National 4/5 Chemistry

Unit 1c - Chemical Changes and Structure

Kirkcaldy High School

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Learning Outcomes

What happens when atoms swap electrons? ◯

What charges do ions have? ◯

What happens when ions get close together? ◯

How does forming an ion affect the electron arrangement? ◯

How can we write formulae for ionic compounds? ◯

How can we work out the charges for transition metal ions? ◯

How do we work out formulae for ions with more than one atom? ◯

How can we write the number of protons, neutrons and electrons for ions? ◯

What do chemical formulae mean? ◯

How can we find out if something conducts electricity? ◯

Which elements conduct electricity? ◯

Do covalent compounds conduct electricity? ◯

Do ionic compounds conduct electricity? ◯

Why do some elements and compounds conduct electricity? ◯

What happens when we pass electricity through a solution of copper chloride? ◯

What happens when we pass electricity through liquid lead iodide? ◯

Why are ionic compounds coloured? ◯

What happens when we pass electricity through a solution of copper chromate? ◯

Are ionic and covalent compounds solids, liquids or gases? ◯

In what ways is the bonding in ionic and covalent compounds different? ◯

Can we dissolve anything? ◯

Formation of ions (N4*)

Aim: What happens when atoms swap electrons?

n covalent bonding, atoms share electrons to reach the same stable electron arrangement as a noble gas. The formation of an ion is another way in which an atom can reach a stable electron arrangement.

Metal ions have a **positive charge**.

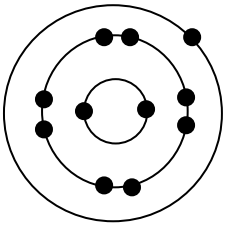
The sodium ion

The atomic number of sodium is 11. The electron arrangement is 2, 8, 1.

Looking at the atomic numbers, the nearest noble gas to sodium is neon with electron arrangement 2, 8.

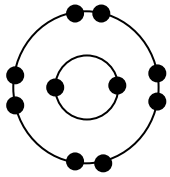
A sodium atom can reach this electron arrangement by losing one electron. Since an electron has one unit of negative charge, the charge left on the sodium ion will be one-positive.

The sodium ion is represented Na+ (there is no need to include the '1' before the +).



sodium atom
Na
2, 8, 1

sodium ion
Na^+
2, 8

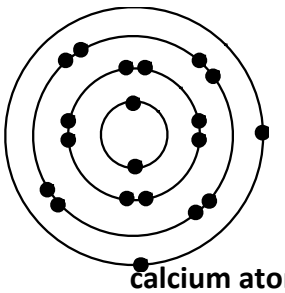


The calcium ion

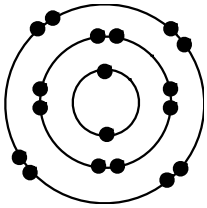
The atomic number of calcium is 20. The electron arrangement is 2, 8, 8, 2.

Looking at the atomic numbers, the nearest noble gas to calcium is argon with electron arrangement 2, 8, 8. A calcium atom can reach this electron arrangement by losing two electrons. Since an electron has one unit of negative charge, the charge left on the calcium ion will be two-positive.

The calcium ion is represented Ca^{2+}.



calcium atom
Ca
2, 8, 8, 2



calcium ion
Ca^{2+}
2, 8, 8

Non-metal ions have a **negative charge**.

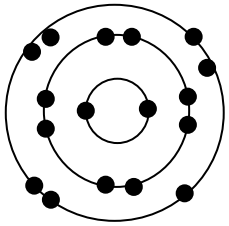
The chloride ion

The atomic number of chlorine is 17. The electron arrangement is 2, 8, 7.

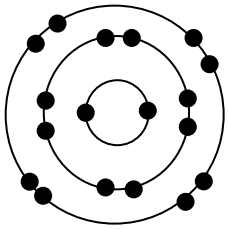
Looking at the atomic numbers, the nearest noble gas to chlorine is argon with electron arrangement 2, 8, 8.

A chlorine atom can reach this electron arrangement by gaining one electron. Since an electron has one unit of negative charge, the charge on the chloride ion will be one-negative.

The chloride ion is represented Cl^- (again, there is no need to include the '1' before the -).



chlorine atom
Cl
2, 8, 7



chloride ion
Cl^-
2, 8, 8

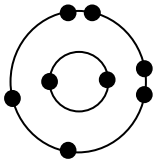
The oxide ion

The atomic number of oxygen is 8. The electron arrangement is 2, 6.

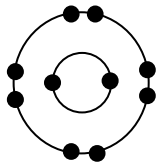
Looking at the atomic numbers, the nearest noble gas to oxygen is neon with electron arrangement 2, 8.

An oxygen atom can reach this electron arrangement by gaining two electrons. Since an electron has one unit of negative charge, the charge on the oxide ion will be two-negative.

The oxide ion is represented O^{2-}.



oxygen
atom
O



oxide ion
O^{2-}
2, 8

Complete the table to show the charge on each of the following ions.

Element	Charge on the ion
lithium	
nitrogen	
aluminium	
fluorine	

Element	Charge on the ion
sulphur	
iodine	
barium	
rubidium	

Formation of ions (N4*)

Aim: What charges do ions have?

A quick way to find the charge on an ion is to look at the group in the Periodic Table that the element is in.

Atoms of elements in the same group have the same number of outer electrons.

The charge on a metal ion is the same as the group that the element is in.

This is the same as the number of electrons that would need to be lost to form the stable electron arrangement of a noble gas.

The charge on a non-metal ion is found by subtracting the group number from 8.

This is the same as the number of electrons that would need to be gained to form the stable electron arrangement of a noble gas.

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
1 +ve	2 +ve	3 +ve		3 -ve	2 -ve	1 -ve

It is easier for atoms of elements in groups 1 to 3 to lose electrons to reach noble gas electron arrangements; this explains why atoms of metal elements do not form covalent bonds.

It is often said that positive ions 'want to' lose electrons and negative ions 'want to' gain electrons.
To what extent do you agree with this statement? Explain your thinking.

