GCSE Chemistry
Revision notes 2015

Contents

Atomic Structure 3
Chemical Bonding 5
The Periodic Table 6
Radioactivity 7
Acids and Alkalis 8
Electrolysis 9
Metals - The Reactivity Series 11
Extraction of Metals 12
Writing Formulae and Balancing Equations 13
The Earth and the Atmosphere 14
Rates of Reaction 15
Products From Crude Oil 16

Atomic Structure

Everything around us is made up of **particles**.

The movement of different particles amongst each other, so that they become evenly mixed, is called **diffusion.**

The random motion of particles is called **Brownian Motion**. This 'random walk' is caused by particles colliding into each other and their container wall.

Solids, liquids and gases are the **Three States of Matter**.

The particles in a **solid** are **tightly packed in a fixed position**. They do vibrate in their fixed positions. This is why a solid has a fixed volume and shape and cannot be compressed.

The particles in a **liquid** are **close together** but can move around and **slide past each other**. This is why a liquid can change its shape but not its volume. A liquid cannot be compressed.

The particles in a **gas** are **far apart**, and they **move around very quickly**. Therefore, a gas has no fixed shape or volume and can easily be compressed.

It is possible for a substance to change from one state to another. Changing state depends on the temperature of the substance.

- **Solid to liquid: Melting.**
- **Liquid to gas: Evaporating.**
- **Gas to liquid: Condensing.**
- **Liquid to solid: Solidifying.**

Some substances can go from solid to a gas - this is called **sublimation.**

If the volume of a gas is kept constant, its pressure increases with temperature.

When a gas is compressed into a smaller volume, its' pressure increases.

If the pressure of a gas is constant, its volume increases with temperature.

When a **solute** (solid) dissolves in a **solvent** (liquid) the product is called a **solution**.

A **saturated solution** is one that can dissolve no more solute at that temperature. Raising the temperature of a solution increases the solubility of the solute.

To separate a solid from a liquid four methods can be used:

1. **Filtering.**
2. **Centrifuging.**
3. **Evaporating.**
4. **Crystallizing.**

To separate a solvent from solution you use **simple distillation**.

To separate two liquids, **fractional distillation** is used.

To separate a mixture of coloured substances we use **chromatography.**

A single particle is called an atom.

Atoms contain three particles, **neutrons, protons** and **electrons**.

Protons (+) and neutrons are located in the **nucleus** of the atom. The electrons (-) whiz around the nucleus in orbits called energy shells/levels.

The first shell can hold only 2 electrons, the second 8 electrons and the third 8 electrons.

Electrons have a negligible mass in comparison with protons and neutrons that carry the same mass.

The **proton number** is the number of protons in the nucleus of an atom.

The **mass number** is the number of protons and neutrons in the nucleus of an atom.

An atom contains the same number of electrons and protons. Since these two particles have opposing charges, an atom overall is neutrally charged.

An **element** consists of only one type of atom.

A **compound** is made up from two or more types of atom bonded together.

Chemical Bonding

Atoms are **most stable** if they have a **full outer shell**.

Atoms bond with one another to achieve full outer shells - this is why **most elements form compounds.**

Noble gases do not form compounds, since they already have full outer shells.

Metal atoms (and hydrogen), such as sodium, **lose electrons** to become ions. **Ions are charged particles**. Since metals lose electrons to achieve full outer shell configurations, the metal ions have **positive charges**. A positive ion is called a **cation**.

Non-metal atoms, such as chlorine, **gain electrons** and become ions. By gaining electrons they can achieve a full outer shell. Since they gain electrons non-metal ions have **negative charges**. A negative ion is called an **anion.**

Metal atoms bond with non-metal ions by **transferring their electrons**. This is called **ionic bonding**.

For some elements, the energy involved in losing or gaining electrons is too much. In these cases their atoms **share electrons**. This bonding associated with the sharing of electrons is called **covalent bonding**.

There are four types of solid, **giant ionic, giant covalent, metallic and simple molecular**.

Sodium chloride is an example of a **giant ionic solid**. It consists of oppositely charged ions held together by electrostatic forces. They are soluble in water and conduct electricity when molten or in solution.

