



OYO STATE LECTURE NOTES

CHEMISTRY

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SS 1 FIRST TERM

A field trip to

1. Mummy's kitchen
2. Mechanics workshop
3. Pharmaceutical store
4. Pure water company in your locality
5. Bakery factory
6. Any other factory, production company or industry you could access
7. Garri processing plant
8. Food and confectionery outfits
9. Feed mills
10. Sales outlets and malls around the town

Discuss your observations with your friends or colleagues and let us compare it with what is to be discussed in the subsequent topics.

Be informed that a good detailed observer will be a good chemist and invariably a good scientist.

CHEMICAL INDUSTRIES

- ◆ **Substances** you see all around including the ones you cannot see are made of substance which are called chemicals. While some exists alone others combine. Some others are capable of breaking down to form other ones and some others could rearrange their known arrangement to form other substance
- ◆ **Chemical industries** are industries that use chemical substances at one stage or the other to produce other chemicals. The substance chemical industries used are called raw materials in chemical terms.
- ◆ **Raw materials** are the starting materials used to produce desired products.
- ◆ **Products** are the finished material of an industry

The products of some industries are the raw materials of others

- ◆ **Natural raw materials** are raw materials produced or made available by natural process (es)

Natural raw materials include; air, water, coal, limestone, petroleum, iron ores, sulphur deposits etc.

- ◆ **Synthetic raw materials** are manmade materials produced as starting materials for other product. E.g thread for textile industries. fruits for juice producer, palm kernel oil for soaps, confectionery, cosmetics, industries etc.

Chemical industries can be divided into heavy chemicals and fine chemicals

- ◆ **Heavy chemicals** are chemicals needed in high demand in terms of quantity. These includes tetreoxosulphate (VI), sodium hydroxides, palm kernel oil. And the likes whose input is high in quantity during production. Purity is not a priority during its production.
- ◆ **Fine chemicals** are chemicals needed in small quantity during production process. They are produced in the purest form attainable. Examples are sodium chloride, dye stuff, analytical chemicals, additives, colourant, preservatives, etc

Chemical industries can also be divided into the following according to their products. ★ ★ ★

- ◆ **Glass industries** have their end product as glass of various forms and shapes using sand, sodium hydroxides, clay in intense temperature and catalysts and colourant when needed
- ◆ **Ceramics industries** use clay as base raw materials, sodium chloride as fine chemical in the presence of intense heat
- ◆ **Pharmaceutical industries** use both organic, inorganic and synthetic raw materials and chemicals to produce drugs as preventives and curative. As purgative or sedatives, stimulants etc.
- ◆ **Metallurgical industries** work on ores of metals by extraction processes adding other raw materials where necessary for specific uses and purposes
- ◆ **Fertilizer industries** use inorganic chemicals such as Nitrogen, phosphorus and potassium in predetermined ratios and quantities with other additives. The core mandate of these

industries is to improve and increase the yield of agricultural products with the soil as the contact point

- ▲ **Paints** industries use purely inorganic chemical and pigments to produce their product in different colours with the view to add colour and glamour to other products.

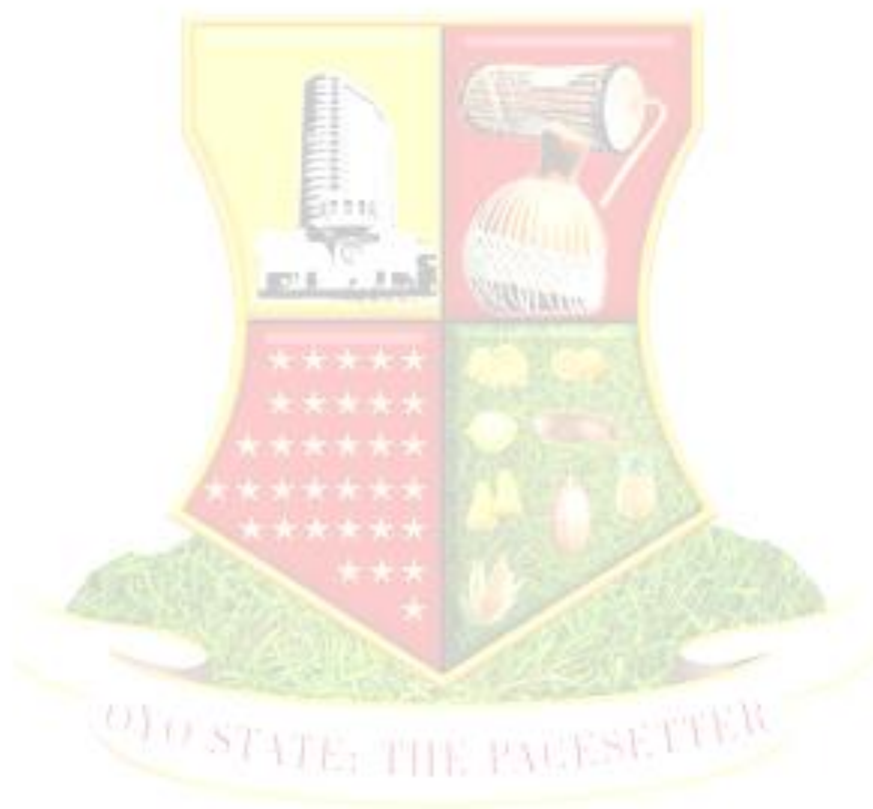
Other divisions are **food and beverages, wood and furniture, confectionery, automobiles, tyre, road and construction industries, soaps and detergents, paints**

Importance of chemical industries

1. they serve as sources of raw materials for other industries
2. they serve as product acquisition point for end users
3. they serve as source of income
4. they serve as employer of labour
5. they serve as research centre
6. they serve as catalyst for quick environmental development
7. they serve as resource centre for educational purposes

Disadvantages of chemical industries

1. Their wastes are sources of sewage, pollution and environmental degradation
2. They depopulate and retard the growth of rural areas
3. The quest for white collar job has shot up the unemployment rate
4. Most are capital intensive



OYO STATE
GOVERNMENT

INTRODUCTION TO CHEMISTRY

DEFINITION Chemistry deals with the study of the composition, the properties of matter and how these elements combine with each other to form more useful ones.

PARTICULATE NATURE OF MATTER

♦ **MATTER** is anything that has mass and occupies a space. Changes occur within and without the matter as a result of the conditions they undergo. These changes are classified as physical and chemical changes.

Physical changes are changes which are easily reversible and do not produce new ones. Example melting of ice. Dissolving ordinary salt or sugar in water and then boiling off the water completely in the presence of heat, magnetization of magnetic materials, etc.

Chemical changes are changes in which the change is permanent in nature. New substances are formed. Example burning of wood, rusting of iron, boiling of egg, etc.

Differences between physical and chemical changes

S/No	Physical change	Chemical change
1.	It is reversible	It is not easily reversible
2.	No new substance is formed	New substance is formed
3.	Minimal heat is sometimes involved	Great amount of heat is involved
4.	Mass remains constant	There is change in mass

CONCEPT OF ATOMS, MOLECULES, AND IONS

Matter is made up of discrete particles called atoms, ions, molecules, elements, compounds.

- ♣ **Atoms:** An atom is the smallest part of an element that can take part in a chemical reaction
- ♣ **Element:** It is a substance which cannot be separated by any physical means
- ♣ **Molecule:** Is the smallest part of any substance that is capable of independent existence.
- ♣ **Ion:** are charged atom, molecule, and compound
- ♣ **Compound:** is the combination of two or more elements chemically joined together
- ♣ **Mixture** is the combination of two or more elements physically joined together

CONSTITUENT OF THE ATOM

Atoms consist of smaller particle called fundamental particles. Three of them are of importance PROTON, NEUTRON, ELECTRON.

- ♣ **Proton** is the positive particle in an atom with a mass equal to that of Hydrogen atom using carbon-12 isotope scale
- ♣ **Neutron** is the electrically neutral part of the atom with a mass also equal to that of the Hydrogen atom
- ♣ **Electron** is the negative part of an atom with a mass of $1/1840$ to that of proton

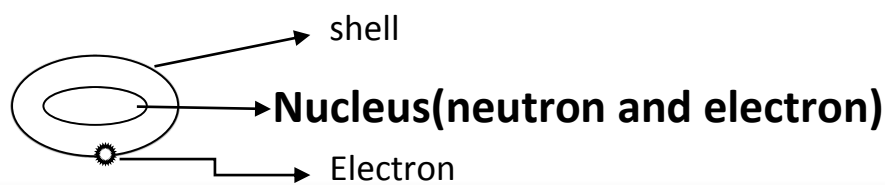
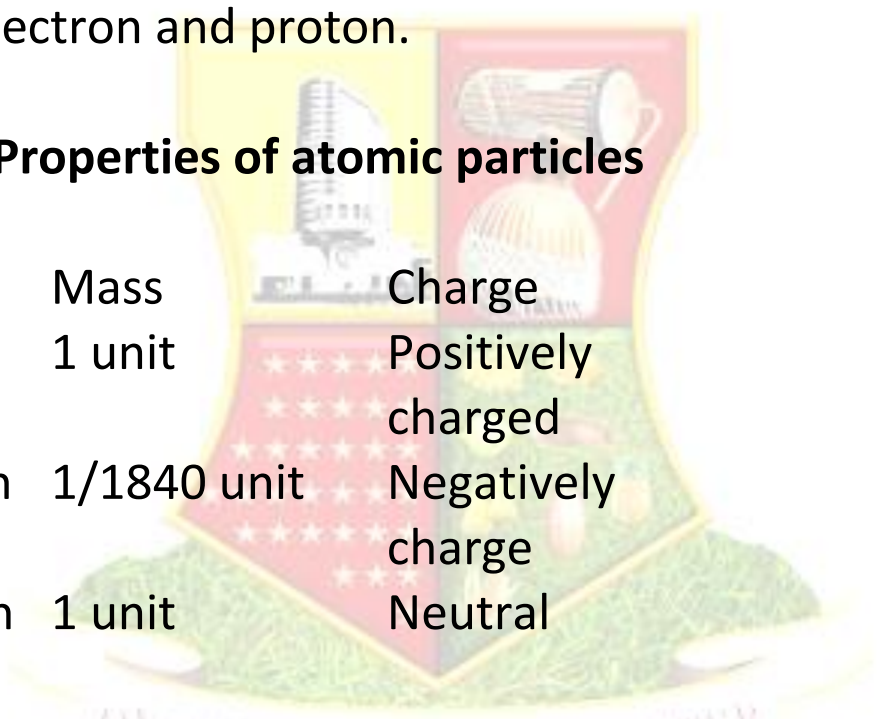


Fig. 1 Diagram of an atom

Rutherford 1906 posits that proton and neutron are found in the nucleus of an atom making the nucleus to be positively charged. Electron is found on the orbit or shell of the atom surrounding the nucleus.

Atom is electrically neutral because they contain the same number of electron and proton.

Table 2 Properties of atomic particles



Particle	Mass	Charge
Proton	1 unit	Positively charged
Electron	1/1840 unit	Negatively charge
Neutron	1 unit	Neutral

DALTONS ATOMIC THEORY

- ◆ All matter are made up of tiny indivisible particle called atoms.
- ◆ Atom can neither be created nor destroyed.
- ◆ Atoms of the same element have the same properties and the same mass
- ◆ Atoms of different element have different mass and different properties.
- ◆ When atoms combine with each other they do so in simple whole number ratio.

Electronic configuration is the arrangement of electron on the shell around the nucleus. Niel Bohr 1913 posits that the electrons in an atom revolve around the nucleus.

Niels Bohr 1913 suggested that electrons revolve round the nucleus on shells or orbits that contains the proton and the neutron

- ◆ The shells are designated with alphabets from the innermost as K,L,M,N,O, etc
- ◆ The shells are associated with defined energy content with K shell having the lowest energy content
- ◆ The shells can also be represented with energy level (n) where K,L,M,N,O are designated as $n = 1, 2, 3, 4, 5$
- ◆ Using the formula $2n^2$, where n is the shell number; the maximum number of electron a shell will contain can be calculated.
- ◆ K- Shell with n is 1 will contain a maximum of two electrons. i.e. $2 \times 1^2 = 2$, when n is 2, M-shell become $2 \times 2^2 = 8$ etc.

ATOMIC NUMBER, MASS NUMBER AND ISOTOPE

- ◆ **ATOMIC NUMBER** is the number of proton or electron an atom contain.
- ◆ **MASS NUMBER** is the total number of protons and/plus the number of neutrons in an atom.

Proton and neutron has 1 unit each and are concentrated at the centre in the nucleus of the atom, with electron around the shell. Atomic number is used to arrange the electron on the shell while the number of proton and neutron determines the weight of the atom.

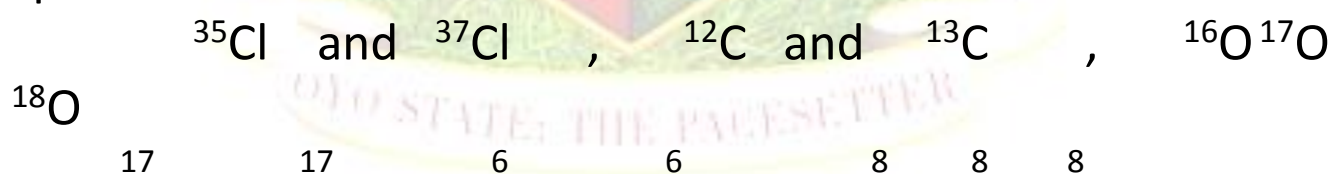
From Dalton's theory it is possible for atoms to have different number of neutron, hence different mass number. For neutral atom the number of proton and the electron is the same.

- ♦ **Isotopes** are atoms of the same element having the same atomic number but different mass number. This is due to the number of neutron they contain
- ♦ Isotopy is a phenomenon or the ability of an atom of the same element to have different mass number.

Isotopes have the same chemical properties since they have same number of electrons but their physical properties are different because of different number of neutron

Chemical X can be represented as A_ZX where A is the mass number and z is the atomic number

Example



* **Relative atomic mass of element (A_r)** : with the existence of isotopy in elements there arose the need to measure the mass of element in relative term with the view to obtain the average mass of respective elements. Relative atomic mass could be obtained using carbon -12 scales.

* **Relative molecular mass (M_r)**: is the sum of the relative atomic masses of elements that makes up the molecules of the substance or compound

Example (A_r Cl=35.5, H=1, Na=23, S=32, O=16, C=12, Ca=40, Mg=24)

$$\begin{aligned} M_r \text{ for NaCl} &= A_r \text{ Na} + A_r \text{ Cl} \\ &= 23 + 35.5 = 58.8 \text{ g/mol.} \end{aligned}$$

$$\begin{aligned} M_r \text{ for MgSO}_4 &= M_r \text{ Mg} + M_r \text{ S} + 4M_r \text{ O} \\ &= 24 + 32 + (4 \times 16) = 120 \text{ g/mol.} \end{aligned}$$

$$\begin{aligned} M_r \text{ for Ca(HCO}_3)_2 &= M_r \text{ Ca} + 2M_r \text{ H} + 2M_r \text{ C} + 6M_r \text{ O} \\ &= 40 + (2 \times 1) + (2 \times 12) + (6 \times 16) \\ &= 40 + 2 + 24 + 96 \\ &= 162 \text{ g/mol.} \end{aligned}$$

Note M_r & A_r have no unit

SYMBOLS, FORMULAE AND EQUATIONS

Brezelius in 1814 proposed the modern symbols being used on the periodic table. This involved the use of the letter or letters of the name of the respective elements; which could be English name, Latin, Greek, or as obtained. This also involved using capital letter for the first letter of the alphabets for the name of the element or the first letter and any other letter within the letters of the name of the element

Table 3. Names of the first 30 elements on the periodic table and their symbols

Hydrogen **H**

Helium He

Lithium Li

Beryllium Be

Boron B

Carbon C

Nitrogen N

Oxygen O

Fluorine F

Neon Ne

Sodium Na

Magnesium Mg

Aluminum Al

Silicon Si

Phosphorus P

Sulphur S

Chlorine Cl

Argon Ar

Potassium K

Calcium Ca

Scandium

Sc

Titanium **Ti**

Vanadium **V**

Chromium **Cr**

Manganese **Mn**

Iron **Fe**

Cobalt **Co**

Nickel	Ni
Copper	Cu
Zinc	Zn

Valences for an element are the combining power of an element: This is the combining power of an element during a chemical reaction. In a simple term it is the number of electron an element is willing to accept or donate during a chemical reaction. Some elements are capable of exhibiting more than one valency e.g Iron (Fe), Cu, Sn, Pb etc.

Table 4 Examples of element and their valencies

Element	Valency	Element	Valency	Element	Valency
H	1	Mg	2	zn	2
Na	1	Ca	2	Pb	2,4
Cl	-1	Al	3	Mn	2,4,5,7
O	-2	Sn	2,4	Cu	1,2

Table 5 compound names and formulae

Name of compound	chemical formula	Name of compound	Chemical formula
Sodium chloride	NaCl	Water	H ₂ O
Carbon Iv oxide	CO ₂	Magnesium hydroxide	Mg(OH) ₂

Calciumtrioxocarbonate (Iv)	CaCO_3	Aluminum sulphate	$\text{Al}_2(\text{SO}_4)_3$
Zinc (II) Oxide	ZnO	Tin (Iv) oxide	SnO_2

Table 6 differences between a mixture and a compound

Mixture

It is either homogenous or heterogeneous

Constituents are physically combined together

Constituents can be combined in any ratio

Their properties are the sum of the individual constituents

Compound

It is always homogenous

Constituents are chemically joined together

Constituents have fixed ratio for combination

Their properties differ from that of the constituents

CALCULATIONS

Calculation of relative atomic mass of isotopic elements from % abundance

1. Given that C-12 has % abundance of 98.9% and C-13 has 1.1% calculates its relative atomic mass
2. Chlorine 35 =75%, and chlorine 37=25% calculate its relative atomic mass

Solutions :

1. relative atomic mass of carbon =

(Atomic mass X % abundance of C-12) + (atomic mass X % abundance of C-13)

$$\begin{aligned} & \frac{12 \times 98.9}{100} + \frac{13 \times 1.1}{100} \\ &= 11.868 + 0.143 \\ &= 12.011 \end{aligned}$$

2. relative atomic mass of chlorine =
(Atomic mass X % abundance of Cl-35) + (atomic mass X % abundance of Cl-37)

$$\begin{aligned} & \frac{35 \times 75}{100} + \frac{37 \times 25}{100} \\ &= 26.25 + 9.25 \\ &= 35.5 \end{aligned}$$

Calculation involving percentage composition of elements in a compound

Example : Calculate the molecular mass of each of the following compounds the percentage composition by mass of each of the elements in their respective compounds

i. NaOH

ii. H₂SO₄

iii. Ca(OH)₂

iv. Al₂(SO₄)₃

Na =23, O=16, H=1, S=32, Ca=40, Al=23,

Solution

$$\begin{aligned} \text{I. } M_r \text{ of NaOH} &= \text{Na} + \text{O} + \text{H} \\ &= 23 + 16 + 1 \\ &= 40 \text{ g mol}^{-1} \end{aligned}$$

$$\begin{aligned}
 \text{ii. } M_r \text{ of } \text{H}_2\text{SO}_4 &= 2\text{H} + \text{S} + 4\text{O} \\
 &= (2 \times 1) + 32 + (4 \times 16) \\
 &= 2 + 32 + 64 \\
 &= 98 \text{g mol}^{-1}
 \end{aligned}$$

$$\begin{aligned}
 \text{iii. } M_r \text{ of } \text{Ca(OH)}_2 &= \text{Ca} + 2\text{O} + 2\text{H} \\
 &= 40 + (2 \times 16) + (2 \times 1) \\
 &= 40 + 32 + 2 \\
 &= 74 \text{g mol}^{-1}
 \end{aligned}$$

Calculation of % compositions of elements in a compound

$$\begin{aligned}
 \% \text{ of Na in NaOH} &= \frac{\text{Na}}{\text{NaOH}} \times \frac{100}{1} \\
 &= \frac{23}{40} \times \frac{100}{1}
 \end{aligned}$$

* **Empirical Formula:** shows the simplest whole number ratio of the atoms present, e.g.

C_2H_6 ; C:H ratio is 1:3. and could be written simply as CH_3

Calculation the Empirical Formula of a Compound

Find the empirical formula of an oxide of magnesium consisting of 0.32g of oxygen and 0.96g of magnesium. (Mg=24, O=16)

Step 1: find the number of moles of the 2 elements. $n(\text{Mg}) =$

Mole = mass / atomic mass

$$\text{Mg} = 0.96\text{g} / 24$$

$$= 0.04 \text{mol.}$$

$$\text{O} = 0.32\text{g} / 16$$

$$= 0.02 \text{mol.}$$

Step 2: Divide the moles by the smallest number.

$$\text{Mg} = 0.04/0.02 = 2$$

$$= 0.02/0.02 = 1$$

Therefore, the empirical formula is Mg_2O

Calculating the Empirical Formula from Percentage Composition

An oxide of sulphur consists of 40% sulphur and 60% oxygen.

(S=32, O=16)

Note the total composition is usually taking as 100%.

Step 1: find the number of moles of the 2 elements.

S = % composition / atomic mass

$$= 40/32$$

$$= 1.25 \text{ mol.}$$

$$\text{O} = 60/16$$

$$= 3.75 \text{ mol.}$$

Step 2: Divide the moles by the smallest number

$$\text{S} = 1.25/1.25$$

$$= 1$$

$$\text{O} = 3.75/1.25$$

$$= 3$$

Therefore, the empirical formula is SO_3

Molecular formula is the formula indicating the actual number of atoms of element present in a compound.

