AN INTRODUCTION TO Ionic Bonding

STRUCTURE AND BONDING

The physical properties of a substance depend on its structure and type of bonding present. Bonding determines the type of structure.

Basic theory

- **the noble gases (He, Ne, Ar, Kr, Xe and Rn) are in Group VIII**
- **they are all relatively, or totally, inert**
- **their electronic structure appears to confer stability**
- **they have just filled their ‘outer shell’ of electrons**
- **atoms without the electronic structure of a noble gas try to get one**
- **various ways are available**
- **the method depends on an element’s position in the periodic table**

IONIC

BONDING

THE IONIC BOND

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.

The nature of ionic bond

An ionic bond is an attraction between oppositely charged ions, which are formed by the transfer of electrons from one atom to another.

IONIC OR COVALENT? - ELECTRONEGATIVITY

Electronegativity is the relative ability of an atom to attract electrons in a covalent bond.

									H 2.1								He
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr

Differences in electronegativity can be used to predict how much ionic or metallic character a covalent bond will have.

Aluminium chloride is a covalent compound even though aluminium is a metal and chlorine is a non metal since the difference in electronegativity between the two elements is only 1.5.

Polarising power of cations

Positive ions with high charge density that is small size and high charge such as Al^{3+} tend to distort the electron clouds of large anions such as Cl^-, thus making the compound covalent instead of ionic

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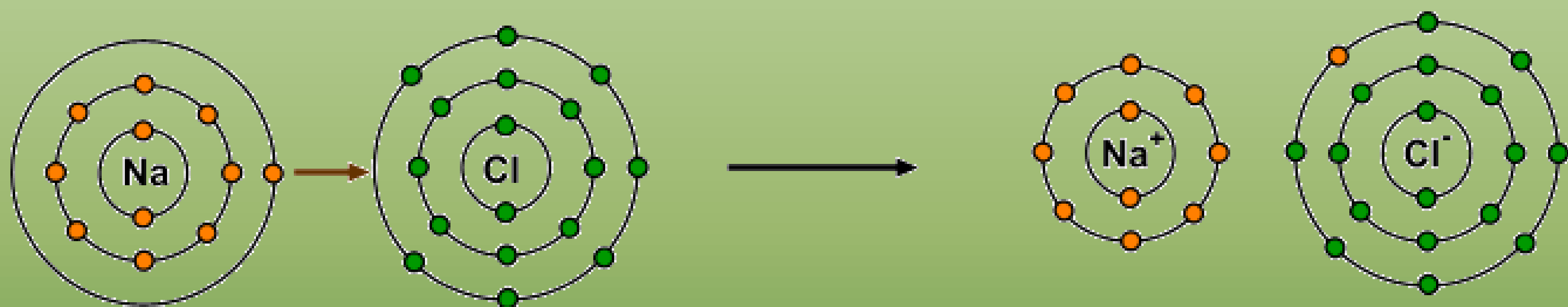
Sodium Chloride



$Na \longrightarrow Na^+ + e^-$ and $Cl + e^- \longrightarrow Cl^-$

$1s^2\,2s^2\,2p^6\,3s^1$ → $1s^2\,2s^2\,2p^6$ and $1s^2\,2s^2\,2p^6\,3s^2\,3p^5$ → $1s^2\,2s^2\,2p^6\,3s^2\,3p^6$

or 2,8,1 → 2,8 and 2,8,7 → 2,8,8

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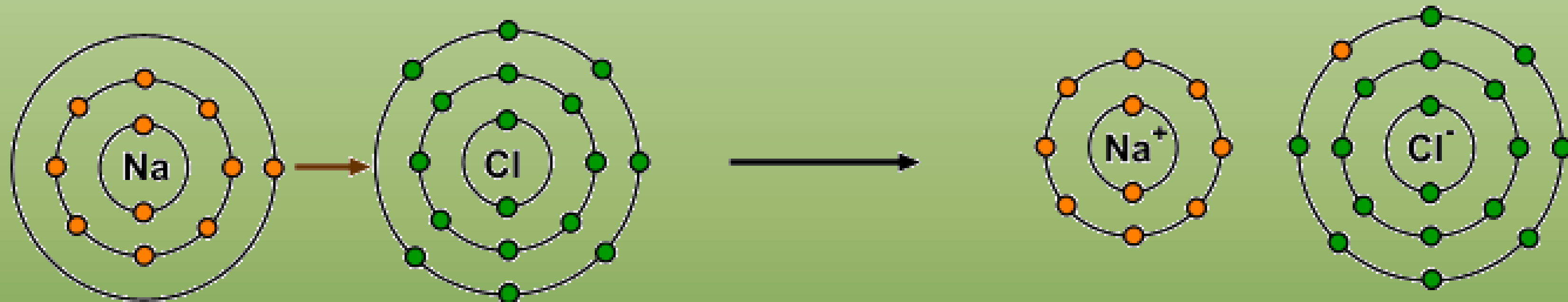


