

Name of the Student: _____

Max. Marks : 19 Marks

Time : 19 Minutes

Mark Schemes

Q1.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	8 alpha decays reduce the proton number by 16 (1) - proton number decreases by only 10, so there must be 6 β^- decays (1) OR - balanced equation written for overall decay (1) - explicit solution to give 6 β^- decays (1)	Example of calculation: ${}_{92}^{238}\text{U} \rightarrow {}_{82}^{206}\text{Pb} + 8\alpha + N\beta^-$ $92 = 82 + (8 \times 2) - N$ $92 = 82 + 16 - N$ $N = 98 - 92 = 6$ Proof must be given to obtain these marks.	2
(ii)	- use of $\lambda t_{1/2} = \ln 2$ (1) - use of $N = N_0 e^{-\lambda t}$ (1) $N/N_0 = 0.1$ (1) $t = 2.5 \times 10^5$ years (1)	Example of calculation: $\lambda = \frac{0.693}{75000} = 9.24 \times 10^{-6} \text{ y}^{-1}$ $\lambda t = -\ln\left(\frac{N}{N_0}\right)$ $\therefore t = \frac{-\ln(0.1)}{9.24 \times 10^{-6} \text{ y}^{-1}} = 2.49 \times 10^5 \text{ y}$	4

Question Number	Acceptable Answer				Additional Guidance	Mark																				
*	IC points	IC mark	Max linkage mark	Max final mark	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The table shows how the marks should be awarded for indicative content and structure and lines of reasoning. <table border="1"> <thead> <tr> <th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr> </thead> <tbody> <tr><td>6</td><td>4</td></tr> <tr><td>5-4</td><td>3</td></tr> <tr><td>3-2</td><td>2</td></tr> <tr><td>1</td><td>1</td></tr> <tr><td>0</td><td>0</td></tr> </tbody> </table> <table border="1"> <thead> <tr> <th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr> </thead> <tbody> <tr> <td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr> <tr> <td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr> <tr> <td>Answer has no linkages between points and is unstructured</td><td>0</td></tr> </tbody> </table> IC2: accept idea that it takes a long time to decay for "unstable nuclei are present...or a long period of time" IC3 accept a reference to binding energy increasing	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	
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	Indicative content: IC1 The rate of decay depends upon the number of unstable nuclei in the sample ($A = -\lambda N$) IC2 Radium has a large half-life, so unstable nuclei are present in the sample for a long time IC3 When a nucleus decays there is a																									
	(small) decrease in mass Δm IC4 Energy is released according to $\Delta E = c^2 \Delta m$ IC5 Δm is small but c is large, so a significant amount of energy is released IC6 Energy released by the decay becomes kinetic energy of the atoms in the sample (hence sample is above the temperature of the surroundings)																									

6

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
	- Radon gas can be breathed in and can cause damage to living cells - Or Once radon is inside the body the alpha particles/radiation can cause damage to living cells (1) - Because alpha (particles) highly ionising (1)	Accept the idea of damage e.g. causing mutations/cancer etc. Must have stated that this happens inside the body	2

Q4.

Question Number	Acceptable answers	Additional guidance	Mark
	- Use of $\lambda = \frac{\ln 2}{t_{1/2}}$ (1) - Use of $N = N_0 e^{-\lambda t}$ (1) - Use of N_S/N_R to determine N/N_0 (1) $t = 3.7 \times 10^9$ year (1) - Comparison of their value with corresponding value in question and valid conclusion (1) Or - Use of $\lambda = \frac{\ln 2}{t_{1/2}}$ - Use of $N = N_0 e^{-\lambda t}$ - Use of N/N_0 to determine N_S/N_R $\frac{N_S}{N_R} = 0.066$ if $t = \text{age of Earth}$ - Comparison of their value with corresponding value in question and valid conclusion	<u>Example of calculation:</u> $\lambda = \frac{\ln 2}{4.88 \times 10^{10} \text{ year}} = 1.42 \times 10^{-11} \text{ year}^{-1}$ $\frac{N_0}{N} = \frac{N_R + N_S}{N_R} = 1 + \frac{N_S}{N_R} = 1.0532$ $1.0532 = e^{1.42 \times 10^{-11} \text{ year}^{-1} \times t}$ $\therefore t = \frac{\ln(1.0532)}{1.42 \times 10^{-11} \text{ year}^{-1}} = 3.65 \times 10^9 \text{ year}$	5