Being given the molecular mass of a molecule or a compound, the molecular formula could be calculated using its empirical formula

Example A compound has an empirical formula of CH_2 and a molecular mass of 42 g mol^{-1} find its molecular formula

Solution

Empirical formula $\times n$ = Molecular formula

Where n = is the multiplying factor

$$(\text{CH}_2)_n = 42 \text{ g mol}^{-1}$$

$$[12 + (1 \times 2)] \times n = 42 \text{ g mol}^{-1}$$

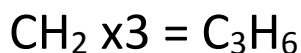
$$(12 + 2) \times n = 42 \text{ g mol}^{-1}$$

$$14n = 42$$

$$n = 42/14$$

$$n = 3$$

Therefore molecular formula is empirical formula multiplied by 3



LAWS OF CHEMICAL COMBINATION

- ♣ **LAW OF CONSERVATION OF MASS** states that matter can neither be created nor destroyed in the course of a chemical reaction.
- ♣ **LAW OF CONSTANT COMPOSITION** states that all pure samples of the same chemical compounds no matter their method of preparation will contain the same elements and will combine in the same proportion by mass.
- ♣ **LAW OF MULTIPLE PROPORTION** states that when two elements A and B combined together to form more than one compound then the several masses of A which combined with a fixed mass of B are in simple ratio.

SS 1 SECOND TERM

ELECTRONIC CONFIGURATION AND CHEMICAL COMBINATION

The chemical behaviors of elements, atoms, compounds etc. are determined by the electronic configuration which is the arrangement of the particles on the shell of an atom.

Table of the **Electronic configuration of the first 30 elements**

ELEMENTS	SYMBOLS	ATOMIC NUMBER	Electron distribution
Hydrogen	H	1	1
Helium	He	2	2
Lithium	Li	3	2,1
Beryllium	Be	4	2,2
Boron	B	5	2,3
Carbon	C	6	2,4
Nitrogen	N	7	2,5
Oxygen	O	8	2,6
Fluorine	F	9	2,7
Neon	Ne	10	2,8
Sodium	Na	11	2,8,1
Magnesium	Mg	12	2,8,2
Aluminum	Al	13	2,8,3
Silicon	Si	14	2,8,4
Phosphorus	P	15	2,8,5
Sulphur	S	16	2,8,6
Chlorine	Cl	17	2,8,7
Argon	Ar	18	2,8,8
Potassium	K	19	2,8,8,1
Calcium	Ca	20	2,8,8,2

CHEMICAL COMBINATION during a chemical reaction valence electrons are exchanged.

✦ **Electrovalent bond (Ionic Bond)** is the transfer of electron during a chemical reaction.

An element **donates** while another one **accepts** for the bonding to take place

Metallic ion donates electron while acidic radical accepts the electron. This is done with the view to obey the octet or duplet configuration of their outermost shell and is thus held together by a strong electrostatic force of attraction. i.e

Sodium atom loses electron to become positively charged sodium ion



On the other hand chlorine atom gains the lost electron to become negatively charged ion.



The complete reaction is written as



In electronic and atomic term

	Before combination	After combination
Name of atom	Sodium chlorine atom atom	Sodium chlorine Ion (+) ion (-)

Proton	11	11
Electron	17	17
	11	10
	17	18
Electronic configuration	2,8,1	2,8
	2,8,7	2,8,8

- ♦ **COVALENT BOND** involves sharing of the bonding electrons donated by the atoms involved in the chemical bonding process. This occurs when elements of relative electro negativity pair together
Molecules are formed.

There is no electrostatic force between the combining atoms,

table 8 Differences between electrovalent and covalent compound

PROPERTY	Electrovalent compound	Covalent compound
Melting point	High ; more than 250°C	Low; less than 250°C
Boiling point	High ; more than 500°C	Low less than 500°C
Electrical conductivity	Good conductor in molten or aqueous form	Usually non conductor
Solubility in water	Usually soluble	Usually insoluble
Solubility in organic solvent	Usually insoluble	Usually soluble

- ♣ **COORDINATE COVALENT BOND (DATIVE BOND)** this type of bond involved the sharing of a pair of electron called “**LONE PAIR ELECTRON**” donated by only one of the reacting atoms
- ♣ **METALLIC BOND** this is a strong force of attraction created by formation of electron cloud as a result of the valence electron in the positive nuclei of metals

- ♣ **Van der waal force of attraction** is a weak intermolecular force of attraction that exists between gaseous molecules

Vander waal force could be polar when the atoms forming the molecule do not have the same electro negativity and the bonding electrons are not equally shared. The bond becomes polar (dipole). Example HCl

Van der waal force could also be non polar when the atoms of the molecule have the same electronegativity value. The electrons are equally shared between the bonding atoms. The molecules formed are called non polar molecules. **E.g Cl₂, H₂, O₂**

- ♣ **HYDROGEN BOND** these are strong intermolecular force of attraction that occur between hydrogen and the high electronegative element in the molecules. This force is in addition to the Vander waal force in the molecules

Hydrogen Bond impart the following characteristics to their molecules

High melting and boiling point

High surface tension

Excellent solvent

High latent heat of vapourization

STATES OF MATTER

Matter exists in three form as solids, liquids and gases.

SOLIDS

- *Have fixed volume
- * fixed shape
- *they are incompressible
- *they do not flow

LIQUIDS

- *Have fixed volume
- *no fixed shape
- * takes the shape of container
- * Incompressible
- * flow easily

GASES

- *have no fixed volume
- *no fixed shape,
- * Compressible
- * flow in all direction

The Kinetic Particle Theory of Matter

- ◆ All particles move randomly and continuously in a straight line
- ◆ The particles are of negligible in size and volume
- ◆ The intermolecular force of attraction between the gaseous molecules are negligible

- ♣ Collisions between particles are elastic. i.e energy is conserved
- ♣ The average kinetic energy of all particles is directly proportional to absolute temperature

APPLICATION OF KINETIC THEORY OF MATTER

DIFFUSION is the spreading and mixing of particles in gases and liquids.

Diffusion of gases Bromine drops are placed into a jar. Another jar full of air is placed on top of jar with bromine, separated with cover. Cover is removed and bromine evaporates, filling both jars with dense reddish-brown bromine vapour.

Explanation: Bromine particles move from lower jar into spaces between air particles in upper jar. At the same time, air particles move down from upper jar to mix with bromine particles in lower jar. Eventually, bromine and air particles are mixed completely.

Diffusion of liquids

CuSO_4 crystals placed in beaker of water, blue particles of the crystals are spread throughout the water to form uniformly blue solution.

Factors Affecting Rate of Diffusion

- ♣ **Temperature** The higher the temperature, the more particles of matter absorb energy making them move faster, the higher the rate of diffusion; the lower the temperature, the slower the rate of diffusion
- ♣ **Mass of particles** Greater mass, the slower it diffuses; Smaller mass, the faster it diffuses A cotton soaked in

aqueous ammonia and another soaked in hydrochloric acid are placed on opposite sides of the tube. NH_3 vapor and HCl vapour diffuse in the tube and a compound is produced inside the tube closer to HCl soaked cotton as the particles are heavier. The greater the mass, the slower particles diffuse. The smaller the mass, the faster particles diffuse.

- ♦ **SOLID particles** are packed close together in orderly arranged manner such that space between them are negligible. They can vibrate but cannot move freely about their fixed position

Particles in liquid are packed closely but not orderly arranged. They have little empty spaces between them than in solid particles. They are not held fixed but free to move throughout liquid particles

Particles in gas are far apart and in random arrangement. They are free to move anywhere in the container

- 1. Melting** is change from solid to liquid by absorbing heat to break force of attraction holding particles together. The temperature at which solid melts to liquid is melting point
- 2. Freezing** is the change of liquid to solid by cooling down of liquid. Freezing point is the temperature at which liquid freezes.
- 3. Boiling** is the change of liquid to gas by absorbing heat to break the forces holding them together. It is the temperature at which liquid boils.
- 4. Evaporation** is change of liquid to gas without boiling, this occurs below boiling point on water surface. It gives cooling effect. Heat energy is absorbed from surroundings.

5. Condensation is the change of gas to liquid. Heat energy is given out as gas particles slow down and move closer to one another to form liquid.

6. Sublimation is the change of solid to gas without melting. Heat is absorbed.

GASEOUS STATE AND GAS LAWS

Gas laws deals with the relationship between the Temperature (T), Pressure (P) and Volume (V) of gases.

Boyle's law states that the volume of a fixed mass of gas is inversely proportional to its pressure at constant temperature. That is when temperature is not changing, the volume of a given gas increases as the pressure decrease and vice versa

$$V \propto \frac{1}{P} \quad \text{i.e. } P \times V = K$$

Where V = volume, P = pressure and K = mathematical constant

Graphical representation of the Boyle's law

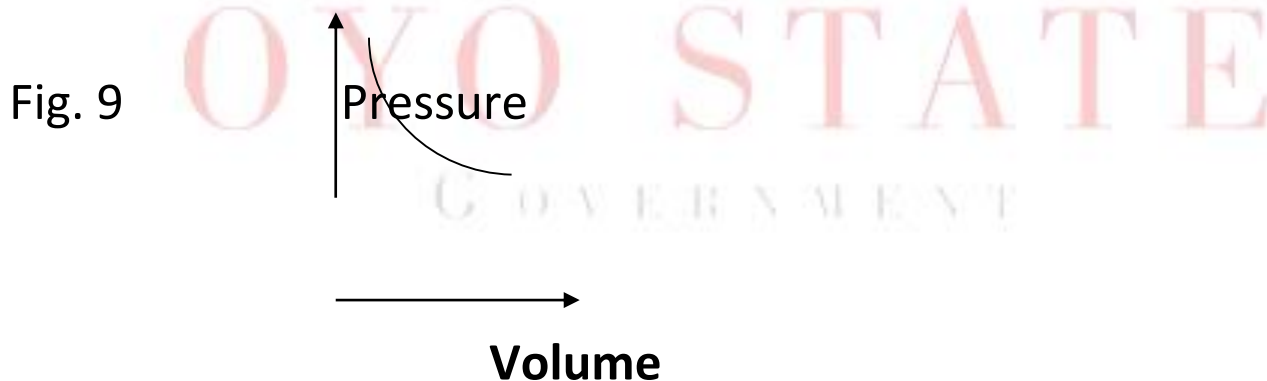
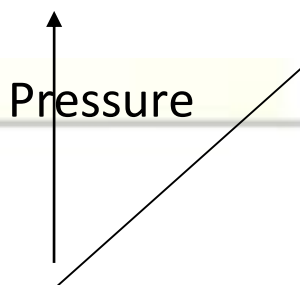


fig.10



1/volume

Charles' Law states that the volume of a given mass of gas is directly proportional to its absolute temperature at constant pressure

$$V \propto T$$

i.e $V / T = \text{constant}$

Fig.11

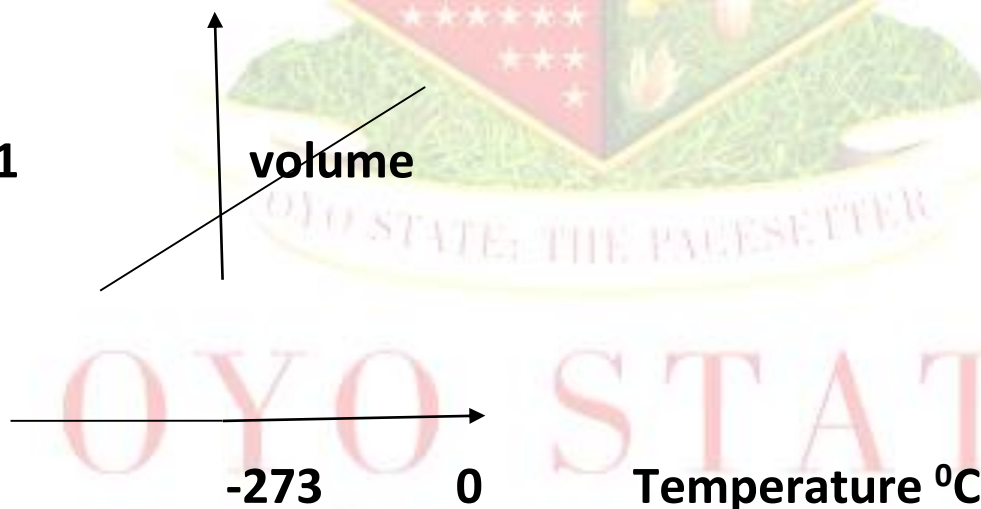
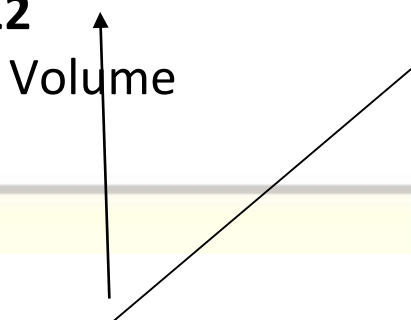



Fig. 12




 Temperature (Kelvin)

General Gas Law has no definition statement rather it deals with change in pressure and volume of a gas at a constant temperature from initial to final. And the change in volume and temperature at constant pressure from initial to final. It is the combination of Boyles and Charles law

P_1 to P_2 initial pressure to final pressure

V_1 to V_2 initial volume to final volume

T_1 to T_2 initial temperature to final temperature

Thus at constant temperature

$$P_1 V_1 = P_2 V_x$$

$$V_x = P_1 V_1 / P_2 \quad \text{.....eqn 1 from Boyle's law}$$

At constant pressure

$$V_x / T_1 = V_2 / T_2$$

$$V_x = V_2 T_1 / T_2 \quad \text{.....eqn. 2 from Charle's law}$$

If P_x in eqn 1 = P_x in eqn 2 then

$$P_1 V_1 / P_2 = V_2 T_1 / T_2$$

$$P_1 V_1 / T_1 = P_2 V_2 / T_2$$

Dalton's law of partial pressure states that the total pressure exerted by a mixture of gases at constant temperature is equal to the sum of the pressures each gas in the mixture will exert if alone.

$$P_T = p_1 + P_2 + P_3 + \text{.....} + P_n$$

P_T = total pressure, P_1 to P_n = partial pressures

Grahams Law of diffusion states that the rate of diffusion of gases at constant temperature and pressure is inversely proportional to the square root of their densities.

$$R_1 / R_2 = \sqrt{d_2} / \sqrt{d_1}$$

Where R_1 and R_2 are initial and final rate,
and d_1 and d_2 are initial and final density respectively

$$R_1/R_2 = \sqrt{M_2}/\sqrt{M_1}$$

M_1 and M_2 are initial and final mass or relative molecular mass

Remember, density is mass per volume (v)

$$d = m/v$$

$$R_1/R_2 = \sqrt{V_1} / \sqrt{V_2}$$

Gay lussac's Law of combining volume

Gay lussac's Law states that when gases react they do so in volumes which bear simple whole number ratio to one another and to the volumes of the products if gaseous, temperature and pressure being constant.

Avogadro's Law states that equal volume of all gases at the same temperature and pressure contain the same number of molecules irrespective of their physical and chemical properties.

Avogadro's constant (N_o) = 6.02×10^{23} that represent the number of particles of any gas in 22.4dm^3 at a standard temperature of 273K and pressure of 760mmHg .

Avogadro's constant allows for calculations of pure substances in moles involving stoichiometric principles. With this the molecular

masses of gases can be calculated by comparing the masses of equal volume of gases

Calculations based on gas laws

Molar Volume of Gas is the volume occupied by one mole of gas. All gases at room temperature and pressure (r.t.p) has a volume of 22.4dm^3 or 22400cm^3 where $1\text{dm}^3 = 1000\text{cm}^3$

Formula: Volume of a gas = Number of moles (n) x Molar volume (M_v)

e.g. What is the number of moles of 240cm^3 of Cl_2 at r.t.p?

$$\begin{aligned} n &= \text{volume} / M_v \\ &= 240 / 22400 \\ &= 0.0107 \text{ mol.} \end{aligned}$$

Molar Volume and Molar Mass

e.g. Find the volume of 7g of N_2 gas at r.t.p. ($N = 14$)

Step 1: Find the number of moles from the mass of nitrogen

$$\begin{aligned} n &= \text{mass} / \text{molar mass} \\ &= 7 / 28 \\ &= 0.25 \text{ mol} \end{aligned}$$

Step 2: Find the volume of nitrogen, now with formula of gas 0.25 mol =

$$\begin{aligned} \text{Volume of gas} &= 0.25 \text{ mol} \times 22.4 = 5.6 \text{ dm}^3 \\ &(\text{or } 5600\text{cm}^3) \end{aligned}$$

Concentration of solutions tells the number of solute in a given volume of solution. Concentration (C)

Calculating the Amount of Solute

$$\text{Moles of solute (n)} = \text{Concentration (C)} \times \text{Volume of solution in (dm}^3\text{)}$$

E.g. what is the mass of solute in 600cm^3 of 1.5 Molar NaOH solution?

Volume of solution in $\text{dm}^3 = 0.60\text{ dm}^3$

$n = 1.5 \times 0.60 = 0.9\text{ mol}$

Mass = $0.9 \times 40 = 36\text{g}$

STANDARD SEPERATION TECHNIQUES FOR MIXTURES

Methods of Purification and Analysis

* **Pure substance** contain single substance and is not mixed with anything else

e.g white sugar, copper sulfate crystals, distilled water

* **Mixture** contains two or more constituents which can easily be separated by physical method.

E.g: seawater (salt, water & dissolved solids), milk (fats & dissolved solids)

How to Obtain Pure Substance

Purification is separation process of mixtures into pure substances by using physical methods without chemical reactions.

Filtration is the process of separating insoluble solid from a liquid.-

Mixture is poured through a filter with tiny holes made of paper.- Large solid particles cannot pass through the pores and trapped in it as residue while tiny liquid particles pass through as filtrate.

Crystallization is the separation of dissolved solid from a solution in form of crystals

Evaporation to Dryness is the separation of dissolved solid from a solution as crystals of salt by evaporating all the liquid off.

Sublimation is the separation of a mixture of solids in which one of it sublimates (by heating the solid mixture to turn one of the substances into vapour without going through liquid state). When mixture of iodine and sand is heated, iodine sublimates (turns into vapour directly) then cools and crystallize when it reaches cold surface

Examples of sublimable solids:

Solid CO_2

Dry solid FeCl_3

Dry solid AlCl_3

Simple Distillation is the separation of pure liquids of wide range of boiling point from a solution by condensing vapourised liquid. Condensed pure liquid is called distillate.

Process of Distillation: Solution is heated, and steam (pure vapour) is produced. The steam is cooled in condenser to form pure liquid. Solute remains in the flask

Fractional Distillation separates mixture of miscible (soluble) liquids with closed range of boiling points. Use of Fractionating column
 Process of Fractional Distillation: E.g. ethanol and water
 Mixture of ethanol and water is placed in flask and heated. Ethanol with lower boiling point boils and vaporizes first and reach fractionating column then cools and condenses into ethanol as it passes through condenser. Temperature will stay constant until all ethanol is distilled. Water will distil the same way after all ethanol is distilled.

* **Separating Funnel** is used to separate immiscible liquids. Two liquids insoluble in each other will create two layers of overlying

liquids of each type. To separate, take the stopper off and turn the tap on to run the denser liquid at the bottom off the funnel and leave the less dense liquid in the funnel by turning the tap off and reset the stopper at its original position.

* **Chromatography** a method of separating and identifying mixtures. Chromatography is used to Separate and identify mixtures of coloured substances in dyes into its components.

e.g Separating substances in urine, drugs & blood for medicinal uses.

To find out whether athletes have been using banned drugs

Separating Mixtures of Coloured Substances

Obtain a dye sample then put a drop of the sample on a pencil line drawn on the filter paper then dip the paper into a solvent with the level below the spot. The dye will dissolve in solvent and travel up the paper at different speed. Hence they are separated.

Identifying Mixtures of Coloured Substances

Characteristics of Pure and impure Substances

2. Pure substances have FIXED MELTING AND BOILING POINTS.

Pure water boils at 100°C and melts at 0°C .

3. Impure substances have NO FIXED MELTING AND BOILING POINTS.

Impure substance melts and boils at a RANGE OF

TEMPERATURES. e.g. starts boil at 70°C , completes boil at 78°C

ACIDS, BASES AND SALTS

Acids : Arrhenius defined an acid as a substance which when in water produces Hydrogen ion (H^+) as the **only** positive ion

Ethanoic acid found in vinegar and tomato juice

Citric acid found in citrus foods like lemons, oranges and grapefruit

Lactic acid found in sour milk and yoghurt, and in muscle respiration

Tartaric acid found in grapes

Tannic acid found in tea and ant's body

Formic acid found in bee stings

Hydrochloric acid found in stomach juices

3 common laboratory acids called Mineral acids includes

Hydrochloric acid (HCl)

Tetraoxosulphate (VI) acid H_2SO_4

Trioxonitrate (V) acid HNO_3

Dilute acids are solution containing small amount of acid dissolved in water

Concentrated acids are solution containing large amount of acid dissolved in water

Physical Properties of Dilute Acids

Acids have a sour taste

Acids are hazardous

acids are irritants (they cause skin to redden and blister)

turn blue litmus paper to red

CHEMICAL PROPERTIES OF AN ACID

Acids react with metals

Acids react with metals to produce hydrogen gas. The gas is tested with a

Burning/glowing splint which shows hydrogen burns with a 'pop' sound.



Acids react with trioxocarbonate (IV) and hydrogentrioxocarbonate (IV)

Carbon(IV)oxide is to be formed. To test this, the gas produced is bubbled into limewater which forms a white precipitate.

trioxocarbonate (IV):



hydrogentrioxocarbonate (IV):



Acids react with bases to form salt and water only

Metal oxides and hydroxides react slowly with warm dilute acid to form salt+water



Uses of Acids

Tetraoxosulphate (VI) Acid - Used in car batteries production

Manufacture of ammonium sulphate for fertilizers-

Manufacture of detergents, paints, dyes, artificial fibres & plastics

Hydrochloric acid can remove rust (iron (III) oxide) which dissolves in acids

Acids are used in preservation of foods (e.g. ethanoic acid)

Hydrogen Ions

Hydrogen gas is formed by acids as $H^+(aq)$ ions present in the acid solutions.

