

CHEMISTRY



Antoine-Laurent de Lavoisier
"Father of Modern Chemistry"

SOME BASIC CONCEPTS

Physical quantities and their measurements in chemistry

- ❑ Measurement is the comparison of a physical quantity (to be measured) with a unit of measurement, that is, with a fixed standard.
- ❑ In 1960, the General Conference of weights and measures (Generale des Poids et mesures, (CGPM) adopted the International system of units. (or SI, after the French Le System Internationale units)
- ❑ This system has seven SI base units (Table 1)
- ❑ In SI, large and small quantities are expressed by using an appropriate prefix (Table 2) with the base units.
- ❑ Derived units: The units of different physical quantities may be derived from the seven basic units (Table 3).

Table 1 **SI Base Units**

Physical quantity	Name of the unit	Symbol
Mass	Kilogram	Kg
Length	metre	m
Time	second	s
Temperature	Kelvin	K
Electric current	Ampere	A
Luminous Intensity	Candela	Cd
Amount of substance	Mole	Mol

Table 2 **SI Prefixes**

Multiple	Prefix	Symbol	Multiple	Prefix	Symbol
10^{24}	Yotta	Y	10^{-1}	deci	<i>d</i>
10^{21}	Zetta	Z	10^{-2}	centi	<i>c</i>
10^{18}	exa	E	10^{-3}	milli	<i>m</i>
10^{15}	peta	P	10^{-6}	micro	μ
10^{12}	tera	T	10^{-9}	nano	<i>n</i>
10^9	giga	G	10^{-12}	pico	<i>p</i>
10^6	mega	M	10^{-15}	femto	<i>f</i>
10^3	kilo	<i>k</i>	10^{-18}	atto	<i>a</i>
10^2	hecto	<i>h</i>	10^{-21}	zepto	<i>z</i>
10	deca	<i>da</i>	10^{-24}	yocto	<i>y</i>

Table 3 **Derived Units**

Quantity	Definition of Quantity	Expression in terms of SI base units
Area	Length squared	m^2
Volume	Length cubed	m^3
Density	Mass per unit volume	kg / m^3 or kgm^{-3}
Velocity	Distance travelled per unit time	m / s or ms^{-1}
Acceleration	Velocity changed per unit time	m / s^2 or ms^{-2}

