APPLIED CHEMISTRY
1ST YEAR

2018-21

CHAPTER:-1

- BASIC CONCEPTS OF CHEMISTRY
- STRUCTURE OF ATOM
- MATTER
- PERCENTAGE COMPOSITION

WHAT IS CHEMISTRY

- CHEMISTRY is the branch of science which deals with the study of composition ,structure and properties of matter.

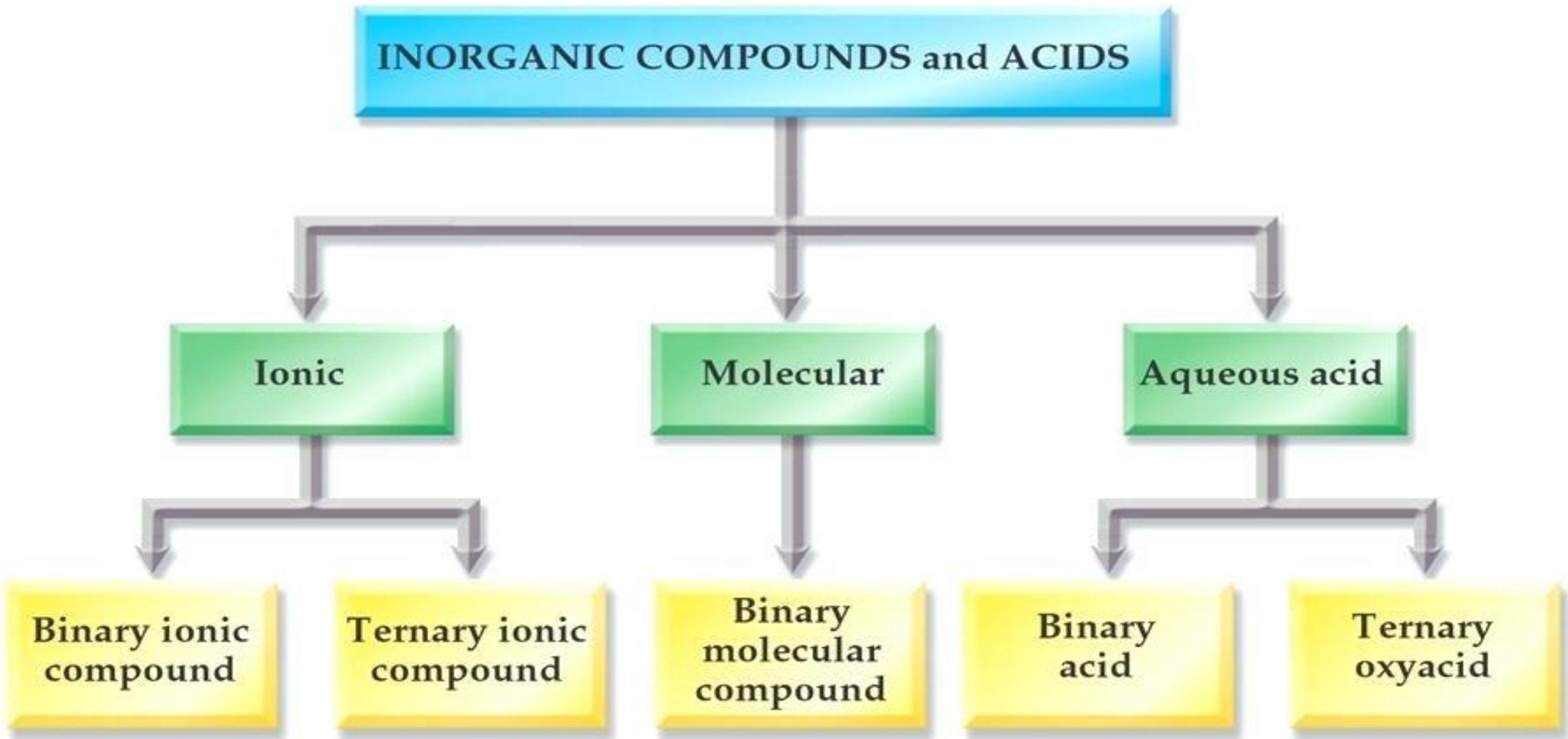
Write branches of chemistry

- Main branches are :-

1. Inorganic
2. Organic
3. Physical
4. Analyltical

Classification of Compounds

- Below is a flow chart for the classification of inorganic compounds.



Matter and it’s classification

- Matter is anything which occupies the space and have mass.it is classify in two catagories:-

- Physical classification

1. Solid,
2. liquid
3. gas
4. plazma

- Chemical classification

1. Pure matter
2. Impure matter

example:- homogenous and heterogenous

Define element compound and mixture.

- Elements :-

  pure substance consists of only one type of . particals is called elements.

1. Metals
2. Non metals
3. Metalloids

- Compound:-
    - Pure substance containing two or more atoms of different element combined in a fixed ratio
    - Example:-H_2O
- Mixture:-Material containing two or more types of substances in any ratio.These are of two types
    1. Hetrogenous Example:- water in sand
    2. Homogenous Example:- water in salt.

S.I UNITS

PHYSICAL QUANTITY	NAME OF SI UNIT	ABBERIVATION
lenght	metre	m
Mass	kilogram	Kg
Time	second	Sec
Electric current	Ampere	A
Temprature	kelvin	K
Amount of substance	mole	Mol
Luminous intensity	candela	Cd

DEFINE SYMBOL,VALENCY,ATOMIC

SYMBOL:-The short notation used for full name of the element .

ex:- H (hydrogen)

Valency:-it is combining capacity of an atom or number of electrons exchange . in Outer most shell during formation of molecule.

Atomic number:-number of protons /electrons present in atom.

Atomic weight:-it is the number of protons and neutrons present in the . . . center of the atom .

H d

Binary Ionic Compounds

Nomenclature :: naming system

Writing the Formula

1. Al^{3+} O^{2-}
2. Al^{3+} O^{2-}
3. Al_2O_3

Naming ::

Al_2O_3

Name of Cation — Name of Anion (with –ide ending)

Aluminum Oxide

Calculation of percentage composition

Calculating Percentage Composition

Calculate the percentage composition of magnesium carbonate, $MgCO_3$.

Formula mass of magnesium carbonate:

24.31 g + 12.01 g + 3(16.00 g) = 84.32 g

$$Mg = \left(\frac{24.31}{84.32}\right) \bullet 100 = 28.83\%$$

$$C = \left(\frac{12.01}{84.32}\right) \bullet 100 = 14.24\%$$

$$O = \left(\frac{48.00}{84.32}\right) \bullet 100 = 56.93\%$$

100.00

Structure of Atom

HISTORY OF THE ATOM

1808 John Dalton

suggested that all matter was made up of tiny spheres that were able to bounce around with perfect elasticity and called them

ATOMS

HISTORY OF THE ATOM

<u>1898</u> <u>Joseph John Thompson</u>

found that atoms could sometimes eject a far smaller negative particle which he called an

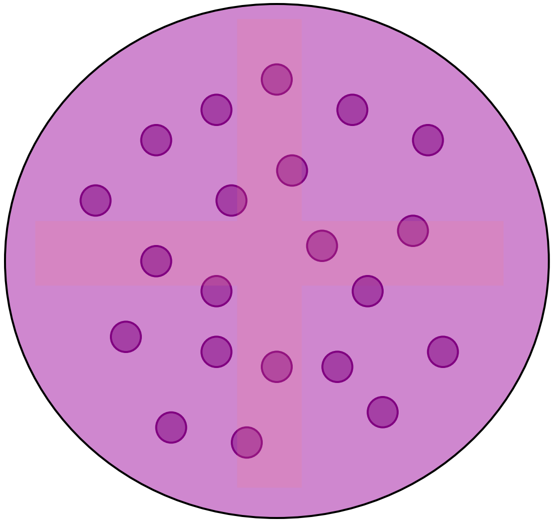
ELECTRON

HISTORY OF THE ATOM

1904

Thompson develops the idea that an atom was made up of electrons scattered unevenly within an elastic sphere surrounded by a soup of positive charge to balance the electron's charge

like plums surrounded by pudding.



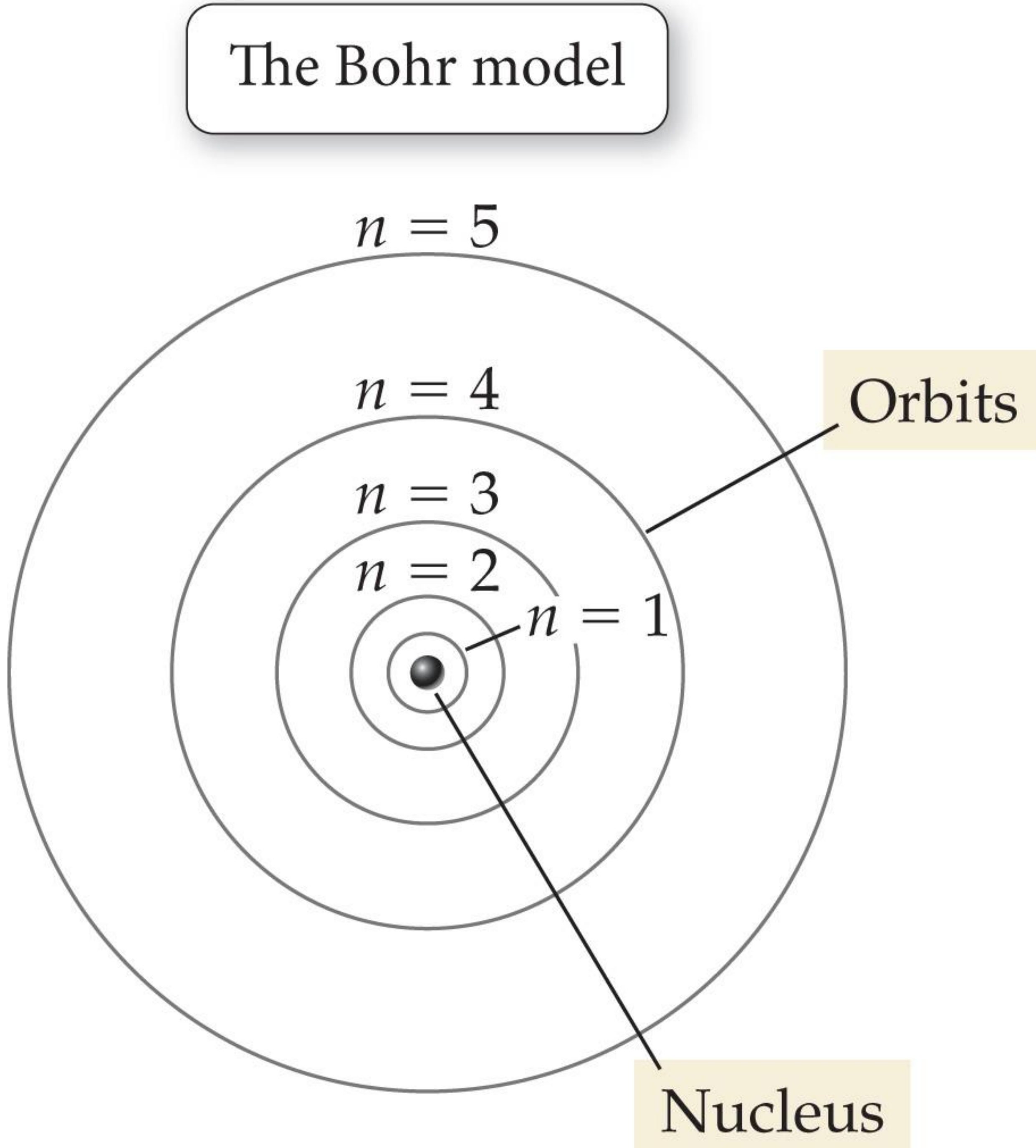
PLUM PUDDING MODEL

HISTORY OF THE ATOM

1913 Niels Bohr

studied under Rutherford at the Victoria University in Manchester.

Bohr refined Rutherford's idea by adding that the electrons were in **orbits**. Rather like planets orbiting the sun. With each orbit only able to contain a set number of electrons.

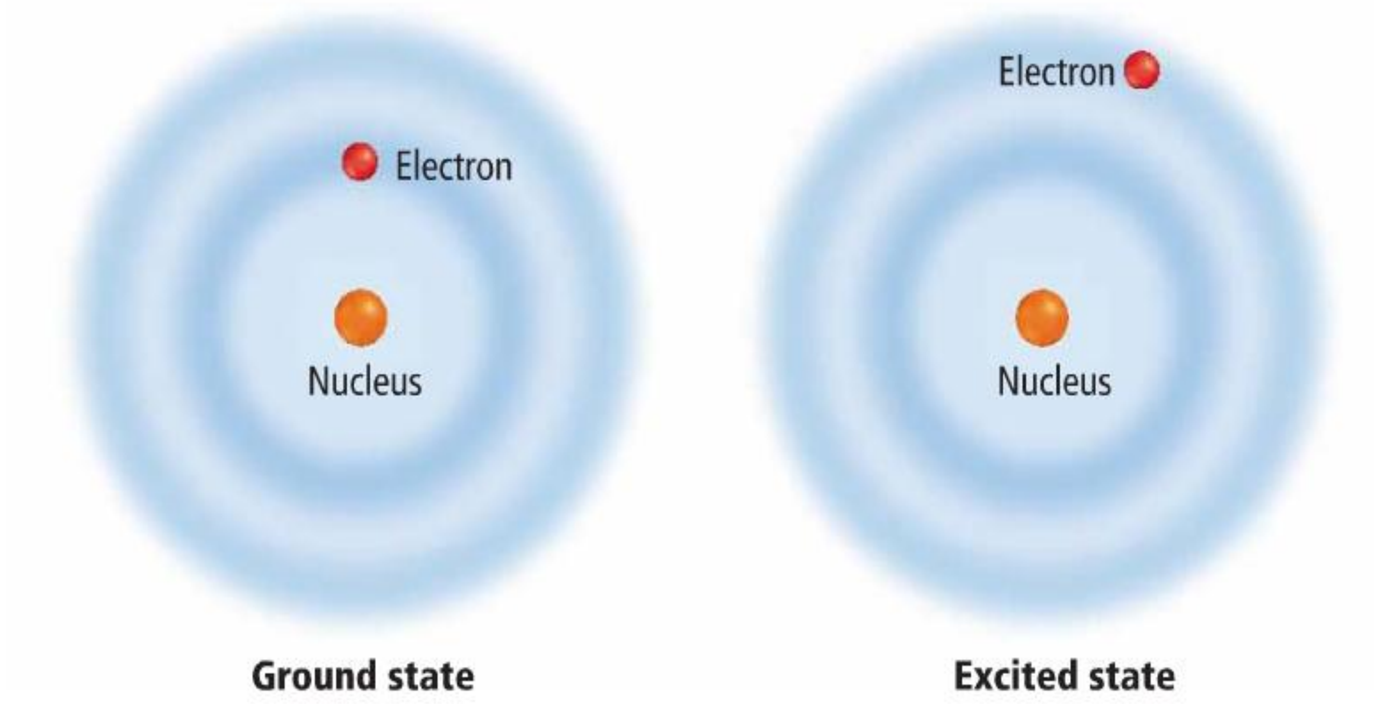

The Bohr model
n = 5
n = 4
n = 3
n = 2
n = 1
Orbits
Nucleus

Bohr's Model of the Atom

- The lowest allowable energy state of an atom is called its **ground state**.
- When an atom gains energy, it is in an excited state.

