

How atoms share electrons in covalent bonds

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lesson

Quick answer: A covalent bond forms when two non-metal atoms share a pair of electrons, so each atom gains a full outer shell. Sharing produces either small molecules, such as water and carbon dioxide, with low melting points, or giant covalent structures, such as diamond and graphite, with very high melting points.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** GCSE C2

What is a covalent bond?

Atoms of non-metals cannot easily give electrons away, so they share them instead. Two atoms each supply an electron to a pair that both nuclei attract, and this attraction holds the atoms together.

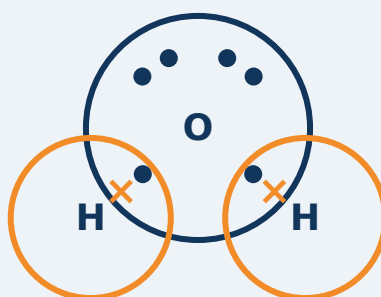
Definition

A **covalent bond** is formed when two atoms share a pair of electrons. One shared pair is a single bond, two shared pairs make a double bond, and three make a triple bond.

Hydrogen needs only 2 electrons to fill its first shell. Most other non-metals need 8 electrons in the outer shell. Count how many electrons an atom is missing and you know how many bonds it forms: hydrogen 1, oxygen 2, nitrogen 3, carbon 4, chlorine 1.

How do you draw a dot-and-cross diagram?

Show only the outer shells. Draw the outer electrons of one atom as dots and those of the other atom as crosses, then overlap the shells so that each shared pair sits in an overlap. Pairs that are not shared are *lone pairs*.



● electron from the central atom × electron from hydrogen

Water: two shared pairs and two lone pairs on oxygen. Every atom ends with a full outer shell.

Molecule	Formula	Shared pairs	Bond types
Hydrogen	H ₂	1	one single bond
Oxygen	O ₂	2	one double bond
Nitrogen	N ₂	3	one triple bond
Carbon dioxide	CO ₂	4	two double bonds
Methane	CH ₄	4	four single bonds
Ammonia	NH ₃	3	three single bonds, one lone pair on N

Worked example

Explain the bonding in ammonia, NH₃.

Nitrogen has 5 outer electrons, so it needs 3 more. Each hydrogen needs 1 more. Three hydrogen atoms each share one pair with nitrogen: 3 shared pairs. Nitrogen has $5 - 3 = 2$ outer electrons left over, which form 1 lone pair. Nitrogen now has $3 + 1 = 4$ pairs, which is 8 electrons.

Answer: 3 single bonds and 1 lone pair on nitrogen.

Why do simple molecules melt so easily?

A simple molecular substance is made of small separate molecules. The atoms inside a molecule are held by strong covalent bonds, but molecules attract each other only weakly. Melting or boiling needs just enough energy to pull molecules apart, so the melting and boiling points are low. There are no free charged particles, so these substances do not conduct electricity.

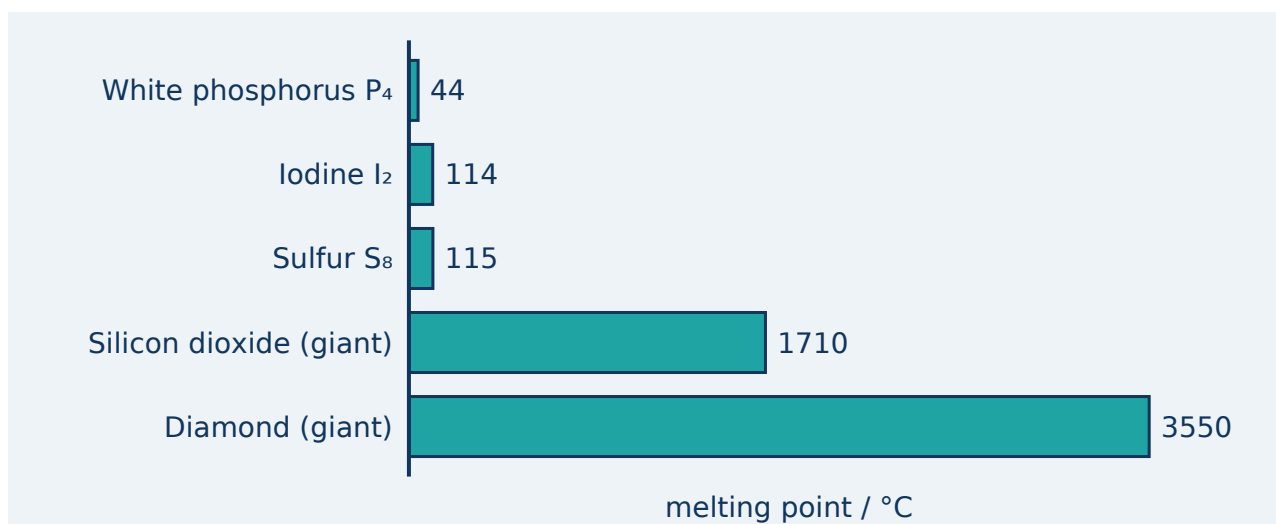
Definition

A **simple molecular substance** consists of small molecules with strong covalent bonds inside each molecule and weak forces between molecules.

