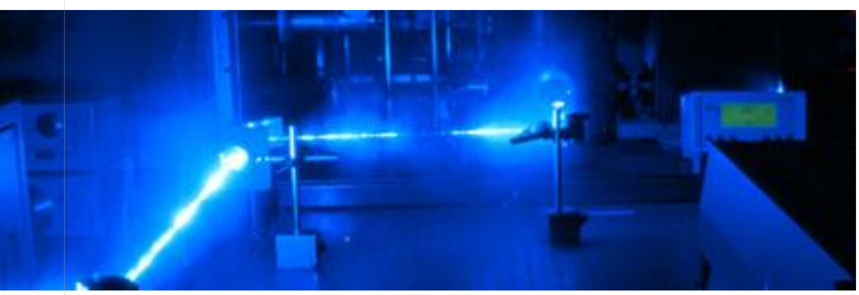
Chemical Reactions

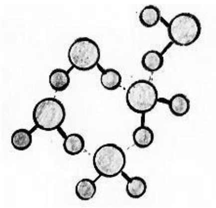
KC Notes

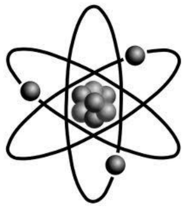
Year 9-10 Science

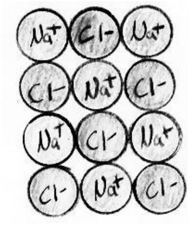


Contents

Atoms and Molecules

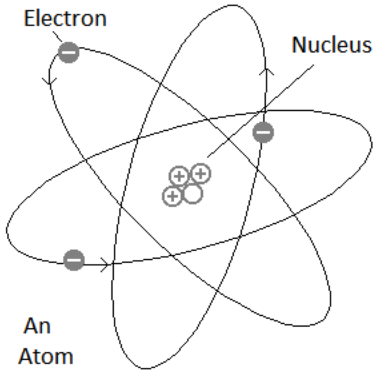






Chemistry is the study of chemicals. Chemicals are combinations of very basic elements, called atoms. They can be liquids, solids or gases. They can be mixed together or exist in a separate state.

Elements



All matter is made up of atoms. Atoms are made up of these three **subatomic** particles, protons, neutrons and electrons. The protons and neutrons are collectively called **nucleons**, because they join together to form **the nucleus** of an atom. The protons have **positive charge**, and the neutrons have **no charge**.

Around the outside, a large distance away, the much smaller particle, the electron, buzzes around. They have a negative charge and are bound to the positive nucleus.

Particle	Charge	Mass	Where it is found
Proton	Positive (+1)	Heavy	Nucleus
Neutron	Neutral (0)	Heavy	Nucleus
Electron	Negative (-1)	Light	Outside the nucleus

Atoms differ by having different number of protons. An atom is defined by the number of protons it has. The different types of atoms that exist are present in the periodic table, and are **elements**.

Just to clarify…

Molecules are two or more atoms joined together.

- Elements consist of one atom.
- Compounds consist of one molecule, or two or more atoms.
- A mixture is two or more compounds or element.

Atomic Number and Mass Number

The number of protons an atom has is called the **atomic number** of the element. For example, Lithium has 3 protons, therefore the atomic number is 3. An atom with the same amount of positive and negative charge means that the atom is **neutral**. However, in chemical reactions, electrons are constantly being borrowed or stolen from other atoms. This means that atoms won't always be neutrally charged, but often will have a charge. If they do, they are called **ions**.

The number of neutrons an atom has, increases as the atom gets bigger. Usually there are many more neutrons than protons. Atoms also can come with different numbers of neutrons: these represent different species of the atom, known as **isotopes**.

The decimal number underneath the symbol on periodic tables is called the **mass number**. It represents the *average* number of *neutrons* + *protons* an atom has as we find it on earth. Chlorine, for instance, has a mass number of 35.5. This tells you about half of the time it is 35 and the other half you find it as 36. It is measured in atomic mass units, or amu.

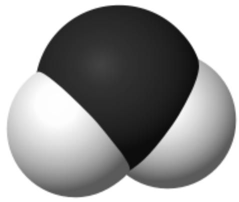
Molecules and Compounds

In chemical reactions, atoms join together to make things called molecules. A molecule is two or more atoms joined together.

Molecules have very different properties from the atoms that compose them. For example, water is made from two hydrogen atoms and one oxygen atom joined together. Hydrogen and oxygen are flammable, but water is not flammable and is a liquid.

Writing Molecular Formulas

We describe a molecule by writing down the number of each type of atom in the molecule. We always make the numbers that count the number of a type of molecule in subscript. For instance, H_2O has two hydrogen atoms and one oxygen atom in each molecule.



The 2 is a *subscript* telling us there are two hydrogen atoms in this molecule. We don't need to put the 1's in. So, one oxygen atom is just O, not O_1.

Numbers in front of a chemical formula tell you how many of this type of molecule are present in whatever you are doing.

$2H_2O$ → Two water molecules

$4O_2$ → Four oxygen gas molecules

If you have *an atom* with three nitrogen atoms and two aluminium atoms, **don't** write:

2Al3N

You must put the numbers underneath the symbols.

Al_2N_3

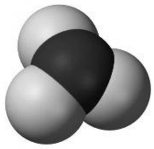
The place out the front of the number **is always reserved** for counting the number of molecules you have.

