FACTFILE:
GCSE DAS CHEMISTRY: UNIT 1.2

Rewarding Learning

Bonding

Learning outcomes

Students should be able to:

1.2.1 demonstrate knowledge and understanding that an ion is a charged particle formed when an atom gains or loses electrons and a molecular ion is a charged particle containing more than one atom; and

1.2.2 **define the terms cation and anion;**

1.2.3 explain, using dot and cross diagrams, how ions are formed and how ionic bonding takes place in simple ionic compounds, restricted to elements in Groups 1 and 2 with elements in Groups 6 and 7, the ions of which have a noble gas electronic configuration;

1.2.3 demonstrate knowledge and understanding that:

- ionic bonding involves attraction between oppositely charged ions;
- ionic bonds are strong; and
- substantial energy is required to break ionic bonds.

1.2.4 recognise that ionic bonding is typical of metal compounds;

1.2.5 describe a single covalent bond as a shared pair of electrons;

1.2.6 explain, using dot and cross diagrams, how covalent bonding occurs in H_2, Cl_2, HCl, **H_2O, NH_3, CH_4** and similar molecules and label lone pairs of electrons;

1.2.7 **draw dot and cross diagrams and indicate the presence of multiple bonds in O_2, N_2 and CO_2;**

1.2.8 recognise covalent bonding as typical of non-metallic elements and compounds;

1.2.9 demonstrate knowledge and understanding that a molecule is two or more atoms covalently bonded and that diatomic means that there are two atoms covalently bonded in a molecule;

1.2.10 demonstrate knowledge and understanding that covalent bonds are strong and that substantial energy is required to break covalent bonds;

1.2.11 demonstrate knowledge and understanding that a covalent bond may be represented by a line; and

1.2.12 **demonstrate knowledge and understanding that metallic bonding results from the attraction between the positive ions in a regular lattice and the delocalised electrons.**

Ionic bonding

When metal atoms react with non-metal atoms, they chemically combine to form compounds. To do this, the metal atom transfers one or more electrons to the non-metal atom so that both end up with full outer shells of electrons. As the number of electrons is different to the number of protons, the atoms are now charged particles known as ions, which are attracted to each other by electrostatic attraction.

An ion is a charge particle formed when an atom gains or loses electrons.

Metal atoms lose electrons to form positive ions (cations) whilst non-metal atoms gain electrons to form negative ions (anions). The number of electrons gained or lost by an atom is related to the group in which the element is found.

Group	1	2	3	4	5	6	7	8
Charge	1+	2+	3+	N/A	3–	2–	1–	N/A
Example	Na^{+}	Mg^{2+}	Al^{3+}	N/A	N^{3-}	O^{2-}	F^{-}	N/A

Ionic compounds generally form when a Group 1 or 2 element and a Group 6 or 7 element react. The ions which form have a noble gas electronic structure (full outer shell).

An **ionic bond is the attraction between oppositely charged ions**. Ionic bonds are strong and substantial energy is required to break them.

For example, when magnesium reacts with oxygen to form magnesium oxide, the magnesium atom loses two electrons to form the Mg^{2+} cation, which has electronic configuration 2,8. The oxygen atom gains these electrons to form the O^{2-} anion, with electronic configuration 2,8. The number of protons and neutrons in each ion remains unchanged from the original atom. The dot and cross diagram below shows this, remember to show electrons of one type of atom as dots, and the other as crosses.

To draw dot and cross diagrams for ionic bonding it is useful to follow the following steps.

