Question Number	Answer	Acceptable answers	Mark
1(a)(i)	27 (1) 33 (1)	accept 33 27 for 1 mark	**(2)**

Question Number	Answer	Acceptable answers	Mark
1(a)(ii)	an electron		**(1)**

Question Number	Answer	Acceptable answers	Mark
1(a)(iii)	A description including **three** of the following points • beta (radiation) is electron(s) (1) • beta has mass (1) • beta has (negative) charge (1) • beta is a better ioniser (1) • beta is less penetrating (1) • gamma radiation is electromagnetic (1) • wave (1) • gamma travels at a speed of light (1) • gamma is just energy (1)	**Allow** ORA where applicable allow em for electromagnetic ignore uses	**(3)**

Question Number		Indicative Content	Mark
QWC	***1(b)**	A description including some of the following points **Similarities (S):** • involve nuclei • involve particles colliding • energy released • can cause explosions/rapid release of energy **Differences (D):** **Fission** • splitting • of heavy nucleus • by neutron • chain reaction • products radioactive • used in power stations at present • rate can be controlled **Fusion** • joining smaller nuclei • to form larger nucleus • occurs in stars • needs very high temperature and/or pressure and/or particle density • because of like charge repulsion	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited description including a similarity OR a difference e.g. (S) both release energy OR (D) one is splitting, one is joining. • 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 description including **EITHER** one similarity AND one difference **OR** some differences / similarities e.g.(S) both give out energy but (D) fission uses uranium, fusion uses hydrogen. **OR** (D)fusion occurs in stars when hydrogen particles join **OR** (S) both involve nuclei and release energy • 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 description including EITHER two similarities (or one detailed) AND one difference OR one similarity and two differences (or one detailed) e.g. (S) uranium gives out energy (D) when it is hit by neutrons and energy is released (D) in fusion when (small) nuclei join. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately g, punctuation and grammar are used with few errors	

Question Number	Answer	Acceptable answers	Mark
		able answers	
2(a)(i)	Any **one** from the following • living things (1) • space (1) • nuclear power stations/accidents (1) • hospitals (1) • industrial processes (1)	Ignore radon gas from ... another radioactive rock a named radioactive substance eg uranium, radium, plutonium	**(1)**

Question Number	Answer	Acceptable answers	Mark
2(a)(ii)	statement 2 only		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(a)(iii)	An explanation linking **two** of the following points • radon gas comes from rocks (1) • types of rocks vary in different parts of the UK (1) • where there is more (of this type of) rock, the reading is higher (1)	may be explained in terms of specific places eg Cornwall	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(b)	A description of a change including the following points • used to be thought beneficial (1) • now known to be extremely {dangerous/hazardous} (1)	{was commonly used (without care)/dangers were not realised} now known to cause cancer now can be used safely {under controlled conditions/medical supervision}	**(2)**

Question Number		Indicative Content	Mark
QWC	***2(c)**	A discussion including some of the following points Appropriate type of radiation is chosen - some passes through - – β and γ not α - significant change with thickness - - β Half-life - reference to half-life - not too long - too much material needed for activity - not too short – expense of replacing regularly - disposal problems Safety issues - shielding • type of radiation • linked to appropriate material and thickness - security • storage of spares • in use - safety procedures / precautions in use	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited discussion of one factor with no reasons e.g.(F) penetration / half-life/ safety. • 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 discussion linking some of one factor (F) with some reasoning (R) **OR** two factors e.g. (F) use a source which has a long/short half life (R) with suitable reason **OR** (F) use radiation which is affected by different thicknesses of paper and (F) mention of half-life. • 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 at least two factors with some reasons e.g. (F) se a (beta) radiation which is affected by thickness (R) because others will not penetrate at all (alpha) or will not be {affected / stopped} by paper (gamma) and (F) some discussion of half-life or safety. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

Question Number	Answer	Acceptable answers	Mark
3(a)	An explanation linking the following points • small percentage / amount of material (1) • activity level low / less than background (1)	radiation/radioactivity for activity within safe limits	**(2)**

Question Number	Answer	Acceptable answers	Mark
3(b)(i)	**B** 50 days		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(b)(ii)	12.5	10 - 15	**(1)**

Question Number	Answer	Acceptable answers	Mark
3(c)	An explanation linking the following points • time for halving (1) • clear as to what is halving (1)	**Allow** for atoms: isotope / element / nuclei / (radioactive) substance /particles/(radioactive) material/radiation/count rate/Bq/activity/radioactivity time for half of the atoms to decay (2) time for the activity/count rate to drop to half (of original value) (2) time for ½ of it to decay (1)	**(2)**

Question Number		Indicative Content	Mark
QWC	***3(d)**	A discussion including some of the following points Model components related to actual machine • lamp – radioactive source (β- source) • sensor (LDR) – Geiger counter arrangement • card – liquid in bottle Interaction of components related to working of machine • rising of card - more liquid in bottle • rising of card – less light – higher resistance – smaller current / reading – circuit switches on if too much light • greater absorption gives less radiation to detect • machine discards bottle if too little liquid, model does not	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited discussion comparing some of the indicative content. E.g. two of the lamp, sensor and card are related to the source (Geiger) counter and liquid respectively. • 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 comparing parts of the process. E.g. Two of the lamp, sensor and card are related to the source Geiger counter and liquid respectively. The rising of the card gives more liquid in the bottle. • 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 the whole process. E.g. the lamp, sensor and card are related to the source Geiger counter and liquid respectively. The rising of the card gives more liquid in bottle. Too much light/ radiation getting through starts the alarm. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

Question Number	Answer	Acceptable answers	Mark
4(a)(i)	any one of X-ray (machines) / smoke alarms/ nuclear/ radioactive waste (1)	nuclear weapons (tests) nuclear power plants (medical) tracers/technetium	**(1)**

Question Number	Answer	Acceptable answers	Mark
4(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)**

Question Number	Answer	Acceptable answers	Mark
4(b)(i)	suitable lines on graph to show halving after about 200 000 years (2) • horizontal line at 7 0 +or –50 Bq on y-axis to curve (1) •meeting (by eye) vertical line from x-axis between 190,000 years and 230,000 years (1)	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)**

Question Number	Answer	Acceptable answers	Mark
4(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 5 = 12

Number			
QWC	*)	a ing points: properties of nuclear waste radioactivity is dangerous some isotopes in nuclear waste have long half-lives/radioactive for thousands of years products of fission are warm identified radiation from nuclear waste e.g alpha, beta, gamma problems caused by nuclear waste leakage of radioactivity contamination of ground/sea water/lakes /rivers contamination of crops/fish/animals/drinking water harm to humans/cancer/radiation poisoning/ damage to cells/mutation of cells or DNA difficulty in transporting safely/ stolen by terrorists fears of local people solutions for dealing with nuclear waste safely long term storage, underground /under the sea radiation shielding, lead/steel/concrete/ containers, sealed in glass. human safety, radiation suits, using tongs/lead jackets safe location, away from people/remote areas/sea cooling, ponds information to persuade local people of safety	**(6)**
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	