Covalent Bonding

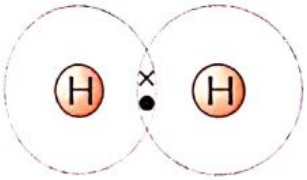
Some elements bond ionically (see page 102) but others form strong covalent bonds. This is where atoms share electrons with each other so that they've got full outer shells.

Covalent Bonds — Sharing Electrons

1) Sometimes atoms prefer to make covalent bonds by sharing electrons with other atoms.
2) They only share electrons in their outer shells (highest energy levels).
3) This way both atoms feel that they have a full outer shell, and that makes them happy. Having a full outer shell gives them the electronic structure of a noble gas.
4) Each covalent bond provides one extra shared electron for each atom.
5) So, a covalent bond is a shared pair of electrons.
6) Each atom involved has to make enough covalent bonds to fill up its outer shell.
7) Here are some important examples:

1) Hydrogen, H_2

Hydrogen atoms have just one electron. They only need one more to complete the first shell...



or H—H

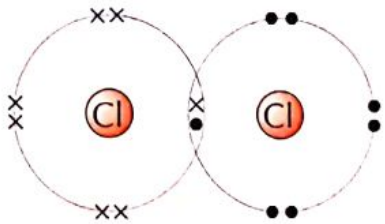
or H × H

In these diagrams, a covalent bond is shown by a line.

...so they often form single covalent bonds to achieve this.

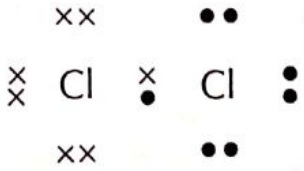
2) Chlorine, Cl_2

...chlorine atoms also need only one more electron...



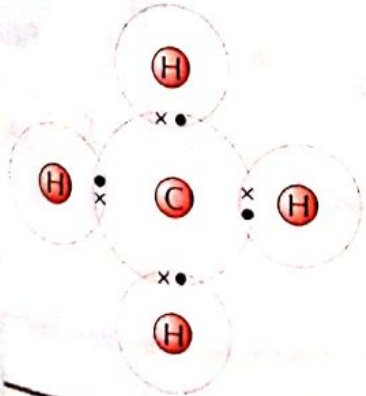
or Cl — Cl

or



These dot and cross diagrams only show the outer shell of electrons.

3) Methane, CH_4



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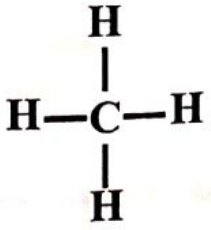

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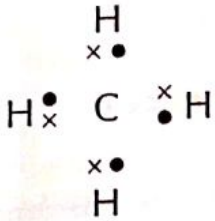
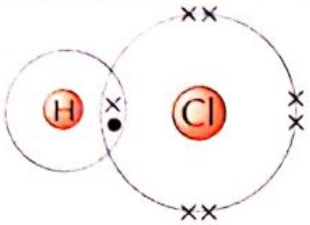


Carbon has four outer electrons, which is half a full shell. So it forms four covalent bonds to make up its outer shell.

More Covalent Bonding

There are five more examples of covalent bonding on this page — just a few diagrams and a smattering of words. What a pleasant page.

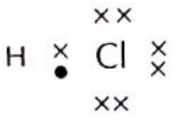
4) Hydrogen Chloride, HCl



or

H—Cl

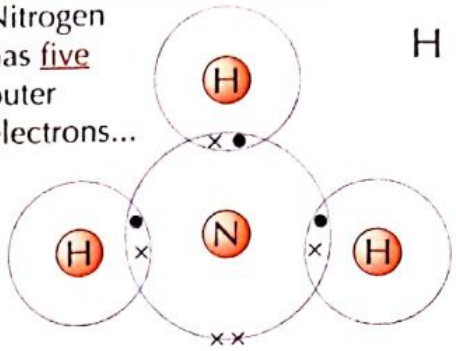
or



This is very similar to H_2 and Cl_2. Again, both atoms only need one more electron to complete their outer shells.

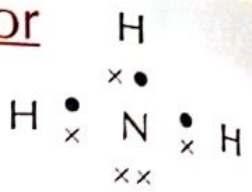
5) Ammonia, NH_3

Nitrogen has five outer electrons...



...so it needs to form three covalent bonds to make up the extra three electrons needed.

or



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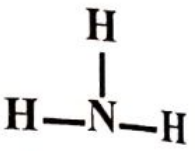
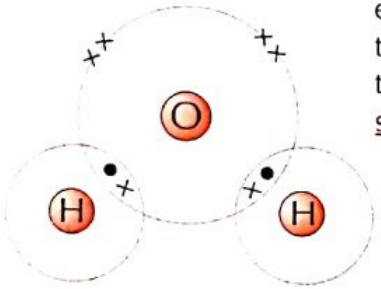


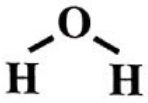
6) Water, H_2O



Oxygen atoms have six outer electrons. They sometimes form ionic bonds by taking two electrons to complete their outer shell. However they'll also cheerfully form covalent bonds and share two electrons instead. In water molecules, the oxygen shares electrons with the two H atoms.

