M1.(a)

	$^{223}_{88}\text{Ra}$	$^{224}_{88}\text{Ra}$	$^{225}_{88}\text{Ra}$	$^{226}_{88}\text{Ra}$
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 $^{225}_{89}\text{Ac}$			✓	
Isotope that decays by alpha decay to form $^{220}_{86}\text{Rn}$		✓		

> *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 × 10⁻¹⁹ ÷ 8.57 × 10⁵ = 3.734 × 10⁻²⁵ (kg)
mass number = 3.734 × 10⁻²⁵ ÷ 1.66 × 10⁻²⁷ ✓ (= 225)
hence $^{225}_{(88)}\text{Ra}$ OR 225 ✓ ✓
OR
calculate specific charge for each isotope ✓
hence $^{225}_{(88)}\text{Ra}$ 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

[1]

M3.C

[1]

M4.C

[1]

M5.(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

Page 3

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]

M6.C

[1]

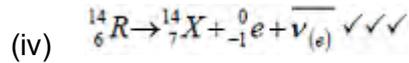**M7.**(a)   (i)   Q / boron / B ✓

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) <u>repulsive</u> below / at 0.5 fm (accept any value less or equal to 1 fm) ✓
<u>attractive</u> 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]

M8.(a) (i) protons = 20 ✓
neutrons = 28 ✓
electrons = 18 ✓

3

(ii) $2 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}$ ✓(C)
-ve sign loses mark

1

(iii) specific charge = 3.2×10^{-19} / (48 ×; 1.67×10^{-27} +18 × 9.11×10^{-31}) ✓

specific charge = 4.0×10^{6} C kg^{-1} ✓
Allow 1.66
Allow CE from (ii)
First mark is for mass if miss out electron mass and do not justify lose first mark

2

[6]

Page 5

M9.(a)   (i)   neutron ✓

                 accept symbols
                 symbols e.g. n

1

         (ii)   electron ✓

                 accept symbols

1

         (iii)   neutron ✓

                 accept symbols

1

     (b)   (i)   antineutrino ✓
                 $V_{(e)}$

1

         (ii)   A=99 ✓
                 Z= 44 ✓

2

         (iii)   specific charge = $43 \times 1.6 \times 10^{-19}$ ✓ / $99 \times 1.66 \times 10^{-27}$ ✓
                 specific charge = 4.2×10^{7} ✓ C kg⁻¹ ✓

                 Correct answer no working −1
                 If include mass of electrons lose 2 and 3 mark

4
[10]