

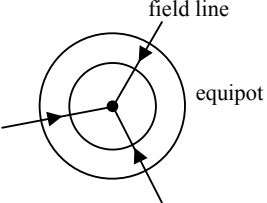
PH4 Mark scheme – January 2011

Question		Marking details	Marks Available
1.	(a)	(i) $pV = \frac{1}{3} N m \overline{c^2}$ or $p = \frac{1}{3} \rho \overline{c^2}$ <u>used</u> . (1) Correct use of N and m or $\rho = 11.0 \text{ kg m}^{-3}$ (1) $c_{r.m.s.} = 286 \text{ m s}^{-1}$ (1)	3
		(ii) $M_r = \frac{1.39 \times 10^{-25}}{1.66 \times 10^{-27}}$ (1) = 84 (1) [or $M_r = m/g \times N_A$] [No unit penalty] [N.B. Alternatives available: 1 mark method; 1 mark answer – factor of 10^3 error → method mark available]	2
		(iii) $pV = nRT$ <u>used</u> (1) $n = \frac{1.7 \times 10^{20}}{6.02 \times 10^{23}}$ (1) [N.B. The mark might be earned in (ii)] $T = 275 \text{ K}$ (1)	3
	(b)	Gets bigger (1) because pressure decreases [and T is ~ constant] (1). [Accept: because it collects dissolved gas(es) or because temperature increases as bubble rises]	2
			[10]
2.	(a)	$\Delta V = 0$ / no change in volume	1
	(b)	Work done = area under graph or by impl. [i.e. area calc attempt] (1) Work done [= [-] $1.5 \times 10^5 \times 4.0 \times 10^{-3}$] = [-] 600 J (1) Minus sign (1) [free-standing mark] [NB Any reasonable method of determining area, including counting squares ✓]	3
	(c)	ΔU : <u>change</u> [or <u>increase</u>] in <u>internal energy</u> of ... (1) Q : <u>heat supplied</u> [“heat in” etc. – direction must be indicated] to (1) W : <u>work done by</u> (1) [NB: not “by or on”] [Subtract 1 mark if “gas” or “system” not mentioned at least once].	3
	(d)	Attempt at area inside the cycle or Area _{BC} – Area _{DA} (1) Area / W [= $0.675 \times 10^5 \times 4.0 \times 10^{-3} - 600$] = - 350 J (1) $\therefore Q = -350 \text{ J}$ (1) [NB final step must be explicit – leaving answer for W doesn't gain the final mark]	3
			[10]

Question		Marking details	Marks Available
3		<p>Sample answer: Microwave oven [although away from central resonance] (1). Driving force: the [e-m fields of the] microwaves (1) Oscillating System: rotation [accept vibration] of <u>water</u> molecules (1) Result: Increased [accept large amplitude] rotational k.e. (1)</p> <p>General scheme: 4 distinct points needed → 4 × (1) Diagram / statement of application [e.g. bridge, car rattle...] ✓ Description of plausible oscillating driving force ✓ Description of plausible system ✓ Large <u>amplitude</u> because of same frequency [or graph showing resonance, with labelled axes] ✓</p>	4 [4]
4.	(a)	$r_1 = \frac{m_2}{m_1 + m_2} d$ <u>used</u> [or $m_1 r_1 = m_2 r_2$] (1) $r_1 = 7.43 \times 10^8 \text{ m}$ (1)	2
	(b)	<p><u>Use of relevant eqⁿ:</u> $T = 2\pi \sqrt{\frac{d^3}{G(m_1 + m_2)}} \text{ or } 2\pi \sqrt{\frac{d^3}{GM}} \text{ or } \frac{GM}{r^2} = \frac{mv^2}{r} \text{ (1)}$ $T = 3.75 \times 10^8 \text{ s}$ (1) Division by (24 × 60 × 60 × 365[.25]) or equiv (1) [=11.88 year]</p>	3
	(c)	$v = \frac{2\pi r}{T}$ [or $v = \omega r$ and $\omega = \frac{2\pi}{T}$] (1) $v = \frac{2\pi \times \text{answer (a)}}{\text{answer (b)}} \text{ (1) [= 12.46 m s}^{-1}\text{]}$	2
	(d)	<p>Doppler shift calculated: $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \rightarrow \Delta\lambda = \frac{v\lambda}{c} = 5.3 \times 10^{-14} \text{ m}$ (1) Upper λ value labelled: $1.28 \mu\text{m} / \lambda_{[0]} + 5.3 \times 10^{-14} \text{ m}$ (1) Lower λ value labelled: $1.28 \mu\text{m} / \lambda_{[0]} - 5.3 \times 10^{-14} \text{ m}$ (1) [Alternatively for 2nd and 3rd marks, indication on the graph that the amplitude of the variation is $5.3 \times 10^{-14} \text{ m}$, e.g. peak to peak $\Delta\lambda$ is shown as $10.6 \times 10^{-14} \text{ m}$] Period labelled: 12 years / $3.75 \times 10^8 \text{ s}$ (1)</p>	4 [11]

