4th Form Chemistry 2017/18

Solubility

Chemical compounds vary in their solubility. Some compounds dissolve in water and can form solutions: these compounds are soluble. Other compounds are insoluble, they do not form solutions and so can never have the (aq) sign.

Luck does not work on solubilities! Solubilities need to be learnt.

There are a series of rules:

1. All nitrates (NO_3) are soluble
2. All ammonium (NH_4) compounds are soluble.
3. All group I compounds (Li, Na, K, Rb and Cs) are soluble.

ALWAYS

4. Most carbonates (CO_3) are insoluble
5. Most oxides (O) are insoluble
6. Most hydroxides (OH) are insoluble *except Barium Hydroxide (BaOH)*

EXCEPT PREVIOUS RULES

7. Most sulfates (SO_4) are soluble *except Ag_2SO_4 $BaSO_4$ $PbSO_4$*
8. Most Group VII compounds (F, Cl, Br, I, and At) are soluble *except those containing Ag or Pb*

Solubility Curves

Soluble substances dissolve in water

A <u>saturated</u> solution is one which cannot dissolve any more substance. By looking at the mass of a solid that is dissolved in a saturated solution at different temperatures, we can draw a graph.

Precipitation Reactions

A precipitation reaction is one in which a solid product is formed from two soluble reactants. On example is to produce $PbI_{2\,(s)}$

$$Pb(NO_3)_{2\,(aq)} + 2KI_{(aq)} \rightarrow PbI_{2\,(s)} + 2KNO_{3\,(aq)}$$

This is the precipitate

Isotopes

Isotopes are atoms of the same element with different numbers of neutrons. They have the <u>same</u> atomic number, however, they have different <u>mass numbers</u>. Most elements have isotopes, the most famous being chlorine, which has two isotopes.

	$^{35}_{17}Cl$	$^{37}_{17}Cl$
Protons	17	17
Neutrons	18	20
Electrons	17	17

Calculating relative atomic mass

Most periodic tables don't have a mass number; instead, they have the relative atomic mass, which is calculated from the masses of the different isotopes and their **abundances.**

- **75%** of Chlorine is ^{35}Cl
- **25%** of Chlorine is ^{37}Cl

RAM (Relative Atomic Mass) of Cl

$$= (\frac{75}{100} \times 35) + (\frac{25}{100} \times 37)$$
$$= 26.25 + 9.25$$
$$= 35.5$$

Another example: **RAM** of Sb

- **57%** of antimony is ^{121}Sb
- **43%** of antimony is ^{123}Sb

$$= (\frac{57}{100} \times 121) + (\frac{43}{100} \times 123)$$
$$= 121.86$$

Combustion

Combustion means burning or exploding. A substance reacts with oxygen, releasing energy (light+heat). For example, magnesium, which burns very well in oxygen with a bright white flame.

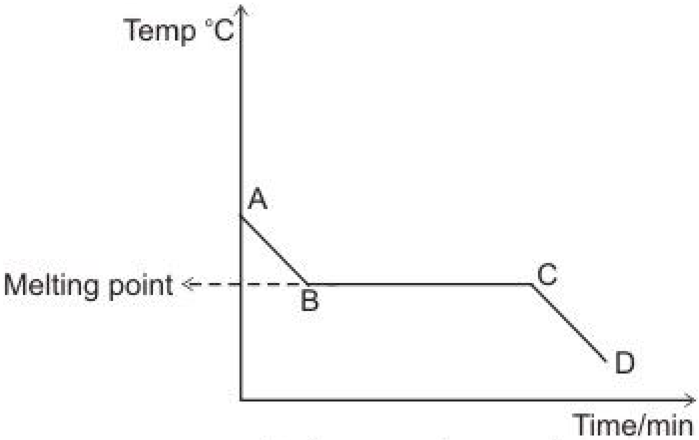
$2Mg + O_2 \rightarrow 2MgO$

Non-metals can also undergo combustion. Sulfur burns well in oxygen with a bright blue flame.

$S + O_2 \rightarrow SO_2$

Cooling Curves

A cooling curve shows the temperature of a pure substance as it cools. These curves have a special shape.



Cooling curve of a pure substance

The flat bit happens at the melting or freezing point. As the liquid cools, the liquid particles lose energy more and more slowly. The means the temperature falls.

