Question number		Answer	Notes	Marks
1 (a) (i)		C (decreases by 2)		1
(ii)		D (decreases by 4)		1
(b)		D (has less penetrating power)		1
(c)		Any four of: MP1 Use of ratemeter / scaler / counter; MP2 Idea of measuring <u>background</u> radiation e.g. background count / correction /subtraction; MP3 A safety precaution (based on distance or absorption) e.g. use of tongs / shielding; MP4 A controlled variable (time / distance / positioning) e.g. "source near/by/to detector", "for a minute"; MP5 A practical consideration e.g. repeat / average / reset (scaler); MP6 Mention of becquerel / Bq	Allow description e.g. "**count** the clicks" Allow Geiger **counter** Ignore GM **detector** or **tube** Ignore descriptions of GM tube Allow "stand back", "wear gloves / protective clothing" "do not point source at people" Ignore "counts per minute" Ignore: mention of anomalies Accept phonetic spellings	4

Total for question 1 = 7 marks

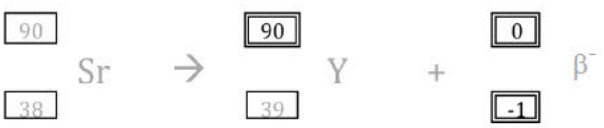
Question number	Answer	Notes	Marks
2 (a)	A activi y		1
(b)	A alpha particle B beta particle		1
(c)			1
(d)	A alpha particle		1
		Total	4

Question number	Answer	Accept	Reject	Marks
3	An explanation including any five of these ideas (in any order): MP1 alpha particles have less penetrating power /less range ; MP2 alphas have more charge; MP3 alphas cause more ionization; MP4 alphas are bigger / have more mass; MP5 (slowing) force on alpha particles is larger; MP6 (kinetic) energy of alpha lost quickly causing ionization; MP7 (larger) alpha particles are more likely to collide with atoms;	Accept reverse arguments, e.g. beta particles have more penetrating power etc Ignore comparisons of energy/ velocity/ momentum		5

Total 5 marks

Question number	Answer	Notes	Marks
4 (a)	idea that background activity should be subtracted (from each reading);		1
(b)	time taken; and either for amount of (radioactive) nuclei / atoms / isotope to halve; OR for (radio)activity to halve	allow "how long it takes" allow • decay by half • decay to half ignore particles / molecules, "breakdown", "reactivity" reject if implies a single nucleus/atom	2
(c) (i)	evidence of use of graph; 56 ± 3 (s);	e.g. lines to two correct points on graph or appropriate subtraction shown in working	2
(ii)	any 1 from: MP1. idea of {more accurate / smoother} curve; MP2. idea that activity changes quickly; MP3. idea that decay takes very little time;	allow more points to plot on graph decays quickly (sample has) short half life	1

Total 6 marks

Question number	Answer	Notes	Marks
5 (a) (i)	90		1
(ii)	time; either for amount of (radioactive) isotope to halve; or for (radio)activity to halve;	Allow for amount - (number of un-decayed) nuclei/atoms/molecules (un-decayed) mass of isotope	2
(iii)	Any two of – MP1 Idea that (beta) radiation causes a stated hazard; MP2 Idea that strontium-90 has a long half-life; MP3 Idea that <u>all</u> beta emission will be absorbed by the body;	 e.g. causes cancer, kills cells, mutates DNA, ionises tissue Accept lasts a long time Accept answers in terms of range	2
(b) (i)	90 and 0; -1;  	Must have both Minus is essential	2
(ii)	Any two ideas from – MP1 They are isotopes of different elements; MP2 Strontium-90 (nucleus/atom) has the same number of protons as other strontium (nuclei/atoms); MP3 Yttrium-90 (nucleus/atom) has the same number of protons as other yttrium (nuclei/atoms);	 Allow use of proton number data (38) Allow use of proton number data (39)	2

Total 9 marks

Question number	Answer	Notes	Marks
6 (a) (i)	B (53)		1
(ii)	D (131)		1
(b)	Any two of - MP1 Beta is (moderately) ionising; MP2 Beta has a short range; MP3 idea that I-131 has a short half-life; MP4 idea that iodine is absorbed (easily) by the thyroid; MP5 (hence) reduces damage to healthy cells; MP6 (hence) does not penetrate out of the body; MP7 (therefore) kills (only) tumour cells;	Ignore I-131 is radioactive, it emits beta	2

Total 4 marks

<table>
<tr><th colspan="3">Question number</th><th>Answer</th><th>Accept</th><th>Reject</th><th>Marks</th></tr>
<tr><td>7</td><td>(a)</td><td></td><td>
<table>
<tr><td>Type of radiation</td><td>Charge</td><td>S</td></tr>
<tr><td>Alpha particle</td><td>(+)2</td><td>Unstable nucleus</td></tr>
<tr><td>Beta particle</td><td>-</td><td>Unstable nucleus</td></tr>
<tr><td>Gamma ray</td><td>0</td><td>Unstable nucleus</td></tr>
</table>
(As shown)
2 ;
Unstable nucleus;</td><td>++

Unstable nuclei</td><td>-</td><td>2</td></tr>
</table>

Question number			Answer	Accept	Reject	Marks
7	(b)		Any three of: MP1 - Idea that alpha particles would not penetrate (enough); e.g. alpha particles absorbed / stopped by {aluminium / foil / a few cm air / paper / card} MP2 - Idea that gamma rays would be too penetrative; e.g. gamma rays {are not absorbed / are unaffected} MP3 - Idea that some beta particles will pass through the foil; e.g. not all of the beta particles are absorbed MP4 - Idea of a correlation between thickness and absorption; e.g. thinner aluminium absorbs fewer beta particles	Ignore references to danger or harm All ideas may be expressed in terms of penetration or absorption. No need to see the word "aluminium," provided the meaning is clear. Accept paper or card will stop alpha for MP1 Accept comparisons of aluminium thickness for MP4		3
	(c)	(i)	$^{90}_{39}Y$ both 90 and 39 for mark			1
		(ii)	B (the number of protons increases);			1
					Total	**7**