

- 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 and the reason for it.

Or

the scattering distribution changes / becomes less distinct because there is a mixture of nuclear masses (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 R against $A^{1/3}$ graph (not graph in question) as $R \propto A^{1/3}$

1

- (ii) Escalate if clip shows ²⁷13Al in the question giving $R \approx 4 \times 10^{-15}$ m.

(using $R = r_0 A^{1/3}$)

$$R = 1.43 \times 10^{-15} \times 51^{1/3} \quad \checkmark$$

$$R = 5.3 \times 10^{-15} \text{ (m)} \quad \checkmark$$

$$(R = 5.2 \times 10^{-15} \text{ m from}$$

$$r_0 = 1.4 \times 10^{-15} \text{ m})$$

First mark for working.

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

Possible escalation.

2

- (c) Escalate if clip shows ²⁷13 in the question and / or the use of 27 in the working.

$$\begin{aligned} \text{density} &= \text{mass} / \text{volume} \\ m &= 51 \times 1.67 \times 10^{-27} \\ &= 8.5 \times 10^{-26} \text{ kg} \end{aligned}$$

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

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

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

Or

$$\begin{aligned} \text{density} &= A \times u / 4/3\pi (r_0 A^{1/3})^3 \\ &= u / 4/3\pi (r_0)^3 \end{aligned}$$

51 × 1.67 × 10⁻²⁷ would gain a mark on its own but 1.66 × 10⁻²⁷ would need u / 4/3 π(r₀)³ as well to gain the mark.

$$\text{top line} = 1.66 \times 10^{-27}$$

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

✓ for one substitution

$$\begin{aligned} \text{density} &= 1.4 \times 10^{17} \quad \checkmark \\ &= (1.37 \times 10^{17}) \\ &\text{kg m}^{-3} \quad \checkmark \end{aligned}$$

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]