$5Al_2N_3$

This means 5 aluminium nitride molecules.

Which atom do you write first?

If we told you to write down the molecule you get when you join nitrogen and fluorine (1 N and 3 F's), how would you know which one to write first? Is it NF_3 or F_3N? Generally, you **write the metal** first, then the metal atom. This means, most left, most highest on the periodic table is first. Therefore, it is NF_3. This isn't always true though, especially where hydrogen is involved.



(NF_3)

Also, the last atom in the molecule has its ending changed by the addition of an –ide. Fluorine becomes fluoride, iodine becomes iodide, oxygen becomes oxide. So, the above molecule is nitrogen fluoride.

How do you know how many?

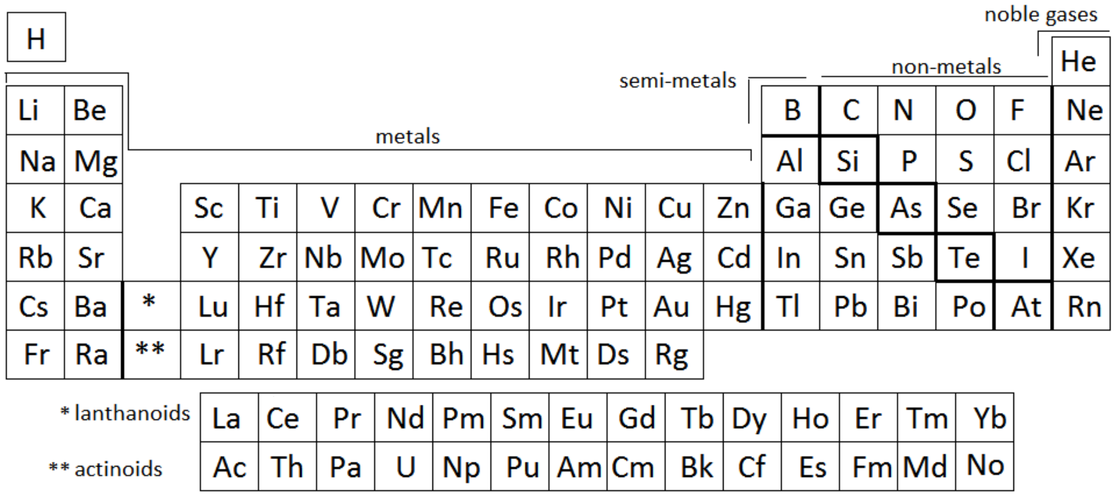
More information on how to write them properly will be later on.

Compounds

An amount of the same type of molecule is called a **compound**. Compounds are sometimes defined as any substance that can be broken down by heat. Under heat, molecules break down into their individual atoms. For the above compound, it will separate into nitrogen and fluorine.

Properties of Matter

The Periodic Table



The **metals** are all those elements to the left of the step. The **non-metals** are all those to the right. Note that there are many more metals than non-metals. B, Si, Ge, As and Te are technically **semi-metals**. They occur between the metals and non-metals. Here are the properties of metals and non-metals, in general.

Properties of Metals and Non-metals

Metals	Non-metals
• Good conductors of electricity and heat • Malleable - can be hammered into shapes • Ductile - can be drawn into wires • Lustre - metals are often shiny and bright • High melting and boiling points - solids	• Poor conductors of electricity and heat • Brittle - tend to break when bending them • Lustre - dull and powdery, variety of lustre • Low melting and boiling points: gases

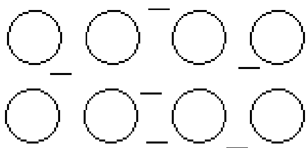
The Structure of Elements

Non-metals are generally composed of separate, individual molecules, usually containing two atoms **Metals** join together in large groups. Metal atoms join together because their electrons are usually not strongly held. **Semi-metals** tend to bond in a complex but symmetrical way, in a network structure.

Metals

Metallic network

Example: Sodium

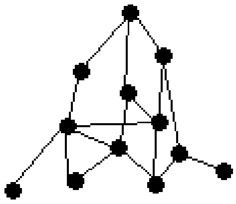


Electrons free to move through lattice

Semi-metals

Covalent network

Example: Silicon

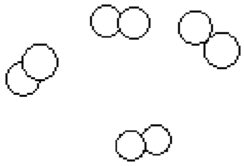


Each atom bonded to four others around it

Non-metals

Discrete molecules

Example: Chlorine



Composed of individual molecules

Acids, Bases and Salts



Acids

You've probably heard about acids before. They occur in many foods we eat: apples, lemons, vinegar, even milk. Almost always, we find them dissolved in water.

Acids are almost always composed of some hydrogen atoms and another part involving non-metals. For instance, hydrochloric acid, HCl, is hydrogen + chlorine.

Apart from knowing the chemical formula for an acid, acid solutions have the following main properties of identification.

Acids:
- have a sour taste
- change the colour of a dye called *litmus* from blue to red
- conduct electricity.

We then make a distinction between the properties of strong and weak acids.