Na ——> Na+ + e^{-} and Cl + e^{-} ——> Cl^{-}

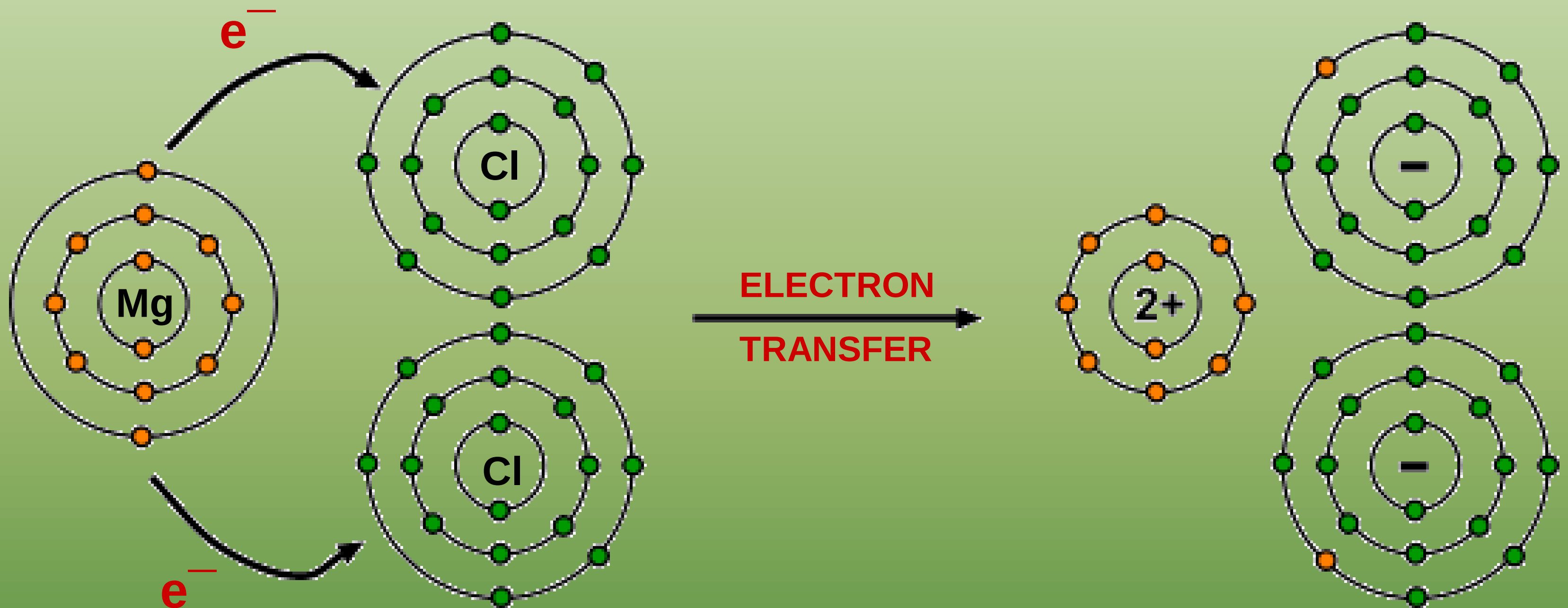
$1s^2\ 2s^2\ 2p^6\ 3s^1$ $1s^2\ 2s^2\ 2p^6$ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

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.

