PH5

Question			Marking details	Marks Available
1	*(a)*		All α absorbed / stopped by paper (1) (nearly) all γ passes through (1)	2
	(b)		${}^{0}_{-1}[\beta]$ correct (1) Conservation of A and Z (but not for trivial ${}^{0}_{0}\beta$) (1)	2
	(c)		$\lambda = \frac{ln2}{T_{1/2}}$ used (1) $\frac{ln2}{28.8\times365\times24\times3600}$ $[= 7.63 \times 10^{-10}\ s^{-1}]$ (1)	2
	(d)		Correct equation used i.e. some understanding of $A = A_0 e^{-\lambda t}$ or $A = \frac{A_0}{2^n}$ (1) Answer correct (110 GBq **ecf** on λ) (1)	2
	(e)		$A = \pm\lambda N$ used (e.g. 140 = 7.6 x 10^{-10} N is ok) (1) N = 1.83 x 10^{20} (1) Mass = 90 u x 1.83 x 10^{20} = 27.4 x 10^{-6} kg (27.4 mg) **ecf** on N (1) **UNIT mark**	3
			Question 1 total	**[11]**

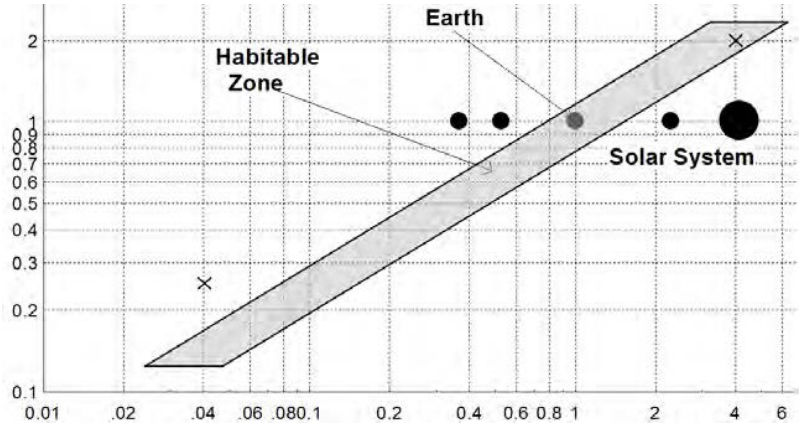
Question			Marking details	Marks Available
2	*(a)*		LHS - RHS attempted (0.1859 u) (1) x 931 or $E=mc^2$ used (must have u to kg conversion) (1) 173.1 [MeV] / 2.78 x 10^{-11} [J](1)	3
	(b)		[more or 3] <u>neutrons</u> are released (1) These can produce fission (or, on average one of these....) (1)	2
	(c)		Control rods stop or absorb neutrons (1) Moderator slows neutrons (1) To increase [probability of] fission (or increase capture X-section) (1)	3
	(d)		[Highly] radioactive for many years / long half life (1) Any sensible **A level standard** comment relating to - storage, leakage, transportation, cost, dirty bombs etc. (1)	2
			Question 2 Total	**[10]**