Strong Acids are:
- Poisonous
- Burn the skin painfully
- Corrode metal

Weak Acids are:
- Not poisonous in small quantities
- Cause the sting of many insect bites
- Give fruits and drinks a pleasant taste

Some Common Acids

Acid	Form.	Common Name	Location/Usage
Strong			
Hydrochloric Acid	HCl	Spirit of salts	Found in human stomach
Nitric	HNO_3	Sprit of nitre	Used in the making of explosives and fertilisers
Sulphuric	H_2SO_4	Oil of vitriol	Found in car batteries
Weak			
Acetic	Vinegar		Used to pickle food, salad dressing
Carbonic	Food Acid		Added to soft drinks
Citric	Citrus		Found in lemons and oranges
Formic	Ant Sting		Causes the sting
Lactic	Milk Acid		Found in sour milk and tired muscles

Bases

We are less familiar with bases in our everyday lives. They turn up particularly in household cleaners. Like acids, we usually find them dissolved in water.

Bases are usually composed of a metal and a non-metal. Technically, a base is a substance that neutralises an acid.

Bases:

- have a bitter taste
- change the colour of a dye called *litmus* from red to blue
- have a soapy, slippery feeling

Strong Bases are:

- poisonous
- caustic to the skin
- destructive to clothing

Weak Bases are:

- not poisonous in small quantities
- used in antacid tablets to relieve upset stomachs
- sometimes used to relieve insect stings
- an ingredient in many cleaning agents because it dissolves grease and oil

Some Common Bases

Base	Common Name	Location/Usage
Strong		
Potassium hydroxide	Ly or potash	Used in industry
Sodium hydroxide	Soda lye or soda	Used to unclog drains
Weak		
Ammonia solution	Ammonia water	Household cleaner
Sodium carbonate	Washing soda	
Sodium tetraborate	Borax	
Calcium hydroxide	Lime water	A test for CO_2
Magnesium hydroxide	Milk of magnesia	Stomach antacid – indigestion tablets

Salts

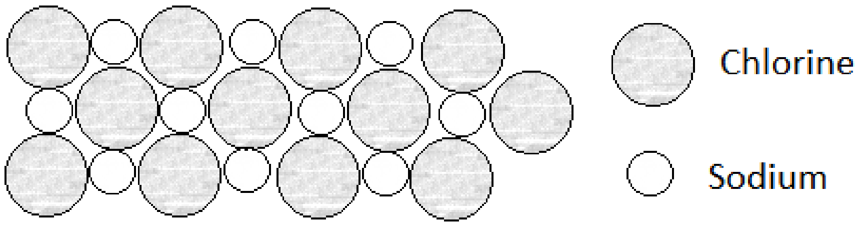
What we mean by 'salt' is much broader than just ordinary table salt. Table salt is just one type, NaCl. Salts are particular molecules formed when a metal bonds to a non-metal molecule. NaCl is a salt, because sodium is a metal, chlorine is a non-metal, and both are bonded together.

The proper definition of a salt is:

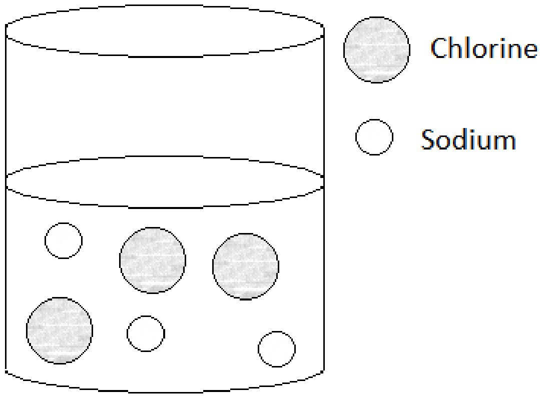
> A salt is a substance that forms when an acid solution and a base solution react.

Note that bases are often types of salts themselves, composed of a metal and non-metal part that can be formed in an acid-base reaction.

Salts form crystals. Salt molecules join together, when not dissolved, to form a large structure, called a crystal. For example, NaCl, sodium chloride, looks like this.



When stirred in water, however, the metal and non-metal parts are separated by the water molecules.



This also happens to acids and bases mixed into water too.

Neutralisation – Producing Salts

When we mix acid and base solutions together, the acid and base react. The hydrogen atoms of the acid join together with the non-metal part of the base to form a fluid, usually water. The other parts form a salt.

For instance, what would happen if we mix hydrochloric acid, HCl, and potassium hydroxide, KOH? The hydrogen atom from HCl joins with the OH from the KOH. But we know that H + OH gives you H_2O, water. The K and Cl also join to form a salt, potassium chloride.

$$\boxed{H}\boxed{Cl} + \boxed{K}\boxed{OH} \rightarrow KCl + H_2O$$

This type of reaction is called a neutralisation reaction, because, both the acid and base are reactive, but once the reaction has occurred the acid and base solutions have lost their acid and base properties. They have been neutralised.

Once dissolved, the oxygen and hydrogen seek each other out, and add to the water in the beaker. The salt remains dissolved, unless it is insoluble.

Indicators

To tell if a solution is acidic, basic or neutral, the scientist will often use an indicator. An indicator is a dye that is coloured differently in an acid from its colour in a base.

Litmus is an indicator that is blue in a basic solution and red in an acidic solution. It will not change colour when anything neutral is added. Litmus is actually made from certain lichens (types of plants).

Another indicator is **phenolphthalein**, which is pink in very basic solutions. It goes clear in *slightly basic* solutions, and remains that way in neutral and acid solutions. Another indicator, **methyl orange**, is yellow in basic, neutral and slightly acidic solutions. It goes salmon pink in more acidic solutions.

