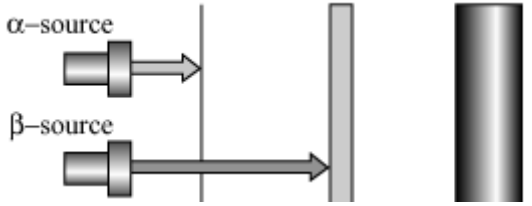
Question	Answer	Marks	Guidance
1	**Level 3: (5 – 6 marks)** **Correctly identifies three sources with an explanation** **AND** **explains the usefulness of all three sources in terms of penetration.** Quality of written communication does not impede communication of the science at this level. **Level 2: (3 – 4 marks)** **Correctly identifies three sources** **OR** **explains the usefulness of all three sources in terms of penetration.** Quality of written communication partly impedes communication of the science at this level. **Level 1: (1 – 2 marks)** **Describes two basic trends in the data** **OR** **identifies one source correctly.** Quality of written communication impedes communication of the science at this level. **Level 0: (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	6	**This question is targeted up to grade A** **Indicative scientific points may include:** **Level 3:** • **X** is gamma, **Y** is alpha, **Z** is beta • gamma – no differential, alpha stopped too easily, beta shows differential with paper (thickness) **Level 2:** • **X** is gamma, **Y** is alpha, **Z** is beta • gamma – no differential, alpha stopped too easily, beta shows differential with paper (thickness) **Level 1:** • **X** / gamma unaffected • **Y** / alpha stopped by paper • **Z** / beta reduced with thickness • one source identified Answers which incorrectly identify X, Y or Z are limited to level 2 (4 marks) **Use the L1, L2, L3 annotations in Scoris; do not use ticks.**
	Total	**6**	

Question	Answer	Marks	Guidance
2 a	a **fast moving** electron (1)	1	if answer line blank allow correct answer circled or underlined more than one answer = 0 marks
b	mass number is unchanged ✓ nucleus has one more neutron ☐ nucleus has one more proton ✓ atomic number decreases by one ☐	1	both ticks required more than two ticks = 0 marks
c i	$\rightarrow {}^{237}_{93}Np + {}^{4}_{2}He$ (2)	2	any two or three numbers correct = 1 mark

Question	Answer	Marks	Guidance
3 a i	Decreases [1] **but** decreases by half / by 30 (decays per second) [2]	2	 **allow** from 60 to 30 [2] **eg 60 and 30 indicated on graph scores [2]** if **NO** marks awarded **allow** by one half life [1]
ii	line starting at 120 and always to the right and above right element A [1]	1	Any line curving upwards (at any part) scores [0] graphs must not cross each other
b	$^{(99)}_{(43)}Tc \rightarrow {}^{99}_{44}Ru + {}^{0}_{-1}\beta$ [1] [1]	2	Mark rubidium and beta independently Both mass **and** atomic number needs to be correct for a mark
	Total	**5**	

Question	Answer	Marks	Guidance
ii	**any two from** alpha particles cause the air inside the smoke detector to ionise (1) idea that smoke particles absorb / stop (some alpha) radiation (1) less ionisation (of air) **with smoke** [1] current is reduced (causing alarm to sound) (1)	2	**Ignore** references to alpha detector **Ignore** merely particles 'hit' But alpha particles absorbed or stopped by smoke particles so less ionisation of air particles (2)
	Total	**6**	

Question			Answer	Marks	Guidance
4	(a)		arrow or line from alpha to front / rear face of paper and arrow or line from beta to front / rear of aluminium (1)	1	**allow** alpha line slightly penetrating paper and beta line slightly penetrating aluminium but not passing all the way through  Do **not allow** mark if radiation emerges from barrier
	(b)		**any two from:** treating or curing cancer / killing cancerous cells / radiotherapy (1) non-destructive testing (1) tracers (1) sterilising equipment/killing bacteria on surgical equipment (1)	2	**not** chemotherapy **ignore** nuclear weapons **allow** industrial, environmental or medical benefits Eg testing for leaks in pipes (1) smoke detectors (0)

Question			Answer	Marks	Guidance
	(c)		**any two from the ideas that:** (as gamma is highly penetrating) it must be placed in a material resistant or thick enough (to stop the radiation penetrating) (1) long term containment needed (1) it may remain radioactive for a long time so long term solutions are required / AW (1) it must be stored where there is no possibility of it contaminating water supply (1) they need to monitor levels of radioactivity for long periods of time (as acceptable radioactivity levels may change over time) (1)	2	Eg. **encased** in glass (1) Eg. placed **deep** underground (1) Eg, long half lives mean so container must not corode (2) **allow** long time to decay (1) **but** long time to decompose (0) **allow** idea of terrorist risk Eg. terrorist use plutonium (1) Eg terrorist use it to make a bomb / dirty bomb (1)
			Total	**5**	

Question			Answer	Marks	Guidance
5	(a)	(i)	(a few sheets of) paper / a few cm of air (1)	1	paper / sheet of paper / a few pieces of paper
		(ii)	**any one from:** idea that the glass / container would absorb / stop the alpha from being detected (1) mention of sensible practical difficulty (1) idea of difficult / not safe to put detector so close to liquid (1)	1	**allow** background radiation needs taking into account (1) eg placing sheets of paper very close to a liquid without the liquid being absorbed by the paper (1) **ignore** 'alpha stopped by liquid'
	(b)	(	**any one from:** idea of increasing confidence in results (1) (get better estimate from) mean / average values (1)	1	**allow** increase reliability (1) **ignore** fair test **ignore** more accurate **allow** to verify / check results / identify anomalies (1) **allow** to take account of random nature of radioactivity (1)
		(ii)	**any two from:** count reduced by aluminium and reduced further by lead (1) a sensible reason for link between lead absorber and gamma (1) a sensible link between aluminium absorber and beta or gamma (1)	2	eg lead stops (alpha beta and) gamma (1) eg aluminium stops beta (1) **but** aluminium stops beta **and** alpha (2) **or** aluminium stops beta but lets gamma through (2)
			Total	**5**	

Question			Answer	Marks	Guidance
6	(a)		<table><tr><td></td><td></td><td></td></tr><tr><td></td><td>smoke detector [1]</td><td></td></tr><tr><td></td><td>thickness gauges or thickness control [1]</td><td>a few mm / cm of aluminium [1]</td></tr><tr><td></td><td></td><td></td></tr></table>	3	**allow** smoke alarm but **ignore** fire alarm **allow** tracer 1] **allow** treating cancer **ignore** paper on its own **allow** sheets of or thin aluminium or metal **allow** steel or lead or few mm of metal or thick metal or named metal **allow** thick or few cm. of card or wood **ignore** aluminium foil or tinfoil / just aluminium / metal on its own
			any two from leak into water / rivers / lakes / sea / water supply / drinking water [1] enters the food chain or food supply / **transferred** to or taken by living organisms [1] cause mutations / increased cancer risk in animals or humans [1] remain radioactive or active or harmful for a (very) long time [1] idea of change of safe or acceptable (radiation) levels in the future [1]	2	**use ✓'s in this question** **ignore** could leak on its own **allow** specific examples eg iodine absorbed by thyroid gland **throughout answer;** **ignore** just kill / harm animals or people **ignore** destroys or harms habitats **ignore** harms soil or land or environment **ignore** terrorist threat **ignore** geological damage
			Total	**5**	