8. IONIC BONDING

Learning outcomes

Candidates should be able to:

1. Define ionic bonding
2. Describe ionic bonding, using the examples of sodium chloride, magnesium oxide and calcium fluoride, including the use of 'dot-and-cross' diagrams.

Initial assessment

1. Draw dot and cross diagrams of the following atoms.
   a. Berellium b. sulphur c. sodium d. chlorine

2. Draw dot and cross diagrams of the following atoms to show only valance shell electrons.
   a. Fluorine b. calcium c. caesium d. oxygen

3. Show the formation of the following compounds
   a. Calcium fluoride

   c. sodium bromide

   e. barium chloride

b. Magnesium oxide

c. potassium sulphide

4. Define ionic bonding.

5. Define bonding.

Definition

Ionic bond (also called an **electrovalent bond)** is the strong force of attraction between the positive ions-cations and negative ions-anions in the ionic crystal lattice. Such as bonds in sodium chloride crystals.

Cation or Positively charged ions are formed when an atom loses one or more electrons. Metal atoms usually lose electrons and form positive ions.

Anion or negatively charged ions are formed when an atom gains one or more electrons. Non-metal atoms usually gain electrons and form negative ions.

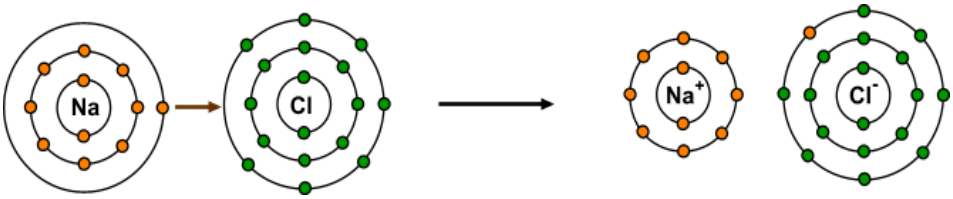
Generally, compounds containing a metal, particularly a group 1 or 2 metal, and a non-metal, particularly a group 6 or 7 non-metal, have ionic bonding.

The attraction between the positive and negative ions is the ionic bond. It is not the transfer of electrons. This is a common error.

When elements form compounds, they either gain, lose or share electrons to get to the nearest stable noble gas electronic configuration.

Explanation with an example

Ionic bonds tend to be formed between elements whose atoms need to "lose" electrons to gain the nearest noble gas electronic configuration (n.g.e.c.) and those which need to gain electrons. The electrons are transferred from one atom to the other.



Na → $Na^+ + e^-$ and Cl + e^- → Cl^-

$1s^2\ 2s^2 2p^6\ 3s^1$ $1s^2\ 2s^2 2p^6$ $1s^2\ 2s^2 2p^6\ 3s^2 3p^5$ $1s^2\ 2s^2 2p^6\ 3s^2 3p^6$

or 2,8,1 2,8 2,8,7 2,8,8

An electron is transferred from the 3s orbital of sodium to the 3p orbital of chlorine; both species end up with the electronic configuration of the nearest noble gas the resulting ions are held together in a crystal lattice by electrostatic attraction.

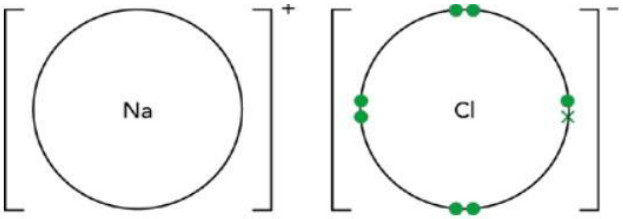
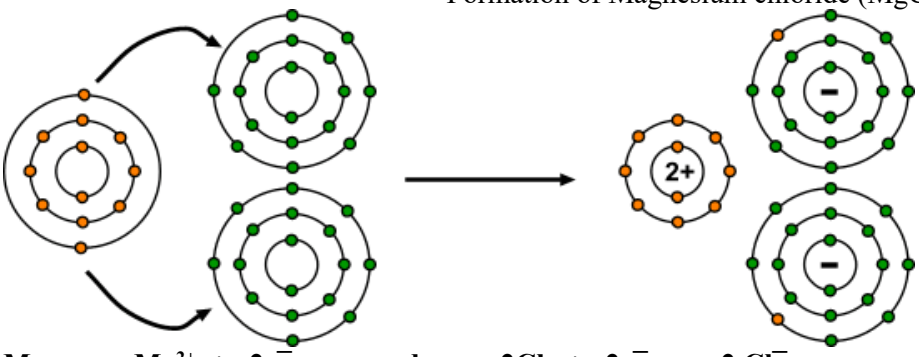
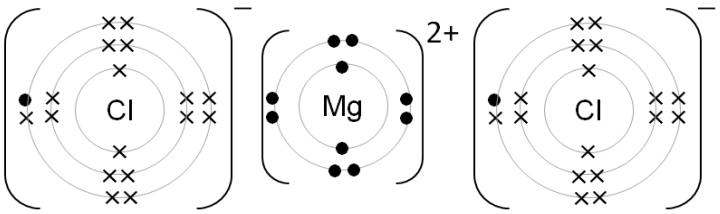


Figure: Dot and cross diagram of sodium chloride(showing only outer electrons)

Formation of Magnesium chloride ($MgCl_2$)



Mg → Mg^{2+} + $2e^-$ and 2Cl + $2e^-$ → 2 Cl^-



Calcium fluoride - classwork

1. Species such as NH_4^+, CO_3^{2-} and PO_4^{3-} are examples of molecular ions.
   Ionic and covalent bonds both involve an electrostatic attraction between different species.
   Identify the species that are electrostatically attracted to one another in:
   an ionic bond [1]

2. LiH is an ionic compound.
Draw a dot-and-cross diagram of LiH.
Include **all** electrons. [2]

3. Calcium ethanedioate is formed when calcium reacts with ethanedioic acid, $(CO_2H)_2$. The compound contains one cation and one anion.
Draw the 'dot-and -cross' diagram of the cation present in calcium ethanedioate. Show **all** electrons. [1]

4. Radium, Ra, is an element found in Group 2 of the Periodic Table. It is a crystalline solid at room temperature and conducts electricity.
Radium chloride, $RaCl_2$, has a melting point of 900°C and is soluble in water.
Draw a dot-and-cross diagram to show the arrangement of **outer electrons** in $RaCl_2$. [1]

Physical properties of ionic compounds

Melting point
very high — **A large amount of energy must be put in to overcome the strong electrostatic attractions and separate the ions.**

Strength
Very brittle — **Any dislocation leads to the layers moving and similar ions being adjacent. The repulsion splits the crystal.**

Electrical conductivity — **don't conduct when solid - ions held strongly in the lattice**
conduct when molten or in aqueous solution - the ions become mobile and the conduction takes place.

Solubility — **Insoluble in non-polar solvents but soluble in water**
Water is a polar solvent and stabilises the separated ions.
Much energy is needed to overcome the electrostatic attraction and separate the ions stability attained by being surrounded by polar water molecules compensates for this

*****This is not a complete note. It is just to guide you. It is recommended to study prescribed textbooks along with this material. *****