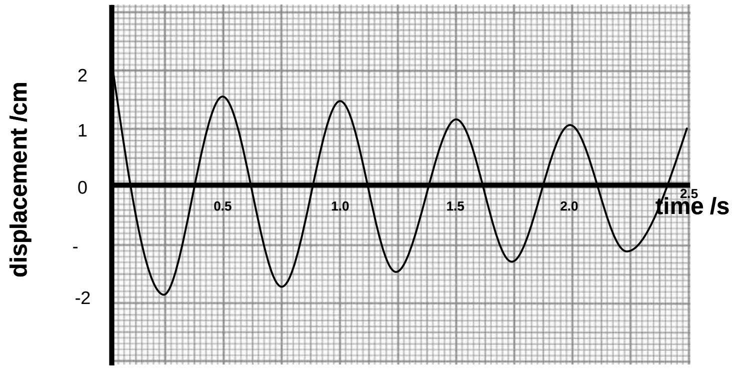
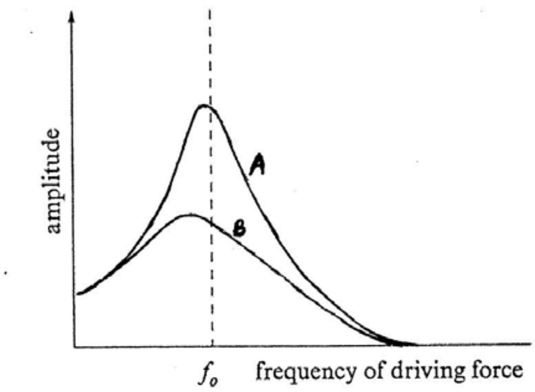
PH4

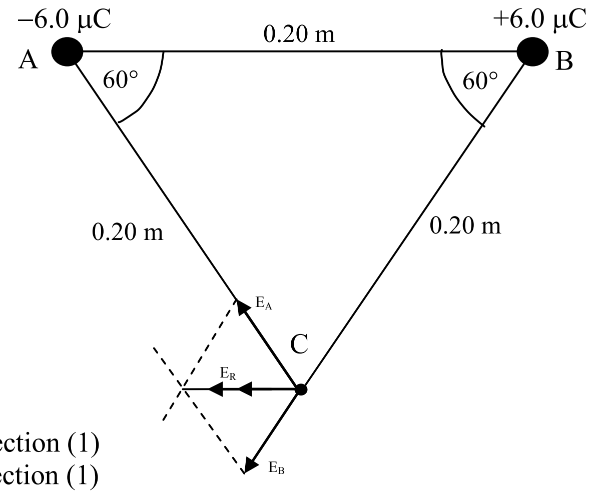
Question			Marking details	Marks Available
1	*(a)*	(i)	Increase (change) in the internal energy [of the system]	1
		(ii)	Heat supplied to (flowing into) [the system]	1
		(iii)	Work done by the system	1
	(b)		$PV = nRT$	
			$T = \frac{PV}{nR}$ (1) $= \frac{(1.01 \text{ x} 10^5)(1.3 \text{ x } 1.00 \text{ x} 10^{-2})}{(0.4)(8.31)}$ $=$ 395 K (1)**unit mark**	2
	(c)	(i)	$(1.01 \text{ x}10^5)(0.3 \text{ x } 1.00 \text{ x}10^{-2})$ = 303 [J] **on gas** (1)	
		(ii)	0 / No work (1)	
		(iii)	$\frac{1}{2}(0.3 \text{ x } 1.00\text{x}10^{-2})(0.2 \text{ x } 1.01\text{x}10^5) + (0.3 \text{ x } 1.00\text{x}10^{-2})(1.01\text{x}10^5)$	
			= 30 + 303	
			= 333 [J] (1) by gas ecf from (c)(i) (1)	4
	(d)		Convincing evidence of multiplication by 3 for the 3 cycles (1)	
			$\Delta U = 0$ (1)	
			$Q = \Delta U + W$ $=$ $0 + 90$ $=$ 90[J] into gas (1) ecf from (c)(iii)	3
			Question 1 total	**[12]**