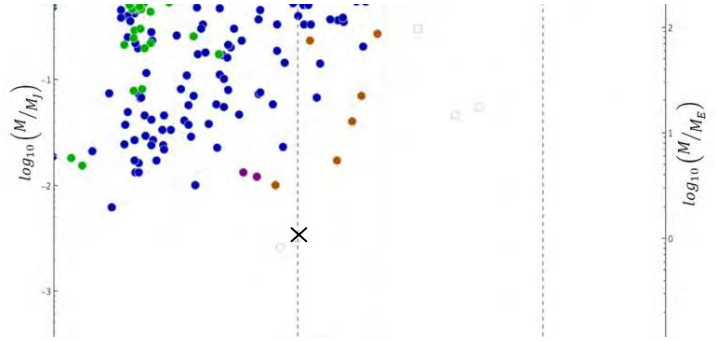
Question			Marking details	Marks Available
3	*(a)*	(i)	$C = \frac{\varepsilon_0 A}{d}$ used $\left(= \frac{8.85\times10^{-12}\times 8.2\times10^{-4}}{0.77\times10^{-3}}\right)$ (1)	
			Answer correct (9.42×10^{-12} F) (1) **UNIT mark**	2
		(ii)	Dielectric accept solid insulator	1
	(b)	(i)	$Q = CV$ (used or implied) (1)	
			Answer correct (5.35×10^{-8} [C]) (1)	2
		(ii)	$Q = Q_0 \exp\left(\frac{-t}{RC}\right)$ used e.g. $Q_0 \exp\left(\frac{-50\times10^{-6}}{47\times33\times10^{-9}}\right)$ (1)	
			$= 5.3 \times 10^{-22}$ [C] (1)	
			Comment e.g. v. small or completely discharged etc. (1) **ecf**	3
		(iii)	$I = \frac{Q}{t}$ and $T = \frac{1}{f}$ (or implied) or $I = Q$ x 20 000 (1)	
			$= 20\,000 \times 5.35 \times 10^{-8} = 1.07 \times 10^{-3}$ [A] (1) **ecf**	2
			Question 3 Total	**[10]**

Question			Marking details	Marks Available
4	*(a)*		Concentric circle / ellipse with wire @ centre (1) Direction correct and unambiguous (1)	2
	(b)	(i)	$B = \frac{\mu_0 I}{2\pi a}$ used (1) $B_1 = 2.4\text{x}10^{-6}$ [T] **and** $B_2 = 3.6\text{x}10^{-6}$ [T] (1) Answer $B = 1.2\text{x}10^{-6}$ [T] (1) **ecf** Out of paper (1)	4
		(ii)	One wire is in the magnetic field of another (can be implied)(1) Field due to I_2 out of paper at I_1 (1) Force to left due to LHR (1) Other wire is opposite due to N3 or opposite field or equivalent (1) **AWARD a maximum of 3 marks** OR One wire is in the magnetic field of another (can be implied) (1) Field due to I_1 out of paper at I_2 (1) Force to right due to LHR (1) Other wire is opposite due to N3 or opposite field or equivalent (1) **AWARD a maximum of 3 marks**	3
			Question 4 Total	**[9]**

Question			Marking details	Marks Available
5	*(a)*		The right side (independent mark) (1) **Force [on electrons (can be implied)]** is to the right (1) Due to LHR or current back to front face (1)	3
	(b)		$V = Ed$ *(or $E=V/d$) (*1) Quoted only or implied $= 3.2\text{x}10^{-6}$ x $2.6\text{x}10^{-3}$(**ecf** from a) $= 8.32 \times 10^{-9}$ [V] (1)	2
	(c)		eE = electrical force **and** Bev = magnetic force (1) equilibrium is reached or electrons pass through unaffected etc. (1)	2
	(d)		Substituting $v = \frac{I}{nAe}$ in $eE = Bev$ **or** calculating $v = 3.93 \times 10^{-5}$ m s^{-1}(1) Rearranging i.e. $B = \frac{EnAe}{I}$ (1) Answer = 0.081 T (1) **UNIT mark** **Or** rearranging $V_H = \frac{BI}{nte}$ (1) $\left\{B = \frac{nteV}{I}\right\}$ Correct substitution (including $t = 0.85$ mm and $V = 8.32$ nV **ecf**) (1) Answer correct (1)	3
			Question 5 Total	**[10]**

Question			Marking details	Marks Available
6	*(a)*		Valid complete statement - 2 marks e.g. Induced emf is proportional to (or equal to) the rate of change (or cutting) of flux (linkage). e.g. Accept induced emf = change of flux / time e.g. Accept emf = rate of flux cutting (bod - missing induced) Nearly complete statement - 1 mark e.g. $\mathcal{E} = [-]\frac{[d]\varphi}{[d]t}$ (terms not defined) e.g. Induced emf is proportional to change of flux (missing rate of)	2
	(b)	(i)	$\mathcal{E} = -\frac{d\varphi}{dt}$ or $\frac{\varphi}{t}$ or $\frac{BA}{t}$ or $\frac{BAN}{t}$ (1) $A = \pi r^2$ used (1) Use of $I = \frac{V}{R}$ (1) Correct answer (1)	4
		(ii)	$\div \sqrt{2}$ (1) = 1410 [A] (1)	2
		(iii)	$P = IV$ or I^2R or V^2/R used (1) = 456 [W] (1)	2
			Question 6 Total	**[10]**

