

Mark Scheme

Q1.

Question Number	Answers	Mark
	The only correct answer is A <i>B is incorrect because an incorrect calibration would give a consistently high or low reading</i> <i>C is incorrect because temperature does not affect the background count rate</i> <i>D is incorrect because a systematic error would be a constant difference between the actual and the recorded count rate</i>	1

Q2.

Question Number	Acceptable answers	Additional guidance	Mark
	The only correct answer is A B is not correct as the open window section of film will be dark and the lead window section of film will be white C is not correct as the open window section of film will be dark and the lead window section of film will be white D is not correct as the open window section of film will be dark and the lead window section of film will be white		1

Q3.

Question Number	Answer	Mark
	D	1

Q4.

Question Number	Answer	Mark
	B	1

Q5.

Question Number	Acceptable answers	Additional guidance	Mark
	The only correct answer is C emitting an alpha particle decreases the nucleon number by 4 and decreases the proton number by 2 A is not correct because emitting an alpha particle decreases the nucleon number by 4 and decreases the proton number by 2, but here the nucleon number has been increased by 2 and the proton number has been increased by 4 B is not correct because emitting an alpha particle decreases the nucleon number by 4 and decreases the proton number by 2, but here the nucleon number has been increased by 4 and the proton number has been increased by 2 D is not correct because emitting an alpha particle decreases the nucleon number by 4 and decreases the proton number by 2, but here the nucleon number has been decreased by 2 and the proton number has been decreased by 4		1

Q6.

Question Number	Answer	Mark
	C	1

Q7.

Question Number	Answer	Mark
	D	1

Q8.

Question Number	Acceptable answers	Additional guidance	Mark
	The only correct answer is B because alpha is the most ionising and gamma is the most penetrating A is not correct because although alpha is the most ionising, gamma and not alpha is the most penetrating C is not correct because alpha, not gamma, is the most ionising and gamma, not alpha is the most penetrating D is not correct because alpha, not gamma is the most ionising, even though gamma is the most penetrating		1

Q9.

Question Number	Answer	Mark
	The only correct answer is C <i>A is not correct because the atomic mass number must decrease by 16, which corresponds to 4 alpha decays</i> <i>B is not correct because the atomic mass number must decrease by 16, which corresponds to 4 alpha decays</i> <i>D is not correct because the atomic number would decrease by 8 due to alpha decay, then increase by 6 due to beta decay</i>	1

Q10.

Question Number	Acceptable answers	Additional guidance	Mark
	- Top line correct (1) - Bottom line correct (1)	<u>Example of calculation:</u> ${}_{37}^{87}\text{Rb} \rightarrow {}_{38}^{87}\text{Sr} + {}_{-1}^0\beta^{-} + \bar{\nu}_e$	2

Q11.

Question Number	Acceptable Answer	Additional Guidance	Mark
	α radiation would be absorbed by the plastic bottle (1) β radiation can penetrate the plastic bottle therefore it could/must be β radiation (1)		2

Q12.

Question Number	Acceptable answers	Additional guidance	Mark
	- Alpha won't penetrate the plastic so the gas can't escape (1) - Alpha won't penetrate the plastic so there is no risk (1)	For MP1, accept answers in terms of the small range of alpha particles in the air in the bag	2

Q13.

Question Number	Acceptable Answer	Additional Guidance	Mark
	α-particles would only travel a few cm (in air), and so wouldn't reach the GM-tube (1) β-particles would probably not pass through the sides of the GM-tube, and so wouldn't be detected so suggestion is correct. (1)	Accept a reference to α-particles not passing through the side of the tube (even if they reached it when d was small) and so not contributing to the count (rate) For 2 marks expect a valid conclusion, as well as a statement of the likelihood of the α-particles and β-particles contributing to the count (rate)	2

Q14.

Question Number	Acceptable answers	Additional guidance	Mark
	- top: 40, 0 (1) - bottom: 20, -1 (1)		2

Q15.

Question Number	Acceptable Answer	Additional Guidance	Mark
	- Top line correct (1) - Bottom line correct (1)	<u>Example of equation</u> $^{137}_{55}\text{Cs} \rightarrow ^{137}_{56}\text{Ba} + ^0_{-1}\beta^- + ^0_0\bar{\nu}_e$	2

Q16.

Question Number	Acceptable Answer	Additional Guidance	Mark
	- Top line correct (1) - Bottom line correct (1)	$^{220}_{86}\text{Rn} \rightarrow ^{216}_{84}\text{Po} + ^4_2\alpha$	2

Q17.

Question Number	Acceptable Answers	Additional Guidance	Mark
	An explanation that makes reference to the following points: - Place an aluminum sheet between the source and the detector (1) - As this will absorb/block the alpha and beta radiation emitted by the source (1)	Allow up to 3 mm of lead	2

Q18.

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

Q19.

Question Number	Acceptable Answer	Additional Guidance	Mark
	- Counting for 1 minute is too short a time (1) Or he should count for at least 3 minutes (1) - He hasn't recorded the background count rate (1) - More than one reading taken and a mean calculated Or should have taken more than two readings (to calculate mean)		3

Q20.

