GCE Physics - PH4

Question			Marking details	Marks Available
1.	*(a)*		Curve for 1st step and line for 2nd step (1) Direction on **both** steps (1) Labelling of state C (1)	3
	(b)	(i)	$V_A = \frac{(0.06)(8.31)(250)}{(8.5\times10^4)} = 1.47\times10^{-3}[\text{m}^3]$	1
		(ii)	$V_B = \frac{(0.06)(8.31)(355)}{(8.5\times10^4)} = 2.08\times10^{-3}[\text{m}^3]$	1
		(iii)	$V_C = \frac{(0.06)(8.31)(355)}{(7.0\times10^4)} = 2.53\times10^{-3}[\text{m}^3]$ (alternatively use $\frac{V_B}{V_A} = \frac{T_B}{T_A}$ and $\frac{V_C}{V_B} = \frac{P_B}{P_C}$ allowing **ecf**)	1
	(c)	(i)	Work done = $p\Delta V = (8.5\times10^4)(2.08-1.47)\times10^{-3} \cong 52$ [J] **ecf** Convincing, correct method.	1
		(ii)	Work done = $-\frac{1}{2}(8.5+7.0)\times10^4(2.53-1.47)\times10^{-3} \cong -82$ [J] **ecf** 1 for: Evidence for "finding area". 1 for: Convincing algebra.	2
	(d)		1 for: **Remaining block** in column 1: C to A = -79 1 for: **All** of column 3: A to B = +131; B to C = +34; C to A = -161	2
			Question 1 Total	**[11]**

Questions			Marking details	Marks Available
2.	*(a)*		$m = \rho V = 10^3\left(1.7\times10^{-3}\right) = 1.7$ [kg]	1
	(b)		**All** points plotted correctly (± half small square division) and straight line (1) Sensible scales on **both** axes (1)	2
	(c)		20 ± 1 [°C]	1
	(d)		3.20 ± 0.05 [min] (or 192 ± 3 s)	1
	(e)		Heat supplied to water in e.g. 2.5 min (Q) $= \left(3\times10^3\right)\left(2.5\times60\right) = 4.5\times10^5$ [J] (1) e.g. $\Delta\theta = 95.5 - 32.5 = 63$ [°C] (1) (or equivalent for second and third marks provided consistent for substitution that follows) Rearranging formula for $c = \dfrac{Q}{m\Delta\theta}$ Substitution of values and result (1) $c = \dfrac{4.5\times10^5}{(1.7)(63)} = 4.2\times10^3$ [J kg^{-1} °C^{-1}] $\quad \left(\pm 0.1\times10^3\right)$	3
	(f)	(i)	[All] temperature measurements lower [because heat taken by container (heat lost) i.e. some reference to heat going elsewhere or lost] (1)	3
		(ii)	Gradient of graph shallower or $\Delta\theta$ smaller (1)	
		(iii)	c larger (overestimated) (1) No **ecf** within this question part.	
			Question 2 Total	**[11]**

Question			Marking details	Marks Available
3.	*(a)*		Rearranging Hooke's Law $k = \frac{F}{e} = \frac{mg}{e}$ (1) Substitution and correct result with **UNIT** $\frac{(2000)(9.81)}{(0.15)} = 1.31\times10^5$ N m^{-1} (1)	2
	(b)	(i)	$e = \frac{(75+85)g}{(1.31\times10^5)} = 0.012$ [m] = 1.2 [cm] (allow **ecf** for *k*). Correct method. (1) Correct result. (1)	2
		(ii)	$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{2160}{1.31\times10^5}} = 0.81$[s] Substitution into formula. (1) Correct result.(1) Award 2 marks for answer of 0.78 [s]	2
		(iii)	Natural frequency of system is $\frac{1}{0.81} \cong 1.24$ [Hz]; the frequency of driving force is essentially equal to this; so resonance occurs. (1) (need all three points) Accept 1.28 [Hz]. Amplitude of oscillation becomes large/maximum (1)	2
	(c)		Any 3x(1): - return ***quickly*** to equilibrium - critical damping - avoid resonance / large amplitude - reduce oscillations - dissipating energy Accept: - comfortable ride - braking better on rough surfaces	3
			Question 3 Total	**[11]**

Question			Marking details	Marks Available
4.	*(a)*	(i)	$\omega = \frac{45(2\pi)}{60} = 4.71$ [rad s^{-1}] Conversion from rotations to radians, with the '45'. (1) Conversion from minutes to seconds and convincing working. (1)	2
		(ii)	$velocity = \omega r = (4.71)(0.08) = 0.38$ [m s^{-1}] Formula and substitution. (1) Result. (1)	2
		(iii)	$acceleration = \omega^2 r = (4.71)^2(0.08) = 1.77$ [m s^{-2}] Formula and substitution. (1) Result (1)	2
		(iv)	Towards point Q, or towards centre of circle.	1
	(b)	(i)	$A = 0.080$ [m]	1
		(ii)	$T = \frac{2\pi}{\omega} = \frac{2\pi}{4.71} = 1.33$[s]	1
		(iii)	$a = -1.77\sin(4.71 \times 0.20) = -1.43$ [m s^{-2}] Substitution of time (1). Result with minus sign (1)	2
		(iv)	A body moves with SHM if its acceleration - is directly proportional to its displacement from a fixed point - is always directed towards that [fixed] point 1 for: each statement	2
		(v)	$a = -\omega^2 A\sin(\omega t)$; $x = A\sin\omega t$ so substitution gives: $a = -\omega^2 x$ convincing manipulation. (1) final expression linking to SHM.(1)	2
	(c)		$x = 0.06\sin\left(4.71t - \frac{\pi}{2}\right)$. 1 for: each correct parameter inserted.	3
			Question 4 total	**[18]**