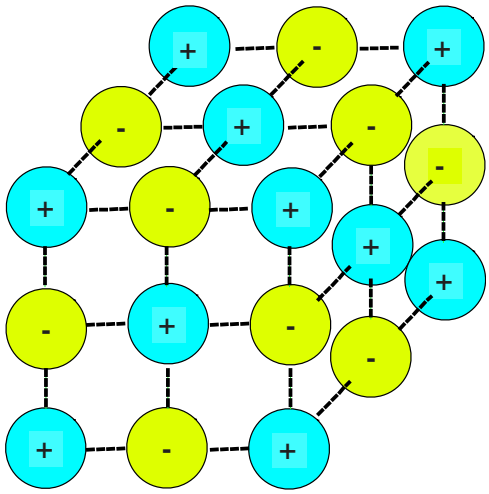
Ionic bonding (N4*)

Aim: What happens when ions get close together?

Some elements and compounds are made up of molecules; there is covalent bonding in these substances.

Other compounds are made of charged particles called **ions**; these compounds are called **ionic compounds**.

Ionic compounds contain both metal ions (positively charged) and non-metal ions (negatively charged). Positive ions attract negative ions. The forces of attraction across the oppositely charged ions are known as **ionic bonds** and keep the ions locked together.



The arrangement of ions in a solid is called a **crystal lattice**. The arrangement of ions in a crystal lattice goes on and on in all directions, *i.e.* the arrangement is three-dimensional.

Colour in the positive ions and negative ions using different colours.

What is meant by … an ion? … an ionic compound? … an ionic bond?

What is meant by a crystal lattice?

Writing formulae for ionic compounds - (i) Using outer electron shells (N4*)

Aim: How does forming an ion affect the electron arrangement?

Ions have the same electron arrangement as a noble gas. This is achieved by the transfer of electrons from metal atoms to non-metal atoms. Since electrons have a negative charge, metal atoms will be left with a positive charge and non-metal atoms will have gained a negative charge.

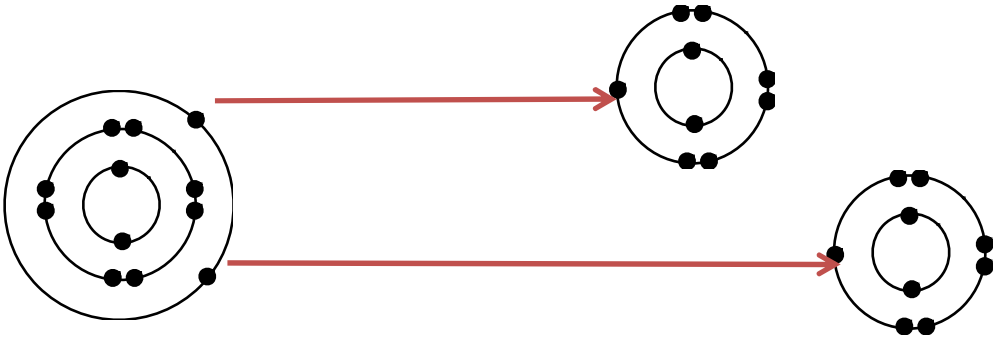
Example 1: lithium chloride

Li
electron arrangement 2, 1

Cl
electron arrangement 2, 8, 7

The transfer of one electron from the lithium atom to the chlorine atom gives the lithium ion the stable electron arrangement of helium and the chloride ion the stable electron arrangement of argon. The formula for lithium chloride is LiCl.

Example 2: magnesium fluoride



Mg
electron arrangement 2, 8, 2

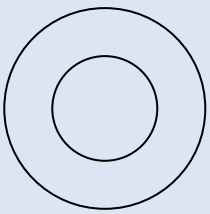
F
electron arrangement 2, 7

The transfer of one electron from the magnesium atom to the fluorine atom gives the fluoride ion the stable electron arrangement of neon. However, two fluorine atoms are required for the magnesium atom to transfer two electrons to give the stable electron arrangement of neon. The formula for magnesium fluoride is MgF_2.

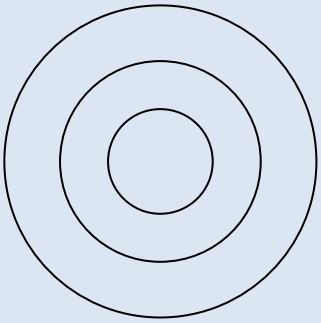
Draw diagrams to show the electron arrangement in the atoms that make up each of the following compounds.

By showing the transfer of electrons to form positive and negative ions, write the chemical formula.

lithium chloride



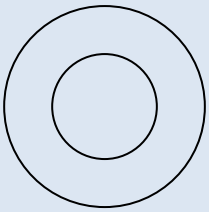
Li



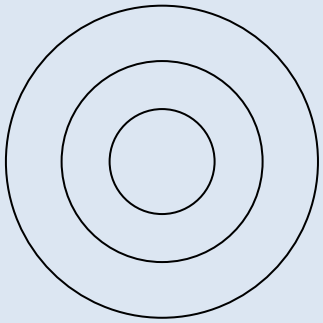
Cl

Formula = _____

potassium fluoride



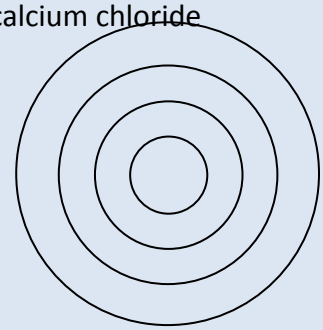
K



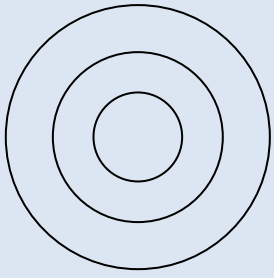
Cl

Formula = _____

calcium chloride



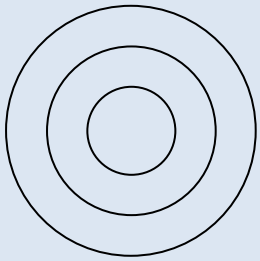
Ca



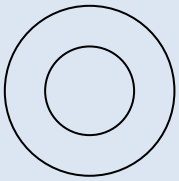
Cl

Formula = _____

magnesium nitride



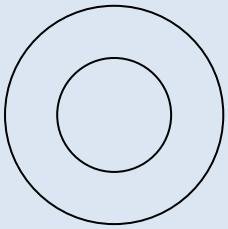
Mg



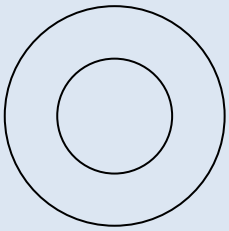
N

Formula = _____

lithium sulphide



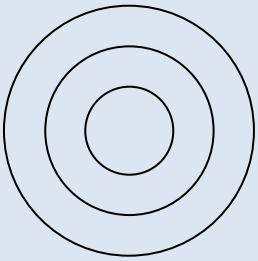
Li



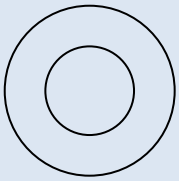
S

Formula = _____

magnesium oxide



Mg



O

Formula = _____

Writing formulae for ionic compounds - (ii) Simple ionic compounds (N4*)

Aim: How can we write formulae for ionic compounds?

