Mark scheme – Radioactive Emissions

Question			Answer/Indicative content	Marks	Guidance
1			**A** ✓	1 (AO1.1)	
			Total	**1**	
2			**B** ✓	1 (AO 1.1)	
			Total	**1**	
3			**B** ✓	1 (AO 1.1)	**Examiner's Comments** This question required candidates to apply their scientific knowledge and analyse the information in the table about nuclear radiation in order to choose the best isotope to use as medical tracer. **Misconception** Many candidates could identify that gamma was the best radiation to use but had the misconception that a half-life of 6 minutes was long enough. Therefore, they incorrectly chose option C. Teaching often emphasises the need for a short half-life to reduce patient exposure to radiation, but this time cannot be shorter than the time required to carry out the procedure.
			Total	**1**	
4			**B** ✓	**1 (AO1.2)**	**Examiner's Comments** This question required candidates to use their knowledge of half-life to interpret the graph. The majority of candidates were able to work out the half-life of the source using the graph.
			Total	**1**	

5			**B** ✓	**1 (AO1.1)**	**Examiner's Comments** Most candidates successfully applied their knowledge of ionisation to identify what happens to the atom for it to become a positive ion.
			Total	**1**	
6			**C** ✓	**1 (AO2.1)**	**Examiner's Comments** Many candidates chose distractor B as they had the misconception that beta radiation will not pass through aluminium foil. While an aluminium plate will stop beta radiation, thin aluminium foil will not be an effective screen for all the beta radiation.
			Total	**1**	
7			Any one from: Gamma can get out of body / least amount of time to do damage to the body / reasonable half-life (1)	1	
			Total	**1**	
8			C	1	
			Total	**1**	
9			B	1	
			Total	**1**	
10			C	1	
			Total	**1**	
11			D	1	
			Total	**1**	
12			Any two from: Alpha has short range (1) Highest ionising power (1) Longer half-life than D (1)	2	
			Total	**2**	

13	a		If the pattern was followed, 160 cm (ideally) should be 4 / 320 cm (ideally) should be 1 (1) Radiation / activity is random (1) Randomness is amplified at low readings / **AW** (1)	3	
	b		Distance doubles count rate is 4 × less / count rate is inversely proportional to the square of the distance / as distance triples activity is 9 × less / **AW** (2)	2	**ALLOW** distance doubles count rate per minute is reduced by more than half (1)
			Total	**5**	
14	a	i	**226** ✓ Th **90** ✓	**2** (AO2.2) (AO2.2)	
		ii	**0** ✓ β **−1** ✓	**2** (AO2.2) (AO2.2)	
		iii	**235** ✓ U → γ = U **92** ✓	**2** (AO2.2) (AO2.2)	**<u>Examiner's Comments</u>** Almost all candidates were able to complete all three decay equations. Of the small number who could not complete the equation the most common error was stating the atomic number of beta as +1 rather than -1.
	b	i	(Radioactive nuclei) are unstable ✓	**1** (AO1.1)	**ALLOW** (nuclei have) too many neutrons **<u>Examiner's Comments</u>** Just over half of the candidates correctly explained that some isotopes are radioactive because the nuclei are unstable or have too many neutrons. Common incorrect responses referred to 'more neutrons' or ideas about numbers of electrons or protons.
		ii	Different numbers of neutrons ✓	**1** (AO1.1)	**<u>Examiner's Comments</u>** The majority of candidates successfully stated that there are a different number of neutrons in carbon-12 and carbon-14.
			Total	**8**	

15	a		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 128 (counts per minute) award 2 marks** Evidence of halving /doubling using data ✓ (Activity =) 128 (counts per minute) ✓✓	1 (AO 2×2.2)	e.g. time to go from 64 to 32 (cpm) is 30 (mins) / initial activity = 64 × 2 If answer is 105 to 127 or 129 to 136 then award a maximum of 1 mark ✓ **<u>Examiner's Comments</u>** Candidates found this question challenging. Most candidates' answers were in the range allowed for 1 or 2 marks but many made the common error of trying to find the differences between values in the table rather than spotting where the activity had halved.
	b		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 20 (minutes) then award 2 marks** Evidence on graph or elsewhere of half of activity indicated ✓ (Half life =) 20 (minutes) ✓	1 (AO 2×2.2)	**ALLOW** 19-21 (minutes) ✓✓ **<u>Examiner's Comments</u>** Most candidates were able to successfully work out the half-life of isotope A from the graph, although there was evidence that some candidates had not read the initial activity from the scale on the y axis correctly.
			Total	**4**	
16		i	The time it takes the number of (undecayed/radioactive) nuclei to halve ✓	2 (AO1.1)	**ALLOW** count-rate or activity for number of undecayed nuclei **ALLOW** the time it takes for half of the (radioactive) nuclei to decay **ALLOW** atoms for nuclei
		ii	It is long enough so the activity does not change significantly / source will not need to be replaced ✓	1 (AO2.1)	**ALLOW** it will last a long time
		iii	Thorium (is greatest risk to begin with) / ORA ✓ As thorium will have a higher activity/count-rate (at the beginning) / ORA ✓	2 (AO2 × 3.2a)	**ALLOW** thorium decays faster / ORA
			Total	**4**	
17			Conclusion 1 (incorrect) **Any one from:** Idea that activity is a random/unpredictable occurrence / AW ✓ Idea that low numbers of counts amplify relative variations / AW ✓	1 (AO 2×3.1b)	**ALLOW** correct answers referring to background radiation/readings **<u>Examiner's Comments</u>** This Assessment Objective 3 question tested candidates' ability to analyse the information from the graph and draw

			Conclusion 2 (incorrect) **Any one from:** (All radioactive isotopes) have a half-life / AW ✓ changes in activity will be small if half-life is long ✓		conclusions about the activity and the half-life. Many candidates agreed with both conclusions and tried to justify their answers. Candidates were most likely to evaluate conclusion 2 correctly and state that all (radioactive) isotopes have a half-life. It was rare to see conclusion 1 evaluated correctly as candidates did not link the graph to the random nature of radioactive decay.
			Total	**2**	
18	a		237 ✓ 93 ✓ He / α ✓	3 (AO2 × 2.2) (AO1 × 1.1)	
	b		(The nucleus contains) 95 protons ✓ (and) 146 neutrons ✓	2 (AO2 × 1.1)	**IGNORE** references to electrons **ALLOW** the nucleus has a charge of (+) 95
	c		**Any two from:** (Agree) Smoke alarms use small amounts of americium-241 ✓ Mainly emits alpha particles which are stopped by skin/soil ✓ Americium-241 is contained within the foil / AW ✓ Americium-241 cannot move out of materials in detector / be inhaled ✓ Soil emits more radiation ✓ **Or** **Any two from:** (Disagree) Smoke alarm contains an isotope with a long half-life ✓ The smoke alarm/foil could be damaged ✓ Americium-241 may contaminate objects (in the waste) ✓ Americium-241 also emits gamma rays (which are more penetrating that alpha particles) ✓ Soil may not absorb all radiation ✓	2 (AO2 × 3.2a)	**IGNORE** vague answers such as ‘bad for the environment’ **ALLOW** gamma is not stopped by the foil
			Total	**7**	