NATIONAL 5 CHEMISTRY
SUMMARY NOTES
Unit One: Chemical Changes and Structure

1. Substances

Elements, Compounds and Mixtures

Elements are the simplest type of substance.
An element contains only ONE type of atom.
A **compound** is a substance with 2 or more elements chemically joined together.
Naming compounds:
Start with element furthest to left in Periodic Table.
If name ends in '_ide', only 2 elements in compound (except if it's '______ hydroxide').
If name ends in '_ite' or '_ate', compound contains 2 elements PLUS **oxygen**.

Mixtures are where 2 or more substances are present but are not chemically joined. These can be easily separated by filtration, distillation, evaporation or chromatography (separates colours).

A **solution** is made when a solid (solute) is dissolved in a liquid (solvent).
Dilute solution = lots of solvent : little solute.
Concentrated solution = little solvent : lots of solute
Saturated solution = no more solute can be dissolved in the solvent. A little more can be dissolved on heating though.

Identifying Chemical Changes

A **new substance** is always formed in a chemical reaction. This can be identified by:
Change of appearance
Gas forming
Solid forming (precipitation)
Energy (temperature) change

A physical change may include some of these but does not form a new substance so can be reversed. Physical changes include freezing, melting, boiling, making a solution.

Energy changes

Exothermic reaction – a reaction in which energy is given out, usually in the form of heat. The reaction gets hotter.

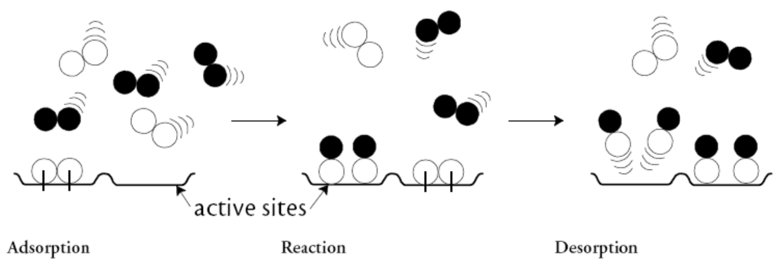
Endothermic reaction – a reaction in which energy is taken in. The reaction gets colder.

2. Reaction Rates

Reaction rates can be increased by increasing the number of collisions by:

1. Increasing the temperature of the reactants.
2. Increasing the concentration of the reactants.
3. Increasing the surface area by decreasing particle size.
4. Adding a catalyst (which does not get used up).

Homogeneous Catalyst – in same physical state as reactants.
Heterogeneous Catalyst – in different state from reactants.



Enzymes are biological catalysts.

$$\text{Average rate} = \frac{\text{Change in factor being measured}}{\text{Given time}}$$

If the end of the reaction is timed:

$$\text{rate} = \frac{1}{\text{time}}$$

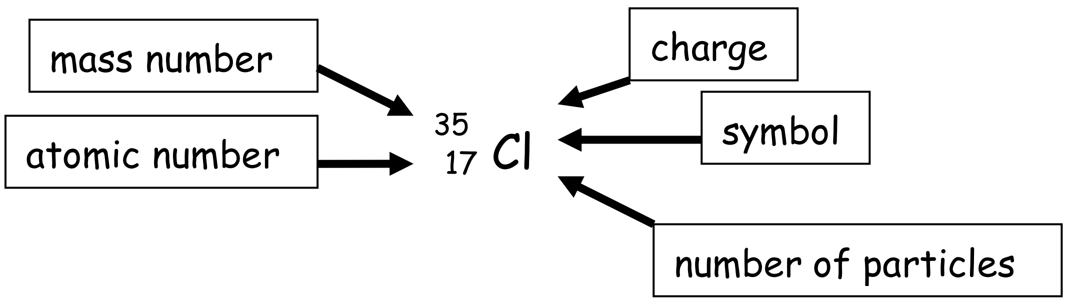
Catalysts are very important in industry:
Catalytic converters use platinum and rhodium to convert poisonous gases into harmless ones in car engines, iron helps makes ammonia for fertilisers, nickel helps turn oil into margarine.