The mostly used indicator, **universal indicator**, goes through the rainbow, from red meaning acidic, green meaning neutral and purple meaning basic.

pH Scale

Scientists would become very confused if they spoke about solutions being 'very or slightly basic' or 'very or slightly acidic' all the time. To describe how acidic or basic a solution is, the scientists use a numbering scale, the pH scale.

Very Acidic			Slightly Acidic			Neutral		Slightly Basic				Very Basic	
1	2	3	4	5	6	7	8	9	10	11	12	13	14

Identifying the Presence of Oxygen, Carbon Dioxide and Hydrogen

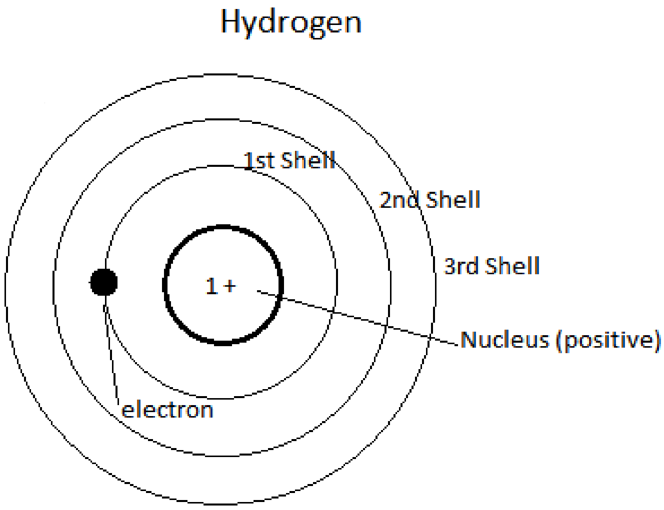
Oxygen is identified through a **glowing splint relighting**. Carbon Dioxide is identified through blowing against limewater, and seeing it becoming cloudy, and Hydrogen is identified by a popping sound in contact with a lighted taper.

Electron Shells and Ions

We have known something about what's inside an atom, earlier in the booklet (Atoms, Molecules and Compounds section). If we take out a magnifying glass, however, and watch the electrons closely, we will see that the electron behaves in certain patterns.

Electron Shells

It has long been known that electrons arrange themselves in patterns of orbits, called **shells**. You can think of a shell as a barrier, or a shield. An electron orbiting a nucleus can't orbit where it feels like, it must fit itself into one of these shells.



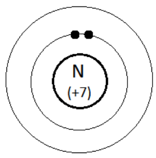
The way they work isn't too difficult to work out. Around any group of nuclei, there is a collection of shells into which electrons fit themselves.

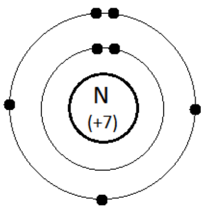
The closest shell to the nucleus, shell one, can carry up to **two electrons** before coming full. Once full, it becomes a shield that prevents any other electrons. Further electrons must fill up shell 2. Shell 2 and 3 can carry **up to 8 electrons**. The electrons are also attracted to the nucleus, so the inner circles must be filled up first.

After these three shells, things get more complicated, so for the meantime it is easiest to deal with elements up to 18 electrons in size.

So, how do these shells work? Let's look at the first nitrogen on the periodic table, 7^{th} in the list. Let's assemble it from scratch, but let's not worry about neutrons, they don't affect how shells form.

Nitrogen has 7 protons, meaning there are 7 electrons. We need to arrange them into shells. We first plot the first two electrons in. They immediately jump to the first shell, as they want to fill up the inner shell.





The next electron is locked out of the first shell and must be content with the second shell. The last four continue adding to the first shell.

The diagram on the right is the finished nitrogen atom.

Electron Rules

There are several rules of electrons.

Rule One

An element has always the same number of electrons as it has protons. This is simply because positive charge must balance negative charges.

Rule Two

Electrons form shells, or orbital paths, around the nucleus. The first shell can have no more than two electrons, the second and third, no more than eight. This rule comes from quantum physics. Think of a filled shell as a barrier preventing other electrons getting close to the nucleus.

Rule Three

Electrons always fill the lower shells first. This is simply a fact of forces. If there is a 'hole' in a shell, an electron will be pulled by the force between the positive nucleus and the electron into that hole. It wants to be as close as possible to the nucleus.

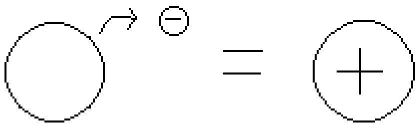
Rule Four

Electrons like to go in pairs. The first two electrons in every shell will form a pair. Electrons after the first pair will not form pairs, until there are at least 5 electrons in that shell. As I have done with the nitrogen atom, there is one pair at the top and three leftover electrons by themselves. If there were one more, to form oxygen, then it would pair up with one of the leftovers.

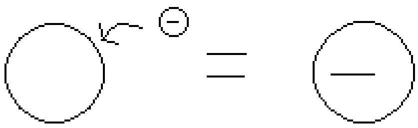
Ions

Ions are elements that have **too many or too few electrons**. Such particles no longer have balanced charge, because the number of electrons no longer balances the number of protons. They are **charged atoms**.

If you have a neutrally charged atom and you **remove an electron**, it becomes **positively charged**.



If you have a neutrally charged atom and you **add an electron**, it becomes **negatively charged**.

