IGCSE Complete Chemistry Notes

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Refined and cleared by KmQ! :D

Unit 1: *States of matter*

Everything is made of particles. Particles in solid are not free to move around. Liquids and gases can. As particles move they collide with each other and bounce off in all directions. This is called random motion.

In 2 substances, when mixed, particles bounce off in all directions when they collide. This mixing process is called diffusion. It's also the movement of particles without a force.

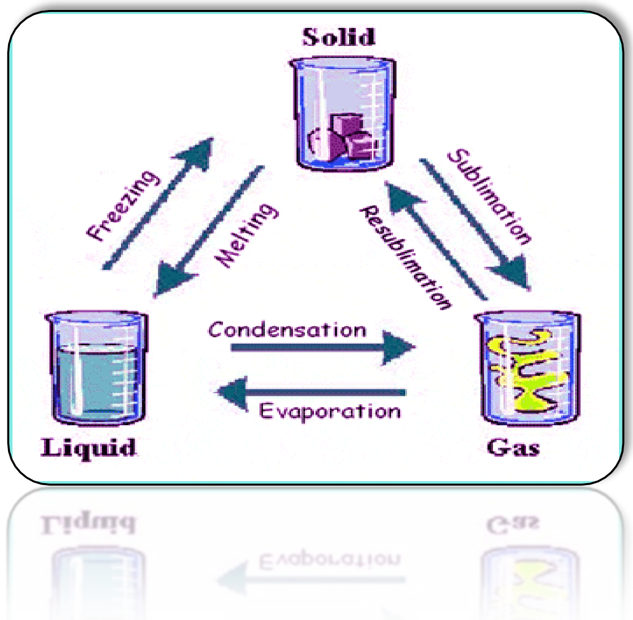
The smallest particle that cannot be broken down by chemical means is called an atom.

·In some substances, particles are just single atoms. For example the gas argon, found in air, is made up of single argon atoms.

·In many substances, particles consist of 2 atoms joined together. These are called molecules.

·In other substances, particles consist of atoms or groups of atoms that carry a charge. These particles are called ions.

Solids liquids and gases



Solid Properties:

- Definite shape and volume
- Normally hard and rigid
- Large force required to change shape
- High Density
- Incompressible

Model:

- Closely packed
- Occupy minimum space
- Regular pattern
- Vibrate in fixed position
- Not free to move

Liquid Properties:

- Definite volume but no shape.
- High Density
- Not compressible

Model:

- Occur in clusters with molecules slightly further apart compared to solids
- Free to move about within a confined vessel

Gas Properties:

- No Fixed volume and no fixed shape
- Low density
- Compressible

Model:

- Very far apart
- Travel at high speed
- Independent and random motions
- Negligible forces of attraction between them

Diffusion in Gases

Gases diffuse in different rates. Those rates depend on their factors:

1. <u>Mass of the particles</u>

The lower the mass of its particles the faster a gas will diffuse.
Why?
Because the lighter the molecules...the faster it will travel (obviously...)

2. <u>The temperature</u>

The higher the temperature, the faster a gas will diffuse.
Why?
Because particles gain energy as they are heated

Mixtures, Solutions, and Solvents

Mixture: Contains more the one substance. They are just mixed together and not chemically combined.

<u>Example</u>: Sand and water.

Solution: It is when a solute and a solvent mix. The solute dissolves in the solvent making a solution.

<u>Example</u>: sugar (solute) dissolves in water (solvent) making a solution of sugar and water.

The solubility of every substance is different.

To help a solute dissolve you could:

- Stir it
- Rise the temperature

If you add excess amount of sugar in a small amount of water...it won't dissolve as there is no space for it. The solution becomes <u>saturated</u>.

Solvent: A substance that allows solutes to dissolve in

Example: Water, Ethanol

Pure substances and impurities

A pure substance is a substance that has no particles of any other substance mixed with it.

An unwanted substance, mixed with a wanted substance, is called an **impurity**.

To check if a substance is pure, you have to check its melting and boiling points.

A pure substance has a definite, sharp, melting point. When a substance is impure, the melting point falls and its boiling point rises. So the more impurity present, the wider and bigger the change in melting and boiling point.

