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

**Total for question 1 = 7 marks**

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| 2 (a) | A activity | | 1 |
| (b) | A alpha particle<br>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):<br><br>MP1 alpha particles have less penetrating power /less range ;<br><br>MP2 alphas have more charge;<br>MP3 alphas cause more ionization;<br>MP4 alphas are bigger / have more mass;<br><br>MP5 (slowing) force on alpha particles is larger;<br>MP6 (kinetic) energy of alpha lost quickly causing ionization;<br>MP7 (larger) alpha particles are more likely to collide with atoms; | Accept reverse arguments, e.g. beta particles have more penetrating power etc<br><br>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;<br><br>and either<br>for amount of (radioactive) nuclei / atoms / isotope to halve;<br><br>OR<br>for (radio)activity to halve | allow "how long it takes"<br><br>allow<br>• decay by half<br>• decay to half<br><br>ignore particles / molecules,<br>"breakdown",<br>"reactivity"<br>reject if implies a single nucleus/atom | 2 |
| (c) (i) | evidence of use of graph;<br><br>56 ± 3 (s); | e.g. lines to two correct points on graph or appropriate subtraction shown in working | 2 |
| (ii) | any 1 from:<br>MP1. idea of {more accurate / smoother} curve;<br><br>MP2. idea that activity changes quickly;<br><br>MP3. idea that decay takes very little time; | allow<br>more points to plot on graph<br><br>decays quickly<br><br>(sample has) short half life | 1 |

**Total 6 marks**

| Question number | Answer | Notes | Marks |
|---|---|---|---|
| 5 (a) (i) | 90 | | 1 |
| (ii) | time;<br><br>either<br>for amount of (radioactive) isotope to halve;<br><br><br><br>or<br>for (radio)activity to halve; | Allow for amount -<br><br>(number of un-decayed) nuclei/atoms/molecules<br><br>(un-decayed) mass of isotope | 2 |
| (iii) | Any two of –<br><br>MP1 Idea that (beta) radiation causes a stated hazard;<br><br>MP2 Idea that strontium-90 has a long half-life;<br><br>MP3 Idea that <u>all</u> beta emission will be absorbed by the body; | <br><br>e.g. causes cancer, kills cells, mutates DNA, ionises tissue<br><br>Accept lasts a long time<br><br>Accept answers in terms of range | 2 |
| (b) (i) | 90 and 0;<br>-1;<br><br>$^{90}_{38}Sr \rightarrow {}^{90}_{39}Y + {}^{0}_{-1}\beta^{-}$ | Must have both<br>Minus is essential | 2 |
| (ii) | Any two ideas from –<br><br>MP1 They are isotopes of different elements;<br><br>MP2 Strontium-90 (nucleus/atom) has the same number of protons as other strontium (nuclei/atoms);<br><br>MP3 Yttrium-90 (nucleus/atom) has the same number of protons as other yttrium (nuclei/atoms); | <br><br><br><br>Allow use of proton number data (38)<br><br>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 -<br>MP1 Beta is (moderately) ionising;<br>MP2 Beta has a short range;<br>MP3 idea that I-131 has a short half-life;<br>MP4 idea that iodine is absorbed (easily) by the thyroid;<br>MP5 (hence) reduces damage to healthy cells;<br>MP6 (hence) does not penetrate out of the body;<br>MP7 (therefore) kills (only) tumour cells; | Ignore I-131 is radioactive, it emits beta | 2 |

Total 4 marks

| Question number | | | Answer | Accept | Reject | Marks |
|---|---|---|---|---|---|---|
| 7 | (a) | | <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)<br>2 ;<br>Unstable nucleus; | ++<br><br>Unstable nuclei | - | 2 |

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