M1.(a) (i) electromagnetic / electrostatic / Coulomb (repulsion between the alpha particles and the nuclei) ✓

The interaction must be named not just described.

1

(ii) the scattering distribution remains the same (because the alpha particles interact with a nucleus) whose charge / proton number / atomic number remains the same or the (repulsive) force remains the same

The mark requires a described distribution <u>and the reason</u> for it.

Or
the scattering distribution changes / becomes less distinct because there is a mixture of nuclear <u>masses</u> (which gives a mixture of nuclear recoils) ✓
(owtte)

A reference must be made to mass and not density or size.

1

(b) (i) use of graph to find r_0
e.g. $r_0 = 6.0 \times 10^{-15} / 75^{1/3}$ ✓
(or $8.0 \times 10^{-15} / 175^{1/3}$)
($r_0 = 1.43 \times 10^{-15}$ m)

Substitution and calculation t must be shown.

Condone a gradient calculation on <u>R against $A^{1/3}$</u> graph (not graph in question) as $R \propto A^{1/3}$

1

(ii) **Escalate if clip shows $^{27}_{13}$Al in the question giving R ≈ 4 × 10^{-15} m.**

(using $R = r_0 A^{1/3}$)
$R = 1.43 \times 10^{-15} \times 51^{1/3}$ ✓
$R = 5.3 \times 10^{-15}$ (m) ✓
($R = 5.2 \times 10^{-15}$ m from
$r_0 = 1.4 \times 10^{-15}$ m)

First mark for working.

Second mark for evaluation which must be 2 or more sig figs allow CE from (i) R = 3.71 × (i).

***Possible escalation**.*

2

(c) **Escalate if clip shows $^{27}_{13}$ in the question and / or the use of 27 in the working.**

density = mass / volume
$m = 51 \times 1.67 \times 10^{-27}$
$(= 8.5 \times 10^{-26}$ kg)

Give the first mark for substitution of data into the top line or bottom line of the calculation of density.

$v = 4/3\pi\ (5.3 \times 10^{-15})^3$
$(6.2(4) \times 10^{-43}$ m^3)

In the second alternative the mark for the substitution is only given if the working equation is given as well.

Or
density = $A \times u / 4/3\pi\ (r_0 A^{1/3})^3$
$= u /4/3\pi\ (r_0)^3$

$51 \times 1.67 \times 10^{-27}$ would gain a mark on its own but 1.66×10^{-27} would need $u / 4/3\ \pi(r_0)^3$ as well to gain the mark.

top line = 1.66×10^{-27}

bottom line = $4/3\pi\ (1.43 \times 10^{-15})^3$

✓ for one substitution

density = 1.4×10^{17} ✓
(1.37×10^{17})
kg m^{-3} ✓

Expect a large spread of possible answers. For example If $R = 5 \times 10^{-15}$ $V = 5.24 \times 10^{-43}$ and density = 1.63×10^{17}.

***Possible escalation**.*

3

[8]

M2. D

[1]

M3. (a) (i) straight on or deflection of zero degrees **(1)**

(ii) the atom consists mainly of open space
[or volume of nucleus is (very much) smaller than volume

of the atom] **(1)**

2

(b) most of the mass of an atom is contained in its nucleus
[or the mass of the nucleus is greater than the mass of the α particle] **(1)**
the nucleus contains a positive charge **(1)**
the charge is concentrated at the nucleus **(1)**

max 2

(c) (i) electrostatic (force)
[or electromagnetic or coulomb] **(1)**

(ii) arrow pointing away from the nucleus
at the closest distance to the nucleus **(1)**

(iii) path showing less deflection at all times

4

[8]

M4.(a) (i) to prevent absorption/deflection/interaction/collision
of the α particle (by the air) **(1)**

(ii) (nucleus) has a positive charge
(or same charge sign as an α particle
(nucleus) contains most of the mass (or is very dense) **(1) (1)** (any two)
(nucleus) is small compared to the separation between nuclei

(iii) electromagnetic or electrostatic or Coulomb **(1)**

4

(b) (particle 1) path is straighter than path of particle 2 **(1)**
(particle 3) path is bent more than path of particle 2, with
minimum radius of curvature near the minimum separation

and in front of the nucleus **(1)**

2

[6]

M5.(a) to prevent the α particles being absorbed or scattered **(1)**
by air molecules **(1)**

(2)

(b) (i) little or no deflection **(1)**
by a majority of α particles **(1)**

(ii) some α particles suffer large deflection
[or backscattering occurs] **(1)**

(3)

(c) **first** path continues undeflected **(1)**
third path shows backscattering (inside the dotted circle) **(1)**
second path undeflected or deflected downwards and
fourth path undeflected or deflected upwards **(1)**

(3)

[8]

M6.(a) α particles have a short range in air (3–5 cm) **(1)**
(or to minimise collisions between α particles and air molecules) **(1)**

(b) the α particles must not be absorbed by the foil **(1)**
(or the α particles must only be scattered once) **(1)**

(c) a majority of α particles pass straight through **(1)**

most α particles do not pass close enough to be deflected
(or few pass close enough to be deflected significantly) **(1)**

atoms consist mainly of open space **(1)**
nuclei are very small (or nucleus much smaller than the atom) **(1)**
the nucleus is massive (or most of the mass of the atom is contained in the nucleus)
the nucleus is positively charged

(or the nucleus and the α particle have the same charge) **(1)**

The Quality of Written Communication marks were awarded primarily for the quality of answers to this part.

[6]