Cambridge (CIE) IGCSE Chemistry

Your notes

Simple Molecules & Covalent Bonds

Contents

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The formation of covalent bonds

Covalent compounds

- Covalent compounds are formed when **pairs** of electrons are **shared** between atoms
- Only **non-metal elements** participate in covalent bonding
- As in ionic bonding, each atom gains a **full outer shell** of electrons, giving them a noble gas electronic configuration
- Covalently bonded substances may consist of small molecules or giant molecules
- When two or more atoms are **covalently** bonded together, we describe them as '**molecules**'
- **Dot-and-cross** diagrams can be used to show the electronic configurations in simple molecules
  - Electrons from one atom are represented by a dot, and the electrons of the other atom are represented by a cross
  - The electron shells of each atom in the molecule overlap and the shared electrons are shown in the area of overlap
  - The dot-and-cross diagram of the molecule shows clearly which atom each electron originated from

Diagram to show the formation of a covalent bond

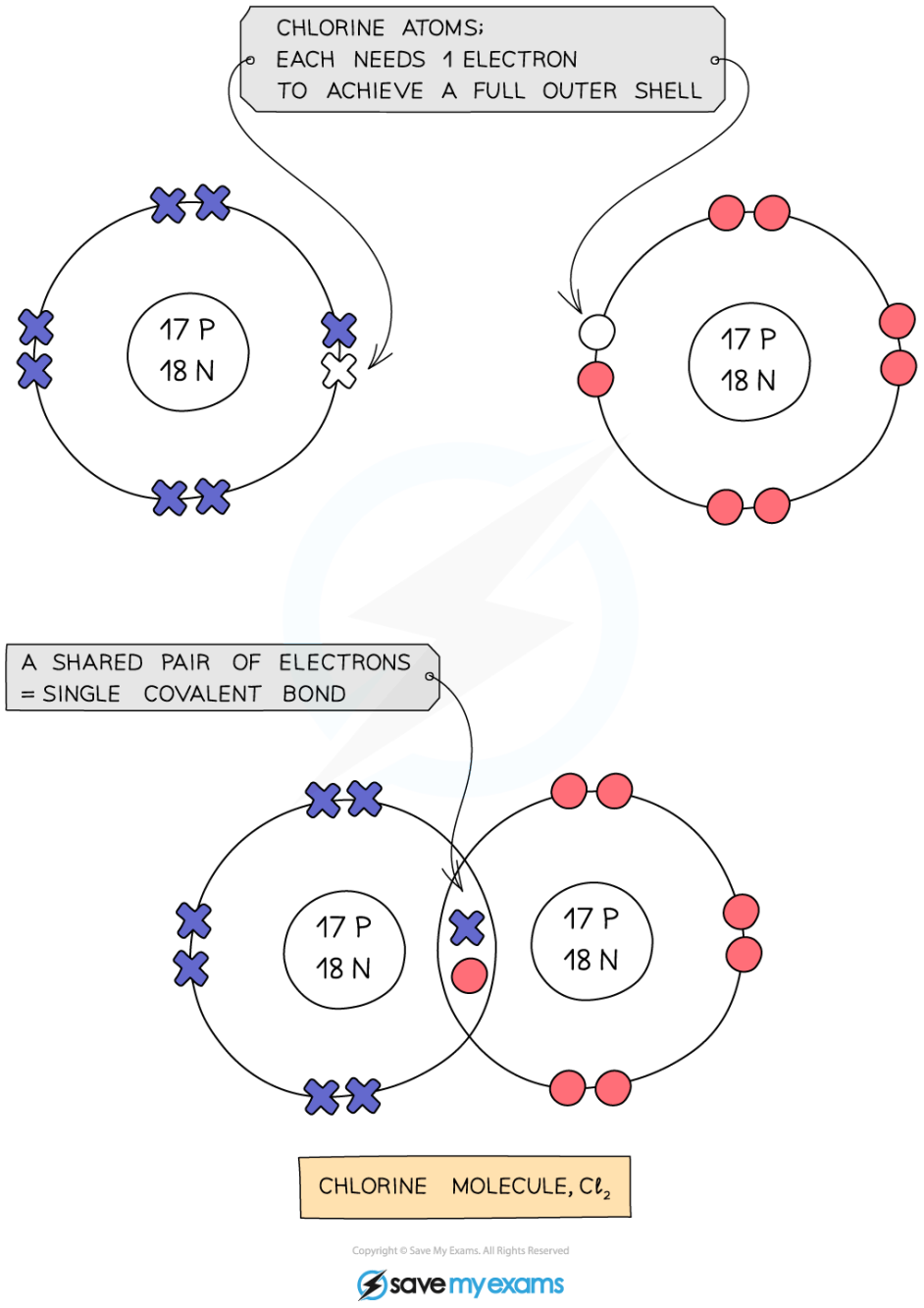

Diagram showing how a covalent bond forms between two chlorine atoms

Examiner Tips and Tricks

When drawing dot-and-cross diagrams for covalent compounds, make sure that the electron shell for each atom is full (remember that the 1st shell can only hold 2 electrons).

