Q1. (2018)

a)

04.4	risk / activity associated with iodine-131 has decreased by a large amount		1	AO3 6.4.2.3
	because of short half-life	allow many half-lives have passed allow half-life is only 8 days 2nd marking point dependent on 1st marking point	1	
	risk / activity associated with caesium-137 will not have decreased by much	allow activity has halved	1	
	because of long half-life	allow only one half-life has passed 4th marking point dependent on 3rd marking point	1	

b)

04.5		an answer of 2136 scores **3** marks		AO2 6.4.2.3
	5 half-lives	allow any correct method eg ½ × ½ × ½ × ½ × ½ = 1/32	1	
	5 × 30 = 150		1	
	1986 + 150 = 2136	any calculation using a value of 137 scores zero	1	

Q2. (2019)

a)

06.7		an answer of $\frac{1}{32}$ or equivalent scores **4** marks		AO3.1a 6.4.2.3	E
	half-life = 50 seconds	this may be indicated on Figure 7	1		
	250 seconds difference in age = 5 half lives	allow 100 seconds = 2 half lives **and** 350 seconds = 7 half lives	1		
	ratio = $\left(\frac{1}{2}\right)^5$ **or** ratio = $\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}$	allow this mark if they have halved $1.25(\times 10^{23})$ five times to get $0.0390625(\times 10^{23})$ for example $1.25(\times 10^{23})$ → $0.625(\times 10^{23})$ → $0.3125(\times 10^{23})$ → $0.15625(\times 10^{23})$ → $0.078125(\times 10^{23})$ → $0.0390625(\times 10^{23})$	1		
	ratio = $\frac{1}{32}$ **or** ratio = 1:32	allow ratio = 0.031 allow 32:1 **or** 32	1		

b)

06.8	tangent drawn on graph	do not allow a line drawn that crosses the graph line	1	AO2.2 6.4.2.1	E
	use of gradient = $\frac{(\Delta \text{ no. of atoms})}{\Delta \text{ time}}$	values must be taken from their tangent drawn at 20 seconds	1		
	gradient = 5.3 ($\times 10^{21}$) (Bq)	allow gradient = 0.053 ($\times 10^{23}$) (Bq) allow a range between 4.7 ($\times 10^{21}$) (Bq) and 5.9 ($\times 10^{21}$) (Bq)	1		

Q3. (2020)

a)

06.1	both are random processes	allow rolling dice is a random process allow radioactive decay is a random process	1	AO1 6.4.2.3

b)

06.2	144 →72 → 36 →18 → 9	allow the probability of not getting a 6 is 5/6	1	AO2 6.4.2.3
	4 half lives	allow 144 × $(5/6)^4$ = 69	1	
	$\frac{20}{4}$ = 5 (rolls of the dice)	allow 69 is closest to 72 so 4 (rolls of the dice) some credible working must be shown to gain this mark	1	

c)

06.3	a dice with 8 sides will have a smaller chance of decay (in one roll)	allow answers in terms of the 6-sided dice or in terms of more or fewer sides. allow the 8 sided dice has a 1/8 chance of decay, whereas the 6 sided dice has a 1/6 chance of decay	1	AO1 6.4.2.3
	so dice with 8 sides have a greater half-life		1	

d)

06.4	nuclei in source **A** are more stable than nuclei in source **B**	allow nuclei in source A are less likely to decay (in a given time period)	1	AO1 6.4.2.3

Q4. (2021)

02.3	beta radiation is only weakly ionising		1	AO3 6.4.2.1

Q5. (2021)

02.4	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO3 6.4.2.1
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content • move the detector very close to the source • record the count rate • position the paper between the source and the detector • record the new count rate • alpha radiation will not penetrate through paper • if the count rate with the paper is (significantly) less than without then the source emits alpha radiation • remove the paper and position the aluminium between the source and the detector • record the new count rate • (alpha and) beta radiation will not penetrate through the aluminium • if the count rate has (significantly) reduced compared with using paper then beta radiation is present • if radiation penetrates through the aluminium then gamma radiation is present • the experiment should be repeated and mean results calculated because radioactivity is a random process To access level 3, the candidate must use the paper sheet, the aluminium sheet and no sheet, and describe how the results would indicate the presence of alpha, beta or gamma radiation.		

