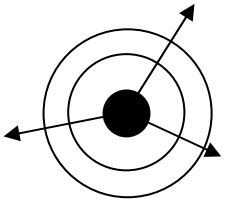
PH4

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 due to decreasing mass (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 orbit 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) $v = \frac{\Delta\lambda}{650\times10^{-9}} \times 3.00\times10^{8}$ (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) $v = \frac{2\pi r}{T}$ or equiv [e.g. $v = \omega r$ and $\omega = \frac{2\pi}{T}$](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)		$d^3 = \frac{T^2 G(M_1 + M_2)}{4\pi^2}$ [i.e. algebra nearly complete] (1) $M_1 + M_2 \approx M_1$ stated [or in words] (1) $d = \sqrt[3]{\frac{(9.81\times24\times365\times3600)^2 \times 6.67\times10^{-11}\times2\times10^{31}}{4\pi^2}}$ (1) [= 1.48×10^{12} m] Allow e.c.f.	3
	(d)		$r_1 \approx \frac{M_2}{M_1} d$ 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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