This means when acids dissolved in water, they produce H^+ ions in it .

Chemical equation: $HCl(s) + \text{water} \rightarrow HCl(aq)$

Ionic Equation: $HCl(s) + \text{water} \rightarrow H^+(aq) + Cl^-(aq)$

*Note that for ionic equation only aqueous solutions are ionized

*However when dissolved in organic solutions, they don't show acidic properties

When metals react with acids, only the hydrogen ions react with metals, .

Chemical equation:

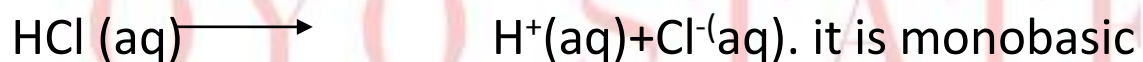


Ionic equation:

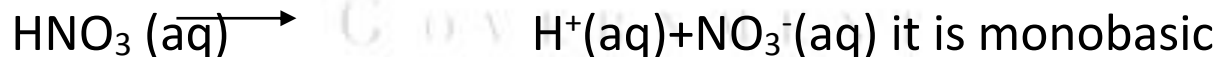


Basicity of an acid is the maximum number of H^+ ions produced by a molecule of acid in a chemical reaction

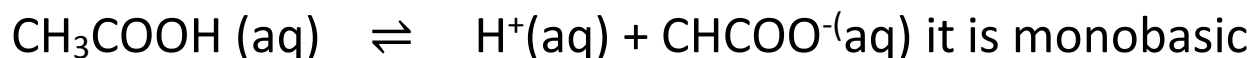
Hydrochloric acid



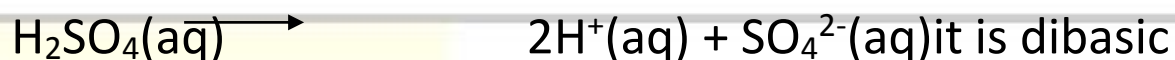
Trioxonitrate (V) acid



Ethanoic acid



Tetraoxosulphate (VI) acid



Strong and Weak Acids

Strong Acids are acids that completely ionize in water. This reaction is irreversible. E.g.

The mineral acids (H_2SO_4 , HNO_3 , HCl)

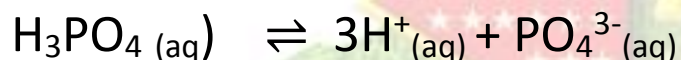


In the above equation SO_4^{2-} is completely ionized in water, forming in 3 kinds of particles:-

- i. H^+ ions ii. SO_4^{2-} ions iii. H_2O molecules

Strong acids react more vigorously with metals than weak acids, hydrogen gas bubbles are produced rapidly.

Weak Acids are acids that partially ionize in water. The remaining molecules remain unchanged as acids. Their reactions are reversible. E.g.



Note Weak acids react slowly with metals than strong acids hydrogen gas bubbles are produced slowly.

Comparing Strong and Weak Acids with Concentrated and Dilute Acids

CONCENTRATION STRENGTH OF ACIDS

Is the amount of solute (acids) dissolved in 1 dm^3 of a solution. i.e how much ions can be dissociated in to from acid or alkali. It can be diluted by adding more water to solution or concentrated by adding more solute to solution. The strength cannot be change. Comparing 10 mol/dm^3 and 0.1 mol/dm^3 of hydrochloric acids and 10 mol/dm^3 and 0.1 mol/dm^3 of ethanoic acids.

10 mol/dm^3 of ethanoic acid solution is a concentrated solution of weak acid

0.1 mol/dm³ of ethanoic acid solution is a dilute solution of weak acid- 10 mol/dm³ of hydrochloric acid solution is a concentrated solution of strong acid-0.1 mol/dm³ of hydrochloric acid solution is a dilute solution of strong acid.

* **Bases** are oxides or hydroxides of metals

* **Alkalis** are bases which are soluble in water

Laboratory Alkalis

Potassium Hydroxide, KOH

Sodium Hydroxide, NaOH

Aqueous Ammonia, NH₄OH

Calcium Hydroxide, Ca(OH)₂

All alkalis produce hydroxide ions (OH⁻) when dissolved in water. Hydroxide ions give the properties of alkalis.

They do not behave as bases in the absence of water.

Alkalis are therefore substances that produce hydroxide ions, OH⁻ (aq) in water.

Physical Properties of Alkalis

Alkalis have a slippery and soap feel

Alkalis are hazardous as well

Dilute alkalis are irritants

Concentrated alkalis are corrosive and burn skin (**caustic** (i.e. burning)**alkalis**)-

Alkalis turn common indicator red litmus to blue

Chemical properties of Alkalis

Alkalis react with acids. The reaction is called **neutralization reaction**

Alkalis react with ammonium compounds

They react with heated solid ammonium compounds to produce ammonia gas



* **Alkalis are precipitating agent.** Alkalis react with salt solution to precipitate metallic hydroxides

e.g

$\text{BaSO}_4(\text{aq})$, contains $\text{Ba}^{2+}(\text{aq})$ ions



The solid formed is a precipitate

And the reaction is called precipitation reaction

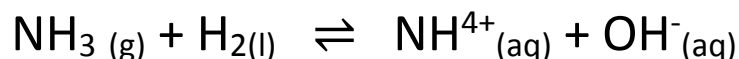
Strong and Weak Alkalis

Strong Alkalis- are base that completely ionizes in water to form $\text{OH}^-(\text{aq})$ ions. Their reactions are irreversible. E.g. NaOH , KOH , $\text{Ca}(\text{OH})_2$



* **Weak Alkalis** base that partially ionize in water. The remaining molecules remain unchanged as base. Their reactions are reversible.

E.g. NH_3



Uses of Alkalis

Alkalis neutralize acids in teeth (toothpaste) and stomach (indigestion)

Soap and detergents contain weak alkalis to dissolve grease

Floor and oven cleaners contain NaOH (strong alkalis)

Ammonia (mild alkalis) is used in liquids to remove dirt and grease from glass

Indicators and pH

4. Indicators are substances that has different colours in acidic and alkaline solutions

Common indicators:

Litmus solution from where paper is made

Methyl orange

Phenolphthalein

The pH Scale

5. pH is a measure of acidity or alkalinity of a solution.

pH 7 is neutral

Solutions of less than pH 7 are acidic. The solutions contain hydrogen ions. The smaller the pH, the more acidic the solution is and more hydrogen ions it contains.

Solutions of more than pH 7 are alkaline. The solution contains hydroxide ions. The bigger the pH, the more alkaline the solution and more hydroxide ions it contains.

Measuring pH of a Solution

6. Universal indicators : It can be in paper or solution form.

Universal paper can be dipped into a solution then pH found is matched with the colour chart. It gives approximate pH value.

pH meter A hand-held pH probe is dipped into solution and meter will show the pH digitally or by a scale.

pH sensor and computer A probe is dipped into solution and will be sent to computer through interface used to measure pH of solution. The pH reading is displayed on computer screen.

7. Ionic equation is equation involving ions in aqueous solution, showing formation and changes of ions during the reaction

Rule to develop ionic equations:

Only formulae of ions that changed in oxidation number is included; Aqueous solutions are written as ions; liquids, solids and gases written in full

Reaction between Metals and Acids. For example, reaction of sodium with hydrochloric acid

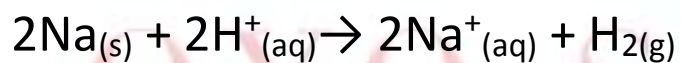


Its ionic equation is written as:



Since $2\text{Cl}^-_{(aq)}$ ions did not have a change in its oxidation number, they are not involved in chemical reaction.

As ionic equation is used to show changes in reactions, we omit $\text{Cl}^-_{(aq)}$ ions. So we are left with:

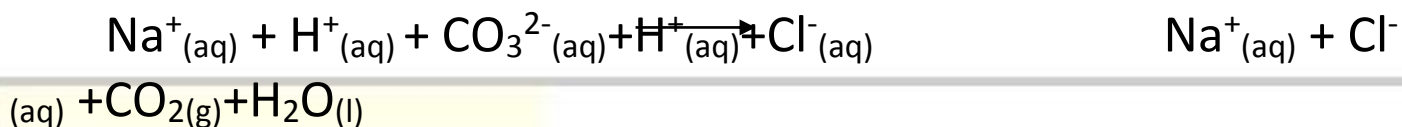


Reaction between Soluble Ionic Compounds and Acids

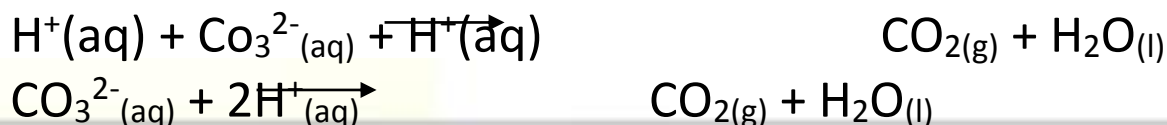
e.g. Reaction of sodium hydrogentrioxocarbonate (IV) with hydrochloric acid



The ionic equation is:



Since $\text{Na}^+_{(aq)}$ and $\text{Cl}^-_{(aq)}$ ions do not change, we omit them, leaving:



Reaction between Insoluble Ionic Compounds and Acids

e.g. Reaction between iron(II) oxide and Tetraoxosulphate (VI) acid



Its ionic equation is : $\text{FeO}(\text{s}) + 2\text{H}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \xrightarrow{\quad} \text{Fe}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{g})$

Note: FeO is written in full as its solid (although it's an ionic compound)

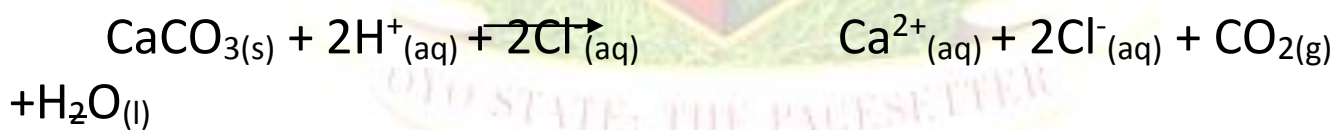
Since $\text{SO}_4^{2-}(\text{aq})$ ions do not change, we omit SO_4^{2-} ions, leaving:



E.g. Reaction between calcium carbonate and hydrochloric acid



Its ionic equation is:



Since $2\text{Cl}^-(\text{aq})$ ions do not change, we omit Cl^- ions, leaving:

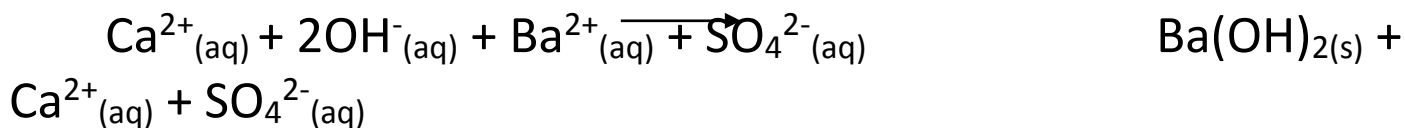


Reactions Producing Precipitate

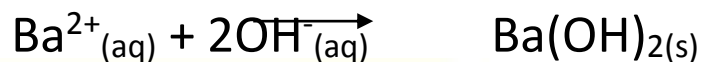
E.g. Reaction between calcium hydroxide and barium sulphate



Its ionic equation is written as:



Since $\text{Ca}^{2+}(\text{aq})$ and $\text{SO}_4^{2-}(\text{aq})$ ions don't change, we omit them, leaving:



Displacement Reactions

E.g. Reactions between magnesium with zinc sulphate



Its ionic equation is written as:



Since $\text{SO}_4^{2-}_{(\text{aq})}$ ions do not change, we omit them, leaving:

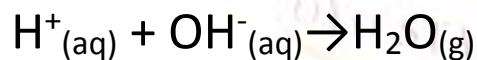


Neutralization: is the reaction between acid and base to form salt and water only. From ionic equation, we know that the reaction only involves H^{+} ions from acids with OH^{-} ions from alkali to form water .

E.g. $\text{NaOH} + \text{H}_2\text{SO}_4$



Ionic equation is:



E.g Plants don't grow well in acidic soil. Quicklime (calcium hydroxide) is added to

Neutralize the acidity of soil according to equation



Reaction between Base and Ammonium Salts

E.g. Reaction between NaOH and NH_4OH

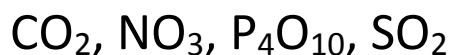


Ionic equation:



Acidic Oxide, Basic Oxide, Amphoteric Oxide, Neutral Oxide

Acidic Oxides are oxide of non-metals, usually gases which reacts with water to produce acids,



Basic Oxides are oxides of metals, usually solid which reacts with water to produce alkalis, e.g. CaO , K_2O , BaO

Amphoteric Oxides are oxides of transition metals, usually solid, which reacts with acids/alkalis to form salt and water, e.g. Al_2O_3 , FeO , PbO

Neutral Oxides are oxides that do not react with either acids or alkalis, hence do not form salts, e.g. H_2O , CO , NO

Preparation of Salts : Soluble and Insoluble Salts

Soluble Insoluble

All Trioxonitrate (V) are soluble

All Tetraoxosulphate (VI) are soluble except BaSO_4 , CaSO_4 , PbSO_4

All Chlorides are soluble except PbCl_2 and AgCl

Potassium, Sodium, Ammonium salts are generally soluble -

All Trioxocarbonate (IV) are **insoluble** except K_2CO_3 , Na_2CO_3 , NH_4CO_3 which are soluble

All metallic oxides **insoluble** except K_2O and Na_2O

Preparation of Insoluble Salts

Insoluble salts,

e.g. BaSO_4 , CaSO_4 , PbSO_4 , PbCl_2 , AgCl

Most trioxocarbonate (IV), can be prepared by reacting compound containing the wanted cation with another compound containing

the wanted anion. This is precipitation reaction. E.g. Preparation of BaSO_4 .

First BaCl_2 , since it contains wanted barium ion, is reacted with K_2SO_4 , since it contains wanted Tetraoxosulphate (VI) ion, to produce solid BaSO_4 & aqueous KCl. BaSO_4 then separated from KCl

by filtration, leaving filtrate of KCl and BaSO_4 left on filter paper. Salt is washed with water to completely remove KCl & filter paper is squeezed with another filter paper to dry BaSO_4 .

Preparation of Soluble Salts

By Neutralization.

E.g. **Reacting Zn with H_2SO_4 .** To prepare ZnSO_4



Zn is added to H_2SO_4 until in excess to ensure no more H_2SO_4 is present. Then the mixture is filtered off to separate Zn from ZnSO_4 . The filtrate (ZnSO_4) is then placed in evaporating dish to evaporate most of water then it's cooled after ZnSO_4 crystals are formed. The crystals then filtered and squeezed between filter papers to dry.

*** By Reacting Insoluble Base with Acid**

E.g. Reacting MgO with Acids



*** By Reacting trioxocarbonate (IV) with Acid**

E.g. Reacting K_2CO_3 with Acids



The same process is used as reaction of acid with metal, just that carbon (IV) oxide is produced. The gas produced can be tested by

bubbling it into lime water which will turn colourless limewater into milky colour.

HYGROSCOPIC, DELIQUESCENT AND EFFLORESCENT SUBSTANCES

- 1. Hygroscopic substances** are capable of absorbing water from the air and not dissolving in it. Silica gel, conc. H_2SO_4 , MgCO_3 , K_2CO_3 , Ca
- 2. Deliquescent substances** are capable of absorbing moisture from the atmosphere and dissolving in it to form a solution. E.g anhydrous CaCl_2 , MgCl_2 , $\text{Cu}(\text{NO}_3)_2$, NaOH pellet
- 3. Efflorescent substances** these are capable of losing their water of crystallization when exposed to the atmosphere. E.g $\text{NaCO}_3 \cdot 10\text{H}_2\text{O}$, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$.

SS 1 THIRD TERM

WATER AND SOLUTIONS

Earth surface is covered with 70% water. Of these about 96% is sea water, 3% is in the form of ice while the remaining 1% is fresh water.

The 1% is not really enough for lives on land. Other waters contain among other things dissolved salts, bacteria, organic matters, as well as other pollutants. Hence the need to treat the available water for usage.

Physical Properties of water

Water is a colourless, odourless and tasteless liquid.

The only substance that exists in the three states of matter
Freezes at 0°C

Boils at 100°C at 760mmHg or 1 atmospheric pressure

Maximum density of 4gcm⁻³ at 4°C

Chemical properties of water

Water is a universal solvent. that is, it is capable of dissolving more substance than any other solvent.

Pure water has a pH of 7

Water react with active metals (K, Na, Ca) to form metallic hydroxides and Hydrogen gas



Note the state of matter for the water to use depends on the position of the elements on the electrochemical series

SOFT AND HARD WATER

Water is a universal solvent and is capable of picking impurity easily.

Water is said to be hard when it contains high concentration of mineral salts especially of calcium and Magnesium.

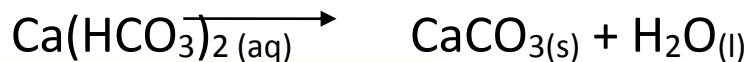
Soft water therefore are water that contains little or no dissolved mineral salts in them.

Hard water does not lather readily with soap

Hardness in water is divided into temporary and permanent hardness

Temporary hardness is caused by the presence of Ca(HCO₃)₂ or Mg(HCO₃)₂ as dissolved minerals .

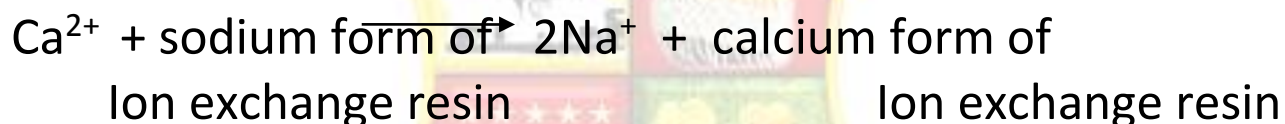
Temporary hardness can be removed by mere boiling. Hence it is called temporary hardness. As in the equation below



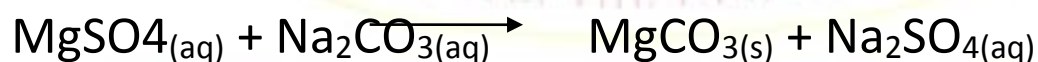
Permanent hardness are caused by the presence of dissolved calcium and magnesium salts of tetraoxosulphate VI and Chlorides. It cannot be removed by ordinary boiling

Methods of Removing hardness from Water

Using Ion Exchange Resin : the hard water is allowed to pass through a chamber containing ionized Na^+ compounds where the Ca^{2+} and Mg^{2+} in the hard water are replaced by Na^+ until all are exhausted.



The use of sodiumtrioxocarbonate IV (washing soda). This precipitate the calcium and magnesium as an insoluble trioxocarbonate IV salts.



Advantages of hard water	Disadvantages of hard water
Does not dissolve lead pipes	It for scum with soap
Calcium and magnesium ion useful for the body	Wastes soap in washing
It give water a pleasant taste	When heated it form scales in pots and kettles

Hydrogen bond exist between water molecule which is an INTERMOLECULAR force of attraction given water its

- (a) viscous nature
- (b) surface tension
- (c) latent heat of vapourization (the energy needed to turn water to steam).

Test for water

1. Water will turn the white colour of anhydrous CuSO_4 to blue hydrated $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
2. Water will change the colour of blue dry CoCl_2 into pink wet $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$

Solubility

Solution is the homogenous mixture of two or more substances.

Solute is the dissolved substance which may be solid, liquid or gas.

Solvent is the substance that dissolves the solute.

Saturated solution is the solution which contain as much solute a solution as it can dissolve at that given temperature in the presence of undissolved solute particle.