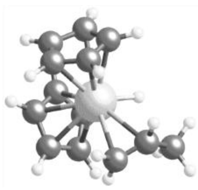
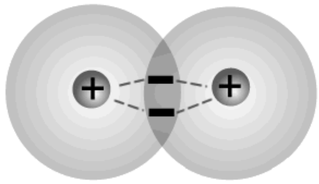
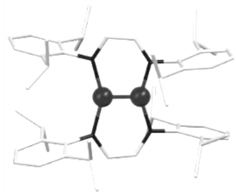


There is a special way of writing symbols if an atom is or has become an ion. We use superscripts.

If Sodium loses an electron, it becomes Na^+.
If Magnesium loses two electrons, it becomes Mg^{2+}.

Cations are positive ions, while **anions** are negative ions.

Chemical Bonds

If a mixture of substances produces new substances, a chemical reaction is said to be taken place. On the microscopic level, this means atoms and molecules are being broken apart and re-joined. Of course, we can't see this, but certain events will suggest to us that chemical reaction is occurring or has occurred. For instance,

- The production of a gas
- A colour change
- A temperature change
- A visible new substance, like a precipitate

Chemical reactions always produce new substances; this is how they are defined.

There are three principles we need to understand with how chemical reactions work.

i) Electrons with almost complete shells **attract** electrons.
ii) Electrons with almost empty outer shells **weakly hold** onto electrons.
iii) Atoms like to form **complete** outer electron shells.

In a chemical reaction, bonds form between atoms so that molecules are created. These bonds form simply because of the above principles. There are actually three types of bonds.

1. **Ionic** bonds, between metals and non-metals
2. **Covalent** bonds, between non-metals
3. **Metallic** bonds, between metals

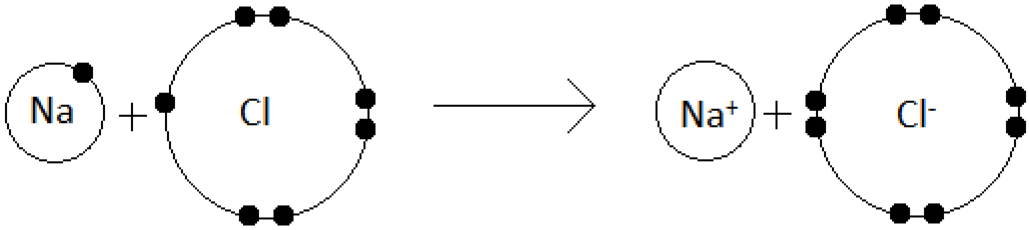
A general rule for these reactions is that atoms must be left **with a complete outer shell** after reaction. If not, then the reaction is generally not possible.

Ionic Bonds

Ionic bonds form between **metal and non-metals**. They occur **because metals only weakly hold** onto their electrons and **non-metals actually want more electrons**. A good example is table salt, NaCl. Sodium is a metal. Chlorine is a non-metal. How do they join?

Well, let's think about sodium to begin with. Sodium is on the **far left** of the periodic table and only has one outer-shell electron. This electron is **very weakly held**, and it would take 7 electrons to fill up the shell.

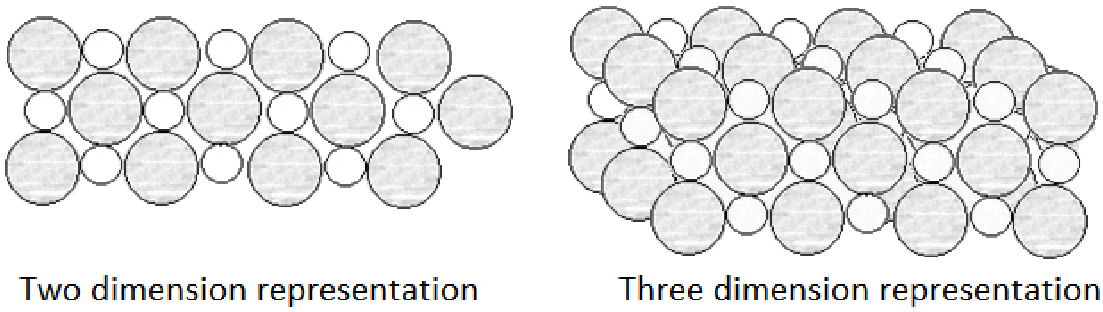
Chlorine, on the other hand, is **missing one electron** in its other shell. Just one. In fact, it desperately wants another one to complete its outer shell. So, you can most likely guess what happens.



When sodium and chlorine come close, chlorine will steal the outer electron of sodium. Now, they are ions that have joined together – Na has lost an electron and has become positive and Cl has gained an electron, becoming negatively charged. They are oppositely charged, which means they will stick together. Note that in both cases, the atoms are left with complete outer shells.

$Na + Cl \rightarrow Na^{+} + Cl^{-} \rightarrow NaCl$ is the equation. Congratulations, it's our first molecule!

Ionic bonds form what are called **crystal lattices**. Because of the positive and negative charges, we can join many of these atoms together to form a solid, which is made of layers of NaCl molecules.



A few more examples will help us get the hang of this.

Let's take a look at aluminium and oxygen. This is difficult, as aluminium has **three** outer shell electrons, and oxygen is missing two. It means that we can't just add single atoms together. If we take another 2 oxygen atoms, meaning there are six spaces missing, we can easily join **two aluminium** atoms with **three oxygen** atoms.

