The structure of an atom

4.4.1.1 · Atomic structure · revision notes

What an atom is made of, how tiny its nucleus is compared with the whole atom, and how electrons change energy level when they absorb or emit electromagnetic radiation. Expect short recall questions, size comparisons in standard form and 2 to 3 mark 'explain' questions on energy levels.

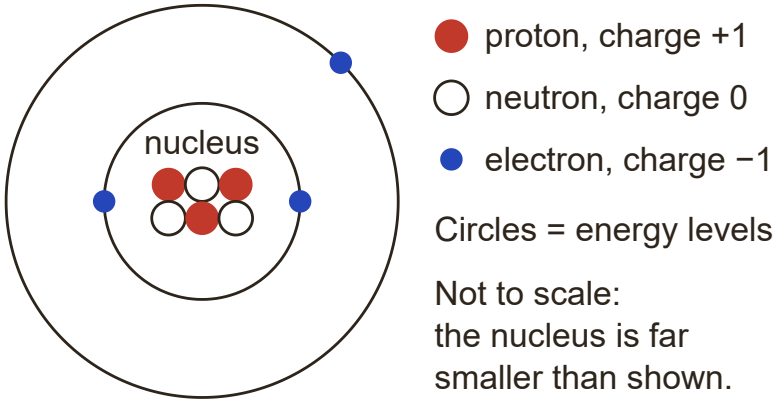
Key facts

- Nucleus = protons (+1) and neutrons (0); electrons (−1) are around the nucleus
- Radius of an atom ≈ 1×10^{-10} m
- Almost all the mass of an atom is in the nucleus
- Electron emits EM radiation → moves to a lower energy level (closer to the nucleus)
- Relative masses: proton 1, neutron 1, electron about 1/2000
- Radius of nucleus < 1/10 000 of the radius of the atom
- Electron absorbs EM radiation → moves to a higher energy level (further from the nucleus)

Notes

Inside an atom

- An atom has a tiny, positively charged **nucleus** made of **protons** and **neutrons**.
- Negatively charged **electrons** are arranged around the nucleus, at different distances from it.



The nuclear model of a lithium atom: 3 protons and 3 neutrons in the nucleus, 3 electrons in energy levels around it. Equal numbers of protons and electrons, so the atom has no overall charge.

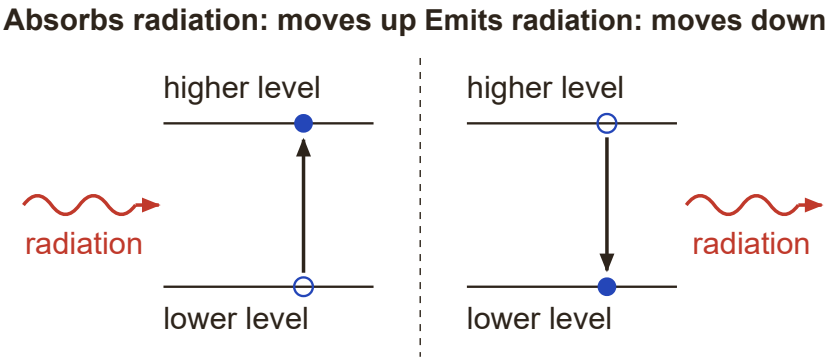
- Relative charges: proton +1, neutron 0 (no charge), electron −1.
- Relative masses: proton 1, neutron 1, electron very small (about 1/2000). So almost all the mass of an atom is in its nucleus.
- An atom has the same number of electrons as protons, so it has no overall charge.

How big is an atom?

- The radius of an atom is about **1×10^{-10} m**.
- The radius of the nucleus is **less than 1/10 000** of the radius of the atom, so it is about 1×10^{-14} m or smaller.
- So an atom is mostly empty space. If an atom were 100 m across, its nucleus would be less than 1 cm across.
- Even though it is so small, the nucleus contains almost all of the atom's mass.

Electrons and energy levels

- Electrons can only be at certain distances from the nucleus. These are called **energy levels** (or shells).
- If an electron **absorbs** electromagnetic radiation, it can move to a **higher** energy level, further from the nucleus.
- If an electron **emits** electromagnetic radiation, it moves to a **lower** energy level, closer to the nucleus.



