PH4 Mark Scheme – January 2010

Question			Marking details	Marks Available
1	*(a)*		Acceleration $\propto$ displacement [from a fixed point] (1) and directed towards a fixed point (1) **Or** $a = [-]\omega^2 x$ (1); – sign **and** defined a and x, ω^2 a constant(1)	2
	(b)	(i)	$T = 2\pi\sqrt{\frac{m}{k}}$ [or by impl.](1) $T^2 = 4\pi^2 \frac{m}{k}$, i.e. correct squaring [or by impl.](1) $m = 0.127$ kg (1)	3
		(ii)	$\omega\left[=\frac{2\pi}{T}\right] = \frac{2\pi}{0.42\text{ s}}$ ✓[=14.96 [rad] s^{-1}]	1
	(c)	(i)	$v_{max} = \omega A$ (**subs**)(1) = 0.194 m s^{-1} [accept 0.19 or 0.20] (1)	2
		(ii)	$a_{max} = [-]\omega^2 A$ (**subs**)(1) = 2.91 m s^{-2} (1) [no penalty for minus sign in answer; no **2nd** penalty for 10^2 error]	2
	(d)	(i)	$^T/_4$ or 0.105 s	1
		(ii)	**Either** $a = [-]\ 2.91 \sin \omega t$ (1) [or impl.] $\omega t = \sin^{-1}\left(\frac{2.9}{2.91}\right)$ (1) [or impl.] $t = 0.054$ s (1) **or** $a = -\omega^2 x \rightarrow x = 0.0094$ m (1) $0.0094 = 0.13 \sin \omega t$ (**subs**) (1) $t = 0.054$ s (1) [–0.054 s loses 2nd mark, or equivalent wrong sector slip, e.g. 4.2 – 0.054 or even 2.1 – 0.054 etc.]	3
				[14]
2	*(a)*		$p\left[=\frac{h}{\lambda}\right] = \frac{6.63\times10^{-34}\text{ J s}}{620\times10^{-9}\text{ m}}$ (✓) [= 1.07×10^{-27} kg m s^{-1}]	1
	(b)		$1.1 \times 10^{-27} = [\pm]\ 1.1 \times 10^{-27} + mv$ [i.e. accept incorrect sign] (1) $2.2 \times 10^{-27} = 1.67 \times 10^{-27}\ v$ (1) $v = 1.28$ m s^{-1} (1) [$mv = 1.1 \times 10^{-27} \rightarrow v = 0.64$ m s^{-1} – 1 mark only]	3
	(c)	(i)	more energy after collision (1) since photon energies are the same / energy increased by hydrogen KE or $½mv^2$ (1)	2
		(ii)	reflected photon has longer wavelength or red shift occurs [or converse argument or frequency argument]	1
				[7]

Question			Marking details	Marks Available
3	*(a)*		$pV = nRT$ (**subs**)(1) $n = \frac{60\times 10^3 \times 0.05}{8.31\times 278}$ (1) [=1.2986]	2
	(b)	(i)	**Either** $p = \frac{1}{3}\rho \overline{c^2}$ (1)* $\rho = \frac{m}{V}$ or $\frac{0.171}{0.05}$ (1) $c_{rms} = 229\ \text{m s}^{-1}$ (1) **or** $pV = \frac{1}{3}Nm\overline{c^2}$ (1) $v = 0.05\ \text{m}^3$ **and** $Nm = 0.171$ (1) $c_{rms} = 229\ \text{m s}^{-1}$ (1) * Mark lost for incorrect substitution (e.g. of ρ) unless final root taken.	3
		(ii)	Division of m by 1.3 (1) Molar mass =0.132 kg / 132 g ((**unit**)) (1)	2 **[7]**
4.	*(a)*		ΔU – <u>change</u> / <u>increase</u> in *internal energy* Q – *Heat* supplied <u>to the gas /system</u> W – *Work* <u>done by the gas / system</u> Marking – all *italic* terms (1); all <u>underlined</u> terms (1)	2
	(b)	(i)	$W = p\Delta V$ **or** area under graph (1) $= 60\ 000 \times 50 \times 10^{-3}$ $= 3\ 000$ J (1)	2
		(ii)	Use of ΔT or $U_2 - U_1$ (1) $\Delta U = 4\ 500$ J (1)	2
	(c)	(i)	0	1
		(ii)	Temperature decreases / gas cools / ΔU –ve (1) Heat flows out / Q –ve (1) [**not** 'decrease in heat']	2
	(d)	(i)	Returns to same temperature / point / p, V, T (1) [**or** internal energy depends only on T [accept p, V, T]]	1
		(ii)	attempt at closed area or AB – CD (1) [or by impl.] W [= 20 000 × 0.05] = 1000 J (1) Q = 1000 J (1)	3 **[13]**

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Q2.

a) The half life is the time taken for half the nuclei to decay.
b) Lambda = ln2/half life = 0.025 per year or 7.85e-10 per second
c) 0.05g/137g = number of moles
   Number of moles x Avogadros number = number of atoms = 2.197e20
   A = lambda*N = 1.72e11Bq
d) 1.7MeV per decay
   1.72e11 decays per second
   2.924e11MeV per second
   2.924e17eV per second
   Divide by e
   0.047W or 47mW   is this correct? Online i only see microwatts as typical powers for pacemakers. Or does only a fraction of the radioactive decay energy reach the circuit?

e) alpha emitter less suitable as alpha particles are larger and therefore more prone to absorption by surrounding human tissue – cell mutation – cancer. Also alpha particles can end up heating the pacemaker casing rather than powering the device.

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3	*(a)*		$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$ (1) (1)	2
	(b)		$P = \frac{E}{t}$ **or** watt = J s^{-1} (1) confinement time = $\frac{E}{P}$: ∴ $\frac{J}{J\,s^{-1}}$ = s (1)	2
	(c)		High temperature → need fast particles to overcome repulsion (1) High density → more ions / particles means more reactions / collisions [∴ more energy out] (1) Long time → more time means more reactions / collisions [∴more energy out] (1)	3
	(d)		Along magnetic field lines → no force [or constant *v*] (1) $\perp^{r}$ to **B**, experience a force [**or F = Bqv**] (1), at right angles (to **v** and **B**) giving circular motion [accept: gives centripetal force](1). Constant velocity (along **B** field) combined with circular motion gives a spiral [or helix] (1)	4
	(e)		Any 3 × (1) from 5: abundance – plenty for at least 1000 years [or similar](✓) safety – cannot get out of control because there is only a small amount of fuel (1) environment – no CO_2 / greenhouse emissions (✓) radioactive for only ~ 50 years [accept: no radioactive waste](✓) output – large amount of energy from small amount of fuel (✓)	3
	(f)	(i)	$0 = 4(m)v + (m)w$ (1) [**or** $5mu = 4mv + mw$] neutron speed = 4 × helium speed (1) [implies 1st mark] KE = $\frac{1}{2}mv^2$ (1) [or by impl] $\frac{1}{2} \times 4mw^2 = 2mw^2$ **and** $\frac{1}{2} \times m(4w^2) = 8mw^2$ (1) [Accept: showing that momentum is conserved with the data supplied for full marks]	4
		(ii)	• pass through walls ✓ • take away KE ✓ • unaffected by **B**-field ✓ • provide heating outside torus ✓ • produce β-emitters [accept r/a particles]✓ } any 2 × (1)	2 **[20]**