M1.(a)

	$^{223}_{88}Ra$	$^{224}_{88}Ra$	$^{225}_{88}Ra$	$^{226}_{88}Ra$
Isotope with smallest mass number	(✓)			
Isotope with most neutrons in nucleus				✓
Isotope with nucleus that has highest specific charge	✓			
Isotope that decays by β^- decay to form $^{225}_{89}Ac$			✓	
Isotope that decays by alpha decay to form $^{220}_{86}Rn$		✓		

one mark for each correct row (ignore first row as already ticked)

allow cross instead of tick and ignore any crossed out ticks

if more than one tick in a row then no mark

4

(b) (i) the atom has lost <u>two electrons</u>✓

1

(ii) (*use of specific charge = charge ÷ mass*)
mass = $3.2 \times 10^{-19} \div 8.57 \times 10^{5} = 3.734 \times 10^{-25}$ (kg)
mass number = $3.734 \times 10^{-25} \div 1.66 \times 10^{-27}$ ✓(= 225)

hence $^{225}_{(88)}Ra$ OR 225✓✓
OR
calculate specific charge for each isotope✓

hence $^{225}_{(88)}Ra$ OR 225✓✓

ignore any reference to electrons
first mark for deduction
bald correct answer scores 2 marks

don't need radium symbol or 88
wrong answer scores zero

3

[8]

M2.(a) A α particles ✓

[auto mark question]

1

(b) (i)

type of radiation	Typical range in air / m
α	0.04 ✓
β	0.40 ✓

Allow students to use their own distance units in the table
α allow 0.03 → 0.07 m
β allow 0.20 → 3.0 m.
If a range is given in the table use the larger value.
A specific number is required e.g. not just a few cm.

2

(ii) reference to the inverse square law of (γ radiation)
or
reference to lowering of the solid angle (subtended by the detector as it moves away)
or
radiation is spread out (over a larger surface area as the detector is moved away) ✓

(owtte)
Ignore any references to other types of radiation.
Any contradiction loses the mark. For example, follows inverse square law so intensity falls exponentially.

1

(c) dust may be ingested / taken into the body / breathed in ✓

First mark for ingestion not just on the body

causing (molecules in human tissue / cells) to be made cancerous / killed / damaged by ionisation ✓

Second mark for idea of damage from ionisation

2

[6]

M3.(a) (90,39)

B1

(0,-1)

B1

$\bar{\nu}_e$

B1

3

(b) $d \rightarrow u$
or
Number of u quarks increases by 1 <u>and</u> number of d quarks decreases by 1

B1

1

(c) (i) Meson

Do not allow hadron

B1

1

(ii) Negative box ticked

B1

1

(iii) Characteristic of particles with strange quarks / they contain the strange quark / they have strangeness

B1

1

(iv) Gluon, W ($^+$ or $^-$) (boson) or Z^o

B1

1

[8]

M4.(a) 95 protons ✓ 1

241 – 95 = 146 neutrons ✓ 1

(b) Beta minus decay. ✓

Marks can be given for a correct equation 1

There is no change in the number of nucleons.

The number of protons increases by 1. ✓

Ignore omitted antineutrino. 1

(c) $^{241}_{95}\text{Am} \rightarrow {}^{A}_{Z}\text{X} + {}^{4}_{2}\alpha$ ✓ 1

Nucleon number = A = 241 – 4 = 237 ✓ 1

Proton number = Z = 95 – 2 = 93 ✓ 1

(d) Ionisation is the removal (or addition) of electrons from (to) an atom or molecule ✓ 1

(e) Only a small quantity of material is needed ✓ 1

The particles it emits do not travel more than a few centimetres ✓

Alternative for 2nd mark: Would be stopped before reaching the outside of the detector 1

[10]

M5. A

[1]

M6. (a) (i) Q / boron / B ✓

1

(ii) P and R / R and P ✓

1

(iii) R ✓

6 / 14 is smallest fraction / 0.43 smallest ratio / 4.13 × 10^7 C / kg ✓

Cannot get second mark if not awarded first mark

2

(iv) $^{14}_{6}R \rightarrow {}^{14}_{7}X + {}^{0}_{-1}e + \overline{\nu_{(e)}}$ ✓✓✓

One mark for each correct symbol on rhs
Ignore −ve sign on e.
Can have neutrino with 0,0 on answer lines
Ignore any subscript on neutrino

3

(b) (i) repulsive below / at 0.5 fm (accept any value less or equal to 1 fm) ✓
attractive up to / at 3 fm (accept any value between 0.5 and 10 fm) ✓
short range OR becomes zero OR no effect ✓

Can get marks from labelled graph
Don't accept negligible for 3rd mark

3

(ii) interaction: electromagnetic / em ✓

(virtual) photon/ γ ✓

2

[12]