Absorbing electromagnetic radiation lifts an electron to a higher level; falling back emits radiation.

How to answer each type of question

Recall: the particles in an atom 1 to 3 marks **Grade 3**

1. Say where each particle is: protons and neutrons in the nucleus, electrons around it.
2. Give relative charges as numbers with a sign: +1, 0, −1.
3. Explain the charge of the nucleus from the particles in it.

Example. (a) Name the two types of particle found in the nucleus of an atom.
(b) Give the relative charge of an electron.
(c) Explain why the nucleus of an atom is positively charged.

Model answer.

(a) Protons and neutrons (1)

(b) −1 (1)

(c) Protons are positive and neutrons have no charge, so the nucleus has an overall positive charge (1)

Calculate: compare the size of an atom and its nucleus

2 marks | Grade 5

1. Write both sizes in the same unit (usually metres).
2. Divide the radius of the atom by the radius of the nucleus.
3. Check the answer is a large number: the atom is much bigger.

Example. The radius of an atom is 1.5×10^{-10} m. The radius of its nucleus is 3.0×10^{-15} m. Calculate how many times larger the radius of the atom is than the radius of the nucleus.

Model answer.

$1.5 \times 10^{-10} \div 3.0 \times 10^{-15}$ (1)

$= 50\,000$ (1)

Explain: electrons and energy levels

2 to 3 marks | Grade 5

1. Say whether electromagnetic radiation is absorbed or emitted.
2. Say whether the electron moves to a higher or lower energy level.
3. Say whether it moves further from or closer to the nucleus.

Example. Light is shone on a gas. Some electrons in the gas atoms move further from the nucleus. A short time later, these electrons move back closer to the nucleus.
(a) Explain why the electrons move further from the nucleus. (2 marks)
(b) State what is given out when the electrons move closer to the nucleus. (1 mark)

Model answer.

(a) The electrons absorb electromagnetic radiation / light (1) so they move to a higher energy level (1).

(b) Electromagnetic radiation (1)

Don't lose marks

- Putting electrons in the nucleus, or saying neutrons are negative.
- Saying the nucleus is 10 000 times bigger than the atom. It is the other way round.
- Mixing up absorb and emit: absorbing radiation moves an electron further from the nucleus, not closer.
- Saying the mass of an atom is spread out evenly. Almost all of it is in the tiny nucleus.
- Dividing the wrong way round in a size comparison and getting a tiny number.

More tips

Memory tricks

- **P**roton = **P**ositive; **N**eutron = **N**eutral. The electron is the only negative one.
- Energy levels are like stairs: going up (further out) needs energy absorbed, coming down (closer in) gives energy out.
- Powers-of-ten check: atom about 10^{-10} m, nucleus about 10^{-14} m. The powers differ by 4, so the atom is about 10^{4} = 10 000 times bigger.
- Use your calculator's $\times 10^{x}$ key for standard form, so you don't need brackets.

Exam technique

- In energy level answers, use the key terms: 'absorbs' or 'emits', 'electromagnetic radiation', 'higher' or 'lower energy level'.
- Give sizes in standard form with the unit, e.g. 1×10^{-10} m.
- When a question asks for a relative charge, give the number with its sign (+1, 0 or −1).

What each grade needs

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

Grade 3

Name the three particles in an atom

Protons and neutrons are in the nucleus; electrons are arranged around the nucleus.

Grade 4

Give the relative charge of each particle

Proton +1, neutron 0, electron −1, so the nucleus is positively charged.

Grade 4

Recall the size of an atom

The radius of an atom is about 1×10^{-10} m.

Grade 5

Compare the sizes of atom and nucleus

The nucleus has a radius less than 1/10 000 of the atom's radius, yet contains almost all of its mass.

Grade 5

Explain how electrons change energy level

Absorbing EM radiation moves an electron to a higher level, further out; emitting EM radiation moves it to a lower level, closer in.

Grade 5

Compare sizes using standard form

Divide the larger size by the smaller one, e.g. 1×10^{-10} m ÷ 1×10^{-14} m = 10 000.

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