$Al + O \rightarrow Al^{3+} + O^{2-} \rightarrow (Al^{3+})_2 + (O^{2-})_3 \rightarrow Al_2O_3$

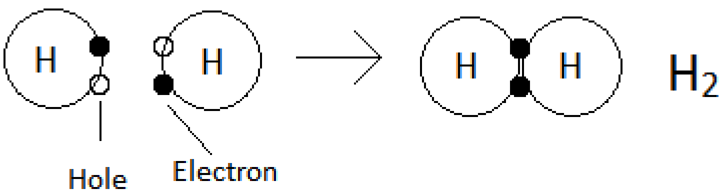
To make it clear, the third step is multiplying the aluminium by two and the oxygen by three. We would write this properly as:

$2Al + 3O \rightarrow Al_2O_3$ You might also have noticed we always write the metal first in any ionic bond.

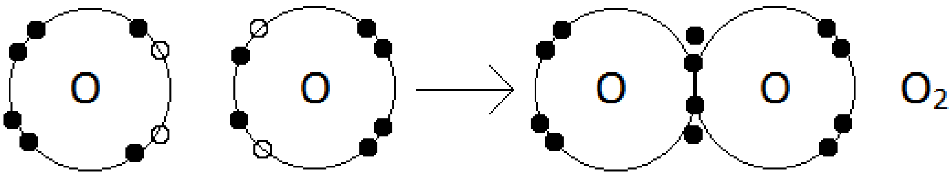
Covalent Bonds

Covalent bonds only occur between **non-metals**. They are, in many ways, more important than ionic bonds. But, how do they occur? It is very hard to remove electrons from non-metals, and they try to steal other electrons. Covalent bonding doesn't occur because electrons are *stolen*. Rather, it occurs when **atoms share electrons** to complete each other's shells.

Let's take the absolutely simplest case of two hydrogen atoms. Both are **missing one electron**, and need one to complete their outer shells. So, they share their electrons with each other, so both end up with complete shells.



Similarly, if we join two oxygen atoms, we can use covalent bonds. This time, we have to share **two pairs** of electrons.



We can represent what is happening by drawing lines from each atom to its neighbour.

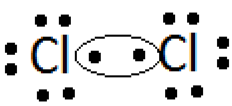
$$H - H \qquad O = O$$

Electron Dot Diagrams

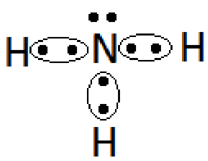
Electron dot diagrams are useful to see whether a covalent bond can take place. You put dots around the chemical symbol to represent the number of electrons in the outer shell. **These diagrams only work between the first 18 elements.** Simply place electrons at each of the four sides of the symbol.

Here are some examples to get the feel of the process. When doing a diagram, you should try to make it symmetrical where possible. Try not to overlap the connections.

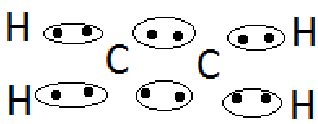
Cl + Cl → Cl_2



N + 3H →/NH_3 (Ammonia)

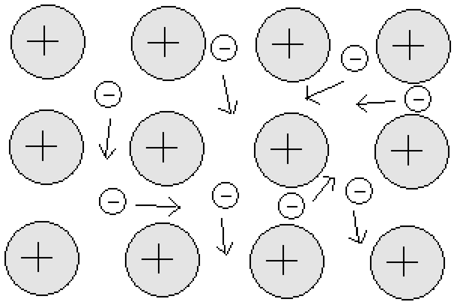


C_2H_4 (Ethane)



Metallic Bonding

Metals can join together to form metallic solids. Metals generally have relatively empty outer shells, meaning **a lot of loose electrons**. These loose electrons can be used to hold the nuclei in place. However, it isn't generally focused much in earlier years.



Writing Chemical Formulas

Valence

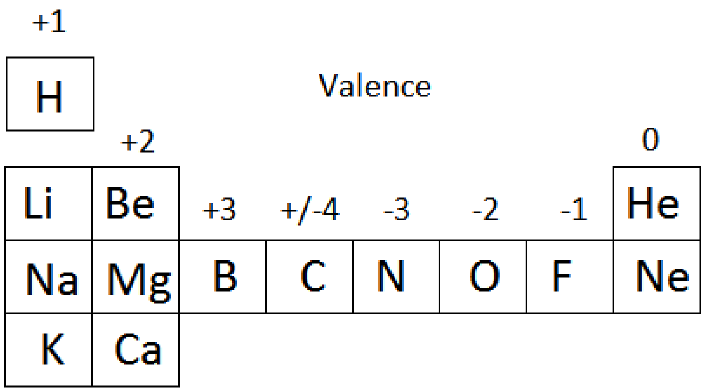
The valence of an element is another word for the amount of electrons an element can lose or gain to achieve a stable number (usually 8) in its outer shell.

We can signify loss with a + sign and gain with a – sign, to indicate the charges the atoms take on when they lose or gain these electrons.

For example, the valence of:
a) Oxygen, is 2-
b) Lithium, is 1+
c) Carbon, is 4- (The element is a non-metal, meaning it needs to gain electrons)

Metals lose electrons and non-metals gain electrons to be stable.

You might have noticed this through the booklet that you can see there is a slight pattern to the valency of elements. You may have noticed that the periodic table is useful in finding the valency of certain elements.



Anything under each group (column downwards) has different valences. For example, K, potassium, has a valence of +1, while Fluorine has a valence of -1.

