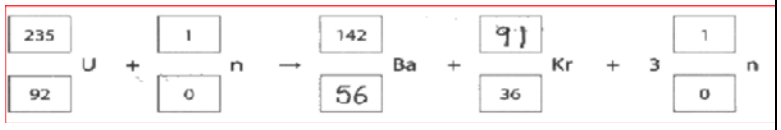
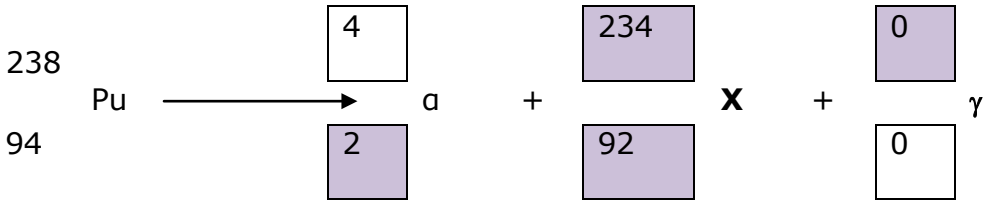
Question number	Answer	Notes	Marks
1 a	91; 56;  		1 1
b	Three FROM – MP1. Neutrons released; MP2. neutrons slowed by moderator; MP3. Can be absorbed by **other** (U) **nuclei**; MP4. Causing further fissions;	ignore comments about control rods collide or react for absorb if MP3 or 4 or both not given then award 1 mark for a description of a first absorption	3
c i	Correct labels for – Control rods; Shielding;	Accept • lines with or without arrow heads (in either direction) • any part of control rod (black in diagram) • any part of external box for shielding	1 1 2

ii	Two from: MP1. Reactor material / waste is **radioactive**; MP2. (radiation) ionises cells/ tissues / organs / body or causes cancer; MP3. radiation is very penetrating;	allow damages for ionises NOT ALLOW bald 'it is dangerous' do not award marks for 'shielding prevents escape of radiation'/eq	

(Total for Question 1 = 9 marks)

Question number	Answer	Notes	Marks
2 (a)	D americium-238;		1
(b) (i)	either order: uranium -234, uranium-235;	accept symbols but not just the numbers	1
(ii)	either order: plutonium-238, americium-238	accept symbols	1
(iii)	either order: uranium-235, americium-238	accept symbols	1
(c) (i)	will decay/ emit radioactive particles (or gamma);	allow named particles 'they are radioactive' 'they emit radioactivity'	3

(ii)	time taken; and either • For **half** of (radioactive) nuclei / atoms /isotope to decay; OR • For (radio)activity to halve;	allow how long it takes Ignore particles /molecules 'break down' 'reactivity' **Reject** for ONE mark ideas of • half of a time • half a nucleus/ an atom • complete decay	

Question number	Answer	Notes	Marks
(d) (i)	 one mark for alpha correct; one mark for gamma correct; one line for **balancing** the top line; NB ECF from alpha and or gamma one mark for **balancing** the bottom line; NB ECF from alpha and or gamma		4
(ii)	Uranium;		1
(e) (i)	proton number / atomic number decreases by 1; nucleon number /mass number remains unchanged (as p and n have same mass);		2
(ii)	plutonium -238;	condone plutonium without nucleon number	1

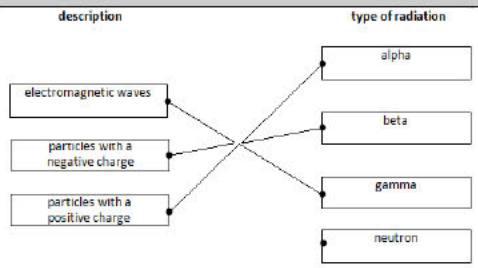
(Total for Question 2 = 15 marks)

Question number	Answer	Notes	Marks
3 (a) i	(Nuclei / atoms) with same number of protons OR same atomic number; different number of neutrons OR different mass number;	Ignore electrons Allow "(nuclei) of the same element" Allow different number of nucleons	2
ii	(stable isotopes) do not emit (ionising) radiation OR (stable isotopes) do not emit alpha, beta and gamma radiation ;	Ignore "radioactive", "decay" ignore idea of remaining the same element for ever	1
(b) i	210 – 84 OR 126		1
ii	ideas that proton number increases by 1; neutron number decreases by 1;	allow a calculation / nuclear equation Ignore discussion of "number of nucleons"	2
iii	beta decay	allow β **or** β^- **or** β^+	1
(c)	Any two of idea that gamma is not a particle; e.g. gamma rays have no (rest) mass gamma rays do not have a proton number gamma rays do not contain any protons or neutrons gamma rays are electromagnetic radiation OR energy; no particles are lost (from the nucleus) when a gamma ray is emitted;	Allow photons	2
		Total	**9**

