Acids, Bases and Salts

Properties of Acids:

- Produce hydrogen ions [H^+] in H_2O.
- Sour taste.
- Turn blue litmus red.
- Act as electrolytes in Solution.
- Neutralize solutions carrying hydroxide ions.
- React with several metals releasing Hydrogen gas.
- React with carbonates releasing CO_2 (g)
- Destroy body tissues.
- corrode metal surface quickly.

On the basis of origin, acids are classified as :

a. Organic acids: Acids derived from living organisms like plants and animals. For example: citric acid is present in fruits, acetic acid present in vinegar, oxalic acid present in tomato, tartaric acid present in tamarind, lactic acid present in sour milk and curd.

b. Mineral acids: They are also called inorganic acids. They are dangerous Example sulphuric acid (H_2SO_4), hydrochloric acid (HCl) etc.

➢ **On the basis of their strength, acids are classified as :**

a. Strong acids: Completely dissociate into its ions in aqueous solutions. Example: Nitric acid (HNO_3), sulphuric acid (H_2SO_4), hydrochloric acid (HCl).

b. Weak acids: Weak acids are those acids which do not completely dissociate into its ions in aqueous solutions. For example: carbonic acid (H_2CO), acetic acid (CH_3COOH).

➢ **On the basis of their concentration, acids are classified as :**

a. Dilute acids: Have a low concentration of acids in aqueous solutions.

b. Concentrated acids: Have a high concentration of acids in aqueous solutions.

➢ **On the basis of number of hydrogen ion, acids can be classified as :**

Monoprotic acid – Such type of acid produces one mole of H^+ ions per mole of acid, e.g., HCl, HNO_3

Diprotic acid - They can produce two moles of H^+ ions per mole of acid, e.g., H_2SO_4.

Triprotic acid - They produce three moles of H^+ ions per mole of acid, e.g., H_3PO_4.

Polyprotic - They can produce more than three H+ ions per mole of acid.

➢ **Properties of Base:**

- Produce hydroxide ions [OH^-] in H_2O.
- Water soluble bases are called alkalies.
- Bitter Taste
- Turn Red Litmus blue.
- Act as electrolytes in Solution.
- Neutralize solutions containing H^+ ions.
- Have a slippery, 'soapy' feel.
- Dissolve fatty material.

➢ **On the basis of their strength, bases are classified as:**

a. Strong bases: Strong bases are those bases which completely dissociate into its ions in aqueous solutions. Example: sodium hydroxide (NaOH), potassium hydroxide (KOH).

b. Weak bases: Weak bases are those bases which do not completely dissociate into its ions in aqueous solutions. For example: ammonium hydroxide (NH_4OH).

➢ **On the basis of their concentration, bases are classified as:**

a. Dilute bases: Have a low concentration of alkali in aqueous solutions.

b. Concentrated bases: Have a high concentration of alkali in aqueous solutions.

➢ **Strength Of Acid Or Base Solutions:**
A scale for measuring hydrogen ion concentration in a solution, called pH scale has been developed. The p in pH stands for 'potenz' in German, meaning power. p= potential or Power H = Hydrogen

pH =7	Neutral Solution	$H_3O^+ = OH^-$
pH>7	Basic Solution	H3O+ < OH –
pH<7	Acidic Solution	H3O+ > OH –

➢ **pH Sensitivity of Plants & Animals:**
• Human body works in a narrow range of pH 7 to 7.8. Acidity can be lethal for plants and animals.
• pH of Digestive System: Stomach secretes HCl to kill bacteria in the food. The inner lining of stomach protects vital cells from this acidic pH.
• pH and tooth decay: Lower pH because of sour food and sweet food can cause tooth decay. The pH of mouth should always be more than 5.5.
➢ **Properties of salts:**
• Salts form by the combination of acid and base through neutralization reaction.
• The acidic and basic nature of salts depends on the acid and base combined in neutralization reaction.

Acid	Base	Salt	Example
Strong	Strong	Neutral	$NaOH + HCl \rightarrow NaCl + H_2O$
Strong	Weak	Acidic	$HCl + NH_4OH \rightarrow NH_4Cl + H_2O$
Weak	Strong	Basic	$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$
Weak	Weak	Neutral	$CH_3COOH + NH_4OH \rightarrow CH_3COONH_4 + H_2O$

• The most common salt is sodium chloride or table salt which forms by the combination of sodium hydroxide (base) and hydrochloric acid.
• Other examples include Epsom salts ($MgSO_4$) used in bath salts, ammonium nitrate (NH_4NO_3) used as fertilizer, and baking soda ($NaHCO_3$) used in cooking.
• The pH of salts solution depends on the strength of acids and base combined in neutralization reaction.
• Indicators – Indicators are substances which indicate the acidic or basic nature of the solution by their colour change.

Chemical properties of acids:

I) Acids react with active metals to give hydrogen gas. $Zn + H_2SO_3 \rightarrow ZnSO_4 + H_2$
II) Acids react with metal carbonate and metal hydrogen carbonate to give carbon dioxide. $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$
III) Acids react with bases to give salt and water. This reaction is called as neutralization reaction. $NaOH + HCl \rightarrow NaCl + H_2O$
IV) Acids react with metals oxides to give salt and water.
$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$

Addition of Acids or Bases to Water

The process of dissolving an acid, specially nitric acid or sulfuric acid or a base in water is a highly exothermic one. As a rule: Always add acid to water and never the other way! The acid must be added slowly to water with constant stirring. If one mixes the other way by adding water to a concentrated acid, the heat generated causes the mixture to splash out and cause burns.

➢ **Chemical properties of Bases:**

I) Reaction with Metals - Certain reactive metals such as Zinc, Aluminium, and Tin react with alkali solutions on heating and hydrogen gas is evolved. $2NaOH + Zn \rightarrow Na_2ZnO_2 + H_2$

II) Reaction with acids -Bases react with acids to form salt and water. $KOH + HCl \rightarrow KCl + H_2O$

III) Reaction with Non -metallic oxides – These oxides are generally acidic in nature. They react with bases to form salt and water. $2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

➢ **Some Important Chemical Compounds:**

• **Common Salt (NaCl)**

Sodium chloride is known as common salt. Its main source is sea water. It is also exists in the form of rocks and is called rock salt.

Common salt is an important component of our food. It is also used for preparing sodium hydroxide, baking soda, washing soda etc.

• **Sodium hydroxide (NaOH)**

Prepared by Chlor Alkali process: Electricity is passed through an aqueous solution of Sodium chloride (called brine). Sodium chloride decomposes to form sodium hydroxide. Chlorine gas is formed at the anode, and hydrogen gas at the cathode. Sodium hydroxide solution is formed near the cathode. $2NaCl(aq) + 2\,H_2O\,(l) \rightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$

• **Bleaching powder**:

Bleaching powder is represented as $CaOCl_2$, though the actual composition is quite complex.

Bleaching powder is produced by the action of chlorine on dry slaked lime. $Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$

• **Baking soda:**

Sodium hydrogen carbonate ($NaHCO_3$) Preparation: $NaCl + H_2O + CO_2 + NH_3 \rightarrow NH_4Cl + NaHCO_3$

• **Washing soda:** Sodium carbonate $N_2CO_3.10H_2$ In the first step, sodium carbonate is obtained by heating baking soda. $2\,NaHCO_3(heat) \rightarrow Na_2CO_3 + H_2O + CO_2$

Then washing sod a is produced by recrystallisation of sodium carbonate $Na_2CO_3 + 10H_2O \rightarrow Na_2CO_3\,.10H_2O$

• **Plaster of Paris:**

Calcium sulphate hemihydrate $CaSO_4.\ 1/2\ H_2O$ Prepared by heating Gypsum at 373K. $CaSO_4.\ 2H_2O(Heat\ at\ 373K) \rightarrow CaSO_4.\ 1/2\ H_2O + 1\tfrac{1}{2}\ H_2O$

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Carbon & Its Compounds

1. Bonding in Carbon

Formation of covalent bond: Covalent bond formation involves sharing of electrons between bonding atoms which may be either same or different. Carbon form covalent bonds.

Covalency: The number of electrons contributed by an atom for sharing is known as its covalency.

Characteristics of covalent compounds:

(i) These compounds are molecular in nature (i.e. they exist as single molecules)
(ii) These are insoluble in water and soluble in benzene, kerosene and petrol etc.
(iii) These compounds are poor conductor of electricity.

2. Allotropy in Carbon

The property due to which an element exists in two or more forms, which differ in their physical and some of the chemical properties is known as Allotropy and the various forms are called Allotropes. Carbon exists in two allotropic form

(i) Crystalline

(ii) Amorphous.

