PH5

SECTION A

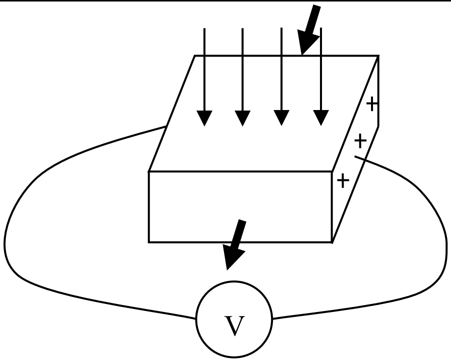
Question			**Marking details**	**Marks Available**
1	*(a)*	(i)	84.6×10^{-9} [C] [for 4.7 nF] (1) 73.8×10^{-9} [C][and 73.8 nC or clearly stated same for other 8.2 nF] (1)	2
		(ii)	$E = \frac{1}{2}CV^2$ or other equation used correctly or C total = 8.8 nF (1) Answer = 1.43×10^{-6} [J] **ecf** on Q but not V (1)	2
	(b)	(i)	Points taken from the curve e.g. Q_0 = 85 nC and (50 ms, 6 nC) (or 85 nC/e = 31 nC) (1) Values substituted correctly e.g. $6 = 85e^{-0.05/CR}$ or CR = 18 ms (1) Answer $R = 3.8 \times 10^{6}$ [Ω] (1) **Award 1 mark** for use of $\frac{\Delta Q}{t}$ t **or** 11 MΩ **Alternative:** Tangent (1) Current (1) $R = 3.8 \times 10^{-6}$ [Ω] (1)	3
		(ii)	$I = \frac{V}{R}$ used or tangent drawn at t = 0 (1) Answer = 4.7×10^{-6} [A] **ecf** (1)	2
		(iii)	After 41 ± 1 ms 10% charge left [or 90% discharged] Or other valid method e.g. taking logs and getting time (1) 83×10^{-3} [s] (first step can be implied) **ecf** (1)	2
			Question 1 Total	**[11]**

Question			Marking details	Marks Available
2	*(a)*	(i)	0	1
		(ii)	$\varphi = B \times l^2$(1) Answer = 4.32×10^{-5} [Wb] (1)	2
	(b)		Change in flux or Faraday's law gives emf (1) Complete circuit or accept emf gives current (1) **Award 1 mark only for:** Current due to Faraday's law	2
	(c)		Force / current / emf **opposes the change** (1) Force on PQ opposite to SR **or** the force is clockwise (1)	2
	(d)		$I = \frac{V}{R}$ used (1) $A = \pi\frac{d^2}{4}$ *or* $\pi \times 3^2(\times 10^{-6})$ i.e. πr^2 used (1) $R = \frac{\rho \times l}{A}$ used (1) $V = \frac{\Delta N\phi}{\Delta t}$ used (1) Answer = 0.19 [A] **ecf** on ϕ and πd^2 (1)	5
			Question 2 Total	**[12]**

Question			Marking details	Marks Available
3	*(a)*		Low *A* numbers do fusion (or arrow / label used) (1) High *A* numbers do fission (or arrow / label used) (1) Moving toward high BE/nucleon (around Fe-56) or Fe-56 is the most stable (or low PE/nucleon or accept work done by strong nuclear force) (1) Higher BE/nucleon is more stable (or low PE/nucleon more stable or more work done more stable) (1)	4
	(b)		1.1 ± 0.1 MeV identified from graph for ${}^{2}_{1}H$ (1) × 2 = 2.2 [MeV] **ecf** (1)	2
	(c)		7.6 ± 0.2, 8.4 ± 0.2, 8.7 ± 0.2 (1) Correct multipliers for each i.e. 235 × 7.6, 137 × 8.4, 96 × 8.7 (1) RHS – LHS or reverse (1) Correct answer e.g. 201 MeV **UNIT mark (**1) [dependent on BE/*A* approximations]	4
			Question 3 Total	**[10]**