When the liquid freezes, new bonds are formed between the particles and the particles stick together in a solid.

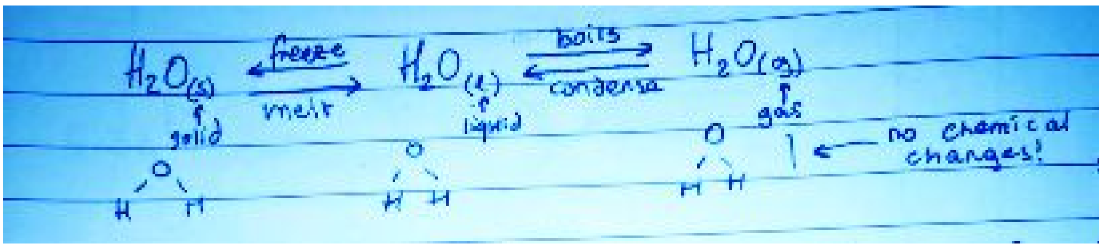
When these bonds are formed, energy is released. Because this energy is released, it stops the substance cooling.

Once the solid is formed, no more bonds are made and the cooling process continues.

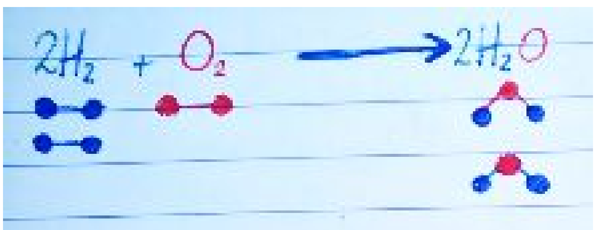
Chemical and Physical Change

Changes of state are **physical** changes. Particles gain or lose energy. They can get closer together or further apart. Bonds are formed or broken between the particles, but no **chemical bonds** are broken or made.

Consider water:



For a chemical change to happen, we need to break and make chemical bonds. Consider making water from hydrogen and oxygen.



When this reaction occurs, we need to break some bonds. Bond-breaking requires energy. It is an **endothermic** process.

The product (water) is formed when new chemical bonds are made. **Bond making** releases energy. It is **exothermic**!

To sum up:

- Breaking bonds *requires* energy
- Making bonds *releases* energy

Kinetic Theory

Kinetic theory is the theory that say “everything is made up of particles, and, unless at absolute zero the particles are constantly moving.

Kinetic theory helps us to explain why diluting a coloured solution makes the solution lighter in colour, and also that gas or liquid particles move by diffusion.

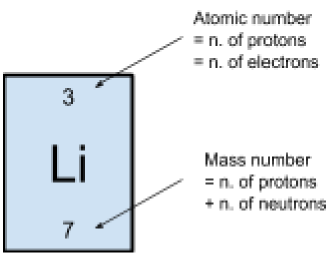
In Chemistry we are particle-arly concerned with two types of particle:

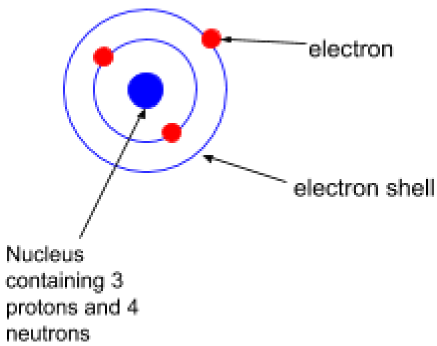
1. Atoms: the smallest particles that can be identified as a particular element.
2. Molecules: are two or more atoms chemically bonded together.