3. Atomic Structure & The Periodic Table

The atom is made up of 3 sub-atomic particles:

Particle	Charge	Mass (amu)	Where found
Proton	+1	1	Nucleus
Neutron	0	1	Nucleus
Electron	-1	0 (almost)	Orbits outside nucleus

Elements are listed in the Periodic Table in order of their Atomic Number.
Atomic number = number of **protons**.
Mass number = number of **protons** + number of **neutrons**.
Number of **electrons** = number of protons – charge.



Electron Arrangement

The electrons occupy energy levels, or electron shells. These shells don't all take the same number of electrons.

Shell	No. of electrons
1	2
2	8
3	8

These shells are filled until all the electrons are placed, giving the electron arrangement of the atom.
Eg, Sodium has **11** electrons so has an electron arrangement of **2,8,1**.
Elements in the same **group** of the Periodic Table have the same number of electrons in their outer electron shell. They also have **similar chemical properties**.

Isotopes
These are atoms of the same element with different mass numbers. This means they have the same atomic number but different mass numbers.

Relative Atomic Mass
This is the average mass of the mass numbers of a sample of an element, including all its isotopes.

For example, a sample of chlorine has an average atomic mass of 35.5 amu. It has 2 isotopes. 75% of the sample have mass of 35amu while 25% have a mass of 37.
Calculation: Ave. mass = $[(75 \times 35) + (25 \times 37)]/100$

As the average is closer to 35, there must be more isotopes of mass 35 in the sample!

In the **Periodic Table**, the **rows** are known as **periods** while the **columns** are known as **groups**.
All elements are found in the Periodic Table in periods (rows) and groups (columns).
All elements have a chemical symbol which has ONE capital letter and a small letter if a 2^{nd} is needed.
Elements in the same group have similar chemical properties.
Group 1 – alkali metals – very reactive (lithium, sodium, etc.)
Group 7 – halogens – very reactive (fluorine, chlorine, etc.)
Group 8 or 0 – Noble gases – completely unreactive (helium, argon, etc.)

4. Bonding, Structure and Properties

Covalent Bonding
This occurs between 2 non-metal atoms.
2 electrons are shared between the 2 atoms and are held in place by the mutual attraction of BOTH positive nuclei to EACH of the electrons (which have a negative charge).

In Molecular Elements
There are 8 diatomic elements (2 atoms held by covalent bonding):
Hydrogen (H_2), Oxygen (O_2), Nitrogen (N_2) and all of the Group 7 elements (Halogens).

In molecular compounds
When non-metal atoms join! Eg. Water (H_2O), ammonia (NH_3), Methane (CH_4) or the diatomic elements. These have specific shapes because of the covalent bonds.

Covalent molecular substances tend to have low melting and boiling points because they only have **Van der Waals'** forces holding the molecules together. Van der Waals' forces increase with increasing size.

Polar Covalent Bonding
This occurs when 2 non-metal atoms form a covalent bond but the electrons are **not shared equally**. They sit closer to one atom than the other. The one closest to the electrons then has a partial negative charge ($\delta-$) while the other atom has a partial positive charge ($\delta+$). This is found in **water**.

Covalent network substances (carbon in the form of **diamond** and **graphite, silicon dioxide, silicon carbide)** have high melting and boiling points because all the atoms are interlinked by strong covalent bonds which take a lot of energy to break.

Ionic Bonding
Between a metal and a non-metal atom.

The **metal** loses its outer electrons to form a **positive** ion.
The **non-metal** takes these electrons to form a **negative** ion.
In both cases the ion ends up with a **full outer electron shell**, like the Noble gases.
The electrostatic force of attraction holds these oppositely charged ions together very tightly. This is why ionic compounds tend to have high melting and boiling points. The structure is a large lattice.