Bohr’s Model of the Atom

- Bohr suggested that an electron moves around the nucleus only in certain allowed circular orbits.



The Nuclear Model of the atom

Particle	Mass (kg)	Charge (C)	Mass (amu)*	Charge (*e*)
Electron	9.10939×10^{-31}	-1.60218×10^{-19}	0.00055	-1
Proton	1.67262×10^{-27}	$+1.60218 \times 10^{-19}$	1.00728	$+1$
Neutron	1.67493×10^{-27}	0	1.00866	0

*The atomic mass unit (amu) equals 1.66054×10^{-27} kg; it is defined in Section 2.4.

Atomic Symbols

- *Show the* mass number and atomic number
- Give the symbol of the element

mass number

$^{23}_{11}\mathrm{Na}$ sodium-23

atomic number

ATOMIC STRUCTURE

He

2 **Atomic number**

the number of protons in an atom

4 **Atomic mass**

the number of protons and neutrons in an atom

number of electrons = number of protons

Basic Definitions

- **“atomic number” = number of protons in the nucleus;**
- **“atomic weight” = average mass of an atom calculated from the masses and natural abundances of all isotopes**

(use *atomic weights* to calculate the molecular weights of compounds from their constituent elements!)

- **“mass number” = sum of protons + neutrons in the nucleus**

- **“isotopic mass” = mass of a single isotope**

Isotopes

- **Atoms with the same number of protons, but different numbers of neutrons.**
- **Atoms of the same element (same atomic number) with different mass numbers**

Isotopes of chlorine

$^{35}_{17}Cl$ $^{37}_{17}Cl$

chlorine - 35 **chlorine - 37**

An ISOTOPE is one of a set of nuclides with the same Z and consequently different A. (*ie* isotopes are the same chemical element but different masses). e.g.

$$^{12}_{6}C \quad ^{13}_{6}C \quad ^{14}_{6}C$$

An ISOTONE is one of a set of nuclides with the same N and consequently different A. e.g.

$$^{39}_{18}A_{21}, \quad ^{40}_{19}K_{21}, \quad ^{41}_{20}A_{21}$$

An ISOBAR is one of a set of nuclides with the same A but different N and Z.

e.g $^{14}_{6}C \quad ^{14}_{7}N \quad ^{14}_{8}O$

ATOMIC STRUCTURE

Electrons are arranged in Energy Levels or Shells around the nucleus of an atom.

- first shell — a maximum of **2** electrons
- second shell — a maximum of **8** electrons
- third shell — a maximum of **18** electrons

ATOMIC STRUCTURE

There are two ways to represent the atomic structure of an element or compound;

1. Electronic Configuration

2. Dot & Cross Diagrams

ELECTRONIC CONFIGURATION

With electronic configuration elements are represented **numerically** by the number of electrons in their shells and number of shells. For example;

Nitrogen **configuration = 2 , 5**

2 in 1st shell

5 in 2nd shell

2 + 5 = 7

$^{7}N_{14}$

SUMMARY

1. The **Atomic Number** of an atom = number of protons in the nucleus.

2. The **Atomic Mass** of an atom = number of Protons + Neutrons in the nucleus.

3. The number of Protons = Number of Electrons.

4. Electrons orbit the nucleus in **shells**.

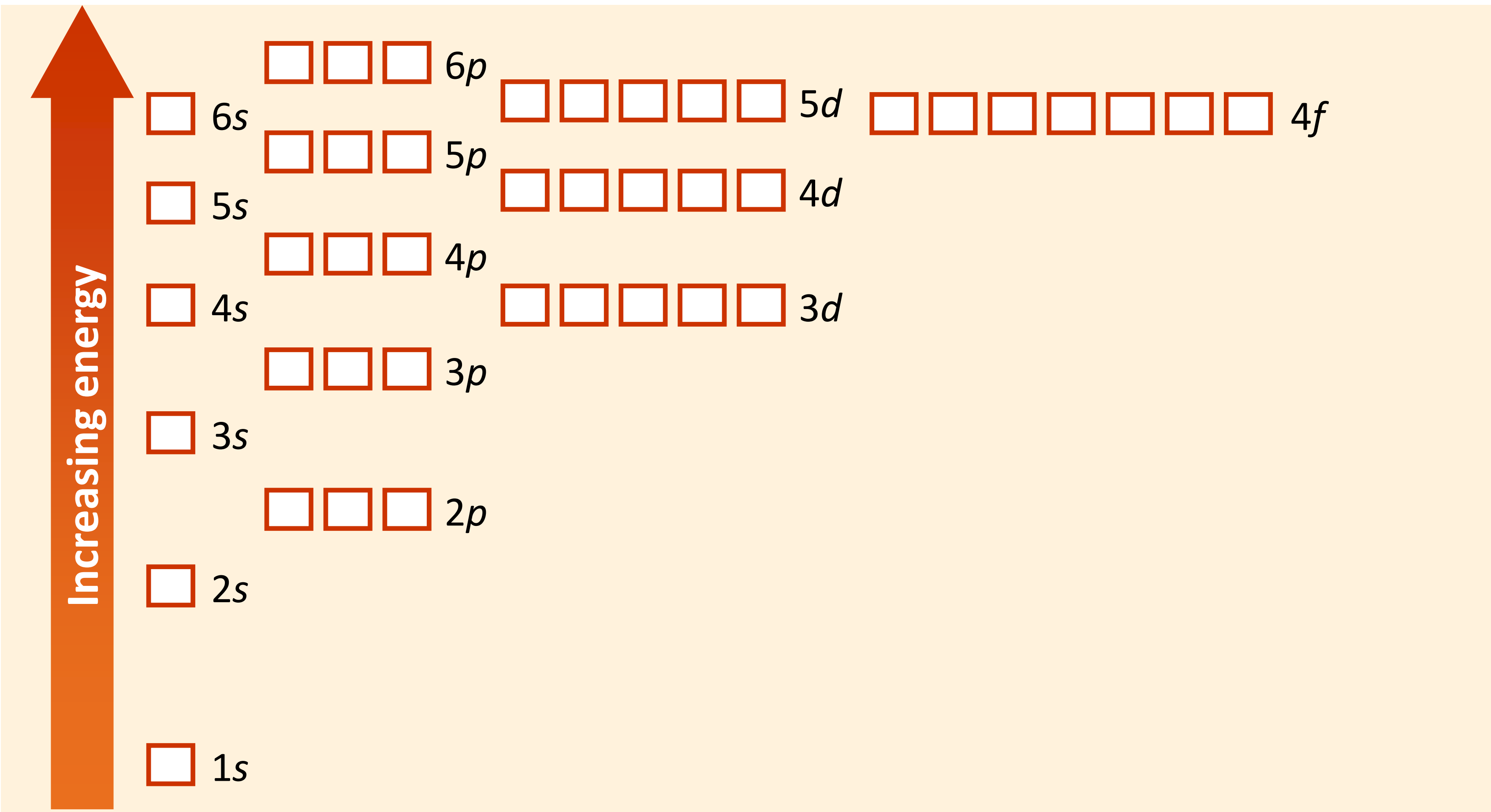
5. Each shell can only carry a **set** number of electrons.

The ways in which electrons are arranged in various orbitals around the nuclei of atoms are called **electron configurations**.

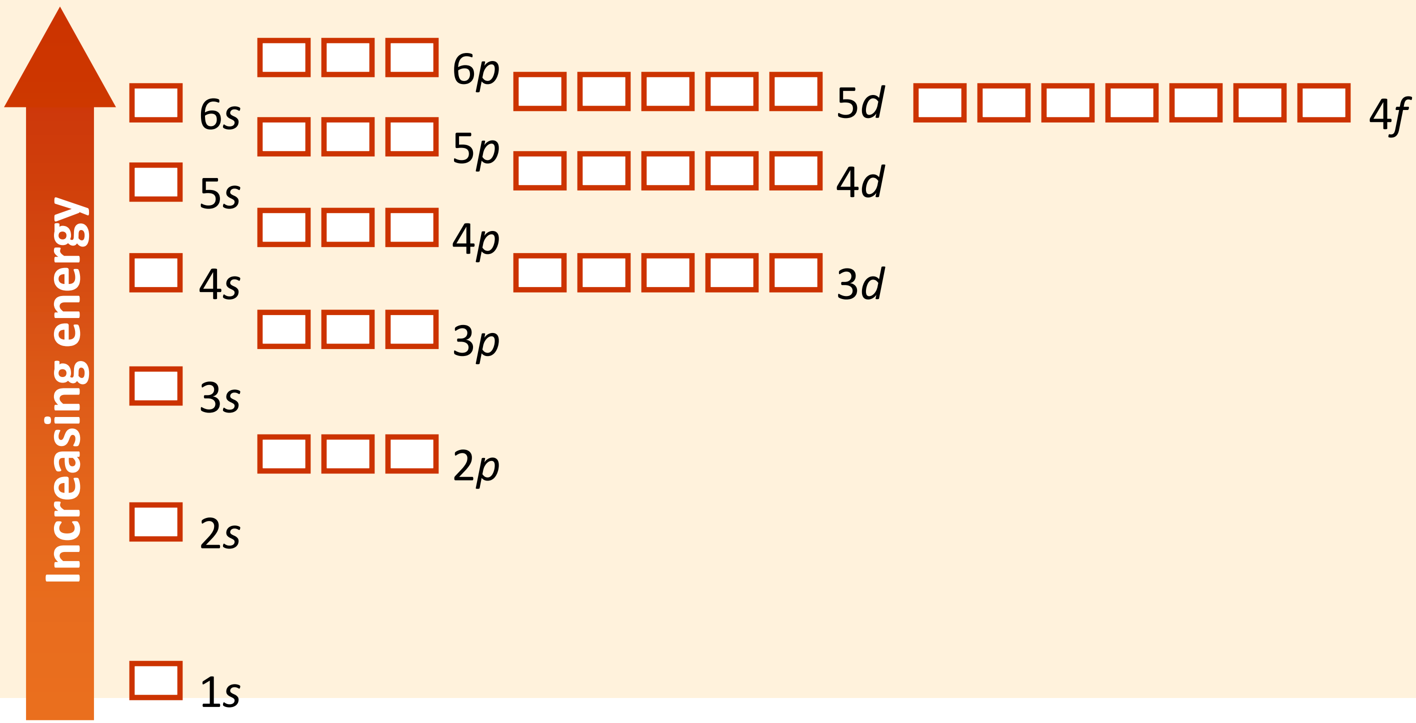
Rules of Electron Configurations.

1. **Aufbau principle**
2. **Pauli exclusion principle**
3. **Hund's rule**

<u>Aufbau Principle</u>, electrons occupy the orbitals of lowest energy first. In the aufbau diagram, each box represents an atomic orbital.



The range of energy levels within a principal energy level can overlap the energy levels of another principal level.



Pauli Exclusion Principle

- According to the **Pauli exclusion principle**, an atomic orbital may describe at most two electrons.
- To occupy the same orbital, two electrons must have opposite spins; that is, the electron spins must be paired.

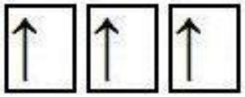
Pauli Exclusion Principle

- **<u>Spin</u>** is a quantum mechanical property of electrons and may be thought of as clockwise or counterclockwise.
- A vertical arrow indicates an electron and its direction of spin (↑ or ↓).
- An orbital containing paired electrons is written as ⇅.

Hund’s Rule

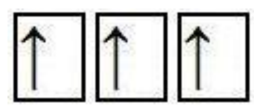
According to **Hund’s rule,** electrons occupy orbitals of the same energy in a way that makes the number of electrons with the same spin direction as large as possible.

Three electrons would occupy three orbitals of equal energy as follows.

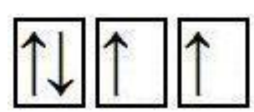


Hund's Rule

Three electrons would occupy three orbitals of equal energy as follows.



Electrons then occupy each orbital so that their spins are paired with the first electron in the orbital.



