Question Number	Answer	Acceptable answers	Mark
1(a)	A		**(1)**

Question Number	Answer	Acceptable answers	Mark
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)**

Question Number	Answer	Acceptable answers	Mark
1(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)**

Question Number	Answer	Acceptable answers	Mark
1(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**

Question Number	Answer	Acceptable answers	Mark
1(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 4=10 marks

Question Number	Answer	Acceptable answers	Mark
2(a)(i)	Any **two** of: Gamma is a wave (1) Alpha is a helium nucleus (1) Alpha is charged (1) Alpha has a mass (1) Gamma penetrates further/ highly (1) Gamma weakly ionising (1) Gamma travels faster (1)	Reverse arguments em radiation Gamma has no charge Gamma has no mass examples of penetrating power alpha highly ionising ignore vague comments eg stronger Ignore uses and dangers	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(b)(i)	D		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(b)(ii)	B		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(c)	An explanation linking: electron(s) (1) is/are lost/gained (1)	 do not allow positive electron knocked off / removed/ released	**(2)**

Question Number		Indicative Content	Mark
QWC	*)	An explanation including some of the following points: <u>Radiation from the front of the lens</u> Alpha particles absorbed by glass Beta particles do not penetrate glass Gamma rays pass through glass Background radiation varies There is a large difference in size between front and back counts Radiation detected is gamma rays only <u>Radiation from side of the lens</u> Alpha particles cannot penetrate aluminium Beta particles are absorbed by aluminium Gamma rays pass through aluminium There is a small/no difference in size between front and side counts Perhaps a few gamma rays absorbed by aluminium Background radiation varies Likely to contain gamma rays only May be different from front count due to random nature of emissions <u>Radiation from the back of the lens</u> Alpha particles absorbed by coating and/or glass Beta particles are emitted the from rear surface Gamma rays emitted from radioactive glass There is a large difference in size between front and back counts Background radiation varies Radiation is both beta particles and gamma rays Difference between front and back counts due to beta particles	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited explanation mentioning two unrelated points, but without linking them properly, e.g. beta particles are stopped by thick aluminium, there is most radiation behind the lens • 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 some points with an appropriate linkage to **one** of the readings e.g. no beta particles escape forwards because the glass absorbs them OR only gamma rays escape to the side because the aluminium stops alpha and beta particles • 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 some of the points with appropriate linkage to a comparison of at least **two** of the readings e.g. no beta particles escape forwards because the glass absorbs them, but beta particles can escape backwards so that count is higher OR only gamma rays can get through the glass and the thick aluminium, so the front and side counts are about the same • 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 6 = 12 marks

Question Number	Answer	Acceptable answers	Mark
3 (a) (i)	A alpha particles		**(1)**

Question Number	Answer	Acceptable answers	Mark
3 (a) (ii)	A suggestion to include Absorbs (ionising) radiation (from the sources)	Stops/reduces radiation/ radioactivity (reaching people); Stops/reduces (alpha) particles or any named ionising radiation (reaching people); Protects people/keeps it safe; Ignore – "so the source cannot pass through"	**(1)**

Question Number	Answer	Acceptable answers	Mark
3 (a) (iii)	One from Buildings/building materials, food, plants, water, outer space, rocks, air, Sun	Cosmic rays/waves; radon (gas); radioactive waste; nuclear accidents/Chernobyl/nuclear explosions; nuclear power stations; do NOT accept everywhere ignore alpha, beta, gamma, microwaves and X-rays, carbon dioxide, nitrogen, (mobile) phones	**(1)**

Question Number	Answer	Acceptable answers	**Mark**
3 (a) (iv)	Any two relevant precautions	Distance (between students and source); no touching; no eating; short exposure time;(use of) film badge/ detector ; Protective clothing; Use of <u>lead</u> (lined) box /keep box shut/ sources in box (when not in use); (stand behind/use of) a screen; Do not point (source) at students; Show video/dvd of demo; Ignore goggles, gloves, lab coats,; Answers referring to the safety of teacher can score a maximum of one of the 2 marks eg use of tongs	**(2)**

