Name of the Student:_____
Max. Marks : 18 Marks **Time : 18 Minutes**

Mark Schemes

Q1.

Question Number	Acceptable Answer	Additional Guidance	Mark
*	This question assesses a student's ability to show a coherent and logical structured answer with linkage and fully-sustained reasoning. **Indicative content:** IC1 There is a fixed probability (λ) of an individual nucleus undergoing decay (in the next second) IC2 For a sample with large number of unstable nuclei there is a predictable pattern IC3 The fraction of nuclei decaying in the next second is equal to the decay constant (λ)	Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. Number of indicative marking points seen in answer / Number of marks awarded for indicative marking points 6 / 4 5–4 / 3 3–2 / 2 1 / 1 0 / 0 Number of marks awarded for structure of answer and sustained line of reasoning Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout / 2 Answer is partially structured with some linkages and lines of reasoning / 1 Answer has no linkages between points and is unstructured / 0 Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning IC points / IC mark / Max linkage mark / Max final mark 6 / 4 / 2 / 6 5 / 3 / 2 / 5 4 / 3 / 1 / 4 3 / 2 / 1 / 3 2 / 2 / 0 / 2 1 / 1 / 0 / 1 0 / 0 / 0 / 0	6

	IC4 Hence the number of nuclei decaying (in the next second) depends on the number of (unstable) nuclei **Or** activity = λN IC5 The number of unstable nuclei decreases		
	exponentially (with time) **Or** number of (unstable) nuclei = $N_0 e^{-\lambda t}$ IC6 So the rate of decay decreases exponentially (with time) **Or** rate of decay = $A_0 e^{-\lambda t}$		

Q2.

Question Number	Answer		Mark
(a)	Activity is the rate of <u>decay</u> (of radioactive nuclei) **Or** the number of <u>decays</u> in a second	(1)	1
(b)	Use of $\lambda t_{1/2} = 0.693$ Use of $A = -\lambda N$ $N = 1.9 \times 10^{12}$ <u>Example of calculation:</u> $\lambda = \frac{0.693}{3.89 \times 10^{8}\ \text{s}} = 1.78 \times 10^{-9}\ \text{s}^{-1}$ $N = \frac{3450\ \text{s}^{-1}}{1.78 \times 10^{-9}\ \text{s}^{-1}} = 1.94 \times 10^{12}$	(1) (1) (1)	3
(c)(i)	Use of $A = A_0 e^{-\lambda t}$ Conversion between seconds and years t = 41 (years) <u>Example of calculation:</u> $0.1 = e^{-(1.78 \times 10^{-9}\ s^{-1})t}$ $t = 1.29 \times 10^{9}$ s $t = 1.29 \times 10^{9}\ \text{s} / (365 \times 24 \times 3600\ \text{s y}^{-1}) = 41$ y	(1) (1) (1)	3
(c)(ii)	This is a very long time and so: The sample's activity will stay approx. constant for the procedure **Or** tritium may be in the body long enough for damage to be caused **Or** the sample can be prepared well in advance of the procedure	(1) (1) (1)	1
	Total for question		8

Q3.

Question Number	Acceptable answers	Additional guidance	Mark
	An explanation that makes reference to the following points: • Use of $\lambda = \frac{\ln 2}{t_{1/2}}$ (1) • (Hence) initial activity of Ac is 50% that of Bi **Or** (Hence) decay constant of Ac is 50% that of Bi (1) • Applies one or two half lives to show fraction of initial activity/number after 10 days for one isotope **Or** Use of exponential decay equation to show fraction of initial activity/number after 10 days for one isotope (1) • Demonstrates quantitatively that both isotopes have the same activity (1)	<u>Alternative approach:</u> $\lambda_{Ac} = \frac{\ln 2}{10}$ $A_{Ac} = \lambda_{Ac} N = \frac{\ln 2}{10} \times N$ After 10 days $A_{Ac} = \frac{1}{2} \times \frac{ln2}{10} \times N = \frac{\ln 2}{20} \times N$ $\lambda_{Bi} = \frac{\ln 2}{5}$ $A_{Bi} = \lambda_{Bi} N = \frac{\ln 2}{5} \times N$ After 10 days $A_{Bi} = \frac{1}{2} \times \frac{1}{2} \times \frac{\ln 2}{5} \times N = \frac{ln2}{20} \times N$ $A_{Ac} = A_{Bi}$ **MP2** can be awarded for use of **both** decay constants in exponential decay equations All four marks may be awarded for a full mathematical demonstration, e.g.: $\lambda_{Ac} = \frac{\ln 2}{10} = 0.0693 \text{ day}^{-1}$ $A_{Ac} = \lambda_{Ac} N = 0.0693 \text{ day}^{-1} \times N$ 10 days: $A_{Ac} = ½ \times 0.0693 \text{ day}^{-1} \times N = 0.0345 \text{ day}^{-1} \times N$ $\lambda_{Bi} = \frac{\ln 2}{5} = 0.139 \text{ day}^{-1}$ $A_{Bi} = \lambda_{Bi} N = 0.139 \text{ day}^{-1} \times N$ 10 days: $A_{Bi} = ½ \times ½ \times 0.139 \text{ day}^{-1} \times N = 0.0345 \text{ day}^{-1}$ $A_{Ac} = A_{Bi}$	4