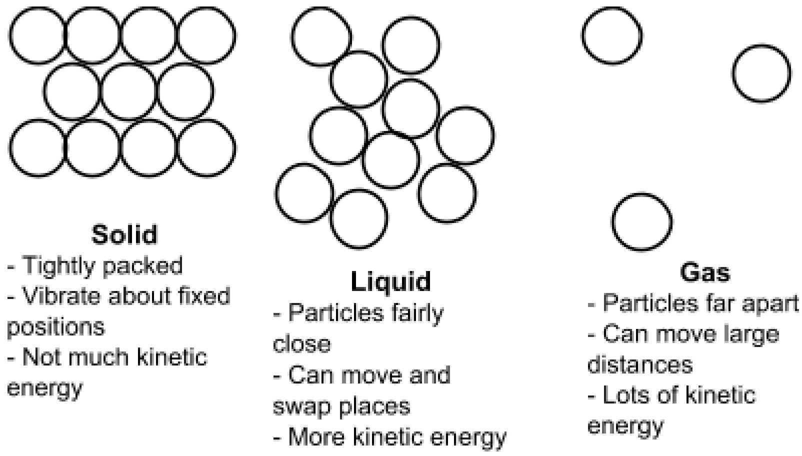
Atoms

Based on a model proposed by Rutherford. He fired positively charged particles at gold foil. Most of the particles passed straight through, showing that most of a gold atom is empty space. A few particles turned around and came back, showing that they had hit something small and positive.

We now have a well established model for atomic structure. This is a drawing of a lithium atom. It has three protons, four neutrons and three electrons. This information can be found on the periodic table.







Protons and neutrons are found inside the nucleus and make up most of the atom's mass. Protons and neutrons have approximately the same mass, while electrons are lightweight. Electrons are arranged in rings; they orbit the nucleus and are negatively charged. Protons have a positive charge. Neutrons, as per the name, are neutral and have no charge.

Molecules

A molecule is two or more non-metal atoms that are chemically bonded together, not necessarily the same elements. For example, liquid water from your tap is made of lots and lots of water molecules. Each water molecule is made of two hydrogen *atoms* and one oxygen *atom.* A compound is a type of molecule, but not all molecules are compounds.

Compounds

Is formed when atoms of different elements react together, forming a molecule. All chemical compounds can be represented by chemical formulae. A chemical formula tells us which atoms are present in a compound. For example:

CO_2 1 carbon & 2 oxygen atoms

H_2O 2 hydrogen & 1 oxygen atom

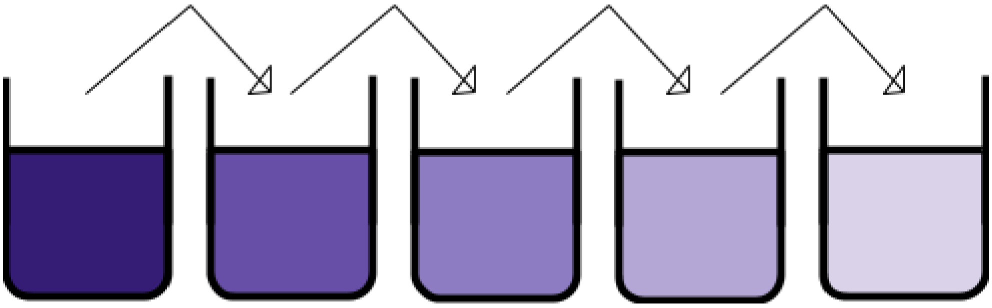
NaCl 1 atom of sodium & 1 atom of chlorine

How do we know what the formula is? The answer lies in something called valencies. Valencies are on the back of your periodic table. Valencies need to match in a formula.

Proving existence of atoms

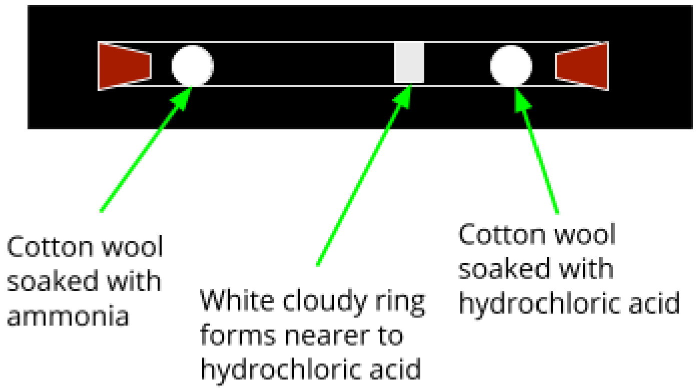
Atoms and molecules are generally too small to be seen. We can show that they are there and exist through a series of experiments.

