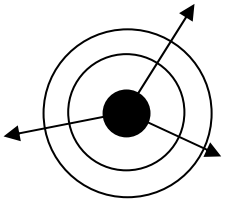
PH4

Question			Marking details	Marks Available
1	(a)		$p = \frac{1}{3}\rho\overline{c^2}$ rearranged e.g. $\overline{c^2} = \frac{3p}{\rho}$ (1) c_{rms} = 514 [m s^{-1}] (1)	2
	(b)	(i)	Mass of particle = $\frac{3.75}{8.06\times10^{22}}$ g (1) [4.63×10^{-26} kg] = 27.9u (1) [so molar mass = 27.9 [g mol^{-1}] [~ 28 g mol^{-1}] **Or:** Amount of gas = $\frac{8.06\times10^{22}}{6.02\times10^{23}}$ mol (1) [= 0.134 mol] So molar mass = $\frac{3.75\,\text{g}}{0.134\ \text{mol}}$ [=28 g mol^{-1}]	2
	(c)	(i)	$p = mv$ used , e.g. $p = 460m$ (1) $p = 2.14 \times 10^{-23}$ kg m s^{-1} / N s ((**UNIT mark**)) (1)	2
		(ii)	$\lambda = \frac{h}{p}$ (1)[manipulation: $p = \frac{h}{\lambda}$ by itself is not enough] [or by impl.] $\lambda = 3.1 \times 10^{-11}$[m] (1) Allow e.c.f.	2
			Question 1 total	**[8]**
2	(a)	(i)	(20.0, 1.00) labelled A and (23.0, 1.00) labelled B	1
		(ii)	(23.0, 0.80) labelled C	1
	(b)	(i)	$n = \frac{pV}{RT}$ (1) [manipulation – or by impl.] = 0.745 [mol] (1)	2
		(ii)	[$N = nN_A$ =] 4.5×10^{23} Allow e.c.f.	1
		(iii)	$T = \frac{pV}{nR}$ [or by impl.]; (or V/T = constant or P/T = constant) T_B = 371 [K] **and** T_C = 297 [K] (1) e.c.f.	2
	(c)		at least two values substituted into $E = mc\Delta\theta$ (1) $\Delta\theta$ = 1.36 [K or °C] (1)	2
	(d)		Area under graph = work or by clear implication (1) detail, e.g. ½ × 0.21×10^5 × 3 × 10^{-3} (1) [square counting ok] 31.5 [J] or 30 [J] (ans) (1)	3
	(e)		$\Delta U = Q - W$ quoted or by clear implication or 1st law quoted (1); and ΔU = 0 (1)	2
			Question 2 total	**[14]**

Question			Marking details	Marks Available
3	(a)		$A = \pi \times 1.8^2$ or implied in numbers (1) Volume per second = $\pi r^2 v$ [or by some method e.g. $m = \rho v$] (1) Mass flow rate = $\pi \times 1.8^2 \times 250 \times 0.4$ [= 1018 kg s^{-1}] (1)	3
	(b)		Thrust = Mass / sec $\times \Delta v$ (1) [or equiv.][i.e. *(a)* $\times \Delta v$] [or by impl.] = 40 [kN] (1)	2
	(c)		Aeroplane momentum is constant (1) [this mark is implied if the candidates imply or state that the exhaust air speed = 250 m s^{-1}] No (overall) change in air momentum (1) **Or** momentum of air forwards (due to drag etc.) (1) is balanced by (momentum of exhaust air backwards (1) **Or** equivalents if candidate states momentum of aeroplane is decreasing (due to small decrease in mass i.e. kerosene loss) e.g. momentum of aeroplane is decreasing <u>due to decreasing mass</u> (1) so overall transfer of momentum to air to the right (1)	2
			Question 3 Total	**[7]**
4	(a)		m_1 Earth's mass (1) m_2 satellite mass (1) r radius of <u>orbit</u> or distance between masses (1) ω angular velocity or angular speed [accept: pulsatance] [of satellite] (1)	4
	(b)		m_2 clearly cancelled and r collected or by implication (1) e.g. $\frac{Gm_1m_2}{r^3} = m_2\omega^2$ $\omega = \frac{2\pi}{T}$ substituted or quoted (1) clear algebra leading to $r = \sqrt[3]{\frac{Gm_1T^2}{4\pi^2}}$ (1) but $r = h + R_E$ (1)	4
	(c)		period of orbit, $T = 24 \times 60 \times 60$ s or 86400 s (1) $h = 35.9 \times 10^6$ m (1)	2
	(d)		$\Delta V = \pm\frac{Gm}{r} \pm \frac{Gm}{r}$ (i.e. attempt at combining potentials) P.E. = $m\Delta V$ used (1) i.e. 850× any change in potential [N.B. $\Delta PE = \pm\frac{Gm}{r} \pm \frac{Gm}{r}$ ✓✓] $\Delta PE = 4.51 \times 10^{10}$ J (**UNIT mark**) (1) Allow e.c.f.	3
			Question 4 Total	**[13]**