Separation methods:

Filter ------------------------- Solid from liquid
Centrifuge ------------------ Solid from liquid
Evaporation ---------------- Solid from its solution
Crystallization -------------- Solid from its solution
Distillation ------------------ Solvent from a solution
Fractional distillation ----- Liquid from each other
Chromatography ---------- Different substances from a solution

Separation methods

1. Filtering

Example:

A mixture of chalk and water...

1. A filter paper is placed in a funnel, the funnel placed on a flask.
2. The mixture is poured on the filter paper.

The chalk (the residue) will remain in the filter paper and the water (the filtrate) will fall down in the flask.

2. Centrifuging

This method is used to separate small amounts of solid and liquid. Inside a centrifuge (it’s a machine), test tubes are spun very fast so the solid gets flung to the bottom.

3. Evaporation

This method is used to separate a solution in which the solid is dissolved in the liquid.

1. The solution is heated so that the liquid evaporates and the solid remains in the bottom of the evaporating dish.

4. Crystallization

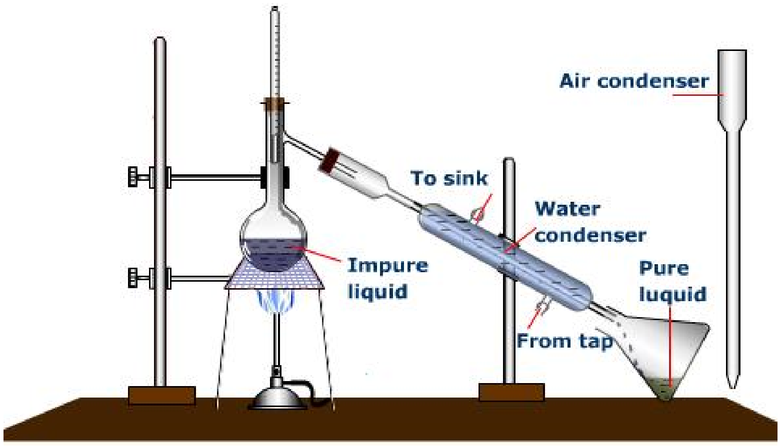
This method is similar to evaporation but here the solid forms crystals then the crystals are left to dry.

Separating a mixture of two solids

1. This can be done by dissolving one in an appropriate solvent.
2. Then filtering one and extracting the other from the solution by evaporation.

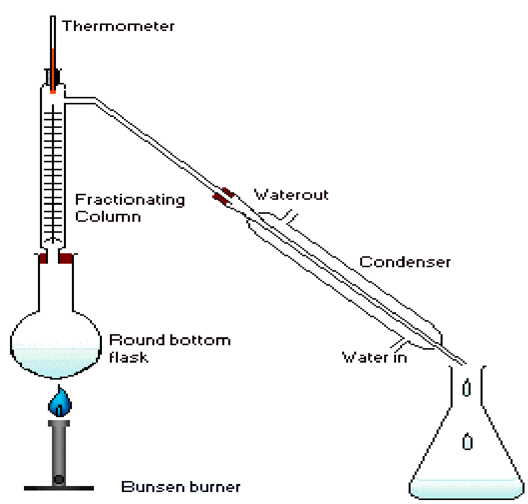
5. Simple distillation

1. The impure liquid is heated.
2. It boils, and steam rises into the condenser.
3. The impurities are left behind.
4. The condenser is cold so the steam condenses to the pure liquid and it drops out on the beaker.



6. Fractional distillation

1. The mixture is heated.
2. The wanted substance boils and evaporates (some of the unwanted liquid will evaporate too) and rises up the column.
3. The substance will condense on the beads in the column causing them to heat.
4. When the beads reach a certain temperature when the wanted liquid wont condense anymore (That's the boiling point) it will rise while the unwanted liquid will condense and drop. The wanted liquid will make its way through the condenser where it will condense and drop down in the beaker.



7. Chromatography

This method is used to separate a mixture of substances. For example you can use it to find how many coloured substances there are in black ink.

