			$\frac{3}{2}\,nRT$ internal energy (accept total KE)	[1]
	(b)	(i)	$N_A \times \frac{1}{2}m\overline{c^2} = \frac{3}{2} \times 1 \times RT$ (1) (or equivalent) e.g. $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ $\overline{c^2} = \frac{3RT}{mN_A}$ (1) (i.e. algebra) rms speed = 1350 [m s^{-1}] (1)	[3]
		(ii)	$p = \frac{1}{3}\rho\overline{c^2}$ (1) $p = 1.16\text{x}10^5$ Pa / Nm^{-2} (1) **ecf** **UNIT mark** Or suitable alternative method	[2]
			Question 2 total	**[7]**

Question			Marking details	Marks Available
3	*(a)*		The [vector] sum of the momenta [of bodies in a system] stays constant [even if forces act between the bodies], (1) provided there is no external [resultant] force. (1)	[2]
	(b)	(i)	$1.78\text{x}10^{-25}$ x u = $5.62\text{x}10^{5}$ x $1.71\text{x}10^{-25}$ ± $1.36\text{x}10^{7}$ x $6.64\text{x}10^{-27}$ (1) i.e. attempt at conservation of momentum u = {$5.62\text{x}10^{5}$ x $1.71\text{x}10^{-25}$ - $1.36\text{x}10^{7}$ x $6.64\text{x}10^{-27}$ }/$1.78\text{x}10^{-25}$ i.e. correct algebra and sign (1) u = 32 600 [m s^{-1}] (1)	[3]
		(ii)	$E = \frac{hc}{\lambda}$ {or E = hf and c = f λ} (1) Algebra and $p = \frac{h}{\lambda}$ (1) (Use of both $E = mc^2$ and $p = mc$ award 1 mark only.)	[2]
		(iii)	$p = \frac{E}{c}$ attempted (1) $5.62\ \text{x}10^{5}$ x $1.71\ \text{x}10^{-25}$ used as a denominator (1) $\frac{6.93\times10^{-22}}{5.62\text{x}10^{5}\ \text{x}\ 1.71\text{x}10^{-25}} \times 100 = 0.72\%$ (1) (accept: $4.5\ \text{x}\ 10^{18}\%$)	[3]
			Question 3 Total	**[10]**

Question			Marking details	Marks Available
4	*(a)*		horizontal arrow to right at P (1) both other arrows correct direction (1) 	[2]
	(b)		$E = \frac{Q}{4\pi\varepsilon_0 r^2}$ used (1) e.g. $\frac{6\times9\times10^9}{3^2}$ E = 6 000 N C^{-1} (1) **UNIT mark**	[2]
	(c)		$E = \frac{Q}{4\pi\varepsilon_0 r^2}$ used for negative charge (1) (answer = 1 800) e.g. $\frac{5\times9\times10^9}{5^2}$ but not $\frac{5\times9\times10^9}{3^2}$ x 2 and x cosθ (1) [= 2 160] resultant = 3 840 [N C^{-1}] [to the right] (1) **ecf** on arrows	[3]
	(d)	(i)	correct equation used (1) e.g. $\frac{5\times9\times10^9}{5}$ Attempt at adding 3 potentials (1) e.g. $\frac{(6-5-5)\times9\times10^9}{5}$ $\frac{1}{4\pi\varepsilon_0}\left\{\frac{6}{3}-\frac{5}{5}-\frac{5}{5}\right\}$ (1) or equivalent obviously giving zero	[3]
		(ii)	(Energy) **-** final total energy must be zero or final potential is also zero (1) (any implied dissipation of energy loses this mark) Initially (resultant) <u>force</u> / <u>field</u> is to the right (1) Then (resultant) force / field is to the left or deceleration (1)	[3]
			Question 4 Total	**[13]**

Question			**Marking details**	**Marks Available**
5	*(a)*		$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ used (1) $\Delta\lambda = \frac{9.4x10^5}{3x10^8} x656 = 2.06\,[\text{nm}]$ (1) $\Delta\lambda = \frac{6.6x10^5}{3x10^8} x656 = 1.44\,[\text{nm}]$ (1)	[3]
	(b)		$F = \frac{GMm}{r^2}$ used **<u>or</u>** $g = \frac{GM}{r^2}$ (1) $F = 2.37 \text{ x } 10^{-11}$ [N] (1)	[2]
	(c)	(i)	$\frac{mv^2}{r} = \frac{GMm}{r^2}$ (1) convincing algebra (1)	[2]
		(ii)	$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{6.67\times10^{-11}8\times10^{39}}{1.5\times10^{20}}}$ **<u>or</u>** calculating M using v (1st mark algebra) (1) $v = 60\,000\,[\text{m s}^{-1}]$ **<u>or</u>** $M = 4.4 \text{ x } 10^{40}$ or $G = 3.675 \text{ x } 10^{-10}$ (1) Comment: (1) allow **ecf** If v - suggests dark matter since actual v is greater If M – yes If G – yes because larger G or stronger gravity	[3]
			Question 5 Total	**[10]**