Remember — it's only the outer shells that share electrons with each other.

or



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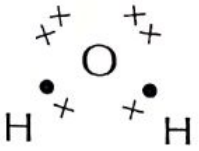
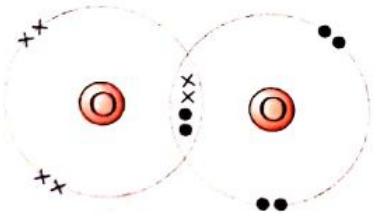
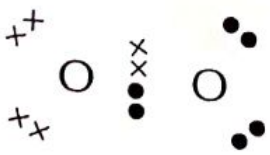


7) Oxygen, O_2



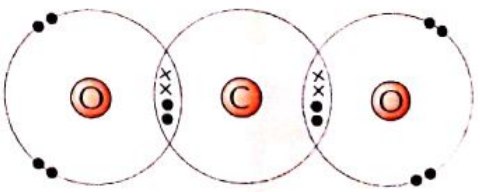
In oxygen gas, oxygen shares two electrons with another oxygen atom to get a full outer shell. A double covalent bond is formed.

or



or O=O

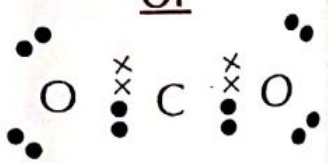
8) Carbon Dioxide, CO_2



or

O=C=O

or



In carbon dioxide, two oxygen atoms share electrons with a carbon atom.

Covalent bonding involves sharing rather than

Covalent Substances

Substances with covalent bonds (electron sharing) can form simple molecules or giant structures.

Simple Molecular Substances

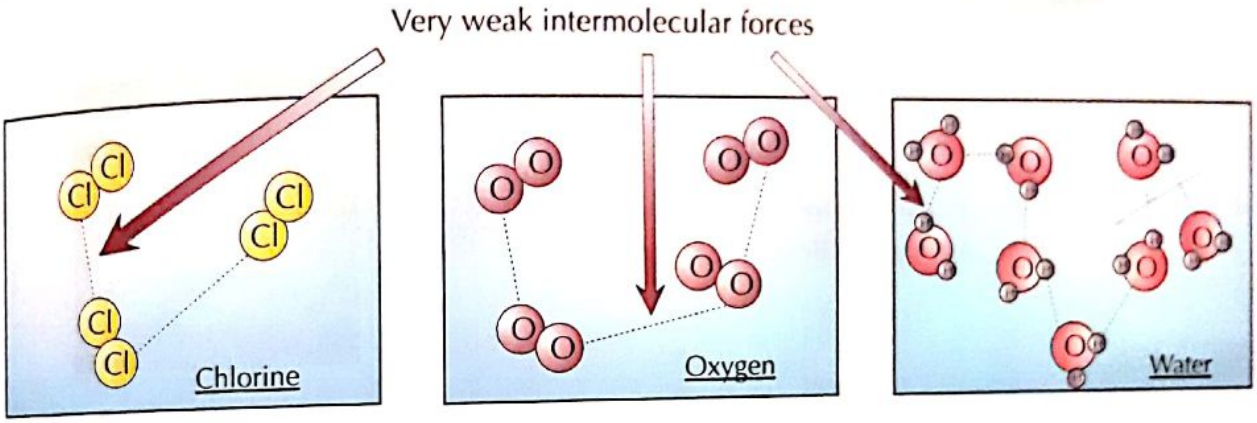
1) The atoms form very strong covalent bonds to form small molecules of several atoms.

2) By contrast, the forces of attraction between these molecules are very weak.

3) The result of these feeble intermolecular forces is that the melting and boiling points are very low, because the molecules are easily parted from each other. It's the intermolecular forces that get broken when simple molecular substances melt or boil — not the much stronger covalent bonds.

4) Most molecular substances are gases or liquids at room temperature, but they can be solids.

5) Molecular substances don't conduct electricity — there are no ions so there's no electrical charge.



Giant Covalent Structures Are Macromolecules

1) These are similar to giant ionic structures (lattices) except that there are no charged ions.

2) All the atoms are bonded to each other by strong covalent bonds.

3) This means that they have very high melting and boiling points.

4) They don't conduct electricity — not even when molten (except for graphite).

5) The main examples are diamond and graphite, which are both made only from carbon atoms, and silicon dioxide (silica) — see the next page.