The crystalline forms are diamond and graphite whereas the amorphous forms are coal, charcoal, lamp black etc.

Fullerenes form another class of carbon allotropes. The first one to be identified was C-60, which has carbon atoms arranged in the shape of a football.

3. Unique Nature of Carbon

Catenation: The property of elements to form long chains or rings by self-linking of their own atoms- through covalent bonds is called catenation. The extent of catenation depends upon the strength of the bonds between the atoms involved in catenation.

4. Saturated and Unsaturated Carbon Compounds

In saturated compounds the valencies of all the carbon atoms are satisfied by single bonds between them. While in the unsaturated compounds, the valencies of all the carbon atoms are not satisfied by single bonds, thus in order to satisfy their valencies, they form double or triple bond between the carbon atoms.

5. Straight chain compounds: The compounds which contain straight chain of carbon atoms e.g. normal butane (C_4H_{10}), normal pentane (C_5H_{12}) etc.

6. Branched chain compounds: Those compounds which are branched. e.g. iso-butane (C_4H_{10}), isopentane (C_5H_{12}), neopentane (C_5H_{12}) etc.

7. Closed chain compounds or Ring compounds:

Cyclic compounds are called closed chain or ring compounds e.g. cyclohexane (C_6H_{12}), cyclopentane (C_5H_{10}), cyclobutane (C_4H_8), cyclopropane (C_3H_6) etc.

8. Hydrocarbons All those compounds which contain just carbon and hydrogen are called hydrocarbons.

9. Functional Group The atom or group of atoms which determine the properties of a compound is known as functional group. e.g. OH (alcohol), CHO (aldehyde), $> C = C <$ (alkene), $C \equiv C$ (alkyne) etc.

10. Homologous Series A series of compounds in which the same functional group substitutes hydrogen in a carbon chain is called a homologous series. e.g. CH_3Cl and C_2H_5Cl differ by a CH2 unit.

11. Nomenclature Chemists developed a set of rules, for naming organic compounds based on their structures which is known as IUPAC rules. The IUPAC name of an organic compounds consists of three parts.

- Prefix
- word root
- Suffix

Word Root: A word root indicates the nature of basic carbon skeleton.

In case a functional group is present, it is indicated in the name of the compound with either as a prefix or as a suffix.

While adding the suffix to the word root the terminal 'e' of carbon chain is removed If the carbon chain is unsaturated then the final 'ane' in the name of the carbon chain is substituted by ene or yne respectively for double and triple bonds.

Chemical properties of carbon compounds

1. Combustion

- All the allotropic forms of carbon burn in the presence of oxygen releasing carbon dioxide along with heat and light.

- The chemical equation for the carbon compounds undergoing combustion are as follows:

  (i) $C + O_2 \rightarrow CO_2$ + heat and light

  (ii) C_2H_5 (Ethane) + $O_2 \rightarrow CO_2 + H_2O$ + heat and light

  (iii) $C_5H_{12}OH$ (Pentanol) + $O_2 \rightarrow CO_2 + H_2O$ + heat and light

- Saturated hydrocarbons undergo combustion giving a clean flame. But in the presence of limited supply of air hydrocarbons produces a sooty flame as a result of incomplete combustion.

Gas stove at home has inlets for sufficient supply of oxygen and hence the mixture burns giving a clean blue flame. But if the inlets get blocked the fuel remains unburnt and hence the bottom part of the cooking vessels gets blackened.

Combustion of fossil fuels such as coal and petroleum containing nitrogen and sulphur leads to the formation of oxides of nitrogen and sulphur that acts as major pollutants in the environment

Take a gas stove having clean inlets for sufficient supply of oxygen. Burn the stove and heat a spoon. The spoon will not get a deposition of a black layer.

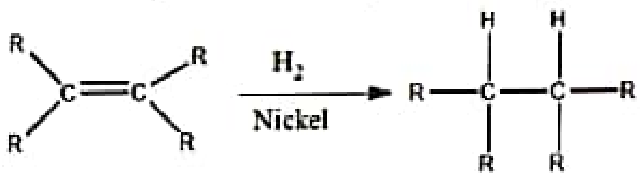
2.Oxidation

Carbon compounds gets readily oxidised on combustion. The following equation shows the conversion of alcohols to carboxylic acid.

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[\text{or Acidified } K_2Cr_2O_7 + \text{Heat}]{\text{Alkaline } KMnO_4 + \text{Heat}} \underset{\text{Acetic Acid}}{CH_3COOH}$$

3. **Addition Reaction**

- During addition reaction an unsaturated hydrocarbon adds hydrogen to the reaction in the presence of catalysts.
- Catalysts such as palladium or nickel proceed a reaction to a different rate without affecting the reaction to give saturated hydrocarbons.

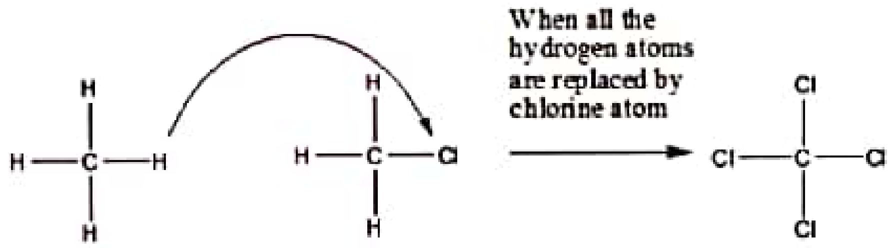


- This reaction is extensively used in the hydrogenation of vegetable oils containing long unsaturated carbon chains using a nickel catalyst.
- Animal fats on the other hand have saturated carbon chains.

4. Substitution Reaction

A reaction in which one functional group or atom is replaced by another functional group or atom is called substitution reaction.

In the presence of sunlight addition of chlorine to hydrocarbons is a fast reaction that results in replacement of the hydrogen atoms one by one. This is an example of substitution reaction because chlorine replaces the hydrogen attached to the carbon atom in the hydrocarbon.



methane Chloromethane perchloromethane

Some Important Carbon Compounds:

Ethanol: Ethanol (also called ethyl alcohol, grain alcohol, drinking alcohol, or simply alcohol) is a chemical compound, a simple alcohol with the chemical formula C_2H_5OH. Its formula can be also written as CH_3-CH_2-OH or C_2H_5-OH (an ethyl group linked to a hydroxylgroup), and is often abbreviated as EtOH. Ethanol is a volatile, flammable, colorless liquid with a slight characteristic odor. It is a psychoactive substance and is the principal type of alcohol found in alcoholic drinks

Properties of Ethanol

- Ethanol exists in liquid state at room temperature.
- Mixture of alcohol to ethane results in the formation of ethanol and it is the active ingredient of all alcoholic drinks. Even a small quantity of ethanol if consumed can causes drunkenness.
- Being a good solvent, it is also used in medicines like tincture of iodine, cough syrups, and many other tonics.
- Reactions of Ethanol
- Reaction with sodium –

Reaction of alcohols with sodium leads to the evolution of hydrogen. Reaction of sodium with ethanol the product formed along with hydrogen is sodium ethoxide.

$$2Na + 2\,CH_3CH_2OH \longrightarrow 2CH_3CH_2ONa + H_2$$

Ethanol Sodium Ethoxide

- Reaction to give unsaturated hydrocarbon:

Reaction of ethanol with excess concentrated sulphuric acid acting as dehydrating agent at 443 K results in the dehydration of Ethanol leading to the formation of Ethene.

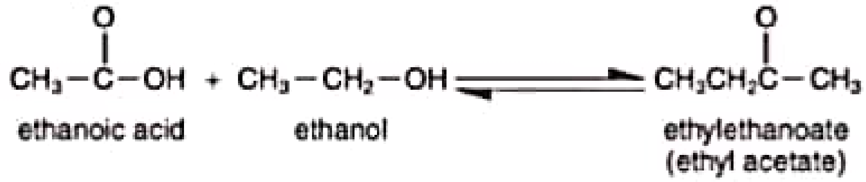
$$2CH_3CH_2OH \xrightarrow[H_2SO_4]{\text{Hot Conc.}} 2CH_2{=}CH_2 + H_2O$$

Ethanol Ethene

Ethanoic acid:

It is a colourless liquid. When pure ethanoic acid freeze like ice, it is known as **Glacial Acetic Acid**. It is formed at a temperature of about 16.6 degree centigrade

Ethanoic Acid/Acetic acid when reacts with ethanol it forms an ester. Ester can be identified by its sweet smell.



Reaction of ester with strong base is used to form soap. This is known as **Saponification**. Acetic acid also reacts with strong base to form sodium acetate and water.

