Mixed Exam Questions – Set 11 - Answers

1.

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

2.

5.

Question	Answers	Additional Comments/Guidelines	Mark
(a)	(using mass defect = $\Delta m = Z\, m_p + N\, m_n - M_{Co}$) $\Delta m = 27 \times 1.00728 + 32 \times 1.00867 - 58.93320$ (u) ✓ $\Delta m = 0.5408$ (u) ✓ Binding Energy = 0.5408 × 931.5 = 503.8 (MeV) ✓ (CE this mark stands alone for the correct energy conversion even if more circular routes are followed.	Look at use of first equation and if electrons are used or mass of proton and neutron confused score = 0. If subtraction is the wrong way round lose 1 mark. Data may come from rest mass eg m_n =939.551 MeV or 1.675×10^{-27} kg or 1.00867 u. So if kg route used $\Delta m = 8.83 \times 10^{-28}$ kg BE = 7.95×10^{-28} J and 497 Mev. Conversion mark (2nd) may come from a wrong value worked through. 0.47(5)	3
(b)	$(2.52 - 1.76) \times 10^{-13} = 7.6 \times 10^{-14}$ J ✓ $7.6 \times 10^{-14} / 1.60 \times 10^{-13} = 0.47$ or 0.48 MeV ✓(0.475 MeV)	Correct answer scores both marks.	2
(c)	6 (specific wavelengths)		1
(d)	(longest wavelength = lowest frequency = smallest energy) $(2.29 \times 10^{-13} - 2.06 \times 10^{-13}) = 2.3 \times 10^{-14}$ (J) ✓ λ (= $h\, c\, /\, E$) = $6.63 \times 10^{-34} \times 3.00 \times 10^{8} / 2.3 \times 10^{-14}$ ✓ $\lambda = 8.6 - 8.7 \times 10^{-12}$ (m) ✓ (8.6478×10^{-12} m)	Allow a CE in the second mark only if the energy corresponds to an energy gap including those to the ground state. The allowed energy gaps for CE are: 2.29, 2.06, 1.76, 0.53, 0.30 all x 10^{-13}J Note substitution rather than calculation gains mark. The final mark must be as shown here and not from a CE above.	3

3.

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 secondary; second line along same path not touching/crossing, etc.,	**1** **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 change of flux linkage	**1** **1**	
	2	$V_p/V_s = n_p/n_s$ (in an ideal transformer); so larger n_s is relative to n_p the larger the secondary voltage	**1** **1**	**9**

4.

Question			Answer	Marks	Guidance
	(a)	(i)	$f = \frac{1}{T} = \frac{1}{10\times10^{-3}}$ frequency = 100 (Hz)	B1	
		(ii)	$2.0\times10^{-2} = B\times1.6\times10^{-3}\times400$ $B = \frac{2.0\times10^{-2}}{1.6\times10^{-3}\times400}$ $B = 3.1 \times 10^{-2}$ (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)**

Question	Answers	Additional Comments/Guidance	Mark
(a)	force between two (point) charges is proportional to product of charges ✓ inversely proportional to square of distance between the charges ✓	Mention of force is essential, otherwise no marks. Condone "proportional to charges". Do not allow "square of radius" when radius is undefined. Award full credit for equation with all terms defined.	2
(b)	V is inversely proportional to r [**or** $V \propto (-)1/r$] ✓ (V has negative values) because charge is negative [**or** because force is attractive on + charge placed near it **or** because electric potential is + for + charge and – for – charge] ✓ potential is defined to be zero at infinity ✓	Allow $V \times r$ = constant for 1st mark	max 2
(c)(i)	$Q(=4\pi\varepsilon_0 rV) = 4\pi\varepsilon_0 \times 0.125 \times 2000$ (for example, using any pair of values from graph) ✓ = 28 (27.8) (± 1) (nC) ✓	**or** gradient = $Q/4\pi\varepsilon_0$ = 2000/8 ✓ (gives Q = 28 (27.8) ±1 (nC) ✓	2
(c)(ii)	at r = 0.20m V = –1250V and at r = 0.50m V = –500V so pd ΔV = –500 – (–1250) = 750 (V) ✓ work done ΔW (= $Q\Delta V$) = $60 \times 10^{-9} \times 750$ = $4.5(0) \times 10^{-5}$ (J) (45 μJ) ✓ (final answer could be between 3.9 and 5.1×10^{-5})	Allow tolerance of ± 50V on graph readings. [Alternative for 1st mark: $\Delta V = \frac{27.8 \times 10^{-9}}{4\pi\varepsilon_0} \times \left(\frac{1}{0.2} - \frac{1}{0.5}\right)$ (**or** similar substitution using 60 nC instead of 27.8 nC: use of 60 nC gives ΔV = 1620V)]	2
(c)(iii)	$E\left(=\frac{Q}{4\pi\varepsilon_0 r^2}\right) = \frac{27.8 \times 10^{-9}}{4\pi\varepsilon_0 \times 0.40^2}$ ✓ = 1600 (1560) (V m^{-1}) ✓ [or deduce $E = \frac{V}{r}$ by combining $E = \frac{Q}{4\pi\varepsilon_0 r^2}$ with $V = \frac{Q}{4\pi\varepsilon_0 r}$ ✓ from graph $E = \frac{625 \pm 50}{0.40}$ = 1600 (1560 ± 130) (V m^{-1}) ✓]	Use of Q = 30 nC gives 1690 (V m^{-1}). Allow ecf from Q value in (c)(i). If Q = 60 nC is used here, no marks to be awarded.	2