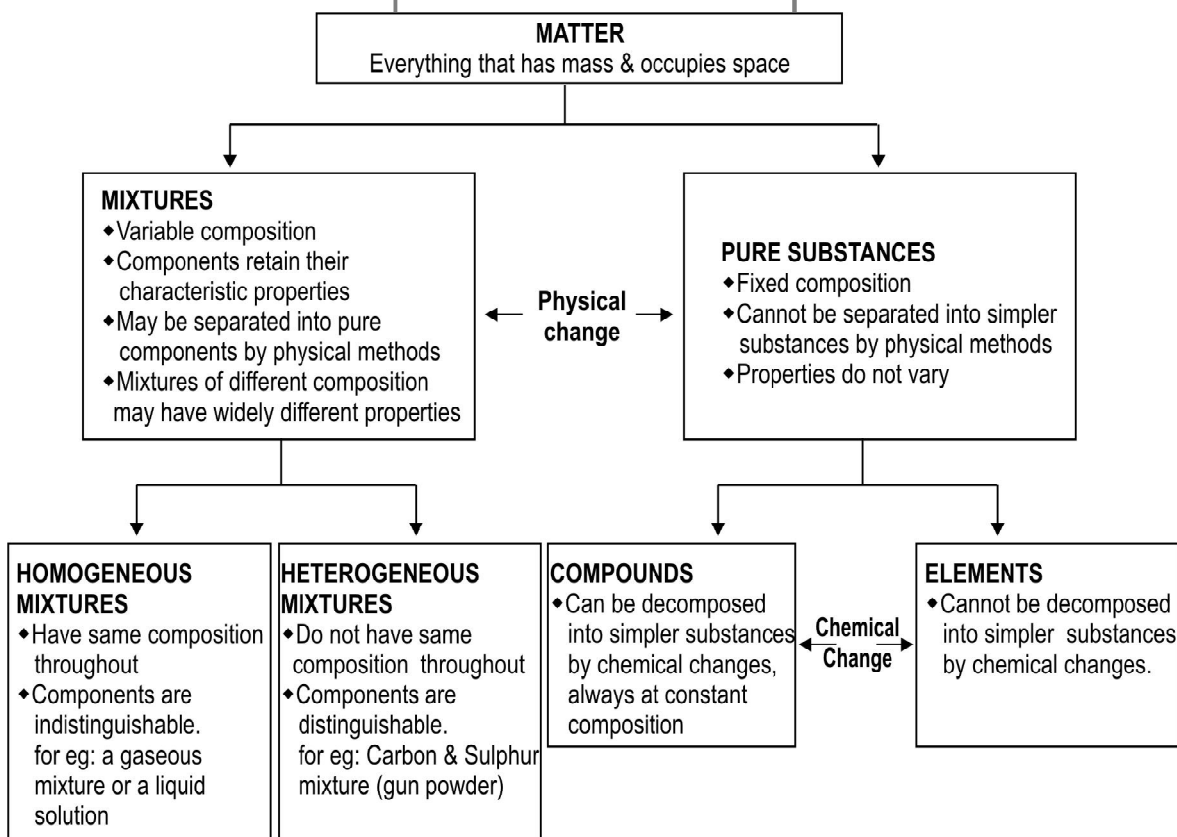
STATES OF MATTER

- ❑ *Matter* is anything that has mass and occupies space.
- ❑ Liquids and gases belongs to fluid state.
- ❑ The gaseous state of a liquid or solid is called *vapour*.
- ❑ States of matter can be ex-

plained in terms of forces operating among, the constituent particles. These forces are called *intermolecular forces*.

- ❑ Matter can classify by its physical state as well as its chemical constitution.

- ❑ With respect to physical state matter exists in three different states - Solid, liquid and gaseous.
- ❑ According to chemical constitution matter can classify as follows:



GENERAL CHARACTERISTICS OF THREE PHYSICAL STATES OF MATTER

❑ **Solid state:**

- 1) Solids are rigid and have definite volume and shape.
- 2) Intermolecular force of attraction are very strong in solids.
- 3) In solids, the constituent particles (atoms, ions or molecules) are completely fixed to their own position.

- 4) In solids, kinetic energy of the particles is very small.
- 5) Solids are almost incompressible.
- 6) Solids diffuse very slowly compared to liquids and gases.

❑ **Liquid State:**

- 1) Liquids have no definite shape

but have definite volume.

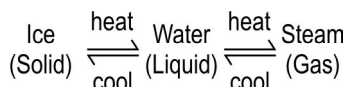
- 2) Liquids are less compressible than gases, but more compressible than solids.
- 3) In a liquid, the particles are neither completely ordered nor completely disordered.
- 4) Liquids diffuse faster than solids.

ids but much slower than gases.

- 5) Kinetic energy of particles in the liquid state will be higher than that in the solid state.

❑ **Gaseous state:**

- 1) Gases have neither definite volume nor definite shape. They take the shape and volume of the container.
 - 2) In gases, the particles are far apart from one another.
 - 3) The intermolecular forces of attraction are very weak.
 - 4) Gases are highly compressible.
 - 5) Gaseous state is the least ordered state.
 - 6) Change of temperature and pressure causes considerable change in volume.
 - 7) Gas molecules possess very high kinetic energy.
- ❑ The state in which matter exists depends upon temperature and pressure.
- ❑ For example water is in the liquid state at room temperature and atmospheric pressure.
- ❑ At 0°C and atmospheric pressure, it exists as a solid (ice).
- ❑ When heated to 100°C at atmospheric pressure, water is converted into a gas (steam)



- ❑ An element consists of only one kind of atoms.
- ❑ Molecules are identifiable units of matter consisting of two or more atoms of the same element or of different elements combined in a definite ratio.

Examples: hydrogen (H₂), oxygen (O₂) etc.

