

# Development of the model of the atom

## 4.4.1.3 · Atomic structure · revision notes

How the model of the atom changed as new evidence was found: from tiny indivisible spheres, to the plum pudding model, to the nuclear model, then Bohr's energy levels, protons and neutrons. Expect 'describe', 'compare' and 'explain' questions, especially on why the alpha particle scattering experiment led to the nuclear model, and sometimes a 6-mark answer.

### Key facts

- Order: tiny spheres → plum pudding → nuclear model → Bohr's energy levels → protons → neutrons (Chadwick)
- Plum pudding: ball of positive charge with electrons embedded in it
- Nuclear model: tiny positive nucleus with most of the mass, electrons around it
- Most alpha particles went straight through → atom is mostly empty space
- A few deflected through large angles → positive charge concentrated at the centre
- Very few bounced back → mass concentrated in a tiny nucleus
- Bohr: electrons orbit at specific distances
- Chadwick: evidence for neutrons

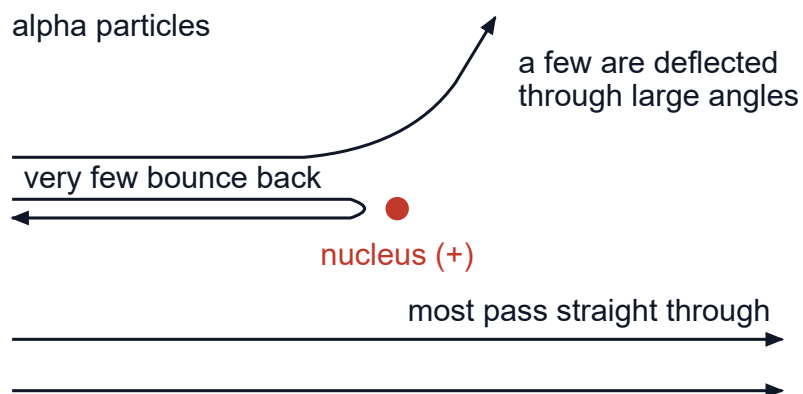
## Notes

### Early models

- Scientific models change when new experimental evidence cannot be explained by the old model.
- Before the electron was discovered, atoms were thought to be tiny spheres that could not be divided.
- The discovery of the **electron** showed that atoms contain smaller particles. This led to the **plum pudding model**: the atom is a ball of positive charge with negative electrons embedded in it.

## The alpha particle scattering experiment

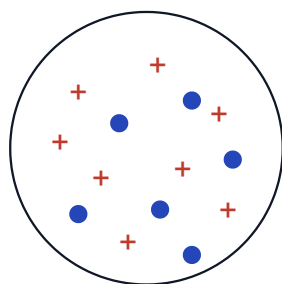
- Positively charged alpha particles were fired at a very thin sheet of gold foil, and detectors recorded where they went.
- The plum pudding model predicted that they would all pass through with very small deflections, because the positive charge and mass were spread out.
- Most** alpha particles passed straight through → most of the atom is **empty space**.
- A **few** were deflected through large angles → the positive charge is concentrated in a tiny region at the centre, which repels the alpha particles.
- A **very small number bounced back** → most of the mass is concentrated in that tiny region, the **nucleus**.



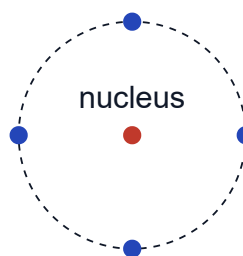
Paths of alpha particles near a gold nucleus (the nucleus is drawn far bigger than it really is).

- So the **nuclear model** replaced the plum pudding model: a tiny, positively charged nucleus containing most of the mass, with electrons around it.

Plum pudding model



Nuclear model



positive charge spread out, tiny + nucleus with most of the mass,  
electrons dotted through it the rest is mostly empty space

Before and after the alpha scattering experiment (red + = positive charge, blue = electrons).

## Later developments

- **Niels Bohr** adapted the nuclear model: electrons orbit the nucleus at specific distances (energy levels). His theoretical calculations agreed with experimental observations.
- Later experiments showed that the positive charge of any nucleus could be divided into smaller particles, each with the same amount of positive charge. These are **protons**.
- **James Chadwick's** experiments provided evidence for **neutrons** in the nucleus, about 20 years after the nucleus became an accepted idea.
- You do not need the details of Bohr's or Chadwick's experimental work.

## How to answer each type of question

### Compare the plum pudding and nuclear models

2 marks

Grade 5

1. Pick a feature: where the positive charge is, where the mass is, or empty space.
2. Say what each model says about it in the same sentence.
3. Use 'whereas' to make the comparison clear.

**Example.** Describe two differences between the plum pudding model and the nuclear model of the atom.

**Model answer.** In the plum pudding model the positive charge is spread through the whole atom, whereas in the nuclear model it is concentrated in a tiny nucleus (1). In the plum pudding model the mass is spread evenly, whereas in the nuclear model most of the mass is in the nucleus (1). Also accept: the nuclear model is mostly empty space; the plum pudding model has no nucleus.

## Don't lose marks

- ✗ Describing the plum pudding model without saying the 'pudding' is positive charge.
- ✗ Saying alpha particles bounced back because they hit electrons. Electrons are far too light to turn an alpha particle back.
- ✗ Saying most alpha particles were deflected. Most went straight through; only a few were deflected through large angles.
- ✗ Mixing up the scientists: Bohr = electrons at specific distances; Chadwick = neutrons.
- ✗ Saying the old model was 'wrong' without saying what new evidence it could not explain.

## More tips

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### Memory tricks

- Order of models: '**Some Pupils Need Better Physics Notes**' = Spheres, Plum pudding, Nuclear, Bohr, Protons, Neutrons.
- Alpha results in three words: **through** (empty space), **deflected** (positive nucleus), **back** (mass in the nucleus).
- **Chadwick** found the **chargeless** particle: the neutron.

### Exam technique

- For each alpha scattering observation, give the observation AND what it shows about the atom.
- In 6-mark answers, keep a clear time order and link every change to the evidence that caused it.
- 'Compare' means each point must mention both models, e.g. using 'whereas'.

## What each grade needs

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What you need to be able to do, from the first marks up to the top grade.

### Grade 3

#### Put the models of the atom in order

Tiny spheres, plum pudding, nuclear model, Bohr's energy levels, then protons and neutrons.

### Grade 4

#### Describe the plum pudding model

The atom is a ball of positive charge with negative electrons embedded in it.

### Grade 5

#### Describe the nuclear model

A tiny, positively charged nucleus containing most of the mass, with electrons around it.

### Grade 5

#### Compare plum pudding and nuclear models

Charge and mass spread out, compared with concentrated in a nucleus with empty space around it.

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