Common mistake

When ice melts or water boils, the covalent bonds between hydrogen and oxygen stay intact. Only the weak forces between molecules are overcome. Never write that covalent bonds break when a simple molecular substance melts.

Larger molecules have stronger forces between them, so chlorine (Cl₂) is a gas, bromine (Br₂) a liquid and iodine (I₂) a solid at room temperature.

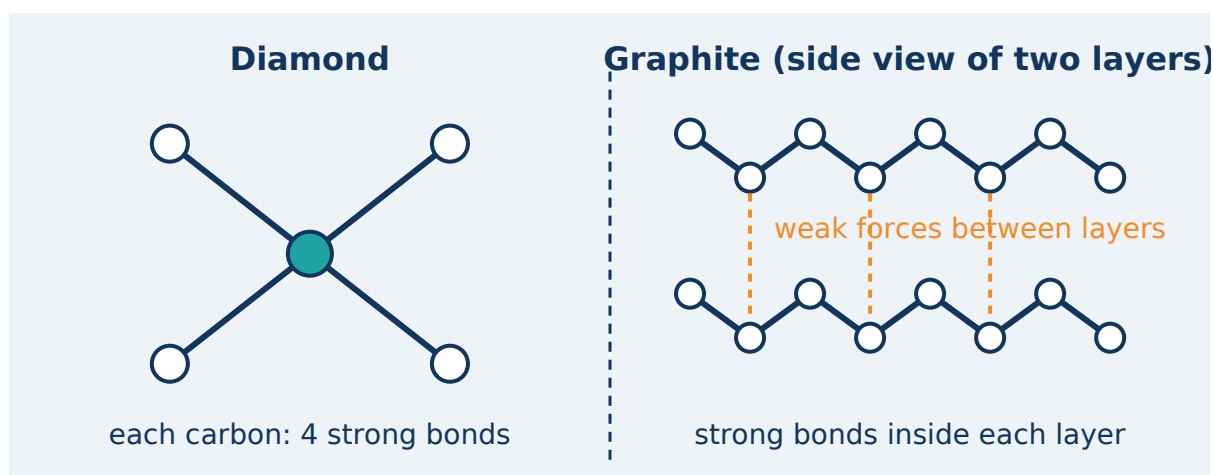


Simple molecules melt at low temperatures. Giant covalent structures need far more energy.

What are giant covalent structures?

In a giant covalent structure, billions of atoms are joined by covalent bonds in one continuous network. Melting means breaking many strong bonds, so the melting point is very high.

Substance	Bonds per atom	Hardness	Conducts electricity?
Diamond	4 (carbon)	extremely hard	no
Graphite	3 (carbon)	soft, slippery layers	yes
Silicon dioxide	Si: 4, O: 2	hard	no



Diamond is one rigid network. Graphite is made of layers that slide over each other.

Each carbon atom in diamond forms four bonds, which makes a rigid network, so diamond is the hardest natural material. In graphite each carbon forms only three bonds in a flat layer. The fourth outer electron is free to move along the layer, so graphite conducts electricity, and the layers slide because only weak forces hold them together.

Worked example

A white solid melts at 1710 °C, does not conduct electricity when solid or molten, and scratches glass. Identify its structure.

A melting point this high means many strong bonds must break. There are no mobile charged particles. **Answer: a giant covalent structure, such as silicon dioxide.**

Lina's tip

For any melting-point question, ask what is being broken. Weak forces between molecules means a low value. Strong covalent bonds throughout the whole structure means a very high value. Name the particles first.

Key points to remember

- A single covalent bond is one shared pair of electrons (2 electrons).
- Simple molecules: strong bonds inside molecules, weak forces between molecules, so low melting and boiling points and no conduction.
- Giant covalent structures (diamond, graphite, silicon dioxide) have a network of billions of bonded atoms and very high melting points.
- Diamond: 4 bonds per carbon, very hard, insulator. Graphite: 3 bonds per carbon, layers, conducts electricity.

How atoms share electrons in covalent bonds: frequently asked questions

What is a covalent bond?

A covalent bond is a shared pair of electrons between two non-metal atoms. The shared pair is attracted to both nuclei, which holds the atoms together.

Why do covalent compounds often have low melting points?

Most covalent compounds are simple molecules. Melting only overcomes the weak forces between molecules, not the strong bonds inside them, so little energy is needed.

Why does graphite conduct electricity but diamond does not?

Each carbon in graphite uses only three outer electrons for bonding. The fourth moves freely along the layer and carries charge. In diamond all four electrons are locked in bonds.

How many covalent bonds can carbon form?

Carbon has four outer electrons and needs four more to fill its shell, so it forms four bonds. These can be single, double or triple bonds, as long as the total is four.

What is the difference between a molecule and a giant structure?

A molecule is a small, fixed group of atoms, such as H_2O . A giant structure has no fixed size, because bonding continues through the whole crystal.