Mixed Exam Questions – Set 12 - Answers

1.

(a)	(i)	alpha-particle / ${}^{4}_{2}He$ / ${}^{4}_{2}\alpha$	B1	
	(ii)	nucleon number for Bi = 209	B1	
		antineutrino / ${}^{(0)}_{(0)}\bar{\upsilon}_{(e)}$	B1	Note: Do not allow incorrect subscript and superscript
(b)	(i)	Aluminium (sheet placed between source and detector)	M1	
		The count (rate) reduces	A1	Allow count (rate) drop to background / zero
		or		Allow 2 marks for 'the range in air is a few m'
		Magnetic / electric field used	M1	
		Electrons identified from correct deflection / motion in field	A1	
	(ii)			Allow credit for alternative methods
		(λ =) ln2/3.3 (h^{-1}) or (λ =) 0.21 (h^{-1})	C1	
		(A_0 =) $12 \times 10^3/e^{-(0.21 \times 7.0)}$ or (A_0 =) 5.219×10^4 (Bq)	C1	Note this is the same as $12 \times 10^3 \div (0.5)^{7.0/3.3}$
		(N_0 =) $5.219 \times 10^4/5.835 \times 10^{-5}$	C1	
		number of nuclei = 8.9×10^8	A1	Note 9.0×10^8 can score full marks if numbers are rounded
		Or		
		(λ =) ln2/[3.3×3600] (s^{-1}) or (λ =) 5.835×10^{-5} (s^{-1})	C1	
		(N =) $1.2 \times 10^4/5.835 \times 10^{-5}$ or 2.057×10^8	C1	Possible ECF for incorrect conversion of time
		(N_0 =) $2.057 \times 10^8/e^{-(0.21 \times 7.0)}$	C1	Note this is the same as $2.057 \times 10^8 \div (0.5)^{7.0/3.3}$
		number of nuclei = 8.9×10^8	A1	

2.

(i)	Proton is repelled (by nucleus) (High-speed) proton can get close to (oxygen) nucleus	B1 B1	 **Allow** 'proton can experience the strong (nuclear) force' **Not** 'collide / hit nucleus'
(ii)	$E = [0.25 - (2.24 - 2.20)] \times 10^{-11}$ (J) **or** 0.21×10^{-11} (J) $\lambda = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{0.21 \times 10^{-11}}$ (Any subject) $\lambda = 9.5 \times 10^{-14}$ (m)	C1 C1 A1	 **Allow** 2 marks for 6.9×10^{-14}; $E = 0.29 \times 10^{-11}$ used **Allow** 1 mark for a value correctly calculated based on any other incorrect value for E (e.g. $8(.0) \times 10^{-14}$ for $E = 0.25 \times 10^{-11}$ and $5(.0) \times 10^{-13}$ for $E = 0.04 \times 10^{-11}$)

3.

(a)		Correct pattern Correct direction of the field	B1 B1	**Note**: At least five field lines must be drawn and of these, two must be perpendicular (by eye) to the surface of the sphere and plate **Note**: This may be shown on just one line
(b)		(Electric potential) is the work done per (unit) charge in bringing a positive charge from infinity (to the point).	B1	**Allow**: work done / energy required to bring a unit positive charge from infinity (to the point)
(c)	(i)	$V = Q/4\pi\varepsilon_0 r$ (Allow any subject) $Q = 4\pi \times 8.85 \times 10^{-12} \times 0.015 \times 5000$ $Q = 8.3(4) \times 10^{-9}$ (C)	C1 C1 A0	**Note** using $E = V/d$ with $E = Q/4\pi\varepsilon_0 r^2$ is wrong physics and hence scores zero **Note** if the value of ε_0 is not given here, it could be implied in the correct 3sf answer **Allow** any subject here if the answer is given to more than 2sf **Allow** the use of $1/4\pi\varepsilon_0 = 9 \times 10^{9}$

	(ii)1	(electric force =) $1.7 \times 10^{-2} \times \tan 4.0$ (Allow any subject) (electric force = 1.19×10^{-3} N)	**M1** **(A0)**	**Not** 1.7×10^{-2} sin4 or 1.7×10^{-2} cos86 **Allow** $1.7 \times 10^{-2} \times$ sin4/cos4
	(ii)2	$E = 1.2 \times 10^{-3}/8.3(4) \times 10^{-9}$ $E = 1.4 \times 10^{5}$ (N C^{-1})	**C1** **A1**	 **Allow** 2 marks for 1.45×10^{5} (N C^{-1}), 8.3×10^{-9} used **Allow** 2 marks for 1.43×10^{5} (N C^{-1}), 1.19×10^{-3} (N) used

4.