Electron Configurations of Selected Elements

Element	$1s$	$2s$	$2p_x$	$2p_y$	$2p_z$	$3s$	Electron configuration
H	↑						$1s^1$
He	↑↓						$1s^2$
Li	↑↓	↑					$1s^2 2s^1$
C	↑↓	↑↓	↑	↑			$1s^2 2s^2 2p^2$
N	↑↓	↑↓	↑	↑	↑		$1s^2 2s^2 2p^3$
O	↑↓	↑↓	↑↓	↑	↑		1s22s22p4
F	↑↓	↑↓	↑↓	↑↓	↑		$1s^2 2s^2 2p^5$
Ne	↑↓	↑↓	↑↓	↑↓	↑↓		$1s^2 2s^2 2p^6$
Na	↑↓	↑↓	↑↓	↑↓	↑↓	↑	$1s^2 2s^2 2p^6 3s^1$

- A convenient shorthand method for showing the electron configuration of an atom involves writing the energy level and the symbol for every sublevel occupied by an electron.

- You indicate the number of electrons occupying that sublevel with a superscript.

- For hydrogen, with one electron in a 1*s* orbital, the electron configuration is written $1s^1$.
- For oxygen, with two electrons in a 1*s* orbital, two electrons in a 2*s* orbital, and four electrons in 2*p* orbitals, the electron configuration is $1s^2 2s^2 2p^4$.
- Note that the sum of the superscripts equals the number of electrons in the atom.

Exceptional Electron Configurations

- You can obtain correct electron configurations for the elements up to vanadium (atomic number 23) by following the aufbau diagram for orbital filling.
- If you were to continue in that fashion, however, you would assign chromium and copper the following incorrect configurations.

Cr $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4 4s^2$

Cu $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9 4s^2$

Exceptional Electron Configurations

Some actual electron configurations differ from those assigned using the aufbau principle because although half-filled sublevels are not as stable as filled sublevels, they are more stable than other configurations.

Glossary Terms

- electron configuration: the arrangement of electrons of an atom in its ground state into various orbitals around the nuclei of atoms
- aufbau principle: the rule that electrons occupy the orbitals of lowest energy first
- Pauli exclusion principle: an atomic orbital may describe at most two electrons, each with opposite spin direction

Glossary Terms

- spin: a quantum mechanical property of electrons; it may be thought of as clockwise or counterclockwise
- Hund's rule: electrons occupy orbitals of the same energy in a way that makes the number of electrons with the same spin direction as large as possible

METALS IN NATURE

-FREE OR NATIVE FORM

they are limited to metals of very low reactivity, for example silver, gold, copper, platinum, nickel.

-COMBINED IN THE FORM OF ORES

These include the majority of metals. Chief ores of economic importance are metal oxides, sulphides, chlorides and carbonates.

The method used to extract a metal from its ore is guided by the position of the element on the Reactivity Series.

Metals high up on the series are strongly bonded in their compounds. Electrolysis is the only method strong enough to extract these.

Example:

Na(sodium), Mg(magnesium) and Al(aluminium)

METALLURGY

The process of extraction of metals from their ores in pure state is called metallurgy.

***Types of Metallurgy* :**

Metallurgy is of three types :

1. *Pyrometallurgy* :.

For example, (*i*) Extraction of Iron from its ore haematite ($Fe_2 O_3$)

(*ii*) Extraction of copper from copper pyrites ($CuFeS_2$)

2. *Electrometallurgy* :

For example, Sodium, Potassium, Aluminium etc. are extracted from their ores by electro metallurgy.

3.*Hydrometallurgy* electropositive metal.

For example, Extraction of silver and Gold is done by hydrometallurgy.

SOME IMPORTANT TERMS USED IN METALLURGY **:**

GANGUE OR MATRIX :

THE UNWANTED EARTHY IMPURITIES LIKE SAND, ROCKS, LIMESTONE, CLAY ETC PRESENT IN AN ORE ARE KNOWN AS **GANGUE** ORE **MATRIX.**

FLUX :

THE ADDITIONAL SUBSTANCE WHICH IS ADDED TO AN ORE TO REMOVE ACIDIC OR BASIC IMPURITIES IS KNOWN AS FLUX.

SLAG :

THE FUSIBLE MASS FORMED BY THE COMBINATION OF GANGUE AND FLUX IS KNOWN AS SLAG.

Steps involved in the extraction of metals from their ores

(*i*) Crushing and grinding of the ore

(*ii*) Concentration or Beneficiation of the ore.

(*iii*) Extraction of metal from concentrated ore.

(i*v*) Purification or refining of the metal.

GENERAL METHODS FOR CONCENTRATION

(1) LEVIGATION

(2) FROTH FLOATATION

(3) MAGNETIC SEPARATION

(4) LEACHING

CONTD

- **EXTRACTION OF METAL FROM ORE**

1.CONVERSION OF ORE IN METAL OXIDE(ROASTING,CALCINATION)

2.CONVERSION OF OXIDE IN METAL

(1) SMELTING

(2) REDUCTION BY HYDROGEN

(3) ELECTROLYTIC REDUCTION

(4)AUTO REDUCTION

Contd

- **PURIFICATION**
- **LIQUATION**
- **DISTILLATION**
- **POLING**
- **CUPELLATION**
- **ELECTRO REFINING**
- **ZONE REFINING**

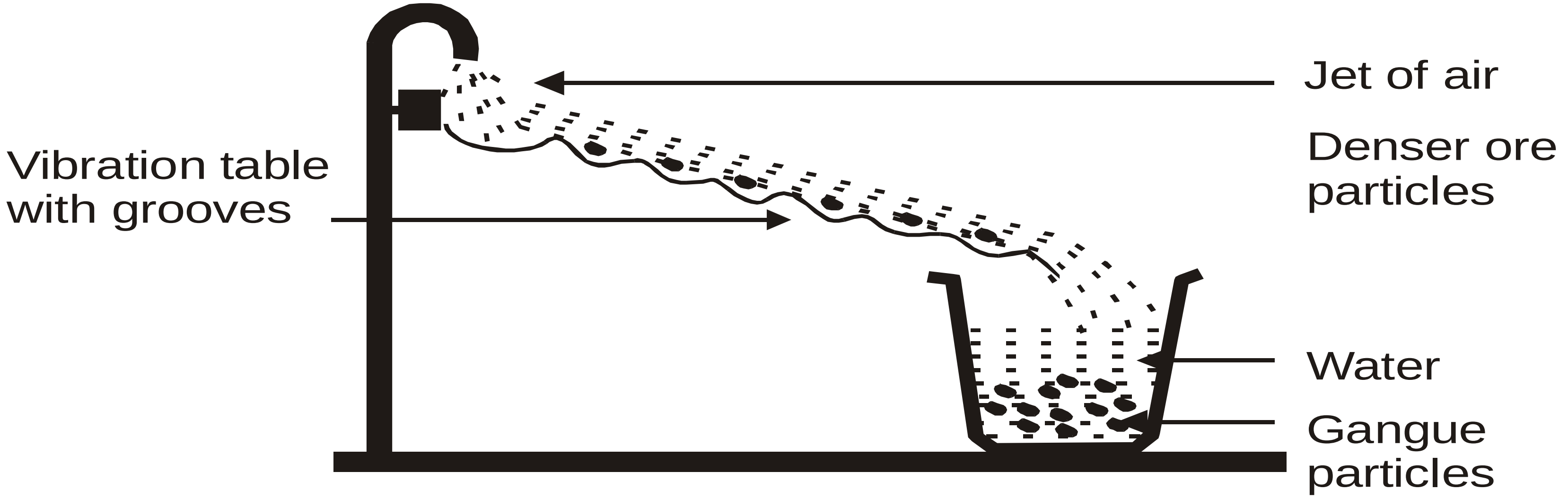
Gravity concentration

- Some ores are heavier than the waste. The ore is shaken by a jolting box, or similar, while wet.
- Particles will separate into layers depending on weight, the metal may be removed as a layer.

Concentration of ore

1. Hand picking : to show by picture

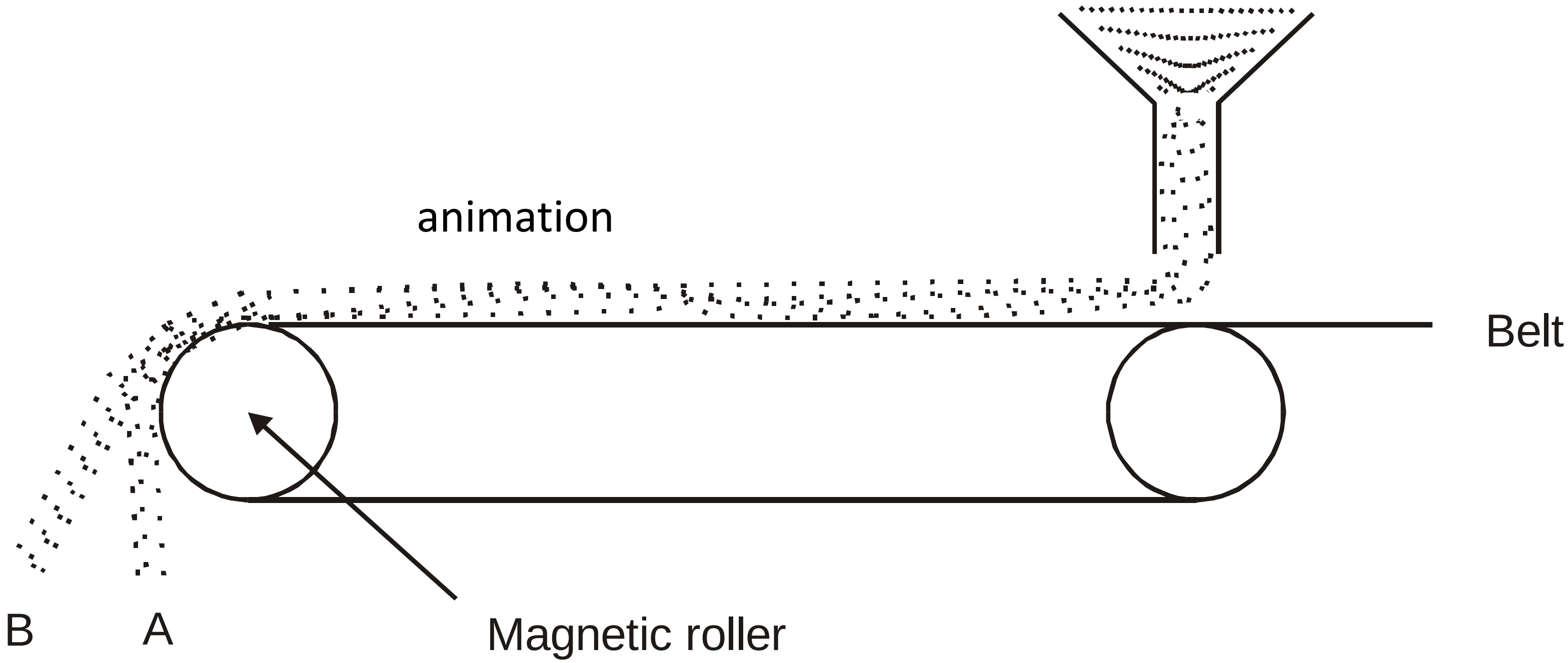
2. Levigation or Hydraulic washing or gravity separation.



Concentration of ore

3. Magnetic Concentration

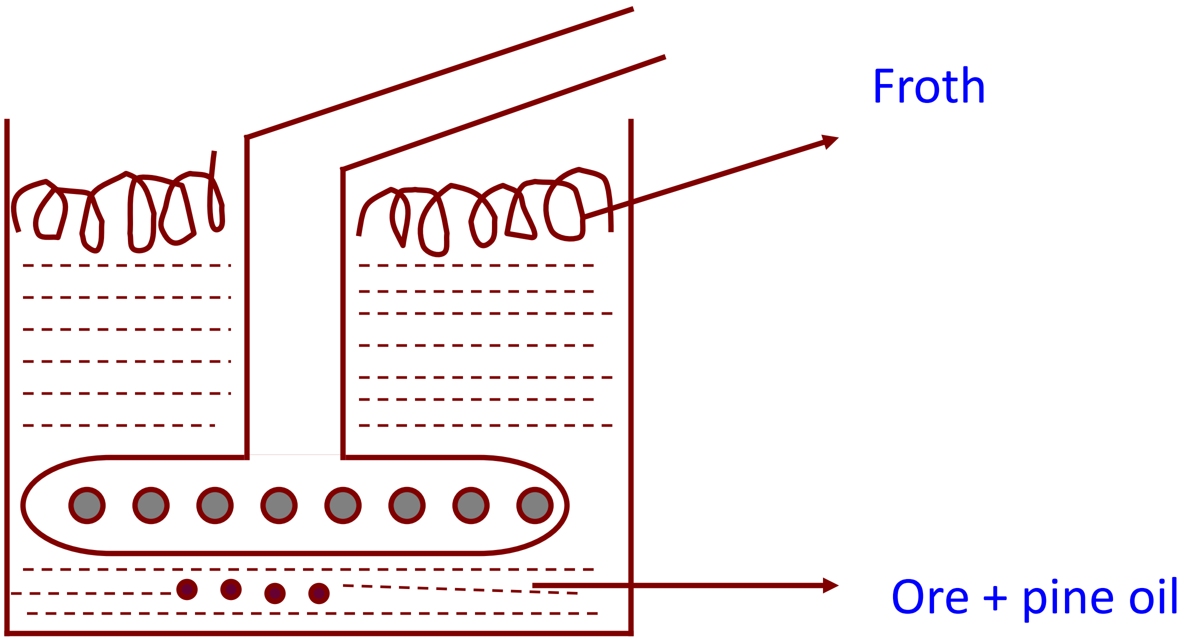
animation



Wolfarite $FeWO_4$ and Cassiterite SnO_2

CONCENTRATION OF ORE

4. Froth Flotation Process



CONCENTRATION OF ORE

5. Leaching

Leaching of bauxite

$Al_2O_3\ 2H_2O + 2NaOH \longrightarrow 2NaAlO_2 + 3H_2O$

Bauxite ore

Sodium aluminate

$Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + 2H_2O$

Aluminum hydroxide

$Al(OH)_3 \xrightarrow{\text{Heat}} Al_2O_3 + 3H_2O$

Oxidation of ore or conversion of ore into oxide

Concentrated ore

↓ Calcination or Roasting

Oxide of ore

Calcinations

- Ore is heated in absence of air.
- Carbonate ores are converted to oxide

$$CaCO_3.MgCO_3 \xrightarrow{\Delta} CaO + MgO + CO_2$$

Dolomite

$$Al_2O_3.2H_2O \xrightarrow{\Delta} Al_2O_3 + 2H_2O$$

Oxidation of ore or conversion of ore into oxide

Roasting

Ore is heated in presence of air.