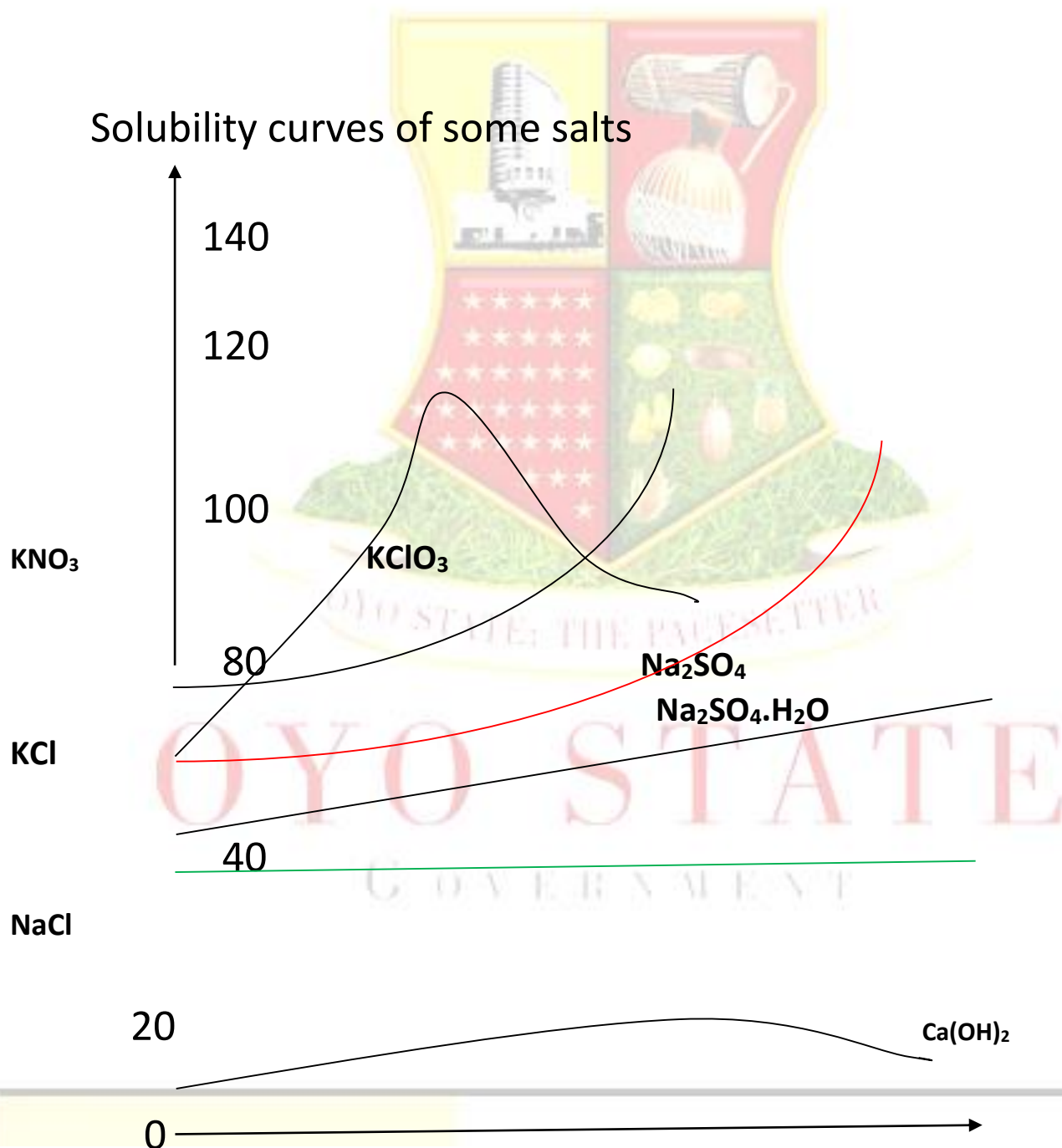
Unsaturated solution are solution which does not contain as much solute as it ought to contain at a given temperature

Supersaturated solution is a solution which contain as much solute than it can dissolve at that given temperature

Solubility of a solute in a solvent is defined as the amount of the solute in grammes which will dissolve in 1000g of the solvent, at a particular temperature.

Solubility is also defined as the maximum number in moles of the solute which will dissolve in 1000cm^3 / 1dm^3 of the solvent at a given temperature.

Solubility curve is a graph indicating the variation between the solubility of a solute in a solvent at a given temperature.





Deduction from the solubility curve

1. The solubility of KClO_3 and KNO_3 increases very rapidly with increase in temperature. ***
2. The solubility of Ca(OH)_2 and NaCl are independent of temperature
3. Na_2SO_4 shows a solubility curve with a sharp breaks at 36°C because the salt exists in solution and $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ at temperature below 36°C but gives up its water of crystallization to become anhydrous at a temperature above 36°C . thus 36°C is referred to as the TRANSITION POINT
4. At all temperature between 0°C and 100°C Ca(OH)_2 has the lowest solubility value
5. The solubility of KCl increases at a constant rate with the rise in temperature.

Uses of solubility curve

1. It is used in purification processes
2. It is used in extraction processes

3. It is applicable in fractional crystallization process
4. It is used in pharmaceutical for the determination of dosage for drug

THE PERIODIC TABLE

1. First periodic table made by Dimitri Mendeleev in 1869 containing 69 elements.
2. The Modern Periodic Table contains 115 elements.
3. Mendeleev arranged the elements according to relative atomic mass while modern periodic table is arranged according to the number of protons an element contained.
4. Period is the horizontal row of elements on the periodic table
5. Group is the vertical column of elements on the periodic table numbered from I to VIII or 0
6. Elements between Group II and Group III on the table are the transition metals

Patterns in the Periodic Table

1. Electronic Structure of Elements in same group has the same number of valence shell electrons in which the value is the same as the group number. e.g. Group II has elements with valence of 2 electrons.
2. Charges on Ions : The charges relate to the group number and equivalent to number of valence electrons
3. Elements on the left side of the periodic table (groups I, II and III) lose electron to form cation
4. Elements on the right side of the periodic table (group V, VI, and VII) gain electron to form anion

5. Elements in Group IV can lose or gain electrons depending on reacting element.
6. Transition metals may form variable cation of 2+, 3+ etc oxidation number

Bonding

* Elements in the same group form the same bond type and number of bonds due to the same number of valence electrons. e.g. Sodium in Group I forms NaCl, so other elements in Group I do the same. (RbCl, KCl, LiCl, CsCl)

Metals and Non-metals

1. On the left side and on the right side of the group IV elements on the periodic table lies the metallic and non metallic elements respectively.
2. Group IV elements are called metalloids and having properties of metals and non-metals.

Changes within the Group

3. Proton number or the atomic number increase going down the group- On each sides of periodic table, the change of the proton number is small & increase gradually while in transition metals, the gradual change is larger

Using the Periodic Table to Predict Properties of elements

1. Formula and Structures
2. Given chlorine, iodine and bromine of Group VII for example forms molecules of Cl_2 , I_2 and Br_2 respectively, predict the molecular formula of Fluorine. F_2 From example, we know elements in same group form the same formula.

Properties of Elements

Properties of element changes down the group. i.e. given list of Group 7 elements, predict the properties of astatine.

Element	Proton Number	Melting Point (°C)	Boiling Point (°C)
Fluorine	9	-220	-118
Chlorine	17	-101	-35
Bromine	35	-7	59
Iodine	53	114	184
Astatine	85	> 114	> 184

Group Properties

Group I Elements (The Alkali Metals)

1. These are metals which react with water to form alkaline solutions.
2. The solutions turn red litmus paper blue.
3. They are the most reactive metals on the periodic table
4. They have one outer shell electrons
5. They are Shiny, silvery solids
6. They are Soft, easily cut with knife - low densities and melting points and these increases down the group.
7. They reacts easily in air. So they're kept in oil
8. They Reacts vigorously (may catch fire or explode) with cold water
9. They make ionic compounds of +1 charge.
10. They have similar formulae
11. They become more reactive down the group

The physical properties and formulae of Group I metals

Name	Symbol	Density (g/cm ³)	Melting point (°C)
Lithium	Li	0.53	180
Sodium	Na	0.97	98
Potassium	K	0.86	64
Rubidium	Rb	1.5	39
Caesium	Cs	1.9	29
Element	Chloride	Nitrate	Sulphate
Oxide			
Lithium	LiCl	LiNO ₃	Li ₂ SO ₄
Li ₂ O			
Sodium	NaCl	NaNO ₃	Na ₂ SO ₄
Na ₂ O			
Potassium	KCl	KNO ₃	K ₂ SO ₄
K ₂ O			

Group VII Elements (The Halogens)

1. These are elements which react with most metals to form salts
2. They are very reactive elements
3. They have seven outer shell electrons
4. Each molecule in the element is diatomic (contains two atoms, eg F₂)
5. Elements become darker and solidify down the group-

6. They have low melting and boiling points which increases down the group

7. All halogens are poisonous

Element point (°C)	Molecular formula State at r.t.p.	Melting point (°C) Colour	Boiling
Fluorine gas	F_2 Pale yellow	-220	-189
Chlorine gas	Cl_2 Greenish yellow	-101	-35
Bromine liquid	Br_2 Reddish brown	-7	59
114 black	Iodine 184	I_2 solid	Shiny

Compounds of the Halogens

1. Halogens give a charge of -1, so they give similar formulae, eg: NaBr, NaI
2. Halogens react vigorously with metals to form ionic salts for the equation: $2K + Br_2 \rightarrow 2KBr$
3. Halogens become less reactive down the group

Displacement Reactions

More reactive halogen displaces less reactive halogen eg: aqueous fluorine was added into sodium bromide solution. State the chemical equation of the reaction.



Group VIII or 0 Elements (The Noble Gases)

1. These are the least reactive elements on the periodic table.
2. They do not form bonds
3. They have stable electronic configuration with complete electrons on their shells
4. Coloured gases consisting of single atoms (monatomic)
5. They have low melting and boiling points

Uses of the Noble Gases

1. Argon is used in light bulbs as it would not react with the hot filament
2. Neon is used in neon advertising strip lights
3. Helium is used in small and weather balloons, and airships for less density

Properties of Transition Elements

1. First transition series are all metals-
2. Transition elements have high melting points
3. They have high density
4. They have variable oxidation state, e.g. Iron (Fe) appear as Fe^{2+} or Fe^{3+}
5. They form coloured compounds, e.g. CuSO_4 is blue, FeSO_4 is green-
6. They form complex ions, e.g. MnO_4^- , Manganese (VII) ions
7. They act as catalysts

Uses of Transition Elements

1. Most transition elements and their compounds act as catalysts which affects chemical reactions
2. Iron is used in Haber process for manufacture of ammonia

3. Vanadium (V) oxide is used in contact process to manufacture sulphuric acid
4. Nickel is used in hydrogenation of alkenes to form saturated fats (e.g. margarine)

Advantages

1. Since transition elements speed up chemical processes in industries, they save time in manufacture
2. Less energy is needed for manufacture in industries, hence lower cost. Since less energy is needed, more energy resources can be conserved, e.g. oil to generate electricity in producing iron.

SS 2 FIRST TERM

ENERGY FROM CHEMICALS

Exothermic Reaction is one which heat energy is given out. This is to form bonds between the reactants which need less energy in them.

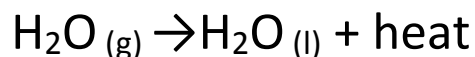
Reaction is written as:

Reactants \rightarrow Products + heat $\Delta H = -nkJ$

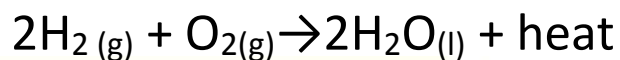
Where ΔH = heat change. n is amount of heat energy released

Changes of State

When gas condenses to water or water freezes to solid, heat is given out. i.e Condensation of steam to water



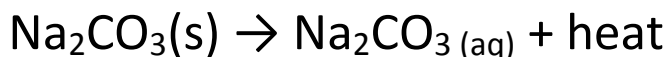
Combustion reactions All combustion (burning) reactions are exothermic. Burning of hydrogen in air



Dissolving anhydrous salts/acids in water

Dissolving solid salt to aqueous solution of the salt gives out heat

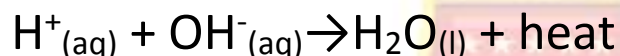
Dissolving Na_2CO_3 in water (or CuSO_4)



Dissolving concentrated acid in water



Neutralization when acid and alkali react it gives out heat due to combining of H^+ ions from acid and OH^- ions from alkali to form water



Metal Displacement

Magnesium reacting with copper(II) Tetraoxosulphate (VI)



Endothermic Reaction is one which heat energy is absorbed. This is to break bonds between the reactants which need more energy in them. Reaction is written as:



Where n is amount of heat energy absorbed

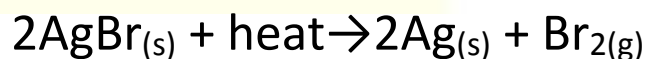
Examples of endothermic changes

Changes of states

When solid melts to water & boils to steam, heat is absorbed to break the bond. Condensation of steam to n water



Photolysis Reaction of light sensitive silver chloride in camera reel in light



Dissolving of Ionic Compounds

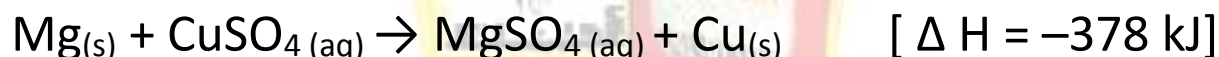
Ionic compounds such as NH_4Cl , KNO_3 , and CaCO_3 absorb heat from surroundings.



Heat of Reaction The amount of energy given out or absorbed during a chemical reaction is enthalpy change

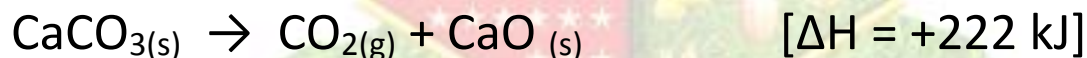
The symbol is ΔH measured in kilojoules (kJ)

Exothermic reaction



378 kJ of heat energy is given out when 1 mol of Mg react with 1 mol CuSO_4 to produce 1 mol of MgSO_4 and 1 mol of Cu.

Endothermic reaction:



222 kJ of heat energy is absorbed when 1 mol of CaCO_3 decompose to 1 mol of CO_2 and 1 mol of CaO.

Heat Energy and Enthalpy Change in Reaction

When bonds are made, heat energy is given out, it's exothermic and ΔH is negative.

When bonds broken, heat energy is absorbed, it's endothermic and ΔH is positive

Activation energy is the minimum energy needed to start a reaction.

It is the energy needed to break the reactant bonds before new bonds are formed as product.

Reactions occur because of collision of particles and sufficient kinetic energy is needed to provide activation energy to break the

bonds and start the reaction by providing extra energy from a heat source.

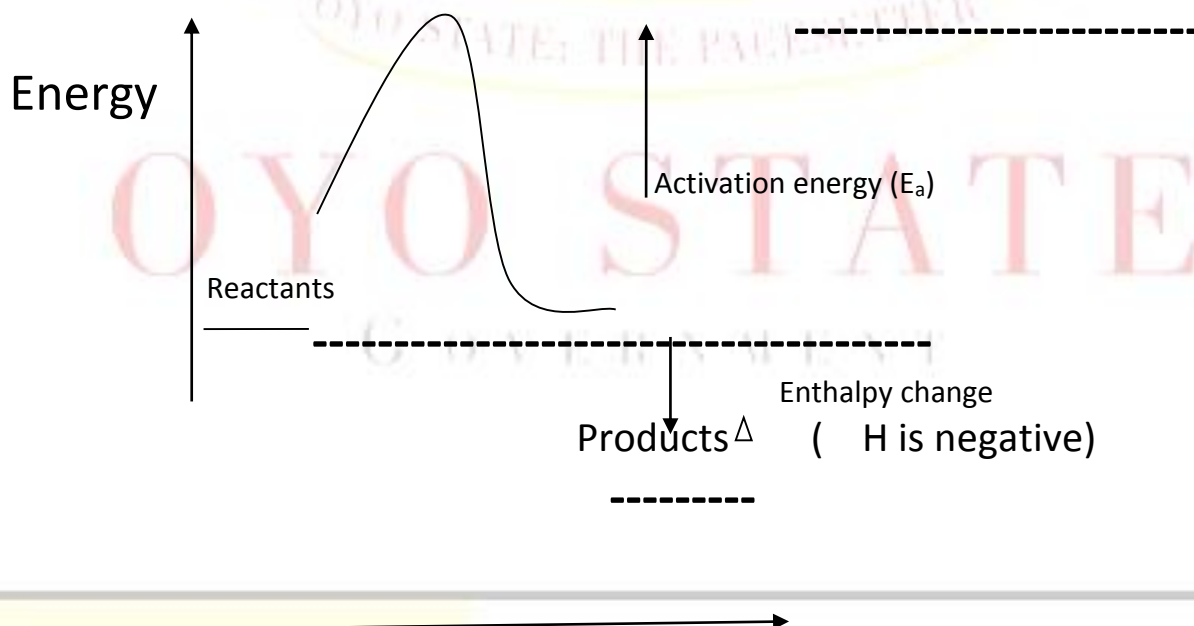
Rate of Chemical Reaction It is the speed for a reactant to be used up or product to be formed.

Rate of reaction is inversely proportional to time taken; the shorter the time needed for reaction to complete, the faster the rate of reaction.

Collision Theory states that for reaction to take place between two or more particle

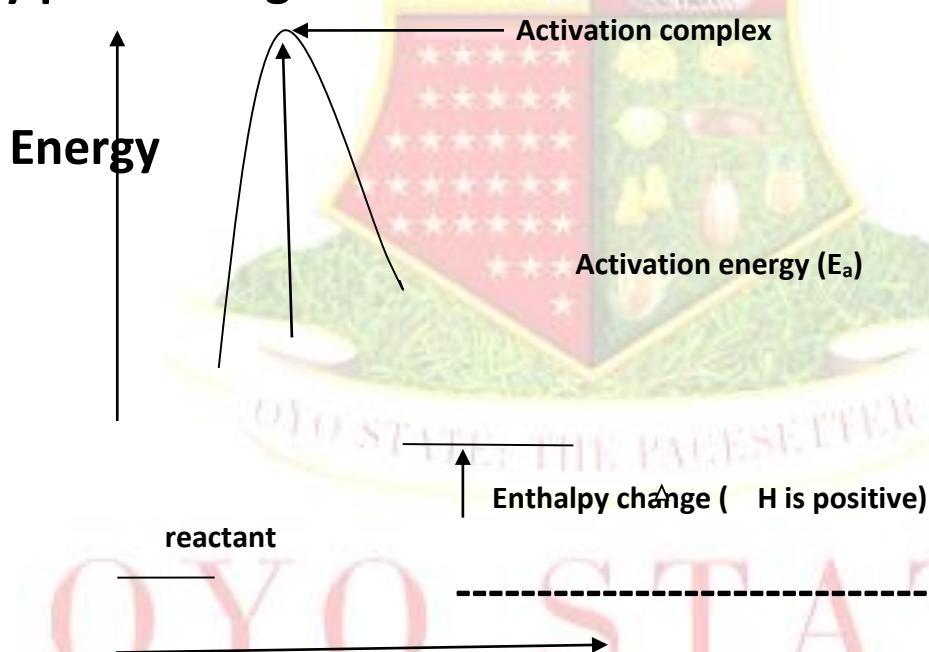
- (a) The reacting particles must collide
- (b) The collision must be effective (effective collision is the collision that result into formation of product)
- (c) The collision must generate certain minimum energy that will be enough to overcome activation complex. This energy is called **activation energy**.

Energy profile diagram for Exothermic Reactions



Reaction coordinate

Energy profile diagram for endothermic Reaction



Reaction coordinate

Factors Affecting Rate of Reaction

3. Particle Size of Reactant When large marble is reacted with acid and compared to reaction of fine marble solids being reacted with acid and the graph of volume of gas against time is plotted, it was found that the reaction involving finer

marble chips produces gas faster than the one with larger marble chunk as the graph of finer chips is steeper.

Explanation: from collision theory

Reactions occur when particles collide. Small particles create larger surface area for more collisions between reacting particles which increases rate of reaction.

- 1. Concentration of Reactant** The increase of concentration means there are more solute particles per unit volume of the solution which favours for more effective collision resulting in an increase in rate of reaction.
- 2. Pressure of Reactant** Only gaseous reactions are affected as gas is compressible. At higher pressure, molecules are forced to move closely together, hence increasing the particles per unit volume of gas and effectively increases the collision between reacting molecules so the rate of reaction increases. High pressure is used in industrial processes (e.g. Haber Process Plant) so that the reaction goes faster.
- 3. Temperature of Reaction** Rate of reaction increases when temperature increases. Particles do not just react upon collision but just bounce until they have enough activation energy to react. With increase in temperature, particles absorb the energy and having enough activation energy, they move faster and collide more effectively per second. Therefore, rate of reaction is increased.
- 4. Effect of Catalyst** what are catalysts? Catalysts are chemical substances which alter speed of reaction without itself being

used at the end of a reaction. It can be reused and only small amount of catalyst is needed to effect a reaction.

Transition metals (e.g. Titanium, Nickel, Iron, Copper) are good catalysts

Most catalyst catalyze one kind of reaction (except titanium)

Reaction Catalyst

Production of sulphur by contact process using Vanadium (V) oxide (V_2O_5)

Production of ammonia by Haber Process Iron (Fe)

Production of hydrogen by cracking of hydrocarbons using Aluminum oxide (Al_2O_3) Silicon dioxide (SiO_2)

Production of margarine by reacting hydrogen with vegetable oil using Nickel (Ni)

Production of plastics using Titanium (IV) chloride, $TiCl_4$

Converting CO into CO_2 in catalytic converters using Titanium (Ti) Rhodium (Rh).

Catalysts lower the need of energy to break bonds so activation energy is lower. Consequently, bond breaking occurs easily and more often when particles collide

Catalyst provide “alternative path” which results in lowering activation energy.

Spontaneity Reaction

Some physical or chemical change occur unaided e.g the melting of ice, oxidation of sodium metal when exposed to air. The parameter that determines the possibility of occurrence is called Entropy (S). it is also called disorder

When disorderliness occur, the energy of the system increases and the Entropy becomes positive

i.e $\Delta S = \text{positive}$ or $S = > 0$

for a non spontaneous change, energy of the system decreases and the Entropy becomes Negative

i.e $\Delta S = \text{negative}$ or $S = < 0$

Gibb's free energy (G) deals with chemical reaction. This refers to free energy of a chemical system. i.e energy available to do work. The relationship between Gibb's free energy and entropy can be expressed using the formula

$$\Delta G = \Delta H - T \Delta S$$

Where ΔG = change in free energy of a system

ΔH = heat change

ΔS = change in entropy of a system

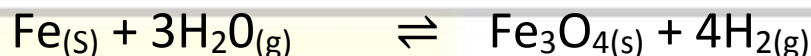
T = absolute temperature at which the reaction occur

Chemical Equilibrium

* **Reversible reactions** are reactions in which the product may react to form the original reactant



Where the direction of reaction depends on the condition. The overall equation can be written as



The \rightleftharpoons sign means that the reaction can go in either direction. The forward reaction where the reactant go through to become product. And the backward reaction where the product is converted back to the original reactant.