The charge on many ions can be worked out from the electron arrangements on page … of the Data Booklet.

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
1 +ve	2 +ve	3 +ve		3 -ve	2 -ve	1 -ve

In an ionic compound, the charge on all positive ions must balance the charge on all negative ions.

Since the overall charge is neutral, the formula for an ionic compound can be worked out by finding the relative number of each ion required to make the overall charge zero.

Example 1: sodium chloride

positive ion negative ion

Na^+ Cl^-

formula Na^+Cl^- or NaCl

Example 2: potassium oxide

positive ion negative ion

K^+ O^{2-}

formula $(K^+)_2O^{2--}$ or K_2O

By balancing the charge on the positive and negative ions, write the chemical formula for each of the following compounds.

sodium chloride

Positive Ion	Negative Ion

Formula

potassium oxide

Positive Ion	Negative Ion

Formula

calcium sulphide

Positive Ion	Negative Ion

Formula

radium oxide

Positive Ion	Negative Ion

Formula

lithium iodide

Positive Ion	Negative Ion

Formula

magnesium bromide

Positive Ion	Negative Ion

Formula

rubidium oxide

Positive Ion	Negative Ion

Formula

strontium nitride

Positive Ion	Negative Ion

Formula

Writing formulae for ionic compounds - (iii) Elements that have variable charge (N5)

Aim: How can we work out the charges for transition metal ions?

Some metals have ions with more than one charge. In compounds of these metals the charge is shown in Roman numerals after the name of the metal element,

e.g. in copper(I) oxide the charge of the copper is one-positive (Cu^{+})

in iron(II) chloride the charge of the iron is two-positive (Fe^{2+})

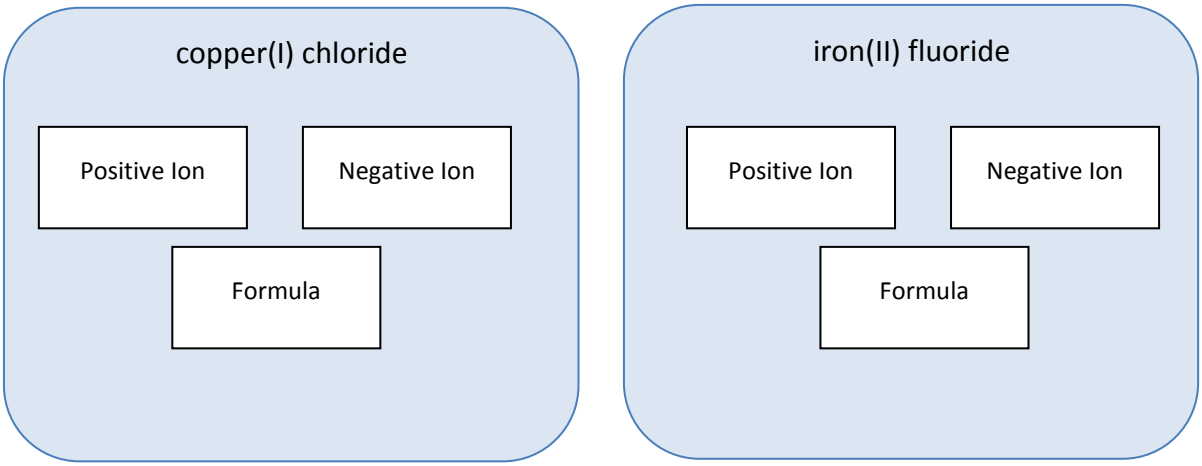
Example 1: copper(I) oxide

positive ion	negative ion
Cu^{+}	O^{2-}
formula	$(Cu^{+})_2O^{2-}$ or Cu_2O

Example 2: iron(II) chloride

positive ion	negative ion
Fe^{2+}	Cl^{-}
formula	$Fe^{2+}(Cl^{-})_2$ or $FeCl_2$

Write the chemical formula for each of the following compounds.



iron(III) oxide

Positive Ion | Negative Ion

Formula

copper(II) sulphide

Positive Ion | Negative Ion

Formula

nickel(II) bromide

Positive Ion | Negative Ion

Formula

cobalt(II) iodide

Positive Ion | Negative Ion

Formula

lead(IV) oxide

Positive Ion | Negative Ion

Formula

vanadium(V) oxide

Positive Ion | Negative Ion

Formula

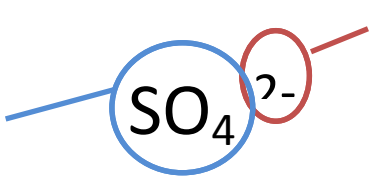
Writing formulae for ionic compounds - (iv) Compounds with group ions (N5)

Aim: How do we work out formulae for ions with more than one atom?

A number of ions consist of a group of atoms which tend to stay together during reactions. These are called **group ions**.

The charge is on the whole group and not on any particular atom,

e.g. the sulphate ion



the charge on the ion is 2 negative

formula for the ion

The formula for and charge of a group ion can be found on page … of the Data Booklet.

The presence of a group ion can usually be recognised from the -ate or -ite name ending which indicates the presence of oxygen.

The exceptions are the ammonium ion and the hydroxide ion.

Apart from the ammonium ion, which has a positive charge like the metal ions, all the group ions have a negative charge.