Sulphide ores converted into oxide.

$$4FeS_2 + 11O_2 \longrightarrow 2Fe_2O_3 + 8SO_2$$

Reduction of oxide to free metal

1. Smelting(Reduction by carbon)

Oxide Ore + C + flux $\longrightarrow$ Metal

$$Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$$

$$CaCO_3 \longrightarrow CaO + CO_2$$

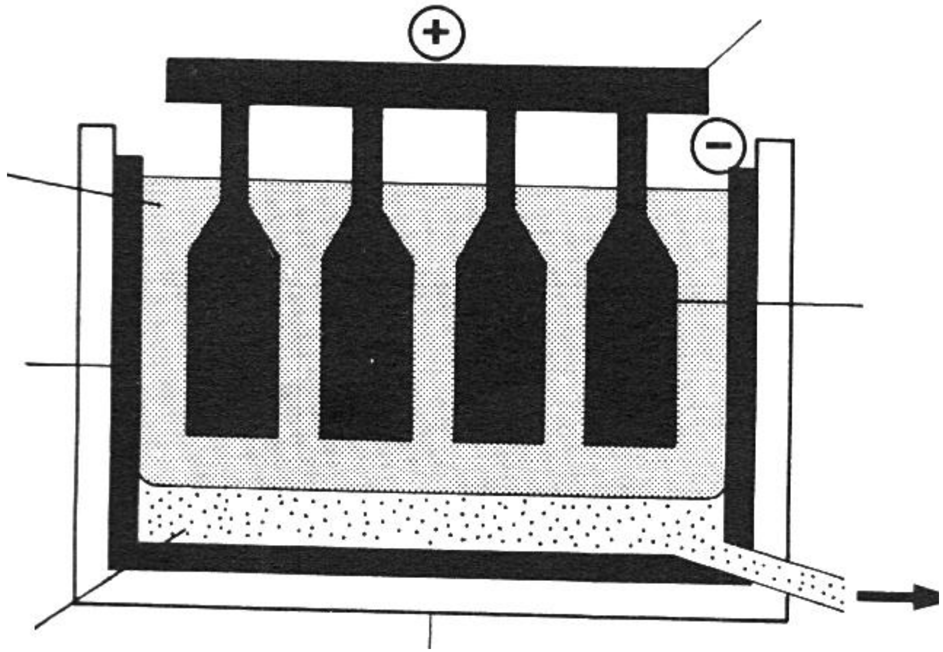
$$\underset{\text{Flux}}{CaO} + \underset{\text{Gangue}}{SiO_2} \longrightarrow \underset{\text{Slag}}{CaSiO_3}$$

Raw materials

Ore – bauxite – aluminium oxide

The ore is dissolved in cryolite to lower the melting point.

The electrolysis cell



Temperature 900 C

Reactions in the cell

- At the cathode

$Al^{3+} + 3e^{-} \rightarrow Al$

- At the anode

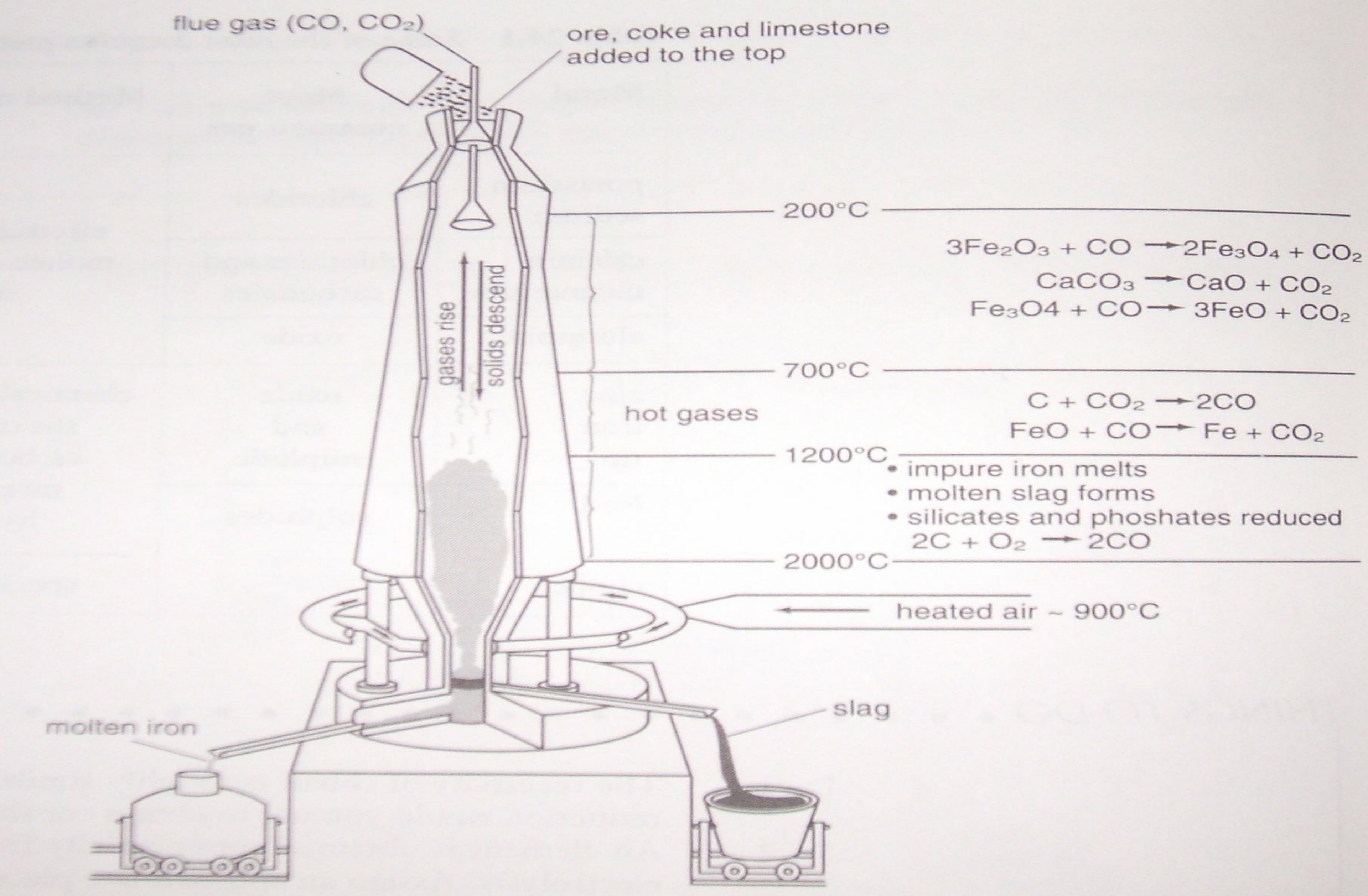
$2O^{2-} \rightarrow O_2 + 4e^{-}$

- The oxygen formed reacts with the carbon anodes to form carbon dioxide.
- They have to be replaced periodically.

THE EXTRACTION OF IRON

Several iron ores exist. The most popular method of iron extraction uses the ***Blast Furnace.*** This is a cylindrical, tapering tower about 30-40m high, constructed of steel lined with refractory bricks.

The principle of the method is the reduction of iron(III) oxide with carbon.



The Blast Furnace (automated).

The Extraction Of Iron using the Blast Furnace

Step 1: Dried heated iron ore, limestone (calcium carbonate) and coke (carbon) are fed into the top of the furnace.

Step 2: Hot air is blown into the furnace near the bottom. The hot air burns the coke producing carbon dioxide and generating great heat.

$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$$

Step 3: The carbon dioxide is then reduced to carbon monoxide by the hot coke.

$$CO_{2(g)} + C_{(s)} \longrightarrow 2CO_{(g)}$$

Step 4: The carbon monoxide reduces the hot iron ore to molten iron which runs to the bottom of the furnace

$$Fe_2O_{3(s)} + 3CO_{(g)} \longrightarrow 2Fe_{(l)} + 3CO_{2(g)}$$

OR

$$Fe_3O_{4(s)} + 4CO_{(g)} \quad 3Fe_{(l)} + 4CO_{2(g)}$$

If limestone were not used, the iron produced in the furnace would have many impurities. The limestone, at the furnace's temperature, breaks down.

$$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$$

The calcium oxide formed combines with silicon dioxide, the main impurity in iron ore, to form a molten ***slag***.

$$CaO_{(s)} + SiO_{2(s)} \rightarrow CaSiO_{3(l)}$$

The slag, being less dense than the molten iron, floats on it and runs off separately from it.

What is steel?

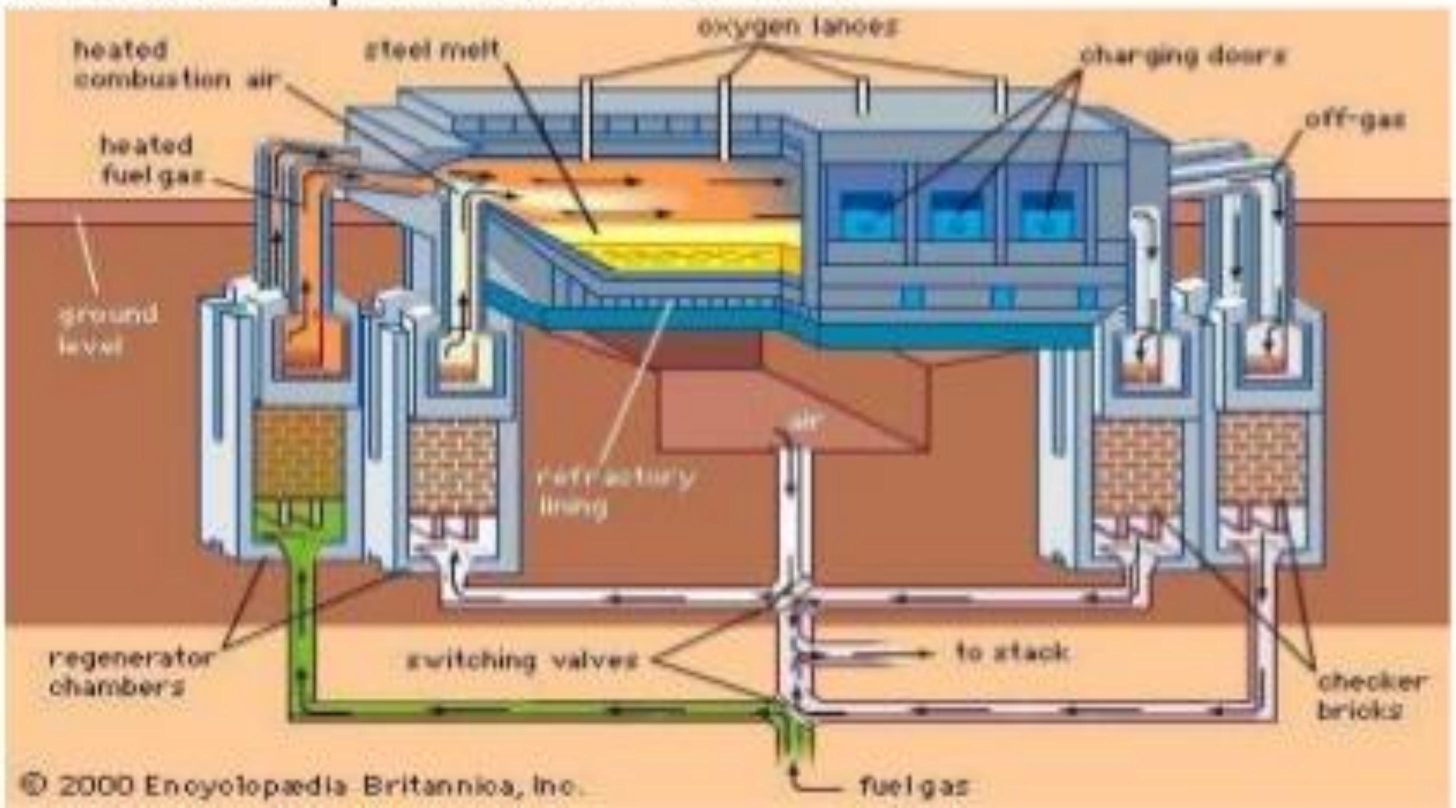
Steel is an alloy of iron and other elements, including carbon, nickel and chromium.

Steel is stronger than pure iron and can be used for everything from sauce pans…

…to suspension bridges!

Open hearth process

- The open hearth process is a batch process and a batch is called a "heat". Heavy scrap, such as building, construction or steel milling scrap is added, together with pig iron from blast furnaces.
- This process was known as the Siemens-Martin process, and the furnace as an "open-hearth" furnace



THE EXTRACTION OF ALUMINIUM

Aluminium is very abundant in the earth's crust, but is never found in its free state. Aluminium is found mainly in the form of aluminosilicates, of which bauxite (Al_2O_3) is the chief source. The crude/mined bauxite is either:

- heated to 3000^{o}C to produce calcined bauxite
- Converted to pure alumina (Al_2O_3)

The process for extracting aluminium from aluminia is ***electrolysis***.

Electrolysis is the process by which the passage of an electric current through a substance causes it to decompose.

In the current process of extracting aluminium from bauxite, an electrolytic cell made of steel using graphite electrodes is used. The current used is 100,000A and the temperature is 1,223K.

