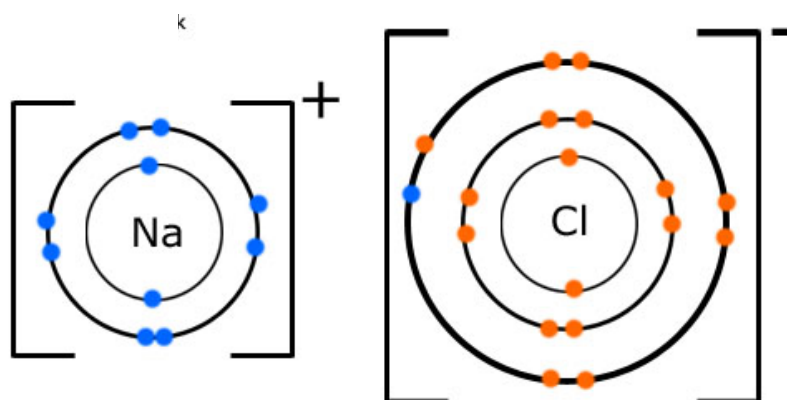


## Unit 3

# Summary of Chemical Bonding

### Ionic Bonding

Bonding occurs between **metals** and **non-metals** like our friend sodium chloride. The reaction can be represented as follows, showing the **electron arrangement** shown and the full form shown below:



Electrons are transferred from a metal to a non-metal forming two oppositely charged ions. Both have the electronic structure of a noble gas. The ionic bond is the **electrical attraction** between these two ions

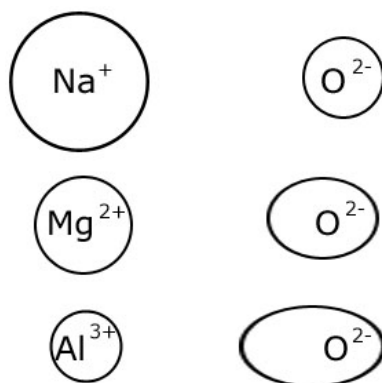
The ions do not work on a 2D basis: they can attract oppositely charged ions in all directions, thus making a huge ionic lattice. In NaCl each cation is surrounded by 6 anions and vice versa. However, it depends on the size of the ions, more or less can surround it.

The **properties** of giant ionic structures are as follows.

Property	Reason
High melting and boiling points	The electrostatic forces between ions are very strong and a lot of energy is required to break up the lattice.
Very poor electrical conductivity as a <b>solid</b> . But very good when <b>molten</b> or <b>dissolved</b> .	As a solid the conductivity is very poor because the electrons are all in a fixed position and cannot transfer charge. However, when molten or dissolved the electrons are free to move. When dissolved the lattice separates into its charged ions: mobile charge carriers.
Soluble in polar solvents (e.g. water)	The lattice is broken up by the polarity of the solvent, this leaves the ions suspended in the solvent.

In reality however, no compound has 100% ionic character where there is a complete transfer of electrons. Between the two extremes of ionic and covalent bonding is a world in between known as **polarization**.

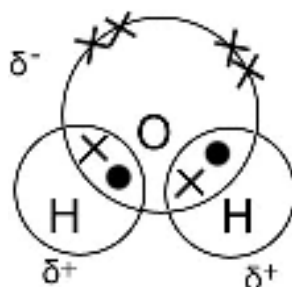
The degree of polarization in ionic compounds is determined by the **charge density** of the cation (positive) and how high the negative charge on the anion is. The charge density is high if the cation is small but at the same time has a high positive charge.



As you go across **period II**, the charge size increases and so does the ion charge. So the charge density increases until Al which has a very high charge density. As you can see in the above representation, the  $\text{Al}^{3+}$  will **distort** the electron cloud more and thus have a greater polarization effect.

## Covalent Bonding

Covalent bonds make molecules and form between non-metals. It is formed when electrons **share a pair of electrons** rather than transfer them. A good example of covalent bonding is water:



Covalent bonds have the following properties...

Property	Reason
Low melting and boiling points	The inter-molecular (see below) bonds between molecules are weak.
Poor electrical and thermal conductivity.	The electrons are in a fixed position and so cannot move to transfer charge.

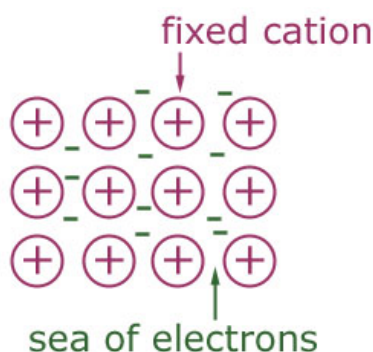
Covalent bonds can be categorized as either **polar** or **non-polar**. In a **non - polar** molecule, the electrons are shared equally because the atoms have **similar electronegativities**.

A **polar** molecule, there are quite different electronegativities. Water (above) is polar. The oxygen molecule is more electronegative so the electrons are unequally shared and shifted towards it. This makes oxygen slightly negative. This is represented by the symbol  $\delta^-$  **delta minus**, and the hydrogen atoms are therefore both  $\delta^+$ . This molecule is a **permanent dipole**.

We also have **dative** covalent bonds (or co-ordinate bonds) when the shared pair of electrons comes from just **one** of the atoms. It is represented in diagrams using an arrow, showing the direction the electron pair is donated.

## Metallic Bonding

As the name suggests, this type of bonding is between metals. In this type of bonding many positive metal ions occupy a fixed position in a lattice (a bit like ionic). Its outer electron energy level become **delocalized**, creating what is known as a **sea of electrons** since they are not fixed and free to move throughout the lattice.



The metallic bond is the electrostatic attraction between the cations and delocalized electrons. This bond is very strong. And below are its properties and explanations for why they are so.

Property	Reason
High melting and boiling points	There are very strong forces between the cations and electrons so a lot of energy is required to break the bonds.
Very good electrical and thermal conductivity.	The delocalised electrons are able to move freely in the 'sea'. These mobile electrons are therefore able to carry charge or heat energy.
Poor Solubility	The electrostatic attraction between ions and electrons is too strong to be broken by the solvent.