Example 1: sodium nitrate

positive ion	negative ion
Na^+	(NO_3^-)
formula	$Na^+(NO_3^-)$ or $Na^+NO_3^-$ $NaNO_3$

Always begin by putting the formula for the group ion in brackets. When the subscript numeral for the group is 1, as above, the brackets can be removed. When the subscript numeral for the group is greater than 1, brackets are essential.

Example 2: calcium nitrate

positive ion	negative ion
Ca^{2+}	(NO_3^-)
formula	$Ca^{2+}(NO_3^-)_2$ or $Ca(NO_3)_2$

The formula for calcium nitrate is $Ca^{2+}(NO_3^-)_2$ not $Ca^{2+}NO_3^-{}_2$.

The formula has one calcium ion for every two nitrate ions. This gives a total of one calcium atom, two nitrogen atoms and six oxygen atoms.

Write the chemical formula for each of the following compounds.

calcium carbonate

Positive Ion | Negative Ion

Formula

radium sulphate

Positive Ion | Negative Ion

Formula

potassium nitrate

Positive Ion | Negative Ion

Formula

copper(I) hydroxide

Positive Ion | Negative Ion

Formula

sodium sulphate

Positive Ion | Negative Ion

Formula

lithium phosphate

Positive Ion | Negative Ion

Formula

aluminium carbonate

Positive Ion | Negative Ion

Formula

ammonium carbonate

Positive Ion | Negative Ion

Formula

lead(II) nitrate

Positive Ion | Negative Ion

Formula

strontium hydroxide

Positive Ion | Negative Ion

Formula

lithium sulphite

Positive Ion | Negative Ion

Formula

ammonium bromide

Positive Ion | Negative Ion

Formula

magnesium hydroxide

Positive Ion | Negative Ion

Formula

ammonium sulphate

Positive Ion | Negative Ion

Formula

Nuclide notation – ions (N5)

Aim: How can we write the number of protons, neutrons and electrons for ions?

This atomic number and the mass number can be written with the symbol of the element in the following way.

Mass Number - 23
Atomic Number - 11 Na^{+}

The atomic number gives the number of protons in the ions of sodium. This is not always given … knowing the symbol of the element, the atomic number can be found from a Periodic Table.

The charge on the ion allows the number of electrons to be found.

The mass number gives the number of protons plus the number of neutrons in the ions of sodium.

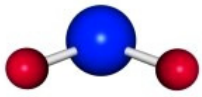
REFER TO A PERIODIC TABLE.
Complete the following table.

Element	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons
$^{35}_{17}Cl^{-}$					18
$^{18}_{8}O^{2-}$					
$^{27}_{13}Al^{3+}$					
	7	14			10
	19			20	18
	26	56			23
			3	4	2

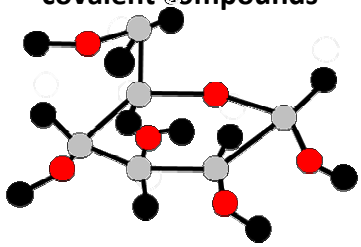
The significance of the formula (N4*)

Aim: What do chemical formulae mean?

Since small molecules consist of definite number of atoms held together by covalent bonds, the chemical formula for a covalent compound shows the actual number of atoms in each molecule,



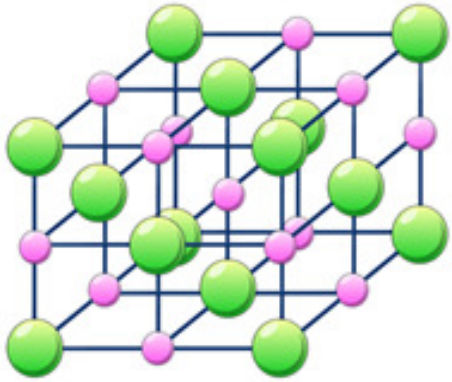
covalent compounds



e.g. H_2O shows **two** hydrogen atoms joined with one oxygen atom,

$C_6H_{12}O_6$ shows **six** carbon atoms, **twelve** hydrogen atoms and **six** oxygen atoms in a molecule.

On the other hand, because a large number of positive and negative ions are held together by ionic bonds to form a crystal lattice, the chemical formula for an ionic compound only indicates the relative number of ions present,



ionic compound

e.g. NaCl shows **equal** numbers Na+ and Cl- ions,

K_2S shows **twice** as many K^+ ions as S^{2-} ions,

Li_2CO_3 shows **twice** as many Li^+ ions as CO_3^{2-} ions

What information is given by the chemical formula C_2H_6O?

What information is given by the chemical formula MgF_2?

What information is given by the chemical formula $LiNO_3$?

What information is given by the chemical formula NH_4Cl?

Conduction of electricity (N4*)

Aim: How can we find out if something conducts electricity?

Electricity is a flow of charged particles. What happens when a substance is included as part of an electrical circuit gives information about the particles in the substance and the way they are held together.

The terminals through which the electrical current enters and leaves the substance under test are called the electrodes. These are usually made of graphite, a form of carbon that conducts electricity but is comparatively unreactive.

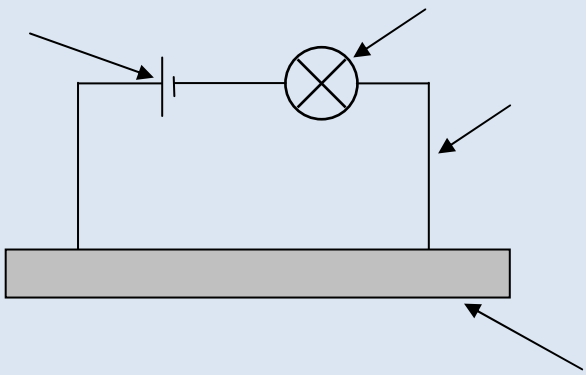
Elements and compounds that conduct electricity are conductors.

Elements and compounds that do not conduct electricity are non-conductors.

What is meant by … a conductor? … a non-conductor?

Why are the electrodes made of carbon?
What form of carbon is used?

Draw a labelled diagram to show how to test a substance to find out whether or not it conducts electricity.



Elements: conductors or non-conductors? (N4*)

Aim: Which elements conduct electricity?

Carry out activity 1.15

The elements in the Periodic Table can be divided into metals and non-metals.