Steps:

1. Drop the black ink on to the center of a filter paper and allow it to dry.

2. Drop water on to the ink spot, one drop at a time.

3. Suppose there are three rings: yellow, red and blue. This shows the ink contains 3 coloured substances.

The substances travel across the paper at different rates. That's why they separate into rings. The filter paper showing the separate substances is called a **chromatogram**. This method works because different substances travel at different speeds because they have different levels of attraction to it.

Uses of chromatography:

- Separate mixtures of substances
- Purify a substance by separating the impurities from it
- Identify a substance

Unit 2: *The Atom*

Atoms are the smallest particles. Each atom consists of a nucleus and a cloud of particles called electrons that whizz around the nucleus.

An element is a substance that contains only one kind of atom.

The periodic table is the "map/address book" for elements where each element is given a symbol (E.g. K for potassium). The group of elements that have similar properties are put in a numbered column. For example, if you know how one element in group 1 behaves, you can easily guess how the others in the same group will behave.

The rows are called periods. The zig-zag line separates metals from non-metals, with the non-metals on the right. So most elements are metals.

A compound contains atoms of different elements joined together where the atoms are chemically combined. For example carbon dioxide is a compound of carbon and oxygen (1 carbon and 2 oxygen molecules).

The symbol for compound is made from the symbols of the elements in it. So the formula for carbon dioxide is CO2.

Isotopes and Radioactivity

You can identify an atom by the number of protons in it. For example, only sodium atoms have 11 protons.

Isotopes are atoms of the same element, with different numbers of neutrons.

Some isotopes are radioactive. That means its nucleus is unstable, sooner or later the atoms breaks down or decays, giving out radiation in the form of rays and tiny particles, as well as large amount of energy.

Like carbon-14, a number of other elements have radioisotopes that occur naturally and eventually decays. But the other two isotopes of carbon (like most natural isotopes) are non-radioactive.

You can know when radioisotopes decay by looking at there half life.
Radiation affects humans as it may causes them radiation sickness but radiation also has some uses.

Uses of radiation:

1. Check for leaks in pipes <u>(industry)</u>
This is done by adding a radioisotope to the oil or gas. At a leak, the radiation is detected using an instrument. Radioisotopes used in this way are called tracers.

2. in cancer treatment <u>(Medical)</u>
Radioisotopes can cause cancer but yet also can cure it. Using radiotherapy the radioisotope will decay and give out rays that can kill cancer cells. These rays will be aimed exactly at the cancer cells.

3. To find the age of old remains
A tiny percentage of a living thing contains carbon-14 atoms. When living thing dies it no longer takes in new carbon atoms. But existing carbon-14 atom decay over time - we can measure the faint radiation from them.

How electrons are arranged

The electrons in an atom circle fast around the nucleus, at different <u>levels</u> from it. These energy levels are caller <u>electron shells</u>. The further the shell is from the nucleus, the higher the energy level.

Each shell can hold a limited number of electrons.

First shell can hold up to 2 electrons
Second shell can hold up to 8 electrons
The third shell can also hold up to 8 electrons

<u>Electronic configuration</u> means the arrangement of electrons in an atom.

Example:
- Argon has the electronic configuration : 2,8,8
- Magnesium has the electronic configuration : 2,8,2

Important points:

- The shells fill in order, from lowest energy level to highest energy level
- All the elements in a group have the same number of electrons in their outer shells. These are called <u>Valency electrons</u>.
- The group number is the same number of outer shell electrons
- The period number shows how many shells there are.
- If an element posses a full outer shell, the element become unreactive

Unit 3: *Atoms combining*

Most elements form compounds because they want a full outer shell and to achieve that they must react with other atoms. For example, sodium has just one electron in its outer shell. It can obtain a full outer shell by losing this electron to anther atoms and by that it becomes a sodium ion. Now because sodium lost a electron...it now has 10 electrons but 11 protons...so it has a 1 positive charge.

An ion is a charged particle. It is charged because it has an unequal number of protons and electrons.

The ionic bond

Example:

Sodium and chlorine react together; sodium gives its electron to chlorine. Now both elements have a full outer shell, but with a charge. Now they are ions.

Sodium now has 10 electrons but 11 protons so it has a positive charge.
Chlorine now has 18 electrons but 17 protons so it has a negative charge.

