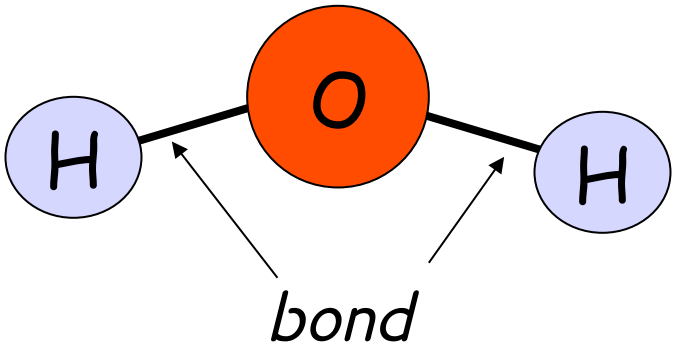
TOPIC: Chemical Bonds



a water molecule

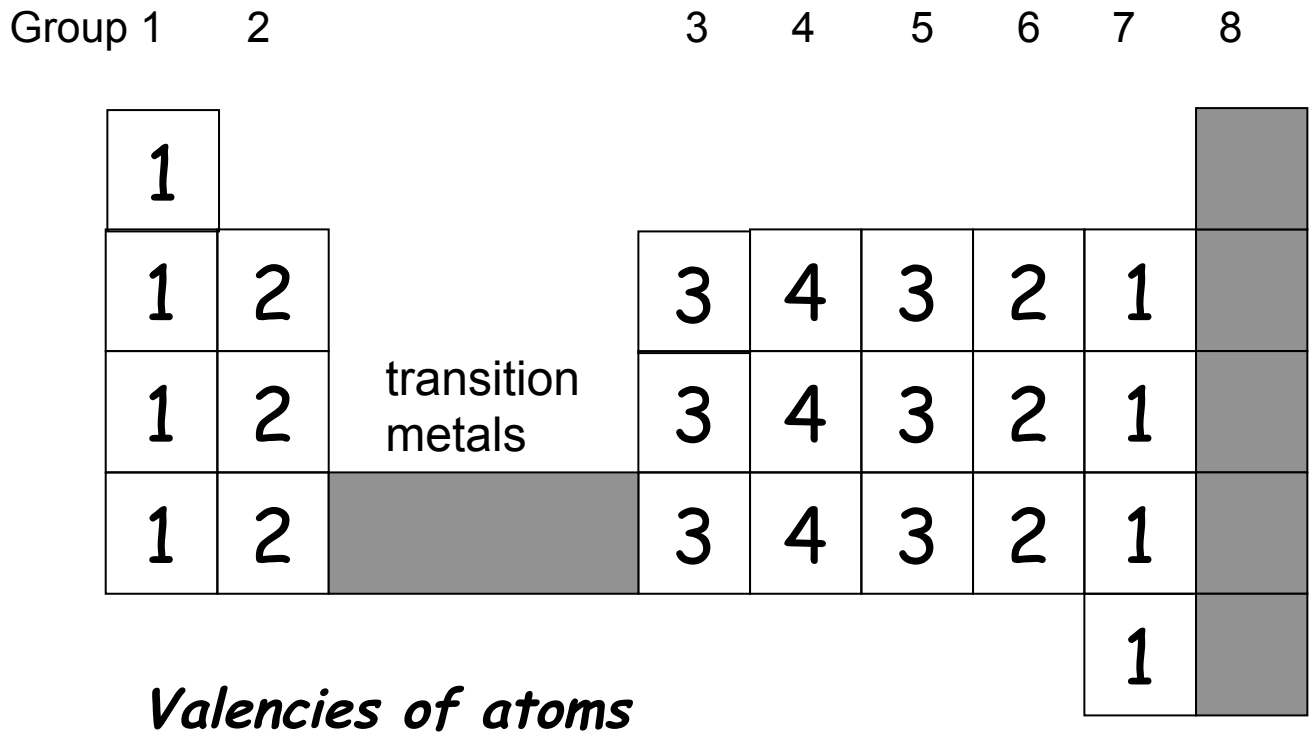
In elements and compounds, the atoms are held together by **chemical bonds**.

Forming a bond makes an atom **more stable**, so atoms form as many bonds are they are able to.

Bonds are made using the **outer shell** electrons of atoms, which are either **transferred** from one atom to another, or **shared** between atoms.