Polyatomic Ions

Polyatomic ions, also known as radicals, are **charged groups of atoms**. They can represent a normal ion, but it is grouped. This means that brackets must be placed around the group of atom symbols to emphasise that the whole group has a charge. This is especially required when you need more than one polyatomic ion.

Here are some important polyatomic ions that should be memorised. Remember, they are charged, so you will need to memorise their charges too. Note that ammonium is the only positively charged polyatomic ion.

Formula	**Charge**	**Name**	**Formula**	**Charge**	**Name**
CO_3^{2-}	2-	Carbonate	SO_4^{2-}	2-	Sulphate
OH^-	1-	Hydroxide	PO_4^{3-}	3-	Phosphate
NO_3^-	1-	Nitrate	NH_4^+	1+	Ammonium

Naming Ionic Compounds

Ionic compounds always have **two-part names**. The name of the positive ion, the metal, goes first. The positive ion has the same name as its atom. For example, in NaCl, the first part is 'sodium'. The name of the negative ion comes second, but the ending is changed to 'ide'. In NaCl, this is 'chloride'. Thus, NaCl would be called 'sodium chloride'.

Naming Covalent Compounds

To name covalent compounds, the name of the non-metal with the lowest electron affinity[1] comes first, and then the ending of the name of the second non-metal is changed to 'ide'. Prefixes are added to indicate the number of atoms of each non-metal. For example, in CO_2, the first non-metal is 'carbon', and the second is 'oxygen', but changed to 'di-oxide'. Thus, CO_2 is 'carbon dioxide'.

Atom Number	1	2	3	4	5	6	7	8	9
Prefix	mono	di	tri	tetra	penta	hexa	hepta	octa	nona

Some More Examples

Ionic Compounds

$CaCO_3$	Calcium Carbonate
KCl	Potassium Chloride
$FeSO_4$	Iron Sulphate
LiBr	Lithium Bromide

Covalent Compounds

N_2O_5	Dinitrogen pentaoxide
PCl_3	Phosphate tetrachloride
SiO_2	Silicon dioxide
KBr_3	Potassium tribromide

[1] Electron Affinity is the energy released when an electron is added to an atom. The higher, and more left an element is, the lower the electron affinity.

Balancing Chemical Equations

When chemists do experiments to see how chemicals react, they may be able to work out the products of the reaction precisely, but that still leaves them to determine one thing:

In what ratio do the reactants react, and in what ratio do they come out?

The ratio between each substance is important, as we want the reaction to work 100% efficiently and not have anything left over. You can then go to the measuring cylinders and make sure you measure your substances in the correct ratio. If you don't, then there will be extra substances left over, and this may slow the reaction down and make the product messy.

When we balance equations, we work out what these ratios need to be by looking at the reaction formula and from knowing the same atoms that go in must be the same that come out.

Step One – Observe the reaction

The compounds mixed together in a reaction are called **reactants**, and the compounds that emerge from the reaction are called **products**.

$$2Li \quad + \quad 2H_2O \rightarrow 2LiOH \quad + \quad H_2$$

Reactants Products

In this step, you watch the reaction to see what happens, noting down the reactants and the products. This can be helped through knowing some of the different types of reactions possible, which will be outlined later.

Step Two – Write the correct formulae for reactants and products

In this step, write down the formula in words and then translate it into chemical symbols.

For example, when magnesium is exposed to oxygen, it burns into magnesium oxide. We can write the unbalanced reaction like this.

$Mg_{(s)} + O_{2\ (g)} \rightarrow MgO_{(s)}$

There are some important things to note:

- We need to write, next to each chemical symbol, what state of matter the compound takes. (s) is used for solid, (g) for gas, (l) for liquid and (aq) for aqueous, suspended/dissolved in water.
- When non-metals occur as a gas they don't appear as single atoms, rather they bind together with others of their kind. Nevertheless, we still refer to them confusingly by their element names.

Hydrogen appears as H_2, not H.
Oxygen appears as O_2, not O.
Nitrogen appears as N_2.
Iodine appears as I_2.
Phosphorous appears as P_4.
Sulphur appears as S_8.

Step Three – Balance the Equation

The basic principle of this step is that:

The same number of each atom that went into a reaction must come out.

This is one of the most important laws in chemistry. This is known as the conservation of mass, where in a chemical reaction, no individual atom is ever created or destroyed. This means, left must equal right.

$Mg + O_2 \rightarrow MgO$	Here is our previous, unbalanced equation. By counting the magnesium and oxygen, you notice that there's two oxygen atoms on the left, while there's only one on the right. **If there's not enough, add one more.**
$Mg + O_2 \rightarrow 2MgO$	We've added one more magnesium oxide on the right, *because we didn't have enough oxygen atoms*. Remember, we've doubled the **whole molecule**, not just magnesium. Now, we count. We're missing a magnesium atom on the left side! **If there's not enough, add one more.**
$2Mg + O_2 \rightarrow 2MgO$	We've added a 2 in front of magnesium on the left. When we count, we see: LHS: 2 magnesium atoms, 2 oxygen atoms RHS: 2 magnesium atoms, 2 oxygen atoms
$2Mg_{(s)} + O_{2\,(g)} \rightarrow 2MgO_{(s)}$	Now, just remember to place in the states. Magnesium and its oxide are solids, while oxygen is a gas.

We've balanced the equation! Let's have another example, a harder one, and start from step one.

