Revision Notes for Intermediate 2 Chemistry

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Study planner

UNIT 1 Building Blocks

	Revision √ 1	2	3	4
1. Substances				
2. Reaction Rates				
3. The Structure of the Atom				
4. Bonding, Structure and Properties				
5. Chemical Symbolism				
6. The Mole				

UNIT 2 Carbon Compounds

	1	2	3	4
1. Fuels				
2. Nomenclature and Structural Formulae				
3. Reactions of Carbon Compounds				
4. Plastics and Synthetic Fibres				
5. Natural Products				

UNIT 3 Acids, Bases and Metals

	1	2	3	4
1. Acids and Bases				
2. Salt Preparation				
3. Metals				

	1	2	3	4
PPAs				

1. SUBSTANCES

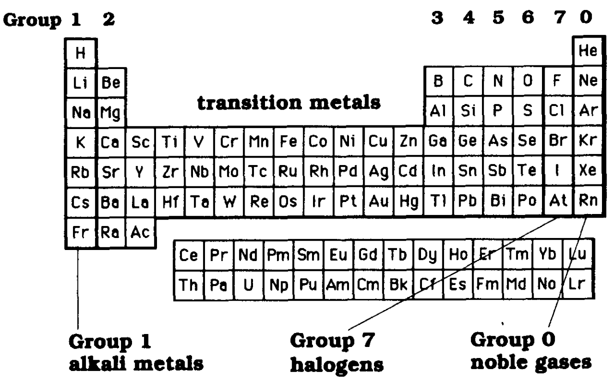
Elements

- ❑ everything in the world is made from **elements**
- ❑ elements cannot be broken down into simpler substances
- ❑ there are just over one hundred different elements in total
- ❑ each element has a name and a symbol
- ❑ for some elements, the symbol is just the first letter of its name; this is always a capital letter,

  e.g. C (carbon), H (hydrogen), S (sulphur)
- ❑ for some elements, the symbol is from two letters of the name; with two letter symbols only the first letter is a capital,

  e.g. Ca (calcium), He (helium), Si (silicon)
- ❑ for some elements, the symbol is from the Latin name,

  e.g. Na (sodium from natrium), Ag (silver from argentum)
- ❑ elements can be solid, liquid or gas; bromine and mercury are the two liquids at room temperature
- ❑ chemists have classified elements by arranging them in the **Periodic Table**



- ❑ elements can be metals or non-metals; the metals are on the left-hand side of the Periodic Table
- ❑ elements can be naturally occurring or made by scientists; the elements made by scientists come after uranium at the bottom of the Periodic Table

- a row of elements in the Periodic Table is called a **period**
- a column of elements in the Periodic Table is called a **group**
- elements in the one group show similar chemical properties
- the **noble gases** is a group of very unreactive elements
- the **alkali metals** is a group of very reactive metals; as a result these metals are stored under oil
- the **halogens** is a group of very reactive non-metals
- the **transition metals** are between Group 2 and Group 3

Compounds

- compounds are formed when elements react together,

  e.g. sodium reacts with chlorine to form sodium chloride (salt), hydrogen reacts with oxygen to form hydrogen oxide (water)
- since the elements in a compound are chemically joined, energy is required to break up a compound,

  e.g. heat energy to break up silver oxide
  electrical energy to beak up copper chloride (in solution)
- **-IDE** compounds usually contain only the two named elements,

  e.g. sodium sulphide contains only sodium and sulphur
- metal hydroxides are exceptions; these compounds contain a metal as well as hydrogen and oxygen
- **-ITE** and **-ATE** compounds contain oxygen as well as the two named elements,

  e.g. both sodium sulphite and sodium sulphate contain sodium, sulphur and oxygen

Chemical reactions

- chemical reactions always produce new substances
- chemical reactions can identified by changes in appearance,

  e.g. colour change, solid formed, gas given off
- chemical reactions which do not involve a change in appearance can be detected by energy changes,

  e.g. a change in temperature

- chemical reactions are taking place all around us in everyday life,

  e.g. burning petrol, digesting food, striking a match, grass growing, iron rusting, epoxy glue setting