Valency

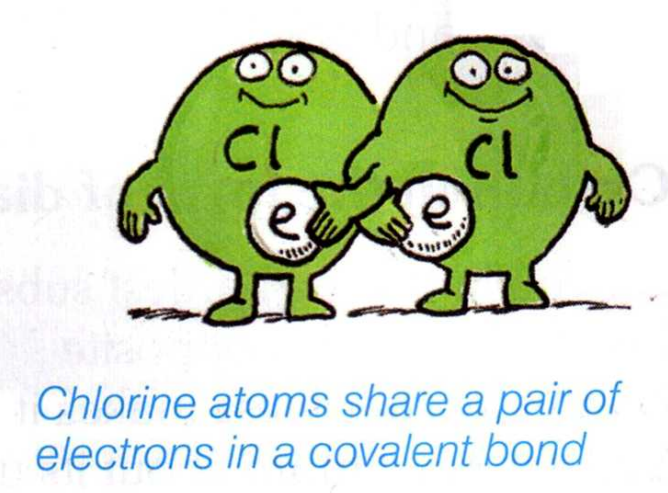
The number of electrons an atom uses for bonding is called its **valency**, and is related to the number of outer shell electrons the atom has.



Valencies of atoms

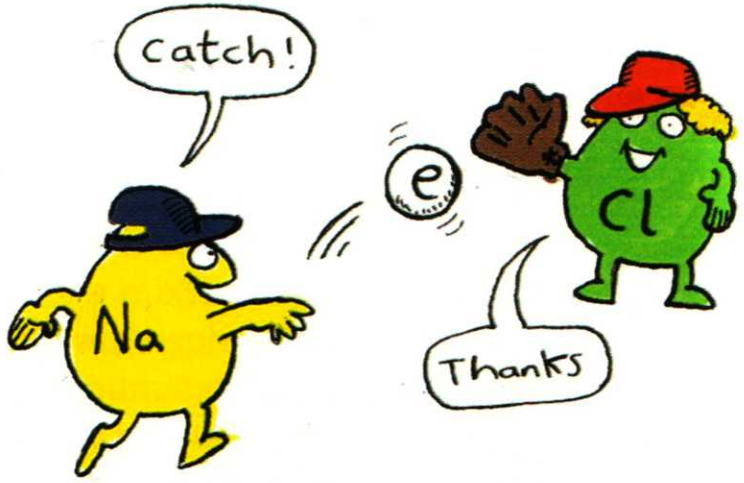
Types of bond

- **Covalent bonds** are formed by atoms **sharing** a **pair** of electrons.
- This type of bond is usually found between non-metal atoms.



Chlorine atoms share a pair of electrons in a covalent bond

- **Ionic bonds** are formed by atoms **losing and gaining** electrons.
- This type of bond is usually found between a metals and non-metals



Metal atoms give electrons to non-metal atoms

Covalent bonding

Many of the substances which make up our natural world are made only from **non-metal atoms.**

e.g. H_2O CH_4 O_2 CO_2 $C_6H_{12}O_6$

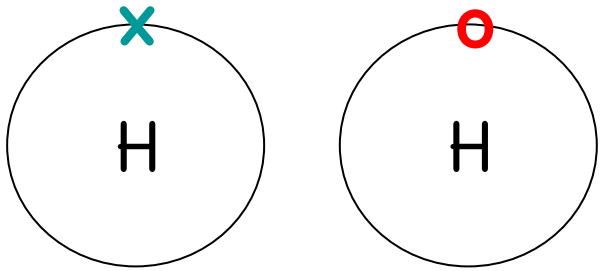
When a covalent bond forms between two atoms, **each** atom shares **one** outer-shell electron with the other atom.

These are now a **shared pair** of electrons, and are counted as part of the outer shell of **BOTH** atoms.

These negatively-charged shared electrons attract the positively-charged nuclei of the two atoms, holding them together **strongly** by **electrostatic attraction**.

Covalent Dot-and-cross diagrams

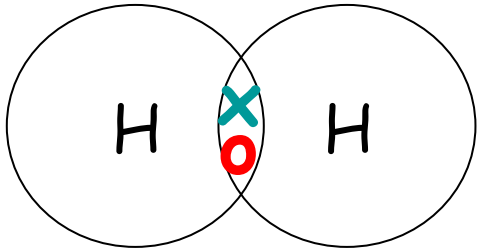
Atoms will keep on forming covalent bonds until their outer shell is full – the number of covalent bonds they form is the same as their **valency**.



two hydrogen atoms

Hydrogen atoms have a valency of 1, so each can share one electron to form one bond.