Question			Marking details	Marks Available
4	*(a)*		360 ± 10 [minutes]	1
	(b)		No [significant] drop after paper [no α] (1) [Small drop after aluminium] so small amount of γ being absorbed / most γ passes through i.e. could be β but some γ would be absorbed ok **Or** accept drop could be attributable to randomness of decay (1) γ present because something gets through 3 mm Al **or** γ present because **bigger** drop after 10 cm Pb [than 3 mm Al] **or** γ present because only absorbed by the Pb (1)	3
	(c)		Activity = $\frac{450}{0.006}$ = 75 000 (1) Activity = λN or $t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ used (1) $N = 2.34 \times 10^9$ (1) Mass = $99 \times 1.66 \times 10^{-27} \times 2.34 \times 10^9 = 3.84 \times 10^{-16}$ kg **UNIT mark** (1) **ecf** on A and $t_{\frac{1}{2}}$ and N	4
			Question 4 Total	**[8]**

Question			Marking details	Marks Available
5	*(a)*		$n = \frac{12\,000}{1.8}$ (1) $B = \mu_0 nI = 0.019$ [T] (1)	2
	(b)	(i)	Either $Bev = \frac{mv^2}{r}$ *or* $Bev = m\omega^2 r$ (1) $v = \omega r$ *and* $\omega = 2\pi f$ quoted (1) Clear algebra (if not immediately understandable then not clear) (1)	3
		(ii)	$f = \frac{3.3\times6\times1.6\times10^{-19}}{2\pi\times12\times1.66\times10^{-27}}$ (1) Answer = 25.3×10^6 [Hz] (1)	2
		(iii)	$6e \times 14.5$ kV $\times$ 24 [= 2.09 MeV] (1) Conversion to J i.e. look out for $\times 1.6\times10^{-19}$ (1) Equating some related energy to $\frac{1}{2}mv^2$ e.g. $\frac{1}{2}mv^2$=14 500 (1) Answer = 5.8×10^6 [m s^{-1}] (1) (**ecf** on these values only 2.4×10^6 and 4.1×10^6 which correspond to q =1e and 12 kicks respectively)	4
			Question 5 Total	**[11]**

Question			Marking details	Marks Available
6	*(a)*			
		(i)	+ve correct	1
		(ii)	voltmeter correct	1
	(b)		$V = Ed$ or $V_H = Bvd$ (1) $Bev = eE$ quoted or $d = 5 \times 10^{-3}$ (1) Answer = 6.3×10^{-6} [V] (1)	3
	(c)		Electrons do not move in the direction of the Hall field (or accept in the direction of the Hall voltage)	1
	(d)		Correct use of $I = nAve$ or $n = \frac{BI}{V_H te}$ (or equiv equation) (1) Answer $I = 0.30 \times 10^{-3}$ [A] (1)	2
			Question 6 Total	**[8]**