Dilution of potassium permanganate



The potassium permanganate has invisible purple particles. We cannot see them but we can see their colour. A small amount of potassium permanganate crystals are able to give colour to a large amount of water, because the potassium permanganate breaks down to individual particles when dissolved in water. Since even the last beaker is somewhat colour, we can say that these individual particles must be very small.

Diffusion of gases



The cotton wool soaked in ammonia provides ammonia gas. The cotton wool soaked in hydrochloric acid provides hydrogen chloride gas. When we place the gases at opposite ends of the tube the gases spread out. A white ring, marking where the diffusing gases meet. The white solid (ammonium chloride) forms closer to the hydrochloric acid end, since ammonia gas particles are lighter and travel faster than the hydrogen chloride.

Electrons and their arrangement

Electrons are found in shells or orbitals which surround the nucleus. As you get further from the nucleus, the shells get bigger. Bigger shells can hold more electrons.

Shell number	Maximum number of electrons
1	2
2	8
3	18 (8 at GCSE)

4	32 (8 at GCSE)

Electron shells always fill from the first shell outwards. The arrangement of electrons in an atom has many different names, but they all mean the same:

- Electron arrangement
- Electron configuration
- Electronic arrangement
- Electronic configuration

It looks like this: ^{12}Mg has an electron arrangement of 2, 8, 2.
[12 is the atomic number, meaning it has 12 protons and 12 electrons]

We need to know the electron arrangement for the first 20 elements.

^{1}H	1	^{6}C	2, 4	^{11}Na	2, 8, 1	^{16}S	2, 8, 6
^{2}He	2	^{7}N	2, 5	^{12}Mg	2, 8, 2	^{17}Cl	2, 8, 7
^{3}Li	2, 1	^{8}O	2, 6	^{13}Al	2, 8, 3	^{18}Ar	2, 8, 8
^{4}Be	2, 2	^{9}F	2, 7	^{14}Si	2, 8, 4	^{19}K	2, 8, 8, 1
^{5}B	2, 3	^{10}Ne	2, 8	^{15}P	2, 8, 5	^{20}Ca	2, 8, 8, 2

All chemical reaction occur, because electrons move from one atom to another. Sometimes they are lost or gained. Sometimes they are shared. If electrons are <u>lost</u> from an atom, a positive <u>**ion**</u> is formed.

Acids and pH

A substance with a pH lower than 7 can be considered acidic. It will turn universal indicator paper red/orange/yellow and turns litmus paper red.

Standard GCSE definition for an acid: *An acid is defined as a substance that releases H^+ in water.*

Acids are important laboratory chemicals and we need to know five of them.

Hydrochloric acid	HCl
Ethanoic acid	CH_3COOH
Sulfuric acid	H_2SO_4
Nitric acid	HNO_3
Phosphoric acid	H_3PO_4

How do we know if a solution is acidic?

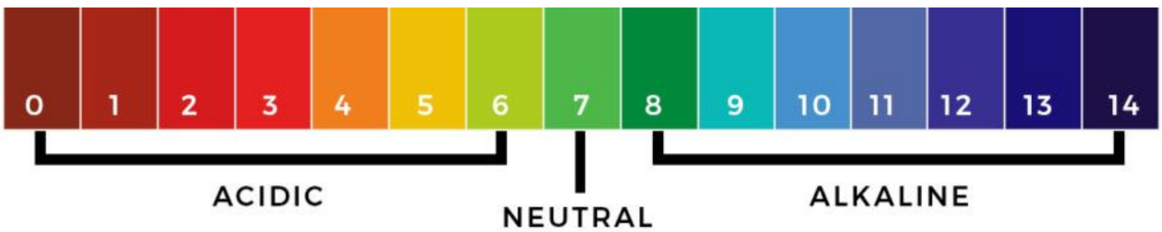
We can use a substance called an indicator, which changes colour in the presence of an acid. There are three common indicators.

Name	Color in Acid	Color when Neutral	Color in Alkali
Litmus	Red	Purple	Blue
Methyl Orange	Pink	Orange	Yellow
Phenolphthalein	Colourless	Pale Pink	Bright Pink

Universal indicator is a mixture of many different indicators. This means that it can have different colours and indicate different strengths of acid and alkali.