THE IONIC BOND

FORMATION OF MAGNESIUM CHLORIDE

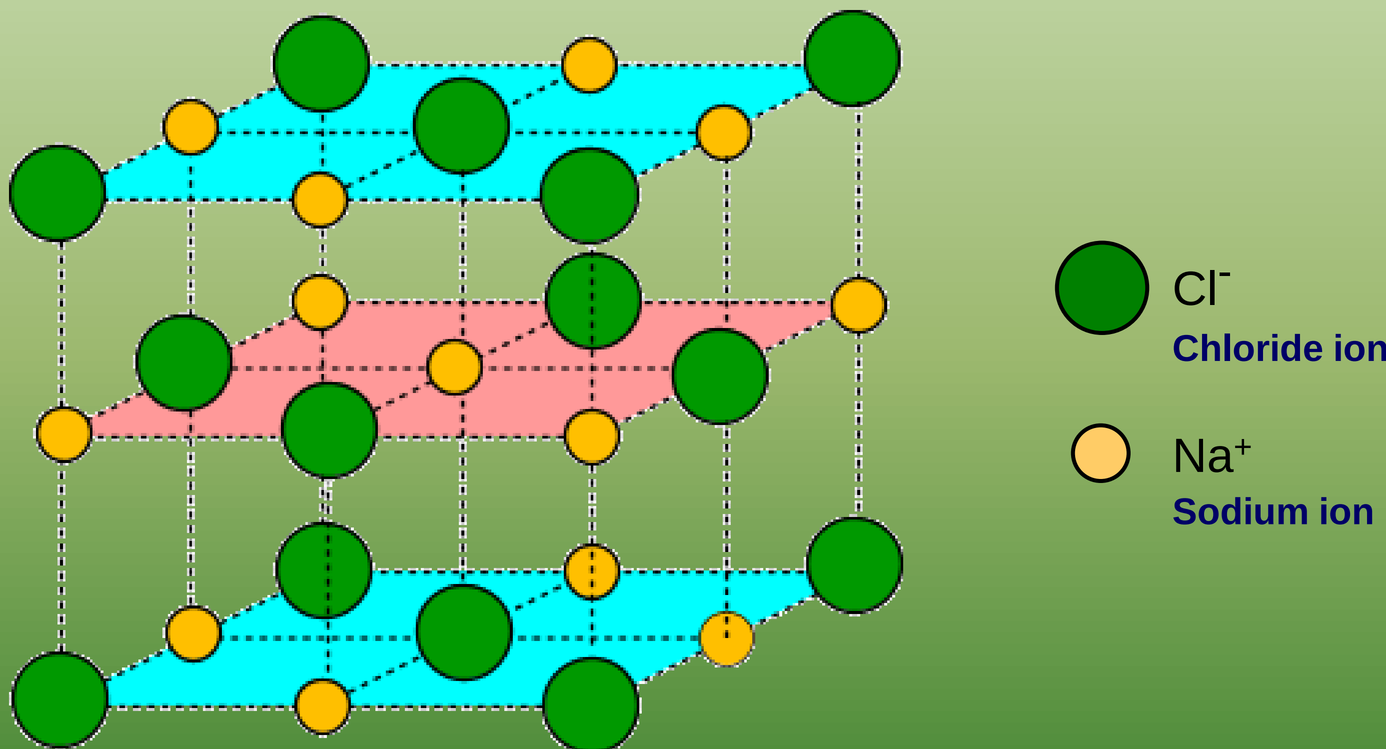


$Mg \longrightarrow Mg^{2+} + 2e^-$ and $2Cl + 2e^- \longrightarrow 2\,Cl^-$

GIANT IONIC CRYSTAL LATTICE

Oppositely charged ions held in a regular 3-dimensional lattice by electrostatic attraction

The arrangement of ions in a crystal lattice depends on the relative sizes of the ions



The Na^+ ion is small enough relative to a Cl^- ion to fit in the spaces so that both ions occur in every plane.

