Selected Questions – Set 6 - Answers

1.

a		94; proton number; neutron	**3**	**3**
b	**i**	$N = N_A m/M = 6 \times 10^{23} \times 2.5 \times 10^{-10}/0.241 = 6.2 \times 10^{14}$ **or** $2.5 \times 10^{-10}/ 241 \times 1.67 \times 10^{-27}$	**2**	**2**
	ii	$0.693/(480 \times 3.15 \times 10^{7}) = 4.58 \times 10^{-11}$ (s^{-1})	**1**	**1**
	iii	$A = \lambda N = 4.6 \times 10^{-11} \times 6.2 \times 10^{14}$; $= 2.9 \times 10^{4}$; Bq or s^{-1}	**3**	**3**
	iv	use $A = 2.9 \times 10^{4}$ $dN = 2.9 \times 10^{4}\, dt = 6.2 \times 10^{12}$; $dt = 6.2 \times 10^{12} / 2.9 \times 10^{4} = 2.1 \times 10^{8}$ s **or** use $N = N_o e^{-\lambda t}$ $\ln N/N_o = -\lambda t$; $-0.01 = -4.6 \times 10^{-11}\, t$; $t = 2.2 \times 10^{8}$ s	**3**	**3**
c	**i**	alpha particles stopped by the walls of container/few cm of air	**1**	**1**
	ii	interacts strongly with/ionises matter; so if ingested will damage gut, etc	**2**	**2**

2.

Question			Answer	Marks	Guidance
	(a)		no: of neutrons = 142	B1	
	(b)	(i)	(5.6 MeV =) 5.6 × $\underline{10^6}$ × $\underline{1.6 \times 10^{-19}}$ energy = 8.96 × 10^{-13} (J)	M1 A0	**Allow**: 5.6 × $\underline{1.6 \times 10^{-13}}$
		(ii)	$\frac{1}{2} \times 6.65 \times 10^{-27} \times v^2 = 8.96 \times 10^{-13}$ $v = \sqrt{\frac{2 \times 8.96 \times 10^{-13}}{6.65 \times 10^{-27}}}$ speed = 1.6 × 10^7 (m s^{-1})	C1 A1	Answer to 3 sf is 1.64 × 10^7 (m s^{-1}) **Note**: The answer is 1.65 × 10^7 (m s^{-1}) if 9 × 10^{-13} (J) is used
	(c)	(i)	activity = $\frac{62}{8.96 \times 10^{-13}}$ activity = 6.92 × 10^{13} (Bq)	C1 A0	**Allow**: activity = $\frac{62}{9 \times 10^{-13}}$ (= 6.89 × 10^{13} Bq) Possible ecf from **(b)(i)**
		(ii)	$\lambda = \frac{0.693}{T}$ $\lambda = \frac{0.693}{88 \times 3.16 \times 10^7}$ decay constant = 2.49 × 10^{-10} (s^{-1}) or 2.5 × 10^{-10} (s^{-1})	C1 A1	**Note**: ln2 = 0.693 **Allow**: 1 mark for using 88 years and getting an answer of 7.9 × 10^{-3}
		(iii)	**1** $A = \lambda N$ $N = \frac{6.92 \times 10^{13}}{2.49 \times 10^{-10}}$ number =2.78 × 10^{23} or 2.8 × 10^{23} **2** mass = $\frac{2.78 \times 10^{23}}{6.02 \times 10^{23}} \times 0.24$ mass = 0.11 (kg)	C1 A1 B1	Possible ecf from **(c)(ii)** **Note**: '7 × 10^{13}/2.5 × 10^{-10} = 2.8 × 10^{23}' Possible ecf for mass from incorrect value for number of nuclei

3.

