


| 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 <ul style="list-style-type: none"> • 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 | <p>Two from: MP1. Reactor material / waste is radioactive; MP2. (radiation) ionises cells/ tissues / organs / body or causes cancer; MP3. radiation is very penetrating;</p> | <p>allow damages for ionises</p> <p>NOT ALLOW bald 'it is dangerous' do not award marks for 'shielding prevents escape of radiation'/eq</p> | |
|----|--|--|--|

(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) | <p>time taken;</p> <p>and either</p> <ul style="list-style-type: none"> • For half of (radioactive) nuclei / atoms /isotope to decay; <p>OR</p> <ul style="list-style-type: none"> • For (radio)activity to halve; | <p>allow how long it takes</p> <p>Ignore particles /molecules 'break down' 'reactivity'</p> <p>Reject for ONE mark ideas of</p> <ul style="list-style-type: none"> • half of a time • half a nucleus/ an atom • complete decay | |
|------|---|--|--|

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|-----------------|--|--|-------|
| (d) (i) | $ \begin{array}{ccccccc} & & \boxed{4} & & \boxed{234} & & \boxed{0} \\ 238 & & & & & & \\ \text{Pu} & \longrightarrow & \alpha & + & \text{X} & + & \gamma \\ 94 & & \boxed{2} & & \boxed{92} & & \boxed{0} \end{array} $ <p> 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 </p> | | 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) | <p>Any TWO of</p> <p>1. Range / penetration of alpha radiation is low;</p> <p>2. Radon (is a gas so) particles /atoms mobile OR americium (solid so) particles / atoms stay in place;</p> <p>3. Radon can be inhaled / damage internal tissue OR radiation from americium stays within smoke detector / absorbed by the plastic;</p> | <p>WTTE throughout this part</p> <p>ACCEPT 'cannot penetrate skin' / 'travel a few cm in air'</p> <p>ACCEPT 'all around us', 'more likely to come into contact', ACCEPT 'contained', 'stays in detector'</p> <p>ACCEPT 'can be breathed in', 'can get inside body', 'can damage (internal) cells /organs' ACCEPT 'high up', 'far from people'</p> | 2 |
| (c) (i) | A (86) | | 1 |
| (ii) | B (134) | | 1 |
| (d) (i) | Bq / becquerel(s); | <p>ACCEPT approximate / phonetic spellings of becquerel / Becquerel / bekerel REJECT B, BQ, bQ, bq</p> | 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

| Question number | Answer | Notes | Marks | | | | | | | | | | | | | | | | |
|----------------------------------|--|--|-------------------|------------------|-----------------------|-----------------|--|----------------------------------|---------|----------------------------------|--------------|---------|---------|---|--------------|--------------|--------------|--|-----|
| 5 (a) | <table border="0"> <tr> <td style="text-align: center;">description</td> <td style="text-align: center;">type of radiation</td> <td></td> </tr> <tr> <td style="text-align: center;">electromagnetic waves</td> <td style="text-align: center;">alpha</td> <td rowspan="4" style="vertical-align: middle;">positive charge to alpha; negative charge to beta; electromagnetic waves to gamma;</td> </tr> <tr> <td style="text-align: center;">particles with a negative charge</td> <td style="text-align: center;">beta</td> </tr> <tr> <td style="text-align: center;">particles with a positive charge</td> <td style="text-align: center;">gamma</td> </tr> <tr> <td></td> <td style="text-align: center;">neutron</td> </tr> </table> | description | type of radiation | | electromagnetic waves | alpha | positive charge to alpha; negative charge to beta; electromagnetic waves to gamma; | particles with a negative charge | beta | particles with a positive charge | gamma | | neutron | One mark for each correct line Minus one mark for two lines from any one box on the left | (3) | | | | |
| description | type of radiation | | | | | | | | | | | | | | | | | | |
| electromagnetic waves | alpha | positive charge to alpha; negative charge to beta; electromagnetic waves to gamma; | | | | | | | | | | | | | | | | | |
| particles with a negative charge | beta | | | | | | | | | | | | | | | | | | |
| particles with a positive charge | gamma | | | | | | | | | | | | | | | | | | |
| | neutron | | | | | | | | | | | | | | | | | | |
| (b) (i) | in this order only: gamma, beta, alpha; | | (1) | | | | | | | | | | | | | | | | |
| (ii) | any two from: can damage cells; can cause mutation; can cause cancer; | allow kill cells/tissues radiation burns radiation poisoning change genes | (2) | | | | | | | | | | | | | | | | |
| (c) | <table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th></th> <th>0.1 cm paper</th> <th>0.5 cm aluminium</th> <th>0.5 cm lead</th> </tr> </thead> <tbody> <tr> <th>alpha radiation</th> <td>stopped</td> <td>stopped</td> <td>stopped</td> </tr> <tr> <th>beta radiation</th> <td>goes through</td> <td>stopped</td> <td>stopped</td> </tr> <tr> <th>gamma radiation</th> <td>goes through</td> <td>goes through</td> <td>goes through</td> </tr> </tbody> </table> <p>Each row correct for 1 mark;;;</p> | | 0.1 cm paper | 0.5 cm aluminium | 0.5 cm lead | alpha radiation | stopped | stopped | stopped | beta radiation | goes through | stopped | stopped | gamma radiation | goes through | goes through | goes through | | (3) |
| | 0.1 cm paper | 0.5 cm aluminium | 0.5 cm lead | | | | | | | | | | | | | | | | |
| alpha radiation | stopped | stopped | stopped | | | | | | | | | | | | | | | | |
| beta radiation | goes through | stopped | stopped | | | | | | | | | | | | | | | | |
| gamma radiation | goes through | goes through | goes through | | | | | | | | | | | | | | | | |
| (d) | any suitable device e.g. (thin window) GM tube; cloud chamber; spark chamber; semiconductor detector; | accept spelling mistakes Geiger counter NB do not accept repeat of stem (film badge or photographic film) | (1) | | | | | | | | | | | | | | | | |

Total for Question 5 = 10 marks

| Question number | Answer | Notes | Marks | | | |
|-----------------|---|---|-------|-------------------|----------------|------------|
| 6 (a) | 3 or 4 ticks correct;; OR 2 ticks correct; | ignore top line as this is given | 2 | | | |
| | Property | | | Type of radiation | | |
| | | | | Alpha particles | Beta particles | Gamma rays |
| | most ionising | | | (✓) | | |
| | largest mass | | | ✓ | | |
| | most penetrating | | | | | ✓ |
| | highest speed | | | | | ✓ |
| | negatively charged | | ✓ | | | |
| (b) (i) | Number of neutrons = 2; Number of protons 2; | Allow same ideas expressed in words | 2 | | | |
| (ii) | Any one of- MP1. Charge is larger (than other radiations); MP2. Mass is larger (than other radiations); | comparative statement needed ignore <ul style="list-style-type: none"> incorrect terminology e.g. more powerful references to protons and neutrons no RA unless particles/radiation specified condone 'alpha particles have more momentum' | 1 | | | |
| (c) (i) | Idea of background radiation; | Allow Idea that some alpha particles (from source) will get through smoke air is all around = insufficient allow | 1 | | | |
| (ii) | Idea that radioactivity is random; | <ul style="list-style-type: none"> fluctuates source emits different numbers of alphas background radiation varies ignore <ul style="list-style-type: none"> random movement of particles | 1 | | | |
| (iii) | Idea that α particles are absorbed / deflected / stopped / scattered; Idea that α particles are affected by <u>smoke</u> ; | allow for both marks smoke blocks the (alpha) particles | 2 | | | |

Total 9 marks