6.
(a)

Answers	Additional comments/Guidelines	Mark
$V = V_0\left(1 - e^{-\frac{t}{RC}}\right)$ with substitution attempted with V_0 being larger than V ✓1 Time to charge to 4.0 V = $t_2 = -R_1C\ln\left(1-\frac{4}{6}\right)$ **OR** Time to charge to 2.0 V = $t_1 = -R_1C\ln\left(1-\frac{2}{6}\right)$ ✓2 $t = t_2 - t_1 = -R_1C\ln\left(\frac{1}{3}\right) - \left\{-R_1C\ln\left(\frac{2}{3}\right)\right\}$ $\left(= -R_1C\left(\ln\frac{1}{3} - \ln\frac{2}{3}\right) = -R_1C\ln\left(\frac{\frac{1}{3}}{\frac{2}{3}}\right)\right) = -R_1C\ln\left(\frac{1}{2}\right) = 0.69R_1C$ **OR** $= R_1C(1.10 - 0.41) = 0.69R_1C$ ✓3	NB The answer can be obtained incorrectly by finding the time to charge to 2V using a 4V supply. This approach may only gain the first mark for an attempted use of the equation. Award 0 for a solution using the discharge equation. Condone R for R_1 ✓2 If given in an equation then then time must be the subject or be in a form that is used to obtain mp3 can be awarded for $t_2 = 1.10 \times R_1C$ **OR** $t_1 = 0.41 \times R_1C$ ✓3 Must see 0.69 R_1C for 3 marks. Only award MP3 for $0.69R_1C$ if the solution involves a time difference.	3

(b)

Answers	Additional comments/Guidelines	Mark
Attempt to find usable data from **Figure 9** ✓$_1$ Determine scaling factor **OR** Determine R_1 ✓$_2$ Calculate Q the charge stored at 4 V or the charging time constant **from a valid method** ✓$_3$ Determine C to a value that rounds to 1×10^{-4} (F) to 2 or more sf (expect to see 1.0×10^{-4} F) ✓$_4$ **Method 1 (from area)** ✓$_{1a}$ Attempt at finding area under I–t graph by counting boxes ✓$_{2a}$ 1 cm^2 box corresponds to charge 0.5×10^{-5} C ✓$_{3a}$ Number of 1 cm^2 boxes = 80 (78 to 82) $Q = (80 \times 0.5 \times 10^{-5}) = (3.9 \text{ to } 4.1) \times 10^{-4}$ (C) ✓$_{4a}$ $C = \frac{\text{their } Q}{4}$ = a value that rounds to 1×10^{-4} (F) (≥ 2 sf required) Award **MAX 1** for estimating the average current by sight and using $C = \frac{IT}{V}$.	**Method 2 (from individual data points)** Possible methods are shown but only final answers requested are needed to gain marks. ✓$_{1b}$ Use of a current and voltage across the resistor, e.g. $I = 2.0 \times 10^{-5}$ A and voltage across resistor = 2 V (when capacitor has 4 V) **OR** $I = 6.0 \times 10^{-5}$ A and voltage across resistor = 6 V (when capacitor has 0 V) ✓$_{2b}$ $R_1 = \frac{V}{I} = \frac{2.0}{2.0 \times 10^{-5}}$ **OR** $\left(\frac{V}{I} = \frac{6}{6 \times 10^{-5}}\right) = 1.0 \times 10^{5}$ (Ω) ✓$_{3b}$ Charging time constant = R_1C Eg using $I = I_0 e^{\frac{-t}{R_1C}}$ then $R_1C = \frac{t}{\ln\left(\frac{I_0}{I}\right)}$ Substituting $I = 2 \times 10^{-5}$ A and $I_0 = 6 \times 10^{-5}$ A and $t = 11$ s. OR Graphical method must include evidence from Figure 9 charging time constant (R_1C) = 10.(0) (s) ✓$_{4b}$ $C = \frac{\text{time constant}}{R_1} = \frac{10.0}{1.0 \times 10^{5}}$ = a value that rounds to 1×10^{-4} (F) (≥ 2 sf required)	4

(c)

Answers	Additional comments/Guidelines	Mark
Reading of relevant discharge data from **Figure 10** provided there is an attempt to use data ✓$_1$ A valid substitution of their data into a relevant equation to find R_1 or R_{Total} ✓$_2$ $R_2 = R_{Total} - \text{their } R_1 = 2.0 \times 10^5\ \Omega$ ✓$_3$ allow **one** ecf from either their R_{Total} **or** their R_1 When R_1 is derived in an earlier question accept this value of R_1 and allow ecf for R_{total} When R_1 is derived in this question, allow one ecf from either their R_{total} or their R_1	✓$_1$ From **Figure 10** this can be the time taken for the voltage to fall to half its value. ✓$_2$ Finding R_{Total} from **Figure 10** 4.0 V to 2.0 V in (32 − 11) s using $t_{\frac{1}{2}} = 0.69RC$ allow $= 0.7RC$ $R_{Total} = 3.0 \times 10^5\ \Omega$ Finding R_1 from **Figure 9** 6.0 A to 3.0 A in 6.8 s using $t_{\frac{1}{2}} = 0.69RC$ allow $= 0.7RC$ $R_1 = 1.0 \times 10^5\ \Omega$ **OR** Using $I = I_o e^{\frac{-t}{R_1 C}}$ for example, with $I = 2 \times 10^{-5}$ A and $I_o = 6 \times 10^{-5}$ A and $t = 11$ s Note R_1 may be taken from **05.2** and not use the graph information.	3