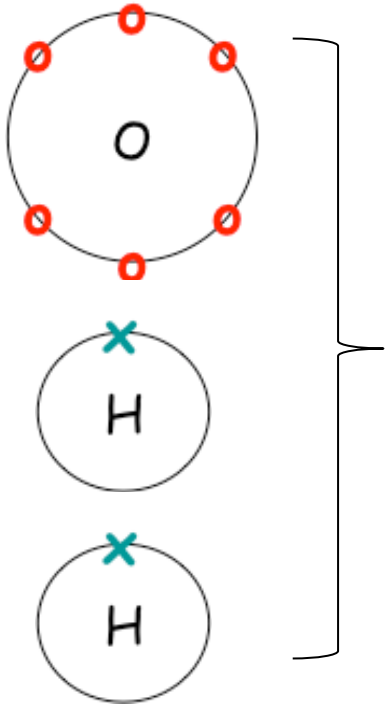
H—H

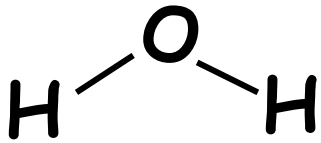


Dot-and cross diagram for a hydrogen molecule, H_2

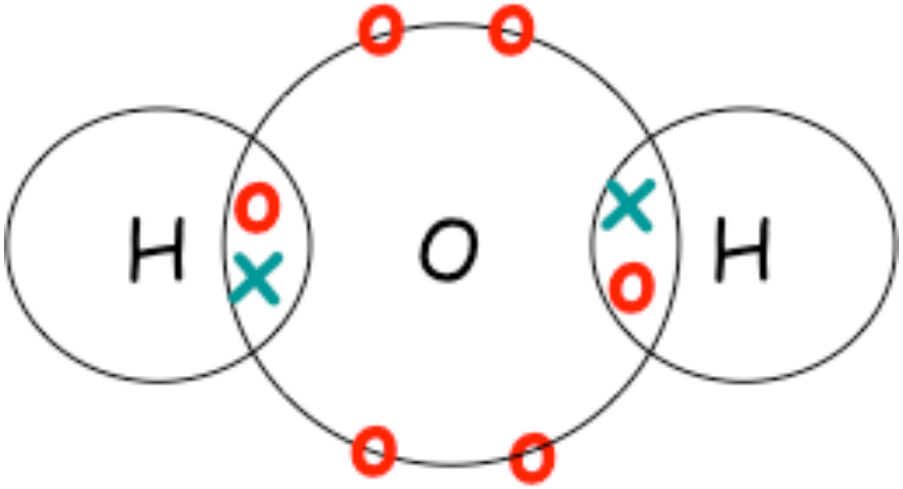
An oxygen atom has a valency of 2, so it shares two of its electrons to form two covalent bonds.

Hydrogen atoms have a valency of 1, so they share one electron and form one bond; we need two hydrogen atoms to bond with each oxygen atom.





a water molecule

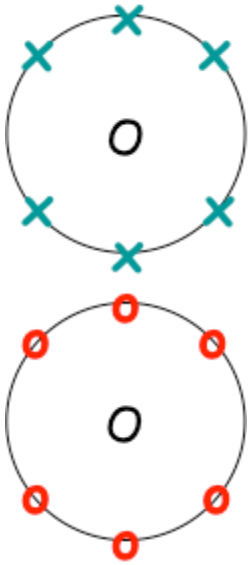


Dot-and cross diagram for a water molecule, H_2O

You are expected to be able to draw dot-and-cross diagrams for these molecules:

Hydrogen	H_2
Water	H_2O
Hydrogen chloride	HCl
Chlorine	Cl_2
Hydrogen bromide	HBr
Bromine	Br
Methane	CH_4
Ammonia	NH_3

If both atoms have a valency of 2 or more, they can share more than one electron with each other.