Q6. (2022)

06.4	D B A C	all four letters must be in the correct order explanation only scores if correct order given	1	AO3 6.4.2.1 6.4.2.3
	explanation			
	a substance with a longer half-life has more stable nuclei	allow the more stable a nucleus, the less likely it is to decay (in a given time)	1	
	so answers are in order of increasing half-life		1	

Q7. (2023)

04.6	60 minutes is 4 half-lives	allow 15 minutes is 1 half-life allow 1568 → 784 → 392 → 196 → 98 allow $\frac{1568}{98} = 2^4$ allow $\frac{98}{1568} = \frac{1}{2^4}$	1	AO3 6.4.2.3
	30 minutes is 2 half-lives		1	
	X = 392		1	

Q8. (2024)

05.3	**radon-222** activity remained (almost) the same	allow the radiation emitted (each second) decreased by a small amount	1	AO3 6.4.2.3
	because 7.4 minutes is only a very small fraction of 3.8 days	allow 7.4 minutes is much smaller than 3.8 days allow the time is much less than the half-life	1	
	vanadium-52 activity decreased by a factor of 4		1	
	because 2 half-lives had passed		1	

Uses and hazards of radiation

Q1. (2019)

A)

06.2	gamma radiation is only weakly ionising **or** most gamma radiation will pass through any detector	allow gamma radiation is very penetrating	1	AO1.1 6.4.2.1	E

B)

06.3	any two from • the radiation spreads out in all directions • only some of the radiation goes into the G-M tube • only some of the radiation passing into the GM tube is detected	allow **2** marks for only some of the radiation passing into the GM tube is detected because gamma is weakly ionising	2	AO1.1 6.4.2.4	E

C)

06.4	to reduce the amount of radiation received because radiation increases the risk of cancer or (genetic) mutation	allow to reduce irradiation (of the teacher) allow causes cancer or (genetic) mutation ignore references to contamination	1 1	AO1.1 6.4.2.1 WS 1.4	E

D)

06.5	a calculation of the product of thickness and count rate a second calculation of the product of thickness and count rate a comparison of the calculated values and a recognition that they are different **OR** A calculation of half the count rate (1) A comparison with the count rate for double that thickness (1) A recognition that the values are different (1)	examples of calculations 0.5 × 110 = 55 1.0 × 60 = 60 1.5 × 33 = 50 2.0 × 18 = 36 2.5 × 10 = 25 e.g. $\frac{110}{2} = 55$ the first two marks may be scored for a count rate divided by 3, 4 or 5 compared with the corresponding count rate for 3, 4 or 5 times the thickness e.g. 55 ≠ 60	1 1 1	AO3.1b 6.4.2.1	E

Q2. (2022)

06.1	beta radiation is more penetrating (than alpha radiation) so beta radiation could irradiate people passing near the smoke detector	allow beta radiation can pass through the case (but alpha radiation cannot) allow beta radiation can travel further (in air than alpha radiation) do **not** allow beta radiation is more ionising allow beta radiation can pass through skin	1 1	AO1 6.4.2.1 6.4.2.4	

Q3. (2023)

A)

04.1	peer review		1	AO1 6.4.2.4	

B)

04.2	it is ionising	ignore references to penetrating ability	1	AO1 6.4.2.4 6.4.2.1	

Q4. (2024)

05.1		allow risk for hazard throughout		AO1 6.4.2.4
	Irradiating **EITHER** radiation enters the water	allow alpha / beta / gamma enters the water allow the water does not become radioactive	1	
	(which) does not affect the hazard	dependent on MP1	1	
	OR because radiation can kill pathogens (1)	allow named pathogens e.g. bacteria, viruses		
	(irradiating) decreases the hazard (1)	dependent on MP1		
	contaminating because radioactive isotopes will enter the water / body		1	
	(contaminating) increases the hazard	dependent on MP3	1	