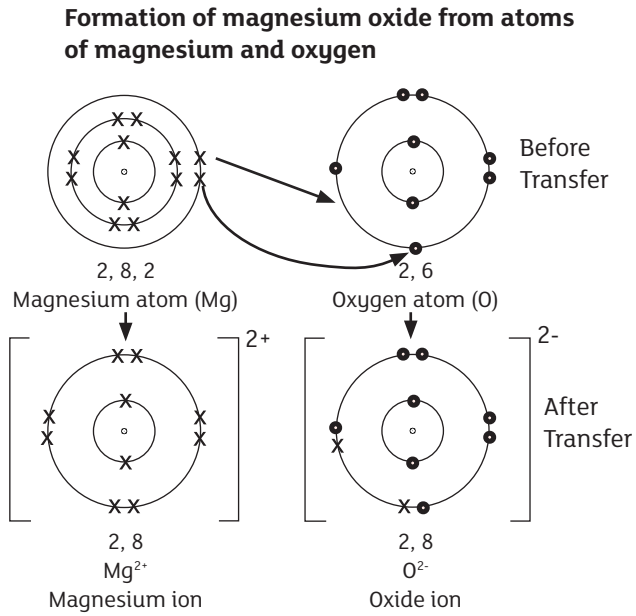
1. Draw the electronic configuration of each atom, one element with dots and the other with crosses and work out how many electrons need to be transferred.