Diamond and graphite are examples of **giant (covalent) molecular solids**. They consist of millions of covalent bonds that cause them to have very high boiling points.

Iodine is an example of a **simple molecular solid**. It has a low boiling point because molecules of I_2 are held together by **weak forces**. They are insoluble in water and do not conduct electricity.

Metals consist of tightly packed atoms whose outer electrons become part of a ' sea ' of electrons. This **delocalisation** of electrons explains why metals are good conductors of heat and electricity.

The Periodic Table

The **Periodic Table** arranges the elements in order of proton number. Hydrogen has a proton number of 1 so heads the table, followed by helium with proton number 2.

Elements whose atoms have 1 electron in their outer shell are put into Group 1 of the periodic table. Group 2 elements have 2 electrons in their outer shell and so on.

The **groups** are arranged side by side in the periodic table. These horizontal rows are called **periods.**

Period 1 elements have their outer electrons in the first energy shell. Period 2 elements have their outer electrons in the second energy shell.

The periodic table has **eight groups of elements**, plus a block of transition metals.

Some of the groups have special names:

- **Group 1:** Alkaline metals.
- **Group 2:** Alkaline earth metals.
- **Group 7:** Halogens.
- **Group 0:** Noble gases.

The **noble gases** are colourless, unreactive gases. As you go down group 0 their density increases.

The **halogens** have similar properties since they all have 7 electrons in their outer shell. **Reactivity does decrease down the group** as it becomes more difficult to gain an extra electron.

Halogens exist as **molecules**.

The **alkali metals** all have one electron in their outer shell. They are **reactive soft metals.**

The alkali metals are reactive with water producing alkaline solutions. Reactivity increases down the group, as the loss of an electron becomes easier as the size of the atom increases.

The **alkaline earth metals** are less reactive than group 1 since they need to lose 2 electrons to gain a full outer shell.

Group 2 reactivity and melting/boiling points increase down the group, as does group1.

Transition metals and their compounds are often used in industry as **catalysts**.

Radioactivity

Some atoms have **unstable nuclei** because of 'extra' neutrons.

Carbon-14 has an unstable nuclei - it has 6 protons and 8 neutrons i.e. extra neutrons!

To become more stable, these unstable nuclei throw particles out - this process is called **decay.**

Carbon-14 is **radioactive**. It is a **radioisotope** and when it decays it gives out **radiation**.

All radioisotopes eventually turn into stable atoms by giving out radiation.

Decay is a **random** process.

Radiation consists of three types of particles:

1. alpha
2. beta
3. gamma

An alpha particle consists of two protons and two neutrons. They can be stopped with paper, slows down quickly in air.

A beta particle is a fast electron. Can travel 20-30cm in air and through thin sheets of paper and metal.

A gamma ray is a high-energy ray. Can travel deep into the body, only thick blocks of concrete or lead can stop it penetrating further.

Radiation can cause cells to mutate - can lead to cancer.

We are surrounded by **low-level radiation** from rocks and cosmic rays called **background radiation**.

Radiation can be useful:

1. Used as tracers
2. To kill germs
3. Cancer treatment
4. Carbon dating - to find the age of once living organisms.
5. Dating rocks.

Acids and Alkalis

Acids are a group of chemicals that taste sour, **turn litmus paper red** and **react with metals to form salts.**

Acids release hydrogen ions, $\mathbf{H^+}$ in **solution**.

Bases are a group of chemicals that feel soapy to touch. They behave in an opposite manner to acids.

Alkalis are soluble bases.

Alkalis turn red litmus blue.

Alkalis **release hydroxide ions**, OH^-, in solution.

Neutral substances, such as water, are neither acidic nor alkaline.

The strength of an acid is measured using a scale called the **pH scale**. The numbers go from 0 to 14.

An acidic solution has a pH number less than 7.

An alkaline solution has a pH number greater than 7.

A neutral solution has a pH number of exactly 7.

To find the pH number of any solution you use **universal indicator**. Universal indicator is a mixture of dyes that change colour depending on what they have been placed in.