Question			Marking details	Marks Available
5.	*(a)*	(i)	The [vector] sum of the momenta of bodies [in a system] stays constant [even if forces act between the bodies] provided there is no external [resultant] force.	2
		(ii)	Idea of conservation of momentum i.e. expression or statement of $p_i = p_f + m_e v$ (1) No need to specify here that momentum of the hydrogen atom is initially zero. Substitution of values and convincing manipulation. (1) $\frac{6.63\times10^{-34}}{620\times10^{-9}} = -\frac{6.63\times10^{-34}}{620\times10^{-9}} + \left(1.67\times10^{-27}\right)v$ $v = 1.28\,[\text{m s}^{-1}]$	2
		(iii)	$E = hf = \frac{hc}{\lambda} = \frac{\left(6.63\times10^{-34}\right)\left(3\times10^{8}\right)}{620\times10^{-9}} = 3.2\times10^{-19}\,[\text{J}]$	1
	(b)	(i)	Equating momenta, rearranging and substitution (1) $mv = \frac{h}{\lambda}$ $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{\left(1.67\times10^{-27}\right)\left(1.28\right)} = 3.10\times10^{-7}\,[\text{m}]\ (=310\,\text{nm})$ Correct value of wavelength (1) (allow **ecf** if substitution incorrect but calculation consistent)	2
		(ii)	Ultraviolet. **ecf**	1
			Question 5 total	**[8]**

Question			Marking details	Marks Available
6.	*(a)*	(i)	$\frac{F}{m} = -\frac{GM}{r^2} = -\frac{\left(6.67\times10^{-11}\right)\left(1.99\times10^{30}\right)}{\left(1.50\times10^{11}\right)^2} = [-]5.90\times10^{-3}$ N kg^{-1} formula and substitution (1) result with **UNIT** (1).	2
		(ii)	$-\frac{GM}{r} = -\frac{\left(6.67\times10^{-11}\right)\left(1.99\times10^{30}\right)}{\left(1.50\times10^{11}\right)} = -8.85\times10^{8}$ [J kg^{-1}] formula and substitution (1) result with sign (1) **ecf**	2
	(b)	(i)	$r_1 = \left(\frac{M_2}{M_1+M_2}\right)d = \left(\frac{1.90\times10^{27}}{1.99\times10^{30}+1.90\times10^{27}}\right)\left(7.79\times10^{11}\right)$ or with approximation (1) $= 7.43\times10^{8}$ [m] (1). $7.43\times10^{8} > 6.96\times10^{8}$ (so centre of mass outside Sun) (1)	3
		(ii)	use of formula and substitution (1) (or with approximation) $T = 2\pi\sqrt{\frac{d^3}{G\left(M_1+M_2\right)}} =$ result from the substitution (1) $2\pi\sqrt{\frac{\left(7.79\times10^{11}\right)^3}{\left(6.67\times10^{-11}\right)\left(1.99\times10^{30}+1.90\times10^{27}\right)}} = 3.75\times10^{8}$ [s] or with approximation. $\omega = \frac{2\pi}{T} = 1.68\times10^{-8}$ [rad s^{-1}] (allow **ecf**). (1) $speed = \omega r_1 = \left(1.68\times10^{-8}\right)\left(7.43\times10^{8}\right) = 12.5$ [m s^{-1}] (1)	4
			Question 6 Total	**[11]**

Question			Marking details	Marks Available
7.	*(a)*	(i)	$separation = 2(0.75)\sin 10^\circ = 0.26$ [m] Factor 2 (1) Formula with substitution for one string. (1)	2
		(ii)	$F = \frac{1}{4\pi\varepsilon_o}\frac{\left(2.55\times10^{-7}\right)^2}{(0.26)^2} = 8.65\times10^{-3}$ [N] Substitution into formula. (1) Result.(1)	2
		(iii)	Method. $PotentialEnergy = \left(-\frac{1}{4\pi\varepsilon_o}\frac{q}{(0.26)}\right)(-q)$(1) Convincing substitution (1) $= \frac{\left(2.55\times10^{-7}\right)^2}{4\pi\left(8.85\times10^{-12}\right)(0.26)} = 2.25\times10^{-3}$ [J]	2
	(b)	(i)	$F = T\sin 10^\circ$ (1) Rearranging to $T = \frac{F}{\sin 10^\circ}$ (1) Substitution and result. $T = \frac{8.65\times10^{-3}}{\sin 10^\circ} = 0.050$ [N] (1) (allow **ecf** for force).	3
		(ii)	Convincing use of $mg = T\cos 10^\circ$ to obtain $m = 5.0\times10^{-3}$ [kg]	1
			Question 7 Total	**[10]**