Giant covalent structures

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

Substances such as diamond, graphite and silicon dioxide, in which every atom is joined to others by strong covalent bonds in a huge network. You need to explain their very high melting points, recognise them from diagrams, and contrast them with substances made of small molecules.

Key facts

- Giant covalent: all atoms joined by strong covalent bonds in a network
- Melting breaks many strong covalent bonds → very high melting points
- Usually do not conduct (no charged particles free to move); graphite is the exception
- Examples: diamond, graphite, silicon dioxide (silica)
- No separate molecules
- SiO_2: each Si bonded to 4 O, each O bonded to 2 Si

Notes

What a giant covalent structure is

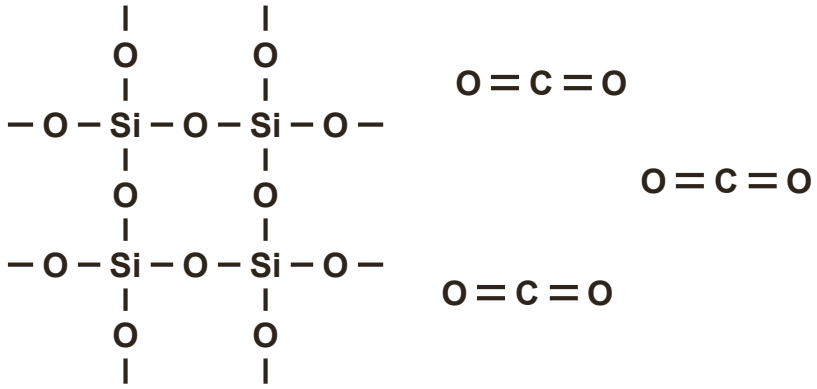
- In a **giant covalent structure**, **all** the atoms are linked to other atoms by **strong covalent bonds**, forming a huge network.
- There are no separate molecules.
- Examples: **diamond** and **graphite** (forms of carbon) and **silicon dioxide**, SiO_2 (silica, the main compound in sand).
- In silicon dioxide, each silicon atom is bonded to four oxygen atoms and each oxygen atom to two silicon atoms, which gives the 1 : 2 ratio in SiO_2.

Properties

- To melt or boil a giant covalent substance, **covalent bonds must be broken**.
- There are a huge number of strong bonds, so a **very large amount of energy** is needed. So these substances are **solids** with **very high melting and boiling points**.
- Most do not conduct electricity, because they have no charged particles that are free to move. Graphite is the exception: it has delocalised electrons.

Recognising them from diagrams

- Look for many atoms joined by lines (bonds) in a repeating network, with bonds going off the edges of the diagram.
- Diamond: each carbon atom joined to four others in 3D. Graphite: flat layers of hexagons. Silicon dioxide: silicon and oxygen atoms alternating in a network.



silicon dioxide: giant covalent, no molecules

carbon dioxide: small separate molecules

Silicon dioxide (left) is one giant network. Carbon dioxide (right) is separate small molecules.

- Not giant covalent: small, complete molecules; chains in brackets with n (polymers); + and − ions (ionic).

Giant versus small: silicon dioxide and carbon dioxide Grade 7+ only

- Carbon dioxide, CO_2, is made of small molecules with weak intermolecular forces between them, so it is a gas at room temperature.
- Silicon dioxide, SiO_2, is a giant covalent structure with strong covalent bonds throughout, so it does not melt until over 1600 °C.

How to answer each type of question

Explain why a giant covalent substance has a very high melting point 3 marks Grade 5

1. Name the structure: giant covalent.
2. Say there are many strong covalent bonds (every atom is linked).
3. Say these must be broken, which needs a lot of energy.

Example. Silicon dioxide does not melt until over 1600 °C.
Explain why, in terms of its structure and bonding.

Model answer. Silicon dioxide has a giant covalent structure (1). There are many strong covalent bonds between the atoms (1). A lot of energy is needed to break these bonds (1).

Identify a giant covalent substance from data

3 marks | Grade 6

1. Look for a very high melting point.
2. Look for 'does not conduct', even when molten (so it is not ionic or metallic).
3. Give the structure and quote the evidence.

Example. Substance W melts at 3500 °C. It does not conduct electricity when solid or when molten. Give the type of structure of W. Give two reasons from the data.

Model answer. Giant covalent (1). It has a very high melting point (1). It does not conduct electricity even when molten, so it is not ionic or metallic (1).

Explain the difference between a giant covalent and a small molecular substance

4 marks | Grade 5

1. Identify each structure: small molecules or giant covalent.
2. Small molecules: weak intermolecular forces, little energy needed to overcome them.
3. Giant covalent: many strong covalent bonds must be broken, a lot of energy needed.
4. Make clear that no covalent bonds break when the small molecules melt or boil.

Example. Carbon dioxide is a gas at room temperature. Silicon dioxide is a solid with a very high melting point.
Explain this difference in terms of structure and bonding.

Model answer. Carbon dioxide is made of small molecules (1) with weak intermolecular forces between them, which need little energy to overcome (1). Silicon dioxide has a giant covalent structure (1) in which many strong covalent bonds must be broken, which needs a lot of energy (1).

Don’t lose marks

- Saying diamond or silicon dioxide has intermolecular forces. They have no separate molecules.
- Saying silicon dioxide has a high melting point because of strong intermolecular forces.
- Writing 'strong bonds' without 'covalent', or saying silicon dioxide has ionic bonds.
- Confusing silicon dioxide (giant covalent) with carbon dioxide (small molecules).
- Saying that all giant covalent substances are hard and don't conduct: graphite is soft and conducts.

More tips

Memory tricks

- Giant covalent: no molecules, so melting means breaking covalent bonds.
- Sand (silica) and diamond both have very high melting points: both are giant covalent.
- Very high melting point + doesn't conduct even when molten → giant covalent. Graphite is the one that does conduct.

Exam technique

- The key phrase is 'many strong covalent bonds', which must be broken and need a lot of energy.
- In compare questions, write about both substances: explaining only one earns at most half the marks.
- Identify the structure first, from the formula, the diagram or the data, then explain the property.

What each grade needs

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

Grade 3

Name examples of giant covalent structures

Diamond and graphite (both forms of carbon) and silicon dioxide (silica).

Grade 4

State that they have very high melting points

They are solids at room temperature with very high melting and boiling points.

Grade 5

Explain their very high melting points

Many strong covalent bonds must be broken, which needs a lot of energy.

Grade 5

Contrast giant covalent and small molecular substances

Melting a giant structure breaks covalent bonds; melting small molecules only overcomes intermolecular forces.

Grade 6

Recognise giant covalent structures from diagrams

A network of atoms all joined by covalent bonds, continuing in all directions, with no separate molecules.

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