Question			Marking details	Marks Available
7	*(a)*		Because their star is the Sun **or** they all orbit the Sun **or** $\frac{M_{star}}{M_{Sun}} = 1$ Accept M_{star} is the same	1
	(b)	(i)		1
		(ii)		1
		(c)	(i) yes **because** it's in the habitable zone **ecf** (1)	
			(ii)[no] **because** it is too hot **or** too close to star **ecf** (1)	2
		(d)	Eliminating r_S (1) $\frac{M_S v_S^2}{r_S} = \frac{GM_S M_p}{d^2} \rightarrow \frac{v_S^2}{M_p d / M_S} = \frac{GM_p}{d^2}$ or $M_S v_S^2 = \frac{GM_S r_S M_p}{d^2} = \frac{GM_p d M_p}{d^2}$	
			Remainder of algebra convincing (1)	2
		(e)	Because Doppler shift $\propto v_S$ (accept depends on) (1)	
			and $v_S \propto M_p$ or v_S increases with M_p (1)	
			and $v_S \propto M_S^{-0.5}$ or v_S decreases with M_S (1)	
			and $v_S \propto d^{-0.5}$ or v_S decreases with d (1)	4

Question			Marking details	Marks Available
7	*(f)*		Some comment about most planets being large mass e.g. nearly all masses greater than M_E or average/median mass is close to mass of Jupiter etc. (1) Some comment about *d* being quite small on average e.g. mean/median *d* is only about 1 AU (not 0 AU!) or nearly all planets inside 10 AU etc. (1) The graph says nothing about the size of the star (1) **Award a maximum of 2 marks only** Most planets towards top left of graph (by itself) scores 1 mark	2
	(g)		 Accept a circle around the correct planet x correct – 1 mark, y correct – 1 mark	2
	(h)		$\frac{\pi r_1^2}{\pi r_2^2} = \mathbf{20^2}$ (1) Drops by 0.25% or drops **to** 99.75% or drops by $^1/_{400}$ (1) (correct answer implies first step)	2
	(i)		Radial velocity gives mass (1) Transit gives radius **or** area **or** diameter (1) Density = $\frac{mass}{volume}$ and volume from area or diameter or radius (1)	3
			Question 7 Total	**[20]**

Question			Marking details	Marks Available
8	*(a)*	(i)	$\omega L = \frac{1}{\omega C}$ or $f = \frac{1}{2\pi\sqrt{LC}}$ (1)	
			$\omega = 2\pi f$ or algebra i.e. $L = \frac{1}{4\pi^2 C f^2}$ (1)	
			L = 0.247 H **UNIT mark** (1)	3
		(ii)	$I = \frac{240}{150}$ (1)	
			Because V_L and V_C cancel or because all voltage across R etc. (1)	2
		(iii)	$V = IX_C$ (1)	
			$= I\omega L$ (1)	
			= 6360 [V] (1)	3
		(iv)	6360 [V] (1)	
			0 (1)	
			0 (1)	
			0 (1)	4

Question			Marking details	Marks Available
8	*(b)*		E - **induced** emf L - (self) inductance (1) For both	
			$\frac{\Delta I}{\Delta t}$ - rate of change of current (1)	2
	(c)		$\mathcal{E} = (-)\frac{d}{dt}(BAN)$ or $\mathcal{E} = (-)\frac{BAN}{t}$ (1)	
			$B = \mu_0 nI$ substituted i.e. $\mathcal{E} = (-)\frac{\mu_0 nIAN}{t}$ (1)	
			$N = nl$ substituted i.e. $\mathcal{E} = (-)\frac{d}{dt}(\mu_0 nIAnl)$ (1)	
			Final arrangement and 'comment' e.g. $\mathcal{E} = (-)\overbrace{\mu_0 n^2 Al}\frac{I}{t}$ (1)	4
	(d)		$L = \mu_0 n^2 \pi r^2 l$ i.e. using πr^2 and $\mu_0 n^2 Al$ (1)	
			Answer [=0.25 H] (1)	2
			Question 8 Total	**[20]**

