Mark Scheme

Q1.

	Answer	Acceptable answers	Mark
	☒ **D**		**(1)**

Q2.

	Answer	Acceptable answers	Mark
	D It is the time it takes for half the atoms to decay		**(1)**

Q3.

	Answer	Acceptable answers	Mark
	A		**(1)**

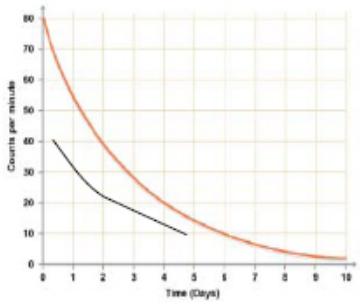
Q4.

	Answer	Acceptable answers	Mark
	axes labelled correctly With label or unit (1) correct shaped smooth curve (1) line does not reach zero activity (1)	activity / Bq / count rate ignore radioactivity time/ seconds/ any time unit	**(3)**

Q5.

Question Number	Answer	Additional guidance	Mark
	processing (1) $\frac{125\ 000}{1\ 000\ 000}$ OR $\frac{1}{8}$ OR 3 half-lives or 3 x 5700 evaluation (1) 17 100	 accept an appropriate attempt using more than one halving 17 000 award full marks for the correct answer without working	**(2)**

Q6.

	Answer	Acceptable answers	Mark
i	1.9-2 (days)		**(1)**
ii	 plotting (0,40), (2,20) and (4,10) **OR ANY**line which passes through those coordinates (1)	Ignore any part of line after 4 days	**(2)**

	smooth curve through those points (1)		

Q7.

Question Number	Answer		Mark
	• point after first half-life 6, 40 (1) • point after second half-life 12, 20 (1) • point after third half-life 18, 10 (1)	within 1 small square by eye smooth curve starting at 80, with a decreasing gradient passing through one correct half-life point scores 2 marks smooth curve starting at 80, with a decreasing gradient passing through two correct half-life points scores 3 marks **if no other mark scored** smooth curve showing decreasing gradient but not going through any correct points scores 1 mark	**(3)** AO 3 1a

Q8.

	Answer	Acceptable answers	Mark
(i)	suitable lines on graph to show halving after about 200 000 years (2) • horizontal line at 750 +or –50 Bq on y-axis to curve (1) • meeting (by eye) vertical	use of data from graph to show halving after about 200 000 years 1500/2 =750(Bq) or 1600/2=800(Bq) gives a half-life of 210,000 +or- 20 000 (years)	**(2)**

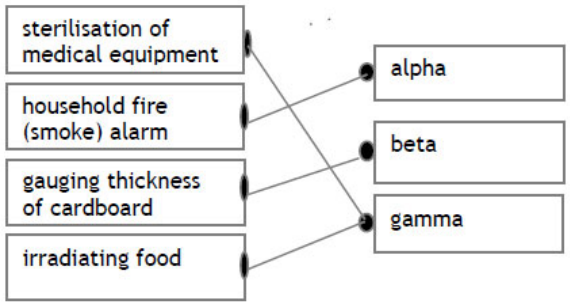
	line from x-axis between 190,000 years and 230,000 years (1)		
(ii)	any one of • penetrates/passes through the skin (1) • ionises (1) • damages tissue/ cells/DNA (1) • mutates cells/DNA(1) • causes cancer(1)		**(1)**

Q9.

Question Number	Answer	Acceptable answers	Mark
(a)	Any one of Treatment of cancer / radiotherapy Imaging e.g.: looking at broken bones, tracers sterilizing (equipment/dressings) (1)	NOT ultrasound applications/ chemotherapy accept(to) cure/kill/detect cancer (cells) accept X-ray(s)/X-ray machine accept PET/CT scans ignore MRI scans accept (to) kill bacteria ignore medical treatment and similar vague statements	**(1)**

Question Number	Answer	Acceptable answers	Mark
(b)	12 hours = 2 half lives (1) 10 (mg) (1)	idea of halving seen e.g. 40 ÷ 2 or 20 (mg) ignore 80 (mg) and 99 ÷ 2 OR idea of 2 half lives seen or 40/4 OR (6 is 1 half-life and)12 is 2 (half-lives) OR 1/4 Give full marks for correct answer with no working.	**(2)**

Q10.

	Answer	Acceptable answers	Mark
(a)		one mark for each correct line	**(4)**
(b)	☒ **D**		**(1)**
(c)	☒ **B** becquerel		**(1)**
(d)	A description including any **two** from: • secure storage (1): • avoid direct contact (1) • wear protective clothing (1) • minimise exposure (1) • shielding (1) • minimise dose (1) • monitor exposure (1) • protect other people (1)	either the purpose, such as to prevent radiation getting out or a description such as lead-lined box/locked away when not in use. do not touch / use tongs /wash after handling lead lined suits/aprons/masks/gloves ignore goggles long distance away / not pointing towards body/ keep sources shielded /stand behind shields short time wear film badge/use Geiger counter (to monitor radiation levels) warning signs / barriers / restricted areas /controlled areas	**(2)**

Q11.