Exothermic and endothermic reactions

- an **exothermic** reaction releases energy, usually in the form of heat, to the surroundings
- the surroundings include the container in which the reaction takes place, the air round about and the reaction mixture itself
- if heat energy is released there will be a temperature rise in the surroundings since the latter absorbs the energy liberated by the reaction,

  e.g. the reaction between methane (CH_4) *and oxygen* (O_2) *(burning of methane)*
- a reaction in which energy is absorbed from the surroundings is called an **endothermic** reaction,

  e.g. the reaction between barium hydroxide pentahydrate ($Ba(OH)_2.5H_2O$) *and ammonium thiocyanate* (NH_4CNS)
- if heat energy is absorbed there will be a temperature fall in the surroundings

Mixtures

- mixtures are formed when substances come together without reacting,

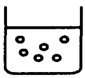
  e.g. air is a mixture of gases, mainly nitrogen and oxygen
- the test for oxygen is that it relights a glowing splint
- there is not enough oxygen in the air for the test to be positive
- heat or electrical energy is not required to separate the elements in a mixture,

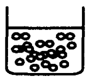
  e.g. iron can be separated from a mixture of iron and sulphur using a magnet, but not from iron sulphide, the compound

Dissolving

- a **soluble** substance dissolves in a liquid
- an **insoluble** substance does not dissolve in a liquid
- the **solvent** is the liquid in which the substance dissolves
- the **solute** is the substance which dissolves in a liquid
- a solute can be a solid, a liquid or a gas,
  e.g. sugar (solid), alcohol (liquid), sulphur dioxide (gas)
- a **solution** is formed when a solute dissolves in a solvent
- in an **aqueous** solution water is the solvent,
  e.g. in an aqueous sugar solution, sugar is the solute and water is the solvent
- a **saturated** solution is one in which no more substance can be dissolved
- a **dilute** solution has a lower concentration of dissolved substance than a **concentrated** solution

dilute solution





concentrated solution

- a solution is diluted by adding more solvent

State symbols

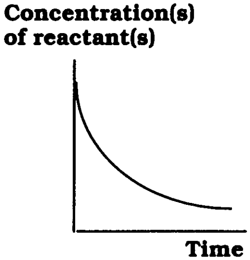
- suffixes can be used after the name or formula to show the chemical state of the substances

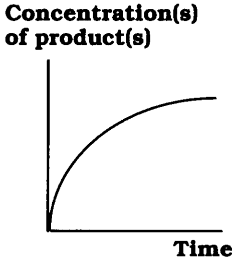
Suffix	Meaning
(s)	solid
(l)	liquid
(g)	gas
(aq)	dissolved in water

2. REACTION RATES

Rates of reaction

- the rate of reaction may be expressed in terms of the changes in concentration(s) of reactant(s) or product(s) in unit time



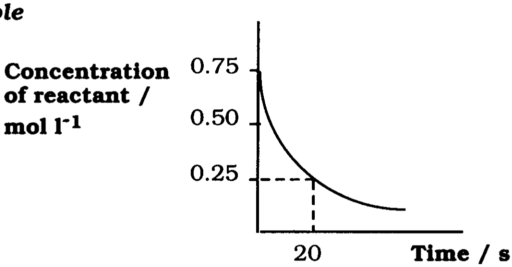


- the reaction rate is most rapid at the start of a reaction and decreases as the reaction proceeds

- when a change in concentration is measured in a given time expressed in seconds, the abbreviated unit of rate is mol l^{-1} s^{-1} (moles per litre per second)

- average rate of reaction = $\dfrac{\text{change in concentration(s) of reactant(s) or product(s)}}{\text{time taken for the change}}$

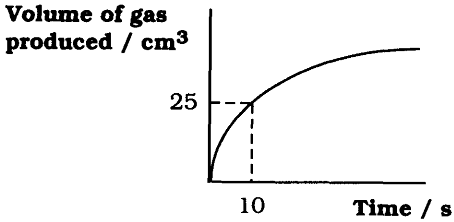
Example



The average rate of reaction over the first 20 s is $\dfrac{0.75 - 0.25}{20} = \dfrac{0.5}{20} =$ **0.025 mol l^{-1} s^{-1}**