Question:	Magnesium metal reacts with hydrochloric acid (hydrogen and chlorine) to produce hydrogen gas and magnesium chloride.	
Step Two	$Mg + \ldots$	We need to write up the equation in word form first. Magnesium metal is simply Mg, while hydrochloric acid is composed of hydrogen and chloride.
	$Mg + HCl \rightarrow \ldots$	We need to look at the valence of both H and Cl, to see if they join normally. H is +1, Cl is -1. They go well together! HCl is our second reactant. We go on to our products…
	$Mg + HCl \rightarrow H_2 + \ldots$	Hydrogen is our first product. Remember, it likes to appear as H_2, not just H.
	$Mg + HCl \rightarrow H_2 + MgCl_2$	Lastly, we have magnesium chloride. Magnesium has a valence of +2, while chlorine only has a valence of -1. This means, we need to double our chlorine! Our magnesium chloride is $MgCl_2$.
Step Three	$Mg + 2HCl \rightarrow H_2 + MgCl_2$	Time to balance! We already know there's two things unbalanced – the hydrogen and the chlorine. We can start with the hydrogen – we haven't got enough so **we add one more** of the molecule.
	$Mg + 2HCl \rightarrow H_2 + MgCl_2$	Now, the hydrogen's balanced. Chlorine became balanced too, while we were balancing hydrogen. But, we're not complete yet…
	$Mg_{(s)} + 2HCl_{(aq)} \rightarrow H_{2\,(g)} + MgCl_{2\,(s)}$	Write down the states! HCl is aqueous, and is dissolved in water.

Some Common Mistakes

You only ever put numbers before the molecules or atoms, never underneath them or between them, when balancing the equation. If you need one more Hydrogen atom on the right side of the above equation, you can't write H_2Cl, because it changes the type of the molecule! You can only double molecules – 2HCl is correct!

Types of Chemical Reactions

The next step, after knowing how to balance equations, is to learn what the common types of chemical reactions that can occur are. These reactions require energy. There are seven main reactions that we need to recognise.

1. Combustion
2. Corrosion
3. Precipitation
4. Neutralisation
5. Acids on metals
6. Acids on carbonates
7. Decomposition

We've already seen neutralisation on page 9, with the production of KCl.

Oxidation

Oxidation reactions are reactions where a substance combines with oxygen gas. Some create problems, others are useful. The first is a fast reaction, called **combustion**. Oxygen does not burn, but it allows other things to burn in it. Other elements, however, burn slowly, and undergo what is called **corrosion**. Lastly, living things use oxygen in **respiration** reactions.

Combustion

The reaction of a substance with air, at high temperatures, is called combustion. Atoms of the element being burned join up with oxygen atoms, and the burned substance is called a **fuel.** Combustion can easily be summarised by this formula:

$$Fuel + Oxygen \rightarrow Carbon\ dioxide + Water$$

For example, when methane burns in oxygen, this is what happens: $\mathbf{CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O}$. The carbon from methane joins up with an oxygen atom to produce carbon dioxide, while the hydrogen and more oxygen join to make water.

Corrosion

Corrosion is the result of metals reacting with air, water or other substances in their surroundings. The metals that react are not very reactive, so this process is generally slow. Again, this is from contact with oxygen.

$$Metal + Oxygen \rightarrow Metal\ Oxide$$

Copper, for example, can become coated with a greenish compound. $\mathbf{2Cu + O_2 \rightarrow 2CuO}$. Copper oxide is released.

Respiration

Living things use oxidation to break down food substances. In cells, oxygen from the air combine with the carbon and hydrogen from our food to release energy. For example, glucose reacts with oxygen.

$$Glucose + Oxygen \rightarrow Carbon\ Dioxide + Water$$

This can be written out as $\mathbf{C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O}$.

Reactions with Acids, Bases and Salts

Precipitation

Precipitation occurs when two soluble salt solutions are mixed and a new combination of metal and non-metal is produced, where one is insoluble.

$$Soluble\ salt + Soluble\ salt \rightarrow Insoluble\ salt + Soluble\ salt$$

For example, if we mix copper sulphate with sodium hydroxide, they react together to form copper hydroxide and sodium sulphate, where copper hydroxide is insoluble.

Neutralisation

The neutralisation reaction involves making the reactants neutral.

$$Acid + Base \rightarrow Salt + Water$$

Acid on Metals and Carbonates

Acid on Metal/Metal Oxide

Many metals react with acids, which also *neutralises* them. These metals join with the non-metal part of the acid. The hydrogen is let off as a gas.

$$Metal + Acid \rightarrow Salt + Hydrogen$$

For example, if you place zinc into sulphuric acid, it will bubble and release hydrogen gas.

If the metal is in the oxide form, then the oxygen joins in with the hydrogen to form water.

$$Metal\ Oxide + Acid \rightarrow Salt + Water$$

Acid on Carbonate

Carbonates are molecules containing CO_3. For example, calcium carbonate is $CaCO_3$. A carbonate fizzes (effervesces; releases a gas) when it reacts with an acid. The gas produced is CO_2.

$$Carbonate + Acid \rightarrow Salt + Water + Carbon\ Dioxide$$

Decomposition

This occurs when a compound is broken down into its separate elements. We can do this through heat or electricity.

$$Molecule \rightarrow Molecule\ part + Molecule\ part$$

Water can be broken down by passing electricity through it: $H_2O \rightarrow H_2 + O$