The different colours correspond to different pH values and at GCSE, the pH scale goes from 1 through to 14.

pH 1 very strong acid
pH 7 neutral
pH 14 very strong alkali



Whilst universal indicator is useful in telling us whether something is a strong or weak acid or alkali, the actual distinction between different pH values is often difficult to see.

Acids react with bases and alkalis. What is the difference between a base and an alkali?

ALL bases will react with an acid to neutralise it.
ALL metal oxides and metal hydroxides are bases.

Reactions of Acids

When acids react, they form compounds called salts.

Different acids form different types of salt:

hydrochloric acid chlorides
sulfuric acid sulfates
nitric acid nitrates

there are some reactions that all acids have in common.

1. acid + metal → salt + hydrogen gas
2. acid + base → salt + water
3. acid + carbonate → salt + carbon dioxide + water

Chromatography

Chromatography is one of the ways of separating **a mixture** of substances. A mixture is two or more substances mixed together but without being chemically bonded.

We separate a mixture by identifying a property of the substances which differs for each individual substance. Indicators differ by solubility level and by colour. In order to identify the specific substances we have separated using chromatography we can either compare them with known substances or we can use a numerical factor called the retention factor or R_f value to compare our substances with data from a database.

The R_f value is specific for a specific substance in a given solvent.

$$Rf\ value = \frac{Distance\ the\ chemical\ travelled\ up\ the\ paper}{Distance\ the\ solvent\ travelled\ up\ the\ paper}$$

R_f values vary with temperature, because solubility varies with temperature.

Definition	**Word**
The part of the apparatus that the solvent and dyes move up	Stationary phase
A ratio that Compares the distance moved by a dye to the distance Moved by The solvent	R_f value
The solvent that moves up the paper in chromatography	Mobile phase
The pattern of spots produced when an ink separate into it's different dyes	Chromatogram

Composition of the atmosphere

Atmosphere has evolved over millions of years. The first atmosphere contained ammonia carbon dioxide and water vapour. Over millions of years chemical reactions occurs and our current atmosphere came into being:

Nitrogen	78%
Oxygen	21%
Argon	0.9%
Carbon dioxide	0.04%

The other gases make up only a small percentage and vary by location.

An experiment to show the percentage of oxygen in the air

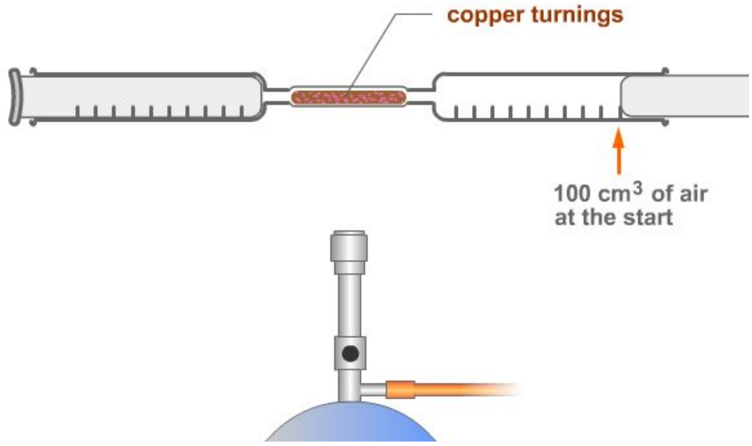
The percentage of oxygen in the air can be measured by passing a known volume of air over hot copper, and measuring the decrease in volume as the oxygen reacts with it. There is an excess of copper turnings so that all the possible oxygen can react. The volume of air will stop decreasing once all the oxygen has reacted.

Note that there is some air in the tube with the copper turnings. The oxygen in this air will also react with the hot copper, causing a small error in the final volume recorded. It is also important to let the apparatus cool down at the end of the experiment, otherwise the final reading will be too high. There could also be a leakage and some air has escaped from the apparatus. Here are the word and symbol equations for this experiment:

copper + *oxygen* → *copper oxide*

$2Cu + O_2 \rightarrow 2CuO$

Gas syringes are used to measure the volume of gas in the experiment.



Results

Volume of air at start 100cm^3

Volume of air at end 75cm^3

$$\frac{100-75}{100} \times 100 = 25\%\ oxygen$$

Some air escaped from the apparatus in our experiment. This means the final volume ended up being *less* than it should be.