

GCE Physics - PH4

Question		Marking details	Marks Available
1.	(a)	Curve for 1 st step <u>and</u> line for 2 nd step (1) Direction on both steps (1) Labelling of state C (1)	3
	(b)	(i) $V_A = \frac{(0.06)(8.31)(250)}{(8.5 \times 10^4)} = 1.47 \times 10^{-3} [\text{m}^3]$	1
		(ii) $V_B = \frac{(0.06)(8.31)(355)}{(8.5 \times 10^4)} = 2.08 \times 10^{-3} [\text{m}^3]$	1
		(iii) $V_C = \frac{(0.06)(8.31)(355)}{(7.0 \times 10^4)} = 2.53 \times 10^{-3} [\text{m}^3]$ (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 = $p\Delta V = (8.5 \times 10^4)(2.08 - 1.47) \times 10^{-3} \cong 52 [\text{J}]$ ecf Convincing, correct method.	1
		(ii) Work done = $-\frac{1}{2}(8.5 + 7.0) \times 10^4 (2.53 - 1.47) \times 10^{-3} \cong -82 [\text{J}]$ 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)	$m = \rho V = 10^3(1.7 \times 10^{-3}) = 1.7 \text{ [kg]}$	1
	(b)	All points plotted correctly (\pm half small square division) and straight line (1) Sensible scales on both axes (1)	2
	(c)	$20 \pm 1 \text{ [}^\circ\text{C]}$	1
	(d)	$3.20 \pm 0.05 \text{ [min]}$ (or $192 \pm 3 \text{ s}$)	1
	(e)	Heat supplied to water in e.g. 2.5 min (Q) $= (3 \times 10^3)(2.5 \times 60) = 4.5 \times 10^5 \text{ [J]}$ (1) e.g. $\Delta\theta = 95.5 - 32.5 = 63 \text{ [}^\circ\text{C]}$ (1) (or equivalent for second and third marks provided consistent for substitution that follows) Rearranging formula for $c = \frac{Q}{m\Delta\theta}$ Substitution of values and result (1) $c = \frac{4.5 \times 10^5}{(1.7)(63)} = 4.2 \times 10^3 \text{ [J kg}^{-1} \text{ }^\circ\text{C}^{-1}]$ ($\pm 0.1 \times 10^3$)	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) (ii) Gradient of graph shallower or $\Delta\theta$ smaller (1) (iii) c larger (overestimated) (1) No ecf within this question part.	3
			Question 2 Total