Some non-metal elements are made up of atoms; others are made up of molecules,

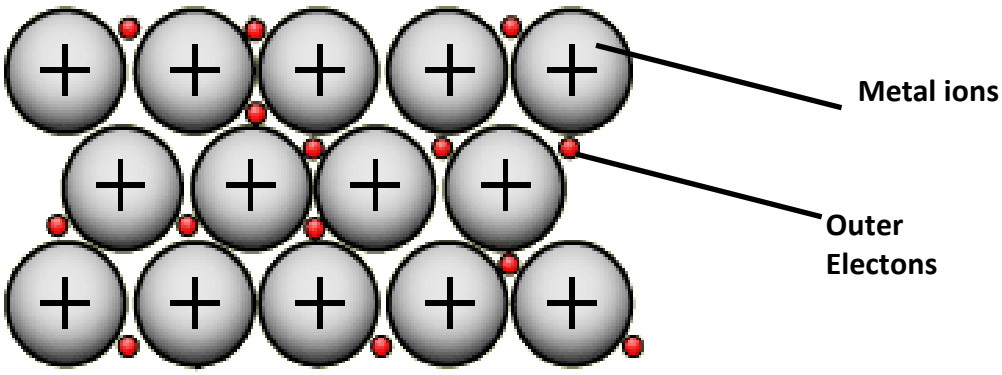
i.e. atoms held together by covalent bonds.

What kind of element conducts electricity?

What can be said about all the elements that do not conduct? Which element is the exception? (Think about the electrodes.)

Does mercury conduct electricity? Do metals in the liquid state conduct electricity?

Atoms are made up of a nucleus that contains positive particles. Negative particles called electrons move around outside the nucleus. In metals, the outer electrons are loosely held. The flow of electricity in metals is a flow of the loosely held electrons in a definite direction.



Which of the particles in an atom moves when a metal conducts?

Place each of the following elements in the correct column in the table below.

solid copper, liquid nitrogen, solid iodine, molten iron, molten magnesium, argon gas, liquid mercury, solid sodium, liquid bromine, chlorine gas

Conductor	**Non-conductor**

Covalent compounds: conductors or non-conductors? (N4*)

Aim: Do covalent compounds conduct electricity?

Carry out activity 1.16

Covalent compounds are (usually) made up of atoms of only non-metal elements.

Elements that are made up of molecules (covalent bonding) do not conduct electricity.

Do covalent compounds conduct electricity … when solid? … when liquid? in solution?

Covalent compounds are made up of molecules.

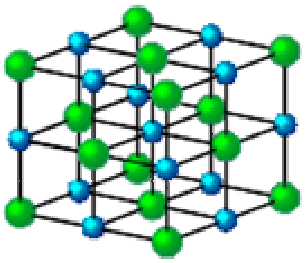
Molecules do not have an overall charge.

Ionic compounds: conductors or non-conductors? (N4*)

Aim: Do ionic compounds conduct electricity?

Carry out activity 1.17

Compounds that contain both a metal and a non-metal element are called **ionic compounds**.



Ionic compounds are made up of charged particles called ions.

In the solid, the forces of attraction keep the ions locked together.

Do ionic compounds conduct electricity … when solid? … when molten (liquid)? in solution?

Since ions in a solid are unable to move, the solids do not conduct electricity.

In a solution, the ions in the dissolved solid become free to move and so the solution conducts.

When an ionic solid is heated, the ions become free to move and so the melt also conducts.

Complete the following table.
Use a √ to show a conductor and an × to show a non-conductor.

Substance	In solid	In solution	As a liquid (melt)
Metal element		insoluble	
Covalent element or compound			
Ionic compound			

Place each of the following compounds in the correct column in the table below.

sodium sulphate solution, hexene (C_6H_{12}), solid magnesium chloride, molten sodium chloride, carbon tetrachloride, barium nitrate solution, solid silver bromide, selenium chloride, molten aluminium oxide, ethanol (C_2H_5OH)

Conductor	**Non-conductor**

Making use of electricity (N4*)

Aim: Why do some elements and compounds conduct electricity?

With an alternating current (a.c.) supply, the direction of the movement of electrons in the metal wires is always changing. With a direct current (d.c.) supply, the direction of the movement of electrons is always the same.

Compounds that are made up of ions do not conduct electricity when they are in the solid state. The ions are not free to move.

Ionic compounds conduct as a solution and when molten (liquid state). The ions are free to move.

The passage of electricity through a solution (or a melt) results in the movement of ions to the electrodes. This process is called **electrolysis**.

The solution (or melt) between the electrodes that does the conducting is called the **electrolyte**.

In order to keep the ions moving in the one direction, a d.c. supply is always used for electrolysis.

The electrode that is connected to the positive terminal of the supply is "positive" (+ve); the other is "negative" (-ve).

The electrodes attract oppositely-charged ions during electrolysis.

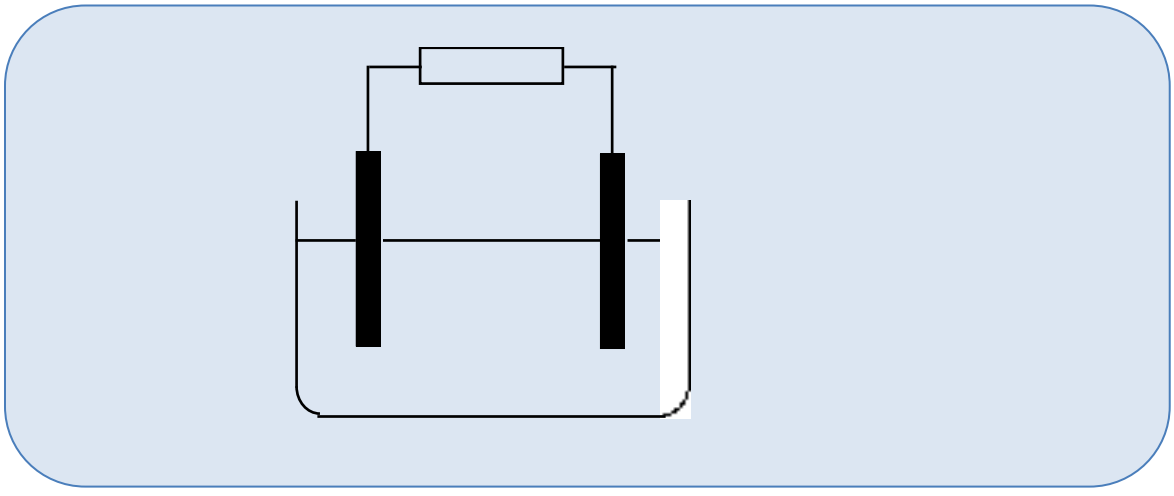
The electrodes are made of carbon, an element that conducts electricity but is comparatively unreactive.