Question number	Answer	Notes	Marks
4 (a)	A (background radiation)		1
(b)	Any TWO of 1. Range / penetration of alpha radiation is low; 2. R on (is a gas so) particles /atoms mobile OR americium (solid so) particles / atoms stay in place; 3. R on can be inhaled / damage internal tissue OR radiation from americium stays within smoke detector / absorbed by the plastic;	WTTE throughout this part ACCEPT 'cannot penetrate skin' / 'travel a few cm in air' ACCEPT 'all around us', 'more likely to come into contact', ACCEPT 'contained', 'stays in detector' ACCEPT 'can be breathed in', 'can get inside body', 'can damage (internal) cells /organs' ACCEPT 'high up', 'far from people'	2
(c) (i)	A (86)		1
(ii)	B (134)		1
(d) (i)	Bq / becquerel(s);	ACCEPT approximate / phonetic spellings of becquerel / Becquerel / bekerel REJECT B, BQ, bQ, bq	1

Question number	Answer	Notes	Marks
(ii)	Time for halving / time for 50% decrease; of the (radio)activity / no of (radioactive) atoms / no of (radioactive) nuclei /emissions;	ACCEPT Number of radon-220 nuclei IGNORE references to 'mass'	2
(iii)	55±4 (s);;	Answer in tolerance, but without obvious working gain full marks IGNORE misread from graph if answer within tolerance If final value missing or outside tolerance, look for evidence of using graph correctly for one mark e.g. appropriate use of activity axis such as lines across at 600 Bq and 300 Bq. or single line across at 350 Bq)	2

Total 10 Marks

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>5 (a)</td><td>

positive charge to alpha;
negative charge to beta;
electromagnetic waves to gamma;</td><td>One mark for each correct line
Minus one mark for two lines from any one box on the left</td><td>(3)</td></tr>
<tr><td>(b) (i)</td><td>in this order only:
gamma, beta, alpha;</td><td></td><td>(1)</td></tr>
<tr><td>(ii)</td><td>any two from:
can damage cells;
can cause mutation;
can cause cancer;</td><td>allow
kill cells/tissues
radiation burns
radiation poisoning
change genes</td><td>(2)</td></tr>
<tr><td>(c)</td><td><table>
<tr><th></th><th>0.1 cm paper</th><th>0.5 cm aluminium</th><th>0.5 cm lead</th></tr>
<tr><td>alpha radiation</td><td>stopped</td><td>stopped</td><td>stopped</td></tr>
<tr><td>beta radiation</td><td>goes through</td><td>stopped</td><td>stopped</td></tr>
<tr><td>gamma radiation</td><td>goes through</td><td>goes through</td><td>goes through</td></tr>
</table>
Each row correct for 1 mark;;;</td><td></td><td>(3)</td></tr>
<tr><td>(d)</td><td>any suitable device
e.g.
(thin window) GM tube;
cloud chamber;
spark chamber;
semiconductor detector;</td><td>accept spelling mistakes
Geiger counter
NB do not accept repeat of stem (film badge or photographic film)</td><td>(1)</td></tr>
</table>

Total for Question 5 = 10 marks

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>6 (a)</td><td>3 or 4 ticks correct;;
OR
2 ticks correct;

<table><tr><td rowspan="2">Property</td><td colspan="3">Type of radiation</td></tr><tr><td>Alpha particles</td><td>Beta particles</td><td>Gamma rays</td></tr><tr><td>most ionising</td><td>(✓)</td><td></td><td></td></tr><tr><td>largest mass</td><td>✓</td><td></td><td></td></tr><tr><td>most penetrating</td><td></td><td></td><td>✓</td></tr><tr><td>highest speed</td><td></td><td></td><td>✓</td></tr><tr><td>negatively charged</td><td></td><td>✓</td><td></td></tr></table></td><td>ignore top line as this is given</td><td>2</td></tr>
<tr><td>(b) (i)</td><td>Number of neutrons = 2;
Number of protons 2;</td><td>Allow same ideas expressed in words</td><td>2</td></tr>
<tr><td>(ii)</td><td>Any one of-
MP1. Charge is larger (than other radiations);
MP2. Mass is larger (than other radiations);</td><td>comparative statement needed
ignore
• incorrect terminology e.g. more powerful
• references to protons and neutrons
no RA unless particles/radiation specified
condone
‘alpha particles have more momentum’</td><td>1</td></tr>
<tr><td>(c) (i)</td><td>Idea of background radiation;</td><td>Allow
Idea that some alpha particles (from source) will get through smoke
air is all around = insufficient</td><td>1</td></tr>
<tr><td>(ii)</td><td>Idea that radioactivity is random;</td><td>allow
• fluctuates
• source emits different numbers of alphas
• background radiation varies
ignore
• random movement of particles</td><td>1</td></tr>
<tr><td>(iii)</td><td>Idea that α particles are absorbed / deflected /stopped / scattered;

Idea that α particles are affected by <u>smoke</u>;</td><td>allow for both marks
smoke blocks the (alpha) particles</td><td>2</td></tr>
</table>

Total 9 marks