Dynamic equilibrium here the forward and the backward reaction proceed at equal rate such that there is no appreciable change At equilibrium at a given temperature,

- (a) The concentration of the reactant and the product remain constant though not necessarily equal
- (b) Chemical reactions are still occurring
- (c) The reactions occur in a closed system (no chemical is added or removed).

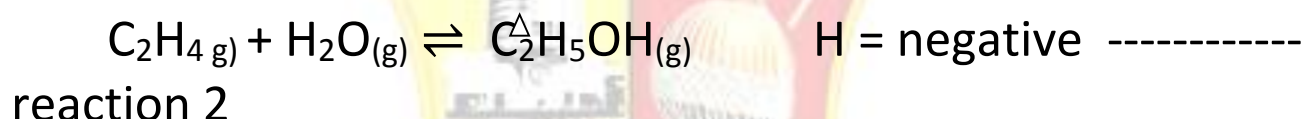
Le Chatelier's Principle when a change occurs on a system in dynamic equilibrium, the system adjust itself in a way to annul the effect of the change

Factors affecting the change in equilibrium position

- (a) **Effect of change in Concentration:** increase in the concentration of a reactant will cause the equilibrium to shift to the right, more of the product will be formed and forward reaction will be favoured. All these are with a few to annul the effect of the increase in concentration. While a decrease in concentration of the reactant will cause the equilibrium to shift to the left more of the reactant will be formed and backward reaction will be favoured then the effect of the decrease in concentration will be annulled

(b) **Effect of change in temperature** for reactions affected by temperature

Increase in temperature will favour only endothermic reaction while decrease in temperature will favour exothermic reaction. So for the reaction



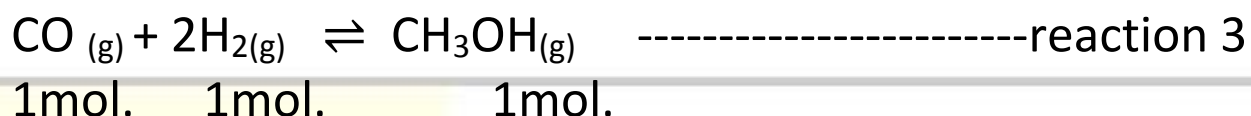
Reaction 1 is an endothermic reaction. It required heat for the reaction to become the product, so increase in its heat content will favour the forward reaction, more of the product will be formed and hence equilibrium will shift to the right. while decrease in temperature will not favour the forward reaction less of the product will be formed or more of the reactant will be formed and equilibrium will shift backward. And vice versa for reaction 2

(c) **Effect of change in pressure** : for gaseous reactant and products

Using Avogadro's law : Volume \propto number of molecule

And Boyle's law : Pressure $\propto 1 / \text{volume}$

For the reaction



2mol. Of reactant = 1mol.of product

There is a reduction in the volume of the reactant which only increase in pressure will favour. Hence increase in pressure will favour the forward reaction, more of the product will be formed and equilibrium will shift to the right or forward. While decrease in pressure will cause the volume to increase, more of the reactant will be formed; equilibrium will shift to the left or backward.

- (d) Effect of catalyst: catalyst is only useful in attaining equilibrium position. Once equilibrium is attained catalyst does not affect or alter the position of equilibrium

Hydrogen

The first element on the periodic table. Having atomic number of one with one electron, it is place in group one floating among the metals on the periodic table.

Hydrogen has three isotopes as indicated below

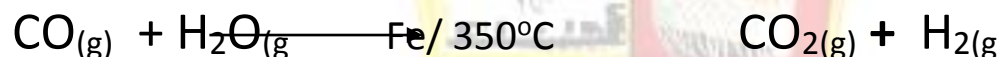
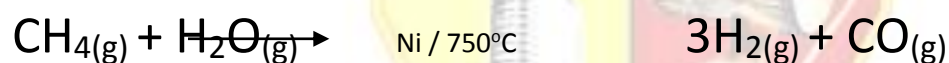
Element	Symbol	Number of proton	Number of neutron	Number of electron
hydrogen	H	1	0	1
deuterium	D	1	1	1
Tritium	T	1	1	1

Method of preparation

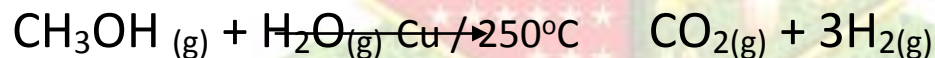
1. When mineral acid react with any of the moderate metal e.g zinc



2. Methane reacting with steam to liberate carbon dioxides in two reactions



3. Methanol and steam in the presence of Cu as catalyst and a temperature of 250°C



4. It is produce industrially by electrolysis of brine solution

Physical properties of hydrogen

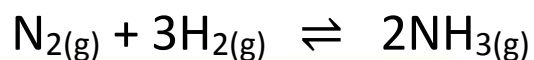
1. Colourless, odourless gas.
2. Has no action on damp blue or red litmus
3. It is insoluble in water
4. It is non poisonous
5. It burns with pale blue flame and does not support combustion

Chemical properties

1. Undergo combustion in the presence of oxygen and a good reducing agent..



2. Reaction with Nitrogen to produce ammonia.



3. Hydrogen react with unreactive metal oxides (CuO, PbO, Fe₂O₃ liberating the metals



Test for hydrogen Hydrogen extinguishes a lighted splint with a pop sound

Uses

1. Employed in the extraction of metals
2. Production of fertilizer and other valuable chemical
3. Hydrogenation process oil to fat, unsaturation to saturation in organic compounds

oxygen

Oxygen is a group VI element on the periodic table. Due to its having six electron in its outermost shell, oxygen undergo ionic as well as covalent bond. It is a non metal

Preparation of Oxygen

1. Catalytic decomposition of Hydrogen peroxide in the presence of Manganese IV Oxide



2. Catalytic decomposition of potassium chlorate (V) in the presence of heat and MnO₂ as catalyst



3. It can be obtained industrially by fractional distillation of liquid air

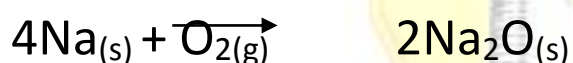
Physical properties of Oxygen

1. It is slightly denser than air

2. It is a colourless, odourless gas and has no action on moist litmus paper
3. It is slightly soluble in water
4. It does not burn but it support combustion
5. It is not poisonous.

Chemical properties of Oxygen

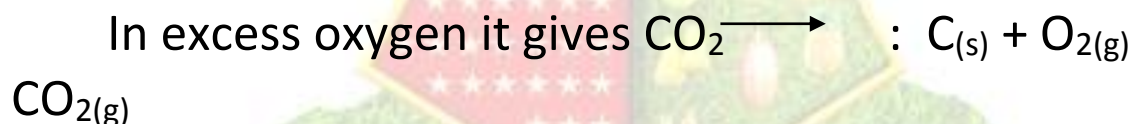
1. It react with metals to form metal oxide.



2. It react with non metal to form acidic oxides



3. It react with carbon in two ways

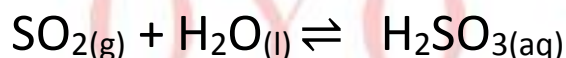


Binary Compounds of Oxides

Binary compound are compounds comprising of two elements.

Oxides contain oxygen and another element.

1. **Acidic oxides** are oxide of non metal which reacts with water to form acid



2. **Basic oxides** are oxides of metal which react with water to form alkalis. Especially the most reactive metal



3. **Neutral oxides** are some oxides of non metal that shows neither acidic nor basic property. E.g Nitrogen (II) oxide, Carbon II Oxide, H_2O .

4. **Amphoteric oxides** are oxides of metal that are capable of reacting with both acid and base to form salt and water only.

E.g ZnO, PbO, Al₂O₃



Uses of Oxygen

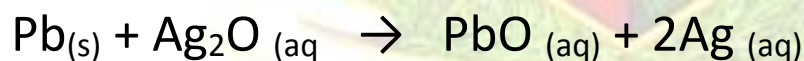
1. Useful in combustion process
2. Used as oxidizing agent
3. Animals breath in oxygen
4. Used in steel making to burn off impurities
5. In oxy acetylene flame in welding process

OXIDATION AND REDUCTION

Oxidation and Reduction Reaction in terms of oxygen and Hydrogen

Oxidation is the gain of oxygen by a substance

Reduction is the loss of oxygen by a substance

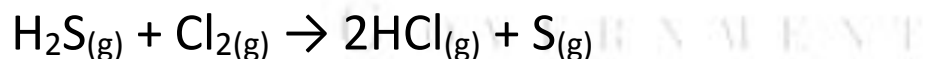


Pb is oxidized as it gains oxygen from Ag₂O to form PbO.

Ag₂O is reduced as it loses oxygen to Pb to form Ag.

Oxidation is the loss of hydrogen by a substance

Reduction is the gain of hydrogen by a substance



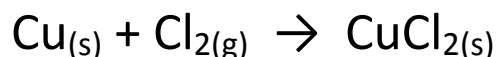
H₂S is oxidized as it loses hydrogen to Cl₂ to form S.

Oxidation and Reduction in terms of Electropositive and electronegative elements

1. **Oxidation** is defined as the addition of electronegative elements to a substance

This is particularly the most reactive non metals of the group VII. They have the tendency to attract electrons in a chemical reaction

2. Reduction is defined as the addition of electropositive element to a substance

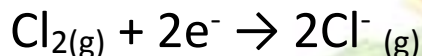
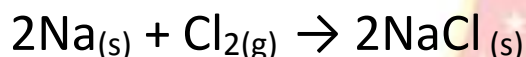


Chlorine is added to copper so copper is oxidized and therefore chlorine is reduced

Oxidation and Reduction reaction in terms of Transfer of Electrons

1. Oxidation is the loss of electrons by a substance

2. Reduction is the gain of electrons by a substance



Na is oxidized as it loses electron to Cl_2 to form Na^+ ions.

Cl_2 is reduced as it gains electron from Na to form Cl^- ions.

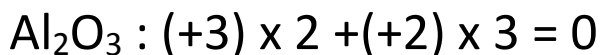
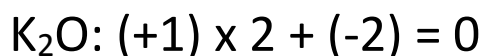
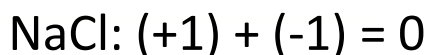
Oxidation State is the charge an atom would have if it existed as an ion

Rules for assigning oxidation state

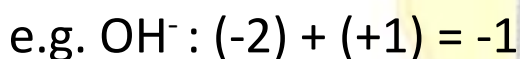
1. Free elements have oxidation state zero, e.g. Cu, Fe, N_2
2. Oxidation of an ion is the charge of the ion, e.g. $\text{Na}^+ = +1$, $\text{Cu}^{2+} = +2$, $\text{O}^{2-} = -2$
3. The oxidation state of some elements in their compounds is fixed, e.g. Group I Elements = +1, Group II Elements = +2, Hydrogen in most compounds = +1

Iron or copper can have either +1, +2, +3, so it's not fixed

4. Oxidation states of the elements in a compound adds up to zero, e.g.

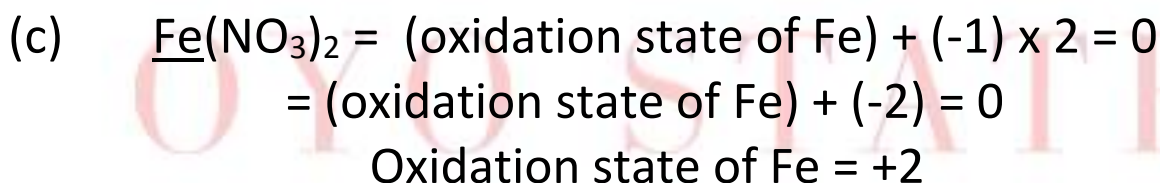
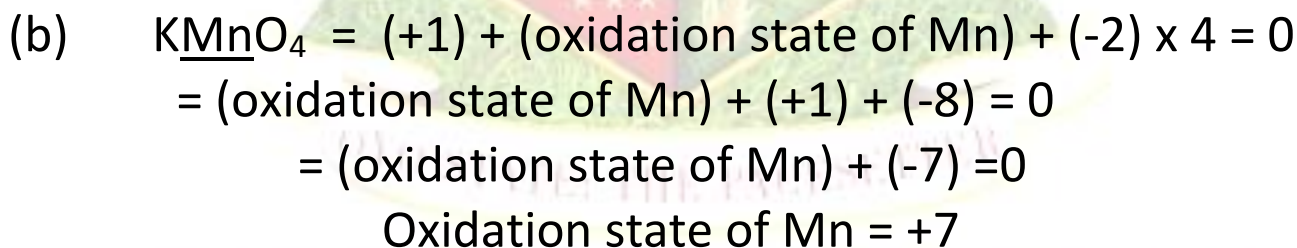
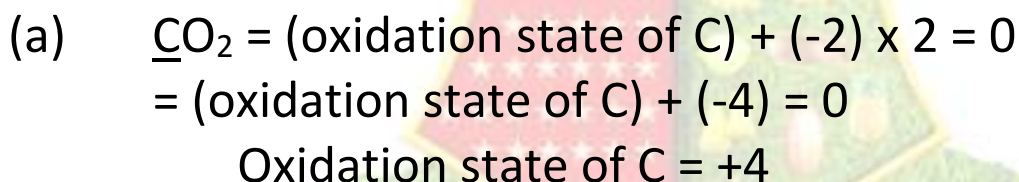


5. Sum of oxidation states of elements in an ion is equal to charge on the ion,



Examples:

Work out the oxidation states of the underlined elements in these compounds:



Note: Transition metals and some common elements may have different oxidation states in different compounds.

Examples of elements with variable oxidation states

Oxidation state -2, -1, 0, +1, +2, +3, +4, +5, +6, +7.

Manganese	Mn	MnCl ₂	MnO ₂	KMnO ₄
Chromium	Cr	CrCl ₂	CrCl ₃	K ₂ Cr ₂ O ₇

Iron	Fe	FeCl ₂	FeCl ₃	Fe ₃ O ₄
Sulphur	S	SO ₂	SO ₃	H ₂ SO ₄
Carbon	C	CO	CO ₂	CaCO ₃

Some compounds with possible variable oxidation states have roman numeral as a guide about their oxidation state, e.g.-

Iron(II) chloride has formula FeCl₂ and iron oxidation state +2

Potassium(VI) dichromate has formula K₂Cr₂O₇ and potassium oxidation state +6

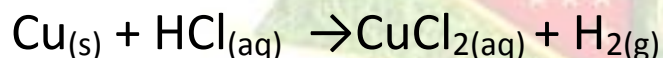
Manganese(IV) oxide has formula MnO₂ and manganese oxidation state +4

Oxidation and Reduction in Terms of oxidation number

Oxidation is the increase of oxidation state by a substance

Reduction is the decrease of oxidation state by a substance.

Examples: Metals with acids



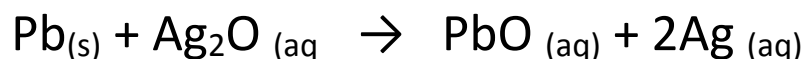
Cu is oxidized as it gains oxidation state from 0 to +2.

H⁺ ions in HCl reduced as it loses oxidation state from +1 to 0.

Oxidizing and Reducing Agent

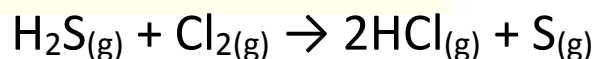
Oxidizing agent is a substance that causes oxidation in another substance

Reducing agent is a substance that causes reduction in another substance



Ag₂O is an oxidizing agent since it was the one that donate oxygen to lead and

Pb is reducing agent for accepting the oxygen

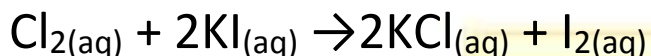


Cl_2 is oxidizing agent, Cl_2 is reduced as it gains hydrogen from H_2S to form HCl ,

H_2S is reducing agent.



Na is reducing agent.



I^- ions in KI oxidized as it gains oxidation state from -1 to 0.

I^- ions is reducing agent Cl_2 is reduced as it loses oxidation state from 0 to -1.

Cl_2 is oxidizing agent

Test for Oxidizing /Reducing Agents

Potassium dichromate (VI), $\text{K}_2\text{Cr}_2\text{O}_7$, Test for reducing agent; orange $\text{K}_2\text{Cr}_2\text{O}_7$ reduces to green Cr^{3+} ions

Potassium manganate (VII) KMnO_4 , Test for reducing agent; purple KMnO_4 , reduces to colourless Mn^{2+} ions.

Note:- Losing electrons means gain in oxidation state. Gaining electrons means loss in oxidation state

Reducing agents

Potassium Iodide, KI , Test for oxidizing agent; colourless I^- ions oxidizes to brown

Carbon monoxide, CO Reduces metal oxide to metal in heated Hydrogen H_2

Reduces copper (II) oxide to copper Sulphur dioxide SO_2 used as bleach and preservative

Metals (highly reactive) Na , Mg , etc. Displaces less reactive metals

ELECTROLYSIS

- 1. Electrolysis** is the chemical decomposition of compound in molten or solution from using electricity
- 2. Electrolyte** is an ionic compound which conducts electric current in molten or aqueous solution, and being decomposed in the process.
- 3. Strong electrolytes** decompose completely to form ions in molten form or aqueous solution. NaOH , NaCl , H_2SO_4 , HCl , CuSO_4
- 4. Weak electrolytes** decomposes partially to form ions in molten or aqueous solution. NH_3 , CH_3COOH , HCN , H_2CO_3 , HF
- 5. Electrode** is a rod or plate where electricity enters or leaves electrolyte during electrolysis. Reactions occur at electrodes.
- 6. Discharge** is the removal of electrons from negative ions to form atoms or the gain of electrons by positive ions to become atoms.
- 7. Anode** is positive electrode connected to positive terminal of direct current source. Oxidation occurs here.

Anode loses negative charge as electrons flow towards the battery, leaving anode positively charged. This causes anion to discharge its electrons here to replace lost electrons and also, negative charge is attracted to positive charge.

- 8. Cathode** is negative electrode connected to negative terminal of direct current source. Reduction occurs here.

Cathode gains negative charge as electrons flow from the battery towards the cathode, making cathode negatively charged. This

causes cation to be attracted and gains electrons to become an atom.

9. Anion is a negative ion. It's attracted to anode.

10. Cation is positive ion. It's attracted to cathode.

Electrolysis of Molten Compounds

Molten or aqueous ionic compounds conduct electricity because ions are free to move.

In solid state ions are held in fixed position within the crystal lattice. Hence **solid ionic compounds** do not conduct electricity. When molten binary compound is electrolyzed, metals move to the cathode while non-metal moves to the anode

Electrolysis of Molten PbBr_2

To produce molten lead(II) bromide, PbBr_2 , you strongly heat the solid until it melts. To electrolyse it, pass current through the molten PbBr_2 . Ions Present are Pb^{2+} and Br^-

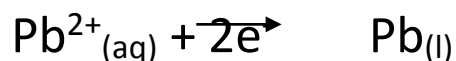
Reaction at Anode

Br^- loses electrons at anode to become Br atoms. Br atoms created form bond together to make Br_2 gas.



Reaction at Cathode

Pb^{2+} gains electrons at cathode to become Pb atoms becoming liquid lead (II).



The Overall Equation



For other compounds that can be electrolyzed the theory is the same as PbBr_2 .

Molten electrolyte	Cathode product
Anode product	
Calcium chloride (CaCl_2)	Calcium, Ca
Chlorine, Cl_2	
Sodium chloride (NaCl)	Sodium, Na
Chlorine, Cl_2	
Aluminum (III) oxide (Al_2O_3)	Aluminum, Al
Oxygen, O_2	
Sodium Iodide (NaI)	Sodium, Na
Iodine, I_2	

Electrolysis of Aqueous Solution

Aqueous solutions contain additional H^+ and OH^- ions from water, totaling 4 different ions in the solution.

2 from electrolyte and 2 from water. Where only 2 of these ions are discharged during the process of electrolysis.

Theory of selective discharge

In the discharge of ions during the electrolysis of aqueous solutions, the theory of selective discharge is operational

Factors affecting the Selective Discharge of Ions during Electrolysis

1. Concentration of ions

2. Position of ion on the electrochemical series

the lower an element is on the electrochemical series, the less stable they are and the more vulnerable they become to be discharged during electrolysis. Hence the lower cations receive electron readily to form its metal while the more reactive ionic metal remain in the solution

3. Nature of the Electrode

At cathode

In CONCENTRATED solutions of nickel/lead compound, nickel/lead will be discharged instead of hydrogen ions of water which is less in concentration than nickel/lead.-

In VERY DILUTE solutions, where hydrogen, copper and silver ions are present silver will be preferable to be discharged, according to its ease to be discharged.-

For reactive ions (potassium, sodium, calcium, magnesium, aluminum) will NEVER BE DISCHARGED in either concentrated or diluted condition. Instead, hydrogen ions from water will be discharged at cathode due to their position on the electrochemical series.

At anode In CONCENTRATED solutions, iodine/chlorine/bromine ions are preferable to be

Discharged, although it's harder to discharge compared to hydroxide ions.

In VERY DILUTE solutions containing iodide/chloride/bromide ions, hydroxide ions of water will be discharged instead of iodide/chloride/bromide, according to ease of discharge.

Sulphate and nitrate are NEVER DISCHARGED in concentrated/dilute solutions.

Electrolysis of Concentrated NaCl

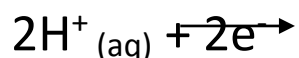
Ions Present are Na^+ , H^+ , OH^- and Cl^-

Reaction at Anode

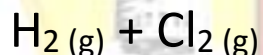
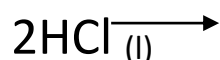
Cl loses electrons at anode to become Cl atoms, although OH^- is easier to discharge. Cl atoms created form covalent bond together to make Cl_2 gas. $2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$

Reaction at Cathode

H^+ gains electrons at cathode to become H atoms becoming hydrogen gas.