The two ions have opposite charges, so they attract each other. The force of attraction between them is strong. It is called an ionic bond.

When sodium reacts with chlorine, billions and billions of sodium and chlorine ions form and they attract each other. But the ions don't stay in pairs. They cluster together so that each ion is surrounded by 6 ions of opposite charges. The pattern grows until a giant structure of ions is formed. The overall charge of the structure is 0 since 1 positive charge and 1 negative charge neutralize each other.

The ionic bonding is only between metals and non-metals.

Important notes:

- Hydrogen and the metals form positive ions
- Non-metals form negative ions, and their names end in -ide
- Group 4 and 5 do not usually form ions because they would have to lose or gain several electrons and that takes too much energy
- Group 0 elements do not form ions; they already have full outer shells
- Some of the transition metals form more than one ion.
- Some ions can be formed from groups of joined atoms. These are called compound ions.

Properties of ionic compound

1. **Ionic compounds have high melting and boiling points.**

This is because ionic bonds are very strong, so it takes a lot of heat energy to break up the lattice.

2. **Ionic compounds are usually soluble in water.**

The water molecules can attract the ions away from the lattice. The ions can then move freely, surrounded by water molecules.

3. **Ionic compounds can conduct electricity when they are melted or dissolved.**

When melted the lattice breaks up and the ions are free to move. Since they are charged, this means they can conduct electricity. The solutions of ionic compounds conduct electricity too because they are also free to move.

The covalent bond

Giving and losing an electron is not the only way to gain full outer shells since atoms can also <u>share</u> electrons.

Covalent bonding is for non-metals only since only non-metals need to gain electrons.

A molecule is a group of atoms held together by covalent bonds.

When a pair of electrons is shared, it is called a single covalent bond, or just single bond.

When 2 pairs of electrons are shared, it is called a double covalent bond, or just double bond.

When 3 pairs of electrons are shared, it is called a triple covalent bond, or just triple bond.

Covalent compounds

A covalent compound is when atoms of *different* elements share electrons with each other.

The molecules in a covalent compound isn’t flat because each electron repel each other and try to get as far apart from each other.

Molecular substances

Most molecular substances are gases or liquids at room temperature. Molecular solids are held in a lattice but the forces between the molecules are weak. All molecular solids have similar structure. The molecules are held in regular pattern in a lattice. So the solids are crystalline.

When you cool down a molecular liquid or gas the molecules lose energy so they start moving slowly and at the freezing point, they form a lattice (a good example would be ice)

Properties of covalent bonding

1. **Covalent compounds have low melting and boiling point**
   This is because the forces between the molecules are weak.

2. **They do not conduct electricity**
   This is because molecules are not charged, so they cannot conduct, even when melted

Giant covalent structures

A giant covalent structure, or macromolecules are made of billions of atoms bonded together in a covalent structure.

Diamond – a giant covalent structure

Diamond is made of carbon atoms held in a strong lattice. Each carbon atom forms a covalent bond to four others. Eventually billions of carbon atoms bond together to form a crystal of diamond.

Diamond properties:

1. It is very hard because each atom is held by four strong bonds.
2. It has a very high melting point because of the strong bonds.
3. It can't conduct electricity because there are no free electrons to carry the charge.

Silica is similar to diamond.

Graphite – a very different giant structure

Like diamond graphite is made only of carbon atoms. So diamond is and graphite are allotropes of carbon (means they are two forms of the same element)

Graphite, unlike diamond, is one of the softest solids on earth.

In graphite, each carbon atom forms a covalent bond to three others. This gives rings of six atoms.

Graphite properties:

1. Is soft and slippery because the sheets can slide over each other
2. Is a good conductor of electricity because each carbon atom has four outer electron and graphite bonds 3 only so the fourth electron is free to move carrying a charge.

Substance	Properties	Uses
Diamond	-Hardest known substance and does not conduct	In tools for drilling and cutting
	-Sparkles when cut	For jewellery
Silica	-Hard, can scratch things	-In sandpaper
	-Hard, lets light through	-For making glass and lenses
	-High melting point	-In bricks for lining furnaces
Graphite	-Soft and slippery	-As a lubricant for engines
	-Soft and dark in color	-For pencil ‘lead’ (mixed with clay)
	-Conduct electricity	-For electrodes, and connecting brushes in generators.