Pure aluminia (aluminium oxide) which melts at 2050^{o}C is dissolved in molten cryolite (sodium aluminium fluoride), Na_2AlF_6. The addition of the cryolite lowers the temperature to 950^{o}C, because *the presence of an impurity lowers the melting point of a substance.* The presence of the cryolite also gives the melt better conducting properties and, in addition, it does not mix with the aluminium metal formed in the electrolysis.

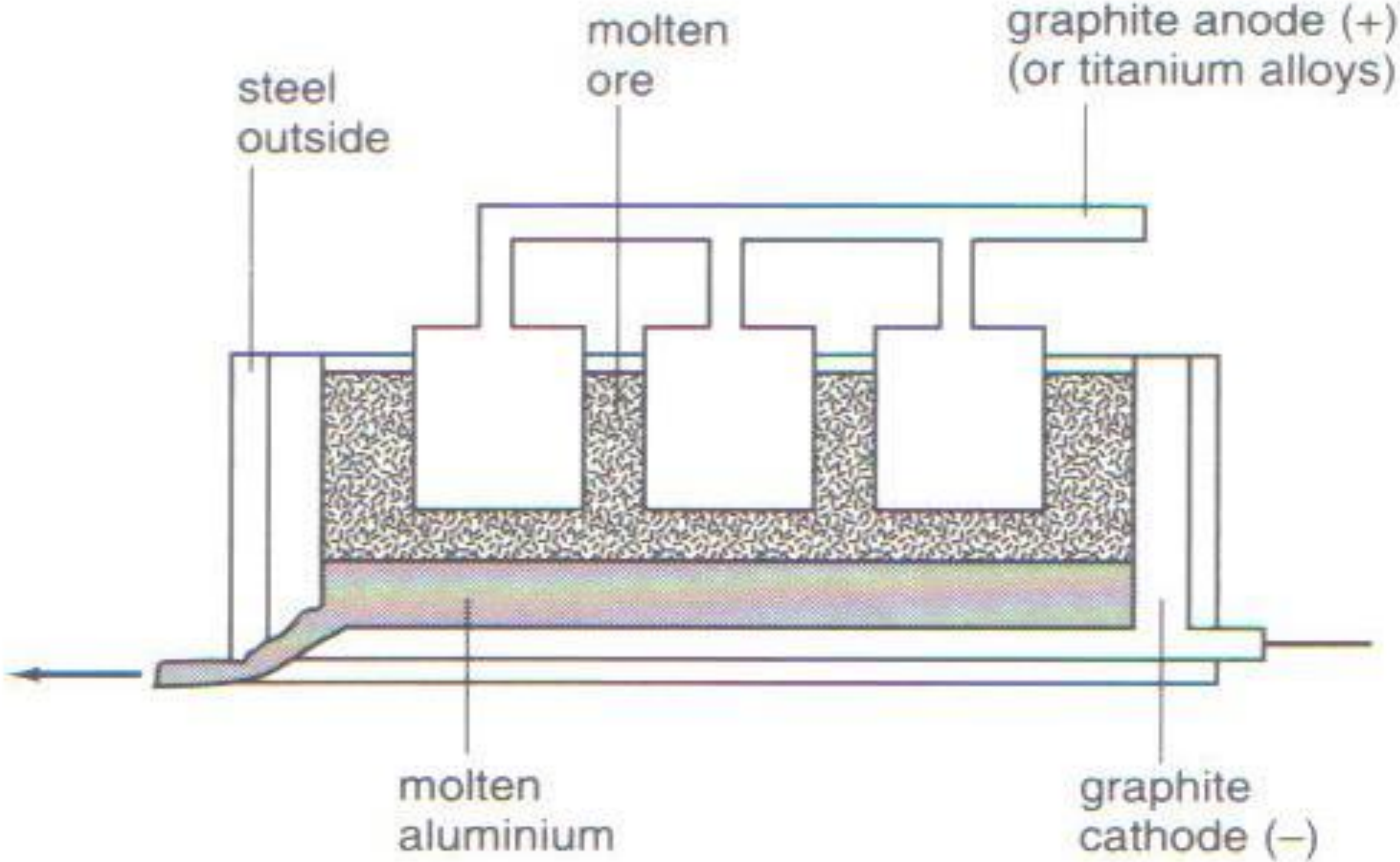
Aluminium is discharged at the graphite cathode, which lines the chamber. The product is 99% pure, the chief impurities being silicon and iron.

Liquid aluminium is tapped off at the end of the cell.

$$Al^{3+}_{(l)} + 3e^{-} \longrightarrow Al_{(l)}$$

Oxygen is the other product that is produced at the anode.

$$2O^{2-}_{(l)} - 4e^{-} \longrightarrow O_{2(g)}$$



Electrolysis of Aluminium.

OCCURRENCE OF COPPER

- Copper pyrite or chalcopyrite ($CuFeS_2$).
- Chalocite (Cu_2S) or copper glance.
- Malachite green [$CuCO_3.Cu(OH)_2$
- Azurite blue [$2CuCO_3.Cu(OH)_2$].
- Bornite ($3Cu_2S.Fe_2S_3$) or peacock ore.
- Melaconite (CuO) etc.

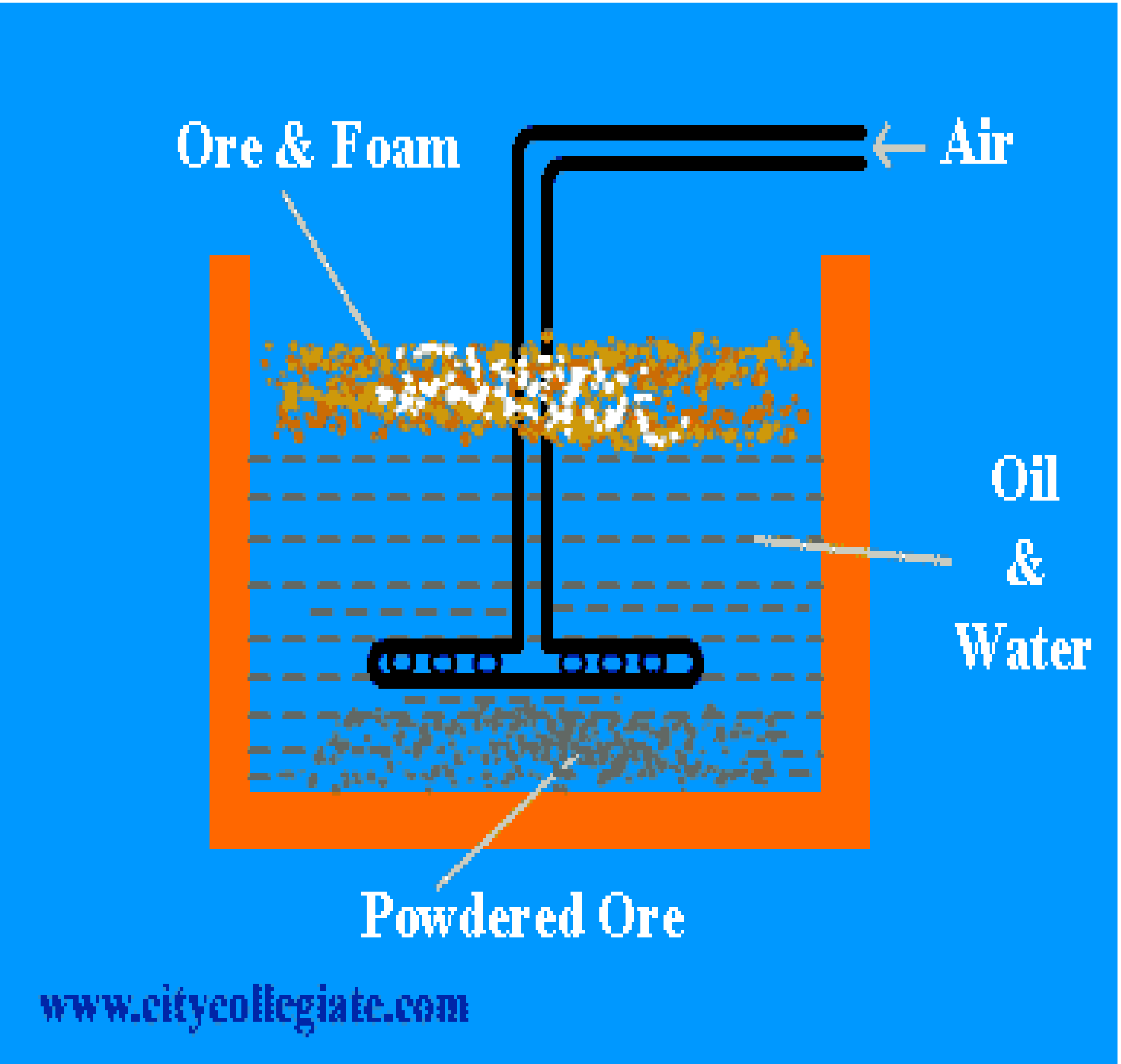
STEPS INVOLVED IN EXTRACTION

- CONCENTRATION
- ROASTING
- SMELTING
- BESSEMERIZATION
- REFINING

CONCENTRATION OF ORE

The finely crushed ore is concentrated by **Froth-Floatation** process. The finely crushed ore is suspended in water containing a little amount of pine oil. A blast of air is passed through the suspension. The particles get wetted by the oil and float as a froth which is skimmed. The gangue sinks to the bottom.

CONCENTRATION OF ORE



- FROTH FLOATATION PROCESS

ROASTING

The following reaction takes place.

$$2CuFeS_2 + O_2 \rightarrow Cu_2S + 2FeS + SO_2$$

$$S + O_2 \rightarrow SO_2$$

$$4As + 3O_2 \rightarrow 2As_2O_3$$

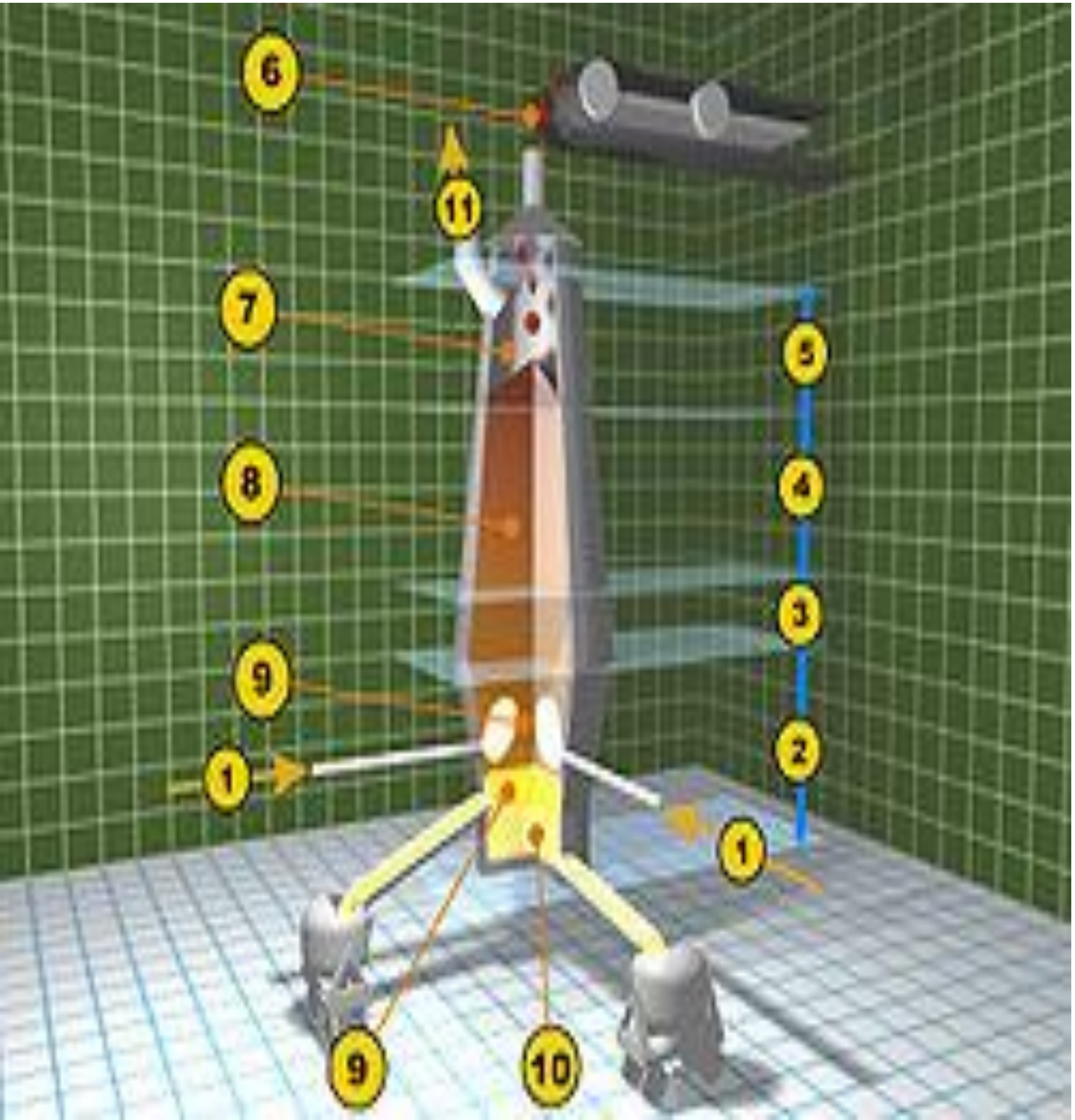
$$4Sb + 3O_2 \rightarrow 2Sb_2O_3$$

Cuprous sulphide and ferrous sulphide are further oxidized into their oxides.