- since it is not always practicable to measure changes in concentration, changes in mass, in grams, and volume, in cubic centimetres, can also be used to measure rates of reactions; when these changes are measured in a given time expressed in seconds, the abbreviated units are g s^{-1} and cm^3 s^{-1} respectively

Example



The average rate of reaction over the first 10 s is $\frac{25 - 0}{10}$ = **2.5 cm^3 s^{-1}**

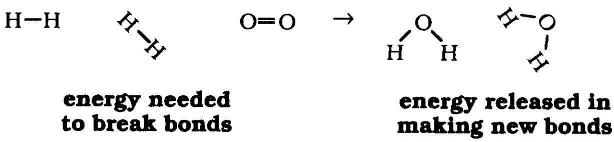
- the rate of reaction is inversely proportional to time taken, i.e. the rate is proportional to "1/time taken"; this means that, for a fixed change in concentration, the shorter the time taken, the faster the rate of reaction

Successful collisions

- for a chemical reaction to occur, reactant particles must collide; this is the basis for the **collision theory**
- not all collisions are successful,

  e.g. *nitrogen and oxygen molecules are constantly colliding in the air without a reaction taking place*
- this is because energy is required to break all bonds in the reactant molecules before new bonds can be formed,

  e.g. *the reaction of hydrogen with oxygen*

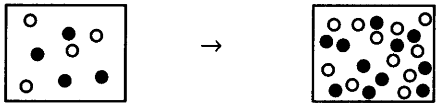


Factors which affect reaction rate

(a) Concentration

See
UNIT 1 PPA 1

- as the concentration of a reactant increases the rate of collisions increases

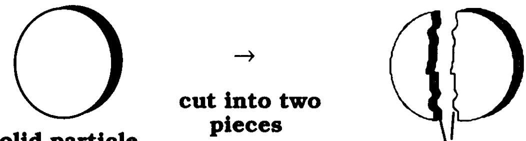


low concentration of reactants → **high concentration of reactants**

- this leads to an increase in the rate of successful collisions and hence reaction rate

(b) Particle size

- as the particle size decreases the surface area increases



solid particle → **cut into two pieces** → **new surfaces exposed**

- collisions can occur on the new surfaces;
  this leads to an increase in the rate of successful collisions and hence reaction rate

(c) Temperature

See
UNIT 1 PPA 2

- the rate of reaction increases as the temperature of the reactants increases
- the effect of temperature on reaction rate cannot just be explained on the basis of an increase in the rate of collisions with a rise in temperature

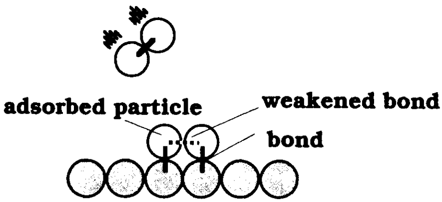
Everyday examples

- there is a risk of explosions in flour mills and coal mines since the dust particles are very small (large surface area)
- bacterial action on food in a freezer is slower than in a fridge and hence it can be kept longer
- an oxyacetylene flame burns at a very high temperature due to the concentration of oxygen

Catalysts

- ❑ a **catalyst** speeds up a chemical reaction
- ❑ a catalyst takes part in the reaction but is **not** used up by the reaction
- ❑ a **heterogeneous catalyst** is one in which the reactants are in a different physical state from the catalyst
- ❑ reactions of gases often involve the use of a solid catalyst,

  e.g. iron in the reaction of nitrogen with hydrogen, platinum in the reaction of ammonia with oxygen, vanadium pentoxide in the reaction of sulphur dioxide with oxygen
- ❑ reactant particles are **adsorbed** on to sites at the surface of the catalyst



