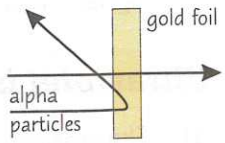
The Model of the Atom

We used to think atoms were tiny solid spheres (like ball-bearings), but they're much more complex than that...

The Theory of Atomic Structure Has Changed Over Time

1) In 1897 J. J. Thomson discovered that electrons could be removed from atoms, so atoms must be made up of smaller bits. He suggested the 'plum-pudding' model — that atoms were spheres of positive charge with tiny negative electrons stuck in them like fruit in a plum pudding.
2) That "plum pudding" theory didn't last very long though. In 1909, Rutherford and Marsden tried firing a beam of alpha particles (see p.174) at thin gold foil. From the plum-pudding model, they expected the particles to pass straight through the gold sheet, or only be slightly deflected.
3) But although most of the particles did go straight through the sheet, some were deflected more than they had expected, and a few were deflected back the way they had come — something the plum-pudding model couldn't explain.



4) Being a pretty clued-up guy, Rutherford realised this meant that most of the mass of the atom was concentrated at the centre in a tiny nucleus.
5) He also realised that most of an atom is just empty space, and that the nucleus must have a positive charge, since it repelled the positive alpha particles.
6) This led to the creation of the nuclear model of the atom.
7) Niels Bohr tweaked Rutherford's idea a few years later by proposing a model where the electrons were in fixed orbits at set distances from the nucleus. These distances were called energy levels (p.173).
8) He suggested that electrons can only exist in these fixed orbits (or shells), and not anywhere inbetween.
9) This model is known as the Bohr model and is pretty close to our currently accepted model of the atom.

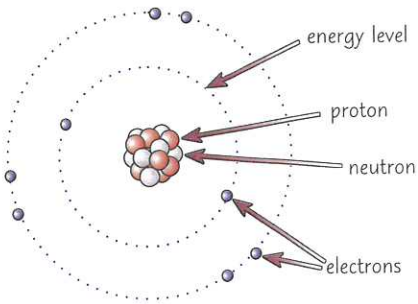
The Current Model of the Atom — Protons, Neutrons and Electrons

The quantities to do with atoms are really tiny, so they're written in standard form: $A \times 10^n$

where A is a number between 1 and 10 and n is the number of places the decimal point would move if you wrote the number out in decimal form.

According to our current model of the atom:

1) An atom is a positively-charged nucleus surrounded by negatively-charged electrons.
2) Virtually all the mass of the atom is in the nucleus. The nucleus is tiny — about 10 000 times smaller than the whole atom. It contains protons (which are positively charged) and neutrons (which are neutral). The rest of the atom is mostly empty space.
3) The negative electrons whizz round outside the nucleus in fixed orbits called energy levels or shells. They give the atom its overall size of around 1×10^{-10} m.



4) Atoms are neutral, so the number of protons = the number of electrons. This is because protons and electrons have an equal but opposite relative charge.
5) If an atom loses an electron it becomes a positive ion. If it gains an electron it becomes a negative ion (p.173).
6) Atoms can join together to form molecules — e.g. molecules of oxygen gas are made up of two oxygen atoms bonded together. Small molecules like this have a typical size of 10^{-10} m — the same sort of scale as the size of an atom.

Particle	Relative Mass	Relative Charge
Proton	1	+1
Neutron	1	0
Electron	0.0005	−1

These models don't have anything on my miniature trains...

That's a whole lot of history, considering this is a book about physics. It's all good, educational fun though.

Q1 a) Describe the current model of the atom. [4 marks]
b) Describe how the radius of an atom compares to the size of its nucleus. [1 mark]

The Model of the Atom

Warm-Up

Which of the following best describes the typical size of an atom?

☐ 1 mm ☐ 1×10^{-5} m ☐ 1×10^{-10} m ☐ 1×10^{-20} m

1 Rutherford came up with a new model of the atom as a result of his scattering experiment. Grade 4-6

a) Name and describe the model that this model replaced.

.....

.....

[2]

b) State **one** property of Rutherford's model of the atom. Describe the observation from Rutherford's scattering experiment that provided evidence for this property.

Property: .....

Observation: .....

.....

[2]

[Total 4 marks]

2 **Figure 1** is an incomplete table showing the relative charges of the subatomic particles in an atom. Grade 4-6

Figure 1

Particle	Proton	Neutron	Electron
Relative charge	.....	.....	–1

a) Complete **Figure 1**.

[2]

b) Describe how these subatomic particles are arranged in the atom.

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[2]

c) An iron atom has 26 protons. State the number of electrons in an iron atom and use this to explain the overall charge of the atom.

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[2]

[Total 6 marks]

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