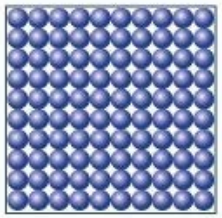
Chemistry C2_3 – Ionic Bonding Page 1

Changes of state

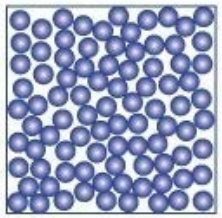


Solid (s)

Melting is the change of state from a solid to a liquid. *The solid must be heated to melt it.*

Melting point (°C)

Freezing is the change of state from a liquid to a solid. *The liquid must be cooled to freeze it.*

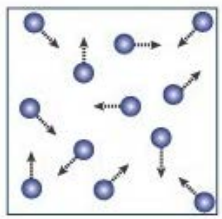


Liquid (ℓ)

Boiling is the change of state from a liquid to a gas. *The liquid must be heated to boil it.*

Boiling point (°C)

Condensing is the change of state from a gas to a liquid. *The gas must be cooled to condense it*



Gas (g)

Melting point: the point where melting *and* freezing take place.

Boiling point: the point where boiling and condensation take place.

(HIGHER ONLY) Limitations of the simple particle model:

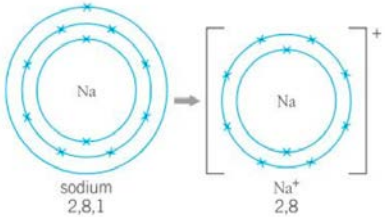
- there are no forces shown
- that all particles are represented as spheres
- spheres are solid, particles are not

The **amount of thermal energy (heat) needed to change state** depends on the **strength of the forces between the particles**. This amount of energy is different for different types of particles.

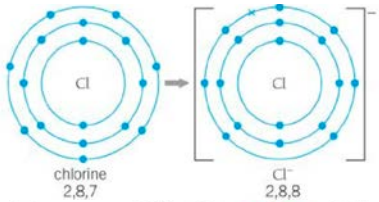
Ionic bonding

ionic bond: *the* ***electrostatic attraction*** *between* ***oppositely charged ions*** *(+ and -)*

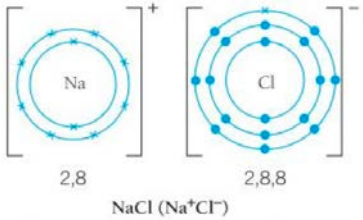
When **metal atoms** react with a **non-metal atoms**, **electrons are transferred** to form **ions**.



Metal atoms ***lose*** *electrons to become* ***positively*** *charged ions and gain a full outer-shell.*



Non-metal atoms ***gain*** *electrons to become* ***negatively*** *charged ions and gain a full outer-shell.*



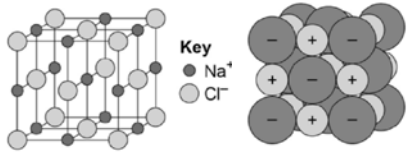
Opposite charges ***attract*** *so the oppositely charged ions bond together.*

The elements in certain **groups** of the periodic table produce ions with particular charges:

Group 1: forms +1 ions
Group 2: forms +2 ions
Group 6: forms -2 ions
Group 7: forms -1 ions

Giant ionic compounds

Ionic compounds have regular structures (a **lattice**) with **strong electrostatic forces of attraction** in **all directions** between **oppositely charged ions**.



Property	Explanation
High melting and boiling points.	Strong electrostatic forces between oppositely charged ions take a lot of energy to break.
Can't conduct electricity when **solid**	When solid, the ***ions*** are fixed so cannot move to carry a charge.
Can conduct electricity when **molten** or in **a solution**	When molten or dissolved, the ***ions*** are free to move and carry a charge.

Formulas of ionic compounds depend on how many of each ion there is and this depends on the charge of the ion.

These ions are made of more than one element

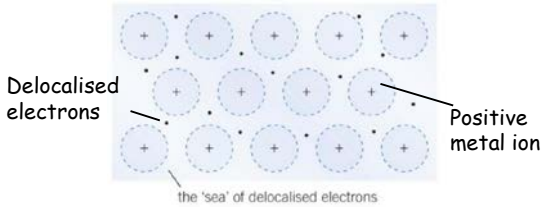
Name of ion	Ion formula
Sulfate	SO_4^{2-}
Carbonate	CO_3^{2-}
Nitrate	NO_3^-
Hydroxide	OH^-
Ammonium	NH_4^+

The numbers of ions in a formula must give an **equal number of positive and negative charges**.