Metallic Bonding
Found in metal elements. The atoms lose their outer electrons which are then **free to move** from one metal ion to the next. This free movement of electrons is why metals conduct electricity.

Solubility
LIKE DISSOLVES LIKE
Ionic compounds dissolve in polar solvents, like water.
Covalent compounds (like candle wax) dissolve in covalent solvents (like hexane).

Electrical Conductivity
Metals conduct when solid or liquid.
Covalent compounds don't conduct at all.
Ionic compounds only conduct when molten (liquid) or in solution because the ions are then free to move.

Type of bonding	**Electrical conductivity**			**Melting/boiling points**
	Solid	Liquid	Aqueous	
Metallic	yes	yes	insoluble	High
Ionic	no	yes	yes	High
Covalent molecules	no	no	no	Low
Covalent network	no	no	no	High

An **electrolyte** is used to **complete the circuit** and is usually a solution of an **ionic** compound. This allows charge to flow.

5. Chemical Symbols & Formulae

All elements have a chemical symbol with one capital letter and a small letter if a second is needed.

Naming Compounds

The rules for naming compounds are:

1. The names of the elements are written from left to right as they appear on the Periodic Table.
2. If there are only 2 elements in the compound the name of the 2nd element ends in '_ide'.
3. If the compound contains oxygen plus at least 2 other elements the second name ends in '_ate' and oxygen is not used in the name, eg. copper sulphate.

If prefixes are used, these tell us the number of each type of atom in a compound, eg. Dinitrogen tetraoxide = N_2O_4.

Prefix	Meaning
Mono	One
Di	Two
Tri	Three
Tetra	Four
Penta	Five
Hexa	Six

Working out formulae

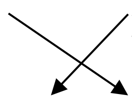
To work out the chemical formula of a compound you use the valency (number of bonds it makes) of the atoms present.

Group No.	1	2	3	4	5	6	7	8
Valency	1	2	3	4	3	2	1	0

Eg. Magnesium chloride

1. Write the symbols of the elements Mg Cl

2. Write the valencies 2 1



3. Swap the numbers over to give the number of each element in the compound (if equal to 1, the number does not need to be put in). $MgCl_2$

If the compound involves the group (complex) ions the valency is the size of the charge on the ion. The data book gives the formulae of these ions.
Eg. Hydrogen sulphate

1. Write the symbols of the elements H (SO_4)
2. Write the valencies 1 2
3. Swap the numbers over to give the number of each element in the compound (if equal to 1 for the group ion, remove the brackets). H_2SO_4

Chemical Equations
A word equation shows the reactants on the LHS and the products on the RHS of an arrow.

hydrogen + oxygen → water

A formula equation replaces the words with the symbols and formulae.

$$H_2 + O_2 \longrightarrow H_2O$$

Equations are balanced to show the same number of each atom on either side of the arrow. Numbers are placed IN FRONT of the substances needing balanced. You can't change the formula! If a half would balance it, multiply everything by 2!
ie. $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$

becomes: $2H_2 + O_2 \longrightarrow 2H_2O$

This means 1 mole of oxygen reacts with 2 moles of hydrogen, forming 2 moles of water.

6. Mass and The Mole

The Formula Mass is the total of the relative atomic masses (RAMs) in a formula of a substance. This is in atomic mass units (amu).

One Mole of any substance = Gram Formula Mass (GFM).

For solids, the number of moles (N) can be calculated using:

$$n = \frac{m}{GFM}$$

where a.m. = actual mass

GFM = gram formula mass

Balanced equations can be used to predict masses and numbers of moles of products. The molar ratio of the balanced equation is used, eg. What mass of water would you get from 1g of H_2?

$$2H_2 + O_2 \longrightarrow 2H_2O$$

molar ratio: 2 : 1 : 2

Calculation

1. n = m ÷ GFM for 'known'

2. use the molar ratio to get 'n' for the 'unknown' from 'n' for the 'known'

3. m = n × GFM for 'unknown'

In solutions:

n = CV

Where n = number of moles (mol)

C = concentration (mol l^{-1})

V = volume in litres (l)

This can also be used to work out the number of moles of a substance in a balanced equation calculation.