Overall Equation



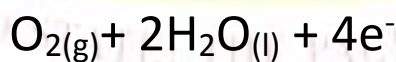
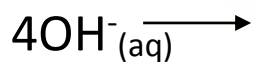
Note: any cation and anion left undischarged in solution forms new bonds between them. E.g. in above, leftovers Na^+ and OH^- combine to form NaOH and a very dilute solutions

Electrolysis of Dilute H_2SO_4

Ions Present H^+ , OH^- and SO_4^{2-}

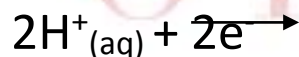
Reaction at Anode

OH^- loses electrons at anode to become O_2 and H_2O



Reaction at Cathode

H^+ gains electrons at cathode to become H atoms becoming hydrogen gas.



Since only water molecule is electrolyzed, the tetraoxosulphate (VI) acid only becomes concentrated.

Electrolysis Using Different Types of Electrodes

Inert Electrodes are electrodes which do not react with electrolyte or products during electrolysis. Examples are platinum and graphite.

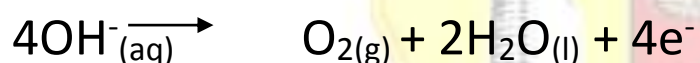
Active Electrodes are electrodes which react with products of electrolysis, affecting the course of electrolysis. Example is copper.

Electrolysis of CuSO₄ Using Inert Electrodes (e.g. carbon)

Ions Present Cu²⁺, H⁺, OH⁻ and SO₄²⁻

Reaction at Anode

OH⁻ loses electrons at anode to become O₂ and H₂O.



Reaction at Cathode

Cu²⁺ gains electrons at cathode to become Cu atoms becoming liquid copper. Hydrogen ions are not discharged because copper is easier to discharge being lower on the electrochemical series.



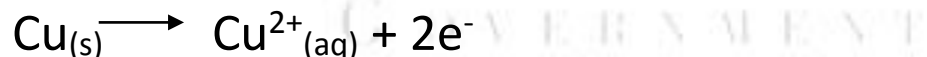
Since copper ions in solution are used up, the blue colour fades. Hydrogen and sulphate ions left forming tetraoxosulphate vi acid.

Electrolysis of CuSO₄ Using Active Electrodes (e.g. copper)

Ions Present Cu²⁺, H⁺, OH⁻ and SO₄²⁻

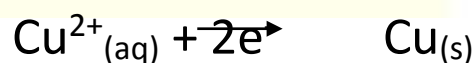
Reaction at Anode

Both SO₄²⁻ and OH⁻ gets attracted here but not discharged. Instead, the copper anode is discharged by losing electrons to form Cu²⁺. So, the electrode size decreases.



Reaction at Cathode

Cu²⁺ produced from anode gains electrons at cathode to become Cu atoms becoming copper. Hence, the copper is deposited here and the electrode increases in size.



Overall Change

There is no change in solution contents as for every lost of Cu^{2+} ions at cathode is replaced by Cu^{2+} ions released by dissolving anode. Only the cathode increases in size by gaining copper metal and anode decreases in size by losing copper. We can use this method to create pure copper on cathode by using pure copper on cathode and impure copper on anode. Impurities in the anode falls off under it.

Electroplating is coating an object with thin layer of metal by electrolysis. This makes the object protected and more attractive. Object to be plated is made to be cathode and the plating metal is made as anode. The electrolyte MUST contain plating metal cation. Example Plating Iron object with Nickel

Reaction at Anode

Ni^{2+} discharged from anode into solution. So, the electrode size decreases.



Reaction at Cathode

Ni^{2+} produced from anode gains electron at cathode to become Ni atoms becoming nickel. Hence, the nickel is deposited here and the electrode grows.



Overall Change There is no change in solution contents while iron object receives nickel deposit.

Uses of Electroplating

Chromium Water taps, motor car bumpers, bicycle parts, Tin cans, Silver sports trophies, plaques, ornaments, cutleries, Nickel Form

corrosion-resistant layer, Gold Watches, plaques, water taps, Silverware, jewelry, watches, Copper Printed circuit boards.

Electrolytic cell : An electric cell consists of 2 electrodes made of 2 metals of different reactivity. The cathode is made of more reactive metal. This is because they have more tendency of losing electrons. The anode is made of less reactive metal. The further apart the metals in reactivity series, the higher voltage is created.

How the Voltage is produced Using zinc and copper as electrodes and sodium chloride as electrolyte as zinc is more reactive than copper, zinc is the cathode while copper is the anode. At the cathode, Zn atoms in anode lose electrons to form Zn^{2+}



Zn^{2+} goes into solution while the electrons lost make the zinc negative.

The electrons flow against conventional current towards copper anode. Both Na^{+} and H^{+}

ions in solution are attracted to the copper anode due to electrons in it but only H^{+} ions discharged, due to selective discharge, to form hydrogen gas.



The overall ionic equation is:

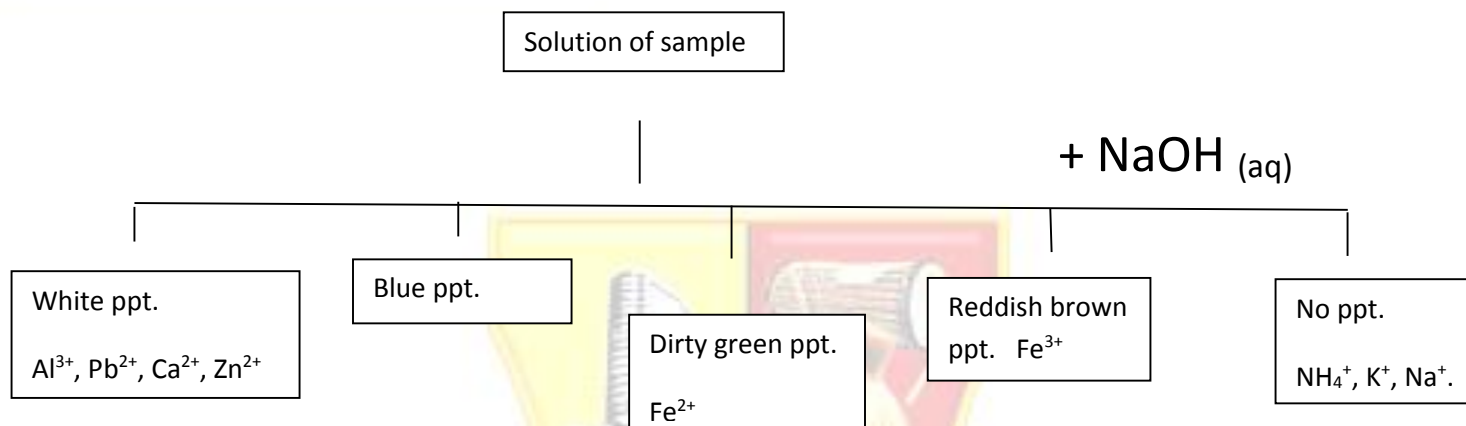


Which comes from the equation?



Qualitative and Quantitative Analysis

Compressed chart indicating test and possible inferences for common cations and anions



Test sample with excess sodium hydroxide solution

For Al^{3+} , Pb^{2+} white ppt. are soluble

For Ca^{2+} , Zn^{2+} white ppt. are insoluble

For Cu^{2+} blue ppt. remain

For Fe^{2+} green ppt. remain

For Fe^{3+} Reddish brown ppt. remain

For K^+ , Na^+ , NH_4^+ there is no observable reaction

Test sample with Ammonium hydroxide solution in drops

For Ca^{2+} there is no observable reaction

Zn^{2+} , Al^{3+} , Pb^{2+} white ppt. is formed

Cu^{2+} blue ppt. is formed

Fe^{2+} green ppt. is formed

Fe^{3+} Reddish brown ppt. is formed

K^+ , Na^+ , NH_4^+ no observable reaction

Test sample with Ammonium hydroxide solution in excess

For Ca^{2+} no observable reaction

Zn^{2+} white ppt. are insoluble

For Al^{3+} , Pb^{2+} white ppt. are soluble

For Cu^{2+} blue ppt. formed a deep blue solution

For Fe^{2+} green ppt. remain

For Fe^{3+} Reddish brown ppt. remain

For K^+ , Na^+ , NH_4^+ there is no observable reaction

SS 2 THIRD TERM

TREATMENT OF TOWN WATER SUPPLY We use water at home for drinking, cooking, washing and bathing. While in industries, we use it as heat exchanger, raw material for food and drinks, as a solvent, cleaning and purification, irrigation, dyeing and bleaching process. Inside that. E.g aluminum, calcium, potassium, etc. Dissolved oxygen given out by aquatic animals by photosynthesis, Organic matter (living/dead plants, animals, microorganisms) exists.

Purification—Taking care of those harmful stuffs

1. Water from rain and river downstream is collected in reservoir.
2. Water is transported via pipe to a flocculation tank where alum, $\text{Al}_2(\text{SO}_4)_3$, and lime, $\text{Ca}(\text{OH})_2$ are added to water so that small solid clay particles join together into large lumps of solid (coagulation).
3. Water is moved to sedimentation tank where the lumps of solid settle to the bottom of the tank. This is called sedimentation.

Carbon, in form of activated charcoal, is added to remove the taste and smell of water.

4. Water is filtered off in filtration tank, where there are sand particles filter which traps the remaining solid particles in water.

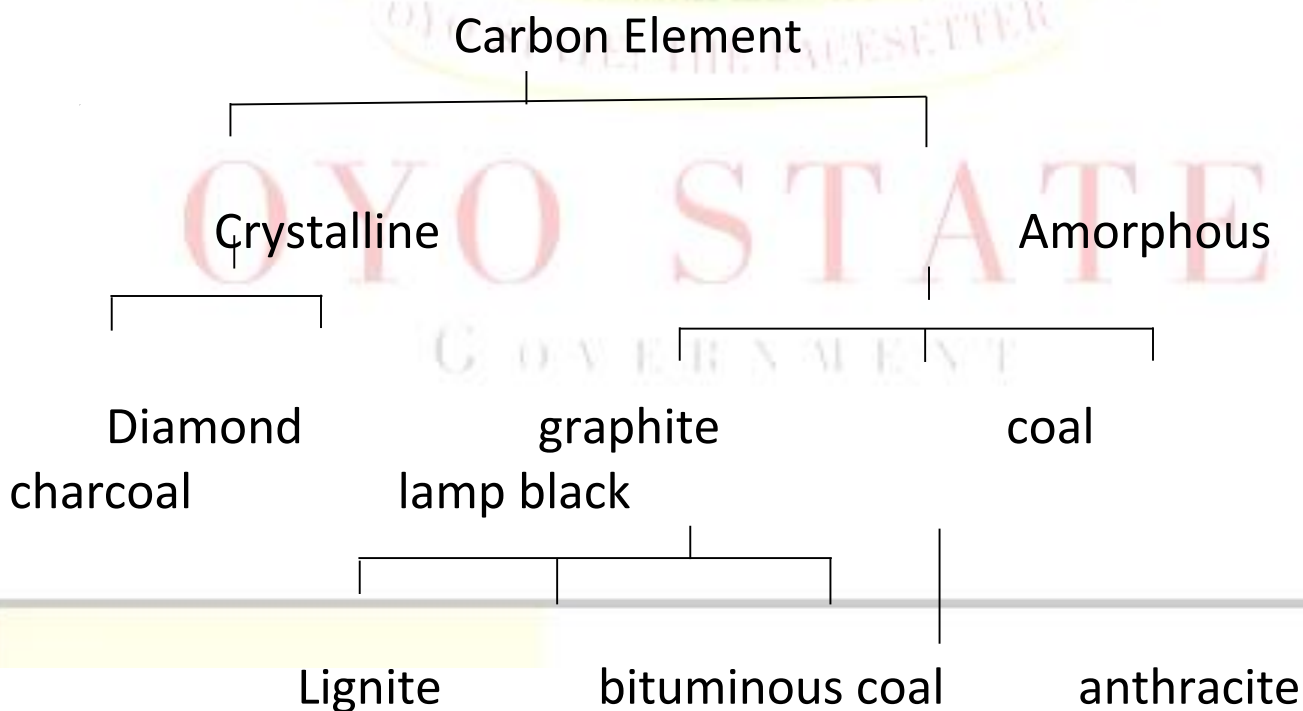
5. Chlorine and fluorine are added in chlorination tank. This is called chlorination. Chlorine is used to kill bacteria while fluorine is used to strengthen teeth.

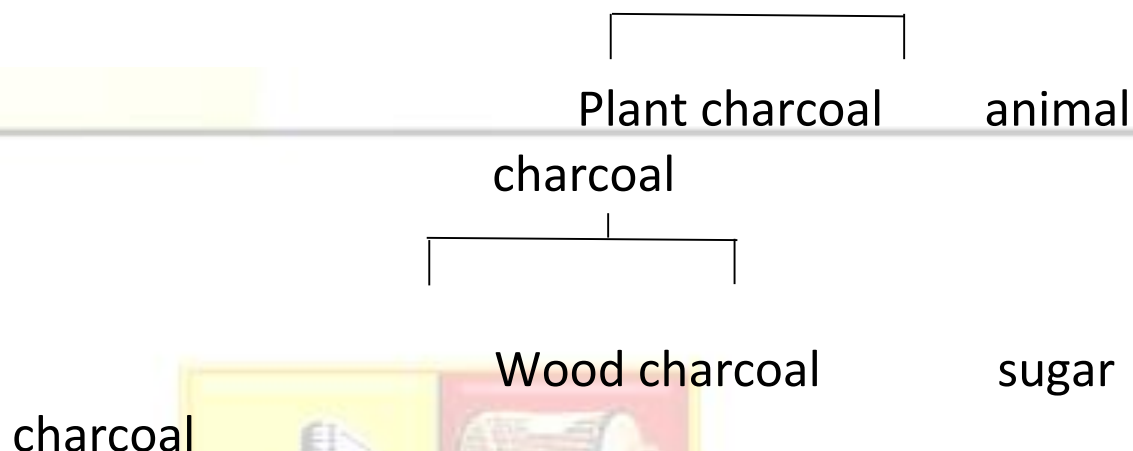
Desalination Ocean is vast source of water. Salts in Sea water must be removed so it is drinkable.

Desalination is the process where seawater is distilled until it becomes steam (free of salt) which is then cooled and condensed into drinking water.

Carbon and its inorganic Compounds

Carbon exists as element and in compounds.





Allotropy is the existence of elements in two or more form having the same but different physical properties

Allotropes are the different form of the element. Examples of the allotropes of carbon are GRAPHITE and DIAMOND.

	Diamond	Graphite
Structure	<ul style="list-style-type: none"> *carbon atoms are arranged in a tetrahedron *carbon atom are joined in a strong covalent bonds resulting in a three-dimensional giant structure 	<ul style="list-style-type: none"> *carbon atoms are arranged in parallel layers *the covalent bond within layers are strong *the covalent bond between layers are very weak and non covalent
Properties	<ul style="list-style-type: none"> *hard and transparent *high melting and boiling points 	<ul style="list-style-type: none"> *soft and black *very high melting and boiling points.

	*Non conductor of electricity	*good conductor of electricity
Uses	*To make jewellerys *as tips for cutting, polishing and grinding tools	*in pencils and graphite composites *as a dry lubricants for machine parts *to make inert electrodes

Destructive distillation of Coal this is the process of heating coal at a high temperature in the absence of air

The products of the destructive distillation of coal are Coal gas, Coke, Coal tar and Ammoniacal liquor.

Coal gas is a mixture of gases which includes H_2 , CH_4 , CO . it is used as fuel for heating and as reducing agents.

Coal tar is a mixture of liquid which includes Benzene, toluene, naphthalene, and anthracene. It can be separated by fractional distillation. It is used in the production of medicines, dyes, explosives, plastics, paints, pesticides and synthetic fibres. The residue of this is the tar used in road construction and waterproof roofs.

Ammoniacal liquor this is a solution of ammonia in water

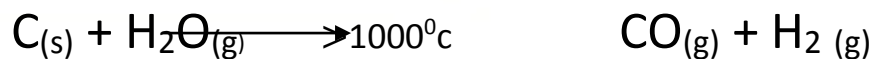


It is used in the production of ammonium compounds, fertilizers

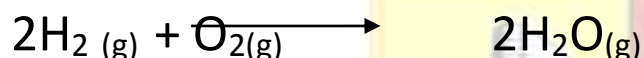
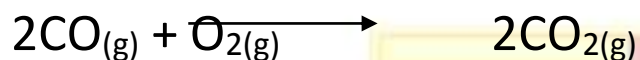
Coke is the non volatile residue. It consists of carbon only. It is used as solid fuel, also used as synthetic gas.

Gasification of Coke is the process which converts coke into useful gaseous fuel. i.e producer gas and water gas which are also referred to as synthetic gas

Water gas is produced when at a temperature $>1000^{\circ}\text{C}$ steam is passed over red hot coke a mixture of CO and H_2 gas is formed

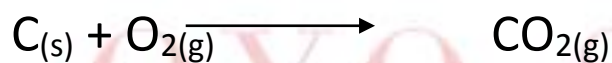


The water gas is used directly as fuel as seen in the equations below



It is also used in the production of methanol where water gas reacts with more H_2 in the presence of an oxide of zinc and chromium as catalyst and at a temperature of 450°C and a pressure of 200 atmosphere

Producer gas in a reactor called the producer hot air containing oxygen is blown from the bottom up a white hot coke. Carbon (IV) oxide is formed. And as the gas rises through the producer CO_2 react with more carbon and CO is produced. Incombustible N_2 from air mixed with the CO to form a mixture of the gases in the ratio 1:2, $\text{CO} : \text{N}_2$ it is called producer gas



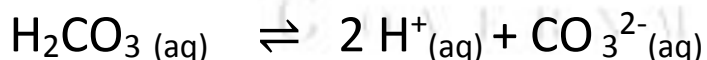
$\text{CO}_{(\text{g})} + \text{N}_2_{(\text{g})} \dots\dots\dots \text{producer gas}$

Oxides of carbon	Carbon (II) oxide	Carbon (IV) oxide
Physical properties	* Colourless, odourless gas	* Colourless, odourless gas

	<ul style="list-style-type: none"> *Poisonous *Insoluble in water 	<ul style="list-style-type: none"> * Denser than air *slightly soluble in water *it sublimates at -78°C
Chemical properties	<ul style="list-style-type: none"> *It is combustible *React as a good reducing agent *Combined with haemoglobin in the blood to form carboxy – haemoglobin 	<ul style="list-style-type: none"> *gas is acidic *a good oxidizing agent.
Uses	<ul style="list-style-type: none"> *Serves as a reducing agent in the *manufacture of some metals e.g lead, iron from their oxides 	<ul style="list-style-type: none"> *used as refrigerants or coolants *used to put fizz to carbonated drinks *used as fire extinguisher

Trioxocarbonate IV acid and salt

Trioxocarbonate acid IV is a weak dibasic acid as we see in the reaction below



Its acidic radicals react with metals according to reactivity series to form salts

Properties of some common trioxocarbonate (IV) salts

Carbonates of	Solubility in water	Action of heat	Action of acid
K Na	Soluble	Does not decompose on heating	All trioxocarbonate (IV) salts reacts with acids to form salt, water and carbon (IV) oxide. Note if an insoluble salt is formed the reaction does not get to completion in which the insoluble salts forms a coating around the salt and thus prevent further reaction with the acid and invariably the reaction will stop.
Ca Mg Al Zn	Insoluble	Decompose to metallic oxide and CO_2 . E.g $\text{CaCO}_{3(s)} \rightarrow \text{CaO}_{(s)} + \text{CO}_{2(s)}$ Note: $\text{Al}_2(\text{CO}_3)_3$ does not exist	
Fe Pb Cu Ag Hg Au		Decomposes into metal, oxygen and CO_2 . E.g $2\text{Ag}_2\text{CO}_{3(s)} \rightarrow 4\text{Ag}_{(s)} + \text{O}_{2(g)} + 2\text{CO}_{2(g)}$	

Uses of some trioxocarbonate (IV) salts

1. K_2CO_3 employed in the manufacture of glass
2. Na_2CO_3 -in cleaning
 - in textile treatment
 - as a food additive
 - to control pH of substances

- * NiCO_3 -in manufacture of ceramics
-in electroplating
- * CoCO_3 - as pigment in ceramics

ORGANIC CHEMISTRY

Organic chemistry is the chemistry of carbon compounds.

Examples of compounds found in living organisms are sugar, fats, plant oils, urea

Characteristics of Organic Compounds They are compounds of carbon and Hydrogen. Other elements in them include oxygen, nitrogen, or a halogen etc. ★ ★ ★ ★

Uses of Organic Compounds Fuels, plastic, rubber, detergents, insecticides, most medicines etc.

Classification of Organic Compounds

Organic compounds can be classified based on their chemical structures

Hydrocarbons are compounds of carbon and hydrogen only

Carbon is a tetravalent element thus while forming covalent bond in a chemical reaction, it is capable of forming bond with possible four other element with its four unpaired electrons

Aliphatic Hydrocarbon contains chain of interlinked carbon atoms which may be straight chain or branched chain. Important member of this group includes Alkanes, Alkenes and Alkynes

Homologous series is a family of organic compounds with a regular structural pattern which each successive member differs in its molecular formula by a $-\text{CH}_2$ group

General Characteristics of Homologous Series

1. They have the same general molecular formula
2. Each member of a group differs by CH_2 - group
3. They show gradual change in their physical properties
4. They can be prepared by similar methods
5. They have the same functional group. Hence similar chemical properties

Functional Group is the special group of atoms available in the compounds forming homologous series which is responsible for the chemical properties of the compound

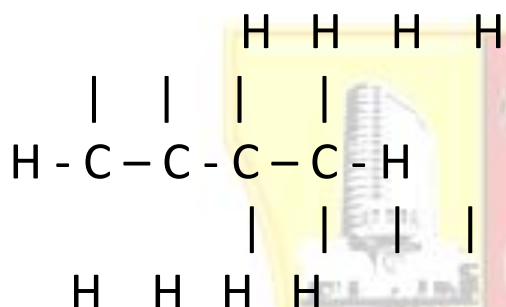
Saturated hydrocarbons are hydrocarbons which the combining capacity of the carbon atoms is as fully used as possible in bonding with hydrogen atoms. They only have single bond in their carbon to carbon structure. e.g Alkanes

Unsaturated hydrocarbons are hydrocarbons whose combining capacity of the carbon atoms is not fully used, in bonding with hydrogen. e.g. only 2 or 3 hydrogen are attached to a carbon atom. This is usually indicated by double bond ($=$) or triple bond (\equiv) with another carbon atoms.