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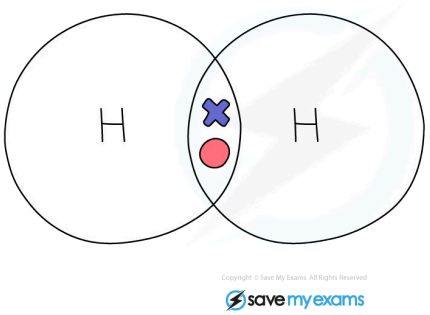
Single covalent bonds

- Many simple molecules exist in which two adjacent atoms share one pair of electrons, also known as a single covalent bond (or single bond)

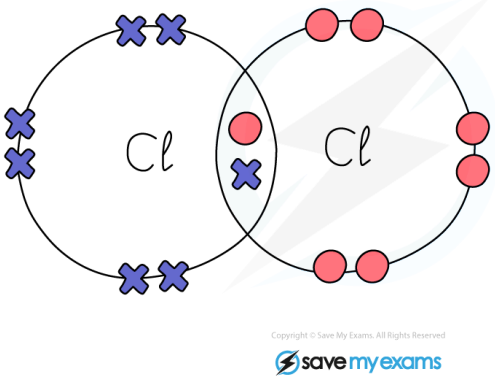
Common Examples of Simple Molecules

Hydrogen:



H — H

Chlorine:



Cl — Cl

Water:

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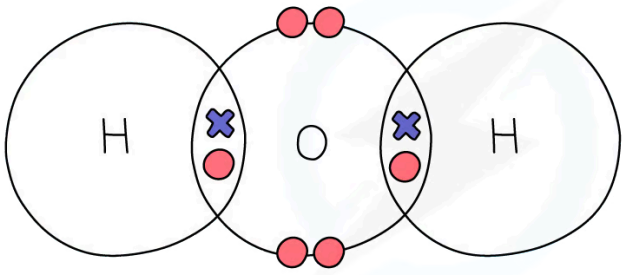
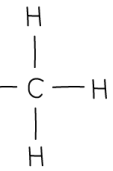
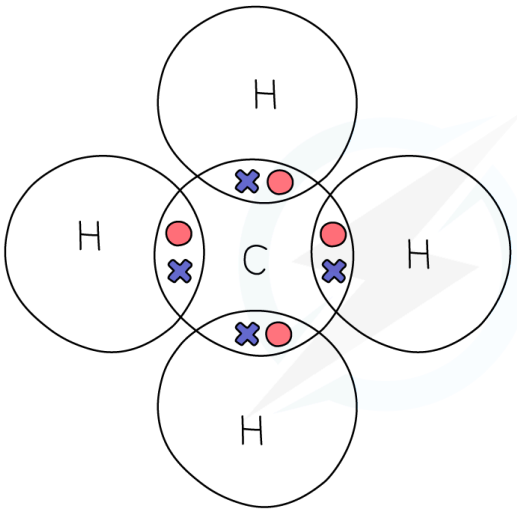




Methane:



Ammonia:

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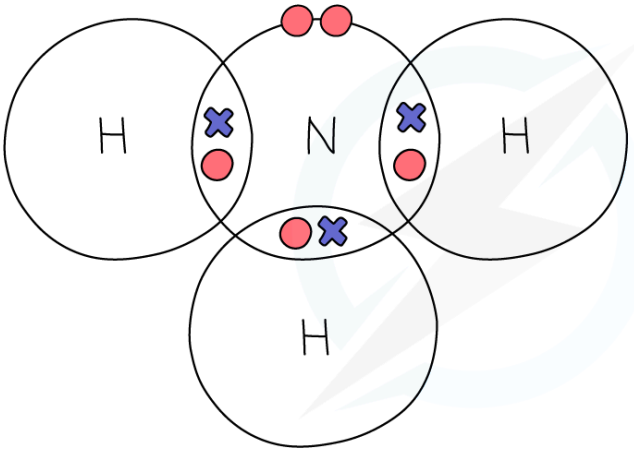
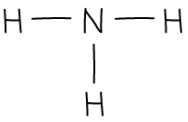
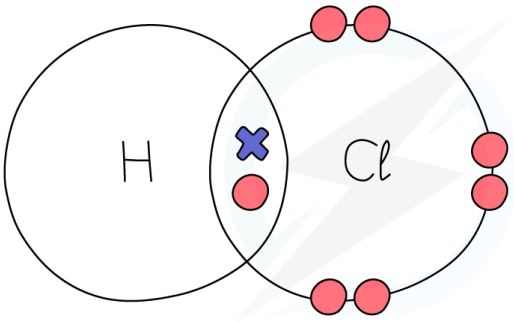