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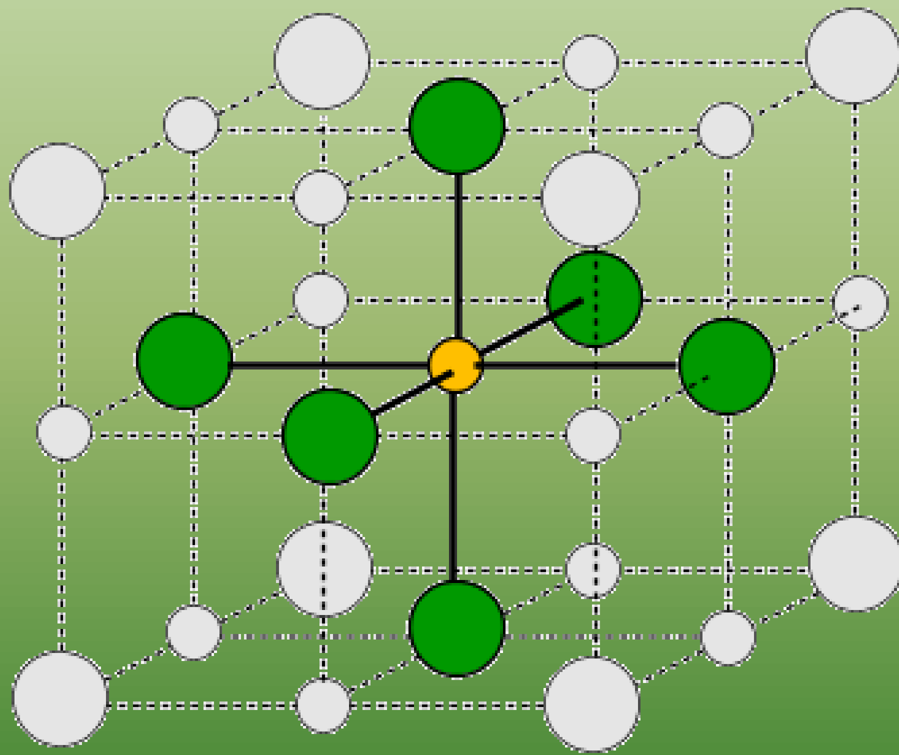

Each Na^+ is surrounded by 6 Cl^- (co-ordination number = 6)
and each Cl^- is surrounded by 6 Na^+ (co-ordination number = 6).

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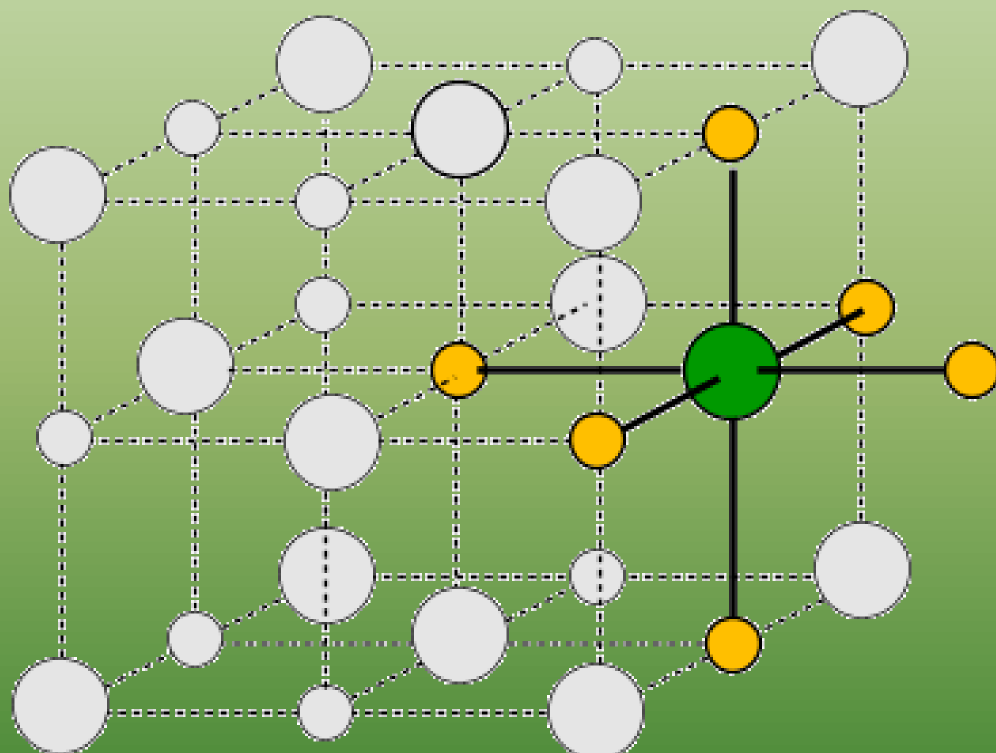

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Physical properties of ionic compounds

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.