Question			Marking details	Marks Available
2	*(a)*	(i)	$Ft = \Delta(mv)$ $\therefore$ 3 (0.15) = 0.200 v v = 2.25 [m s^{-1}] Or equivalent but clear method must be shown	1
		(ii)	(0.200) (2.25) = (0.200 + m_B) (1.20) (attempting to use conservation of momentum) (1) $m_B = \dfrac{(0.200)(2.25) - (0.200)(1.20)}{120}$ (1) = 0.175 [kg]	2
		(iii)	KE before collision = $\frac{1}{2}$(0.200) (2.25)^2 = 0.506[J] (1) KE after collision = $\frac{1}{2}$(0.200) (0.15)^2 + $\frac{1}{2}$(0.175) (2.40)^2 = 0.506 [J] (1) KE before collision = KE after collision [so collision is elastic] (1)	3
	(b)	(i)	$E = hf = \dfrac{hc}{\lambda}$ (1) $= \dfrac{6.63x10^{-34}x3x10^{8}}{500x10^{-9}} = 3.98x10^{-19}$ [J] (1)	2
		(ii)	N^o arriving each second = $\dfrac{(1500)\ (100)}{(3.98\ x10^{-19})}$ = 3.77 x10^{23} **allow ecf for *E* from (i)**	1
		(iii)	Momentum of 1 photon $= \dfrac{h}{\lambda} = \dfrac{(6.63x10^{-34})}{(500\ x10^{-9})}$ (1) = 1.33x10^{-27} [kg m s^{-1}] Change of momentum of 1 photon 2 (1) x 1.33x10^{-27} = 2.65x10^{-27} [kg m s^{-1}] Total change of momentum of photon in 1 s = (2.65x10^{-27}) (3.77x10^{23}) = 9.99x10^{-4} [kg m s^{-1}] (1) **Allow ecfs from (b)(i) and (ii)** Force = Change of momentum per second = 9.99x10^{-4} = 1.0x10^{-3}[N] (force on sail is equal and opposite to force on photons)	3
			Question 2 total	**[12]**

Question			Marking details	Marks Available
3	*(a)*		Acceleration α displacement from central (fixed) point (1) is directed towards the central (fixed) point (1)	2
	(b)	(i)	$\omega = \frac{2\pi}{T} = \frac{2\pi}{0.40} = 15.7$ [rad s^{-1}] (1) $v_{max} = \omega A = (15.7)(0.05) = 0.79$ [m s^{-1}] (1)	2
		(ii)	$a_{max} = \omega^2 A$ (1) $= (15.7)^2(0.05) = 12.3$ [m s^{-2}] (1)	2
	(c)		$x = 0.05 \sin\left(15.7t - \frac{\pi}{2}\right)$ [m] 0.05 (1) 15.7 (1) $-\frac{\pi}{2}$ (1) or accept $-90°$	3
	(d)		Loses contact when $a = -g$ (1) $-\omega^2 x = -g$ $x = \frac{9.81}{(15.7)^2} = 0.04$ [m] (1)	2
			Question 3 total	**[11]**

Question			Marking details	Marks Available
4	*(a)*	(i)	 Scales on both axes (1) Period and shape (1) Amplitude (1)	3
		(ii)	e.g. air resistance magnetic damping friction by itself is not enough - needs either reference or implication to air resistance	1
	(b)	(i)	 General shape with label (accept if peak on or just to left of f_o)	1
		(ii)	Smaller values than A with peak not to the right and correct shape	1
		(iii)	At a certain driving frequency there is a maximum (peak) in the amplitude of the oscillating load. At this frequency the system is at resonance.	1
		(iv)	e.g. microwave cooking (1) driving force : by microwave radiation (1) responding oscillator : water molecules (1)	3
			Question 4 Total	**[10]**

Question			Marking details	Marks Available
5	*(a)*	(i)	$PV = n\,RT$ $n = \frac{PV}{RT} = \frac{(3.04 \times 10^5)(0.025)}{(8.31)(280)} = 3.27$[mol]	1
		(ii)	$N = n\,N_A = (3.27)\,(6.02\text{x}10^{23}) = 1.97\text{x}10^{24}$ **allow ecf from (i)**	1
		(iii)	$\rho = \frac{(m_r \text{ x } 10^{-3})n}{V} = \frac{(4\text{x}10^{-3})(3.27)}{0.025} = 0.52$[kg m^{-3}] (1) formula with m_r (1)	2
		(iv)	$P = \frac{1}{3}\rho\overline{c^2}$ $\sqrt{\overline{c^2}} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3(3.04x10^5)}{0.52}} = 1324[ms^{-1}]$ (1) **allow ecf from (iii)** Rearrange equation (1)	2
	(b)	(i)	(Combining of the two given equations to give) $\frac{1}{3}N m\overline{c^2} = nRT$ (1) KE of gas (i.e. of the N molecules) = $\frac{1}{2}Nm\overline{c^2}$ [= number of atoms x $\frac{1}{2}m\overline{c^2}$] (1) (can award for K.E. of one molecule i.e. K.E. = $\frac{1}{2}m\overline{c^2}$ only if it is clearly noted that it is for one molecule) $\therefore$ KE of gas [$\frac{1}{2}Nm\overline{c^2}$] = $\frac{3}{2}nRT$ manipulation mark (1) Internal energy of gas (U) = KE + PE and PE = 0 (for ideal gas) (1) [or internal energy is only the KE] (so $U = \frac{3}{2}n\,RT$)	4
		(ii)	$U = \frac{3}{2}n\,RT = \frac{3}{2}$ (3.27) (8.31) (280) = 11 413 [J]	1
			Question 5 Total	**[11]**

