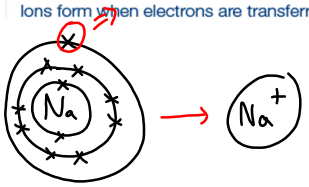
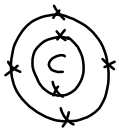
Ions form when electrons are transferred



Group number	Example	Number of valence electrons	Electrons lost or gained	Number of electrons transferred	Charge on ion formed	Type of element
1	sodium	1	lost	1	1+	metal
2	calcium	2	lost	2	2+	metal
13	aluminium	3	lost	3	3+	metal
14	carbon	4	–	–	–	non-metal
15	phosphorus	5	gained	3	3–	non-metal
16	oxygen	6	gained	2	2–	non-metal
17	bromine	7	gained	1	1–	non-metal

Note that elements in Group 14, having four electrons in their outer shell, do not have a tendency to gain or to lose electrons, and so they generally do not form ions. This is because the energy involved in transferring four electrons would simply be too large to be favourable. These elements therefore react to form a different type of bond, which we will discuss later in this chapter.



doesn't form ions

Polyatomic ion name	Charge on ion	Symbol	Example of compound containing this ion
nitrate	1–	NO_3^-	lead nitrate
hydroxide	1–	OH^-	barium hydroxide
hydrogencarbonate	1–	HCO_3^-	potassium hydrogencarbonate
carbonate	2–	CO_3^{2-}	magnesium carbonate
sulfate	2–	SO_4^{2-}	copper sulfate
phosphate	3–	PO_4^{3-}	calcium phosphate
ammonium	1+	NH_4^+	ammonium chloride

Ionic compounds form when oppositely charged ions attract

Exercises

1 Write the formula for each of the compounds in the table on page 142.
2 Write the formula for each of the following compounds:
(a) potassium bromide (d) copper(II) bromide
(b) zinc oxide (e) chromium(III) sulfate
(c) sodium sulfate (f) aluminium hydride
3 Name the following compounds:
(a) $Sn_3(PO_4)_2$ (d) $BaSO_4$
(b) $Ti(SO_4)_2$ (e) Hg_2S
(c) $Mn(HCO_3)_2$
4 What are the charges on the positive ions in each of the compounds in Q3 above?
5 What is the formula of the compound that forms from element A in Group 2 and element B in Group 15?
6 Explain what happens to the electron configurations of Mg and Br when they react to form the compound magnesium bromide.

Ionic compounds have a lattice structure

The electrostatic charge on ions causes them to be surrounded by ions of the opposite charge in a lattice structure .

The formula unit of sodium chloride is NaCl as this is the simplest ratio describing the ions present.

The coordination number is six as each Cl- and Na+ is surrounded by 6 of the oppositely charged ions.

The strength of the lattice structure can be described by the lattice energy .

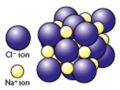


Figure 4.1 The NaCl lattice is built up from oppositely charged sodium and chloride ions.

The physical properties of ionic compounds reflect their lattice structure

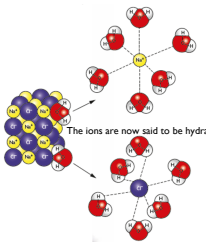
In general, ionic compounds have high MP's and BP's. Why?

It requires a lot of energy to overcome all of the electrostatic forces of attraction.

Ionic compound	Charge on metal ion	Melting point
Na_2O	1+	1132 °C
MgO	2+	2800 °C

Mg^{2+} O^{2-}

Na^+ O^{2-} Na^+



Solubility

Solubility refers to the ease with which a solid (the solute) becomes dispersed through a liquid (the solvent) to form a solution. You probably know from common observations that common salt, sodium chloride, readily dissolves in water but does not dissolve in oil. Why is this? There are several factors involved, but in general, solubility is determined by the degree to which the separated particles of solute are able to form bonds or attractive forces with the solvent.

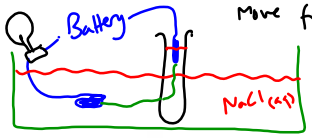
Na^+ Cl^-

800°C

Electrical conductivity

When can ionic compounds conduct electricity?

When dissolved in water or in a molten (liquid) state. The ions can move freely.

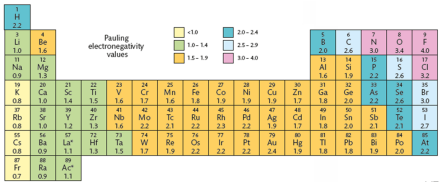


Brittleness

Ionic compounds are usually brittle, which means the crystal tends to shatter when force is applied. This is because movement of the ions within the lattice places ions of the same charge alongside each other, so the repulsive forces cause it to split.

They will break before they bend

Different ionic compounds have a different extent of ionic character



ionic compounds
reactive metal + reactive non-metal
electronegativity difference > 1.8

covalent compounds
two non-metals
electronegativity difference << 1.8

polar covalent compounds
0 < electronegativity difference < 1.8

Pure covalent

Cl — Cl

$\delta+$ H — N $\delta-$

Na^+ Cl^-

Exercises

7 Which fluoride is the most ionic?
A NaF B CsF C MgF_2 D BaF_2
8 Which pair of elements reacts most readily?
A Li + Br_2 B Li + Cl_2 C K + Br_2 D K + Cl_2
9 You are given two white solids and told that only one of them is an ionic compound. Describe three tests you could carry out to determine which it is.