Alkanes

1. Usually used as fuels. examples: natural gas, petrol, diesel
2. They are homologous series with a general formula of $\text{C}_n\text{H}_{2n+2}$. Where n is the number of carbon atom. Example: propane has three carbon atom, thus $n=3$. Then the formula of propane is C_3H_8
3. Their names end with a suffix – ane
4. Each member differs from the next by $-\text{CH}_2$ atoms. Eg: methane: CH_4 , ethane: C_2H_6

Structure of Alkanes shows how all atoms in a molecule joined together by drawing lines between atoms to represent the bonds. Example: butane has a formula of C_4H_{10} , therefore the structural formula is:



It has 4 carbon atoms bonded together with 10 hydrogen atoms. Organic compound containing only single bond is saturated. Eg: methane

All alkanes are saturated. All alkenes are unsaturated

Physical Properties of Alkanes

1. Melting points and boiling points increase as the bonds become larger and heavier which increases the forces of attraction between molecules so more energy (from heat) is needed to separate them with the increase of strength of forces of attraction.
2. Alkanes are Insoluble in water but soluble in organic solvents such as tetra chloromethane as alkanes are organic compounds.
3. Alkane density increases down the series; all alkanes are less than $1g/cm^3$
4. Alkanes become more Viscous going down the series as the longer molecules tangles together when it flows.

- Alkanes become less flammable down the series as Boiling point becomes larger.
- Alkanes are unreactive with metals, water, acids or bases because the C – C and C – H covalent bonds are harder to break

Chemical properties of alkanes

- Combustion Alkanes burn in air to always form carbon dioxide and water.



- When there is insufficient oxygen, the product is ALWAYS carbon monoxide and unburnt carbon.



Higher alkanes burn less completely and give soot (unburnt carbon) and CO

Reaction with Chlorine/Other Halogens (Alkyl Halides)

Chlorine molecule replaces the hydrogen atom in the alkane with chlorine atom

Substitution reaction the reaction in which one or more atoms replaces other atoms in a molecule. Light is needed to break covalent bond between chlorine molecule atoms

Alkenes

They have a general formula C_nH_{2n}

All alkene names end with suffix – ene.

The formula of one alkene differs from the next by $-\text{CH}_2$ atoms.

They have similar chemical properties like alkanes going down the series.

No. of C atoms	Name	Molecular formula	Structural formula	state of matter
2	ethene	C_2H_4	$CH_2 = CH_2$	gas
3	propene	C_3H_6	$CH_3CH_2 = CH_2$	gas
4	butene	C_4H_8	$CH_3CH_2CH = CH_2$	gas
5	pentene	C_5H_{10}	$CH_3CH_2CH_2CH = CH_2$	liquid

Structure of Alkenes

Alkene compound containing $C = C$ double bond, it is said to be unsaturated because not all Carbon atoms are bonded to the maximum number of 4 other atoms

Reactions of Alkenes

Combustion : alkenes burn in air to form carbon dioxide and water

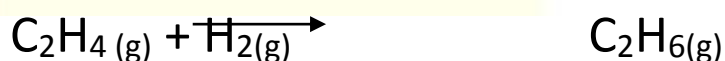


Incomplete combustion forms soot and CO. This is produced more than in alkane

Addition Reaction Is the reaction of 2 or more molecules to form a single product.

E.g **Addition of hydrogen:** Alkenes react with hydrogen to form alkanes, called

Hydrogenation. Nickel is used as catalyst and then heat.



Nomenclature

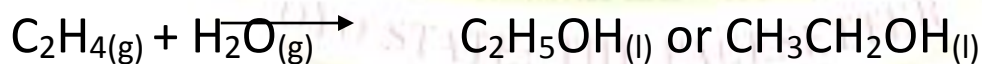
ALKENE is named according to the number of carbon atoms it contains.

Addition of bromine to ethene for example. Bromine add to C = C double bond of alkene molecules. In the presence of Phosphoric acid (H_3PO_4), high temperature of 300°C and 60-70 atm. pressure are needed as catalyst .Eg: ethene to 1,2 –dibromoethane



Nomenclature (n)(bromo) + (alkene name), where n is the number of bromine atoms. E.g. Above, Ethene reacts with 2 bromine atoms producing DI(2) BROMO(Bromine) ETHENE(alkene name). Hence we call the product DIBROMOETHANE.-

Addition of water Alkene reacts with water, in the form of steam, to produce alcohol. Alkene + steam is passed over phosphoric acid (H_3PO_4) catalyst and temperature of 300°C . H_2O molecule adds to C = C bonds to form alcohol.



Nomenclature

(alkene name) + (-ol) E.g. in above, the alkene ethene (C_2H_4) reacts with steam to form

ETHANOL(alkene name –ETHAN + OL group of alcohol)-

Polymerization The joining of several identical alkene molecules to form a big molecule Eg: Ethene poly(ethene)

Testing for Unsaturated Compounds

Mix bromine solution with alkene (for liquid alkenes –shake).
Reddish-brown colour of bromine disappears. This shows that the compound is an alkene.

Foods of Unsaturated Compounds

The Manufacture of Margarine (Poly unsaturated food) – food containing $C = C$ bond in their molecules

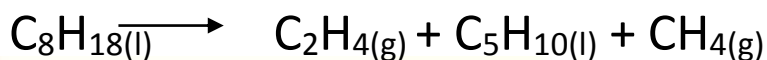
Eg : Vegetable oil to produce margarine: Hydrogen is reacted with vegetable oil in the presence of nickel catalyst and heat, this add to $C = C$ bond, increasing the molecular mass of the compound. With increase in mass, the compound has higher boiling point. Therefore margarine is solid at room temperature. Since only some $C=C$ bonds react with hydrogen, margarine is partially hydrogenated and each has different hardness, depending on the number of $C=C$ bonds.

The Cracking of Alkanes

Cracking is the breaking down of higher molecular Hydrocarbon into smaller ones in the presence of heat, pressure and catalyst.

Higher molecular Hydrocarbon can be cracked into shorter chain hydrocarbons because of the higher value of its carbon to create more variety of products as it occur in petrochemical industries. We crack alkane by catalytic cracking, which is, using catalyst to break alkane into simpler hydrocarbons. We crack alkane to get more valuable hydrocarbons. The total number of carbon and hydrogen atoms from products should be equal to the total number of carbon and hydrogen atoms in cracked alkane.

E.g. Octane can be cracked into simpler hydrocarbons such as the reaction below.



Isomers are compounds with same molecular formula but different structural formula.

Due to different chain length, they have different physical properties (e.g. boiling point).

Isomerism is the ability of a compound to exist in two or more different structural form.

Nomenclature deals with the naming of organic compounds.

IUPAC have developed a system by which this is achieved. This involved a set of rules.

Rules for naming organic compounds

1. By counting, identify the longest possible carbon atom in the given compound called the root or the parent. This will form the last part of its name
2. Identify all the attaching functional groups to the parent. This is called the branching, which are named according to their order of strength.

Number of carbon atoms	1	2	3	4	5	6	7	8	9	10
------------------------	---	---	---	---	---	---	---	---	---	----

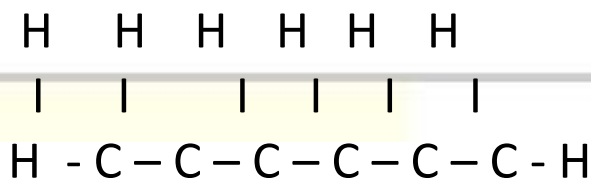
prefix name		met-	eth-	prop-	but-	pent-	hex-
hept-	oct-	non-	dec-				

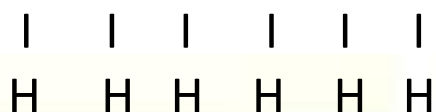
Homologous series	General formula	Functional
group	suffix name	

Alkane ane	C_nH_{2n+2}	C-C	-
Alkene -ene	C_nH_{2n}	C=C	
Alkyne -yne	C_nH_{2n-2}	$C\equiv C$	
Alkanol	ROH	-O-H	-ol
Alkanoic -oic	RCOOH	-COOH	
Alkanoate -oate	RCOOR'	-COOR	
Alkaone -one	RCOR'	-COR	
Alkanal -nal	RCOH	-COH	
Ether ether	RCOCR'''	-C-O-C-	
Amine amine	R-NH ₂	- NH ₂	
Amide (NH ₂)	R-CO-(NH ₂) amide	-CO-	

Note Alkyl group $R = C_nH_{2n+1}$

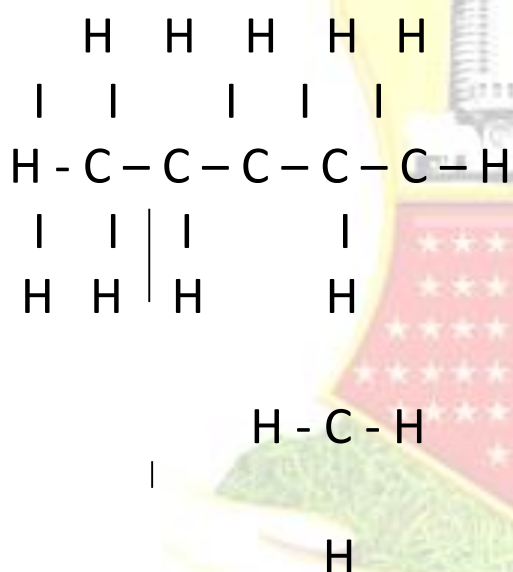
Different alkyl groups of different carbon content R' , R'' , R'''



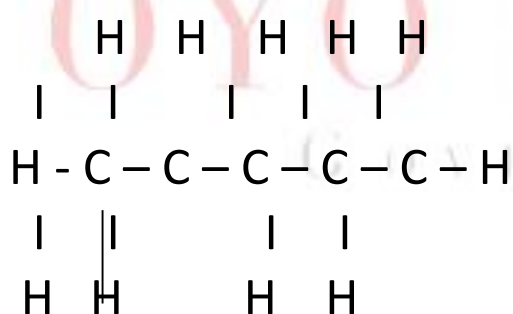


The structure above is C_6H_{14} and it is simply **hexane** or **n-hexane**

But there are more variations of C_6H_{14} and each variation has its own name. The figure below shows the nomenclature (i.e. how to name) these isomers.

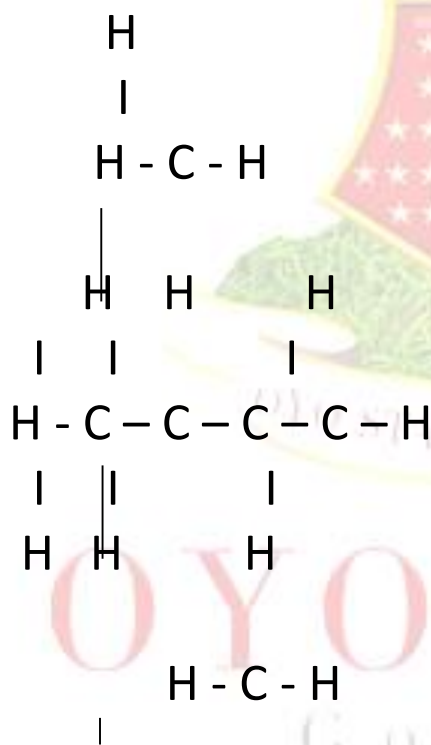


The structure above is 2-methylpentane. The number 2 indicates the position of methyl group (CH_3) attached to a carbon atom from the nearest end.



H

The methyl group is on carbon 3 and so the name is 3-methylpentane.

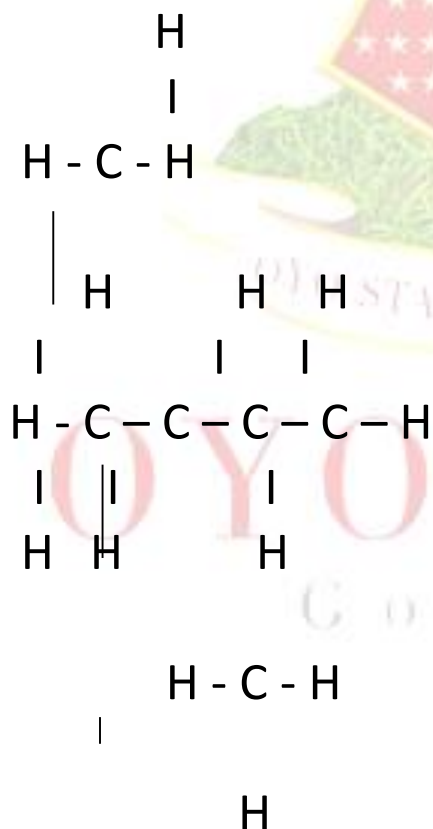


H

The name is 2,2-dimethylbutane.

There are 2 possible numbers: 2 or 3 but since 2 are closer, we put 2 in place. Also the second number 2 indicates the position of the second methyl group attached to carbon atom. Since it is attached

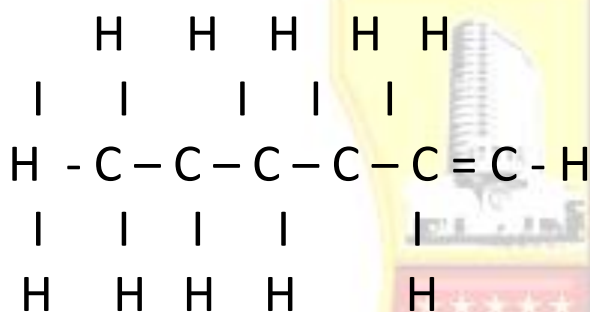
to the same carbon atom as the first methyl group, we put the same number 2 with a , (2,2) and a dash (-) which is used to separate numeric from the name. Also note that the name is now “**butane**”. This comes from the number of carbon atoms in the STRAIGHT chain only. The turns leading to methyl is ignored. Bear in mind that “**di**” in “dimethyl” indicates the number of methyl groups in the isomer (“di” means two). One methyl has no prefix, if it’s three it is “tri” and so on. Note that Students often misinterpret this as 1,2,2-trimethylpropane while in fact, we do not take the last bend in the chain as another methyl group. Instead, we consider it as PART OF THE STRAIGHT CHAIN.



The figure above is another isomer called 2,3-dimethylbutane. It is possible to flip the positions of methyl group without changing

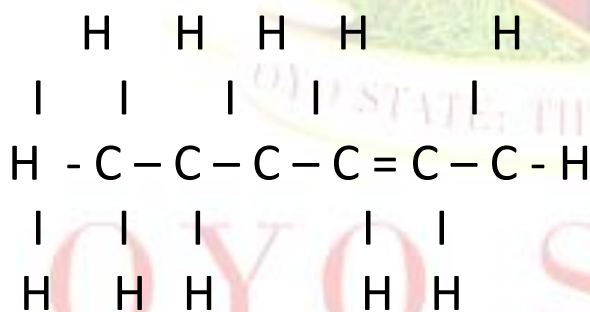
formula- Note that the second number is 3 while in fact, the position closest to the end of isomer is 2.

For isomerism in alkene and in alkyne we apply the same theory as isomerism in **alkane**, and just to only add a double bond or triple bond as it applies.



The compound above is Hexene, Hex-1-ene or n-Hexene. Notice that the double bond is on carbon 1 of the nearest carbon to the end.

For alkene, double bond position can be changed.



This figure is hept-2-ene, where the number in between indicates position of double bond from nearest isomer and so on

Alkanols (Alcohol)

1. Are homologous series with general formula $\text{C}_n\text{H}_{2n+1}\text{OH}$
2. They have $-\text{OH}$ functional group (hydroxyl group)

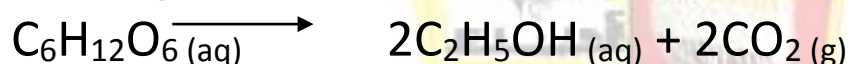
3. All alcohols end with suffix -ol

First three members are Methanol CH_3OH , Ethanol $\text{C}_2\text{H}_5\text{OH}$ or $\text{CH}_3\text{CH}_2\text{OH}$, Propanol $\text{C}_3\text{H}_7\text{OH}$ or $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$

Note For alcohol, the $-\text{OH}$ is not of ionic hydroxide ion, OH^- , but is covalent bond between oxygen and hydrogen, $\text{O}-\text{H}$

Manufacturing of Ethanol Fermentation of sugars with yeast-
Reacting ethene with steam Fermenting glucose

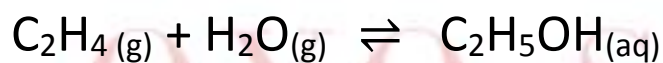
Fermentation is the breakdown of sugars into smaller molecules by microorganisms.



Temperature is kept constant at 37°C to prevent destruction of yeast at higher temperatures. Oxygen is removed by limewater and carbon dioxide is produced during fermentation. Alcohol is separated from solution by fractional distillation.

Reacting Ethene with Steam

Ethene and steam are passed over phosphoric acid H_3PO_4 (as a catalyst) under high temperature of 300°C and pressure of 65 atm.



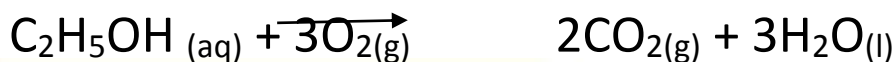
Since this is reversible reaction, both ethene and water are produced aside from ethanol. The ethanol is separated by fractional distillation.

Uses of Alcohol

As organic solvent; alcoholic drink; preservatives; vehicle fuel

REACTIONS OF ALCOHOL

Combustion Alcohols burn in air to produce carbon dioxide and water. E.g. combustion of ethanol



Oxidation

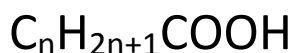
1. Alcohol can be prepared in laboratory by warming alcohol with oxidizing agent (e.g. acidified potassium chromate (VI)). The product is carboxylic acid and water. E.g. oxidation of ethanol produces water and ethanoic acid



2. Alcohol can be oxidized when left in air with bacterial enzymes as catalyst. The products are carboxylic acid and water. E.g. ethanol produces water and ethanoic acid when left in air.



Carboxylic Acids homologous series with general formula



1. They have –COOH functional group (carboxyl group)-
2. All carboxylic acids end with suffix – oic acid

First three members of the series

Methanoic acid, HCOOH

Ethanoic acid, CH₃COOH

Propanoic acid, C₂H₅COOH

PREPARATION OF CARBOXYLIC ACIDS.

Natural gas is passed over air and catalyst to form ethanoic acid and water. E.g. production of ethanoic acid from methane



PROPERTIES OF CARBOXYLIC ACIDS Carboxylic acids are weak acids (partially ionizes in water) -Carboxylic acids react with metals to form metal ethanoate (salt) and hydrogen

E.g. Reaction between calcium and ethanoic acid forming calcium ethanoate and hydrogen



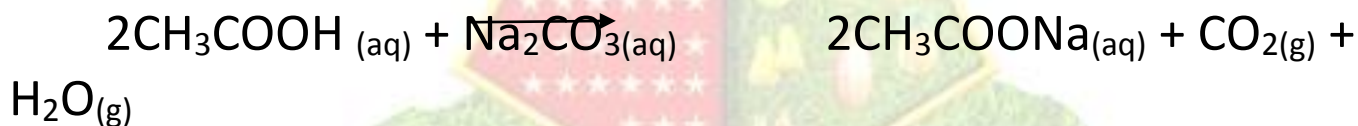
Carboxylic acids react with bases to form salt and water (neutralization)

E.g. Ethanoic acid reacts with sodium hydroxide to form sodium ethanoate and water.



Carboxylic acids react with carbonates and bicarbonates to form salt, carbon dioxide and hydrogen.

E.g. Ethanoic acid reacts with sodium carbonate to form sodium ethanoate and water.



ESTERIFICATION

ESTER is organic compound made from carboxylic acid and alcohol with the removal of one molecule of water.

Tetraoxosulphate (VI) acid is added as catalyst then heat the mixture. The reaction is reversible.

ESTER NOMENCLATURE:

Macro molecules is a large molecule made by joining together many small molecules

Polymer is a long-chain macromolecule made by joining together many monomers

Polymerization is the addition of monomers to make one large polymer

ADDITION POLYMERISATION is the one in which small molecules (monomers) join together to form one molecule as the only product. From monomer to polymer Example: Formation of poly (ethene) from ethene Ethene has double bond. Other ethene molecules add to this unsaturated compound during polymerization to form bigger compound.

Repeat unit is the simplest part of the polymer which is repeated many times to form the polymer. We take the repeat unit to write the simplified formula of the polymer, where n is a large number. From this repeat unit, to find the monomer formula, we add double bond between C–C and remove the bonds on each of their sides. Ester name is [alcohol] yl [carboxylic acid] oate. For instance, example above is butyl propanoate, where “butyl” is from butanol; “propanoate” is from propanoic acid. Some plastic variations and their uses are shown

CONDENSATION POLYMERISATION is the joining of monomers together to form polymers along with the elimination of water molecules. Nylon Di carboxylic acid and di amine undergo condensation polymerization to form nylon. The linkage between monomers in nylon is called amide linkage. Therefore we can also call nylon as polyamide. Today, we use nylon as:- a replacement of stockings and manufacture of garments to replace silk-make tents and parachutes due to strength-fishing lines- rugs and carpets Terylene Dicarboxylic acid (acid with 2 – COOH groups) and diol (alcohol with 2–OH groups) undergo condensation polymerization to form terylene.