2. Show with arrows, the transfer of electrons.

3. Draw the electronic configuration of each ion.

4. Write the charge of each ion.

Formation of magnesium oxide from atoms of magnesium and oxygen

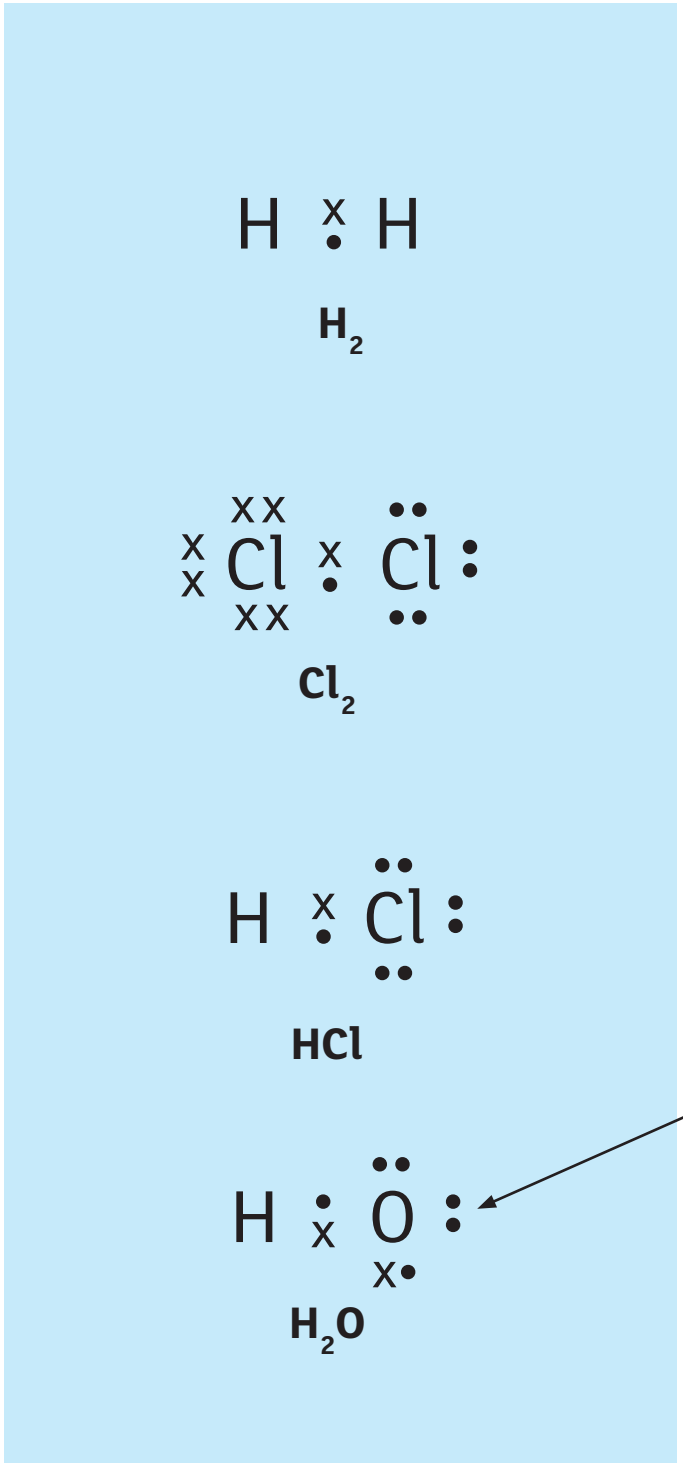


Covalent Bonding

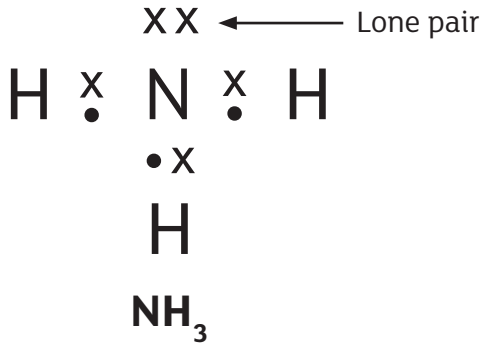
A covalent bond is a shared pair of electrons.

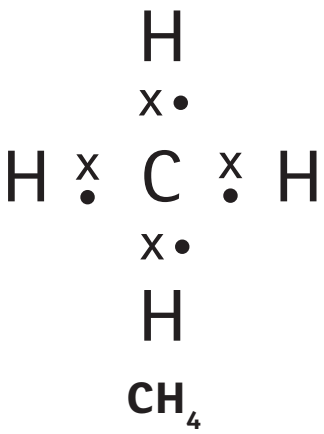
A molecule is two or more atoms covalently bonded together. Diatomic means that there are two atoms covalently bonded in a molecule.

Molecules such as those shown below are held together by covalent bonding. Covalent bonding is typical of non-metallic elements and compounds.

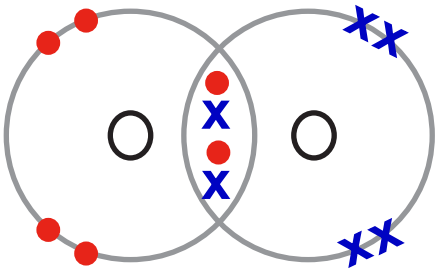


A lone pair is an unbonded pair of electrons (represented as •• or ××).

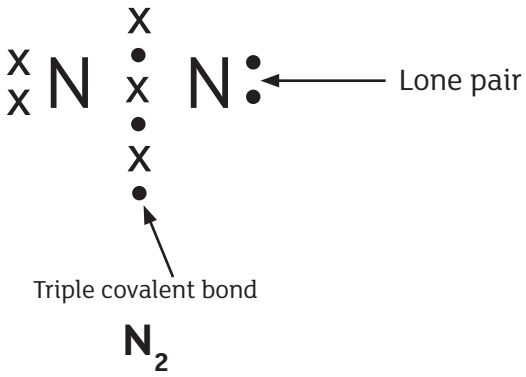




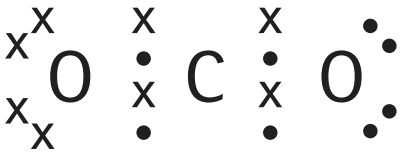
Some non-metal elements which exist as diatomic molecules have more than one shared pair of electrons between their atoms; the element oxygen is one such example. Each oxygen atom shares two electrons, giving a total of two shared electron pairs and four electrons shared in total. This is known as a double covalent bond.



If three pairs of electrons are shared then a **triple bond** results.
Nitrogen, N_2, has a triple bond.



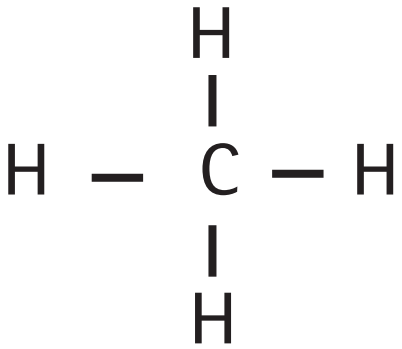
N_2



CO_2

A covalent bond may also be represented by a line, a single covalent bond is a single line, a double covalent bond is two lines, and a triple covalent bond is three lines.