(a)		${}^{2}_{1}\mathrm{H}$ has two nucleons	**B1**	
		binding energy per nucleon = 1.1 MeV (per nucleon)	**B1**	**Allow** 1.76 × 10^{-13} J (per nucleon)
(b)		The protons / nuclei repel each other	**B1**	**Not** atoms / particles
		(At high temperature) particles have more KE **and** hence can get close (enough to fuse)	**B1**	**Allow** 'enough KE to get close' **Not** atoms or ions
(c)		$E = hc/\lambda$ **and** $E = mc^2$ or $E = 2 \times mc^2$	C1	**Allow** $hc/\lambda = 2mc^2$ with or without the factor of 2
		$\lambda = \dfrac{6.63 \times 10^{-34}}{\mathbf{2} \times 9.11 \times 10^{-31} \times 3.0 \times 10^{8}}$	C1	**Note**: The mass must be $2m_e$ to score this and the next mark
		maximum wavelength = 1.2 × 10^{-12} (m)	**A1**	**Not** de Broglie equation $\lambda = h/mv$ with speed of c; which gives 2.4 × 10^{-12} (m) **Allow** 2 marks for 6.6 × 10^{-16} (m); mass of neutron or proton used instead **Allow** the following marks for 1.02 MeV recalled: E = 1.63 × 10^{-13} (J) C1 $\lambda = \dfrac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{1.63 \times 10^{-13}}$ C1 maximum wavelength =1.2 × 10^{-12} (m) A1

5.

a	i	*Two examples (any order):* • when charged particle is at rest **or** not moving relative to field ✓ • when charged particle moves parallel to magnetic field ✓	2
a	ii	$BQv = \frac{mv^2}{r}$ ✓ (gives $BQr = mv$) B and Q are constant so $r \propto$ momentum (mv) ✓	2
b	i	upwards (perpendicular to plane of diagram) ✓	1
b	ii	$v\left(= \frac{BQr}{m}\right) = \frac{0.48 \times 1.60 \times 10^{-19} \times 0.19}{1.67 \times 10^{-27}}$ ✓ = 8.7(4) × 10^6 (m s^{-1}) ✓	2
b	iii	length of path followed (= length of semi-circle) = πr ✓ time taken $t\left(= \frac{\pi r}{v}\right) = \frac{\pi \times 0.19}{8.74 \times 10^6}$ = 6.8(3) × 10^{-8} (s) ✓ [**or** $\frac{v}{r} = \frac{BQ}{m}$ gives $t = \frac{\pi r}{v} = \frac{\pi m}{BQ}$ ✓ $= \frac{\pi \times 1.67 \times 10^{-27}}{0.48 \times 1.60 \times 10^{19}}$ = 6.8(3) × 10^{-8} (s) ✓]	2

b	iv	$v \propto r$ (and path length $\propto r$) ✓ t = (path length/ v) **or** (πr / v) so r cancels ($\therefore$time doesn't depend on r) ✓ [**or** $t\left(=\frac{\pi r}{v}\right)=\frac{\pi rm}{BQr}$ ✓ $=\frac{\pi m}{BQ}$ (because r cancels) ✓] [**or** $BQv = m\omega^2 r$ gives $BQ\omega r = m\omega^2 r$ and $BQ = m\omega = 2\pi fm$ ✓ $\therefore$ frequency is independent of r ✓]	2

c		$v_{max} = 8.74 \times 10^6 \times \left(\frac{0.47}{0.19}\right) = 2.16 \times 10^7$ (m s^{-1}) ✓ E_k (= ½ mv_{max}^2) = ½ × 1.67 × 10^{-27} × (2.16 × 10^7)^2 ✓ (= 3.90 × 10^{-13} J) $= \frac{3.90\times10^{-13}}{1.60\times10^{-13}}$ = 2.4(4) (MeV) ✓	3

6.

a	i	60 (degrees) ✓	1

a	ii	angle required is 150° ✓ which is 5π/6 [**or** 2.6(2)] (radians) ✓	2

b	i	(magnitude of the induced) emf ✓	1

b	ii	frequency $\left(=\frac{1}{T}\right)=\frac{1}{40\times10^{-3}}$ ✓ (= 25 Hz) no of revolutions per minute = 25 × 60 = 1500 ✓	2

b	iii	maximum flux linkage (=BAN) = 0.55 (Wb turns) ✓ angular speed $\omega\left(=\frac{2\pi}{T}\right)=\frac{2\pi}{40\times10^{-3}}$ ✓ (= 157 rad s^{-1}) peak emf (= $BAN\omega$) = 0.55 × 157 = 86(.4) (V) ✓ [**or**, less accurately, use of gradient method ✓ {e.g. $\varepsilon\left(=\frac{\Delta(N\Phi)}{\Delta t}\right)=\frac{0.5-(-0.5)}{(16-4)\times10^{-3}}=\frac{1.0}{12\times10^{-3}}$ } = 83 (± 10) (V) ✓ ✓ (max 2 for (iii) for values between 63 and 72 V or 94 and 103V)]	3

c		sinusoidal shape of constant period 40 ms ✓ correct phase (i.e. starts as a minus sin curve) ✓	2

d		$BAN = 0.55$ ∴ flux density $B=\frac{0.55}{4.0\times10^{-3}\times550}$ ✓ = 0.25(0) (T) ✓	2