Question			Answer	Marks	Guidance
	(a)		The neutrons interact with other uranium (nuclei) / the neutrons cause further (fission) reactions	B1	**Not**: neutrons interact with uranium <u>atoms</u> / <u>molecules</u> / <u>particles</u>
	(b)		**Fuel rod**: Contain the <u>uranium</u> (nuclei) / fissile material **Control rods**: Absorb (some of the) neutrons *Controlled chain reaction*: The control rods are inserted into the reactor so as to allow (on average) one neutron from previous reaction to cause subsequent fission (AW) **Moderator**: Slows down the (fast-moving) neutrons / lowers the KE of (fast moving) neutrons / makes the (fast moving) neutrons into thermal neutrons Slow moving neutrons have a greater chance of causing fission / of being absorbed (by U-235) / sustaining chain reaction	B1 B1 B1 B1 B1	**Show annotation on Scoris** **Not** 'contains fuel' **QWC mark** **Allow**: Fast moving neutrons are captured (easily) by uranium-238 (nuclei leaving insufficient number of nuclei for fission / chain reaction) for the last B1 mark
	(c)	(i)	power = $3.0 \times 10^9/0.22$ power = 1.36×10^{10} (W) or 1.4×10^{10} (W)	B1	
		(ii)	energy = $1.36 \times 10^{10} \times 8.64 \times 10^4$ energy = 1.18×10^{15} (J) or 1.2×10^{15} (J)	B1	Possible ecf from **(c)(i)**
		(iii)	(number of reactions per day) = $\dfrac{1.18\times10^{15}}{3.2\times10^{-11}}$ mass = $\dfrac{1.18\times10^{15}}{3.2\times10^{-11}}\times3.9\times10^{-25}$ mass = 14.4 (kg) or 14 (kg)	C1 A1	Possible ecf from **(c)(ii)** **Note**: Using 1.2×10^{15} (J) gives an answer of 14.6 (kg); allow 15 (kg)
	(d)		Nuclear waste is (radio)active for a long time (AW) Causes ionisation	B1 B1	**Allow**: '*Nuclear waste can have long* half *life'*

4.

a		$E = V/d$;= $40 \times 10^3/6 \times 10^{-4} = 6.7 \times 10^7$; $N\ C^{-1}$ **or** $V\ m^{-1}$	**3**	**3**
b	**i**	one closed loops through primary passing through iron core and	**1**	
		secondary; second line along same path not touching/crossing, etc.,	**1**	
	ii	all magnetic flux (created by primary current) passes through iron core/ low reluctance path (so links both coils)/AW	**1**	
		(magnetic flux = BA and) magnetic flux linkage = BAn ;	**1**	
		the secondary coil has a different number/many more turns than the primary so flux linkage is different	**1**	
		max 2		
	iii	voltage is only induced across spark gap when the magnetic flux is changing	**1**	
	iv 1	the shorter the time the greater the voltage; because V α rate of	**1**	
		change of flux linkage	**1**	
	2	$V_p/V_s = n_p/n_s$ (in an ideal transformer); so larger n_s is relative to	**1**	
		n_p the larger the secondary voltage	**1**	**9**

5.

Question			Answer	Marks	Guidance
	(a)	(i)	Correct direction of force at **A** (and marked **F**)	B1	
		(ii)	The force is perpendicular to velocity / motion (hence no work done on the electron) or No (component of) acceleration / force in direction of velocity / motion (hence no work done on electron) or No distance moved in the direction of the force	B1	
	(b)		$F = \frac{mv^2}{r}$ force = $\frac{9.11\times10^{-31}\times(6.0\times10^7)^2}{0.24}$ force = 1.4×10^{-14} (N)	C1 A1	**Note**: Answer to 3sf is 1.37×10^{-14} (N) **Allow**: 1 mark for 1.4×10^n; $n \neq -14$ (POT error)
	(c)		$F = BQv$ $1.37\times10^{-14} = B\times1.60\times10^{-19}\times6.0\times10^7$ $B = 1.4 \times 10^{-3}$ (T)	C1 A1	Possible ecf from **(b)** **Note**: Answer to 3 sf is 1.43×10^{-3} (T) for 1.37×10^{-14} (N) **Note**: Using 1.4×10^{-14} (N) gives 1.46×10^{-3} (T) **Note**: Using $B = mv/Qr$ gives 1.42×10^{-3} (T)
	(d)		Using $(E =) mc^2$ and $(E =) \frac{hc}{\lambda}$ **(QWC)** $2\times mc^2 = 2\times\frac{hc}{\lambda}$ or $mc^2 = \frac{hc}{\lambda}$ or $mc = \frac{h}{\lambda}$ Correct substitution (any subject) $\lambda = 2.4 \times 10^{-12}$ (m)	B1 C1 A1	Eg: $2\times9.11\times10^{-31}\times(3.0\times10^8)^2 = 2\times\frac{6.63\times10^{-34}\times3.0\times10^8}{\lambda}$ Answer to 3 sf is 2.43×10^{-12} (m) **Allow**: 1 mark for 1.21×10^{-12} (m) or 4.86×10^{-12} (m) for the C1A1 marks

6.