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 $\frac{(2000)(9.81)}{(0.15)} = 1.31 \times 10^5 \text{ N m}^{-1}$ (1)	2
	(b)	(i) $e = \frac{(75 + 85)g}{(1.31 \times 10^5)} = 0.012 \text{ [m]} = 1.2 \text{ [cm]}$ (allow ecf for k). Correct method. (1) Correct result. (1)	2
		(ii) $T = 2\pi \sqrt{\frac{m}{k}} = 2\pi \sqrt{\frac{2160}{1.31 \times 10^5}} = 0.81 \text{ [s]}$ Substitution into formula. (1) Correct result. (1) Award 2 marks for answer of 0.78 [s]	2
		(iii) Natural frequency of system is $\frac{1}{0.81} \cong 1.24 \text{ [Hz]}$; 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) $\omega = \frac{45(2\pi)}{60} = 4.71 \text{ [rad s}^{-1}\text{]}$ Conversion from rotations to radians, with the '45'. (1) Conversion from minutes to seconds and convincing working. (1)	2
		(ii) $velocity = \omega r = (4.71)(0.08) = 0.38 \text{ [m s}^{-1}\text{]}$ Formula and substitution. (1) Result. (1)	2
		(iii) $acceleration = \omega^2 r = (4.71)^2(0.08) = 1.77 \text{ [m s}^{-2}\text{]}$ Formula and substitution. (1) Result (1)	2
		(iv) Towards point Q, or towards centre of circle.	1
	(b)	(i) $A = 0.080 \text{ [m]}$	1
		(ii) $T = \frac{2\pi}{\omega} = \frac{2\pi}{4.71} = 1.33 \text{ [s]}$	1
		(iii) $a = -1.77 \sin(4.71 \times 0.20) = -1.43 \text{ [m s}^{-2}\text{]}$ 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
	(c)	(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
		$x = 0.06 \sin\left(4.71t - \frac{\pi}{2}\right).$ 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) $\frac{6.63 \times 10^{-34}}{620 \times 10^{-9}} = -\frac{6.63 \times 10^{-34}}{620 \times 10^{-9}} + (1.67 \times 10^{-27})v$ $v = 1.28 \text{ [m s}^{-1}\text{]}$	2
		(iii) $E = hf = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34})(3 \times 10^8)}{620 \times 10^{-9}} = 3.2 \times 10^{-19} \text{ [J]}$	1
	(b)	(i) Equating momenta, rearranging and substitution (1) $mv = \frac{h}{\lambda}$ $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{(1.67 \times 10^{-27})(1.28)} = 3.10 \times 10^{-7} \text{ [m]} (= 310 \text{ nm})$ 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) $\frac{F}{m} = -\frac{GM}{r^2} = -\frac{(6.67 \times 10^{-11})(1.99 \times 10^{30})}{(1.50 \times 10^{11})^2} = [-]5.90 \times 10^{-3} \text{ N kg}^{-1}$ formula and substitution (1) result with UNIT (1).	2
		(ii) $-\frac{GM}{r} = -\frac{(6.67 \times 10^{-11})(1.99 \times 10^{30})}{(1.50 \times 10^{11})} = -8.85 \times 10^8 \text{ [J kg}^{-1}\text{]}$ formula and substitution (1) result with sign (1) ecf	2
	(b)	(i) $r_1 = \left(\frac{M_2}{M_1 + M_2}\right)d = \left(\frac{1.90 \times 10^{27}}{1.99 \times 10^{30} + 1.90 \times 10^{27}}\right)(7.79 \times 10^{11})$ or with approximation (1) $= 7.43 \times 10^8 \text{ [m]} (1)$ $7.43 \times 10^8 > 6.96 \times 10^8$ (so centre of mass outside Sun) (1)	3
		(ii) use of formula and substitution (1) (or with approximation) $T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}} =$ result from the substitution (1) $2\pi \sqrt{\frac{(7.79 \times 10^{11})^3}{(6.67 \times 10^{-11})(1.99 \times 10^{30} + 1.90 \times 10^{27})}} = 3.75 \times 10^8 \text{ [s]}$ or with approximation. $\omega = \frac{2\pi}{T} = 1.68 \times 10^{-8} \text{ [rad s}^{-1}\text{]} (allow \textbf{ecf}). (1)$ $speed = \omega r_1 = (1.68 \times 10^{-8})(7.43 \times 10^8) = 12.5 \text{ [m s}^{-1}\text{]} (1)$	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) $F = \frac{1}{4\pi\epsilon_0} \frac{(2.55 \times 10^{-7})^2}{(0.26)^2} = 8.65 \times 10^{-3}$ [N] Substitution into formula. (1) Result.(1)	2
		(iii) Method. $Potential\ Energy = \left(-\frac{1}{4\pi\epsilon_0} \frac{q}{(0.26)}\right)(-q)(1)$ Convincing substitution (1) $= \frac{(2.55 \times 10^{-7})^2}{4\pi(8.85 \times 10^{-12})(0.26)} = 2.25 \times 10^{-3}$ [J]	2
	(b)	(i) $F = T \sin 10^\circ$ (1) Rearranging to $T = \frac{F}{\sin 10^\circ}$ (1) Substitution and result. $T = \frac{8.65 \times 10^{-3}}{\sin 10^\circ} = 0.050$ [N] (1) (allow ecf for force).	3
		(ii) Convincing use of $mg = T \cos 10^\circ$ to obtain $m = 5.0 \times 10^{-3}$ [kg]	1
Question 7 Total			[10]