- ❑ the bonds in the reactant particles are weakened and the particles are in favourable positions
- ❑ a collision is likely to be more successful than it would have been without a catalyst
- ❑ a reaction takes place and the product particles leave the catalyst surface
- ❑ **catalyst poisoning** can occur if impurities are adsorbed on to the surface of the catalyst taking up sites which could otherwise have been occupied by reactant particles
- ❑ industrial catalysts have to be **renewed** due to poisoning of the catalysts by impurities in the reactant;
  when the catalyst is renewed the 'spent' catalyst is removed and replaced by fresh catalyst
- ❑ some industrial catalysts which have been poisoned can be **regenerated**; this involves 'cleaning' the catalyst by removing impurity from the active sites, usually by heating with a gas which reacts with the impurity,

  e.g. in catalytic cracking, air is used to burn off carbon from the catalyst

Addition polymers

- plastics are made of very long chain molecules; the large molecule is called a **polymer**

- polymers are made by the joining together of small molecules; the small molecule is called a **monomer**

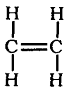
- polymers made from unsaturated monomer units by the opening of carbon to carbon double bonds are called **addition polymers**; the process is called **addition polymersation**

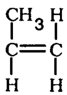
- the name of the polymer is derived from the name of the monomer

Monomer	Polymer
ethene	poly(ethene)
propene	poly(propene)
styrene	polystyrene
vinyl chloride	polyvinylchloride (PVC)

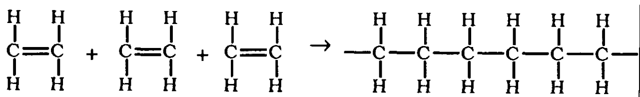
- when thinking about addition polymerisation, it is useful to draw the alkene monomer in the shape of an  with the double bond in the middle,

e.g.

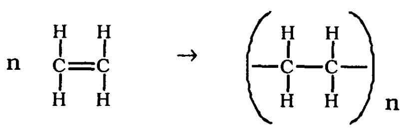

for ethene, CH_2=CH_2


for propene, CH_3-CH=CH_2

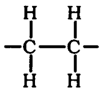
- molecules of ethene (a monomer) can join together by the breaking of the carbon to carbon double bonds to form poly(ethene) (a polymer)



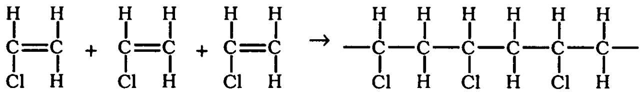
- the polymerisation of ethene can be represented as:



where n is a large number

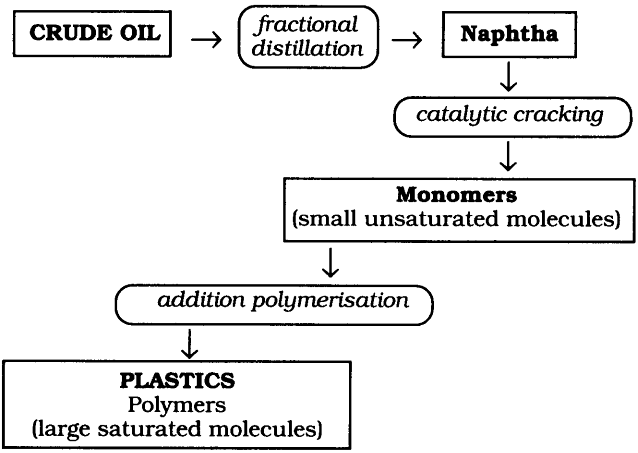
❑  is called the repeating unit

❑ other polymers can be formed in a similar way,
e.g.



vinyl chloride **polyvinylchloride**

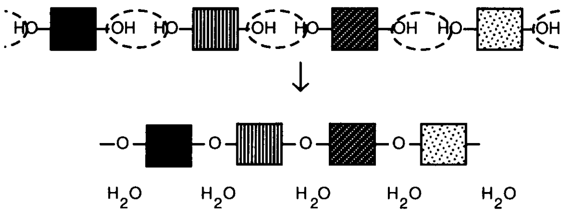
❑ the processes involved in the production of plastics from crude oil are shown in the following flow diagram



Condensation polymerisation

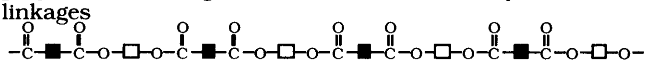
- **condensation polymers** are made from monomers with two functional groups in each molecule; the long chain is built up since condensation can occur at both ends of the molecule

- in **condensation polymerisation** the monomers usually link together by the loss of the elements to make water; a hydrogen atom from one monomer combines with a hydroxyl group from another,
  e.g.