$NaOH + CH_3COOH + CH_3COONa + H_2O$

Soaps and Detergents

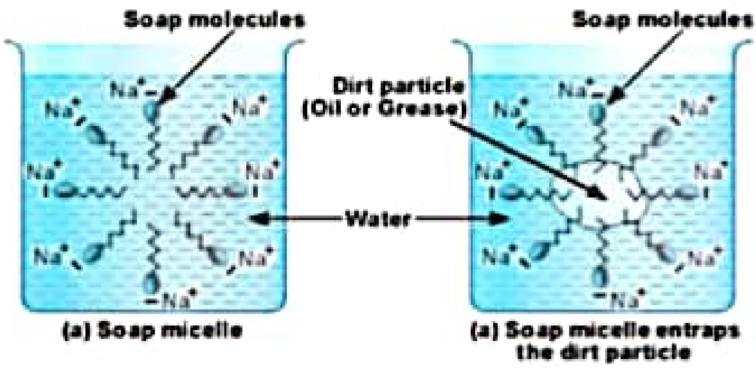
Sodium or potassium salt of carboxylic acid is known as **Soap**. They work most effectively in soap water. Detergents are sulphonate or ammonium salt of long chain of carboxylic acid. They can work effectively on soft as well as hard water.

Cleansing Action of Soaps and Detergents

Cleansing action of soaps and detergents is due to ability to minimize the surface tension of water, to emulsify oil or grease and to hold them in a suspension of water. When soap dissolves in water, it forms soap anions and soap cations. The hydrophobic part of soaps and detergents are soluble in grease and hydrophilic part is soluble in water.

Soap and Micelle Formation

When dirt and grease are mixed with soap water, soap molecules arrange them in tiny clusters known as **Micelle**. The hydrophilic part sticks to the water and form outer surface of the micelle and hydrophobic part binds to oil and grease.



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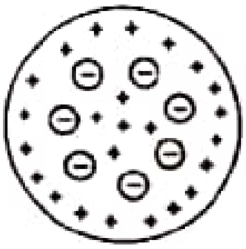
STRUCTURE OF ATOM

Dalton's Atomic Theory

All elements are consists of very small invisible particles, called atoms. Atoms of same element are exactly same and atoms of different element are different.

Thomson's Atomic Model

Every atom is uniformly positive charged sphere of radius of the order of 10^{-10} m, in which entire mass is uniformly distributed and negative charged electrons are embedded randomly. The atom as a whole is neutral.



Limitations of Thomson's Atomic Model

1. It could not explain the origin of spectral series of hydrogen and other atoms.
2. It could not explain large angle scattering of α – particles.

Rutherford's Atomic Model

On the basis of this experiment, Rutherford made following observations

(i) The entire positive charge and almost entire mass of the atom is concentrated at its centre in a very tiny region of the order of 10^{-15} m, called nucleus.

(ii) The negatively charged electrons revolve around the nucleus in different orbits.

(iii) The total positive charge 011 nucleus is equal to the total negative charge on electron. Therefore atom as a overall is neutral.

(iv) The centripetal force required by electron for revolution is provided by the electrostatic force of attraction between the electrons and the nucleus.

Limitations of Rutherford Atomic Model

(i) **About the Stability of Atom** According to Maxwell's electromagnetic wave theory electron should emit energy in the form of electromagnetic wave during its orbital motion. Therefore. radius of orbit of electron will decrease gradually and ultimately it will fall in the nucleus.

Bohr's Atomic Model

Electron can revolve in certain non-radiating orbits called stationary or bits called energy levels

Total no. Of elections in a shell=2n2

Where n= no. Of shells

RADIOACTIVITY

Nucleus

The entire positive charge and nearly the entire mass of atom is concentrated in a very small space called the nucleus of an atom.
The nucleus consists of protons and neutrons. They are called nucleons.

Terms Related to Nucleus

(i) **Atomic Number** The number of protons in the nucleus of an atom of the element is called atomic number (Z) of the element.

(ii) **Mass Number** The total number of protons and neutrons present inside the nucleus of an atom of the element is called mass number (A) of the element.

(iii) **Nuclear Size**

1 Fermi

(iv) **Nuclear Density** Nuclear density is independent of mass number and therefore same for all nuclei

(v) **Atomic Mass Unit** It is defined as 1 / 12th the mass of carbon nucleus.

Isotopes

The atoms of an element having same atomic number but different mass numbers. are called isotopes.

e.g., $_1H^1$, $_1H^2$, $_1H^3$ are isotopes of hydrogen.

Isobars

The atoms of different elements having same mass numbers but different atomic numbers, are called isobars.

e.g., $_1H^3$, $_2He^3$ and $_{10}Na^{22}$, $_{10}Ne^{22}$ are isobars.

Isotones

The atoms of different elements having different atomic numbers and different mass numbers but having same number of neutrons, are called isotones.

e.g., $_1H^3$, $_2He^4$ and $_6C^{14}$, $_8O^{16}$ are isobars.

Isomers

Atoms having the same mass number and the same atomic number but different radioactive properties are called isomers,

Nuclear Force

The force acting inside the nucleus or acting between nucleons is called nuclear force. Nuclear forces are the strongest forces in nature.

- It is a very short range attractive force.
- It is 100 times that of electrostatic force and 10^{38} times that of gravitational force.

According to the Yukawa, the nuclear force acts between the nucleon due to continuous exchange of meson particles.

Radioactivity

The phenomena of disintegration of heavy elements into comparatively lighter elements by the emission of radiations is called radioactivity. This phenomena was discovered by Henry Becquerel in 1896.

Radiations Emitted by a Radioactive Element

Three types of radiations emitted by radioactive elements

(i) α-rays

(ii) β-rays

(iii) γ – rays α-rays consists of α-particles, which are doubly ionised helium ion.

β-rays are consist of fast moving electrons.

γ – rays are electromagnetic rays.

[When an α – particle is emitted by a nucleus its atomic number decreases by 2 and mass number decreases by 4.

$$_ZX^A \xrightarrow{\alpha\text{-particle}} {}_{Z-2}Y^{A-4}$$

When a β -particle is emitted by a nucleus its atomic number is Increases by one and mass number remains unchanged.

$$_ZX^A \xrightarrow{\beta\text{-particle}} {}_{Z+1}Y^{A}$$

When a γ – particle is emitted by a nucleus its atomic number and mass number remain unchanged

Half-life of a Radioactive Element

The time is which the half number of atoms present initially in any sample decays, is called half-life (T) of that radioactive element.

Units of Radioactivity

Its SI unit is Becquerel (Bq).

Its other units are Curie and Rutherford.

1 Curie = $3.7 * 10^{10}$ decay/s

1 Rutherford = 10^6 decay/s

Nuclear Fission

The process of the splitting of a heavy nucleus into two or more lighter nuclei is called nuclear fission.

When a slow moving neutron strikes with a uranium nucleus ($_{92}U^{235}$), it splits into $_{56}Ba^{141}$ and $_{36}Kr^{92}$ along with three neutrons and a lot of energy.

$$_{92}U^{235} + {}_0n^1 \longrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + \text{energy}$$

Nuclear Chain Reaction

If the particle starting the nuclear fission reaction is produced as a product and further take part in the nuclear fission reaction, then a chain of fission reaction started, which is called nuclear chain reaction.

Nuclear chain reaction are of two types

(i) Controlled chain reaction

(ii) Uncontrolled chain reaction

Nuclear Reactor

The main parts of a nuclear reactor are following

(i) **Fuel** Fissionable materials like $_{92}U^{235}$, $_{92}U^{238}$, $_{94}U^{239}$ are used as fuel.

(ii) **Moderator** Heavy water, graphite and beryllium oxide are used to slower down fast moving neutrons.

(iii) **Coolant** The cold water, liquid oxygen, etc. are used to remove heat generated in the fission process.

(iv) **Control rods** Cadmium or boron rods are good absorber of neutrons and therefore used to control the fission reaction.

Atom bomb working is based on uncontrolled chain reaction.

Nuclear Fusion

The process of combining of two lighter nuclei to form one heavy nucleus, is called nuclear fusion.

Three deuteron nuclei ($_1H^2$) fuse, 21.6 MeV is energy released and nucleus of helium ($_2He^4$) is formed.

$$_1H^2 + {}_1H^2 + {}_1H^2 \longrightarrow {}_2He^4 + {}_1H^1 + {}_0n^1 + 21.6\,\text{MeV}$$

In this process, a large amount of energy is released.

Nuclear fusion takes place at very high temperature approximately about 10^7 K and at very high pressure 10^6 atmosphere.

Hydrogen bomb is based on nuclear fusion.

The source of Sun's energy is the nuclear fusion taking place at sun.