Properties of Diamond:

- Hard substance
- High MP / BP
- Cant conduct electricity

Properties of Graphite:

- Soft and slippery
- Good Conductor

Properties of Silica:

- High BP / MP
- Hard

Comparing Bonds

Differences in STRUCTURE

Covalent	Ionic
Molecular	ionic
Shares electrons	Exchange electrons
Simple molecules	Giant lattices
Non metal only	Metals and non metals

Differences in PROPERTIES

Dissolves in organic liquid (not water)	Dissolves in water
Low Boiling and melting point	High boiling and melting point
Does no conduct electricity	Conducts electricity

Metallic bonding

Metals form giant structures in which electrons in the outer shells of the metal atoms are free to move. The metallic bond is the force of attraction between these free electrons and metal ions. Metallic bonds are strong, so metals can maintain a regular structure and usually have high melting and boiling points.

Properties of metals:

1. **Metals have high melting points**

This is because it takes a lot of heat energy to break up the lattice.

2. **Metals are malleable and ductile.**

Malleable: They can be bent and pressed into shapes.

Ductile: They can be drawn out into wires.

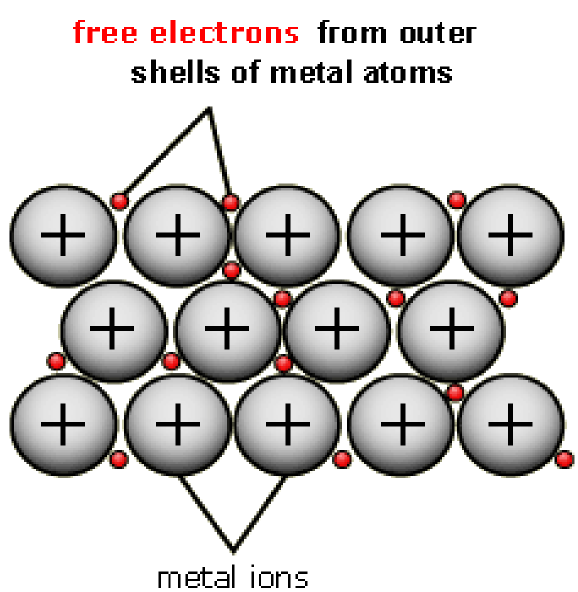
This is because the layers can slide without the metallic bond breaking, because the electrons are free to move too.

3. **Metals are good conductors of heat**

That's because the free electrons take in heat energy, which makes them move faster and they quickly transfer the heat through the metal structure.

4. **Metals are good conductors of electricity**

This is because the free electrons can move through the lattice carrying the charge.



Unit 4: *The Periodic Table*

The periodic table is a list of all the elements, in order of increasing atomic number.

The columns are called groups.

The rows are called periods.

Groups

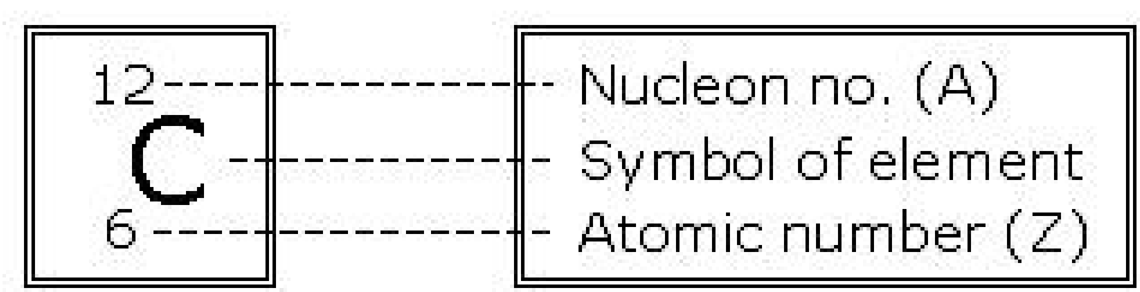
- The group number tells you how many electrons there are in the outer shell of the atoms.
- The outer-shell electrons are also called valency electrons and their number shows how the elements behave.
- All elements in a group have similar properties.
- Group 0 elements have a *full outer shell*. This makes them unreactive.
- Some of the groups have special names:

Group 1 – **The alkali metals**

Group 2 – **The alkaline earth metals**

Group 7 – **The halogens**

Group 0 – **The noble gases**



Periods

The period number gives information about the number of electron shells that are available in that period.