Question		Marking details	Marks Available
5.	(a)	[centripetal force =] $m\omega^2 r$ [or $\omega^2 r$ and ma] (1) $F = 32.5 \times 1.4^2 r$ [= 63.7 r] (1) Friction [of the surface on the shoes] provides centripetal force [or is the resultant etc.] (1) [Accept $F = m\omega r^2$ for 1 st and 3 rd marks as F is defined in the question]	3
	(b)	$63.7 r = 114$ [N] (1) $r = 1.79$ and relevant comment, e.g. if r greater, $F > 114$ N (1) [Alt: Subst $r = 1.8$ m and comment that $F > 114$ N]	2
	(c)	$T = \frac{2\pi}{\omega}$ [or by impl.] (1) = [$\frac{2\pi}{1.4}$] 4.49 s (1)	2
	(d)	$v = \omega A$ [or by impl.] (1) = [1.4×1.8] 2.52 m s ⁻¹ (1) [If $v = A\omega \cos \omega t$, or equiv, then $\cos \omega t = 1$ must be stated for 1 st mark]	2
	(e)	$a = \omega^2 A$ [or by impl.] (1) = [$1.4^2 \times 1.8$] 3.53 m s ⁻² (1) occurs at the extremities / when $x = \pm A$ etc. (1) [If $a = A\omega^2 \cos \omega t$, or equiv, then $\cos \omega t = 1$ must be stated for 1 st mark]	3
	(f)	At least one cycle of wave drawn with correct amplitude [1.8 m e.c.f.] (1) Reasonable shape of sinusoid + correct period + correct phase [i.e. sin wave] (1)	2
	(g)	Use of $-1.00 = \sin \omega t$ (1) $1.4t = \sin^{-1}\left(\frac{-1}{1.8}\right)$ (1) [= -0.59] $t = -0.42$ s (1) [Mysterious loss of - sign loses 1 mark] $t_1 = \frac{T}{2} + 0.42$ [2.42 s] and $t_2 = T - 0.42$ [4.07 s] (1)	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Max 2 marks for reading from graph ± 0.1 s, i.e 2.6, 2.7 s ✓ 4.0, 4.1 s ✓ </div> 4
			[18]

Question		Marking details	Marks Available
6.	(a)	$p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{519.8 \times 10^{-9}} = 1.275 \times 10^{-27} \text{ kg m s}^{-1} / \text{Ns ((unit))}$	1
	(b)	$p = mv = 9.11 \times 10^{-31} \times 1400$ (1) $= 1.275 \times 10^{-27} \text{ kg m s}^{-1}$ \therefore momenta cancel or sum = 0. [Comment needed] (1)	2
	(c)	Yes – momenta cancel afterwards also. [i.e. Yes + sensible comment, e.g. reflection symmetry, e.g. wavelength and speed unchanged. Accept mention of C of M frame]	1
	(d)	Loss of photon energy (1) = gain in kinetic energy [of electron] (1) [“Photon energy decreases; Electron KE increases” → 1 mark]	2
			[6]
7.	(a)	Use of $\frac{GMm}{r^2}$ (1)[or by impl.] = $\frac{6.67 \times 10^{-11} \times 1.99 \times 10^{30} \times 1.31 \times 10^{22}}{(7.38 \times 10^{12})^2}$ Force = $3.19 \times 10^{16} \text{ N}$ (1)	2
	(b)	$\frac{GM_1}{r_1^2} = \frac{GM_2}{r_2^2}$ (1) $\frac{r_2^2}{r_1^2} = \frac{m_2}{m_1}$ (1) $\frac{r_2}{r_1} = 8.11 \times 10^{-5}$ (1) → $r_2 = 6 \times 10^8 \text{ m}$ (1)	4
	(c)	Alt: $\frac{GM_1}{r_1^2} = \frac{GM_2}{(d-r_1)^2}$ (1) $M_1(d-r_1)^2 = M_2r_1^2$ (1) remaining algebra (1) GPE = $[-]\frac{GMm}{r}$ [or $V = [-]\frac{GM}{r}$ and GPE = $m\Delta V$] (1) Attempt at calculating 2 PEs or 2 Vs (1) [PEs: -2.36×10^{29} and -3.92×10^{29} , Vs: 1.8×10^7 and 3.0×10^7] $\Delta E_k = [-]\Delta E_p = 1.56 \times 10^{29} \text{ J}$ (1) e.c.f. i.e. the mark is for equating the gain of KE to the loss in PE.	3
			[9]

Question		Marking details	Marks Available
8.	(a)	<p>At least 2 field lines shown with correct direction (1) At least two equipotentials surfaces shown [reasonable sketch circles centred on -Q] (1) Labelling (1)</p> 	3
	(b)	<p>(i) <u>Use</u> of $F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2}$ (1) = 5.62 N (1)</p> <p>(ii) <u>Use</u> of $V = \frac{1}{4\pi\epsilon_0} \frac{Q}{r}$ and $\Delta E_p = q\Delta V$ or use of $E_p = \frac{1}{4\pi\epsilon_0} \frac{Qq}{r}$ (1) $\Delta E_p = [-] 0.45 \text{ J}$ (1) $\therefore E_{k[\text{max}]} = 0.45 \text{ J}$ [explicit] (1) [NB Free-standing mark – awarded if KE gain = PE loss stated]</p>	2
	(c)	<p><u>Use</u> of $E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$ (1) = $2.81 \times 10^6 \text{ V m}^{-1}$ (1) Horizontal cpts cancel \therefore direction down [could be in diagram] or stated algebraically, e.g. $2E \cos \theta$ (1) $E_{\text{res}} [= 2E \sin \theta = 2 \times \frac{3}{5} \times 2.81 \times 10^6] = 8.6 \times 10^6 \text{ V m}^{-1}$ [or N C^{-1}] (1) ((unit))</p>	3
			4
			[12]