Thermonuclear Energy

The energy released during nuclear fusion is know as thermonuclear energy. Protons are needed for fusion while neutrons are needed for fission process.

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Matter, Metal and Compounds

MATTER IN OUR SURROUNDING

Matter is anything which has mass and occupies space. All solids, liquids, and gases around us are made of matter. Scientists believe that matter is made of tiny particles that clump together. A substance is a pure kind of matter having only one kind of constituent particle (atom or molecule). Water, iron, gold, copper, aluminium and oxygen are examples of substances. All substances are matter, but all forms of matter are not substances.

Matter can ordinarily exist in three states—solid, liquid, and gas. These three states of matter have different properties. Water exists in all the three states namely steam or water vapour (gas), water at room temperature (liquid), and ice (solid). This is the only substance that exists naturally in all the three states.

Matter can be classified in many ways. However, the following are the two main ways of classifying the matter:

1. By the physical state of matter as a solid, liquid, or gas.
2. By the chemical composition of matter as an element, a compound, or a mixture.

We shall discuss these classifications in the next section.

Classification of matter based on physical states. Matter can ordinarily exist in three states-1. Solid, 2. Liquid and 3. Gas.

Water exists in all the three states namely steam or water vapour (gas), water at room temperature (liquid) and ice (solid). This is the only substance that exists naturally in all the three states.

- The characteristic properties of different states of matter depend on intermolecular forces. The forces holding molecules together are called intermolecular forces. Intermolecular forces try to keep molecules together, but thermal energy always tries to keep them far apart.
- It is the competition between molecular interaction energy and thermal energy that decides whether a given substance under given conditions will be a solid, liquid, or gas.
- Thermal or heat energy can convert one state of matter into another state. Thus, a particular state of matter depends on both intermolecular force and the thermal energy that basically depends upon temperature.

Solid: We are surrounded by innumerable solid objects. A piece of wood, a stone, a pencil, a pen, and a computer all are examples of solid's. A solid has a definite size and shape which do not change on their own.

Liquid: Water is a liquid. Mustard oil and kerosene oil are other examples of liquids. Can you think of some more examples? A liquid has a definite volume. However, a liquid does not have a definite shape. It takes the shape of its container. A liquid can flow. You can pour a liquid or spill it. Liquids have properties intermediate between solids and gases. The intermolecular forces in liquids are weaker than solids but stronger than gases. In liquids, the constituent particles do not occupy fixed position as in solids, but they have freedom of movement as in gases.

Gases: A gas occupies the entire volume of the container irrespective of its size. In gases, molecules move freely because the intermolecular forces are very weak and are unable to keep the gas molecules together in bulk. We cannot see gases, but they are all around us. We can feel the presence of air when the wind blows. The wind is moving air and is a mixture of many gases like oxygen, nitrogen, argon, carbon dioxide, and others.

Plasma: The fourth state of matter is called plasma. This state contains ionised gas with super energetic and super excited particle.

Different Characteristics of the Three States of Matter

State of Matter	Volume	Density	Shape	Fluidity	Corn-pressibility	Inter-molecular Forces
Solid	Fixed	High	Definite	Does not Shape	Negligible flow	Very strong
Liquid	Fixed	Lower	It takes When com-pared to solid	Flows the shape of container	Very small smoothly	Weak when compared to solid
Gas	Has no Fixed Volume	Low definite shape	Has no smoothly	Flows pressible	Highly com-	Very weak

Classification of Matter According to Chemical Composition

Pure Substance

Elements: A chemical element is a pure substance, and it consists of one type of atom distinguished by its atomic number. Examples of some elements are: helium, carbon, iron, gold, silver, copper, aluminium, hydrogen, oxygen, etc.

Elements are the building blocks of the Universe. In total, 118 elements have been listed so far. Out of the total 118 known elements, about 94 occur naturally on earth, and the remaining have been synthesized artificially by nuclear reactions.

Elements in Earth's Crust and Human Body

Compound: These contain more than one kind of atoms. These cannot be separated into constituent atoms by simple physical methods.

Example: $C_6H_{12}O_6$ (glucose), NaC1 (salt), SiO_2 (silica).

Impure Substance

A substance is said to be impure, if all the constituent particles of that substance are not same in their chemical nature.

Mixture: These are obtained by mixing two or more substances in any proportion.

Mixtures can be divided into two categories:

1. **Homogenous Mixture:** They have uniform composition throughout like sugar solution, air, true solutions.
2. Heterogeneous: They have non-uniform composition like a mixture of salt and sugar in unknown concentration, colloidal solutions.

Colloidal Solution: These kinds of solutions are heterogeneous in nature and contain two phases, i.e., dispersed phase and dispersed medium. They can scatter light because of the presence of large solute particles, i.e., they show

Tyndall effect and Brownian movement. (Blue colour of the sky is also due to scattering of light by dust particles suspended in air).

- Colloidal solutions are purified by dialysis.
- They are of following types on the basis of dispersed phase and dispersed medium.

Type of Colloid	Dispersed Phase	Dispersed Medium	Example
Emulsion	Liquid	Liquid	Milk
Aerosol	Liquid	Gas	Fog clouds
Gel	Liquid	Solid	Jelly, cheese
Aerosol (solid)	Solid	Gas	Smoke, automobile
Sol	Solid	Liquid	Milk of magnesia
Solid sol	Solid	Solid	Coloured gemstone
Foam	Gas	Liquid	Shaving cream
Foam	Gas	Solid	Foam rubber

Separation of Mixture: Some important chemical and physical methods are discussed further:

1. **Distillation:** It is a method of separating mixtures based on difference in volatilities of compounds in a boiling liquid mixture.
2. It is used to separate liquids having very less difference in their boiling points. For example, a mixture of acetone (329 K) and methyl alcohol (338 K).
3. **Crystallisation:** It is used to separate a mixture of inorganic solids with the help of a suitable solvent; their examples include separation of a mixture of sugar and salt by using ethyl alcohol.
4. **Vacuum Distillation:** It is also known as distillation under reduced pressure. It is used to obtain glycerol and H_2O and to concentrate sugarcane juice in sugar industry.
5. Steam Distillation: It is used to separate a steam volatile compound from non-volatile or non-steam volatile compounds. It is used to purify sandwood oil, aniline, nitrobenzene, etc.
6. **Chromatography:** It is the modern technique used for separation and purification of organic compounds. It is used for the separation of coloured pigments from a plant.

Properties of Matter

1. **Melting Point:** It is a temperature at which a substance converts from its solid state to liquid state. After adding impurities, the melting point decreases.
2. **Boiling Point:** It is a temperature at which vapour pressure of a liquid becomes equal to atmospheric pressure and at which a substance converts from its liquid state to gaseous state. Atmospheric pressure usually decreases with height; hence, at high altitudes, the boiling point of the water is less than 100°C.
3. **Evaporation:** It is the process of conversion of a liquid into vapours at any temperature below its boiling point. It increases with increase in surface area.
4. **Condensation:** It is the process of conversion of gas into liquid. Solid, liquid, and gases are interconvertible by changing the condition of temperature and pressure.

METAL AND THEIR COMPOUNDS

hose elements which can donate electrons and form cations are called metals, like Na, Ca, and Mg.

Physical Properties of Metals

1. Metals are good conductors of heat and electricity.
2. They are ductile in nature.
3. They have lustre.
4. They are solid at room temperature (only Hg Mercury is liquid in nature at room temperature).
5. They all have high values of boiling point and melting point.
6. They all have high density (only sodium and potassium have low density).
7. Metals are sonorous in nature (means they produce sound).
8. Metals have high tensile strength.

Chemical Properties of Metals

1. Produce many compound after reaction with no-metals.
2. They form cation after losing an electron.
3. They produce metal oxide after reaction with oxygen, and metal oxides are basic in nature.
4. They produce metal hydroxide after adding water in them.

SODIUM

Symbol: Na, Atomic Number—11, Mass Number—23

Sodium is a highly reactive metal in periodic table and found in Earths crust (2.27% of total metals); sodium is a soft metal and can easily be cut with knife.

Occurrence and Extraction: Due to highly reactive element, it does not exist freely in nature, but it is found in the form of ores of chloride, nitrate, carbonate, borate, etc.

Physical and Chemical Properties: Sodium is white like silver, but it is very soft and light, so it can be cut through knife and floats in water. Due to a highly reactive nature, sodium is kept inside the kerosene oil (K-oil). But sodium is soluble in benzene and ether.

Uses: As a reducing agent, in synthetic reactions, and in making tetraethyl lead (anti-knocking) compound by the use of an alloy of sodium-lead.