Hydrogen chloride:



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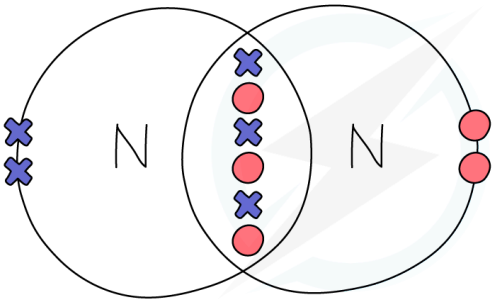
Covalent bonds in complex covalent molecules

Extended tier only

- Some atoms need to share more than one pair of electrons to gain a full outer shell of electrons
- If two adjacent atoms share two pairs of electrons, two covalent bonds are formed, also known as a **double bond**
- If two adjacent atoms share three pairs of electrons, three covalent bonds are formed, also known as a **triple bond**

Nitrogen:

- When 2 nitrogen atoms react they share 3 pairs of electrons to form a triple bond



N ≡ N

Ethene:

- In ethene, the 2 carbon atoms share 2 pairs of electrons
- This is known as a double bond

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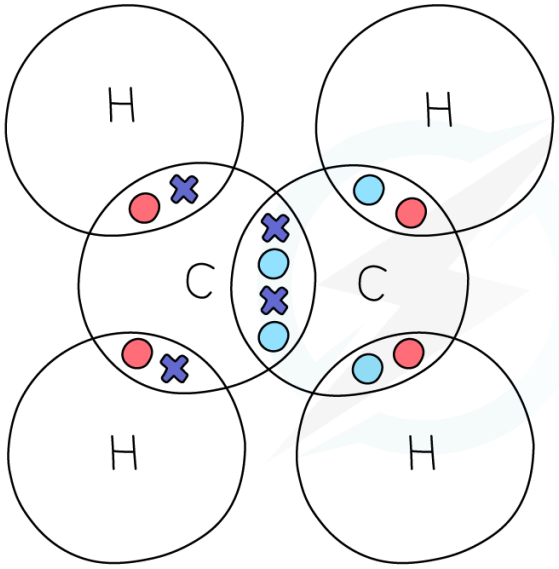
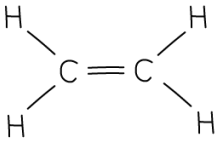
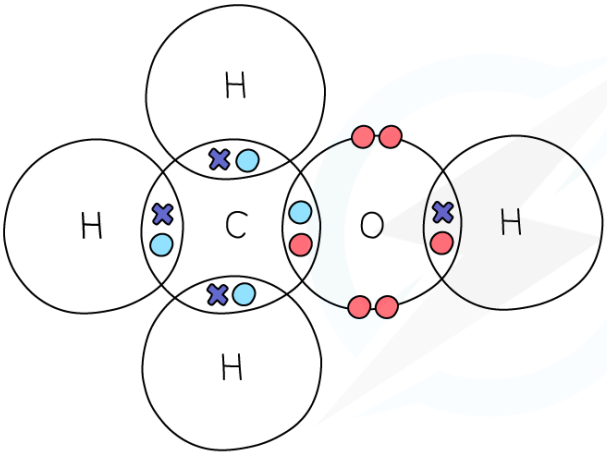
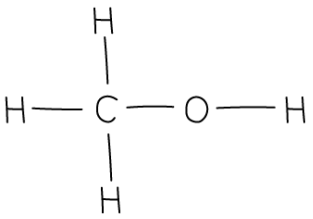


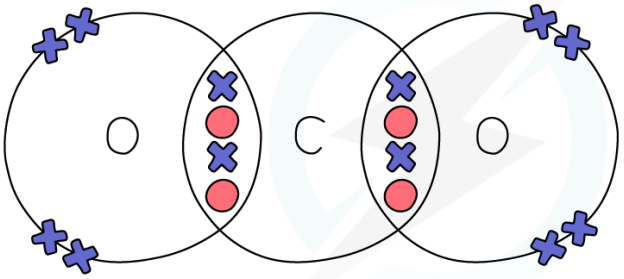


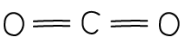
Methanol:





Carbon Dioxide:





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Examiner Tips and Tricks

Be careful when drawing dot-and-cross diagrams, it is a common mistake for students to draw the wrong type of diagram.

