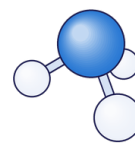


Covalent bonding

GCSE Chemistry — revision notes



How to use these notes: cover the right-hand column. Read each question and answer it from memory, out loud or on paper, then uncover and check. Mark the ones you missed and come back to them.

1. What a covalent bond is

Questions	Key points
Why do non-metal atoms share electrons?	- most stable with a full outer shell (like the noble gases) - non-metal atoms are short of electrons - neither can pull electrons right off the other → they share
What is a covalent bond?	a shared pair of electrons between two atoms
What holds the two atoms together?	- nuclei positive, shared pair negative each nucleus is attracted to the shared pair - electrostatic attraction → a strong bond
What is a molecule?	- group of atoms joined by covalent bonds - fixed number of atoms (water is always H₂O) - no overall charge
How does a hydrogen molecule form?	- each H atom has 1 electron - shells overlap → both electrons shared - each H now has 2 electrons in its shell (like helium)
Where do you find covalent bonds?	- most non-metal elements: H₂, O₂, N₂, Cl₂ - compounds of non-metals only: H₂O, CO₂, CH₄, NH₃, HCl
How can you tell from a formula that the bonding is covalent?	- every element a non-metal → covalent - metal + non-metal (e.g. NaCl) → ionic
How big is an atom? A small molecule?	- atom about 10⁻¹⁰ m (0.1 nm) across - small molecule: only a few atoms across

Summary covalent bond = shared pair of electrons, held by both nuclei's attraction to it. Non-metals only. Molecules have a fixed number of atoms and no charge.

2. How many bonds does an atom make?

Questions	Key points
When does an atom stop sharing?	- when its outer shell is full: 8 electrons (2 for hydrogen) - number of bonds = number of electrons it is short of
How many bonds do H, C, N, O and Cl make?	H (group 1): 1 outer electron, needs 1 → 1 bond C (group 4): 4 outer, needs 4 → 4 bonds N (group 5): 5 outer, needs 3 → 3 bonds O (group 6): 6 outer, needs 2 → 2 bonds Cl (group 7): 7 outer, needs 1 → 1 bond
What is an unpaired electron?	- one the atom can share - each one makes one bond
What is a lone pair?	- two outer-shell electrons already paired up, not shared in a bond - still count towards the 8 - NH₃: 1 on N; H₂O: 2 on O; HCl: 3 on Cl

Summary bonds = electrons short of a full shell. C 4, N 3, O 2, H and Cl 1. Unshared pairs are lone pairs.

3. Drawing dot and cross diagrams

Questions	Key points
What do the dots and crosses show?	- dots = one atom's electrons, crosses = the other atom's - electrons are all identical: the symbols only show where each came from
Which shells do you draw? Which layouts are accepted?	- usually outer shells only (question will say if inner shells wanted) - overlapping circles with the pair in the overlap, or symbols only (no circles)
How do you draw one?	- work out each atom's outer electrons - atom making most bonds goes in the middle - each bond: one dot + one cross in the overlap - add the rest as lone pairs - check: 8 around every atom, 2 around every hydrogen
Hydrogen, H ₂ ?	1 single bond, no lone pairs: H–H
Chlorine, Cl ₂ ?	1 single bond, 3 lone pairs on each Cl: Cl–Cl
Hydrogen chloride, HCl?	1 single bond, 3 lone pairs on Cl: H–Cl 8 electrons around Cl, 2 around H
Water, H ₂ O?	2 single bonds, 2 lone pairs on O: H–O–H

Ammonia, NH_3 ?	• 3 single bonds, 1 lone pair on N
Methane, CH_4 ?	• 4 single bonds, no lone pairs: all 4 of carbon's outer electrons shared

Summary dot + cross in each overlap, lone pairs on the rest of the shell, then count: 8 around each atom, 2 around H.

