Question	Answer	Marks	Guidance
1 a	**any two from** radioactive waste / radiation **leak** (in event of an accident) [1] **but** radioactive waste is active for a long time / difficult to dispose of or manage safely [2] plutonium / waste used to make (nuclear) bombs [1] accidents can be severe [1]	2	**maximum 2 marks** **allow** nuclear waste [1] **ignore** toxic **ignore** merely 'radiation' **eg. Risks from:** meltdown / explosion / earthquake / tsunami [1] **allow** (exposure to) radioactive waste can cause cancer [2] **allow** radioactive waste can contaminate water (supplies) [2] **allow** radioactive waste needs to be encased (in glass) / buried (deeply) underground [2] Eg. greater terrorist risk [1] **Eg.** After effects can cause cancer / mutations / ionisation / damage to DNA [1]
b	**any two from** reduce time spent near reactor (i.e. rescue workers to reduce exposure to radiation) [1] extra medication given [1] radiation (doses) monitored (to limit / check exposure) [1] use of shielding / protective clothing [1]	2	**maximum 2 marks** **allow** exclusion zone [1] **eg.** radiation tablets [1] **allow specific examples** **eg.** 'use of radiation badges / radiation detecting (to limit exposure)' [1] **eg.** gasmasks / lead (lined) suits [1]

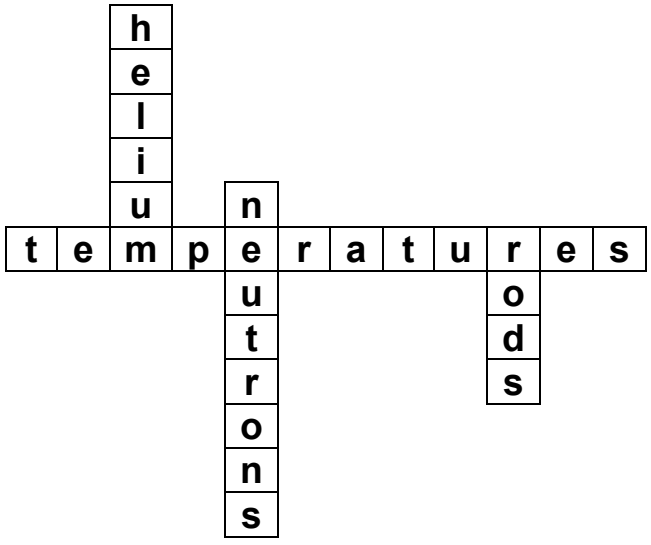
c	measure radioactivity (in area) [1] (allow back) when activity (almost) equals background / when activity (almost) equals safe level / AW [1]	2	**Eg.** use radiation detectors / Geiger tubes or counters [1] **ignore** merely 'when it is safe' 'when level is low enough or acceptable' [1]
	Total	**6**	

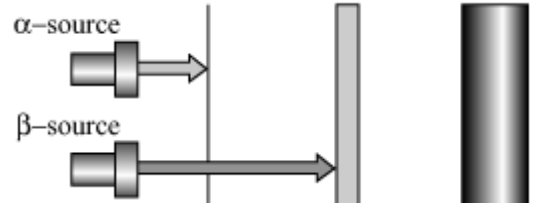
Question	Answer	Marks	Guidance
2 a OVERLAP	**any two from** (idea that for **absolute dating**) absolute dating gives a more exact date / ora (1) (Idea about **absolute dating**) not enough Carbon-14 in old rocks (for absolute dating) or absolute dating only works when there is enough carbon in the sample (1) (idea that **relative dating**) can get the age of (very) old plants / wider age range of plants / ORA [1] (idea that for **relative dating**) need comparative data eg. requires knowledge of the ages of surrounding rocks (1) Idea that using **both methods** together gives a more **reliable** / valid / complete answer or both results support each other / [1]	2	**Allow carbon dating for absolute dating** **Eg** more accurate / precise **Ignore** 'better result' **allow** relative dating can get the age of (very) old rocks [1] **Eg both methods** give more certain answer [1] **Eg, both methods** give more confidence in the result [1] **Allow both methods** give a more accurate answer [1] **Accuracy mark can only be given once.**
b	lead (1)	1	if answer line blank allow correct answer circled or underlined more than one answer = 0 marks
	Total	**3**	