Remember, if the compound contains **metal** and **non-metal**, it is an **ionic** compound and you need to draw the ions separated, with square brackets around each ion, together with a charge.

If the compound contains **non-metal** atoms only, it is a **covalent** compound, the shells should overlap and contain one or more pairs of electrons.

Your notes

Properties of simple molecular compounds

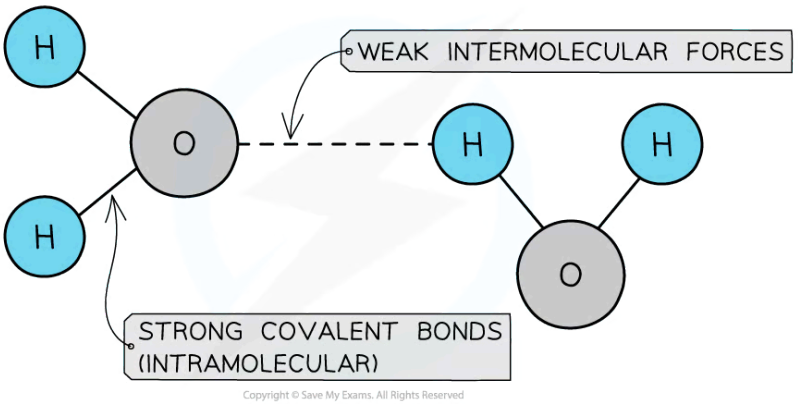
- Small molecules are compounds made up of molecules that contain just a few atoms **covalently bonded** together
- They have **low** melting and boiling points so covalent compounds are usually **liquids** or **gases** at room temperature
- As the molecules increase in **size**, the melting and boiling points generally increase
- Small molecules have poor electrical conductivity

Explaining the properties of simple molecular compounds

Extended tier only

Linking bonding and properties

- Small molecules have covalent bonds joining the atoms together, but weak intermolecular forces that act between neighbouring molecules
- They have **low** melting and boiling points as there are only **weak intermolecular** forces acting **between** the molecules
- These forces are **very weak** when compared to the covalent bonds and so most small molecules are either gases or liquids at room temperature
- As the molecules increase in **size** the intermolecular forces also increase as there are more electrons available
- This causes the melting and boiling points to **increase**

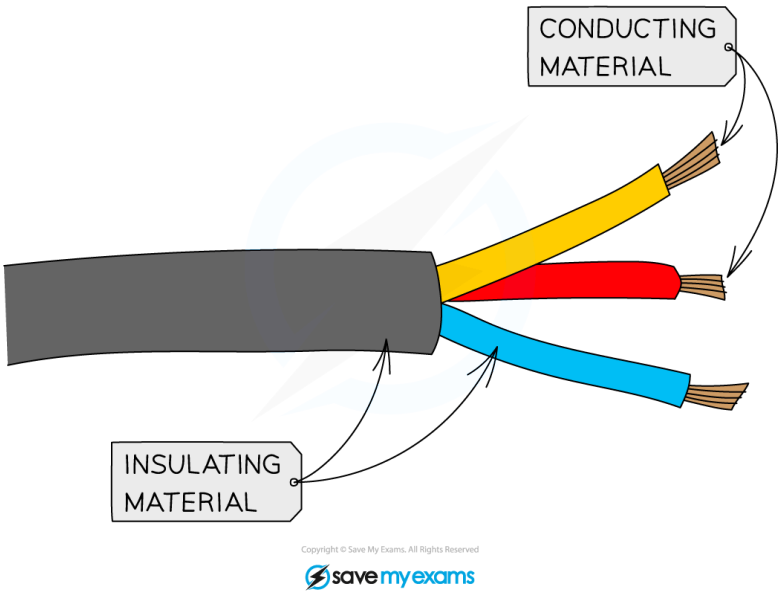


The bonds between hydrogen and oxygen in water are COVALENT, and the attractions between the molecules are INTERMOLECULAR FORCES which are about one tenth as strong as covalent bonds

Your notes

Electrical Conductivity

- Molecular compounds are **poor conductors** of electricity as there are no free ions or electrons to carry the charge.
- Most covalent compounds do not conduct at all in the solid state and are thus **insulators**
- Common insulators include the plastic coating around household electrical wiring, rubber and wood



The plastic coating around electrical wires is made from covalent molecules that do not allow a flow of charge

Examiner Tips and Tricks

The atoms within covalent molecules are held together by covalent bonds while the molecules in a covalent substance are attracted to each other by intermolecular forces.