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$$

$$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$$

SMELTING PROCESS (REDUCTION BY CARBON)



- SMELTING IS CARRIED OUT IN **BLAST FURNACE**

1 HOT AIR BLAST

2 MELTING ZONE

3, 4 REDUCTION ZONE

5 PREHEATING ZONE

6 ORE,SILICA,COKE

7 EXHAUST GASES

8COLUMN OF ORE,SILICA,COKE

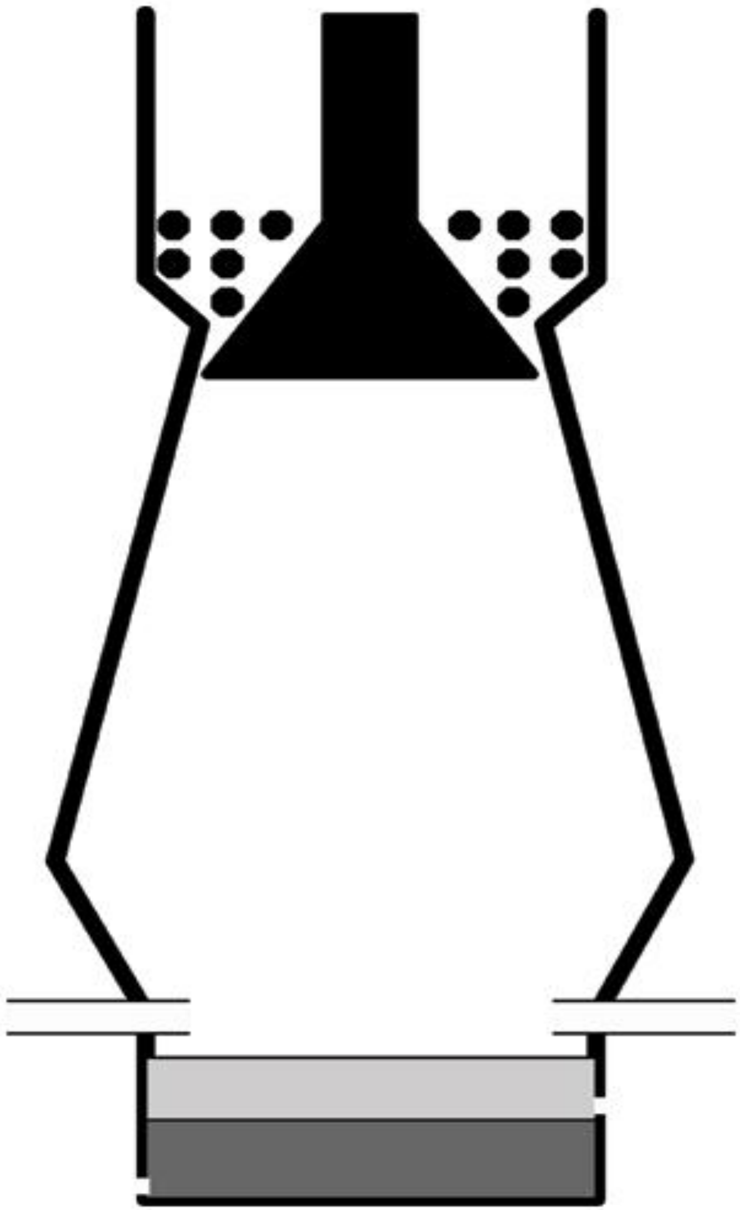
9 REMOVAL OF SLAG

10 MOLTEN MATTER

11COLLECTION OF WASTE GASES

PROCESS OF SMELTING

The roasted ore is mixed with coke and silica (sand) SiO_2 and is introduced in to a blast furnace. The hot air is blasted and FeO is converted in to ferrous silicate $FeSiO_3$



SMELTING

The roasted ore is mixed with coke and silica (sand) SiO_2 and is introduced in to a blast furnace. The hot air is blasted and FeO is converted in to ferrous silicate ($FeSiO_3$).

$$FeO + SiO_2 \rightarrow FeSiO_3$$

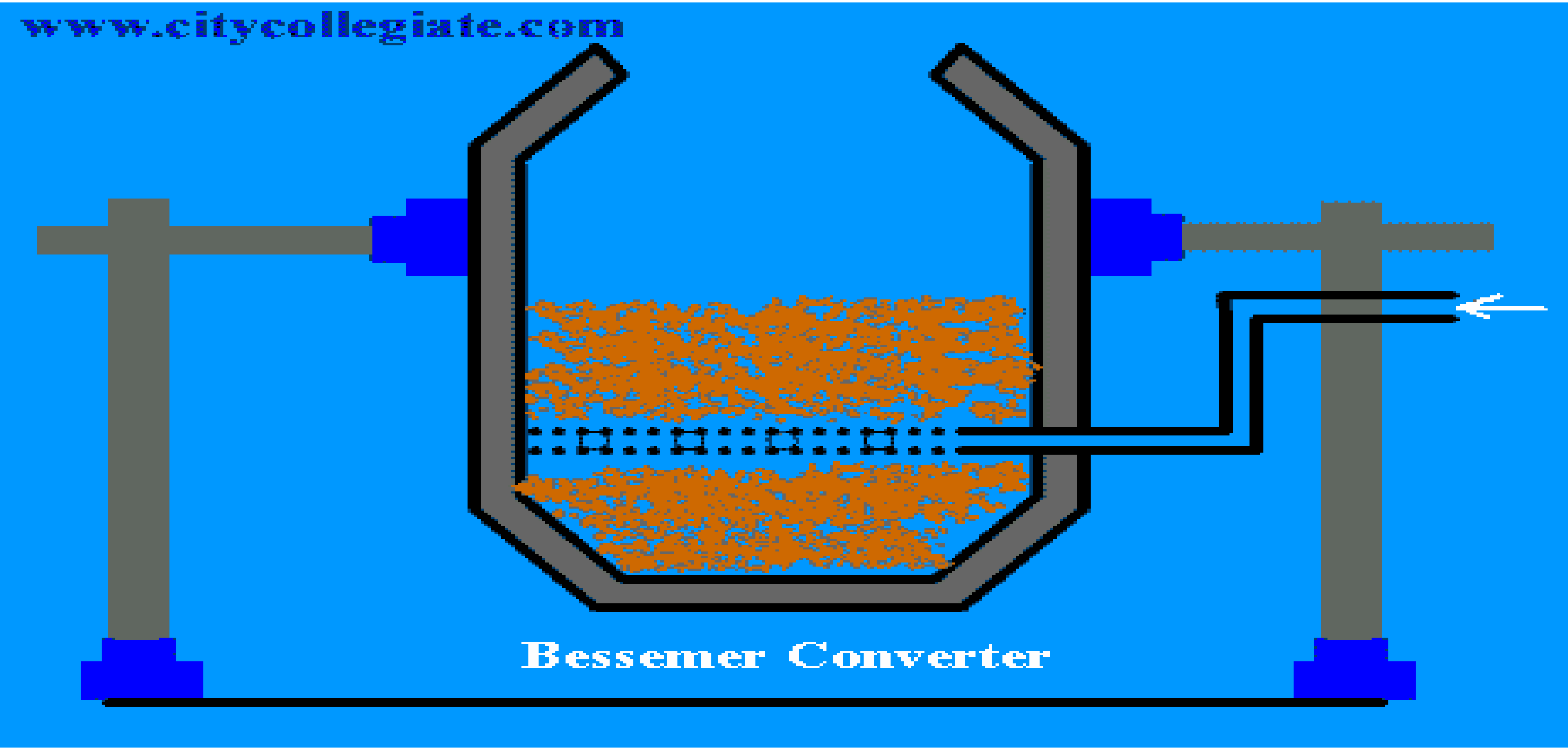
$$Cu_2O + FeS \rightarrow Cu_2S + FeO$$

$FeSiO_3$ (slag) floats over the molten matte of copper

BESSEMERIZATION

Copper metal is extracted from molten matte through bessemerization. The matte is introduced in to Bessemer converter which uphold by tuyers. The air is blown through the molten matte. Blast of air converts Cu_2S partly into Cu_2O which reacts with remaining Cu_2S to give molten copper.

BESSEMERIZATION



- $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$

  $2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$

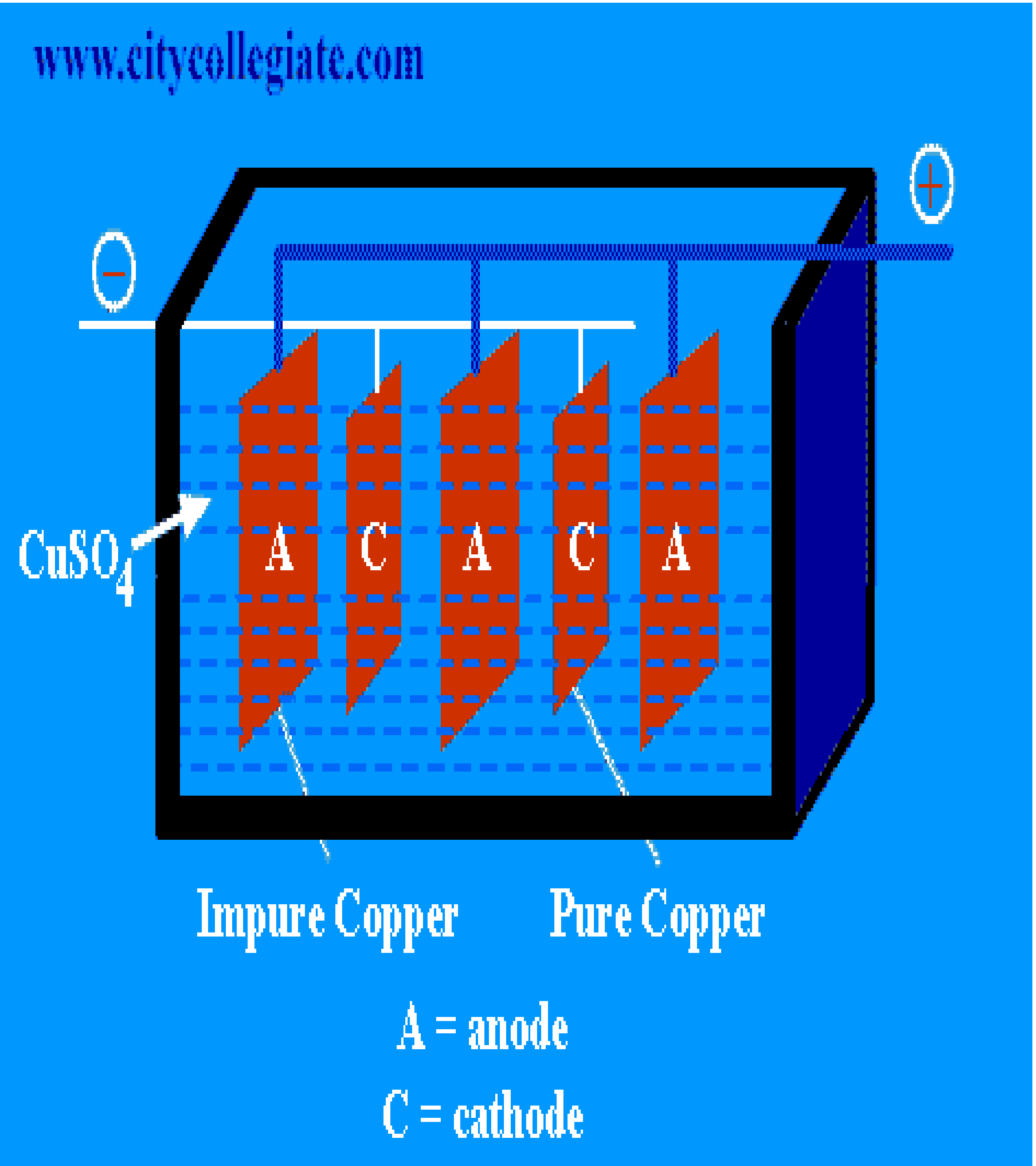
REFINING OF COPPER

Blistercopper is refined by electrolysis. Blocks of blister copper are used as anodes and thin sheets of pure copper act as cathodes. The cathode plates are coated with graphite in order to remove depositing copper. The electrolyte is copper sulphate ($CuSO_4$) mixed with a little amount of H_2SO_4 to increase the electrical conductivity. Optimum potential difference is 1.3 volt for this electrolytic process

Contd

During electrolysis, pure copper is deposited on the cathode plates and impurities which are soluble and fall to the bottom of the cell as anode mud or sludge.

REFINING OF COPPER



- $Cu \rightarrow Cu^{+2} + 2e^-$ (at the anode)

  $Cu^{+2} + 2e^- \rightarrow Cu$ (at the cathode)

  This electrically refined copper is 100% pure

ALLOY

An alloy is a homogeneous mixture of two or more metals or metals and non-metals.

From industrial point of view, alloy classified in two categories

1. Ferrous alloys
2. Non-Ferrous Alloys

ALLOYS

MIXTURE OF VARIOUS METALS

Brass, Bronze

Magnalium, Duralumin

Steel, Invar

Nichrome, Alnico

Purpose of Making Alloys

Pure metals possess few important physical and metallic properties, such as melting point, boiling point, density, specific gravity, high malleability, ductility, and heat and electrical conductivity. These properties can be modified and enhanced by alloying it with some other metal or nonmetal, according to the need.

Inrease Corrosion resistance

Enhance the hardness of a metal:

Lower the melting point:

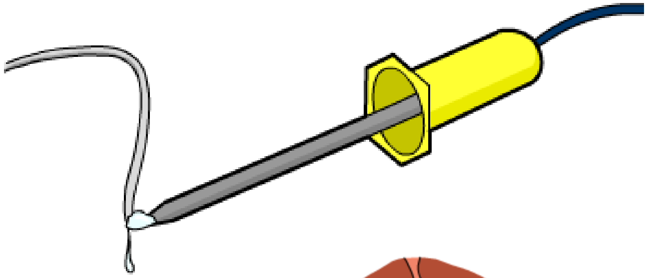
Enhance tensile strength:.