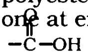
Polyesters

- **polyesters** are long chain molecules with many ester linkages

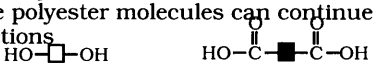


and represent different arrangements of carbon and hydrogen atoms

- polyesters are formed from alcohols with two -OH groups, one at either end of the molecules and acids with two

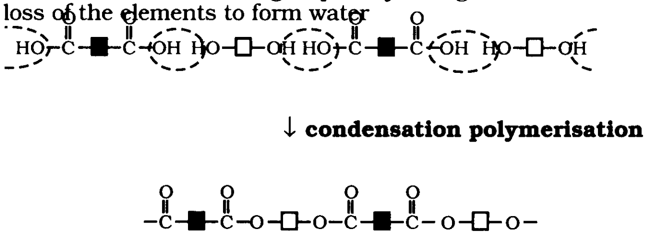


groups, one at either end of the molecules; this means the polyester molecules can continue to grow in both directions



alcohol **acid**

- the acid and the alcohol group can join together with the loss of the elements to form water



Amines

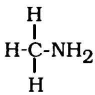
- the **amines** are a homologous series of carbon compounds all containing nitrogen atoms

- the functional group in amines is the **amine** (or **amino**) group (-$\mathbf{NH_2}$)

- each member of the series has a name which ends in -**amine** and a prefix which indicates the number of carbon atoms in the molecule.

e.g.

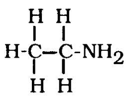
1
methylamine



CH_3NH_2
CH_5N

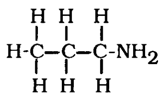
KEY
Number of carbon atoms
Name
Full structural formula
Shortened structural formula
Molecular formula

2
ethylamine



CH_3-CH_2NH_2
C_2H_7N

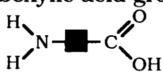
3
propylamine



CH_3-CH_2-CH_2NH_2
C_3H_9N

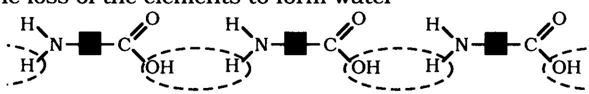
Polyamides

- **polyamides** are formed from molecules with amine groups and carboxylic acid groups

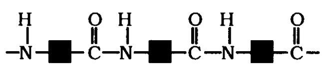


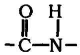
amine group **carboxylic acid group**

- the acidic and the amino groups can join together with the loss of the elements to form water

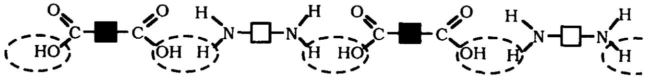


↓ **condensation polymerisation**



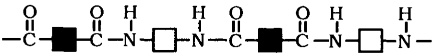
-  the link is called an **amide** link and the polymer is called a polyamide

- nylon is a polyamide that can be made from two different monomer units; one is a diacid and the other is a diamine

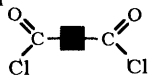


diacid **diamine**

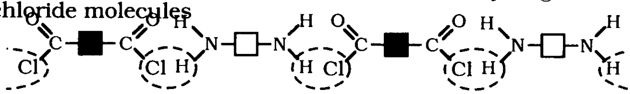
↓ **condensation polymerisation**



- in practice, nylon is made from the chloride of the acid rather than the acid



- the condensation involves the elimination of hydrogen chloride molecules



diacid chloride **diamine**

↓ **condensation polymerisation**