A **neutralisation** reaction occurs when you add an acid to an alkali - they cancel one another out. A salt and water are the two products of neutralisation.

Electrolysis

There are several types of reaction:

1. Combination.
2. Decomposition.
3. Fermentation.
4. Precipitation.
5. Electrolysis.
6. Neutralisation.
7. Redox.
8. Combustion.

When a chemical reaction occurs, **bonds are broken and then made**.

Breaking bonds requires energy to be taken in. Bond making releases energy.

Bond energy is the energy required to break one mole of bonds, measured in kilojoules. It is also **the energy given out when bonds are broken**.

An **exothermic** reaction, gives out energy to its surroundings.

An **endothermic** reaction takes in energy from its surroundings.

Activation energy is the **minimum** amount of energy required to start a reaction.

The decomposition of a compound by electricity is called **electrolysis**.

Molten ionic compounds are most typically used in electrolysis, since they allow electricity to flow.

Positive ions (cations) travel to the **cathode** (-ve electrode).

Negative ions (anions) travel to the **anode** (+ve electrode).

In the electrolysis of solutions the ions in the ionic compound compete with hydrogen ions and hydroxide ions from the water.

Electrolysis can be used to **deposit metals** such as copper, using copper sulphate and copper electrodes.

You can use electrolysis to coat one metal with another. This is called **electroplating.**

The chlor-alkali industry uses electrolysis to produce sodium hydroxide, hydrogen and chlorine gas. Brine (sodium chloride solution) is used in this electrolysis.

Some reactions never go to completion; they have a **forward** and a **back** reaction. These reactions are called **reversible** reactions.

A reversible reaction is in **equilibrium** when the forward and back reaction proceeds at the same rate.

Metals - The Reactivity Series

Metals are:

1. Strong.
2. Malleable.
3. Ductile.
4. Sonorous.

Metals have **high melting** and **boiling points.**

Metals are **good conductors** of heat and electricity.

Non-metals are:

1. Brittle.
2. Dull.
3. Not strong.

Non-metals are **poor conductors** of heat and electricity.

Non-metals have **low melting** and **boiling points.**

Some metals react oxygen to form **oxides**.

Some metals react with water to form salts. Potassium, sodium and calcium form hydroxides, for example, alkaline solutions. Magnesium and other less reactive metals form oxides.

Although many metals react with oxygen, water or even dilute acids, they **react differently**. Some metals are more reactive than others.

The **Reactivity Series** is a list of metals in order of reactivity.

A metal will always displace a less reactive metal from solutions of its compound - displacement reactions. This is because the more reactive the metal, the more easily it gives up electrons.

Extraction of Metals

Metals often appear in the Earth's crust as an **ore**. An ore is the metal usually in the form of a compound, most commonly an oxide. When the ore is dug up, and decomposed to the metal alone, we call this **extracting**.

The more reactive a metal the more difficult to extract.

Unreactive metals, such as gold and silver can be found as pure elements in the Earth's crust.

There are different methods of extraction:

1. Electrolysis.
2. Heating with carbon monoxide.
3. Roasting in air.

Metals are a non-renewable resource. Hence, it is important to **recycle** used metals.

Aluminium is extracted from the ore bauxite, using electrolysis. At the cathode, aluminium is formed and at the anode oxygen gas forms.

Aluminium has many useful properties:

1. Shiny.
2. Good conductor of heat and electricity.
3. Malleable and ductile.
4. Low density.

Iron is extracted from the ore haematite (iron oxide) using a blast furnace.

Cast iron and steel are two useful by-products from the extraction of iron.

The corrosion of iron and steel is called **rusting**.

Rusting of iron occurs if both **water and oxygen** (usually from the air) is present.

To help prevent rust, several methods may be used:

1. Paint or grease.
2. Galvanising.
3. Sacrificial protection.

Writing Formulae and Balancing Equations

The relative atomic mass of an element is the average mass of its isotopes compared with an atom of carbon-12.

Isotopes occur when atoms have different numbers of neutrons but the same number of protons.

A **mole** is a specific amount of atoms. One mole equals **6.02×10^{23} atoms**. This number is known as **Avogadro's number**.