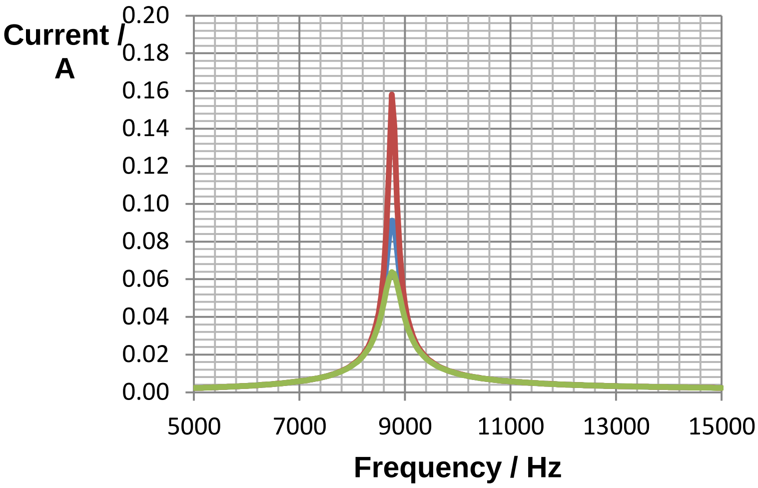
SECTION B

Question			Marking details	Marks Available
7				
	(a)		KE given to water (1) Air resistance (1) **Award 2 marks for:** Water runs out before pressure drops to 1 atm Accept PE given to water [even though water runs out in 1.6 m] Accept viscosity [or friction] of water Accept KE given to bottle [only 1/10th of mass of ball] Don't accept heat or sound	2
	(b)		$v = -20\ln\left(1 - \frac{5.9}{1.5} \times 0.175\right)$ (1) $v = 23.3$ [m s^{-1}] (1)	2
	(c)		kg s^{-1}, m^{2}, kg m^{-3} and m s^{-1} (0 or 1 unit correct 0 marks) (2 or 3 units correct 1 mark) (All 4 correct 2 marks) If all 4 units correct but algebra is incorrect then deduct 1 mark	2
	(d)		Rearranging i.e. $u = \frac{\Delta m/_{\Delta t}}{\pi r^2 \rho}$ (1) Answer = 25 [m s^{-1}] (1)	2
	(e)		**Any 3 × (1) from:** Rocket equation assumes constant *u* Volume increasing so pressure decreasing Pressure is decreasing so *u* is decreasing Thrust is decreasing	3

Question			Marking details	Marks Available
	(f)		$\Delta p = 6.8 \times 10^5$ [Pa] (1) $u = \sqrt{\frac{2\times6.8\times10^5}{1000}} = 36.9$ [m s^{-1}] (1)	2
	(g)		mg - weight or gravitational force **and** $0.0107v^2$ - air resistance / drag accept <u>skin / air</u> friction (1) Weight decreases (1) Air resistance increases (1)	3
	(h)		Squaring equation 6 or rearranging equation 5 (1) Convincing algebra (1)	2
	(i)	I	Fast process or no time for heat to flow or equivalent	1
		II	The gas does <u>work</u> so <u>internal energy</u> decreases **Or** $\Delta U = -W$	1
			Question 7 Total	**[20]**

SECTION C

Question			Marking details	Marks Available
8	*(a)*	(i)	$\omega L = \frac{1}{\omega C}$ or $f = \frac{1}{2\pi\sqrt{LC}}$ (1) $= \frac{1}{2\pi\sqrt{0.022\times15\times10^{-9}}}$ or $f = \frac{1}{2\pi\sqrt{0.022\times90\times10^{-9}}}$ (1) 8 761 [Hz] and 3 577 [Hz] (1)	3
		(ii)	$Q = \frac{2\pi f L}{R}$ or $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$ (1) Correct matching of f and R or R and C (1) 61 (1) 10 (1)	4
	(b)		$Z = \sqrt{\left(\omega L - \frac{1}{\omega C}\right)^2 + R^2}$ used (1) $I = \frac{3.2}{Z}$ i.e. $I = \frac{V}{Z}$ used (1) 1.7 [mA] (1)	3

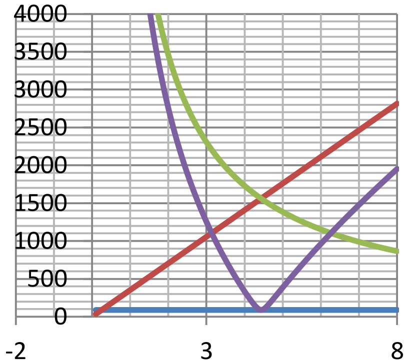
<table>
<tr><th colspan="3">Question</th><th>Marking details</th><th>Marks Available</th></tr>
<tr><td>8</td><td>(c)</td><td>(i)</td><td>
Shapes similar and asymptotic to original (1)

20 Ω with higher peak and 50 Ω with lower (implied if not labelled) (1)

20 Ω with peak current of 160 mA (1)

50 Ω with peak current of 64 mA (1)</td><td>4</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>ωL increases (wrt f) or graph (1)

$\frac{1}{\omega C}$ decreases (wrt f) (1)

low frequency behaviour explained e.g. X_C very large, Z large at low freq (1)

high frequency behaviour explained e.g. X_L very large, Z large at high freq (1)

$\omega L - \frac{1}{\omega C} = 0$ at resonance making Z a minimum (1)