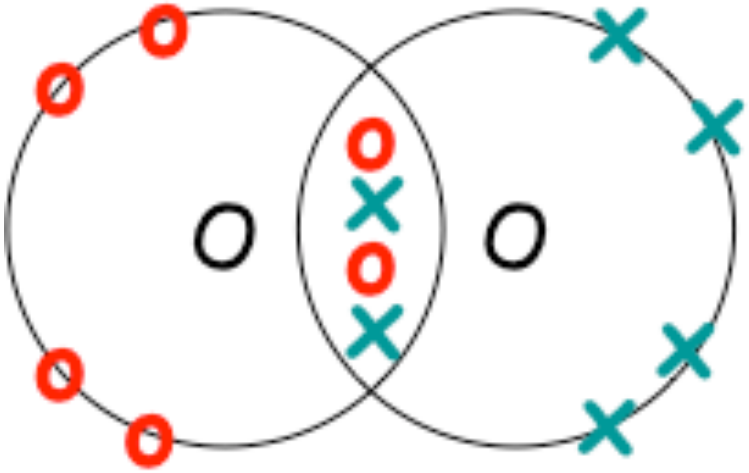


two oxygen atoms

Oxygen atoms have a valency of 2. so each can share two electrons with the other, making two covalent bonds between the SAME two atoms – a **double bond.**

O=O

an oxygen molecule



Dot-and cross diagram for an oxygen molecule, O_2

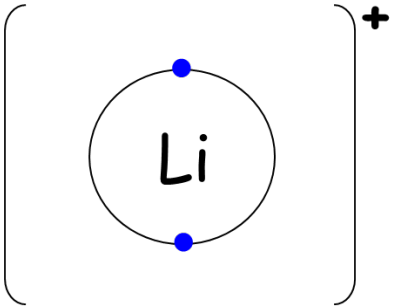
You are expected to be able to draw dot-and-cross diagrams for these molecules that contain double or triple covalent bonds:

Carbon dioxide	CO_2
Nitrogen	N_2
Oxygen	O_2

How ions are formed

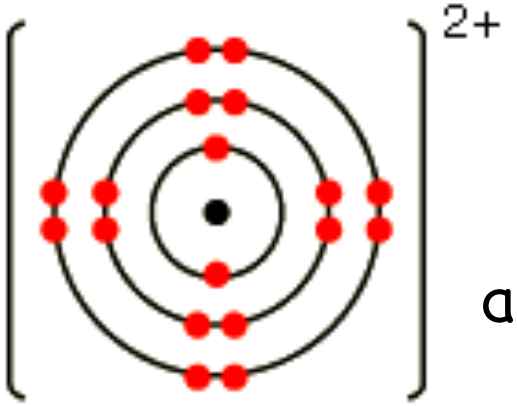
An **ion** is an atom which has lost or gained electrons, to become more stable, usually gaining a **full outer shell**.

An ion has a **charge.** How do we know what the charge is?