Compounds of Sodium

- Sodium Hydroxide (NaOH): The compound NaOH is called caustic soda, which is used as a petroleum purifier, in manufacturing of soaps, to produce glazing in pulp paper, cotton cloth, etc., and in the production of the artificial silk.
- Sodium Bicarbonate ($NaHCO_3$): It is also called edible soda, and breads get such exposer by an emergent gas CO_2.
- Sodium Chloride (NaCl): This is called common salt or ordinary salt, which is prepared by the vaporization process of sea water.
- Borex-sodium Tetra Borate Deca Hydrate ($Na_2B_4O_7.10H_2O$): This is a white crystalline solid that is soluble in water.

MAGNESIUM

Symbol: Mg, Atomic Number—12, Mass Number—24

Physical and Chemical Properties: The metal magnesium doesn't exist in nature in free state, because it is highly reactive. This is a white and extremely glazed metal like silver. The metal magnesium is malleable and ductile; that's why it can easily be transformed into a thin wire or ribbon.

The boiling point and melting point of this metal is 650°C and 110°C.

Uses: The metal magnesium is used in making flash light ribbon, in photography and in fire crackers, in the composition of alloys, etc.

Alloys:

Magnalium—Mg + Al + Cu + Fe

Duralumin—Al + Cu + Mg

Elektron—Mg + Zn + Cu

1. **Magnesia (MgO):** The magnesia4Mg0) is also called milk of magnesia, which is a white coloured powder. This is slightly soluble in water, it is fluorescent to the light and it is fused at a very high temperature; therefore, magnesia is used in layer lining of blast furnace.
2. **Magnesium Sulphate ($MgSO_4$):** This compound naturally occurs in the form of epsomite in epsome, which are abundantly found in hot water spring. This is a colourless crystalline solid substance. This is frequently used in cotton industry, in the manufacturing of soap, paint, etc. This is also used as a catalyst with platinum in the manufacturing or production of sulphuric acid (H_2SO_4).
3. **Magnesium Alva [$Mg(OH)_2.MgCO_3.3H_2O$]:** This compound is used in removing the acidity from the human stomach and it is used as an antacid tablet.

ALUMINIUM

Symbol: Al, Atomic Number—12, Mass Number—24

Physical and Chemical Properties: Aluminium doesn't occur in nature in free state but occurs in the forms of compounds like bauxite ($Al_2O_3.2H_2O$), Corundum (Al_2O_3), Diaspore ($Al_2O_3.H_2O$). Al is a white glazing metal like silver. This is a good conductor of heat and electricity, and it is malleable and ductile.

Its melting point and boiling point are 659.8°C and 2,200°C.

Uses: This metal (aluminium) and its alloys are frequently used in aircrafts, motor vehicle industries. The cooking utensils are manufactured by the alloys of it and by the metal itself.

Alloys of Aluminium

Alloys	**Composition**
Aluminium bronze	Al + Cu
Magnelium	Al + Mg + Cu + Fe
Nickelloy	Al + Ni + Cu
Durallum	Mn + Mg

Compounds of Aluminium

Aluminium Chloride ($A1C1_3$): This is used as a catalyst in Friedel Craft reaction which occurs on an extensive level. This is also used as a catalyst in the production of Gasoline. It is also used in cracking of petroleum anhydrous $AlC1_3$.

Potash Alum [$K_2SO_4.A1(SO_4)_3.24H_2O$]: This is a double salt that appears as a colourless crystalline solid. This is also used in pulp-paper and leather industries, as an antiseptic and as a germicide after shaving, as a germicide for purification of water, etc.

Aluminium Hydroxide [$Al(OH)_3$]: This is a white amorphous powder insoluble in water, and it is a covalent compound. This is used in making fire proof and water proof clothes; in the name of aluminium gel, it is used as a drying agent, freshly precipitated $Al(OH)_3$ absorbs colouring matter forming insoluble lakes.

CALCIUM

Symbol: Ca, Atomic Number—20, Mass Number—40

Physical and Chemical Properties: This is a white metal like silver and it is soft when compared with the other metals but hard when compared with lead, whose relative density is 1.55. This metal also exhibits the phenomenon of malleability and ductility.

The boiling point and melting point of this metal are 851°C and 1439°C.

Uses: This metal is used in removing water which is present in small amounts in alcoholic solution. It is also used in removing elements like nitrogen, sulphur, and oxygen. which are present in small amounts during the process of metal extraction.

Compounds of Calcium

Calcium Oxide (CaO): This is also called quick lime. This is basically a white porous solid substance that reacts rapidly with water and calcium hydroxide is formed.

Calcium Hydroxide [$Ca(OH)2$]: This is also called slaked lime, and it is obtained by reacting quick lime (CaO) with water.

Calcium Chloride ($CaC12$): This occurs in a very small amount in sea water and ocean. It is basically a colourless, crystalline solid substance in which each molecule has six crystals of water.

Bleaching Powder [$Ca(OCI)C1$]: This is an oxychloride of calcium, and it is produced on large scale by Hasen Clever's process. It is an extremely temporary compound used in bleaching action of paper and cloth or garment. This is also used as an insecticide or a germicide, as a water purifier, and as an anti-infective agent.

Iron

Symbol: Fe, Atomic Number—26, Mass Number—56

Physical and Chemical Properties of Iron: Pure iron is like a silver white, soft, ductile, and malleable metal. The specific gravity of iron is 9.85, its melting point and boiling point are 1,533°C and 2,450°C. It is a transition metal and ferromagnetic, and it is attracted by the magnet. Fe is a transition metal, and it doesn't occur in nature in free state, but it is found in the form of ore. In nature, it is also found abundantly in green vegetables and in the haemoglobin of the blood.

Alloys of Iron

Steel	**Other Element with Fe**	**Special Feature or Properties**	**Uses**
Stainless steel	Cr	Very hard and strong, doesn't form rust.	Used in making cooking utensils, surgical instruments, blades, etc.
Nickel Steel	Ni	Very hard and elastic, free from rusting.	Used in making axles, electric wire, aircraft, auto Parts, etc.
Tungsten steel	W	Very hard and strong.	Used in making spring, magnets, saws, axles, and cutting gools.

Compounds of Iron

Ferrous Sulphate ($FeSO_4$): The hydrated ferrous sulphate is called green vitriol ($FeSO_4.4H_2O$). This is a light green crystalline solid highly soluble in water.

Ferric Chloride ($FeCl_3$): It is used as a laboratory reagent in the production of blood coagulating medicines. Mohr's Salt [FeSO4.(NH4)2SO4.6H201(CaC12): This is a green colour crystalline solid soluble in water but insoluble in alcohol. This is used in volume synthesis, in making blue ink, in colouration of leather, and garment. as an insecticide, as a reducing agent in the laboratory.

COPPER

Symbol: Cu, Atomic Number—29, Mass Number—64

Physical and Chemical Properties: This is a tough, reddish colour metal whose specific gravity is 8.95, and its melting point and boiling point are 1083°C and 2310°C. It is malleable and ductile. This is a good conductor of heat and electricity.

Alloys of Copper

Alloys	**Composition**	**Uses**
Brass	Cu + Zn	Used in making idols, household utensils, etc.
German silver	Cu+ Zn + Ni	Used in making idols and utensils.
Bell metal	Cu + Sn	Used in making bells, utensils, idols, coins, etc.
Delta metal	Cu +, Zn	Used in making propellers of ships, as resistant of sea water.

Compounds of Copper

Cupric Sulphate $(CuSO)_4$: This is the main compound of copper, and it is also called blue vitriol $(CuSO)_4.5H_2O$. This is basically a solid crystalline substance of blue colour in water. A mixture of $CuSO_4.5H_2O$ and $Ca(OH)_2$ is called Bordeaux Mixture, and it is used as a fungicide.

Cuprous Oxide (Cu_2O): This is a red colour solid substance, insoluble in water. It is obtained as a red precipitate by heating $CuSO_4$ with glucose and NaOH solution.

SILVER

Symbol: Ag, Atomic Number—47, Mass Number—108

Physical and Chemical Properties: This is a white, shining, solid metallic substance, malleable and ductile. This is the best conductor of heat and electricity. The relative density of it is 10.47, while its melting point and boiling point are 960°C and 1,955°C.

Uses of Silver: Silver is used in making ornaments, utensils, coins, silver pt. alloy in filling of tooth cavities, silver plating, etc.

Compounds

Silver Chloride (AgC1): This is called Horn silver, which is frequently used in making photochromic glass.

Silver Iodide (AgI): It is used in producing artificial rains.

Silver Nitrate (AgNO3): This is used as a laboratory reagent in making hair dyes, in electroplating of silver compounds, in making special ink which is used by washerman in clothes marking, and as a voter-marker on the finger of the hand.