$I \propto \frac{1}{Z}$ or equivalent equation etc. (1)</td><td>6</td></tr>
<tr><td></td><td></td><td></td><td>Question 8 Total</td><td>[20]</td></tr>
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Question			Marking details	Marks Available
9	*(a)*	(i)	Diagram showing either angle (accept θ) or baseline (1) Attempt to use $b = r\theta$ and indication that θ must be in radians, Or attempt to use $b/2 = r \tan(\theta/2)$ or equiv. Or by implication. (1) $r = 1.96 \times 10^6$ [km] or 1.92×10^6 [km] or convincing answer. (1)	3
		(ii)	Showed comet (far) beyond Moon. (1) But according to Aristotle nothing changes beyond Moon [yet comet was new – and went away]. (1)	2
	(b)	(i)	Diagram showing relevant areas (1) r_P, r_A, $v_P\Delta t$, $v_A\Delta t$ marked on diagram or meanings otherwise shown (1) $(\frac{1}{2})r_P v_P \Delta t = (\frac{1}{2})r_A v_A \Delta t$ or equivalent (1)	3
		(ii)	Use of $\frac{v_P}{v_A} = \frac{r_A}{r_P}$ [= 1.10] or by implication (1) 10 % [increase] (1)	2
		(iii)	Explicit use of $\frac{mv^2}{r}$ (1) $\frac{v_P}{v_A} = \frac{r_A}{r_P}$ used convincingly to give $\frac{F_P}{F_A} = \frac{r^2_A}{r^2_P}$ or equiv. (1)	2
	(c)	(i)	Towards S or equivalent	1
		(ii)	Any 3 of ... • Sun at S, planet's path ABCDEF... • If time interval is shrunk, path becomes smooth • Equal areas swept out in equal times • Showed that for an elliptical path ... • ... force had to vary as inverse square of Sun-planet distance	3
		(iii)	Planets swirled in whirlpool (vortex) around the Sun (1) Any 2 of …. (2) • easy to understand • gave a *mechanism* • Newton didn't say what *caused* gravitation Descartes' vortex theory can't be made to account for actual orbits [that is for Kepler's laws] or Newton's theory accounted for so many phenomena so economically [or similar point] (1)	4
			Question 9 Total	**[20]**

Question				Marking details	Marks Available
10	*(a)*	(i)		Strong (covalent) bonds between ions in structure. Accept molecules arranged irregularly or amorphous structure present (1) [No dislocations present] so no slip (accept no movement of dislocations). Accept different sized atoms seize up the structure (1) Do not accept 'untangle'.	2
		(ii)		Scratches (on surface) weaken material or break surface bonds. Scratches have stress concentrations at their tips- can be awarded from diagram. Cracks propagate through material. Correct direction of bending is to open the crack [ANY 2] (credit well annotated diagrams) [Local] stress cannot be relieved by slip / plastic flow/ dislocation movement.	2
		(iii)		Compression (1]) [Do not accept 'stress] More difficult for cracks to develop/ widen/ propagate (1)	2
	(b)	(i)		Gradient shown = 80 GPa e.g. $\dfrac{800\text{x}10^6}{0.01}$ seen.	1
		(ii)		Area under graph = [½ × 0.01 × 800 × 10^6 + ½ × 0.08 × 100 × 10^6 + 0.08 × 800 × 10^6] = 72 [MJ m^{-3}] (1) Volume = π × (1.25 × 10^{-3})^2 × 2.5 = 12.3 × 10^{-6} [m^3] (1) Work done = 72 × 10^6 × 12.3 × 10^{-6} = 884 [J] (1) (**ecf** on both area and volume).	3
		(iii)		Initial straight line of same gradient. (1) Yield point at 1 000 MPa. (1) Linear plastic region of small slope (accept zero slope) stopping at 5% strain. (1)	3
		(iv)	(I)	Creep: **[Gradual/slow/Over time]** AND **[extension/stretching/deformity or increase in strain]** (1) (under a constant load). Necking: **Localised** (or reference to 'section' or 'region') **thinning** (of structure/material before breaking- accept diagram) (1)	2
			(II)	Same shaped curve but steeper gradient (1) Stopped at 15% and *t* < 400 hrs (approx.) (1)	2
		(v)		Repeated bending, stretching or hammering of metal alloy (1) Dislocations become tangled / traffic jam effect **or** new dislocations created (1) Stopping each other from moving (or inhibiting plastic deformation or collect at grain boundaries) (1)	3
				Question 10 Total	**[20]**