Question			**Marking details**	**Marks Available**
6	*(a)*		period = 44 [days] ± 2 days (1) correct conversion to seconds (allow **ecf**) (1) (= 3.83x10^6 s)	[2]
	(b)		$v = \frac{2\pi r}{T}$ or equivalent e.g. $v = \omega r \quad and \quad \omega = \frac{2\pi}{T}$ (1) $r = \frac{vT}{2\pi} = \frac{18xa}{2\pi}$ (1) (=1.097 x 10^7) **ecf** on *T*	[2]
	(c)		$d^3 = \frac{T^2 G(M_1+M_2)}{4\pi^2}$ i.e. algebra nearly complete (1) $(M_1 + M_2) \approx M_1$ either written or worded (1) *d* = 3.6x10^{10} [m] (1) **ecf**	[3]
	(d)		Values substituted correctly into a correct equation (1) M_2 = 5.9x10^{26} [kg] (1) **ecf** on *d* and *r* i.e. 100 times / [much] larger than the Earth (1) (allow **ecf** on *M*)	[3]
			Question 6 Total	**[10]**

<table>
<tr><th colspan="3">Question</th><th>Marking details</th><th>Marks Available</th></tr>
<tr><td>7</td><td>*(a)*</td><td></td><td>$T = \frac{pV}{nR}$ or implied (1)
$T = \frac{84000\times2}{49.3\times8.31}$ = 410 [K] **and** $T = \frac{104000\times1.2}{49.3\times8.31}$ = 305 [K] (1)</td><td>[2]</td></tr>
<tr><td></td><td>*(b)*</td><td>(i)</td><td>U = 190 [kJ] allow **ecf**</td><td>[1]</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>U = 250 [kJ] allow **ecf**</td><td>[1]</td></tr>
<tr><td></td><td>*(c)*</td><td></td><td>no area under graph or no change in volume</td><td>[1]</td></tr>
<tr><td></td><td>*(d)*</td><td></td><td>temp constant / internal energy only depends on temperature /
because they are isotherms</td><td>[1]</td></tr>
<tr><td></td><td>*(e)*</td><td>(i)</td><td>A **clear** valid method (remember **show that...**) e.g. trapezium (1)
(counting squares ok)
DA= $\frac{1}{2}$(140 000 + 84 000) x 0.8 = 89.6 [kJ] (1)
or better $\frac{1}{2}$(140 000 + 105 000) x 0.4 (no penalty for mysterious -ve sign or +ve sign) + $\frac{1}{2}$(105 000 + 84 000) x 0.4 = $\pm$ 86.8 [kJ]</td><td>[2]</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>BC = $\frac{1}{2}$(104 000 + 64 000) x 0.8 = 67.2 [kJ] (1)
or better $\frac{1}{2}$(104 000 + 78 000) x 0.4 (sign penalised here!)
$\frac{1}{2}$(78 000 + 64 000) x 0.4 = 64.8 [kJ]</td><td>[1]</td></tr>
<tr><td></td><td>*(f)*</td><td></td><td>**Allow ecf**
<table>
<tr><th></th><th>AB</th><th>BC</th><th>CD</th><th>DA</th><th>ABCDA</th></tr>
<tr><td>W</td><td>0</td><td>67[kJ]</td><td>0</td><td>-90 kJ</td><td>-23[kJ]</td></tr>
<tr><td>ΔU</td><td>-60 [kJ]</td><td>0</td><td>60 [kJ]</td><td>0</td><td>0</td></tr>
<tr><td>Q</td><td>-60 [kJ]</td><td>67[kJ]</td><td>60 [kJ]</td><td>-90 kJ</td><td>-23[kJ]</td></tr>
<tr><td></td><td>(1)</td><td>(1)</td><td>(1)</td><td></td><td>(1)</td></tr>
</table></td><td>[4]</td></tr>
<tr><td></td><td></td><td></td><td>**Question 7 Total**</td><td>**[13]**</td></tr>
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