A mole of a substance is obtained by weighing out the RAM or formula mass in grams. This is because, for example, 12 grams of carbon contains 6.02×10^{23} atoms. 18 grams of water would contain 6.02×10^{23} molecules of water, i.e. 1 mole.

The **formula** of a compound tells you how many atoms of each element combine.

The **empirical formula** is the simplest ratio of atoms in a compound.

The Earth and the Atmosphere

The **atmosphere** is a **layer of gas** around the Earth.

Air is a **mixture of gases.** It is most dense at sea-level and thins out as we rise through the layer of atmosphere called the **troposphere**.

The Earth formed about **4600 million years** ago.

The **ozone layer** protects us from the Sun's most harmful ultraviolet rays.

The atmosphere is maintained by nature recycling substances in living things. All living things depend upon **oxygen, nitrogen, carbon dioxide** and **water**.

The Earth's surface is formed and forever changing by different processes occurring.

Igneous rocks are formed from the **hot liquid rock (molten magma) from volcanoes solidifying.** Interlocking crystals are often found in these rocks.

Sedimentary rock is formed from **sediments**. Due to weathering and erosion, larger rock may crumble into smaller ones and be transported until they eventually settle on sea or riverbeds. Over the years these fragments of rock compress together. Sedimentary rock is often crumbly due to its formation from small bits of rock. Often they are layered, and on some occasions fossils may be present.

Metamorphic rock occurs when **heat or pressure or both cause a rock to change its structure.**

Rates of Reaction

Rate is a measure of the speed that a reaction takes place at. In other words it **is a measure of the change that happens in a single unit of time.**

When measuring rate of a reaction we usually measure the **amount of reactant used up per unit** of time or the **amount of product produced per unit of time**.

When measuring the amount of product produced, a syringe can be used if the product is a gas. Alternatively, if the gas is allowed to escape during the reaction a measure of mass lost could be used to measure the rate.

The **rate changes throughout the reaction**.

The rate is greatest at the start, but gets less as the reaction proceeds.

Rate of reaction can be changed by:

1. Change in concentration of reactants
2. Change in temperature
3. Change in surface area of reactants
4. Use of a catalyst.

A reaction goes faster when the concentration of a reaction is increased.

A reaction proceeds at a quicker rate when the temperature is raised. When the temperature increases by 10^oC, the rate approximately doubles.

Increasing surface area of solid reactants increases the rate of a reaction.

Catalysts increase the rate of a reaction by lowering the activation energy. This means more successful collisions will take place over a period of time.

A catalyst is a substance that changes the rate of a chemical reaction but remains chemically unchanged.

Products from Crude Oil

Organic chemistry is the study of **carbon** compounds.

Many organic compounds are to be found in **crude oil**.

Crude oil is a **mixture** of useful compounds. **Fractional distillation** separates crude oil into **fractions**.

The compounds within the different fractions differ by their carbon content, ease of burning, smell, colour, and melting/boiling point. The **lighter fractions are smaller molecules and have lower boiling points**. Petrol is one such fraction. The **heavier fractions are long chained hydrocarbons** with high boiling points. The **lighter fractions are used as fuels** and are hence in greater demand than the heavier fractions such as bitumen, which is used on roads.

Cracking is the process by which long chained compounds are broken down into smaller chained compounds.

Reforming is the process that changes chained molecules into branched.

The fractions are made up of **hydrocarbons**. Compounds that contain hydrogen and carbon only.

Alkanes are a family of hydrocarbons with the general formula C_nH_{2n+2} . They are described as **saturated** compounds.

Alkenes are another family of hydrocarbons with the general formula C_nH_{2n} . They are described as being **unsaturated** due the presence of a **double bond**.

Both alkanes and alkenes carry out combustion in oxygen producing carbon dioxide and water.

Alkenes are more reactive than alkanes due to **addition reactions** occurring to their double bond. The alkanes are saturated so addition does not occur.

Polymerisation is a reaction whereby alkenes bond to one another forming long chains. The products of polymerisation are called **polymers** or **plastics**.

Alkenes readily carry out polymerisation as they can add to their double bonds.

Terms and conditions