Selected Questions – Set 2 - Answers

1.

Question			Answers	Marks	Guidance
	(a)	(i)	$2\,{}^{1}_{0}\mathrm{n}$	B1	**Allow** answer in words, e.g. 'two neutrons' **Allow** $2 \times {}^{1}_{0}\mathrm{n}$
	(a)	(ii)	${}^{0}_{-1}\mathrm{e}$ / ${}^{0}_{-1}\beta^{(-)}$	B1	**Not** e / e^- / β / β^- **Allow** electron
			${}^{(o)}_{(0)}\bar{\nu}_{(e)}$	B1	**Allow** (electron) anti-neutrino
	(b)	(i)			**Allow** other correct methods
			(activity =) $\frac{2000}{9.0\times10^{-13}}$	C1	**Note** 2.22×10^{15} scores this C1 mark
			$(\lambda =) \frac{0.693}{88\times3.16\times10^{7}}$	C1	**Note** 2.49×10^{-10} (s^{-1}) scores this C1 mark
			$(A = \lambda N)$		
			$2.22\times10^{15} = 2.49 \times 10^{-10} \times N$ (Any subject)	C1	**Note** $N = 8.91 \times 10^{24}$ scores all three C1 marks Possible ECF for incorrect value(s) of activity and or λ
			(mass =) $\frac{8.91\times10^{24}}{6.02\times10^{23}}\times0.238$		
			mass = 3.5 (kg)	A1	**Allow** 3 marks for 0.21 (kg) if 120 W is used
	(b)	(ii)	(energy =) 0.120 (kW) × 24 (h)	C1	
			energy = 2. 9 (kW h)	A1	**Allow** 1 mark for 48 (kW h); 2 kW used instead of 0.12 kW **Allow** 1 mark for 2900; 120 used instead of 0.12

2.

Question	Answer	Marks	Guidance
(a)	The (minimum) energy needed to separate / remove all the nucleons / protons and neutrons (to infinity)	B1	**Allow**: The energy released when (stationary) nucleons combine to form the nucleus **Allow**: The (minimum) energy required to break the nucleus into its (separate) nucleons **Allow**: binding energy = mass defect × speed of light^2 **Allow**: 'Work (done)' in place of 'energy'
(b)	BE per nucleon = $4.53 \times 10^{-12}/4$ BE per nucleon = 1.13×10^{-12} (J)	 B1	 **Allow** 2 sf answer of 1.1×10^{-12} (J)
(c)	The helium nucleus has greater charge / The helium nucleus experience greater repulsive force Helium nuclei need to get close together (for the strong force to initiate fusion)	B1 B1	
(d)	$(\frac{1}{2} m v^2 = \frac{3}{2} kT)$ $\frac{1}{2} \times 6.6 \times 10^{-27} \times v^2 = \frac{3}{2} \times 1.38 \times 10^{-23} \times 10^8$ speed = 7.9×10^5 (m s^{-1})	C1 A1	 **Allow**: KE $\approx kT$; this gives an answer of 6.47×10^5 (m s^{-1})

3.

(i)	$^{40}_{20}Ca$ $^{0}_{-1}e + \bar{\nu}_{(e)}$ or electron + (electron) antineutrino	B1 B1	**Allow**: $^{0}_{-1}\beta$ but not β^- or e^- for the electron
(ii)	There is a decrease in mass Energy (released) given by $(\Delta)E = (\Delta)mc^2$ **or** Binding energy increases Energy (released) is the difference between the binding energies (of Ca and K nuclei)	M1 A1 M1 A1	**Ignore** Δm being referred to as the 'mass defect' **Allow**: binding energy per nucleon increases
(iii)	$\lambda = \frac{0.693}{4.2\times10^{16}}$ / $N = \frac{0.012}{100}\times\frac{4.5\times10^{-4}}{0.040}\times6.02\times10^{23}$ $A = 1.65\times10^{-17}\times8.127\times10^{17}$ activity = 13 (Bq)	C1 C1 A1	**Allow**: 1 mark for either $\lambda = 1.65\times10^{-17}\ s^{-1}$ or $N = 8.127\times10^{17}$ **Note**: Answer to 3 sf is 13.4 (Bq) **Note**: 1.3×10^{3} (Bq) scores 2 marks; division by 100 omitted

4.

Question			Answers	Marks	Guidance
	(a)		The charge / Q on each capacitor is the same $V \propto C^{-1}$	M1 A1	 **Allow** $Q = VC$ and some explanation
	(b)		(total resistance =) 27 (kΩ) or 27000 (Ω) (total capacitance =) 100 (μF) or 1.0×10^{-4} (F) (time constant =) $27 \times 10^{3} \times 100 \times 10^{-6}$ time constant = 2.7 (s)	C1 C1 A1	 **Allow** 10^{-4} (F) **Note** 2.7×10^{n} with $n \neq 0$ scores 2 marks
	(c)	(i)	$(V =) 1.5 \times 10^{-4} \times 40 \times 10^{3}$ or 6 (V) $(Q =) 6.0 \times 1200 \times 10^{-6}$ charge = 7.2×10^{-3} (C)	C1 A1	**Allow** I in the range 1.50 to 1.55 **Allow** other correct methods Possible POT error **Not** C and R values from **(b)**
	(c)	(ii)	Current starts at 3.0 ($\times 10^{-4}$ A) Graph showing shorter time constant	B1 B1	**Allow** $\pm 0.05 \times 10^{-4}$ (A)

5.

Question			Answer	Marks	Guidance
	(a)	(i)	Correct shape of (exponential) decay curve (labelled **L**)	B1	**Note**: The curve must show a gradient of decreasing magnitude as time increases and appear to have a finite value of V at $t = 0$ **Ignore** any levelling of the curve or $V = 0$ towards the end
		(ii)	Correct shape of curve (labelled **H**)	B1	**Note**: As **(i)** and this curve must show a smaller time constant than **(i)**; the initial V can be different **Note**: One of the curves must be labelled
		(iii)	Correct explanation in terms of constant-ratio for V values for fixed intervals of t	B1	**Allow** V is halved every half-life; V decreases to 0.37 (of its initial value) after every time constant **Note**: This can be scored on a suitably labelled sketch graph in either **(iii)** or Fig. 4.1
	(b)	(i)	(time constant = $6.9 \times 10^{-6} \times 240$) time constant = 1.7×10^{-3} (s)	B1	**Note**: Answer to 3 sf 1.66×10^{-3} (s)
		(ii)	charge = $6.9 \times 10^{-6} \times 1.4$ (= 9.66×10^{-6} C) ($\Delta t = 1/120 = 0.0083$ s) current = $\frac{6.9 \times 10^{-6} \times 1.4}{0.0083}$ current = 1.2×10^{-3} (A)	C1 C1 A1	Possible ecf from **(b)(i)** for value of total capacitance **Note**: Answer to 3 sf 1.16×10^{-3} (A) **Allow**: 2 marks for $9.66 \times 10^{-6} \times 60 = 5.8 \times 10^{-4}$ (A); Δt = 1/60 s used **Allow**: 2 marks for $9.66 \times 10^{-6} \times 240 = 2.3 \times 10^{-3}$ (A); Δt = 1/240 s used
		(iii)	The capacitors do not fully discharge (AW) Any one from: • Period (of switching) is (halved to) 4.2×10^{-3} (s) (and this time is comparable to the time constant) • The time constant (of the circuit) and period of mechanical switch are comparable / similar	B1 B1	