Question			Answer	Marks	Guidance
	(a)	(i)	$f = \frac{1}{T} = \frac{1}{10 \times 10^{-3}}$ frequency = 100 (Hz)	B1	
		(ii)	$2.0 \times 10^{-2} = B \times 1.6 \times 10^{-3} \times 400$ $B = \frac{2.0 \times 10^{-2}}{1.6 \times 10^{-3} \times 400}$ $B = 3.1 \times 10^{-2}$ (T)	C1 C1 A1	**Allow**: 2 mark for 3.1×10^{n}; $n \neq -2$ (POT error) Answer to 3 sf is 3.13×10^{-2} (T) **Special case**: 12.5 scores 1 mark; number of turns omitted
		(iii)	(e.m.f. = -) rate of change of flux <u>linkage</u> <u>Tangent</u> drawn on Fig. 3.1 at 2.5 (ms) or 7.5 (ms) or 12.5 (ms) Values substituted to determine the gradient. The gradient must be 12.5 ± 1.0 (V)	B1 B1 B1	**Allow**: $E = (-)\frac{\Delta(N\phi)}{\Delta t}$ or (e.m.f. =) gradient **Alternative**: maximum e.m.f. = $2\pi f \times$ maximum flux linkage C1 maximum e.m.f. = $2\pi \times 100 \times 2 \times 10^{-2}$ C1 maximum e.m.f. = 12.6 (V) or 4π (V) A1
	(b)		$P = \frac{V^2}{R}$ $P = \frac{12^2}{150}$ power = 0.96 (W)	C1 A1	Possible ecf from **(a)(iii)**

7.

Question			Expected Answers	Marks	Additional guidance
	(a)		Electromotive force is the energy transferred (from one form of energy) to electrical per unit charge	B1	**Allow:** 'electrical energy (gained) per unit charge' **Not:** electrical energy per coulomb
	(b)		Magnetic flux is the product of the (magnetic) flux density and the area (normal to the field)	B1	**Allow:** $\phi = BA$, where B = (magnetic) flux density and A = area. If $\phi = BA\cos\theta$ is used, then θ must be defined as the angle (between the normal to the plane of the area and the magnetic field) **Do not allow** 'field strength' for 'flux density'
	(c)	**(i)**	A changing (magnetic) flux is produced (in the primary coil / in the iron core) The iron core links this (magnetic) flux /(magnetic) flux density to the secondary coils The changing (magnetic) flux / (magnetic) flux density through secondary induces e.m.f. (in secondary coils)	B1 B1 B1	**Allow:** A changing (magnetic) flux density is produced (in the primary coil) but **not** '*changing (magnetic) field*' **Allow:** The rate of change of (magnetic) flux (linkage) induces an e.m.f. (in the secondary coil)
		(ii)	Any one from: More coils / turns on secondary Less coils / turns on primary Laminate the core	B1	**Not:** Increase frequency of alternating supply
	(d)	**(i)**	$\frac{n_s}{4200} = \frac{12}{230}$ (Any subject) number of turns = 219 or 220	C1 A1	**Note:** A bald answer 219 or 220 scores 2 marks
		(ii)	current = $(12.0 - 11.8)/0.35$ current = 0.57 (A) -- $P = VI$ or $P = I^2R$ or $P = V^2/R$ $P = 0.2 \times 0.57$ or $P = 0.57^2 \times 0.35$ or $P = 0.2^2/0.35$ power = 0.114 (W) or 0.11 (W)	C1 A1 C1 A1	Possible e.c.f. from **(ii)1**