For example CH_4 is:



N_2 is:

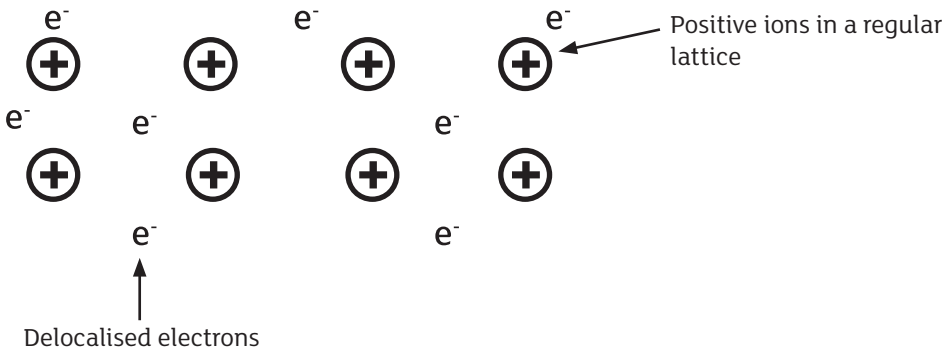
Metallic Bonding

Metal atoms have a small number of electrons in their outer shell. When these atoms are close together these electrons become delocalised, meaning they can move throughout the metal. This creates a lattice of positively charged ions in a sea of delocalised electrons. The lattice is held together by electrostatic attraction.

Metallic bonding is the attraction between the positive ions in a regular lattice and the delocalised electrons.

Delocalised electrons are electrons which are free to move throughout the whole structure.

The bonding in a metal is shown:



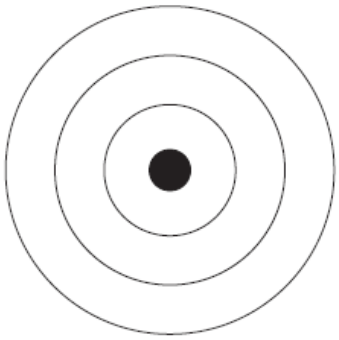
Revision Questions

1.

Sodium reacts with chlorine to form the compound sodium chloride.

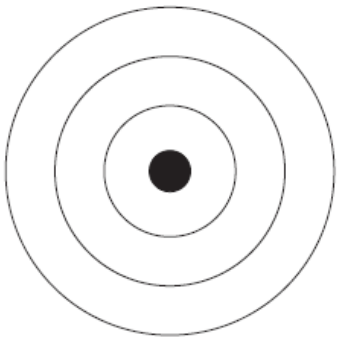
(a) Complete the diagrams below to show the arrangement of **all** of the electrons in a sodium atom and a chlorine atom.

(i) Sodium atom



[1]

(ii) Chlorine atom



[1]

In Part (b) you will be assessed on your written communication skills including the use of specialist science terms.

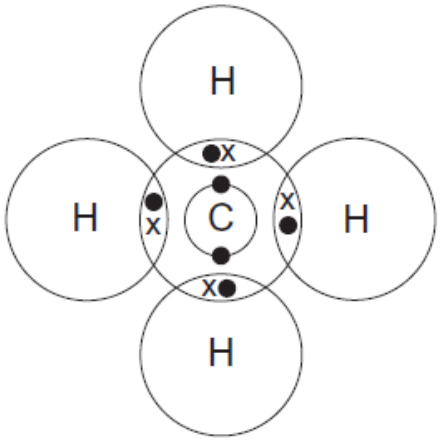
(b) Explain, using electronic structures, how sodium and chlorine bond to form the compound sodium chloride.

[6]

2.

Methane, water and nitrogen occur as molecules.

The diagram below shows the electrons in the atoms of carbon and hydrogen in a molecule of methane.



(a) **(i)** Draw a dot and cross diagram to show the **outer electrons** of the atoms in a molecule of water.

[3]

(ii) Label the **lone pairs** of electrons in **your** diagram. [1]

(b) Nitrogen is made up of **diatomic** molecules.

(i) What is meant by the term **diatomic**?

_____

_____ [1]

(ii) Draw a dot and cross diagram to show how the outer electrons are arranged in a molecule of nitrogen.

[3]

3. The formula for sodium oxide is Na_2O.

(a) Draw diagrams to show how two sodium ions and an oxide ion are formed when two sodium atoms react with an oxygen atom.

[4]

(b) Explain how the **ions** are held together in the compound, sodium oxide.

_____

_____

_____

_____ [2]