GOLD

Symbol: Au, Atomic Number—79, Mass Number—197

Physical and Chemical Properties of Gold: This is a golden, yellowish solid substance insoluble in the acids like HCL, HNO_3, and $H2SO_4$. But soluble in aqua regia and NaCN solution. It is the most malleable metal, ductile, and good conductor of heat and electricity. It doesn't react with air but dissolves in sodium cyanide (NaCN) and potassium cyanide (KCN) and sodium aurocyanide and potassium aurocyanide are formed.

Uses of Gold: This is used in making ornaments, coins, salt photograph of gold, in electroplating, and in sugar industries. Thin layers of gold are used in pharmaceutical industries.

Compounds of Gold

Auric Chloride $(AuCl_3)$: This is a green powder insoluble in water, and, on heating, it explodes violently. That's why it is called fulminating gold. Thus, it is used as a detonator.

Rold Gold (Cu + Al): This is called artificial form of gold, which resembles like gold, and it is used in making cheap ornaments.

Silver Nitrate $(AgNO_3)$: This is used as a laboratory reagent, in making hair dyes, in electroplating of silver compounds, in making special ink which is used by washerman in clothes marking, and as a voter-marker on the finger of the hand.

PLATINUM

Symbol: Pt, Atomic Number—78, Mass Number—195

Uses of Platinum: This is used in making ornaments, laboratory equipment and devices, electrodes, alloys, and as a catalyst in Oswald's process.

ZINC Symbol: Zn, Atomic Number—30, Mass Number—65

Physical and Chemical Properties: This is a bluish white, hard, and brittle metallic substance. At a normal temperature, it is neither malleable nor ductile. It is a good conductor of heat and electricity.

The melting point, boiling point, and specific density of the zinc are 419.5°C, 907°C, and 7.1 kg/dm³ respectively.

Uses of Zinc: This is used in the laboratory in the preparation of H2 gas; it is also used in the galvanization of iron sheets to protect iron from rusting, buckets, boxes, and many household articles are made from these sheets.

Compounds of Zinc

Zinc Sulphate (ZnSO4): This is used in textile industry for soaking cotton threads before spinning, in making preserver of wood and hides, in manufacturing of lithopone white pigment, and in Calico printing and dyes industries.

Zinc Sulphide (ZnS): This occurs in nature in the form of zinc blende. It is a white solid that is insoluble in water. This exhibits the virtue of phosphorescence, and, therefore, it is used in making phosphorescent screens.

Zinc Chloride (ZnCl2): Anhydrated zinc chloride compound acts as a water absorber. The electroplating of ZnC12 is done to protect the costly wooden furnitures from germs or insects.

MERCURY

Symbol: Hg, Atomic Number—80, Mass Number—200

Physical and Chemical Properties: Mercury is a white, shining metal like silver which occurs in the liquid state at an ordinary temperature.

Uses of Mercury: Mercury is a very useful liquid metal used in making mercury thermometer, barometer, and used as a contact liquid in electrical industrial preparation of vermillion.

Compounds of Mercury

Mercurous Chloride (Hg_2Cl_2): This is also called calomel. It is a white, crystalline powder which is insoluble in water and dil. acids.

Mercuric Chloride ($HgC1_2$): This is also called corrosive sublimate which is a deadly poison. This is a colourless, crystalline solid, which is moderately soluble in cold water but extremely soluble in hot water.

Mercuric Sulphide (HgS): This is also called vermillion, which is a red colour solid crystalline substance.

LEAD

Symbol: Pb, Atomic Number—82, Mass Number—207

Physical and Chemical Properties of Lead: Lead is a soft, bluish grey metal with a bright lustre, and it is used as a paper marker. It doesn't react with dry air but reacts with moist air and forms the layer of hydroxide first and then of carbonate.

It also reacts with Conc. H_2SO_4 in which SO_2 gas is emerged out. When/ it reacts with dil.HNO3,then nitric oxide is formed, while with conc. HNO_3,/ HNO_3, NO_2 gas is formed in the form of a brownish smoke.

Uses of Lead: Lead is a very useful metal, and it is used in making alloys, lead accumulators, lead shots (bullet) and coverings of electric cables, lead chambers, lead pipes, lead-arsenic bullets, in nuclear research, etc.

Compounds of Lead

Lead Dioxide (PbO_2): It is used in Match Industry for making ignition surface of match boxes, used for preparation of $KMnO_4$.

Lead Acetate [$Pb(CH_3COO)_2$]: This is also called **SUGAR OF LEAD,** and it is a white crystalline sugar like substance soluble in water, and its crystals are sweet in taste.

Lead Tetra Ethyl [$Pb(C_2H_5)_4$]: It is a colourless mobile liquid having a special smell soluble in petrol.

URANIUM

Symbol: U, Atomic Number—92, Mass Number—238

Physical and Chemical Properties: This is a lustrous, white metal, and it is malleable and too ductile but an impure brittle metal. This is the most radioactive element which occurs naturally. This is paramagnetic and has a relative density. Uranium is also called metal of hope.

Melting point and Boiling point are 19.05, 1850°C and 3500°C respectively.

Isotopes of Uranium: There are three isotopes of uranium—${}_{92}U^{234}$, ${}_{92}U^{235}$, and ${}_{92}U^{238}$. The most abundantly occurring uranium in nature is ${}_{92}U^{238}$ (99.28%), while ${}_{92}U^{235}$ (0.71%) and ${}_{92}U^{234}$ (0.006%) occur in very 92 small amounts. The isotope ${}_{92}U^{235}$ is used in nuclear (atomic) reactor as a nuclear fuel.

NON-METALS

In modern periodic table, there are 22 non-metals, in which there are 11 gases, 1 liquid, and 10 solids. Bromine occurs in the state of liquid, while hydrogen, nitrogen, oxygen, chlorine, etc. are in gaseous state.

HYDROGEN

Symbol: H, Atomic Number—1, Mass Number—1

Uses of Hydrogen: This is used as a fuel (liquid hydrogen) in the rocket, in the production of ammonia (NH3) by Haber's process, in the manufacturing of vegetable ghee, in the production of Gasolene, in filling the balloons, etc.

Various forms of Hydrogen

Nascent Hydrogen: In the process of chemical reaction, a suddenly emerged hydrogen gas is called atomic hydrogen.

Isotopes of Hydrogen: There are three isotopes of hydrogen—Protium ($_1H^1$), deuterium ($_1H^2$), and tritium ($_1H^3$).

1. **Protium ($_1H^1$):** It has equal atomic number and mass number, and it is equal to 1.
2. **Deuterium ($_1H^2$):** This is called heavy hydrogen and it has atomic number = 1, mass number = 2. It was invented by Urey Brickwedde and Murphy in 1931. It is used in explaining the mechanism of organic reaction and as a bombarding particle of the nuclear reactions.
3. **Tritium ($_1H^3$):** Tritium ($_1H^3$) is a rarely occurring isotope of hydrogen, and it is a beta emitter and a radioactive substance. Atomic number and mass number of it is 1 and 3, respectively, while its half-life period is 12.4 years.

Compounds of Hydrogen and its Isotopes

1. **Heavy Water (D_2O):** The density of heavy water (D_2O) is more than ordinary water (H_2O).
2. **Hydrogen Peroxide (H_2O_2):** This is a light bluish dense liquid without any smell, and, due to presence of Hydrogen bonding, it (H202) looks like an ordinary water (H20) and is an associated liquid.
3. Ordinary Water (H_2O): This is a compound whose pure form is neutral, and its pH is 7. Pure water is a bad conductor of electricity, but an acidic water is a good conductor of electricity. At 4°C, the density of the water is maximum and its volume is minimum. The ordinary water transforms into ice at 0°C. The rainy water is the purest form of the water, and 97% parts of the entire water are assumed to be confined in ocean surroundings, while the rest 3% is only assumed to be confined in the pure form. The conversion of water into the ice and into the water vapour are examples of physical changes.

Types of Water

Hard Water: Hard water is not good for drinking because its taste is not good, and it is harmful for the health. In it chloride, sulphate and bicarbonate of calcium and magnesium salts are dissolved. Also, washing soap doesn't produce leather with hard water.

Soft Water: Soft water is good for drinking because its taste is good, and its is not harmful for the health. Washing soap produces leather with soft water.