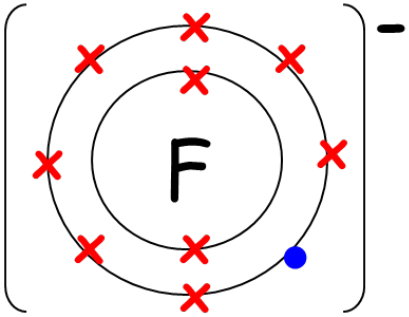
Li^+

a lithium ion



Ca^{2+}

a calcium ion



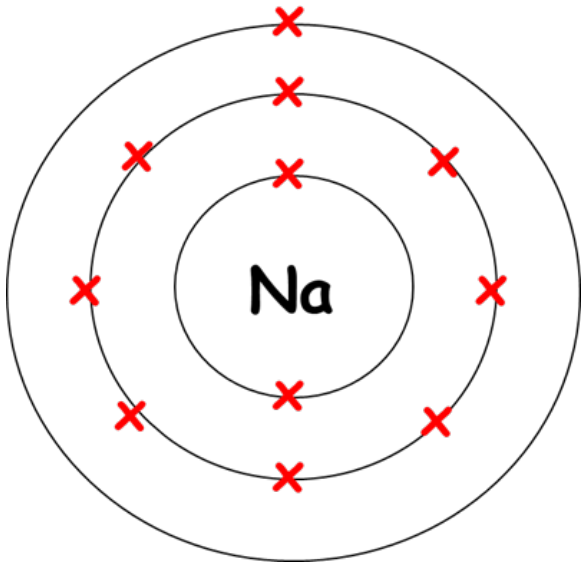
F^-

a fluoride ion

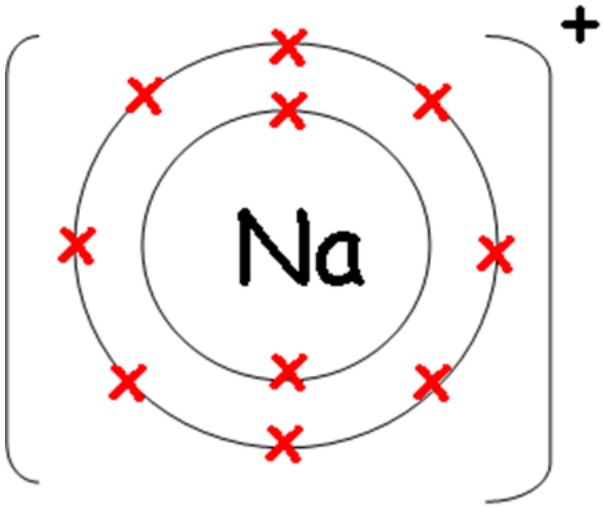
How have these ions been formed from atoms?

For metal atoms (Groups 1,2 3):

- They lose their outer shell electron(s)
- They become **positively charged ions**
- Amount of charge = valency = what Group they are in



Loses 1 electron



Na [2,8,1]

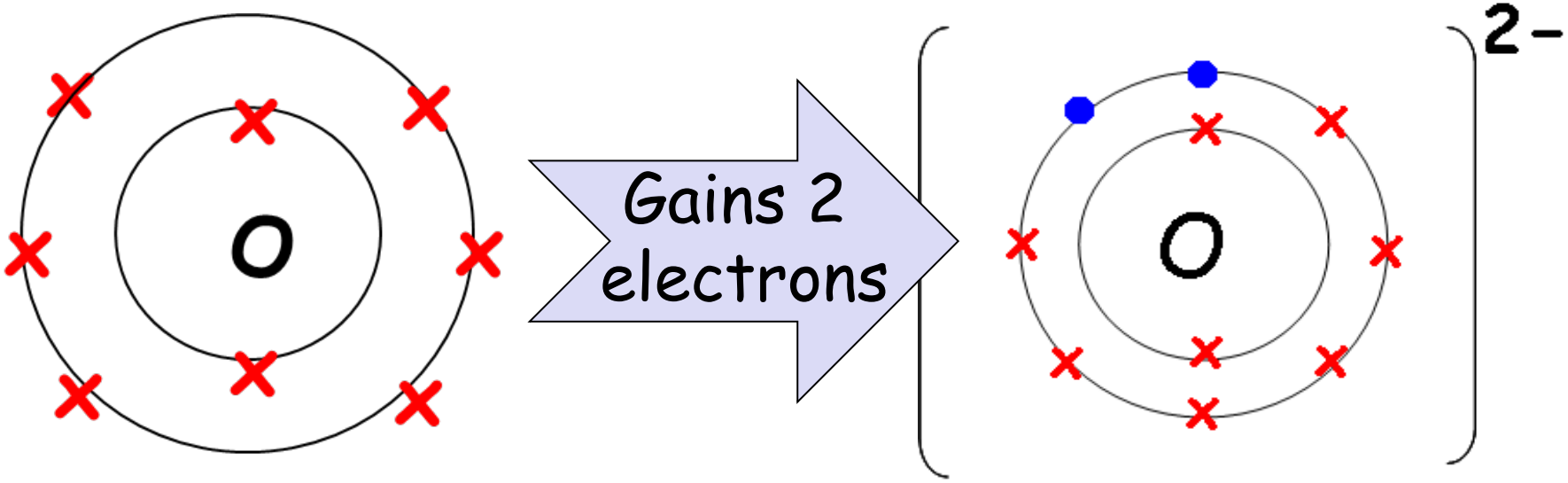
sodium atom

Na^+ $[2,8]^+$

sodium ion

For non-metal atoms (Groups 5,6,7):

- They gain electrons to complete the outer shell
- They become **negatively charged ions**
- Amount of charge = valency (= 8 – Group)
- **Name changes to an –ide ending**