Question			Marking details	Marks Available
9	*(a)*	(i)	Either in words or on diagram, for first mark 2 of; for second 3 of: Interference mentioned, 2 sources mentioned or labelled, wavefronts labelled, lines of constructive or destructive interference labelled.	2
		(ii)	**Newton**: Light is moving [or flow of] corpuscles [particles](1) **Huygens**: Light is a wave. (1) But H had no notion of periodic nature of wave (1) [**or** of wavelength **or** of interference]	3
	(b)	(i)	Two coils and iron core shown on diagram. (1) When current switched on or off [accept either] in one coil, (1) Current flowed [or equivalent] in other coil. (1) Detected by deflection of compass needle close to a [long] wire connected across the secondary. (1)	4
		(ii)	Any Two of Lines shown by compass needle or iron filings. Cutting by conductor induces emf [accept current] in conductor **or** emf induced in a circuit if number of lines linking it changes. Lines under tension **or** light/radiation is a wave propagating along the lines.	2

Question			Marking details	Marks Available
9	*(b)*	(iii)	spinning 'beads' [**or** cells, vortices…] (1)	
			axis of spin along lines of force. (1)	2
	(c)	(i)	Laws of Physics the same in all inertial frames. [Accept: No privileged (special) frame of reference.] (1)	
			Speed of light independent of the motion of its source. [Accept: speed of light always the same.] (1)	2
		(ii)I	time of flight = 0.36 [m] / 0.60 x 3.0 x 10^8 [s] [= 2.0 ns] [or by implication](1)	
			attempt to use this as Δt in time dilation formula (1)	
			Correct evaluation of $\sqrt{(1 - v^2/c^2)}$ or its reciprocal [0.8 or 1.25] [or by implication] (1)	
			= 1.6 [ns] time (1)	4
		II	Time [between events] as found by clock moving with pion **or** by clock present at both events. Accept : time as experienced by pion.	1
			Question 9 Total	**[20]**

Question			Marking details	Marks Available
10	*(a)*		(2x1) from: crystalline- long range, regular (unit cell repeated) Amorphous- short range, irregular Polymeric- long chain molecules (no order between, only within molecules)	
			2 examples given (1)	3
	(b)	(i)	Equation applied to both sections correctly i.e. $\frac{F\frac{L_0}{2}}{AY}$ and $\frac{F\frac{L_0}{2}}{2AY}$ (1)	
			Extensions added i.e. $\frac{F\frac{L_0}{2}}{AY} + \frac{F\frac{L_0}{2}}{2AY}$ (1)	
			Convincing algebra (1)	3
		(ii)I	Line drawn correctly	1
		II	Re-arrange for ***A*** bar, **2*A*** bar or **combination (1)**	
			Correct force-extension combination for each of above (1)	
			Answer = 2 x 10^{11} [N m^{-2}] (1)	3
		III	Both extensions correct i.e. 2 μm and 4 μm (ecf on line) (1)	
			Correct method of finding energy e.g. $\frac{1}{2}Fx$ or $\frac{1}{2}\sigma\varepsilon \times V$ or area (1)	
			Answer correct E_p = 6 x 10^{-4} [J] (**ecf** on line usually 12x10^{-4} [J]) (1)	3
			Alternative: Areas under graph lines - same method applies	

Question			Marking details	Marks Available
10	*(c)*	(i)	Hysteresis labelled/described correctly (1)	
			Permanent set labelled/described correctly (1)	
			Correct sketch (1)	3
		(ii)I	Untangling of molecules (rotation about single bonds) (1)	
			Small force causes large extension (1)	2
		II	Increasing temperature increases random rotation about single bond (molecules 'ravel' up and become shorter) (1)	
			(Given) force produces smaller extension (1)	2
			Question 10 Total	**[20]**