Question	Answer	Marks	Guidance
3 a	**any two from:** person may have different diets / foods or drinks [1] person may live in different areas of UK (where there is more radon gas / granite) [1] person may have had more medical tests / treatment **involving radiation** [1] person may use aeroplanes more (and so be exposed to more cosmic rays) [1] person is close to / works in a **nuclear** power station / **nuclear** facility / radiology / radiography [1]	2	**Allow buildings** Eg. Radiotherapy treatment. **Ignore** unqualified medical tests **ignore** medical workers allow idea that near hospitals that use radiation [1]
b	**any two from:** compare different areas [1] show / compare changes over time [1] provides more data [1] check each other's data / reliability / peer review [1] idea of informing other scientists / public /government [1]	2	
	Total	**4**	

Question			Answer	Marks	Guidance
4	(a)		**[Level 3]** Detailed description of what the graph shows **AND** an explanation of how the information could be interpreted **AND** used. Quality of written communication does not impede communication of the science at this level **(5–6 marks)** **[Level 2]** Describes what the graph shows **AND** an explanation of how the information could be interpreted **OR** used. Quality of written communication partly impedes communication of the science at this level **(3–4 marks)** **[Level 1]** Describes what the graph shows **OR** a description of how the information could be interpreted **OR** used. Quality of written communication impedes communication of the science at this level **(1–2 marks)** **[Level 0]** Insufficient or irrelevant science. Answer not worthy of credit. **(0 marks)**	6	**This question is targeted at grades up to C/D.** **Relevant points include:** **Description of what the graph shows.** • level of radioactivity changes as the detector moves along the pipe. • radioactive level is relatively low at the start • as the detector moves along the pipe the level rises rapidly/reaches a peak • level then falls rapidly after peak • level is lower after the peak than it was at the start **Explanation of how the information can be interpreted** • to find where there is a problem with the pipe • the peak shows that tracer is leaking and indicates a crack or break • there is a blockage as the level after is lower than before the peak • the blockage is not complete as radioactivity is not zero • radiation used must be gamma **Explanation of use of the information** • so that workers dig in the right place • so that workers do not waste time/energy resources digging up the whole pipe • the peak shows where the problem is **Use the L1, L2, L3 annotations in Scoris; do not use ticks.**

Question			Answer	Marks	Guidance
	(b)		half-life of **Y** is (approximately) 1 hour/h/hr (1) half-life of substance **X** is (approximately) 4 hour/h/hr (1) **if no marks scored above**: the idea that substance **Y** has a shorter half-life (than substance **X**) / ora for X scores (1)	2	**allow** range 0.75 - 1 hour correct units required for this marking point **allow** range 3.5 - 4 hours correct units required for this marking point **ignore** 'between 3 to 4 hours' **but** half-life of **X** is 4 x that of **Y** (2) **Ignore** incorrect units if stated for this marking point **ignore** substance X remains radioactive longer as targeting A* for 1 of the marks
			Total	**8**	

Question			Answer	Marks	Guidance
5	(a)		 (2)	2	answers in crossword take precedent but if crossword blank **allow** answers next to the clues 0 or 1 correct = 0 marks 2 or 3 correct = 1 mark 4 correct = 2 marks
	(b)		**any two ideas from:** • no data / no evidence • secrecy • cannot be proved / be reproduced / cannot get similar or reliable results • disagrees with fundamental physics	2	 Eg. Not all data published (1) Eg. (some) experimental details are (still) secret (1) Eg. fusion needs high temps or pressures / won't happen at low temperatures or pressures / AW (1)
			Total	**4**	

Question			Answer	Marks	Guidance
6	(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
7	(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	