The linkage between the monomers in terylene is called ester linkage. Therefore we can call this polymer as

Polyester. Today, we use terylene in fabrics as its strong, resists stretching and sinking and does not crumple when washed.

PROBLEMS ASSOCIATED WITH PLASTICS

Plastics are non-biodegradable –they cannot be decomposed by bacteria. Therefore, many plastic waste will pollute the Earth- Plastics produce toxic gas (such as hydrogen chloride) when burnt and this contributes to acid rain.- Plastics produce carbon dioxide when burnt –increases global warming.- Plastics that require CFC during production may contribute to global warming when the CFC is allowed to escape.

Natural Macromolecules

CARBOHYDRATES contain carbon, hydrogen & oxygen where the ratio of Hydrogen to Oxygen is 2 to 1. General formula is $C_n(H_2O)_n$.

The simplest carbohydrate is $C_6H_{12}O_6$ (glucose). Glucose polymerizes each other to form starch. The overall reaction is:



Starch can also be broken down into glucose by heating with dilute tetraoxosulphate (VI) acid. This is HYDROLYSIS.

PROTEINS have similar linkage to that of nylon. Only that their monomers are only amino acids joined together. They are formed by condensation polymerization. Proteins can be called as polyamide as it has amide linkage. Proteins can also be broken

down into amino acids by boiling protein with tetraoxosulphate VI acid. This adds water molecule unto the polymer.

FATS have similar linkage to that of Terylene (ester linkage). Only that their monomers consists of glycerol and fatty acids; different from Terylene. Fats can also be broken down to sodium salts of fatty acids and glycerol by boiling it with an acid or alkali. This is **HYDROLYSIS**.

Metal and their compounds

The earth provides the natural source of metals in form of ores. Which can be extracted purified and shaped into the required form for human and material use. Metals are grouped on the left side of the periodic table as group I, II and III

Properties of Metals

Physical properties

1. Ductile can be stretched to form wires
2. Malleable can be bent and beaten into different shapes
3. Good conductors of electricity and heat
4. Lustre (Shiny)
5. High melting points and boiling points except mercury and sodium
6. High density except sodium
7. High tensile strength (Strong)

Chemical properties of Metals

1. They react by losing electron, hence a strong reducing agent



2. When they are oxidized they form basic oxide which if soluble forms alkaline solution



3. They react with dilute acid to liberate Hydrogen



ALLOYS are mixture of metallic elements or metallic with non-metallic elements. Generally pure metals are weak in nature as the layers of atoms slide over each other easily. Whereas in alloy of 2 metals or more, they have different sizes of atoms so this disrupts the orderly layer of atoms making it difficult for atoms to slide over.

Uses of Alloy:

Steel (iron and carbon as trace element), **Brass** (copper 70% and zinc 30 %). It is tough and corrosive-resistant

Coin metals (copper with other metals e.g. nickel). It is tough, heat resistant and stands up to wear

Stainless Steel is an alloy of iron 73%, chromium 18%, nickel 8%, carbon 1% **Uses:** Cutleries, Medical instruments for hospital operations, Kitchen sinks, Steel objects in chemical factories and oil refineries.

Reactions on the reactivity series

Reaction of Metals with Water

Potassium, Sodium, and Calcium reacts with cold water to form:



Magnesium, Zinc, Iron reacts with **steam** to form:

Zinc Blende

Zinc sulphide

ZnS

Iron

Haematite

Iron(III)oxide

 Fe_2O_3

Iron Magnetite

Iron(II) trioxide

 Fe_3O_4

Tin Cassiterite

Tin(IV) oxide

 SnO_2

Lead Galena

Lead (II) sulphide

PbS

Copper Chalcopryite

Copper (II) sulphide +Iron sulphide

 $\text{CuFe}_2 (\text{CuS} + \text{FeS})$

Mercury Cinnabar

Mercury (II) sulphide

HgS

Extraction is the process of removing the Metal ores from ground. The ores contain useful and unwanted materials. Unwanted materials are separated to obtain concentrated mineral. The Metal is then extracted from the mineral.

Occurrence of Metals

Metal ores are compounds, usually as:-Metal oxides, eg: Al_2O_3 , Metal sulphide, eg: HgS, Metal carbonates, eg: MgCO_3

General Method of Extraction of Metals

Least Reactive metals are the easiest to extract; extracted by physical methods

Less Reactive metals are harder to extract than least reactive; by blast furnace; usually occur as compounds of oxides or sulphides.

Most Reactive metals are the hardest to extract. Strong bonds in compounds; extracted by electrolysis. i.e. decomposing compounds with electricity.

Uses of Metals

The choice of metals over another depends on 3 factors:

1. Physical properties (e.g. melting point, strength, density, conductivity)
2. Chemical properties (e.g. resistance to corrosion)
3. Cost

The Uses of Some Metals and Reason for the choice of the metals

Aluminum Drink cans-Window frames-Low density, non-toxic, cheap-Resists corrosion, strong

Copper Electrical wires-Water pipes-Ductile, good conductor of electricity-Strong, malleable, resists corrosion **Gold** Jewelry-Protective coating-Shiny and attractive, very malleable-Good reflector of heat and light **Titanium** Supersonic aircraft-

Spacecraft-Light but strong, resists corrosion Recycling of Metals

Extraction of Iron

Iron is extracted from its ore haematite (Fe_2O_3). In the Blast Furnace

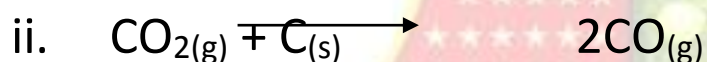
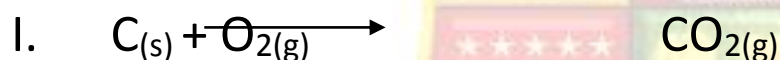
1. Oxygen in the air reacts with coke to give carbon dioxide:
2. Carbon dioxide produced in 1 above reacts with more coke to produce carbon monoxide
3. The carbon monoxide reacts with iron(III) oxide to produce molten iron, which runs down to the bottom of the furnace

4. The limestone decomposed by heat to form calcium oxide and carbon dioxide

5. Iron ore contains many impurities (silicon, sulphur, phosphorus, etc.) Sand, SiO_2 , reacts with calcium oxide to produce slag (calcium silicate). Slag runs down to the bottom of the furnace, floating on top of molten iron

6. Molten iron & slag tapped off separately in furnace. Slag is for road construction.

7. Referring to equation, not all iron(III) oxide reacted with carbon, only small amount



Steel Iron made from blast furnace is not pure enough in quality as it contains impurities which makes it brittle (can break easily). it cannot be bent or stretched. Most iron is converted into steel which is an alloy of iron and carbon with small amounts of other elements.

Advantages of steel:-it is strong and tough-it can be bent and stretched without shattering

Manufacturing Steel Impurities of iron is removed by blowing oxygen into molten iron to change the impurities into oxides.

They are then combined with Calcium Oxide and removed as slag. Carbon and other metals are added in certain percentage to make steel.

Different Types of Steel:-

- 1. Mild steel**—is low carbon steel with 0.25% carbon. It is strong and quite malleable. It is used for car bodies, ships, railway lines and steel rods to reinforce concrete-
- 2. Hard steel**—is a high-carbon steel with about 1% carbon. It is harder than mild steel and less malleable. It is used to make tools-
- 3. Stainless steel**—is iron with large amounts of chromium and nickel. It is hard, shiny and does not rust. It is used to make cutleries, medical instrument and pipes in chemical industries.
- 4. Rusting—corrosion of iron and steel** **Rust** —brown solid product formed during rusting Rust is hydrated iron(III) oxide $\text{Fe}_2\text{O}_3 \cdot x \text{H}_2\text{O}$ where water molecules varies.

Conditions for Rusting : Tubes A B and C are tubes where iron nails are put. A is left open, B contain boiled water and C contains solid CaCl_2 . After a few days, only nail in tube A rusts. This shows that air and water is needed for rust. In boiled water, the nail doesn't rust in B as boiled water removes dissolved air while in C, CaCl_2 , keeps air dry so there's no water. Other factor is the dissolved salt.

Preventing Rusting

- a. Surface protection
- b. Sacrificial protection

- c. Use of stainless steel Surface Protection
- d. covers metal with a layer of substance e.g Paint, Grease or oil (this also help to lubricate
- e. Plastic protection
- f. Metal Plating –covering metal with thin layer of another metal (e.g. tin, chromium, silver)

Advantage –These methods are cheap (except metal plating)

Disadvantage -If the layer is broken, air and water can reach metal to rust

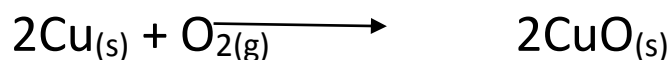
Sacrificial Protection is to sacrifice more reactive metal to corrode with water and air by layering it over less reactive metal (e.g. iron covered by magnesium). If layer is broken, water & air reach underneath layer, overlying metal still protect it. Applications:1) Galvanized Iron–is steel coated with zinc, usually used on roofs. 2) Protecting ships–blocks of zinc are attached to hulls to corrode instead of steel which is the ship metal. 3) Underground steel pipes–these are attached to magnesium block using insulated copper cables. Magnesium corrodes first steel.

ATMOSPHERE AND ENVIRONMENT

Air The atmosphere is a layer of air containing mixture of several gases. This mixture composition varies according to time and place. The composition of water vapour varies from 0 - 5%, depending on the humidity of air.

Percentage Composition of Oxygen in Air

A known volume of air is passed through tube with burning copper powder and oxygen in air will react with hot copper powder to produce black copper oxide



If oxygen is depleted, the readings on both syringes will be steady and the reaction has completed. Hence, to find the volume of oxygen in air collected in syringe Volume of O_2 = Initial volume of air – Final volume of air Example, the initial volume of air in one syringe is 80cm^3 and the final volume is 64cm^3 . Hence, the percentage volume of O_2 in air is

$$\begin{aligned} \% \text{ Volume of } \text{O}_2 &= 80 - 64 = 16\text{cm}^3 \\ &= 16/80 \times 100\% = 20\% \end{aligned}$$

Liquefaction of Air Firstly, CO_2 is removed by passing air through NaOH . Then, the air is cooled to -25°C to freeze water vapour to be removed and the remaining air is cooled and compressed to become liquid which is then separated into its constituents by fractional distillation as each constituent has different boiling point.

Combustion MOST substances react with O_2 in an exothermic reaction, which is called combustion. If flames are produced during combustion, it is called burning. ALL carbon compounds burn in O_2 to produce CO_2 while ALL hydrogen containing compounds burn in O_2 to produce H_2O . When adequate supply of oxygen is available during burning; it will create a complete combustion. If otherwise, the combustion is incomplete



Typical Combustion Reaction

When air hole is closed, oxygen cannot enter reaction chamber, and hence soot (unburnt carbon) and CO is produced from incomplete hydrocarbon gas combustion. As a result, flame is yellow due to glowing specks of hot soot in heat and the flame is not hot. When air hole is opened, air supplies plenty of oxygen, allowing complete combustion.

Oxygen in combustion Reaction used as

1. As rocket fuel
2. In steel making, to burn off impurities
3. In oxy-acetylene cutting and welding
4. In oxygen tanks for deep sea divers and mountain climbers to provide oxygen
5. For respiration for most animals
6. Used as oxygen tents in hospital to aid patients with respiratory problems

Pollution is the process of making the environment dirty as against the well being of the inhabitant.

Types of pollution include water, air and soil.

Pollutants in the soil and water are metallic compounds such as cadmium, iron, manganese, etc. from waste discharge, like Phosphates from fertilizers, detergents or sewage treatment plants, Nitrates from fertilizers or sewage treatment plants are also present.

Sewage from sewage treatment plants or septic systems, Harmful **microbes** from sewage treatment plants, septic systems, naturally occurring in water or growing in abundance due to pollution. Acid

from industrial discharges, Oil spills from oil tankers. **While** mineral salt are needed for basic functions of human body such as bone growth, fluid regulation, normalize nerve and muscle functionality, metabolism control, aquatic plants to make food and produce oxygen for aquatic organisms. Dissolved oxygen is needed for respiration and growth of aquatic life. Organic matter for growth of aquatic organisms

Acid Pollutant is Harmful as it Kills aquatic organisms and plants. It makes water acidic and corrosive as well as unsafe to drinking.

Nitrates Causes eutrophication which deprives marine organisms of oxygen. Nitrate ions may cause breathlessness or kill babies when consumed

Phosphates Can cause eutrophication as it encourages the growth of algae, hence killing aquatic organisms when they die and takes away oxygen

Heavy metal ions these are carcinogenic that can cause skin cancer, liver cancer, lung cancer, etc.

Sewage Contains pathogens which when consumed carry diseases such as diarrhea

Oil Is capable of trapping bird's feathers and kills them eventually. Oil spills also depletes oxygen as air is not able to mix with water to provide sufficient oxygen for the aquatic animals.

Air Pollution: Pollutants are substances in atmosphere which are harmful for living things and environment, for contributing to air pollution. From nature, pollutant sources are volcanoes, forest fires, decay of dead matter, etc. but from humans, they are exhaust fumes, power stations, oil and gas, etc. Air pollutants are:

Carbon monoxide from unburnt hydrocarbons; exhaust fumes; forest fires. It combines with haemoglobin when inhaled, which produces carboxyhaemoglobin that reduces efficiency of haemoglobin to transport oxygen. Cells then die. It is prevented by installing catalytic converters in cars, Reduce number of cars on road, Create efficient engines in cars to ensure complete hydrocarbon combustion

2. **Sulphur dioxide** it is obtained from the Combustion of fossil fuels containing sulphur impurities; volcanic eruptions. Side effect includes Lung irritation, eye irritation, and acid rain. It can be Prevented using fuels containing sulphur impurities, e.g. coal- Reduce the sulphur impurities inside fossil fuels, Spray exhaust gases from factories with water/ hydrated CaO /alkalis to absorb sulphur dioxide before it is released into the atmosphere, also by adding CaO to soil and rivers to neutralize acid rain.

3. **Oxides of nitrogen** (NO , NO_2 , N_2O_4) it is obtained generally from Lightning activity; forest fires; internal combustion engines (as nitrogen oxides are formed by oxygen and nitrogen under high temperature); power stations. Side effects includes eutrophication (lung damage), acid rain. Can be controlled by installing catalytic converters in cars, Design car engines which run at lower temperatures.

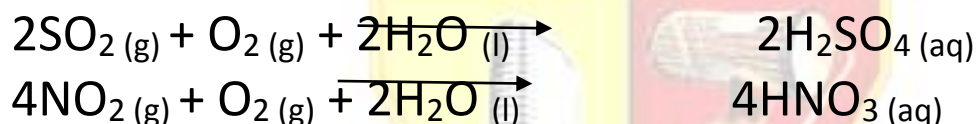
Control for Pollution

Setting up of minimum standards for Proper disposal of rubbish to prevent more water pollution.

Legislations to Prohibit activities potentially causing water pollution near rivers/reservoirs such as camping or swimming

Enforcement of legislation by Dispatching monitors to prevent accidents and activities that could result in pollution

ACID RAIN Acid is formed by 2 main constituents SO_2 and NO_2 (Sulphur dioxide/nitrogen dioxide), both react with oxygen and water to form tetreoxosulphate VI acid/ trioxonitrate V acid. This is called hydrolysis.

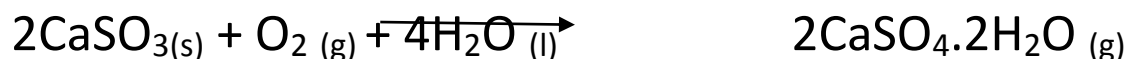


Effects of Acid Rain -The acid corrodes buildings, CaCO_3 materials and metal statues, Acid rain damages trees, Acid rain increases acidity of soil, making soil unsuitable for plant growth, Fish cannot survive in acidic water,

Aggravates respiratory ailments such as bronchitis and asthma. Acid Rain can be controlled by Removing sulphur dioxide from fuel gases by desulphurization (the removal of sulphur dioxide from fuel or waste gases), Adding $\text{Ca}(\text{OH})_2$ to soil to neutralize acid from acid rain, Burn fuels with less sulphur. The product is CO_2 , which is non-polluting gas, and calcium sulphite.



To increase profit, calcium sulphite further oxidized to produced gypsum to be sold



4. **Methane** is obtained from the decomposition of vegetable matter; rice field; cattle ranching; natural gas; mines. It is highly flammable, it is a greenhouse gas. It is controlled using

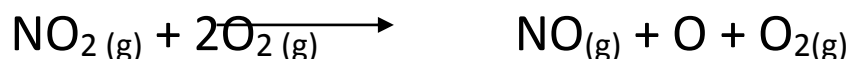
Cattle and other ruminant animals as improved diet, Animal manure and rotting vegetation can be used as biomass fuel

5. **Unburnt hydrocarbons** is obtained from internal combustion engines; incomplete combustion of hydrocarbons. It is Carcinogenic, it forms photochemical. It can be prevented by installing catalytic converters in cars, by reducing the number of cars on road, by creating more efficient engines in cars to ensure complete hydrocarbon combustion

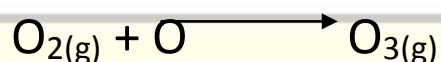
6. **Ozone** It is an allotrope (two/three different forms of a pure element) of oxygen having structural formula O_3 having characteristic odour. It is created by reaction of nitrogen oxides with volatile organic compounds in presence of UV radiation. It reacts with unburnt hydrocarbons to form photochemical smog capable of causing eye, nose and throat irritation.

It corrodes and kills plants and trees. it can be controlled using HCFCs which destroys faster.

PHOTOCHEMICAL SMOG is a hazy brown air, which is a mixture of fog and smog, that reduces visibility, causes eye irritation and breathing difficulties. It is produced by reaction between NO_2 and O_2 in the presence of sunlight to form NO , Oxygen atom and O_2 molecule. This reaction is called photochemical reaction.



The oxygen atom is reacted with the oxygen molecules formed to form ozone, O_3 .



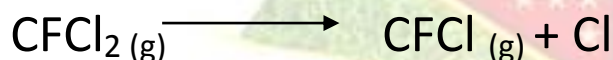
Ozone can react with unburnt hydrocarbons to produce eye-irritating substances.

DESTRUCTION OF OZONE LAYER

Use of ozone layer in stratosphere: It blocks UV rays from sun which causes skin cancer; acts as blanket to block out high sun energy radiation and prevent it from penetrating into Earth's surface. It is depleted when Ozone layer absorbs some UV radiation and reflects some back to space. CFCs, found in coolants in refrigerator and air conditioners, propellants in aerosols and blowing agents, are released into the atmosphere. In the presence of light, CFC decomposes into Cl_2 at the stratosphere where ozone is located.



further decomposes to produce more chlorine atoms, Cl, and CFCI



As a result, the Cl atoms produced react with O_3 molecules to form chlorine oxide, ClO, and oxygen O_2 .



The reaction uses up ozone which covers the earth and hence creating a hole in the layer. Harmful UV rays from sun can now reach Earth through these holes. To control depletion of ozone layer HCFCs is used which destroys faster than CFCs.

GLOBAL WARMING Greenhouse effect is the trapping of heat from sun by greenhouse gases to regulate Earth temperature so that not all heat is reradiated back to space. However, increased industrialization releases more greenhouse gases to atmosphere,

contributing to Global Warming (increase in temperature of Earth's atmosphere due to trapping of heat by greenhouse gases).

EXAMPLES OF **GREENHOUSE GASES** ARE:

1. **Carbon Dioxide** which is naturally occurring or by combustion of hydrocarbons.
2. **Methane** which occur naturally or emitted during production of fuels or from decaying vegetable matter.
3. **Nitrogen II Oxide** is produced by industrial and agricultural activities, and by incomplete combustion of hydrocarbons.

Side Effect of Global Warming It melts polar icebergs, floods low lying areas and coastal regions alter the climatic conditions of certain places, alter crop yield, and evaporation of water supply.

Control of GLOBAL WARMING Reduce the use of fossil fuels, Use alternative forms of energy such as wind, tidal and hydroelectric power, Use more electric vehicles, Reduce number of cars on road, Create efficient engines in cars to ensure complete hydrocarbon combustion.

CARBON CYCLE about 0.03% of the atmospheric air is carbon dioxide and this is kept constant by the process of carbon cycle. Carbon cycle is the removal of carbon dioxide by plants by photosynthesis and the replacement of these carbon molecules by combustion, respiration and natural processes. In the past the rate of absorption of carbon dioxide balances the rate of production of carbon dioxide. Men over the time have upset this balance. **Plants** use carbon dioxide from atmosphere, sunlight and chlorophyll for photosynthesis of sugars. Some carbon is used up in plants for growth and development, while some others are

released to atmosphere during respiration. When plants die & decomposed by microorganisms, CO_2 released to atmosphere.

Animals on the other hand as herbivores and omnivores eat plants, they gain carbon from them to grow and develop. Carnivores eating these animals also gain the carbon. When animals respire, they release carbon dioxide. When they die and decay due to microorganism, they release carbon dioxide which is later taken in by plants.

NON-LIVING THINGS Carbon monoxide and carbon dioxide are released from electric power, plants, exhaust fumes and factory emissions. Man burns fossil fuels, which needs millions of years to form, that takes in oxygen and releases carbon dioxide. This makes man depleting natural resource as they use them rapidly than the time needed to form, damaging natural environment and upsetting balance of carbon cycle.

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