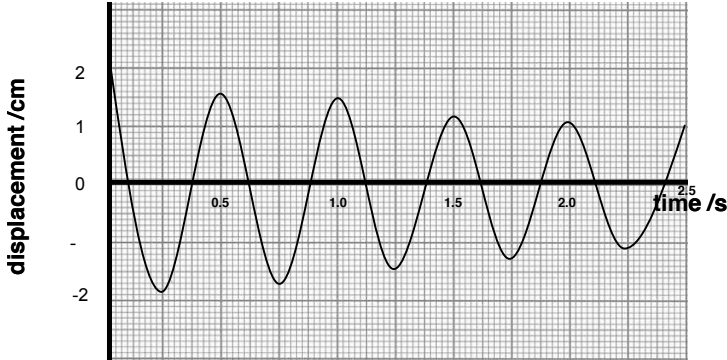
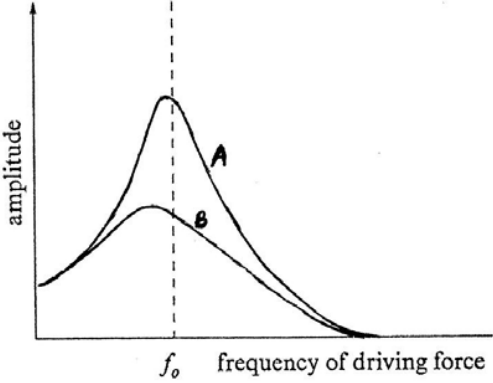


PH4

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)	$PV = nRT$ $T = \frac{PV}{nR} (1) = \frac{(1.01 \times 10^5) (1.3 \times 1.00 \times 10^{-2})}{(0.4) (8.31)} = 395 \text{ K} (1) \text{unit mark}$	2
	(c)	(i) $(1.01 \times 10^5) (0.3 \times 1.00 \times 10^{-2}) = 303 \text{ [J] on gas} (1)$ (ii) 0 / No work (1) (iii) $\frac{1}{2} (0.3 \times 1.00 \times 10^{-2}) (0.2 \times 1.01 \times 10^5) + (0.3 \times 1.00 \times 10^{-2}) (1.01 \times 10^5)$ $= 30 + 303$ $= 333 \text{ [J]} (1) \quad \text{by gas ecf from (c)(i) (1)}$	4
(d)	Convincing evidence of multiplication by 3 for the 3 cycles (1) $\Delta U = 0 (1)$ $Q = \Delta U + W = 0 + 90 = 90 \text{ [J] into gas} (1) \text{ ecf from (c)(iii)}$	3	
		Question 1 total	[12]

Question		Marking details	Marks Available
2	(a)	(i) $Ft = \Delta(mv) \quad \therefore 3(0.15) = 0.200 v \quad v = 2.25 \text{ [m s}^{-1}\text{]}$ 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) $m_B = \frac{(0.200)(2.25) - (0.200)(1.20)}{1.20} \quad (1) = 0.175 \text{ [kg]}$	2
		(iii) KE before collision = $\frac{1}{2}(0.200)(2.25)^2 = 0.506 \text{ [J]} (1)$ KE after collision = $\frac{1}{2}(0.200)(0.15)^2 + \frac{1}{2}(0.175)(2.40)^2 = 0.506 \text{ [J]} (1)$ KE before collision = KE after collision [so collision is elastic] (1)	3
	(b)	(i) $E = hf = \frac{hc}{\lambda} (1) = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{500 \times 10^{-9}} = 3.98 \times 10^{-19} \text{ [J]} (1)$	2
		(ii) $N^\circ \text{ arriving each second} = \frac{(1500)(100)}{(3.98 \times 10^{-19})} = 3.77 \times 10^{23}$ allow ecf for E from (i)	1
		(iii) Momentum of 1 photon $= \frac{h}{\lambda} = \frac{(6.63 \times 10^{-34})}{(500 \times 10^{-9})} (1) = 1.33 \times 10^{-27} \text{ [kg m s}^{-1}\text{]}$ Change of momentum of 1 photon $2(1) \times 1.33 \times 10^{-27} = 2.65 \times 10^{-27} \text{ [kg m s}^{-1}\text{]}$ Total change of momentum of photon in 1 s $= (2.65 \times 10^{-27})(3.77 \times 10^{23}) = 9.99 \times 10^{-4} \text{ [kg m s}^{-1}\text{]} (1)$ Allow ecfs from (b)(i) and (ii) Force = Change of momentum per second = $9.99 \times 10^{-4} = 1.0 \times 10^{-3} \text{ [N]}$ (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) $\omega = \frac{2\pi}{T} = \frac{2\pi}{0.40} = 15.7 \text{ [rad s}^{-1}\text{]} (1)$ $v_{\max} = \omega A = (15.7)(0.05) = 0.79 \text{ [m s}^{-1}\text{]} (1)$ (ii) $a_{\max} = \omega^2 A (1) = (15.7)^2 (0.05) = 12.3 \text{ [m s}^{-2}\text{]} (1)$	2
	(c)	$x = 0.05 \sin\left(15.7t - \frac{\pi}{2}\right) \text{ [m]}$ 0.05 (1) 15.7 (1) $-\frac{\pi}{2}$ (1) or accept -90°	3
	(d)	Loses contact when $a = -g (1)$ $-\omega^2 x = -g$ $x = \frac{9.81}{(15.7)^2} = 0.04 \text{ [m]} (1)$	2
		Question 3 total	[11]