Hardness of Water: The hardness of water is of two types:

1. **Permanent Hardness:** The existence of the hardness of water due to the chloride and sulphate of the Calcium and Magnesium salts is called permanent hardness of water. The permanent hardness of water is removed by mixing sodium carbonate in it, and, sometimes, it is also removed by boiling the hard water by the means of distillation.
2. **Temporary Hardness:** The existence of the hardness of water due to the bicarbonates of calcium and magnesium salts is called temporary hardness of water. The temporary hardness of water can be removed by boiling it. If sodium carbonate is mixed up to the water and boiled, then both permanent and temporary types of hardness can be removed.

SILICON

Symbol: Si, Atomic Number—14, Mass Number—28

Occurrence and uses of Silicon: Silicon occurs in nature abundantly in the form of sand and stone but never found in free state. This is a non-metallic element, which also exhibits the characteristic of allotropy. The hydride of the silicon is called Silane.

NITROGEN

Symbol: N, Atomic Number—7, Mass Number—17

Occurrence and uses of Nitrogen: Nitrogen is the main component of the atmospheric air, and, in the form of compound, it is also found as ammonia, as ammonium compounds, and in nitrate forms. There are no allotropes of nitrogen like carbon, and, according to the volume, it is 78% in atmospheric air.

Nitrogen is also used in the electric bulbs and thermometer for measuring the high temperature. It is also used in the artificial pregnancy of cows for which the sperm of bull is kept in it.

Fixation of Nitrogen: The process of transformation of atmospheric nitrogen by the bacteria in the roots of useful nitrogenous compounds is called fixation of nitrogen. The fixation of nitrogen takes place both naturally and artificially. Symbiotic Bacteria namely rhizobium take part in the nitrogen fixation process in the joints of the roots of the leguminous plants. The process of transformation of nitrogenous compounds into nitrogen is called denitrification. Such process is performed by certain bacteria called denitrifying bacteria. Also, in the process of denitrification, released nitrogen by its compounds directly goes to the atmosphere.

Compounds of Nitrogen

Ammonia (NH_3): Ammonia is manufactured at industrial level by Haber's process.

Liquefied ammonia is used in freezing ice in the refrigerators, ammonia is used in the production of ammonium salts and urea, in cleaning, in the production of nitric acid (HNO_3) by Oswald's process and in the production of sodium carbonate (Na_2CO_3) by Solvay's process, in the production of hydrogen, etc.

PHOSPHORUS

Symbol: P, Atomic Number—15, Mass Number—31

Occurrence and Extraction" of Phosphorus: Phosphorus is a very reactive non-metal and easily catches fire in air in nature and that's why phosphate. Animal bones contain nearly 58% calcium phosphate, while it is found in small amounts in blood and urine of the animals as well as in the plants. There are various ores of phosphorus existing in nature, and a few of them are phosphorite [$Ca_3(PO_4)_2$], chloraphite [$Ca_3(PO_4)_2CaC1_2$], and redonda phosphate ($A1PO_4$).

OXYGEN

Symbol: O_2 (molecule formula—O_2) Atomic Number—8, Mass Number—16

Element — P-block

Occurrence and Preparation of Oxygen Gas: Oxygen gas was firstly invented by a Sweden based scientist Scheele in 1772. It is a colourless, odourless gas, which is slightly heavier than atmospheric air. It reduces into a deep blue liquid on cooling, it doesn't burn itself but favours the process of combustion. A mixture of helium and hydrogen gas is used in the artificial inhalation. There are three isotopes of oxygen—${}_8O^{16}$, ${}_8O^{17}$, and, ${}_8O^{18}$.

SULPHUR

Symbol: S, Atomic Number—16, Mass Number—32

Allotropes of Sulphur:

1. **Crystalline Allotropic Forms:**
   (a) Rhombic or Octahedral or a-sulphur.
   (b) Prismatic or Monoclinic or 13-sulphur.

2. **Non-crystalline Allotropic Forms:**
   (a) Plastic sulphur
   (b) White sulphur
   (c) Milky sulphur

Compounds of Sulphur

1. **Sulphur Dioxide (SO_2):** During volcanic eruption, the main gas which releases is sulphur dioxide, and it is a colourless, suffocating, and a gas of bitter smell. This gas is also used as an antichlor. It exhibits the property of bleaching action, but it is temporary. The structure of SO_2 is angular.
2. **Sulphuric Acid (H_2SO_4):** It is called chemical king of all the acids, and it is also known as oil of vitriol. On the industrial level, H_2SO_4 is manufactured by two processes- Contact process and Lead Chamber process.
3. **Hydrogen Sulphide (H_2S):** During volcanic eruption, hydrogen sulphide gas is also released in small amount. This is basically a colourless gas, which is poisonous (toxic), and its smell is like rotten eggs.

CHLORINE

Symbol: Cl, Atomic Number—17, Mass Number—35

Uses: The chemical substances like bleaching powder, chloroform, etc. are manufactured by chlorine. It is also used as a drinking water purifier, as a germicide, in removing colours from the garments and cloths, in whitening sugar, etc. It is also used in the production of toxic gases like phosgene, mustard gas, etc.

BROMINE

Symbol: Br, Atomic Number—35, Mass Number—80

Uses: In the production of salts of bromide, hypobromide, bromates etc. in making toxic and weeping gases, in the production of AgBr used in photography. It is also used as a reactant in organic chemistry, in the production of KBr, which is used in the form of sleeping drugs and pain reliever.

IODINE

Symbol: I, Atomic Number—35

Uses: It is used as a tincture of iodine and iodoform in the form of antiseptic and analgesic. Iodex (compound of iodine) is used as an external application of pain reliever medicine of bone injuries. This is also used in the manufacturing of several dyes and drugs, and in the preparation of photographic paper, film, and plates. Iodine is also used as a stronger germicide (insecticide).

INERT GASES

Helium (He): This is a light non-volatile gas, and it is the second largest element found in the universe. Helium is used in filling the tyres of the aircraft, and, due to its lightness with comparison to air, it helps in uplifting the aircrafts to upward. To obtain the weather related information's or observations, helium gas-filled balloons are left in open sky, and relevant predictions and calculations are made. The mixture of helium and oxygen is used by deep sea diver (sailor) on the behalf of air, because, at larger pressure, helium is less soluble than nitrogen. The mixture of helium and oxygen is also used in artificial breathing, specially to the patients suffering from asthma in hospitals. Liquid helium is used as a low temperature reagent in the experiments occurring at a low temperature.

Neon (Ne): This gas is frequently used in fluorescent bulbs and in glazing advertisement. This is also used in Neon lamp through which symbolic indication is given to the aircrafts pilot at the aerodrome or airport. Infact, this light of the lamp extremely shines in the fog. Thus, neon is today used frequently in discharge lamps and fluorescent bulbs, which are used frequently in the advertisement.

Argon (Ar): This is the most abundantly occurring gas in the atmosphere, and it is used in filling the ordinary electric bulbs, because, in the presence of this gas, filaments of the bulb have a longer live and remain intact even after the regular and longer use. This gas is also used in high temperature metallurgical operations and the processes involve behind it or in creating vacuum (being evacuated) in the arch welding of the alloys.

Xenon (Xe): This gas forms the maximum number of chemical compounds.

Redon (Rn): This is a radioactive element. This element is used in Radiotherapy in the treatment of cancer.

CARBON

Carbon is the sixth most abundant element in the universe. It can exist in the free state or in the form of its compounds. It is the major chemical constituent of most organic matter. Carbon is the second most common element in the human body after oxygen. Carbon is present in coal, oil, and natural gas.

Carbon atoms can form compounds by combining with other carbon atoms as well as atoms of other elements. Carbon has the unique property of forming long chains of carbon atoms. These long chains serve as a backbone on which various groups can attach to give a large variety of compounds.

Carbon can form bonds with atoms of other elements such as hydrogen (H), nitrogen (N), oxygen (O), sulphur (S), and halogens. It also has the property of self-combination, i.e., bond formation with the other carbon atoms. Thus, carbon can form long chains of carbon atoms. This unique property of forming long chains is known as catenation.

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Fuel

The substance that undergoes combustion is called as fuel.

E.g., Wood, Coal, Petroleum, kerosene etc.

Carbon + Oxygen ----------- Carbon dioxide + Heat.

Caloric Value of a fuel

The amount of heat produced by the complete combustion of 1 kg of a fuel is called it's calorific value.

Unit = KJ /Kg

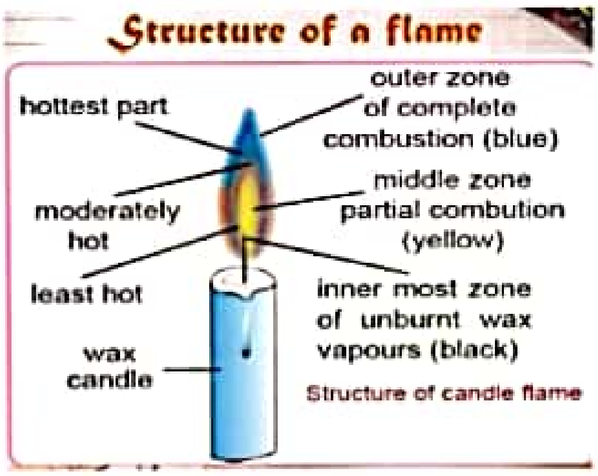
Calorific value is measured by Bomb Calorimeter.