Chemical reactions take place at the electrodes:

At the negative electrode, positive ions gain electrons to form atoms.

At the positive electrode, negative ions lose electrons to form atoms.

Label the diagram below: battery (d.c. supply), +ve electrode, -ve electrode, electrolyte. Add +ve and –ve ions to the electrolyte. Now add arrows to show the direction of movement of the ions and electrons.



What is meant by … electrolysis? … an electrolyte?

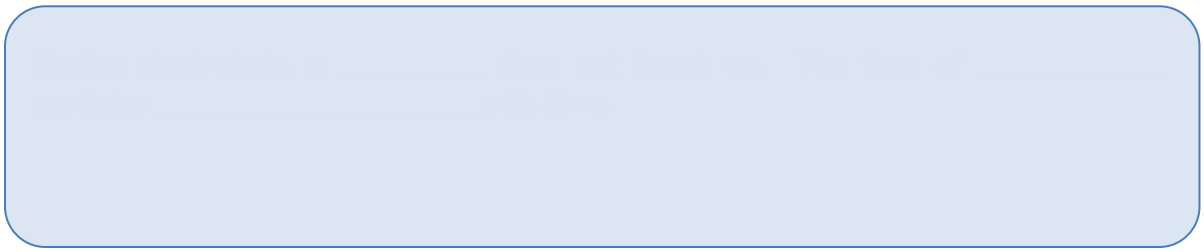
Why is a d.c. supply used for electrolysis?

"It conducts electricity" means different things for metals and for electrolytes. When electricity flows through a metal, what name is given to the charged particles that move?

When electricity flows through an electrolyte, what name is given to the charged particles that move?

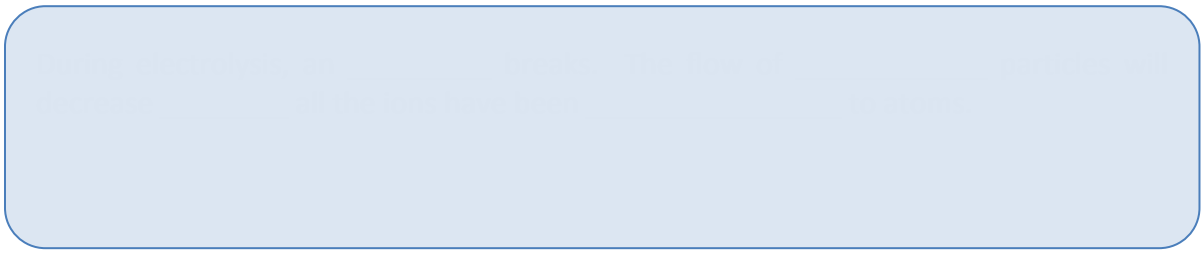
What do you think happens to a metal during electrolysis, i.e. does the metal break up?

What do you think happens to the flow of the charged particles (current) with time?



What do you think happens to an electrolyte during electrolysis, i.e. does the electrolyte break up?

What do you think happens to the flow of the charged particles (current) with time.

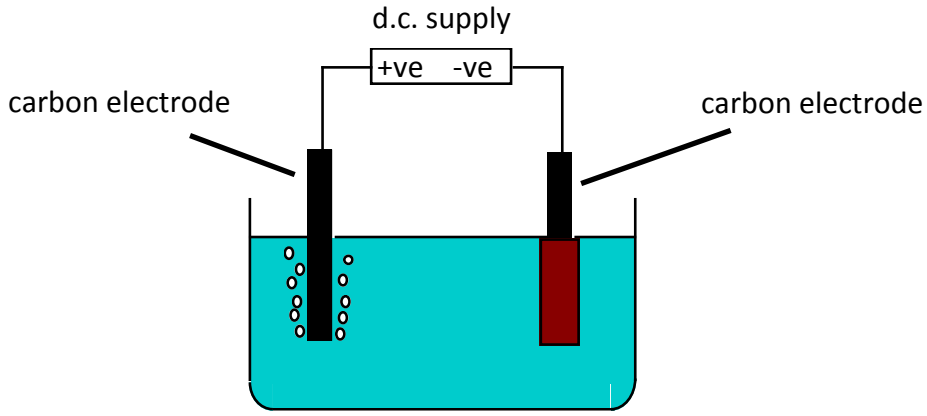


Electrolysis of copper chloride solution (N4*)

Aim: What happens when we pass electricity through a solution of copper chloride?

Carry out Activity 1.18

The process that involves breaking up of an ionic compound in solution (or as a melt) by the passage of electricity is called **electrolysis**. The compounds in the solution (or melt) break up as the ions separate out and new products formed.



What is seen at the negative electrode? Which element is formed?

What is seen at the positive electrode? Which element is formed?

The copper ion has a positive charge.

At the negative electrode, the reaction taking place is:

$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$

The chloride ion has a negative charge.

At the positive electrode, the reaction taking place is:

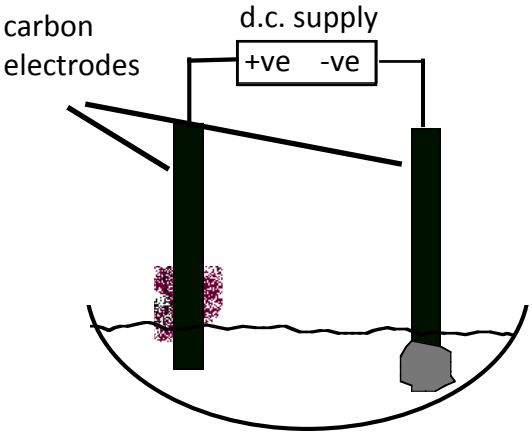
$2Cl^{-}(aq) \rightarrow Cl_2(aq) + 2e^{-}$

Electrolysis of lead iodide melt (liquid) (N4*)

Aim: What happens when we pass electricity through liquid lead iodide?