4. Double and triple bonds

Questions	Key points
What are double and triple bonds?	• double bond: 2 shared pairs (4 electrons), drawn as = • triple bond: 3 shared pairs (6 electrons), drawn as three lines
Oxygen, O_2 ?	• each O needs 2 → share 2 pairs → one double bond ($\text{O}=\text{O}$) • 2 lone pairs on each O
Carbon dioxide, CO_2 ?	• C needs 4, each O needs 2 → a double bond to each O ($\text{O}=\text{C}=\text{O}$) • no lone pairs on C; 2 on each O
Nitrogen, N_2 ?	• each N needs 3 → share 3 pairs → one triple bond • 1 lone pair on each N • very strong bond → one reason nitrogen gas is so unreactive
How do you check a displayed formula?	• each line = one shared pair • lines to each atom match its bonds: C 4, N 3, O 2

Summary O_2 one double bond, CO_2 two double bonds, N_2 one triple bond. Count the lines.

5. Other ways to show a molecule

Questions	Key points
Dot and cross: shows? leaves out?	• shows: shared electrons, lone pairs, where each electron came from • leaves out: 3D shape; atom sizes; electrons are really all the same and don't sit still
Displayed formula: shows? leaves out?	• shows: which atoms are joined; single, double or triple bonds • leaves out: electrons (incl. lone pairs); 3D shape
Ball and stick: shows? leaves out?	• shows: 3D shape and the angles between bonds (every H–N–H angle in ammonia is 107°) • leaves out: electrons; bonds aren't sticks; atoms much closer than drawn; sizes not to scale

Space-filling: shows? leaves out?	• shows: relative sizes of atoms, how closely they pack, overall 3D shape • leaves out: bonds hard to see or count; electrons
What shapes do methane, ammonia and water really have?	• methane: not a flat cross; 4 H as far apart as possible → pyramid with a triangular base • ammonia: a pyramid, nitrogen at the top • water: bent, not straight
How do you get a formula from a model?	• count each type of atom → molecular formula • 1 N joined to 3 H → NH_3

Summary every model leaves something out. Dot and cross = electrons; displayed = bonds; ball and stick = shape and angles; space-filling = sizes.

6. Simple molecular substances

Questions	Key points
What is a simple molecular substance?	• made of lots of separate small molecules • e.g. water, carbon dioxide, methane, oxygen, the halogens
What are the two kinds of force?	• covalent bonds: inside each molecule, strong • intermolecular forces: between molecules, weak
What happens when a simple molecular substance melts or boils?	• only the weak intermolecular forces are overcome • covalent bonds do not break • ice, water, steam: all H_2O molecules, only the distance between them changes
Why are their melting and boiling points low?	• little energy needed to overcome the weak intermolecular forces • most are gases or liquids at room temperature
Why do bigger molecules have higher boiling points?	• intermolecular forces stronger as molecules get bigger • more energy needed to separate them
How do the halogens show this?	• F_2 (M_r 38): melts -220°C, boils -188°C, gas • Cl_2 (M_r 71): -101°C, -34°C, gas • Br_2 (M_r 160): -7°C, 59°C, liquid • I_2 (M_r 254): 114°C, 184°C, solid
How do you tell the state at room temperature (20°C)?	• above the boiling point → gas • between melting and boiling points → liquid • below the melting point → solid

Why don't they conduct electricity?

- molecules have **no overall charge**
- nothing charged can move through the substance to carry a current

Summary strong bonds inside, weak forces between. Melting and boiling only overcome the weak forces, so low melting and boiling points, rising with size. No charge, so no conduction.

7. The mistakes that cost marks

Questions	Key points
"The covalent bonds break when water boils." What's wrong?	• they don't break • write: "the weak intermolecular forces are overcome"
"Simple molecules have weak covalent bonds." What's wrong?	• covalent bonds are strong • the forces between the molecules are weak
What loses marks on a dot and cross diagram?	• leaving out lone pairs (e.g. water without oxygen's two) • shared electrons outside the overlap • a single bond in O₂, CO₂ or N₂ • fix: count 8 around every atom (2 around hydrogen)
"They don't conduct because they are covalent." What's wrong?	• not a reason • write: "the molecules have no overall charge, so nothing charged can move to carry a current"
How do you tell ionic from covalent?	• metal + non-metal → ionic • only non-metals → covalent

Summary bonds strong, forces between molecules weak. Draw every lone pair. No charge means no current.