Question			Marking details	Marks Available
11	*(a)*	(i)	A-scan measures distances / depths (1) B-scan provides images (moving) pictures (1)	2
		(ii)	Any valid application e.g. development of foetus, scanning young (born) babies' skulls imaging liver, kidneys, heart locating arteries/veins/nerves locating fluid (puss, blood etc.) inside body (esp abdomen&lungs)	1
		(iii)I	Time = 7.5 x 2 μs (1) Distance = time x 1.45 x 10^3 (=21.8 mm) (1) Thickness = 0.5 x distance (=10.9 mm) (1)	3
		II	Both pulses at start or only the first pulse (accept second pulse very faint)	1
	(b)	(i)	More electrons emitted or hit target (1) Output higher **intensity** (1)	2
		(ii)I	2.8 x 10^{18}	1
		II	80000 x 1.6 x 10^{-19} = 1.28 x 10^{-14} J (accept 80 keV)	1

Question			Marking details	Marks Available
11	*(b)*	(iii)	High X-ray dose / high exposure / expensive / CT scanner in high demand	1
	(c)		*y*-axis pd or voltage etc. **and** x-axis time (1)	
			y- axis units – mV (1)	
			x-axis unit – s (1)	3
	(d)		Nuclei precess/wobble around field lines (1)	
			Radio waves at resonance frequency change/flip orientation of nuclei (1)	
			Orientation goes back to field direction (while emitting radio waves) (1)	3
	(e)		Lower (1)	
			Alpha are more damaging/ionising (to tissue) (1)	2
			Question 11 Total	**[20]**

Question			Marking details	Marks Available
12	*(a)*		3 valid points for/against coal & nuclear 3 marks 2 valid points for/against coal & nuclear 2 marks 1 valid point for/against coal & nuclear 1 mark Coal Acid rain, global warming/CO_2 emitting, other specified pollution e.g. smog & carcinogenic particulates, causes asthma, can be very high output power Nuclear Danger of accident/leak in high population area, decommissioning very expensive, waste radioactive for many years **and** must be contained, expensive in general, no CO_2 emission, can be very high output power 2 valid local points 2 marks 1 valid local point 1 mark Local points Large number of local jobs (and plenty of people to fill vacancies), plenty of water available (Thames), less need for long power cables, good rail links, very expensive land prices, causes asthma (but cannot be counted twice), risk of radioactive leak in high population area (but cannot be counted twice), reduces already poor air quality in London etc.	5
	(b)		Substitution of $\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$ (1) Rest of algebra $\frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$ (1)	2
	(c)		$1 - \frac{T_2}{T_1} = 1 - \frac{323}{773} = 0.58$ or 58%	1

Question			Marking details	Marks Available
12	*(d)*	(i)	$\times \frac{100}{35}$ (i.e. $3.6 \times \frac{100}{35} = 10.3$ GW) (1)	
			$\div 25$ (i.e. $10.3 \div 25$) (1)	
			Answer = 0.411 [tonnes s^{-1}] (1)	3
		(ii)	Method correct i.e. (1) $\times 2.1 \times 24 \times 60 \times 60$ (even if 10.3 GW $\times 2.1 \times 24 \times 60 \times 60$)	
			Answer = 653 tonne (653×10^3 kg) (1)	2
	(e)	(i)	$A = 2\pi rl$ used (allow 1st mark for πdl) (1)	
			Correct answer = 90 [m^2] (1)	2
		(ii)	$\frac{\Delta Q}{\Delta t} = -Ak\frac{\Delta \theta}{\Delta x}$ used (1)	
			Values substituted correctly i.e. $7.24 \times 77 \frac{45}{0.0254}$ (1)	
			Answer correct = 9.87×10^5 [W] (1)	3
		(iii)	Lagging (or description of equivalent) (1)	
			With material of high *k* (or *U*) (1) (accept apt material e.g. fibre glass, rockwool etc.)	2
			i.e. wrap fibre glass around the pipe - 2 marks	
			Question 12 Total	**[20]**