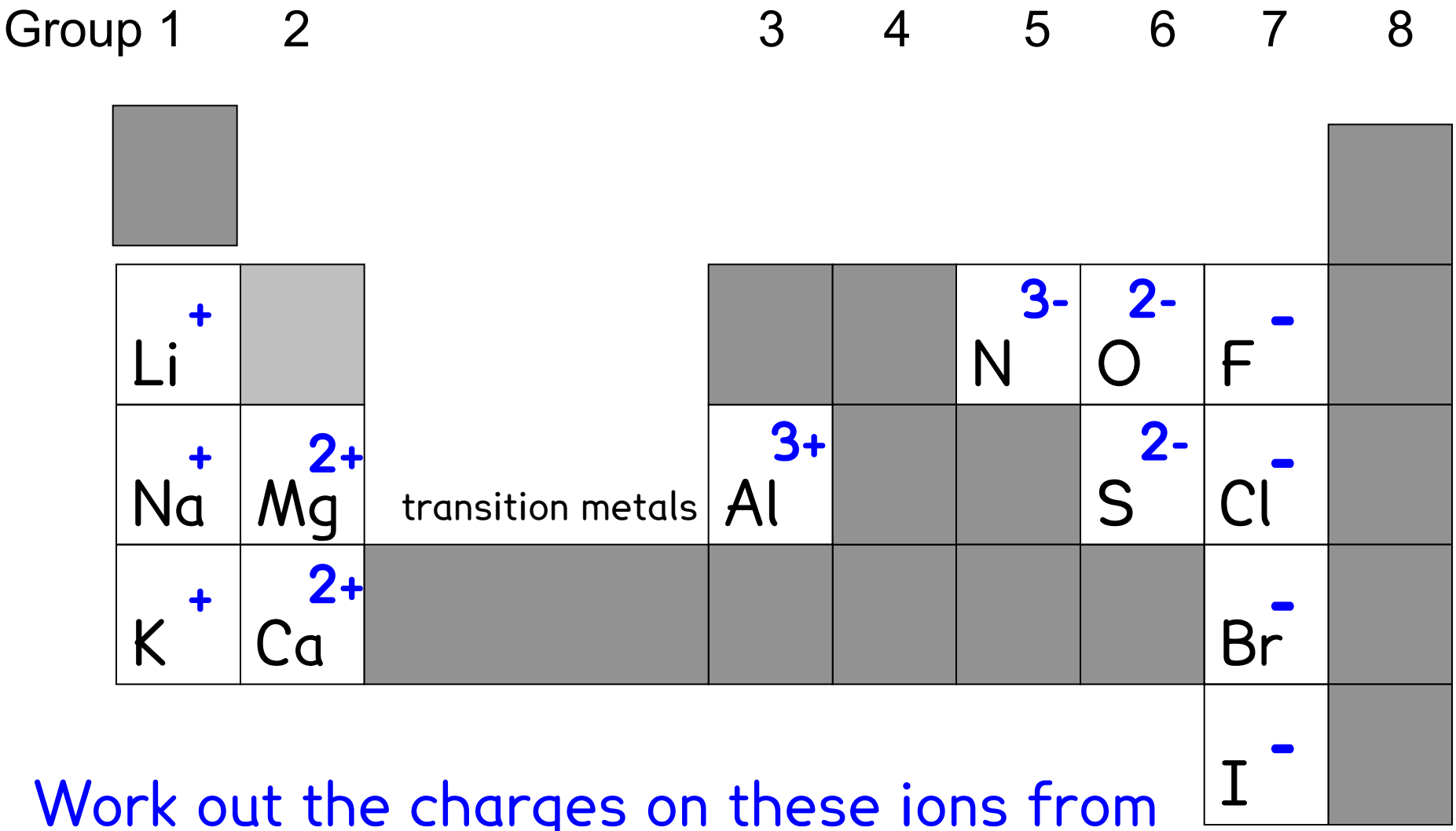


O [2,6]

oxygen atom

O^{2-} $[2,8]^{2-}$

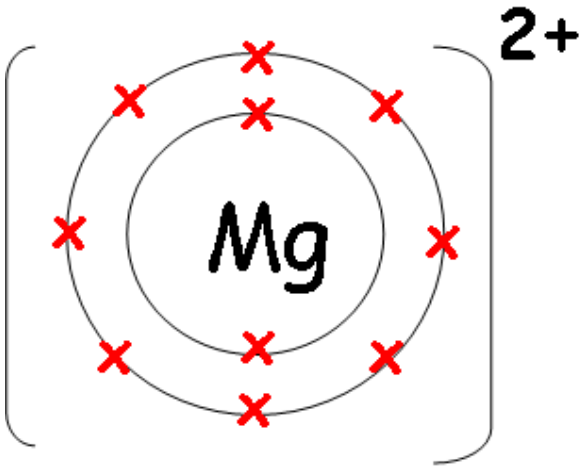
oxide ion



Work out the charges on these ions from the group they are in, and whether they are metals or non-metals.

