Diamond

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

Diamond is a form of carbon with a giant covalent structure in which each carbon atom is bonded to four others. You must explain why it is very hard, has a very high melting point and does not conduct electricity. It often appears alongside graphite in comparison questions.

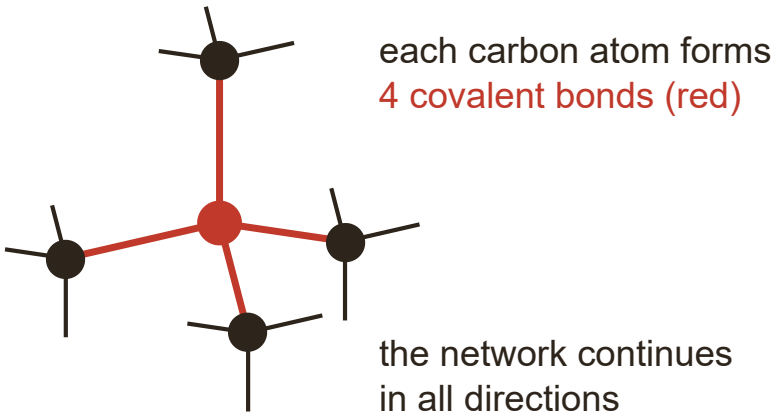
Key facts

- Diamond: carbon atoms, each forming 4 covalent bonds
- Very hard: strong covalent bonds hold every atom rigidly
- Does not conduct: no delocalised electrons (all 4 outer electrons used in bonds)
- Giant covalent structure: a rigid 3D network
- Very high melting point: many strong covalent bonds to break

Notes

Structure and bonding

- Diamond is made of **carbon atoms only**.
- Each carbon atom forms **four covalent bonds** with four other carbon atoms.
- This makes a **giant covalent structure**: a rigid 3D network that continues in all directions, with no separate molecules.



Diamond: every carbon atom is bonded to four others in a rigid 3D network.

- A carbon atom has four outer electrons, and in diamond **all four** are used in covalent bonds.

Properties explained

- **Very hard**: every atom is held in place by strong covalent bonds in a rigid 3D network, so the atoms cannot easily be moved out of position.
- **Very high melting point**: to melt diamond, a huge number of strong covalent bonds must be broken, which needs a very large amount of energy.
- **Does not conduct electricity**: all the outer electrons are used in bonds, so there are **no delocalised electrons** (and no ions) free to move and carry charge.

Uses and comparison

- Its hardness makes diamond useful for cutting tools, such as the tips of drills and saws used to cut rock, glass and metal.
- Graphite is also carbon with a giant covalent structure, but each atom forms only three bonds. This one difference explains why graphite is soft and conducts electricity.

How to answer each type of question

Explain why diamond has a very high melting point (or is very hard) 3 marks **Grade 5**

1. Describe the structure: giant covalent, each carbon atom bonded to four others.
2. Say there are many strong covalent bonds.
3. Melting point: a lot of energy is needed to break them. Hardness: the atoms are held rigidly in place.

Example. Explain why diamond has a very high melting point.

Model answer. Diamond has a giant covalent structure in which each carbon atom is bonded to four others (1). There are many strong covalent bonds (1). A lot of energy is needed to break these bonds (1).

Explain why diamond does not conduct electricity 2 marks **Grade 6**

1. Say each carbon atom uses all four outer electrons in covalent bonds.
2. So there are no delocalised electrons (no charged particles free to move).

Example. Explain why diamond does not conduct electricity.

Model answer. Each carbon atom uses all four of its outer electrons to form covalent bonds (1), so there are no delocalised electrons / no charged particles free to move (1).

Explain why diamond is suitable for a use

4 marks | Grade 7

1. Pick out the properties the use needs (from the question).
2. State each property.
3. Explain each property using the structure and bonding.

Example. Drill bits for drilling through rock are often tipped with diamond. The tip gets very hot during drilling.
Explain why diamond is suitable for this use, in terms of its structure and bonding.

Model answer. Diamond is very hard (1) because each carbon atom forms four strong covalent bonds in a rigid giant structure (1). Diamond has a very high melting point, so it does not melt when the tip gets hot (1), because a lot of energy is needed to break its many strong covalent bonds (1).

Don’t lose marks

- Saying diamond is made of molecules or has intermolecular forces.
- Saying diamond is hard because of ionic bonds, or because of 'strong forces' without saying covalent bonds.
- Saying diamond doesn't conduct because it has no free ions. The key point is that it has no delocalised electrons.
- Writing that each carbon atom in diamond forms three bonds. That is graphite.

More tips

Memory tricks

- Diamond: 4 bonds per carbon = 0 spare electrons = no conduction.
- Hard, high, no flow: diamond is very hard, has a very high melting point, and lets no charge flow.
- Diamond vs graphite: 4 bonds vs 3 bonds. Almost every difference in properties comes from this.

Exam technique

- Start every diamond answer with the structure: giant covalent, each carbon atom bonded to four others. Then link each property to it.
- Use 'many strong covalent bonds' for hardness and melting point, and 'no delocalised electrons' for conductivity.
- In comparisons with graphite, write about both substances, point by point.

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 diamond is a form of carbon**
Diamond is made only of carbon atoms, in a giant covalent structure.

Grade 4 — **Describe the bonding in diamond**
Each carbon atom forms four covalent bonds with other carbon atoms.

Grade 5 — **Explain why diamond is very hard**

Many strong covalent bonds hold the atoms rigidly in a 3D network.

Grade 5 **Explain diamond's very high melting point**

A lot of energy is needed to break the many strong covalent bonds.

Grade 6 **Explain why diamond does not conduct electricity**

All four outer electrons of each carbon atom are used in bonds, so there are no delocalised electrons.

Grade 7 **Link diamond's properties to its uses**

Its hardness and very high melting point make it useful for cutting tools and drill tips.

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