Hydrogen

Hydrogen sits alone in the table because it’s the only element with one electron shell.

Trends in the periodic table

The elements in each numbered group shows trends in their properties. For example as you go down group 1, the elements become more reactive or as you go down group 7 the elements become less reactive and so on.

Group 1: *The alkali metals*

Their physical properties:

1. Like all metals, they are good conductors of heat and electricity.
2. They are softer than most other metals and they have low density.
3. They have low melting and boiling points, compared to most metals.

Their chemical properties:

1. All alkali metals react vigorously with water, releasing hydrogen gas and forming hydroxides. The hydroxides give alkaline solutions.
2. They react with non-metals. With chlorine they react to make chlorides and with oxygen they make oxides.

They form ionic compounds in which the metal ion has a charge of 1+. The compounds are white solids, which dissolve in water to give a colorless solution.

The trend in physical properties

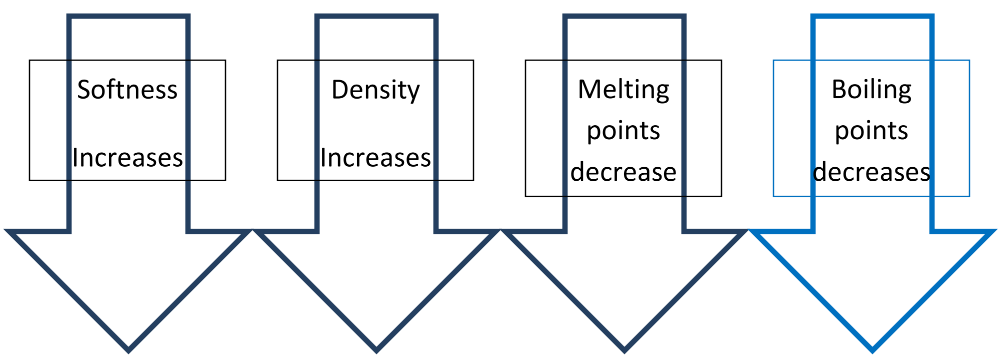
Lithium

Sodium

Potassium

Rubidium

Caesium



Why they have similar properties?

Because atoms with the same number of valency electrons react in a similar way.

As you go down the group reactivity increase.

Why?

Because the atoms get larger down the group because they add electron shells.

Group 7: *The halogens*

A non-metal group.

- Form colored gases.
- Are poisonous
- Are brittle and crumbly in their solid form, and do not conduct electricity.
- Form diatomic molecules (means they exist as 2 atoms)

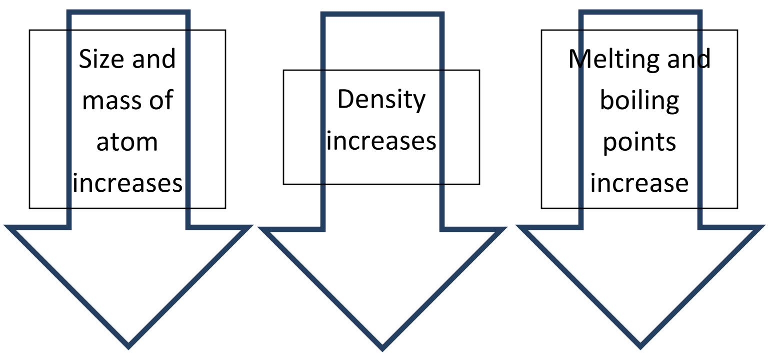
Trends in their physical properties

Fluorine

Chlorine

Bromine

iodine



Trends in their chemical properties

Reactivity increases as you go up group 7.

Why?

Because the smaller the atom, the easier it is to attract the electron – so the more reactive the element will be.

Why are they so reactive?

Because their atoms are only one electron short of a full shell.