Question		Marking details	Marks Available	
4	(a)	(i)	 <p>Scales on both axes (1) Period and shape (1) Amplitude (1)</p>	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)		1
		(ii)	Smaller values than A with peak not to the right and correct shape	1
		(iii)	At a <u>certain driving frequency</u> there is a <u>maximum (peak)</u> in the <u>amplitude</u> 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) $PV = nRT$ $n = \frac{PV}{RT} = \frac{(3.04 \times 10^5)(0.025)}{(8.31)(280)} = 3.27[\text{mol}]$	1
		(ii) $N = n N_A = (3.27)(6.02 \times 10^{23}) = 1.97 \times 10^{24}$ allow ecf from (i)	1
		(iii) $\rho = \frac{(m_r \times 10^{-3})n}{V} = \frac{(4 \times 10^{-3})(3.27)}{0.025} = 0.52[\text{kg m}^{-3}]$ (1) formula with m_r (1)	2
		(iv) $P = \frac{1}{3} \rho \overline{c^2}$ $\sqrt{\overline{c^2}} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3(3.04 \times 10^5)}{0.52}} = 1324[\text{ms}^{-1}]$ (1) allow ecf from (iii)	2
	(b)	(i) (Combining of the two given equations to give) $\frac{1}{3} N \overline{mc^2} = nRT$ (1) KE of gas (i.e. of the N molecules) = $\frac{1}{2} N \overline{mc^2}$ [= number of atoms x $\frac{1}{2} \overline{mc^2}$] (1) (can award for K.E. of one molecule i.e. K.E. = $\frac{1}{2} \overline{mc^2}$ only if it is clearly noted that it is for one molecule) \therefore KE of gas [$\frac{1}{2} N \overline{mc^2}$] = $\frac{3}{2} nRT$ 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 $U = \frac{3}{2} nRT$)	4
		(ii) $U = \frac{3}{2} nRT = \frac{3}{2} (3.27)(8.31)(280) = 11\,413$ [J]	1
		Question 5 Total	[11]

Question		Marking details	Marks Available	
6	(a)	(i) (ii) (iii)	<p> E_A – direction (1) E_B – direction (1) E_R – “horizontal” and to the left (1) ecf from (i) & (ii) </p>	1 1 1
		(b)	$E = 2 \frac{1}{4\pi\epsilon_0} \frac{6 \times 10^{-6}}{(0.2)^2} \cos 60^\circ$ $E = 2 \frac{1}{4\pi \cdot 8.85 \times 10^{-12}} \frac{6 \times 10^{-6}}{(0.2)^2} \cdot \frac{1}{2} = 1.35 \times 10^6 \text{ N C}^{-1}$ <p> Substitution of Q and r (1) factor of 2 (1) answer with unit (1) Allow ecf from (a) </p>	3
		(c)	(i) $V = -\frac{1}{4\pi\epsilon_0} \frac{6 \times 10^{-6}}{(0.6)} (1) + \frac{1}{4\pi\epsilon_0} \frac{6 \times 10^{-6}}{(0.4)} (1) = -8.99 \times 10^4 + 13.49 \times 10^4$ $= 4.5 \times 10^4 \text{ [V]} (1)$ (ii) $W = q \Delta V = (2 \times 10^{-6}) (4.5 \times 10^4) = 0.09 \text{ [J]} (1) \text{ ecf from (c)(i)}$ <p>formula and substitution (1)</p> (iii) $\frac{1}{2} m v^2 = 0.09 (1) \quad (\text{PE} \rightarrow \text{KE}) \quad \text{allow ecf from (c)(ii)}$ $v = \sqrt{\frac{2(0.09)}{5 \times 10^{-3}}} = 6 \text{ [m s}^{-1}\text{]} (1)$ <p>Question 6 Total</p>	3 2 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 $\frac{(149.6 \times 10^9)^3}{(1.00 \times 365.25 \times 24 \times 60 \times 60)^2} = 3.36 \times 10^{18} \text{ [m}^3 \text{ s}^{-2}\text{]} (1)$ For Jupiter $\frac{(778.6 \times 10^9)^3}{(11.86 \times 365.25 \times 24 \times 60 \times 60)^2} = 3.37 \times 10^{18} \text{ [m}^3 \text{ s}^{-2}\text{]} (1)$ Both essentially equal so data consistent with Kepler's third law. (1) (accept answers in other units e.g. $\text{m}^3 \text{ yr}^{-2}$)	3
	(c)	A body moving in a <u>circular motion</u> experiences an <u>acceleration towards the centre</u> of the circle. This is known as centripetal acceleration.	1
	(d)	$\frac{GM_s m}{r^2} = \frac{mv^2}{r} (1)$ m : mass of planet or equivalent method $v^2 = \frac{GM_s}{r}$ also $v = \frac{2\pi r}{T} (1)$ Combine $\left(\frac{2\pi r}{T}\right)^2 = \frac{GM_s}{r} (1)$ $\frac{4\pi^2 r^2}{T^2} = \frac{GM_s}{r}$ $M_s = \frac{4\pi^2}{G} \frac{r^3}{T^2} = \frac{4\pi^2}{(6.67 \times 10^{-11})} (3.36 \times 10^{18}) = 2 \times 10^{30} \text{ [kg]} (1)$	4
		Question 7 Total	[11]