	Answer	Acceptable answers	Mark
(i)	Idea of 2 half-lives (1) 11 400 = 2 × 5700 Idea of halving activity twice (1)	11 400 / 5700 = 2	**(3)**

	0.55 × 2 × 2 Calculation (1) 2.2 (Bq)	 2.2 (Bq) for three marks	
(ii)	Explanation linking two of: • Background radiation affects the measurement (1) • Needs to be subtracted from readings (1) • Background radiation is variable (1) • Background radiation needs to be averaged (1)	accept interfering / including varies with place/time/random nature repeating test improves reliability	**(2)** **t**
(iii)	One relevant idea: (New method) more accurate (1) Hard to measure a small activity (1) Background radiation affects readings (1) Need to find difference of two small quantities (1) Can test smaller samples (1)	ignore better method/results / more reliable difficult to distinguish between the reading and background	**(1)** **grad**

Q12.

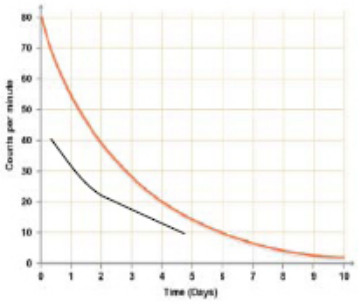
	Answer	**Acceptable answers**	**Mark**
(a)	A		**(1)**
(b)	axes labelled correctly With label or unit (1) correct shaped smooth curve (1) line does not reach zero activity (1)	activity / Bq / count rate ignore radioactivity time/ seconds/ any time unit	**(3)**
(c)(i)	Idea of 2 half-lives (1) 11 400 = 2 × 5700 Idea of halving activity twice (1) 0.55 × 2 × 2 Calculation (1) 2.2 (Bq)	11 400 / 5700 = 2 2.2 (Bq) for three marks	**(3)**

(c)(ii)	Explanation linking two of: • Background radiation affects the measurement (1) • Needs to be subtracted from readings (1) • Background radiation is variable (1) • Background radiation needs to be averaged (1)	accept interfering / including varies with place/time/random nature repeating test improves reliability	**(2)** **t**
(c)(iii)	One relevant idea: (New method) more accurate (1) Hard to measure a small activity (1) Background radiation affects readings (1) Need to find difference of two small quantities (1) Can test smaller samples (1)	ignore better method/results / more reliable difficult to distinguish between the reading and background	**(1)** **grad**

Total for question = 10 marks

Q13.

	Answer	**Acceptable answers**	**Mark**
(a)	A description to include • name of detector / move detector over the ground (1) • where leak is, there will be an increased rate (1)	(move) until a {leak/high reading} is found	**(2)**
(b)	D It is the time it takes for half the atoms to decay		**(1)**
(c)i	1.9-2 (days)		**(1)**
(c)ii		Ignore any part of line after 4 days	

	 plotting (0,40), (2,20) and (4,10) **OR ANY**line which passes through those coordinates (1) smooth curve through those points (1)		**(2)**

		Indicative Content	
QWC	***(d)**	An explanation including some of the following ideas **Need for measurement (N)** Background radiation • is {always present/all around us} • has (natural) source(s) exemplified by space, l rocks, food, nuclear/medical sources etc. • would give false reading in experiment **How and why to measure(H)** Background radiation measurement • is taken at site of experiment **because**it is dif different places • is taken with all apparatus **except**source in pl • is taken before and after **because**{it can char / they need an average} • {must be worked out for same time as (or long experiment / rate found} **so**analysis is simpler • It is {taken several times/ averaged} **because** **Analysis (A)** Background radiation measurement • must be subtracted from {measurements with count rate}	

Level	**0**	No rewardable content
1	**1 - 2**	• A limited explanation mentioning any **two** from N or **one** from H or A e.g. Background comes from space and rocks.(N) It is there all the time. (N) OR Readings for background must be repeated because they are random. (H) OR Background must be taken away from all other readings (A) • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	**3 - 4**	• A simple explanation ***linking*** aspects of two ideas i.e. **N**+ **H** OR **N**+ **A** OR **H**+ **A** e.g Take readings without source (H) and subtract them from the main readings with source present.(A) OR It should be taken several times because it is random (H)so that the average can be subtracted from the main readings (A) • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	**5 - 6**	• A detailed explanation ***linking*** **A** with EITHER N + an idea from **H** OR two or more idea e.g Background radiation is there all the time. (N) You need to take readings at the place where you will do the experiment and with all the apparatus set up except the source because BR changes from place to place.(H) Then you should subtract background readings from the main experimental readings.(A) OR Take several readings of count rate for averaging since the effect is random (H) and make sure that they are taken in the same place.(H) Then subtract from readings in main experiment.(A) • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Q14.

