Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*		$\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} = \frac{\ln 2}{3.8}$ day^{-1} [=0.182 day^{-1}] (1) Activity after 12 days $A = A_0 \exp\left(-\frac{12 \ln 2}{3.8}\right)$ (1) substitution = $0.112A_0$ (1) ∴ % reduction = 88.8%(1) (Accept variation because of rounding) **Alternative** Number of half-lives, $n = \frac{12}{3.8} = 3.16$ [or by implication] (1) Fraction after 12 days $= 2^{-3.16}$ (1) = 0.112 (1) = 11.2% ∴ Percentage reduction = 88.8% (1)		4		4	4	
	(b)		Any 4 × (1) 1) Counts is reduced significantly (or equivalent alternatives e.g. by almost a half) by the paper, so alpha particles present (✓) 2) Another significant reduction (or alternative e.g. essentially all of the remaining radiation is stopped) by the aluminium, so beta particles present (✓) 3) Count with lead is larger than with aluminium (but almost the same) so no gamma present (✓) 4) The measured counts with aluminium and lead are essentially the same, so this is because of background radiation / the background radiation is approximately 25 counts per minute. (✓) 5) Randomness of nuclear decay is the reason for increased value with lead. (✓)		4		4		4
			Question 5 total	**0**	**8**	**0**	**8**	**4**	**4**

#2

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
	(a)		Diagram showing source, absorber and detector or equivalent stated in words (1) I. Take measurement with no source and no paper/aluminium – [to measure the background radiation] or show awareness of background. II. Measure count rate with no paper/aluminium. **(1 for both I and II)** III. Insert [a few sheets of] paper between the source and receiver and take measurement. If reduction from count in II then alpha particles present. (1) IV. Insert [a few mm of] aluminium between the source and receiver and take measurement. If reduction in the count from that in III then beta particles are also present **and** if count is still above the background level, then gamma radiation is present – this penetrates the aluminium. (1)	4			4		4
	(b)	(i)	$\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} = \frac{\ln 2}{(11.4 \times 24 \times 60 \times 60)}$ Substitution (1) 7.037×10^{-7} s^{-1} **unit** (1) **Alternative solution:** $\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} = \frac{\ln 2}{11.4}$ substitution (1) $= 0.0608$ days^{-1} **unit** (1)	1	1		2	2	
		(ii)	$\frac{57.0}{11.4} = 5$ so 5 half lives (1) Activity $= \frac{1}{2^5}A_o = \frac{1}{32}A_0$ (1) **Alternative solution:** $A = A_0 e^{-\lambda t}$; $t = 5T_{\frac{1}{2}}$ and $\lambda = \frac{\ln 2}{T_{\frac{1}{2}}}$; substitution $A = A_0 e^{-5 \ln 2}(1)$ $= A_0 \frac{1}{2^5} = \frac{1}{32}A_0(1)$	1	1		2	2	
		(iii)	Let the initial number of particles be N_0, so number of particles remaining after 57 days $= \frac{1}{32}N_0$ i.e. $A \propto N(1)$ Decrease in the number of nuclei in 57 days $= \left(1 - \frac{1}{32}\right) N_0$ i.e. decrease (1) Percentage decrease $= \frac{\left(1-\frac{1}{32}\right)N_0}{N_0}$ 100% $= 96.875\%$ i.e. percentage (1) Answer only of 3% award 2 marks only	1	1 1		3	3	
			Question total	**7**	**4**	**0**	**11**	**7**	**4**

#3

Question				Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*			$^{228}_{90}Th \rightarrow {}^{224}_{88}Ra + {}^{4}_{2}\alpha$ (1) $^{90}_{38}Co \rightarrow {}^{90}_{39}Y + {}^{0}_{-1}\beta$ (1)		2		2		
	(b)			Nucleon mass = 90.727 u **or** nucleon mass +38 e (90.747u) (1) Mass defect attempted with or without electrons 0.84 u or 0.82 u (1) × 931 and division by 90 (1) Answer = 8.69 [MeV per nucleon] (1) If electrons not taken into account answer = 8.47 [MeV per nucleon] award 3 marks 782 or 762 [MeV per nucleon] award 2 marks	1	1 1 1		4	3	
	(c)	(i)		Probability of landing on black face = ¼ **or** 0.25 **or** 25 %		1		1	1	1
		(ii)	I.	Probability of not decaying (i.e. of remaining) after 1 throw = 1 – 0.25 = 0.75 (1) Probability of remaining after 2 throws = 0.75^2 **or** probability of remaining after n throws = $(0.75)^n$ (1)		2		2	2	2
			II.	Number predicted = $N_0 \times (0.75)^n = 31.76 = 32$ Accept 31 or 31.76		1		1	1	1
			III.	Close to 0.75 for many throws **or** mean close to 0.75 or 32 is close to 35 or fits quite well with $(0.75)^n$ (1) Some further out e.g. 0.90 (1) Random process [these results are to be expected] (1)			3	3		3
				Question 6 total	**1**	**9**	**3**	**13**	**7**	**7**