Properties of small molecules

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

Why substances made of small molecules have low melting and boiling points and do not conduct electricity. The key idea, tested again and again, is that melting and boiling overcome the weak intermolecular forces between molecules, not the strong covalent bonds inside them.

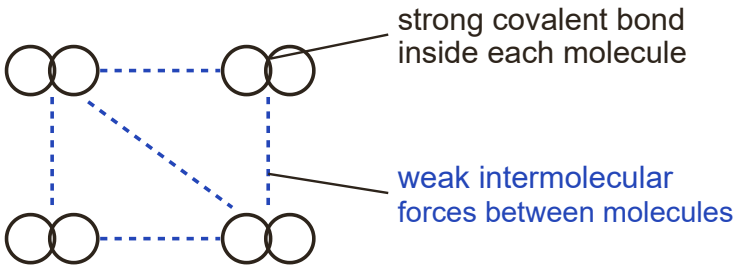
Key facts

- Small molecules: strong covalent bonds inside, weak intermolecular forces between
- Weak forces → little energy needed → low melting and boiling points
- Larger molecules → stronger intermolecular forces → higher melting and boiling points
- Melting and boiling overcome the intermolecular forces, NOT the covalent bonds
- Usually gases or liquids at room temperature
- Molecules have no overall charge → do not conduct electricity

Notes

Bonds inside, forces between

- Small molecules (e.g. H_2, O_2, Cl_2, H_2O, CO_2, CH_4) have **strong covalent bonds** between the atoms **inside** each molecule.
- Between separate molecules there are only **weak intermolecular forces**.
- When a molecular substance melts or boils, it is the **intermolecular forces** that are overcome. The covalent bonds **do not break**: the molecules stay the same.



Melting or boiling overcomes the weak forces (dashed), not the covalent bonds.

Low melting and boiling points

- Weak intermolecular forces need only a **small amount of energy** to overcome.
- So substances made of small molecules have **low melting and boiling points**. They are usually **gases or liquids** at room temperature.
- The intermolecular forces **increase with the size of the molecules**, so larger molecules have higher melting and boiling points.
- Example: in Group 7, fluorine and chlorine are gases, bromine is a liquid and iodine is a solid at room temperature, because the molecules get larger down the group.
- Example: methane, CH_4, boils at −162 °C, but pentane, C_5H_{12}, which has larger molecules, boils at 36 °C.

No electrical conductivity

- Molecules have **no overall electric charge**, and there are no ions or delocalised electrons free to move.
- So substances made of small molecules **do not conduct electricity**, whether they are solid, liquid or gas.

How to answer each type of question

Explain why a molecular substance does not conduct electricity 1 to 2 marks **Grade 4**

1. Say the molecules have no overall electric charge.
2. So there are no charged particles free to move and carry charge.

Example. Explain why liquid bromine does not conduct electricity.

Model answer. Bromine is made of molecules that have no overall electric charge (1), so there are no charged particles free to move and carry charge (1).

Explain why a molecular substance has a low boiling point 2 to 3 marks **Grade 5**

1. Say it is made of small molecules.
2. Say there are weak intermolecular forces between the molecules.
3. Say only a small amount of energy is needed to overcome them.

Example. Chlorine, Cl_2, boils at −34 °C.
Explain why chlorine has a low boiling point.

Model answer. Chlorine is made of small molecules (1). There are weak intermolecular forces between the molecules (1). Only a small amount of energy is needed to overcome these forces (1).

Explain what happens to the molecules on boiling

2 marks | Grade 5

1. Say that boiling overcomes the weak forces between molecules.
2. Say that the covalent bonds inside the molecules do not break.

Example. A student says: 'When water boils, the bonds in the water molecules break.'
Explain why the student is wrong.

Model answer. Boiling overcomes the weak intermolecular forces between the water molecules (1). The strong covalent bonds inside the molecules do not break, so the steam is still made of H_2O molecules (1).

Explain a trend in boiling points

3 marks | Grade 5

1. Describe the trend from the data.
2. Link it to the size of the molecules.
3. Larger molecules → stronger intermolecular forces → more energy needed to overcome them.

Example. The table gives the boiling points of three substances made of small molecules.

Substance	Formula	Boiling point in °C
methane	CH_4	−162
propane	C_3H_8	−42
pentane	C_5H_{12}	36

Explain the trend in boiling points.

Model answer. The boiling point increases as the molecules get larger (1). The intermolecular forces get stronger as the size of the molecules increases (1). So more energy is needed to overcome the intermolecular forces (1).

Don’t lose marks

- Saying covalent bonds break when a molecular substance melts or boils. This is the most common mistake in the topic.
- Writing 'weak covalent bonds'. Covalent bonds are strong; it is the intermolecular forces that are weak.
- Writing 'weak bonds' or 'weak forces' without saying they are between the molecules.
- Saying the molecules themselves melt or expand when heated.
- Explaining a trend with 'more bonds' instead of 'stronger intermolecular forces between larger molecules'.

More tips

Memory tricks

- Inside strong, between weak: covalent bonds hold each molecule together; intermolecular forces hold the molecules to each other.
- Low melting point and never conducts → small molecules.
- Bigger molecule, bigger boiling point.

Exam technique

- Always write 'intermolecular forces' or 'forces between molecules'. A vague 'bonds' usually loses the mark.
- If you compare with a giant covalent substance, say that its covalent bonds must be broken to melt it.
- Quote the data when you describe a trend.

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 small molecules have low boiling points**
Substances made of small molecules are usually gases or liquids at room temperature.

Grade 4 — **State that small molecules don't conduct electricity**
The molecules have no overall electric charge.

Grade 5 — **Explain low boiling points using intermolecular forces**
Only weak intermolecular forces must be overcome, which needs little energy.

Grade 5 — **Say which forces are overcome on boiling**
The intermolecular forces are overcome; the covalent bonds inside the molecules do not break.

Grade 5 — **Explain boiling point trends using molecule size**
Larger molecules have stronger intermolecular forces, so they have higher melting and boiling points.

Grade 5 — **Compare intermolecular forces with covalent bonds**
Covalent bonds are strong and intermolecular forces are weak, which explains the bulk properties of molecular substances.

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