Question Number	Answer	Acceptable answers	Mark
3 (b) (i)	Calculation of number of half-lives 8 ÷ 4 = 2 (half lives) (1) evaluation of mass 6 ÷ 2 = 3 ÷ 2 = 1.5 (mg) (1)	Award 1 mark for clearly calculating mass halves after 4 days eg 6/2 = 3 (mg) 6/4 = 1.5 scores 2 marks Allow rounded 2 mg if clear they calculated 1.5 mg give full marks for correct numerical answer, 1.5 (mg) even if no working	**(2)**

Question Number	Answer	Acceptable answers	Mark
3 (b) (ii)	An explanation linking any two of the following points • people inhale radon (gas) (1) • radon is quite likely to/may decay in the lungs (before being exhaled) (1) • causes ionisation of cells (in lungs) (1) • increases risk of (lung) cancer (1)	Breathe in radon (gas)/ breathe it in/ radon (gas) gets into the body; Gives out radiation in the body / alpha (particles) very ionising; causes damage to (DNA of) cells (in lung)/cell mutations/kills cells; (Damages the body is insufficient) (causes lung) cancer	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(a) (i)	B		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(a) (ii)	Any one of the following Rocks Food Radon gas Cosmic rays Own bodies Fall-out Sun/stars (1)	Plausible named food such as coffee, brazil nut, bananas Space Specified medical/industrial use of x-rays Ignore smoke alarms, power stations (in normal use)	**(1)**

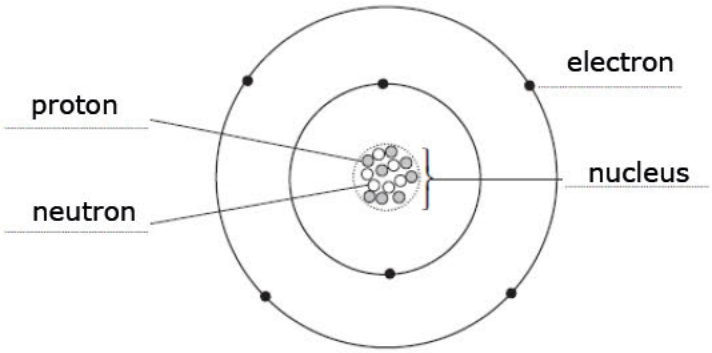
Question Number	Answer	Acceptable answers	Mark
4(a) (iii)	An explanation linking • personal circumstances such as geographical location nature of their work lifestyle (1) • the consequences such as radiation from radon gas/particular rocks/fall-out (eg Chernobyl) greater exposure to x-rays greater exposure to cosmic rays (1)		**(2)**

Question Number	Answer	Acceptable answers	Mark
4(a) (iv)	D		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b) (i)	From the graph Time taken to fall (from 120 to) 60 (1) = 8 days (1)	Any other suitable pair of readings from graph 8.1, 8.2 Full marks for correct answer even if no working is evident	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(b) (ii)	2.2 (days) (1)	between 2.0 and 2.5 2	**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b) (iii)	Any one of the following: • Mutation of dna • Ionisation of cells • (Increases risk of) cancer (1)	damage / mutate cells	**(1)**

Question number	Answer	Mark
5(a)(i)	One mark for each correct label (4)  	(4)

Question number	Answer	Mark
5(a)(ii)	B	(1)

Question number	Answer	Mark
5(a)(iii)	zero/0/no charge	(1)

Question number	Answer	Mark
5(b)(i)	434	(1)

Question number	Answer	Additional guidance	Mark
5(b)(ii)	34	allow 29 to 39	(1)

Question number	Answer	Additional guidance	Mark
5(b)(iii)	Radioactive decay is a random process	allow because background count changes every time	(1)