Modify color:

Provide better castability:

Alloys have been used for thousands of years. **Bronze**, an alloy of copper and tin, was commonly used by civilizations before iron extraction methods were developed.

- **brass**: an alloy of copper and zinc.
  It does not tarnish and is used for door knobs, buttons and musical instruments.



- **solder**: an alloy of zinc and lead. It is used in electronics to attach components to circuit boards.

- **amalgam**: an alloy of mercury and silver or tin. It is used for dental fillings because it can be shaped when warm

  and resists corrosion.

LIQUID FUELS

What is fuel?

- Any substance used to produce energy is called Fuel.
- Any combustible substance which may be burnt to supply heat for practical applications without the formation of excessively objectionable byproducts.

Liquid fuel

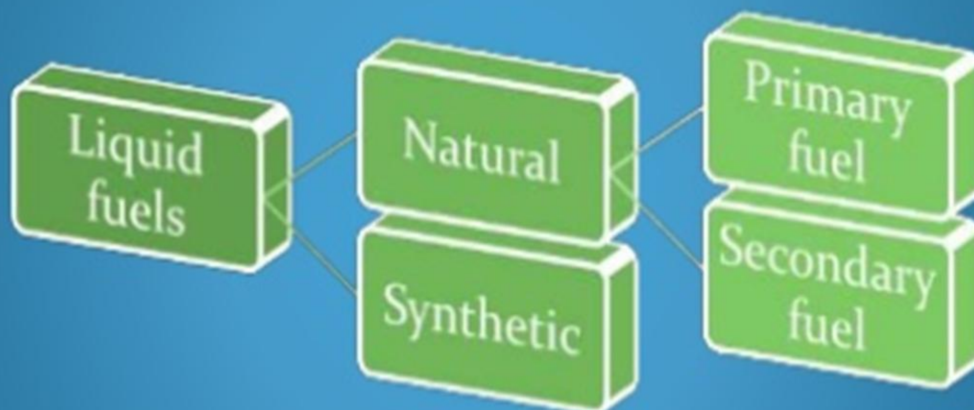
- **Liquid fuels** are those combustible or energy-generating molecules that can be harnessed to create mechenical energy, usually producing kinetic energy.
- They also must take the shape of their container.

Properties of liquid fuels

- **Density**
  - Ratio of the fuel's mass to its volume at 15 °C,
  - kg/m^3
  - Useful for determining fuel quantity and quality
- **Viscosity**
  - Measure of fuel's internal resistance to flow
  - Most important characteristic for storage and use
  - Decreases as temperature increases

- **Flash point**
  - Lowest temperature at which a fuel can be heated so that the vapour gives off flashes when an open flame is passes over it
  - Flash point of furnace oil: 66°C
- **Pour point**
  - Lowest temperature at which fuel will flow
  - Indication of temperature at which fuel can be pumped

Classification of liquid fuel



Differences Between Coal and Petroleum

Coal	Petroleum
Formed from land plants decaying under mildly reducing conditions	Formed mainly from sea plants and animals decaying under strongly reducing conditions
Seams remain where deposited, i.e., location of existing deposits are usually same as the location of accumulation of debris	Can migrate under effects of temperature and pressure, i.e., location of existing deposits may not be the same as location of accumulation of debris

Oil Shales

- Oil shales contain a solid combustible mixture of hydrocarbons called ***kerogen***.

Gasoline or Petrol and its Characteristics

- **Gasoline** is the most widely used liquid fuel.
- Production of gasoline is achieved by distillation of crude oil. The desirable liquid is separated from the crude oil in refineries. It contains some undesirable unsaturated straight chain hydrocarbons and sulphur compounds. It has boiling range of 40-120°C.
- Liquid gasoline itself is not actually burned, but its fumes ignite, causing the remaining liquid to evaporate and then burn. Gasoline is extremely volatile and easily combusts, making any leakage potentially extremely dangerous.

Cherectristics of ideal gasoline

- It must be cheap and readily available.
- It must burn clean and produce no corrosion.
- It must be knock resistant.
- It should be pre-ignite easily.
- It must have a high calorific value

Kerosene Oil

- Kerosene oil is obtained between 180-250°C during fractional distillation of crude petroleum.
- When kerosene is used in domestic appliances, it is always vaporized before combustion.
- By using a fair excess of air it burns with a smokeless blue flame.

USES

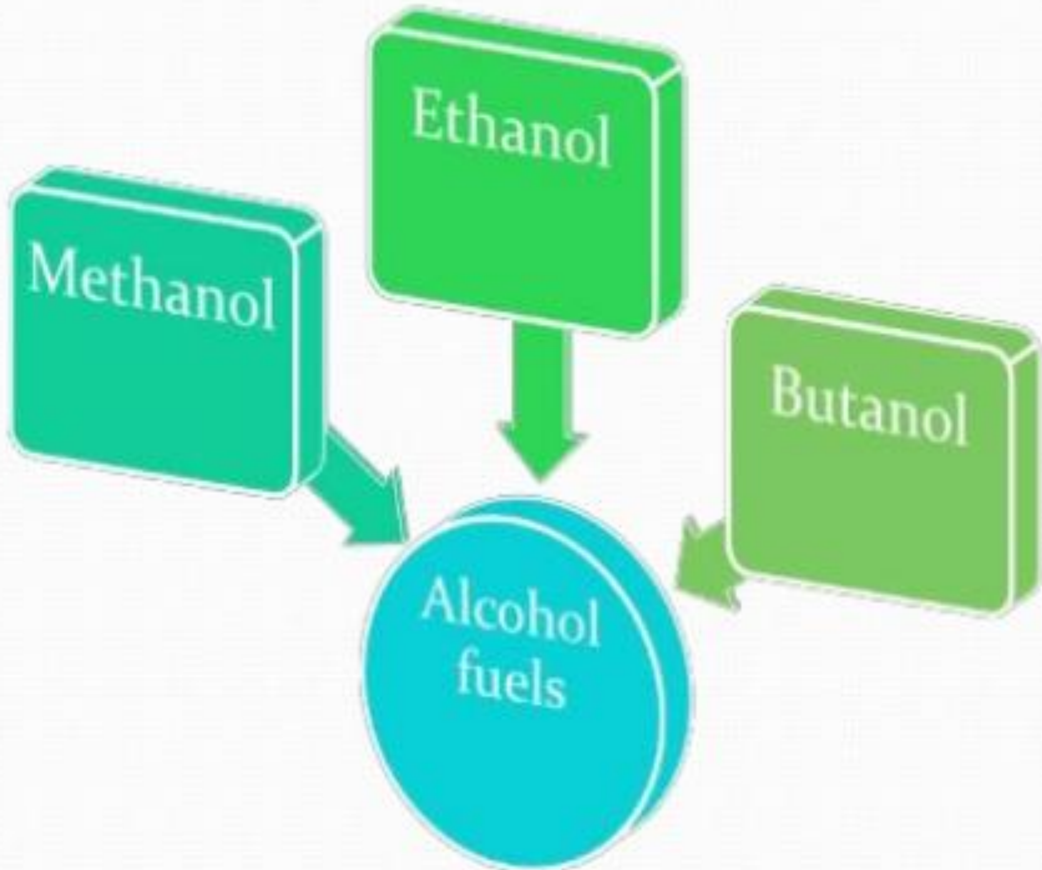
- ✓ Illuminant
- ✓ Jet engine fuel
- ✓ Tractor fuel (TVO)
- ✓ Additives

Diesel Fuel and its Characteristics

- Conventional **diesel** is similar to gasoline in that it is a mixture of aliphatic hydrocarbons extracted from petroleum.
- The diesel fuel is obtained between 250-320°C during the fractional distillation of crude petroleum.
- Diesel generally contains 85% C and 12% H.
- Diesel fuels consist of longer hydrocarbons and have low values of ash, sediment, water and sulphalt contents.
- Calorific value is about **11,000** kcal/kg.
- Deisel easily ignite below compression temperature.
- It is used in diesel engine.

Synthetic liquid fuel

- Liquid fuel from coal and/or natural gas.
- When petroleum is not easily available, chemical processes such as the Fischer-Tropsch process can be used to produce liquid fuels. These are known as non-petroleum fossil fuels.


Ethanol
Methanol
Butanol
Alcohol fuels

Alcohol fuel

Methanol

- Methanol is the lightest and simplest alcohol, produced from the natural gas component methane and by distillation of wood.
- Its application is limited primarily due to its toxicity.
- Used in some race cars and model airplanes.

Ethanol

- Used as a fuel, most often in combination with gasoline.
- There is increasing interest in the use of a blend of 85% fuel ethanol blended with 15% gasoline. This fuel blend called E85.

Butanol

- It is formed by fermentation of biomass by bacterium *Clostridium acetobutylicum*.
- It has high energy content about 10% lower than gasoline.
- Major disadvantages of butanol fuel are high flash point, toxicity and foul odour.

Advantages

- Possesses higher calorific value.
- Combustion without the formation of dust, clinker or ash.
- Firing easier & easily extinguishable.
- Less excess furnace space.
- No wear & tear on furnace parts like solid fuels.
- Low sulphur content.
- For equal heat output lesser space & weight then solid.

Disadvantages

- Costlier than solid fuels.
- Requirs costly storage tanks.
- High risk of fire hazards especially of volatile liquids.
- Requirement of especially designed burners for efficient burning.
- They give bad odour.

POLYMERS AND PLASTICS

POLYMERS :

Polymers are the substances with very high molecular masses and each molecule of which consists of a large number of simple molecules joined by covalent bond.

MONOMER :

The repeating unit present in a polymer is known as **Monomer**

POLYMERISATION:

the process by which monomers are converted into polymers is called

TYPES OF POLYMERS

There are mainly two types of polymers

- Natural : cotton, silk, wood, leather…
- Synthetic : plastics, nylon, latex…

FOR EXAMPLE, POLYTHENE IS OBTAINED FROM A LARGE NUMBER OF ETHENE MOLECULES BY POLYMERISATION.

$$\underset{\text{(Monomer)}}{n\,(CH_2 = CH_2)} \xrightarrow[\text{high pressure}]{O_2} \underset{\text{(Polymer)}}{\underset{\text{Polythene}}{-\!\!\left(CH_2 - CH \right)\!\!-_n}}$$

SYNTHETIC POLYMERS

- There are two basic types of synthetic polymers
  - Thermoplastics (plastics, Styrofoam)
    - These can be softened by heating and hardened by cooling - easily recycled
    - Can easily be cast into various shapes
  - Thermosets (epoxy's, adhesives)
    - These harden after being heated
    - Can easily be cast into different shapes
    - Cannot be reformed

THERMOPLASTICS

- Thermoplastics soften when heated and can be moulded into required shapes when in this state. They will harden again on cooling. By heating and cooling, they can be softened and heated over and over again.

COMMON THERMOPLASTICS

- Low Density Polyethylene. Branch chain polymer produces weak, soft and flexible polymer. The most common polymer. Used for buckets, bags, electrical cable, cups, etc.
- High Density Polyethylene. Linear chain polymer which is stiff, strong and resists chemicals. Used for bottle crates, barrels and plumbing joints.
- Polypropylene. Tough and rigid polymer with high impact strength. Used for chairs, helmets, hinged boxes and toys.

- Polystrene. Brittle in solid form and is used for jugs, egg boxes, jar tops. Expanded or foamed polystyrene is soft, low density and a heat insulator and used for coffee cups, packaging and house insulation.

- Polyvinyl Chloride. Rigid uPVC is used for gutters and doors. The plasticised version is more flexible and used for coats, suitcases, hose pipes, etc.

- Acrylic. PMMA can be transparent or opaque and is brittle but machines well. It is used for car lights, shop signs, safety glasses, etc.

- Nylon. Produced by condensation polymerisation, Nylon is hard wearing and resistant to chemicals. Used for clothing, nets, ropes, gears.

THERMOSETTING PLASTICS

- Will only mould once.
- Strong primary bonds are connected by strong covalent bonds.
- Cross-link process (curing) formed by heat and pressure.
- Non-reversible structure cannot be softened by heating.

Common thermosets

- Polyester Resin. Polymerises at room temperature with the addition of a hardener. It is often reinforced with glass fibre (GRP) for strengthening and is used for boats, some vehicle bodies and roofing.

- Epoxy resins. Cross-link polymers used for adhesives.

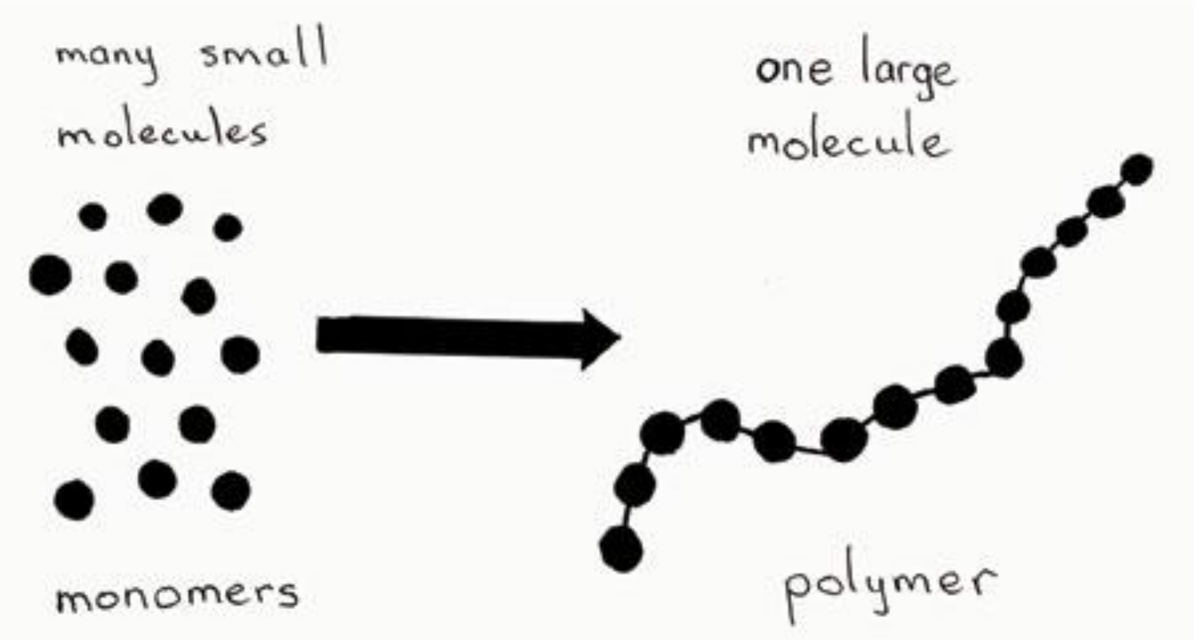
- Polyurethanes. Has a wide range of properties as structure can be adjusted from soft ‘foam’ rubber to hard steering wheels and paints.