Question Number	Answer	Acceptable answers	Mark
(a)	C - kill microbes in the food		**(1)**

Question Number	Answer	Acceptable answers	Mark
(b)(i)	From the graph Time taken to fall (from 8000) to 4000 (1) = 5.3 (years) (1)	Any other suitable pair of readings from the graph. Between 5.1 and 5.5 Full marks for correct answer even if no working is evident	**(2)**

Question Number	Answer	Acceptable answers	Mark
(b)(ii)	3 x 5.3 (= 15.9 years)	Allow attempt at extrapolation only if the answer is between 15.5 and 16.5 Allow ecf of 3 half lives from bi.	**(1)**

Question Number	Answer	Acceptable answers	Mark
(c)(i)	Comparison including any two from Same number of protons (1) Different number of neutrons (1) Cobalt-60 is unstable (1)	 Same atomic/proton number/charge Different nucleon number/mass number/atomic mass Cobalt 60 is radioactive Ignore reference to electrons	**(2)**

Question Number		Indicative Content	Mark
QWC	* **(c) (ii)**	A discussion which includes description of the hazards (H) and / or possible precautions (P) to reduce risks arising from them such as • In either option. o Rods are radioactive (H) o Gamma radiation is highly penetrating / ionising (H) o Radiation from them can cause cancer / damage to organisms / people / environment (H) o Need for shielding (P) o Security to prevent public access (P) • Transportation / reprocessing o Danger of accident during transport (H) o Need to be suitably protected against damage. (P) o Danger of interception/high-jacking/terrorists (H) o Need security (P) o Workers could be exposed to radiation (H) o Special facilities required (P) • Disposal o Can damage environment if not properly contained (H) o Special disposal facilities, not landfill (P) o Remain radioactive for some time (H) o Need to be kept secure while decaying to safe levels. (P) o Relatively short half-life means that very long term storage is not necessary. (P)	**(6)**

Level	0	No rewardable content
1	1 - 2	• a limited description of hazards or precautions in one option e.g. The rods are radioactive. Radiation can cause cancer. When the rods are disposed of then they will remain radioactive for some time. • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	3 - 4	• a simple discussion of hazards for both options or a detailed discussion of one option. • A detail discussion may **either** expand on several descriptive points about the hazard **or** may include suitable precautions. e.g. The gamma radiation from the rods is highly penetrating. If they were simply put into landfill then they could damage the environment and so they would need special storage facilities until they had decayed to a safe level. • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	5 - 6	• a detailed discussion of hazards for both options. e.g. Response as above PLUS if they were transported back to the reactor then they must be in very strong containers so that, if there was an accident, they would not be damaged and allow radioactive material to escape. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

(Total for Question = 12 marks)

Q15.

	Answer	Acceptable answers	Mark
(a)(i)	any one of X-ray (machines) / smoke alarms/ nuclear/ radioactive waste (1)	nuclear weapons (tests) nuclear power plants (medical) tracers/technetium	**(1)**
(a)(ii)	an explanation linking: comes from granite / rocks (1) none/ less of these (rocks) in some areas (1)	in some areas/Cornwall/Aberdeen the second mark is dependent on the first.	**(2)**
(b)(i)	suitable lines on graph to show halving after about 200 000 years (2) • horizontal line at 750 +or –50 Bq on y-axis to curve (1) • meeting (by eye) vertical	use of data from graph to show halving after about 200 000 years 1500/2 =750(Bq) or 1600/2=800(Bq) gives a half-life of 210,000 +or- 20 000 (years)	**(2)**

	line from x-axis between 190,000 years and 230,000 years (1)		
(b)(ii)	any one of • penetrates/passes through the skin (1) • ionises (1) • damages tissue/ cells/DNA (1) • mutates cells/DNA(1) • causes cancer(1)		**(1)**

Total marks for question = 12

		Indicative Content	
QWC	***(c)**	an explanation which may include some of the followi <u>properties of nuclear waste</u> radioactivity is dangerous some isotopes in nuclear waste have long half-lives/ra thousands of years products of fission are warm identified radiation from nuclear waste e.g alpha, beta <u>problems caused by nuclear waste</u> leakage of radioactivity contamination of ground/sea water/lakes /rivers contamination of crops/fish/animals/drinking water harm to humans/cancer/radiation poisoning/ damage cells/mutation of cells or DNA difficulty in transporting safely/ stolen by terrorists fea people <u>solutions for dealing with nuclear waste safely</u> long term storage, underground /under the sea radiation shielding, lead/steel/concrete/ containers, se human safety, radiation suits, using tongs/lead jackets location, away from people/remote areas/sea cooling, information to persuade local people of safety	

Level	**0**	No rewardable content
1	**1 - 2**	• a limited explanation mentioning at least one point, but without linking, e.g. radioactivity is dangerous ; nuclear waste should be stored underground ; terrorists might steal nuclear waste; • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	**3 - 4**	• a simple explanation mentioning two points with an appropriate linkage e.g. nuclear waste is dangerous and it must be stored underground ; the isotopes in nuclear waste have long half-lives so they must be stored for a long time; • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy

3	**5 - 6**	• a detailed explanation mentioning a range of points with appropriate linkages e.g. gamma rays from nuclear waste causes damage to cells so it must be stored away from where people live ; the isotopes in nuclear waste have long half-lives so they must be stored underground or in remote areas; • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	