Question			Marking details	Marks Available
6	*(a)*	(i) (ii) (iii)	 E_A – direction (1) E_B – direction (1) E_R – "horizontal" and to the left (1) ecf from (i) & (ii)	1 1 1
	(b)		$E = 2 \dfrac{1}{4\pi\varepsilon_0} \dfrac{6\text{x}10^{-6}}{(0.2)^2} \cos 60°$ $E = 2 \dfrac{1}{4\pi 8.85\text{x}10^{-12}} \dfrac{6\text{x}10^{-6}}{(0.2)^2} \cdot \dfrac{1}{2} = 1.35\text{x}10^6 \text{ N C}^{-1}$ **Substitution of *Q* and *r* (1) factor of 2 (1) answer with unit (1)** **Allow ecf from (a)**	3
	(c)	(i)	$V = -\dfrac{1}{4\pi\varepsilon_0} \dfrac{6\text{x}10^{-6}}{(0.6)}$ (1) $+ \dfrac{1}{4\pi\varepsilon_0} \dfrac{6\text{x}10^{-6}}{(0.4)}$ (1) $= -8.99\text{x}10^4 + 13.49\text{x}10^4$ $= 4.5\text{x}10^4$ [V] (1)	3
		(ii)	$W = q\,\Delta V = (2\text{x}10^{-6})(4.5\text{x}10^4) = 0.09$ [J] (1) **ecf from (c)(i)** formula and substitution (1)	2
		(iii)	$\frac{1}{2} m v^2 = 0.09$ (1) (PE → KE) **allow ecf from (c)(ii)** $v = \sqrt{\dfrac{2\ (0.09)}{5\text{x}10^{-3}}} = 6$ [m s^{-1}] (1)	2
			Question 6 Total	**[13]**

Question			Marking details	Marks Available
7	*(a)*		1. Planets move in elliptical orbits with the Sun at one focus (1) 2. Line joining a planet to the Sun sweeps out equal areas in equal time[intervals]. (1) 3. $r^3 \propto T^2$ r- semi major axis (or accept radius), T- period of orbit (1)	3
	(b)		Consider $\frac{r^3}{T^2}$, For Earth $\frac{(149.6 \text{ x}10^9)^3}{(1.00\text{x}365.25\text{x}24\text{x}60\text{x}60)^2} = 3.36\text{x}10^{18}$ [m^3 s^{-2}] (1) For Jupiter $\frac{(778.6 \text{ x}10^9)^3}{(11.86\text{x}365.25\text{x}24\text{x}60\text{x}60)^2} = 3.37\text{x}10^{18}$ [m^3 s^{-2}] (1) Both essentially **equal** so data consistent with Kepler's third law. (1) (accept answers in other units e.g. m^3 yr^{-2})	3
	(c)		A body moving in a <u>circular motion</u> experiences an <u>acceleration towards</u> the <u>centre</u> of the circle. This is known as centripetal acceleration.	1
	(d)		$\frac{G M_S m}{r^2} = \frac{mv^2}{r}$ (1) m: mass of planet or equivalent method $v^2 = \frac{GM_S}{r}$ also $v = \frac{2\pi r}{T}$ (1) Combine $\left(\frac{2\pi r}{T}\right)^2 = \frac{GM_S}{r}$ (1) $\frac{4\pi^2 r^2}{T^2} = \frac{GM_S}{r}$ $M_s = \frac{4\pi^2}{G} \frac{r^3}{T^2} = \frac{4\pi^2}{(6.67\text{x}10^{-11})} (3.36\text{x}10^{18}) = 2\text{x}10^{30}$ [kg] (1)	4
			Question 7 Total	**[11]**