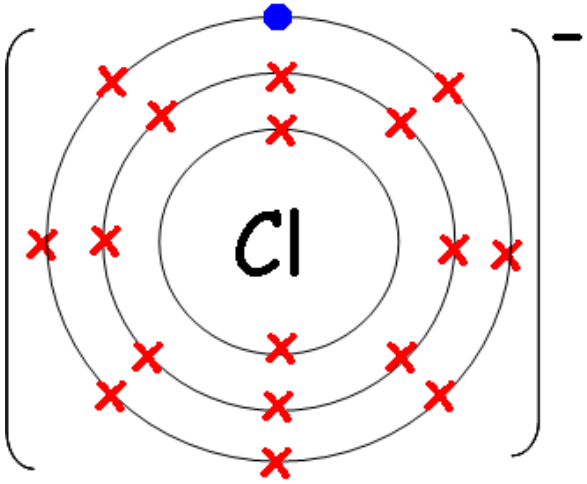
Practice:

draw a magnesium ion



Mg^{2+} $[2,8]^{2+}$

a chloride ion

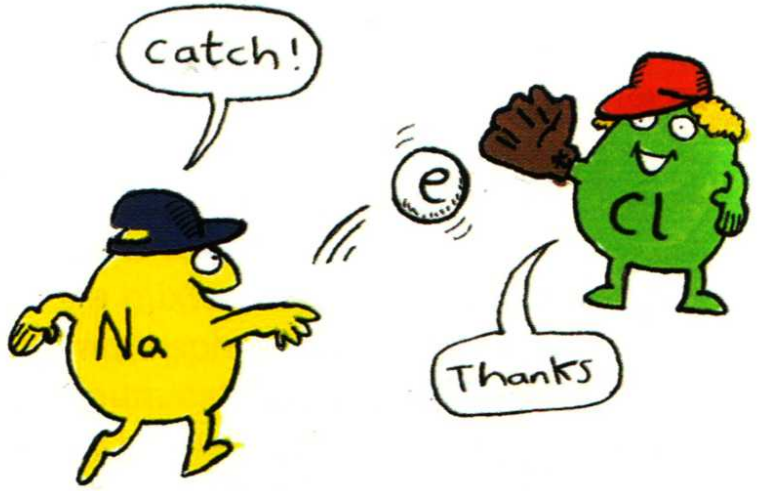


Cl^- $[2,8,8]^-$

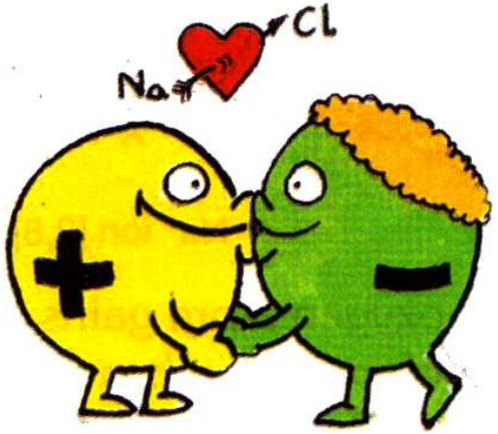
Ionic Bonding

When metal atoms give their outer-shell electrons to non-metal atoms, they become **oppositely charged** ions.

There is a **strong electrostatic attraction** between the oppositely-charged ions – this is an **ionic bond**.



Metal atoms give electrons to non-metal atoms

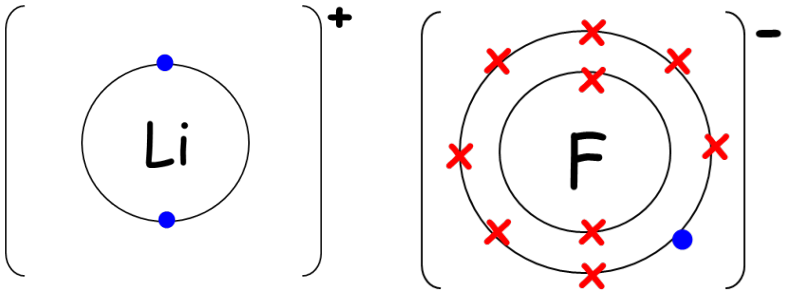


Opposites attract!