Hydrogen has highest calorific value.

Hydrogen is also called clean fuel.

Hydrogen is least polluting fuel.

Hydrogen is also called fuel of future.



Fossil Fuels –
Fuels formed from dead remains of living organisms (fossils) are called fossil fuels.
E.g., Coal, Petroleum and natural gas

- **Coal**
- Coal was formed by decomposition of large land plants and trees buried under the earth about 300 millions years ago.
- **Carbonisation** – The process of formation of coal.

Destructive Distillation – The strong heating of coal in the absence of air is called destructive distillation.

Products of destructive distillation –

1. Coal gas

2. Coal tar

3. Coke

• Coal gas

It is a mixture of methane, carbon monoxide and hydrogen

Coal gas was used for street lightning in London (1810)

It was used for street lightning in New York around 1820.

• Coal Tar

It is a mixture of about 200 carbon compounds.

E.g , Benzene , toluene, naphthalene, anthracene , phenol ,aniline.

The products of coal tar are used to make synthetic fibres, drugs, plastics, synthetic dyes, perfumes, paints explosives etc.

Coal tar has been used for metalling the roads.

These day bitumen (a petroleum product) is used.

• Coke

It is almost pure form of carbon.

It is 98% carbon.

• Petroleum

It is dark coloured thick liquid fossil fuel. It has strong foul smell due to the presence of sulphur containing compounds in it. It is commonly called as crude oil. The economy of a nation depends to a great extent on petroleum wealth, that's why petroleum is called the black gold.

Its name is derived from Latin words Petra (meaning rock) and Oleum (meaning oil). Thus, petroleum literally means "rock oil".

Origin of petroleum: Petroleum is a complex mixture of solid, liquid and gaseous hydrocarbons, mixed with salt water and earthy particles. It is always found trapped between two impervious rocks.

It is believed that petroleum is formed by the anaerobic decomposition of extremely small sea animals and plants which got buried in the sea bed millions of years ago. Let us see how this happened.

Occurrence of petroleum: Petroleum occurs at a moderate depth (500 m to 200 m) between the 2 layers of impervious rocks. The petroleum is lighter than it water & hence, floats over it. Natural gas is found above petroleum, trapped between the rock cap & petroleum layer.

Drilling of oil wells: The hole is drilled in the Earth's crust & when it reached the rock cap, the natural gas comes out first with a great pressure. When the pressure of gas subsides, petroleum starts flowing out due to the pressure of natural gas.

Refining of petroleum: Petroleum is a mixture of several hydrocarbons. It also contains water, salt and rocky materials. It cannot be used in this made form either as a fuel or a basic material to produce other useful components. Before being put to use, it has to be purified or refined. The process of separating the various components of petroleum from one another is known as the refining of petroleum. This is done by a process called fractional distillation which is based on the fact that the different components of petroleum have distinctly different boiling points.

In fractional distillation, crude petroleum is heated to a temperature of ,4U0°C or slightly above in a furnace.

Uses of petroleum

(1) Petroleum products are used as fuels.

(2) Lubricating oils, and vaseline are used as lubricants.

(3) Paraffin wax, products of petroleum, is used for manufacturing candles, polishes, waxed paper, water proofing, etc.

(4) Some of the by-products of petroleum after purification are used in the preparation of medicines, ointments, face creams and cosmetics.

- **Natural gas**

Natural gas was formed millions of years ago along with petroleum when microscopic sea plants & animals died & got buried under the sand & mud. These plants & animals under anaerobic conditions changed to gas.

Composition

It consist mainly of methane (about 85%), ethane (about 10%) propane (about 3%) natural gas is compressed at high pressure then it is called CNG (compressed natural gas). CNG is used for power generation.

It is now being used as a fuel for transport vehicles because it is less polluting. The great advantage of CNG is that it can be used directly for burning in homes and factories where it can be supplied through pipes. Such network of pipeline exists in Vadodara (Gujarat) and some parts of Delhi.

Occurrence

It is generally found trapped between impervious rocks, sometimes along with petroleum & sometimes without petroleum.

In our country, natural gas has been found in Tripura, Rajasthan, Maharashtra and in the Krishna Godavari Delta.

Uses of natural gas

(1) As a fuel - It has a very high calorific value of 55 kJ/g

(2) As a source of hydrogen & carbon

Why petroleum is also known as black gold?

Explanation

Many useful substances are obtained from petroleum which can be used for the manufacture of detergents, fibers (polyester, nylon, acrylic etc.) polyethene and many other plastics.

Due to its great commercial importance, petroleum is also called Black Gold.

Some important fuels

1. **LPG – Liquid petroleum gas**

   It is a mixture of Butane, Isobutane and Propane
   Ethyl mercaptan is added into LPG to detect leakage

2. **CNG – Compressed Natural Gas**

   It is a mixture of methane, ethane

3. **Coal gas –**

   It is a mixture of methane, carbon monoxide and hydrogen

4. **Biogas –**

   It is a mixture of methane and carbon dioxide.

5. **Water gas – $CO + H_2$**

6. **Producer gas – $CO + N_2$**

• **Polymers**

It is a very big molecule formed by combination of large number of molecules

The small molecules which join together to form a polymer are called monomer

Polymers	Monomers
1. DNA /RNA	Nucleotide
2. Protein.	Nucleic Acid
3. Starch, glycogen, cellulose	Glucose
4. Natural Rubber.	Isoprene
5. Synthetic Rubber.	Chloroprene.
6. PVC.	Vinyl Chloride
7. Polythene.	Ethene.

• **Fibres**

A very thin thread like strand from which cloth is made, is called fibre

It is of two types

1. Natural fibres

2. Synthetic fibres

1. Natural fibres- The fibres obtained from plants and animals are called natural fibres

e.g., Cotton, silk, wool, jute, flax

2. Synthetic fibres- The man made fibres produced from chemical substances are called synthetic fibres

e.g., Rayon, Nylon, Polyester, Acrylic, Kevlar

• **Rayon**

It is also called artificial silk

It is the first synthetic fibre

Rayon is obtained by the chemical treatment of wood pulp(which contains cellulose)

• **Nylon**

- Nylon is a polyamide

It is the first fully synthetic fibre

• **Polyster**

Terylene is a popular polyester

• **Acrylic**

- It is often used as substitute for wool

• **Kevlar**

Used in manufacture of bullet proof jackets

• **Plastic**

Plastics are also polymers

Types of plastics

1. Thermoplastic - A plastic which can be softened repeatedly by heating and can be moulded into different shapes again and again, is called a thermoplastic

e.g., Polythene, PVC, Polycarbonates

2. Thermosetting plastics - A plastic which once set, does not become soft on heating and cannot be moulded a second time, is called a thermosetting plastics

e.g., Bakelite and melamine

• **Explosives**

Dynamite-

Dynamite is an explosive made of nitroglycerin. It was invented by the Swedish chemist and engineer Alfred Nobel in Geesthacht, and patented in 1867

Today, dynamite is mainly used in the mining.

T.N.T. (Trinitrotoluene)-

Trinitrotoluene, or 2-methyl-1,3,5-trinitrobenzene, is a chemical compound with the formula $C_6H_2(NO_2)_3CH_3$. It is used as explosive

T.N.P (Trinitrophenol)-

It is also called picric acid

T. N. G. (Trinitroglycerine)-

It is also called Noble Oil

It is used in manufacture of dynamite

R. D. X. (Research and Development Explosive)

Chemical name- Cyclotrimethylenetrinitramine

Chemical formula- C 3H 6 N 6 O 6

It is also called Cyclonite, hexogen and T 4

It was discovered by George Friedrich Henning of Germany.

Natural Resources: The resources which are obtained from nature, are called as natural resources.

Types of Natural Resources:

(i) Inexhaustible Natural Resources

(ii) Exhaustible Natural Resources

1. Inexhaustible natural resources: The resources which are available in large quantities in nature and will not be depleted even after continuous usage are known as Inexhaustible natural resources.

Examples are sunlight, water, wind, etc.

2. Exhaustible Natural Resources: The resources which are available in limited quantities in nature and will get depleted after continuous usage, are known as Exhaustible natural resources.

Examples are forests, coal, natural gas, etc.

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