Question Number	Acceptable answers	Additional guidance	Mark
	- correct values of A and Z for α and β 5α 4β	<u>Example of calculation:</u> $^{226}_{88}\text{Ra} \rightarrow ^{206}_{82}\text{Pb} + x\ ^{4}_{2}\alpha + y\ ^{0}_{-1}\beta$ $226 - 206 = 4x$ $x = 5$ $88 - 82 - (5 \times 2) = -y$ $y = 4$ $^{226}_{88}\text{Ra} \rightarrow ^{206}_{82}\text{Pb} + 5\ ^{4}_{2}\alpha + 4\ ^{0}_{-1}\beta$	(3)

Q21.

Question Number	Acceptable answers	Additional guidance	Mark
	A description that makes reference to the following points: - Measure the background count (rate) (1) - Measure count (rate) from source (1) - Use paper to absorb alpha radiation (1) - Percentage = $\frac{\text{count with paper}(-\text{background rate})}{\text{count from source}(-\text{background rate})} \times 100$ (1)		4

Q22.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	An explanation that makes reference to the following: • use a GM tube and counter to measure the number of counts in a known time (1) • place a piece of aluminium a few mm thick between the source and the detector (1) • α and β will not penetrate aluminium but γ will (1) • so the source that is unchanged is Co 60 and the one with a decreased count is Ra 226 (1)	Answers may refer to the use of a ratemeter instead of a counter	

	<u>OR</u> use a GM tube and counter to measure the number of counts in a known time • place a strong magnet near the source (1) • α and β will be deviated but γ will not (1) • so the source that is unchanged is Co 60 and the one with a decreased count is Ra 226 (1)		(4)
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Question Number	Acceptable answers	Additional guidance	Mark
(ii)	An explanation that makes reference to a precaution and the reason for it - make sure the source remains at a distance of at least 30 cm from your body to minimise exposure (1) OR - make sure the source is always pointed away from you to minimise exposure (1) OR - only use one source at a time to minimise exposure (1) - the sources emit ionising radiation which can be harmful to your cells (1)		(2)

Q23.

Question Number	Answer	Mark
(a)(i)	Alpha particles ionise the air Or alpha particles strip electrons from air molecules (1) The ions/electrons move (in the electric field between the plates) (1)	2
(a)(ii)	Smoke particles capture electrons (and reduce the free charge able to move) Or alpha particles collide with smoke particles and reduce amount of ionisation (1)	1
(b)(i)	Random means we cannot identify which atom/nucleus will be the next to decay Or we cannot identify when an individual atom/nucleus will decay Or we cannot state exactly how many atoms/nuclei will decay in a set time Or we can only estimate the fraction that will decay in the next time interval (1) Spontaneous means that the decay cannot be influenced by any (external) factors. (1)	2
(b)(ii)	${}_{95}^{237}\text{Am} \rightarrow {}_{93}^{237}\text{Np} + {}_2^4\alpha$ Top line correct (1) Bottom line correct (1)	2
Total for question		7

Q24.

Question Number	Answer	Mark																				
(a)(i)	Ionising radiation removes electrons from atoms/molecules (1)	1																				
(a)(ii)	<table border="1"><tr><td colspan="3">Least ionising $\longrightarrow$ most ionising</td></tr><tr><td>γ</td><td>β</td><td>α</td></tr></table> (1)	Least ionising $\longrightarrow$ most ionising			γ	β	α	1														
Least ionising $\longrightarrow$ most ionising																						
γ	β	α																				
(b)(i)	<table border="1"><tr><td></td><td>Paper</td><td>0.5 cm aluminium</td><td>0.5 cm lead</td><td></td></tr><tr><td>α radiation</td><td>stopped</td><td>stopped</td><td>stopped</td><td>(1)</td></tr><tr><td>β radiation</td><td>passes through</td><td>stopped</td><td>stopped</td><td>(1)</td></tr><tr><td>γ radiation</td><td>passes through</td><td>passes through</td><td>passes through</td><td>(1)</td></tr></table>		Paper	0.5 cm aluminium	0.5 cm lead		α radiation	stopped	stopped	stopped	(1)	β radiation	passes through	stopped	stopped	(1)	γ radiation	passes through	passes through	passes through	(1)	3
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β radiation	passes through	stopped	stopped	(1)																		
γ radiation	passes through	passes through	passes through	(1)																		
(b)(ii)	(There is the possibility of) exposure to neutrons (1) Uncharged particles are not (directly) ionising (1)	2																				
	Total for question	7																				

Q25.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	- The detector area exposed to γ-radiation is larger in the set-up of Student A (1) - So the count (rate) will be greater (at a given distance from the source) (1) - Hence (the percentage uncertainty will be smaller for) Student A (1)	<u>Alternative MP1 and MP2</u> d should be measured to the middle of the counter (1) - The error (or uncertainty) in d is reduced in set-up of Student A (1) MP3 dependent on MP1 and MP2	3

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: - Record the background count (rate) and subtract from recorded count (rate) (1) - Gives count (rate) of source only (1) Or As background count adds to the count from the source - Record the count for a longer time (1) - As this will increase the total count (at a given distance) (1)	Allow “Adds a systematic error” <u>Alternative MP3 and MP4</u> - Repeat the measurement of the count and calculate a mean (1) - As radioactive decay is random (1)	4