Metals as conductors

4.2.2.8 · Bonding, structure and the properties of matter · revision notes

Why metals are good conductors of electricity and of thermal energy: both depend on the delocalised electrons. Questions are often 2 marks on their own, or part of a comparison with ionic compounds, graphite or covalent substances.

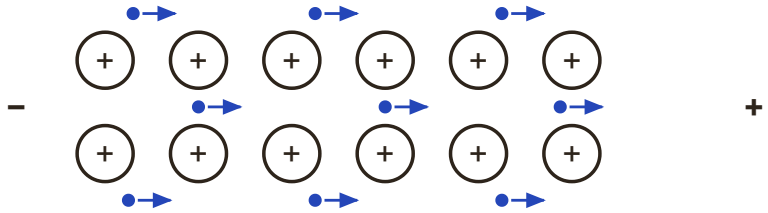
Key facts

- Metals conduct electricity: delocalised electrons carry charge through the metal
- To conduct electricity: charged particles that are free to move
- Graphite conducts because it has delocalised electrons, like a metal
- Metals conduct thermal energy: energy is transferred by the delocalised electrons
- Metal (solid or liquid): electrons move. Ionic compound (molten or dissolved): ions move

Notes

Conducting electricity

- An electric current is a flow of charge. A substance conducts if it has **charged particles that are free to move**.
- In a metal, the outer shell electrons are **delocalised**: they are free to move through the whole structure.
- In a circuit, the delocalised electrons move through the metal and **carry electrical charge**. So metals are good conductors of electricity.



delocalised electrons (blue) move through the metal, carrying charge

In a circuit the delocalised electrons flow towards the positive terminal.

- This works whether the metal is solid or molten, because the delocalised electrons are always there.

Conducting thermal energy

- Metals are also good conductors of **thermal energy**.
- The delocalised electrons move through the structure and **transfer energy** quickly from hotter parts of the metal to cooler parts.
- This is why pans are made of metal, and why a metal object feels cold to touch: it conducts energy away from your hand quickly.

Comparing conductors

- **Metals**: conduct when solid or liquid; **delocalised electrons** move.
- **Graphite**: conducts as a solid; like a metal, it has **delocalised electrons**.
- **Ionic compounds**: conduct only when molten or dissolved in water; **ions** move.
- **Small molecules, polymers, diamond and silicon dioxide**: do not conduct, because no charged particles are free to move.
- Copper is used for electrical wires because it is a very good conductor and can be drawn out into wires.

How to answer each type of question

Explain why a metal conducts electricity — 2 marks — Grade 5

1. Name the particles: delocalised electrons.
2. Say they are free to move through the structure and carry charge.

Example. Explain why copper is a good conductor of electricity.

Model answer. Copper has delocalised electrons (1), which are free to move through the metal and carry electrical charge (1).

Explain why a metal is a good thermal conductor — 2 marks — Grade 6

1. Name the particles: delocalised electrons.
2. Say they transfer energy through the metal.

Example. Saucepans are often made of aluminium.
Explain why aluminium is a good conductor of thermal energy.

Model answer. Aluminium has delocalised electrons (1). These move through the metal and transfer energy quickly (1).

Compare conduction in different substances — 4 marks — Grade 7

1. For each substance, name the particles that could carry charge.
2. Say whether those particles are free to move in the state described.
3. Conclude whether each substance conducts.

Example. Explain why solid magnesium conducts electricity but solid magnesium chloride does not.

Model answer. Magnesium has delocalised electrons (1), which are free to move through the structure and carry charge (1). In solid magnesium chloride, the ions are held in fixed positions in the lattice (1), so there are no charged particles free to move (1).

Don’t lose marks

- Saying ions move in a metal. The positive ions stay in place; the delocalised electrons move.
- Saying 'electrons carry the current' without saying they are delocalised or free to move.
- Forgetting the delocalised electrons when explaining thermal conduction: the specification links it to them.
- Writing that the electrons 'carry current' or 'carry electricity', or move 'throughout' the metal. Say they move through the metal and carry charge.

More tips

Memory tricks

- Electricity and heat in metals have the same answer: delocalised electrons.
- Ask 'what moves?': electrons in metals and graphite; ions in molten or dissolved ionic compounds; nothing in molecular substances.
- Delocalised = not stuck to one atom = free to move.

Exam technique

- Conduction answers need two points: the particle (delocalised electrons) and what it does (moves through the structure, carrying charge or energy).
- In comparison questions, write a sentence about each substance; don't leave the examiner to work out the second half.
- Use 'charge' for electrical conduction and 'energy' for thermal conduction.

What each grade needs

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

Grade 3 — **State that metals conduct electricity and heat**
Metals are good conductors of electricity and of thermal energy.

Grade 4 — **Name the particles that carry the charge**
Delocalised electrons carry electrical charge through the metal.

Grade 5 — **Explain electrical conduction in metals**
The delocalised electrons are free to move through the structure, carrying charge.

Grade 6 — **Explain thermal conduction in metals**
Energy is transferred through the metal by the delocalised electrons.

Grade 7 — **Compare conduction in metals and ionic compounds**
Metals conduct when solid because electrons move; ionic compounds conduct only when molten or dissolved, because ions move.

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