Question			Marking details	Marks Available
11	*(a)*	(i)	A/B/D	1
		(ii)	C	1
		(iii)	A	1
	(b)		$V = \frac{hc}{e\lambda}$ (must rearrange) (1) 6.2×10^4 V (must have valid unit) (1)	2
	(c)		Reduces scattering/ spreading accept 'ensures (X-rays) are all parallel / perpendicular [to the patient] (1) [leading to] sharper image / better resolution (1)	2
	(d)	(i)	Radio (waves)	1
		(ii)	Cause Hydrogen atoms to resonate (1) Flip alignment producing a magnetic field (1)	2
		(iii)	Not good for dense objects/bone/ Uncomfortable/ Claustrophobic/cannot be used with pacemakers/ expensive	1
	(e)	(i)	Depolarization of ventricles/ repolarisation of atria (1) Contraction of ventricles (1)	2
		(ii)	Repolarization of ventricles (1) Relaxation of ventricles/ ventricles return to normal (1) Do NOT accept ventricles expand	2
	(f)	(i)	Doppler	1
		(ii)	$0.4 \times \frac{1500}{500} = 2v$ (1) $v = 0.6$ [m s^{-1}] allow 1 mark only for 1.2 m s^{-1} (1)	2
	(g)	(i)	Gamma /γ	1
		(ii)	Very expensive/need a cyclotron / particle accelerator Ignore any reference to radiation dose	1
			Question 11 Total	**[20]**

Question			Marking details	Marks Available
12	*(a)*		Any 3 of: More than one isotope of uranium Only U-235 fissile / U-238 unsuitable for fission Need higher concentration of U-235 Get rid of U-238 since neutron absorber/'sink'	3
	(b)		More fissile nuclei obtained (1) U-238 captures neutrons **or** decays to plutonium 239 via beta (1)	2
	(c)		Any 2 of: More easily controllable or no chain reaction Hydrogen & deuterium more plentiful / more easily sourced / can be extracted from sea water No [long term] radioactive products. More energy released per fusion	2
	(d)	(i)	Overcome electrostatic repulsion /forces (1) Needs high / enough (K)E (or velocity, speed) of deuterium/tritium (1) <u>KE proportional to temperature</u> or only tail end of distribution with high enough energy (1)	3

Question			Marking details	Marks Available
		(ii)	$n = or \geq \frac{3.5\times10^{28}}{0.9\times120000000}$ (1) Multiplying by $2.5 \times 1.67 \times 10^{-27}$ (1) Answer = 1.35×10^{-6} [$kg\ m^{-3}$] (1)	3
	(e)		9×10^{16} (1) $\times 2 = 18 \times 10^{16}$ [J] (1)	2
	(f)		Coal - **any 2 of**: acid rain, CO_2, non-renewable, lasts hundreds of years, increase asthma, damage to buildings/trees/etc, global warming (1) Natural gas - **any 2 of:** less acid rain, CO_2, non-renewable lasts tens or hundreds of years, global warming (1) Biomass - **any 2 of:** acid rain, CO_2 neutral (roughly), renewable/lasts millions of years, increase asthma, damage to buildings/trees/etc, (roughly) no global warming, large land area needed (1) Uranium-235 **any 2 of**: no acid rain, no CO_2, lasts thousands of years, no increase asthma, no damage to buildings/trees/etc, (little or) no global warming, leak or explosion risk, disposal of waste, hazardous waste, large energy output per kg of fuel (1) Wind **any 2 of:** no acid rain, no CO_2, renewable/lasts millions of years, no increase asthma, no damage to buildings/trees/etc, no global warming, low power, weather dependent/unreliable, large area (1) (ugly/kills birds/noisy/disrupts TV signals OK but only 1 point max for these) NOTE: No marks for cheap/expensive - eliminated in stem!!	5
			Question 12 Total	**[20]**