Question			Marking details	Marks Available
5	(a)		 concentric rings: minimum 2 (1) arrows out: minimum 2 (1) correct labelling (1)	3
	(b)		field inward [or equivalent e.g. opposite]	1
	(c)		values substituted into $E = \frac{Q}{4\pi\varepsilon_0 r^2}$ (1) [or by impl.]	
			$E = 2.05 \times 10^7$ V m^{-1} or N C^{-1} [or equivalent] ((**UN IT mark**))(1)	2
	(d)	(i)	values substituted into $V = \frac{Q}{4\pi\varepsilon_0 r}$ (1) [or by impl.]	
			$V = 3.24 \times 10^6$ [V] (1)	2
		(ii)	zero	1
	(e)		$\Delta V = 3.24 \times 10^6$ [V] [or by impl.] Allow e.c.f. (1) $\Delta PE = q\Delta V$ (1) $E_k = 7.94$ [J] (1)	3
			Question 5 Total	**[12]**
6	(a)		$f = \frac{1}{T}$ (1); $f = 1.23$ [Hz] (1)	2
	(b)		$\omega = 2\pi f$ or $\frac{2\pi}{T}$ (1) = 2π x 1.23 (allow e.c.f.) or 2π/0.81 = (7.76 rad s^{-1})	2
	(c)		natural frequency (period) close to walking frequency (period) (1) **resonance** occurs (1) which could break (or damage) bridge (1)	3
	(d)		A and ω subbed into $y = A \sin \omega t$ (1) $y = -10.3$cm (1) [N.B. y ~2.0 cm if calculators set to degrees - 1 mark only]	2
	(e)	(i)	$a = \omega^2 x$ or $\omega^2 A \sin \omega t$ (1) $\omega^2 x = 9.81$ m s^{-2} (1) $x = 16.1$ [cm] [16.3 if ω=7.76 rad s^{-1} used] (1)	3
		(ii)	Point indicated at ~ 0.12 s ecf (1) and 2nd point anywhere > 0.28 s (1)	2
			Question 6 Total	**[14]**

Question			Marking details	Marks Available
7	(a)		$\Delta\lambda = 2.50\ [\pm 0.05] \times 10^{-14}$ m (1) $v = \dfrac{\Delta\lambda}{650\times10^{-9}} \times 3.00\times10^{8}$ (1) [= 11.54 m s^{-1} if 2.5×10^{-14} m used]	2
	(b)		period = 12.4 - 2.6 [= 9.8 years] allow 9.8 ± 0.1 years (1) $v = \dfrac{2\pi r}{T}$ or equiv [e.g. $v = \omega r$ and $\omega = \dfrac{2\pi}{T}$](1) radius = 5.68×10^{8} [m] (1) Allow e.c.f on T [$r = 5.90$ x 10^{8} m if $v = 12$ m s^{-1} used]	3
	(c)		$d^3 = \dfrac{T^2 G(M_1 + M_2)}{4\pi^2}$ [i.e. algebra nearly complete] (1) $M_1 + M_2 \approx M_1$ stated [or in words] (1) $d = \sqrt[3]{\dfrac{(9.81\times24\times365\times3600)^2 \times 6.67\times10^{-11}\times2\times10^{31}}{4\pi^2}}$ (1) [= 1.48×10^{12} m] Allow e.c.f.	3
	(d)		$r_1 \approx \dfrac{M_2}{M_1} d$ or similar (1) $M_2 = 7.7 \times 10^{27}$ kg (1) Allow e.c.f.	2
	(e)		The temperature of the planet is greater than that of the Earth [or equiv.] (1) Because of factors of 3000 **and** 10^2 [or $3000/10^2$ seen] (1) [Accept 30 times hotter]	2
			Question 7 Total	**[12]**

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