Activity 1.19

The lead iodide melt breaks up as the ions separate out and new products are formed.



At the negative electrode,

positive ions gain electrons to form atoms.

At the positive electrode,

negative ions lose electrons to form atoms.

What is seen at the negative electrode? Which element is formed?

What is seen at the positive electrode? Which element is formed?

The lead ion has a positive charge.

At the negative electrode, the reaction taking place is:

$Pb^{2+} + 2e^- \rightarrow Pb$

The iodide ion has a negative charge.

At the positive electrode, the reaction taking place is:

$2I^- \rightarrow I_2 + 2e^-$

Complete the table below to show the products at the positive and negative electrodes in the electrolysis of molten compounds.

Compound	Product at positive electrode	Product at negative electrode
iron chloride		
magnesium oxide		
copper iodide		
zinc sulphate		

Electricity can be used to obtain aluminium from molten aluminium oxide.

Why does the mixture need to be kept molten?

Why does aluminium form at the negative electrode?

Colours of compounds (N4*)

Aim: Why are ionic compounds coloured?

Carry out activity 1.19 Flame testing

Many ionic compounds are coloured. These compounds dissolve in water to give coloured solutions.

Some ions are colourless, *e.g.* Na^+ and Cl^-. In the solid form they appear white due to reflection of light from the crystals; in solution they are colourless.

Some ions are coloured, *e.g.* Cu^{2+}. For an ionic compound X^{+ve} Y^{-ve}, the colour of the compound is determined by the colour of X and Y.

Complete the following table.

Compound		**Positive ion**		**Negative ion**	
Name	**Colour**	**Name**	**Colour**	**Name**	**Colour**
sodium chloride	none	sodium	none	chloride	none
potassium sulphate	none				
sodium nitrate	none				
copper chloride	blue				
copper sulphate					
copper nitrate					
nickel nitrate	green				
nickel sulphate					
sodium dichromate	orange				
potassium dichromate					
potassium permanganate	purple				

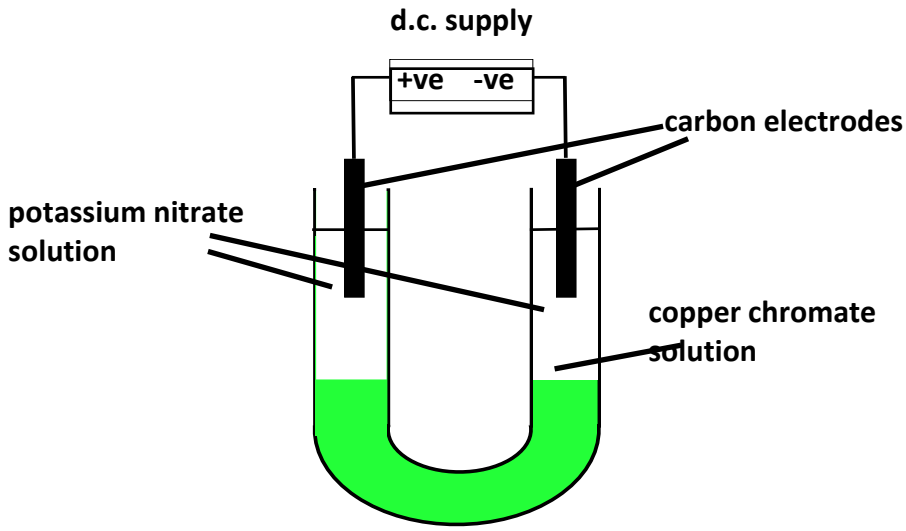
Ions are not usually the same colour as the atoms of the element, *e.g.* copper ions are blue but copper atoms are brown, bromide ions are colourless but bromine molecules are brown.

Electrolysis of copper chromate solution (N4*)

Aim: What happens when we pass electricity through a solution of copper chromate?

Carry out Activity 1.21

The combination of two coloured ions will give a coloured compound.



Copper ions are positive; they are blue in colour.

Chromate ions are negative; they are yellow in colour.

The colour of copper chromate solution is green, a 'blend' of the colour of the copper and chromate ions of the compound.

What colour is seen at the positive electrode? Why?

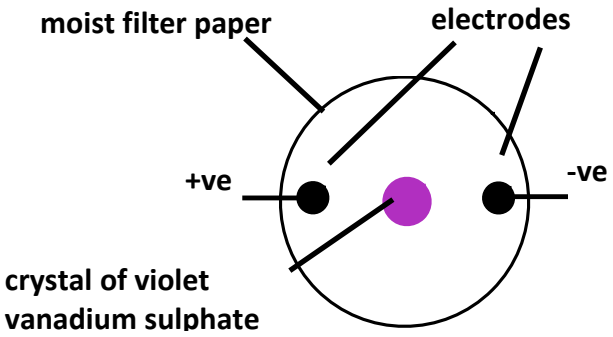
What colour is seen at the negative electrode? Why?

The positive copper ions are attracted to the negative electrode.

The negative chromate ions are attracted to the positive electrode.

Vanadium sulphate is violet and sodium sulphate is white.

A crystal of vanadium sulphate
was placed on moist filter paper.
A high voltage was applied.



What is the colour of the vanadium ion?

What will be observed when the current is switched on?

Potassium nitrate is white while nickel nitrate is green and potassium permanganate is purple.

What is the colour of the nickel ion? ……. the permanganate ion?

Explain what will be observed at each electrode in the electrolysis of nickel permanganate solution.

Solids, liquids and gases (N4*)

Aim: Are ionic and covalent compounds solids, liquids or gases?

The state of a compound at room temperature is an indication of the type of bonding in the compound.

Look at the compounds in the table below and complete the table to show the state of each at room temperature.

Compound	Type of bonding	Solid, liquid or gas
sodium chloride	ionic	
water (H_2O)	covalent	
methane (CH_4)	covalent	
calcium oxide	ionic	
paraffin wax ($C_{12}H_{52}$)	covalent	
carbon dioxide	covalent	
acetone (C_2H_6O)	covalent	
potassium iodide	ionic	
sugar ($C_{12}H_{22}O_{11}$)	covalent	

Are ionic compounds solid, liquid or gas at room temperature?