Compound	Ions present	Formula
Sodium chloride	Na^+ and Cl^-	NaCl
Sodium oxide	Na^+ and O^{2-}	Na_2O
Magnesium oxide	Mg^{2+} and O^{2-}	MgO
Magnesium chloride	Mg^{2+} and Cl^-	$MgCl_2$

Metallic bonding

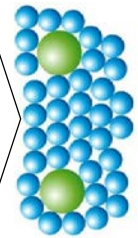
metallic bond: *the* ***electrostatic attraction*** *between* ***positively-charged metal ions*** *which share a sea of* ***delocalised electrons.***



Properties of metals and alloys

Property	Explanation in terms of bonds
High melting point	It takes a lot of energy to break strong metallic bonds.
Conduct heat and electricity	Electrons are delocalised so are free to move and carry heat or charge (current) **throughout**.
Malleable and ductile	Atoms arranged in layers that slide over each other making metals easy to shape.

Pure metals are too soft for many uses and so are mixed with other metals to make **alloys** which are harder.
The different sizes of particles in an alloy disrupt the layers and change the properties.



Reactions of Group 1 metals

- Group 1 elements react vigorously with **Chlorine** to form chlorides, which dissolve in water to form colourless solutions.
  E.g. sodium + chlorine → sodium chloride
- Group 1 elements react with **oxygen** in the air to form metal oxides. Only the surface of the metal reacts and are usually stored in oil to prevent a reaction occurring.
  E.g. potassium + oxygen → potassium oxide
- Group 1 metals all react with water to produce a metal hydroxide and hydrogen.
  E.g. sodium + water → sodium hydroxide + hydrogen

Group 0 (The Nobles Gases)

- Group 0 elements are also known as **The Noble Gases**.
- These elements are unreactive due to having a complete outer shell of electrons which is very stable.
- The boiling point of Noble Gases increases down the group.

The Transition Metals

- The transition metals are found in the central section of the periodic table and include chromium (Cr), cobalt (Co) and iron (Fe).
- In general transition metals are harder, stronger, denser and have higher melting points than group 1 metals.
- Compared to Group 1,The transition metals are much less reactive with oxygen and water. Some do not react at all or require heating and few react with the halogens.
- They are commonly used as catalysts and form coloured compounds whereas group 1 metals form white compounds.
- The same element can also form ions with different charges.
  E.g. copper can form Cu^{+} and Cu^{2+}.

Group 1 (The Alkaline Metals)

- Group 1 metals are also known as **The Alkaline Metals**. They are known as the alkaline metals as they produce an alkaline solution when reacting with water.
- The chemical characteristics are due to the single electron in the outer shell of the elements. Group 1 elements need to lose an electron to complete there outer shell.
- Density and reactivity of group 1 metals **increase** down the group whereas the melting point **decreases**.

Group 7 (Halogens)

- Group 7 elements are also known as **Halogens**.
- The chemical characteristics are due to the seven electrons in the outer shell of the elements. Group 7 elements need to gain an electron to complete there outer shell.
- Halogens exist as diatomic molecules (paired atoms)
  E.g. F_2, Cl_2, Br_2
- A more reactive Halogen can displace another Halogen from a compound.
  E.g. potassium bromide + fluorine → fluorine bromide + potassium
- The density, boiling point and melting point of elements **increase** down the group whereas reactivity **decreases** down the group.

Explaining trends

The reactivity of elements is closely linked to the ability of electrons to be lost or gained. The more easily an electron is lost or gained the more reactive an element.

The reactivity of Group 1 elements increases as you go down the group because:

- group 1 elements are metals, so the outer electron is lost
- the atoms get larger as you go down the group.
- the outer electron gets further from the nucleus as you go down the group and there is more shielding.
- the attraction between the nucleus and outer electron gets weaker as you go down the group - so the electron is more easily lost

The reactivity of Group 7 elements decreases as you go down the group because:

- group 7 elements are non-metals, so they want to gain an electron
- the atoms get larger as you go down the group
- the outer electron shell gets further from the nucleus as you go down the group and there is more shielding.
- the attraction between the nucleus and the outer shell gets weaker as you down the group - so it's harder to gain an electron