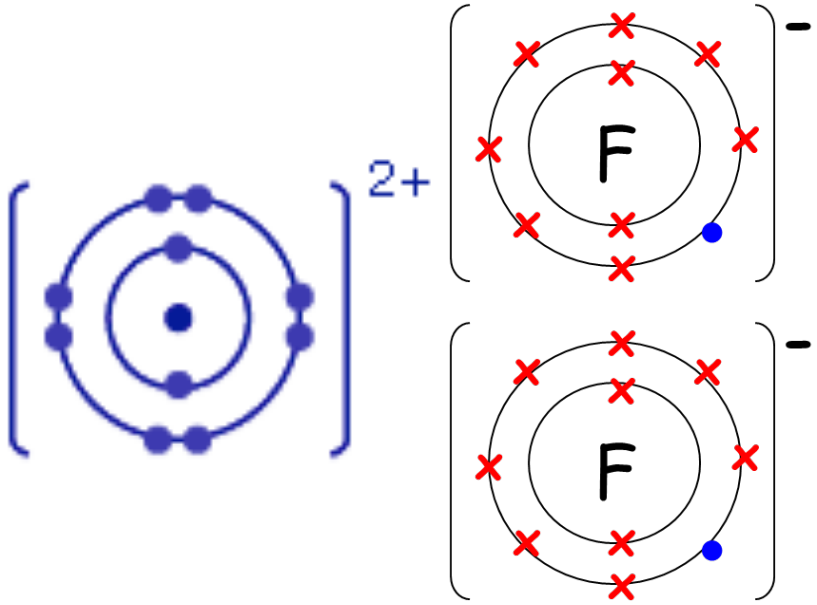
How many of each ion?

- The charge has to balance: equal amounts of + and –
- The same number of electrons have to be lost as gained

- So if we have a 2+ ion, we'll need two 1- ions etc.



lithium fluoride, LiF

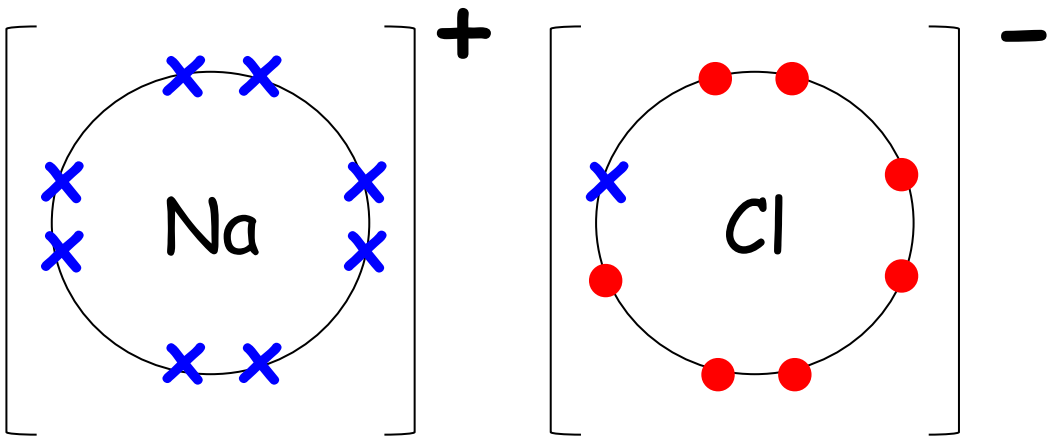


magnesium fluoride, MgF_2

Ionic dot-and-cross diagrams

These usually show **only the outer shell** electrons, because only these are involved in bonding.

- Draw outline first, with brackets
- Put correct charge on each ion, check balanced
- Draw a full (or empty) outer shell for the metal ion(s)
- Fill in the electrons for the non-metal atom(s)
- Add transferred electrons to fill the outer shell(s)



sodium chloride

You are expected to be able to draw dot-and-cross diagrams for ionic compounds:

- Any metal from Group 1, 2 or 3

bonded to

- Any non-metal from Group 5, 6 or 7

e.g.

sodium nitride	**calcium phosphide**	**aluminium nitride**
potassium oxide	**magnesium sulphide**	**indium oxide**
lithium bromide	**strontium chloride**	**gallium fluoride**