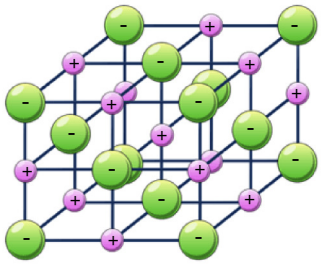
Compounds that are liquid and gas at room temperature have what kind of bonding?

What conclusion can be reached about the bonding in compounds that are solid at room temperature?

Differences in bonding (N5)

Aim: In what ways is the bonding in ionic and covalent compounds different?

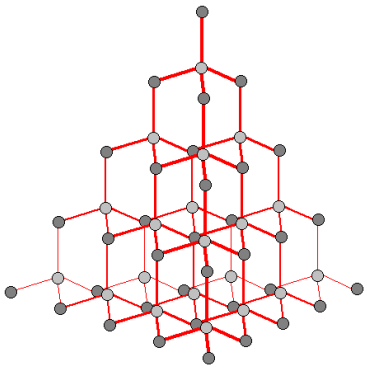
Ionic compounds *e.g.* sodium chloride



Ions in a crystal lattice are held together by strong forces of attraction across the oppositely charged ions in the crystal lattice.

A lot of energy is needed to separate the ions. This is the reason that ionic compounds are all solid at room temperature, *i.e.* melting and boiling points are above room temperature.

Covalent network substance, *e.g.* diamond



Atoms in a covalent network substance are held together by covalent bonds. Covalent bonds, like the forces of attraction between ions, are strong. A lot of energy is needed to break the covalent bonds and separate the atoms.

This is the reason that covalent network substances are all solid at room temperature.

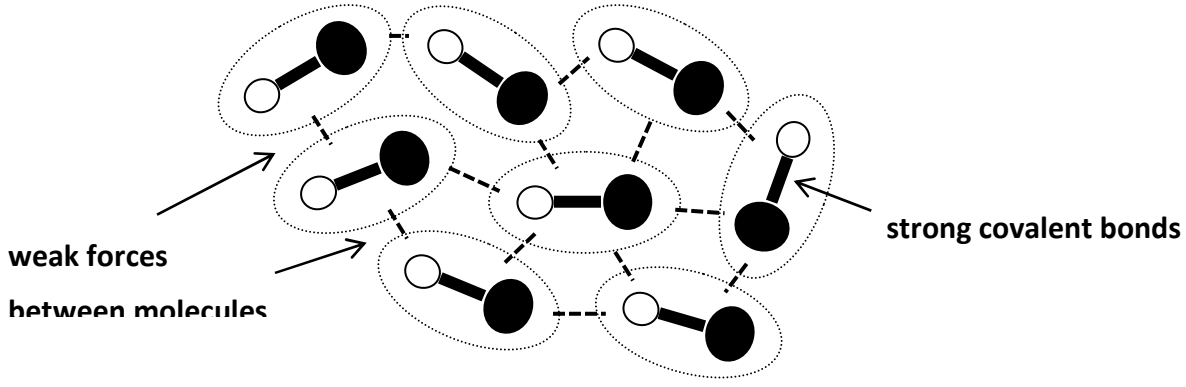
Covalent molecular substances

When a covalent molecular substance melts or boils, the heat energy makes the molecules move faster and further apart.

The forces of attraction holding together the different atoms in a covalent bond are strong and so a lot of energy is required to break the covalent bonds.

However, the forces of attraction holding different molecules together are weaker than covalent bonds and so less energy is required to separate the molecules.

This is the reason covalent molecular substances are often/usually liquids or gases at room temperature.



As molecular mass increases, the strength of the forces of attraction between different molecules increases. As a result, the energy required to separate the molecules increases.

This is the reason that covalent molecular substances with a high mass can be solid at room temperature.

The compounds P, Q, R and S all contain chlorine.

Chloride	**P**	**Q**	**R**	**S**
Boiling point /°C	1690	62	76	1412
Melting point /°C	1074	-63	-112	714

Which TWO of these chlorides have a molecular structure?

The table below shows the melting and boiling points of two oxides.

Compound	**Bonding**	**Melting point /°C**	**Boiling point /°C**
CaO	ionic	2614	2850
SO_2	covalent	-73	-10

The pupil wrongly concluded that ionic bonding is stronger than covalent bonding.

Why is the conclusion incorrect?

Compound X does not conduct electricity. It has a melting point of 1700 °C. State the type of bonding and structure that exist in compound X. Explain.

Titanium chloride, TiCl4, is a colourless liquid that boils at 132 °C. State the type of bonding and structure that exist in titanium chloride. Explain.

Explain why potassium chloride has a melting point of 730 °C but phosphorus trichloride has a melting point of -91 °C.

Explain why fluorine and chlorine are gases at room temperature and yet bromine is a liquid and iodine is a solid.

Solubility (N4*)

Aim: Can we dissolve anything?

Carry out Activity 1.22

A **solvent** is a liquid in which substances can dissolve. It is often useful to know whether or not a substance is soluble or insoluble in a particular solvent.

The most common solvent is water. Solids, liquids and gases are all soluble in water, *e.g.* salt (a solid), alcohol (a liquid) and carbon dioxide (a gas) all dissolve to form an **aqueous solution**.

Some substances, *e.g.* nail-polish, are insoluble in water. These substances are soluble in **non-aqueous solvents**, *e.g.* nail varnish can be removed by dissolving in acetone.

What is meant by a non-aqueous solvent?

What is the likely bonding in compounds that are soluble in water?

What is the likely bonding in compounds that are insoluble in water but dissolve in non-aqueous solvents?

Some paints are made from covalent substances. Stains caused by these paints cannot be removed by water … turpentine, a non-aqueous solvent, is used.

There are exceptions to the above 'guide', *e.g.* sugar, $C_{12}H_{22}O_{11}$, is a covalent compound and is soluble in water.

Place each of the following compounds in the correct column in the table below. sodium chloride, pentene (C_5H_{10}), potassium nitrate, lithium iodide,chloroform ($CHCl_3$), camphor ($C_{10}H_{16}O$)

Soluble in water	**Insoluble in water**