7. Acids & Alkalis

pH Scale

pH is measured using Universal indicator, pH paper or a pH meter.
The scale can go from -1 to 15 but most substances lie between 1 and 14.
Acids have a pH < 7
Alkalis have a pH > 7
Neutral substances have a pH = 7.

The pH scale is dependent on the concentration of $H^+(aq)$ ions and is based on the fact that water is partially ionised.

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

Acids and alkalis affect the pH when added to **water**, so change the H^+ ion concentration.
In water:

Concentration of H^+ = Concentration of OH^-

In acids:

Concentration of H^+ > Concentration of OH^-

In alkalis:

Concentration of H^+ < Concentration of OH^-

Soluble **metal oxide** form **alkalis**.
Soluble **non-metal** oxides form **acids**.

All fizzy drinks are acidic because of the carbon dioxide gas dissolved in them.
Most cleaning compounds tend to be alkaline.
Strong acids are those which are **completely** dissociated into ions (ie. Every molecule is broken into ions).
Weak acids are those which are only **partially** dissociated into ions.
All alkanoic acids (eg. Ethanoic) are weak acids. Hydrochloric, sulphuric and nitric acids are all strong.

Strong alkalis are those which are **completely** dissociated into ions (ie. Every molecule is broken into ions).
Weak alkalis are those which are only **partially** dissociated into ions.

Ammonia solution (ammonium hydroxide) is a weak alkali. Ammonia is also very water-soluble and has a pungent smell (wet nappies). Sodium, potassium and calcium hydroxides are all strong.

Strong vs Weak

Strong acids have a higher ion concentration than a weak acid of the same concentration. This means they:

- React faster
- Have a higher electrical conductivity
- Have a lower pH

However, they are neutralised by the **same** amount of a base.

Effect of Dilution

Diluting an acid increases its pH towards 7.
Diluting an alkali decreases its pH towards 7.
Diluting both reduces their electrical conductivity.

8. Salt Preparation

Reactions of Acids

Neutralisation reaction: moves the pH of an acid to 7, producing water.
Base: a substance which neutralises an acid.
Alkali: a soluble base.
Salt: ionic compound formed from the negative ion of the acid and the positive ion from the neutraliser (usually metal).

Acid	Type of salt
Hydrochloric	… chloride
Nitric	… nitrate
Sulphuric	… sulphate
Ethanoic	… ethanoate

1. acid + alkali (metal hydroxide) → salt + water
2. acid + metal oxide → salt + water
3. acid + metal carbonate → salt + water + carbon dioxide
4. acid + metal (MAZINTL) → salt + hydrogen

1 → 3 are neutralisations, while 4 is a displacement.

Spectator ions: Ions which do not change during the reaction so don't actually take part in the reaction.

Acid rain: caused by sulphur dioxide, nitrogen dioxide and carbon dioxide. Affect buildings, structures and wildlife. Farmers use lime to neutralise the effects on soils and lakes.

Precipitation: formation of an insoluble salt from 2 solutions.

How you know a precipitation reaction will take place:

1. Use the solubility data on page 5 of the databook.
2. Take the names of the 2 soluble chemicals you start with:
   For example: **lead** nitrate + **potassium** iodide
3. Swap the 2 positive ions to make 2 new substances:
   That is: **lead** iodide + **potassium** nitrate
4. If one of these compounds is insoluble, then a precipitation reaction will occur!

How to spot a precipitation reaction equation:

1. Check the state symbols.
2. The 2 reactants must both be (aq) and one product must be (s).

Example: $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

Titration Calculations

At the end point (neutralisation) of a titration:

Number of H^+ ions = Number of OH^- ions

So the calculation is:

1. n = CV for the 'known'
2. use the molar ratio from the balanced equation to get 'n' for the 'unknown' from 'n' for the 'known'
3. C = n÷V for the 'unknown'