- Phenol formaldehyde. Hard and brittle, ‘Bakelite’ has been used for electrical fittings and saucepan handles.
- Urea formaldehyde. Good electrical and thermal properties and used for electrical fittings and door handles.

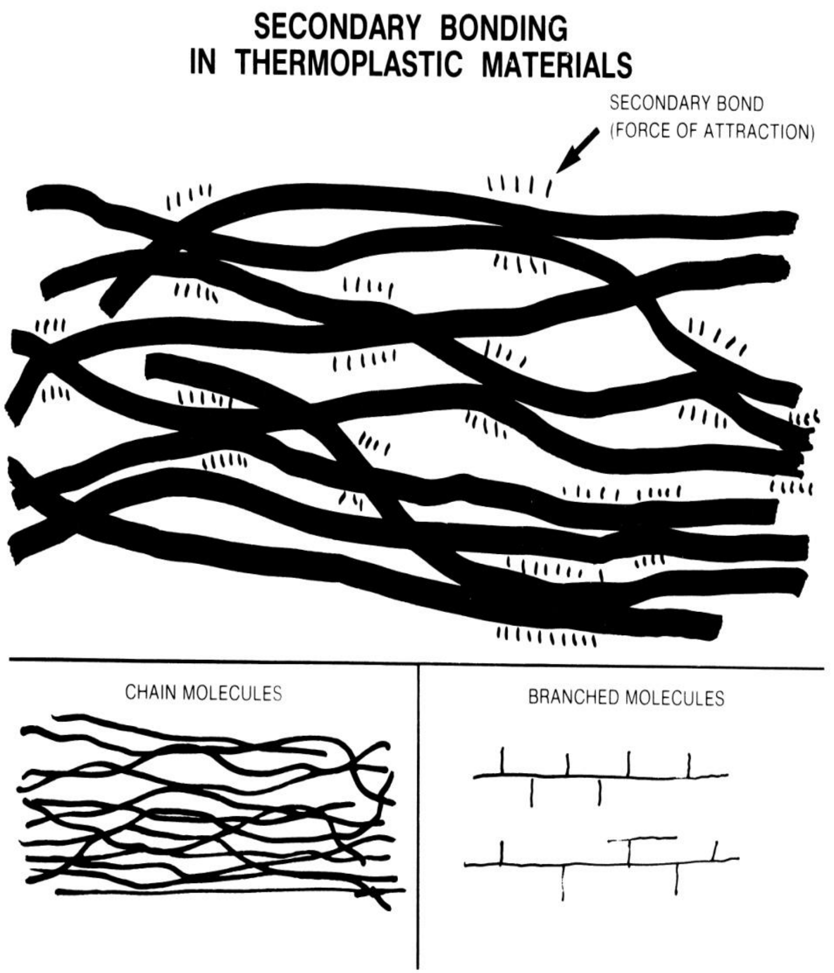
POLYMER STRUCTURE

The molecular structure of plastics can be;

- Linear chain
- Branch chain
- Cross-links



LINEAR AND BRANCH CHAIN

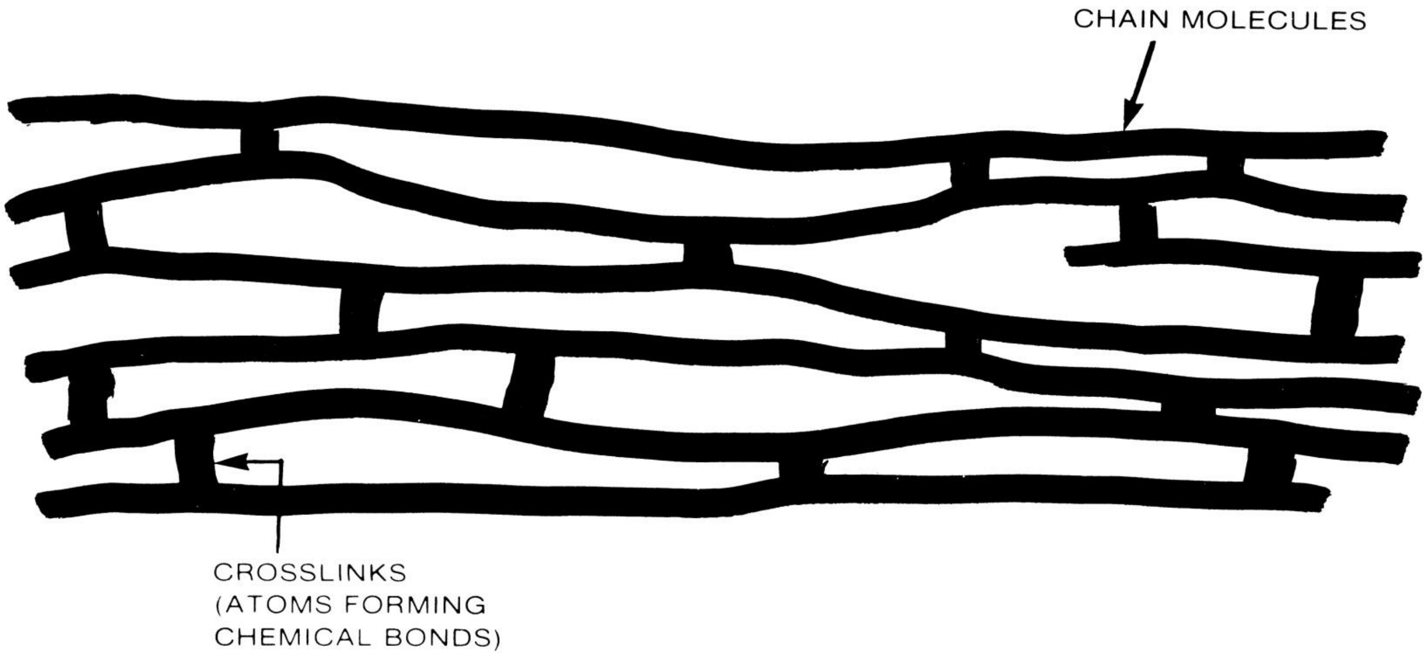


The bonding between adjacent molecules is secondary bonding or Van der Waal forces of attraction. These can be weakened by heating.

CROSS LINKS

Primary bonding occurs with cross linking of adjacent molecules. This results in a rigid, non-reversible structure.

STRUCTURE OF THERMOSETTING POLYMERS



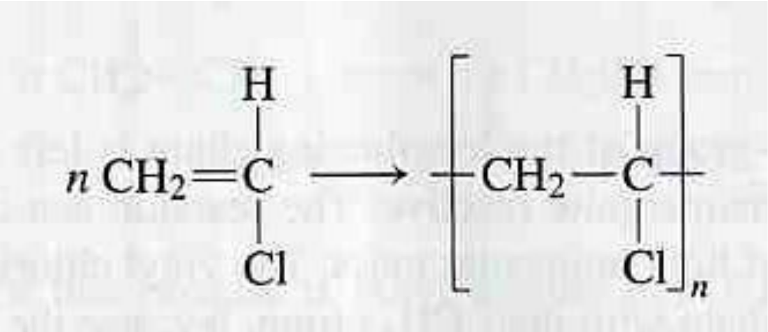
METHODS FOR MAKING POLYMERS

ADDITION POLYMERIZATION AND CONDENSATION POLYMERIZATION

Addition polymerization:

monomers react to form a polymer without net loss of atoms.

Most common form: free radical chain reaction of ethylenes



n monomers one polymer molecule

Two main synthetic approaches

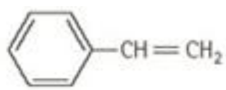
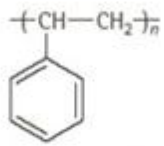
- *Addition* polymerization
  - Simply adding monomers together – synthetic plastics
- *Condensation* polymerization
  - Combination by exclusion of a small molecule (usually water) – extensively used by nature

Polymers have revolutionized containers and other household items

Polymers Related to Polyethylene: Their Properties and Uses

Name	Formula: Monomer	Formula: Polymer	Recycling Symbol	Properties[a] and Uses
Polyethylene	$H_2C{=}CH_2$	$-\!\!\left[CH_2-CH_2\right]\!\!-_n$	2 HDPE, 4 LDPE	Unreactive, flexible, impermeable to water vapor; packaging films, containers, toys, housewares
Polypropylene	$CH_3CH{=}CH_2$	$-\!\!\left[CH(CH_3)-CH_2\right]\!\!-_n$	5 PP	Lowest density of any plastic; indoor–outdoor carpeting, upholstery, pipes, bottles
Polyisobutylene	$CH_2{=}C(CH_3)_2$	$-\!\!\left[CH_2-C(CH_3)_2\right]\!\!-_n$	7 OTHER	Elastomer; inner tubes, truck and bicycle tires
Polyvinyl chloride (PVC)	$H_2C{=}CHCl$	$-\!\!\left[CH_2-CH(Cl)\right]\!\!-_n$	3 V	Self-extinguishing to fire; pipe, siding, floor tile, raincoats, shower curtains, imitation leather upholstery, garden hoses
Polytetrafluoroethylene (Teflon)	$F_2C{=}CF_2$	$-\!\!\left[CF_2-CF_2\right]\!\!-_n$	7 OTHER	Very unreactive, nonstick, relatively high softening point; liners for pots and pans, greaseless bearings, artificial joints, heart valves, plumbers' tape, fabrics

Common addition polymers cont'd

Polymer	Monomer	Polymer structure	Recycling code	Uses
Polystyrene			6 PS	Housings for large household appliances such as refrigerators, auto instruments and panels, clear cups and food containers, and foam cups and packing
Polyacrylonitrile (Orlon)	$H_2C{=}CHCN$	$-[CH_2-CH(CN)]_n-$	7 OTHER	Carpets and knitwear
Polymethyl methacrylate (Lucite, Plexiglas)	$H_2C{=}C(CH_3)COOCH_3$	$-[CH_2-C(CH_3)(COOCH_3)]_n-$	7 OTHER	Substitute for glass, airplane windows, contact lenses, fiber optics, paint
Polyvinyl acetate	$H_2C{=}CH-O-C(=O)-CH_3$	$-[CH_2-CH(O-C(=O)-CH_3)]_n-$	7 OTHER	Adhesives, paint, chewing gum, safety glass

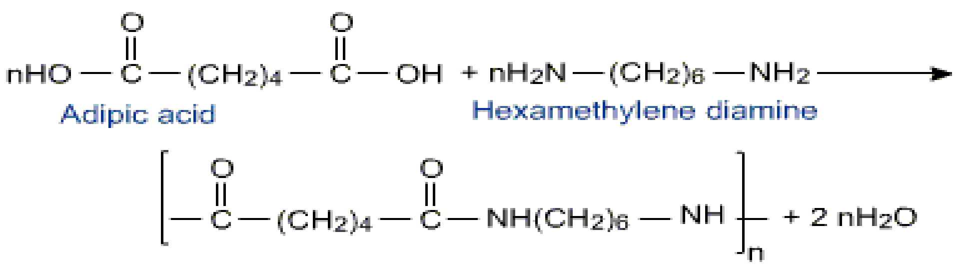
Condensation polymerization

Condensation polymerization: the polymer grows from monomers by splitting off a small molecule such as water or carbon dioxide.

Example: Nylon-66

. NYLON-66:-

It is prepared by condensation polymerization of hexamethylenediamine and Adipic acid.



The fibres of Nylon-66 have very high tensile strength. They are quite tough and resistant to abrasion.

Uses:

It is used in making bristles of toothbrush, socks, sheets, ropes, etc and also in textile industries

Uses of Polymers

- Polymers are incorporated into nearly every aspect of daily life
  - Entertainment
  - Sports
  - Clothes
  - Hobbies/Toys
  - Household products
  - Automotive

APPLICATIONS OF POLYMERS:

In Industries:

Polymers are the most important substances used in industrial production as follows:

Used in the manufacture of squeeze bottles and flexible pipes.

Used in making gramophone records.

Used for making soft drink bottles, drinking cups, baby feeding bottles and refrigerator linings.

Used for making automobile parts(motor tyre, gears, etc), windshields for fighter planes.

Used for making wood substitutes, paints, adhesives, matrix for composites.

Used in making bristles of toothbrush, socks, sheets, ropes, and textile industries, etc.

Polymer membranes are used for purification of air and water.

Polythene used for packaging materials for various industrial and agriculture produce.

IN DAILY LIFE:

Polymers are the backbone of the modern civilization. The polymers are commonly used in our day to day life example cars, bikes, scooters, furniture, clothing, medical equipments, plastic ware, etc. The article of common use such as radio, televisions, mobiles, sun glasses, bottles, buckets, packaging containers, toys, electrical switches, kitchen wares (bowl, mugs, saucers, plates, trays, etc) and other decorative articles are made up of polymers.

Summary

- Polymers are made up of large chains of repeating units, called monomers
- Individual chains interact to form a stronger overall substance through entanglements and cross-links
- Polymers are incorporated into almost every aspect of daily life
- Polymers are lightweight, strong, and inexpensive