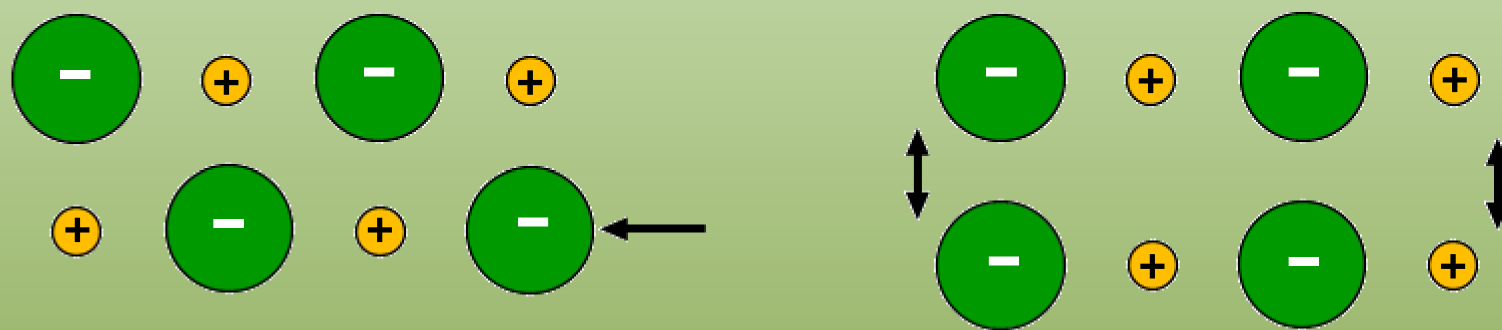
Electrical don't conduct when solid - ions held strongly in the lattice
conduct when molten or in aqueous solution - the ions become mobile and conduction takes place.

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

IONIC BONDING

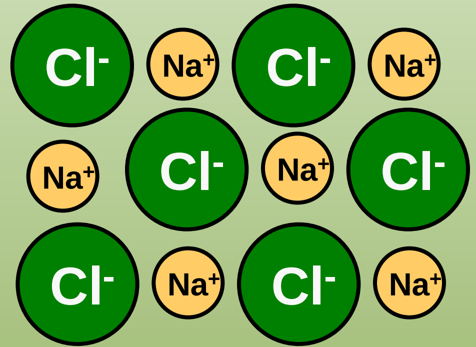
BRITTLE IONIC LATTICES



IF YOU MOVE A LAYER OF IONS, YOU GET IONS OF THE SAME CHARGE NEXT TO EACH OTHER. THE LAYERS REPEL EACH OTHER AND THE CRYSTAL BREAKS UP.

IONIC COMPOUNDS - ELECTRICAL PROPERTIES

SOLID IONIC COMPOUNDS DO NOT CONDUCT ELECTRICITY



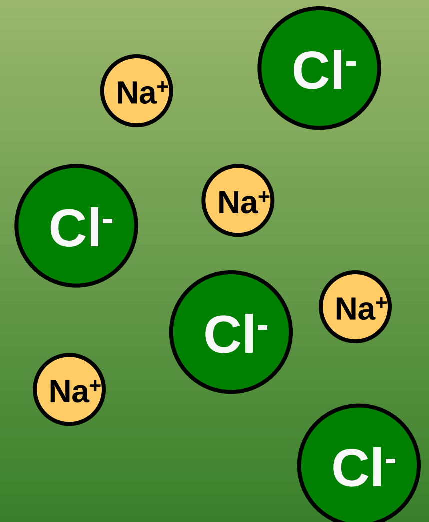
IONS ARE HELD STRONGLY TOGETHER

+ IONS CAN'T MOVE TO THE CATHODE

- IONS CAN'T MOVE TO THE ANODE

MOLTEN IONIC COMPOUNDS DO CONDUCT ELECTRICITY

SOLUTIONS OF IONIC COMPOUNDS IN WATER DO CONDUCT ELECTRICITY



IONS HAVE MORE FREEDOM IN A LIQUID SO CAN MOVE TO THE ELECTRODES

DISSOLVING AN IONIC COMPOUND IN WATER BREAKS UP THE STRUCTURE SO IONS ARE FREE TO MOVE TO THE ELECTRODES

THE END