- ❑ In a compound two or more than two different types of atoms are present. Example: Water (H₂O), Carbon di oxide (CO₂), Salt (NaCl) etc.
- ❑ A compound is quite different from a mixture.
- ❑ Elements in a compound lose their individual chemical characteristics.
- ❑ In a mixture, each of the constituents retains its characteristic property.
- ❑ A mixture to a large extent shows the combined behaviour of the substances present in it.

The de-Broglie relation:

- ❑ The French physicist Louis de Broglie in 1924 postulated that “matter, like radiation, should exhibit a dual behaviour”.
- ❑ He proposed the following relationship between the wave length λ of a material particle, its linear momentum P, and Planck constant, h

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

- ❑ The waves associated with particles in motion are called matter waves or de-Broglie waves.

Heisenberg uncertainly principle:

- ❑ It is impossible to determine simultaneously both the position and momentum of an object with certainty.
- ❑ It acquires significance when applied to elementary particles. Mathematically it can be stated

that $\Delta p \cdot \Delta x \geq \frac{h}{4\pi}$ where Δp is the uncertainty in momentum, Δx is the corresponding uncertainty in position and 'h' is Planck's constant.

- ❑ Space lattice: It is a regular repeating arrangement of points in space and forms the basis of classification of all structures.
- ❑ There are five types of two dimensional lattices.
- ❑ They are hexagonal, square, rectangular, rhombic and parallelogram lattices.

Gas Laws:

- ❑ Boyle's law: The pressure of a fixed amount of a gas varies inversely with the volume if the temperature is maintained constant.
- ❑ Mathematically the law represented as

$$P \propto \frac{1}{V} (n, T \text{ constant}) \text{ or } V \propto \frac{1}{P} (n, T \text{ constant})$$

Different types of Solids

Type of solid	Constituent particles	Physical nature	Electrical conductivity
Molecular	Molecules	Soft	Insulator
Metallic	Atoms	Hard	Conductor
Network or Covalent	Atoms	Hard	Insulator
Ionic	Ions	Hard but brittle	Insulator

ie, $P = \text{constant} / v$

or $PV = \text{constant}(n \text{ \& } T \text{ constant})$

- ❑ Charles law: pressure remaining constant the volume of a fixed amount of a gas varies directly with its absolute temperature.

ie, $V \propto T$

or $V/T = \text{constant}(n, p \text{ constant})$

- ❑ Avogadro law: It states that at a given temperature and pressure the volume of a gas is directly proportional to the amount of gas.

ie, $V \propto n(P \text{ and } T \text{ constant})$

or $V = \text{constant} \times n$

Where 'n' is the amount of substance.

- ❑ In a generalised way we can say: All gases containing equal amounts of substance occupy the same volume at the same temperature and pressure

Ideal Gas Equation

Boyles law $V \propto \frac{1}{P} (n, T \text{ constant})$

Charles law $V \propto T (n, P \text{ constant})$

Avogadro's law $V \propto n (P, T \text{ constant})$

Combining the three

$$V \propto \frac{1}{P} \times T \times n$$

$$\text{ie, } V \propto \frac{nT}{P}$$

$$\text{or } V = a \text{ constant} \times \frac{nT}{P}$$

This constant is known as universal gas constant and is denoted as 'R'

$$\text{Then, } V = \frac{R \times n \times T}{P}$$

$$PV = n \times R \times T$$

$$\text{ie, } PV = nRT$$

This equation is called ideal gas equation.

ATOMIC STRUCTURE

- ▶ The term 'atom' was introduced by Ostward, means indivisible.
- ▶ The structure of atom was discovered by **Niels Bohr**
- ▶ The first atomic theory was postulated by **John Dalton** in 1808, a poor English School master.
- ▶ Plum Pudding (water melon) model of atom was suggested by J.J. Thomson.
- ▶ Atoms link together in group called molecules.
- ▶ All substances are made of tiny particles called molecules.
- ▶ A molecule is the smallest particle of a substance that can exist independently.
- ▶ The term molecule was introduced by **Avogadro**.
- ▶ The central part of atom is called nucleus. Protons and neutrons are present in nucleus and electrons are revolving around the nucleus in definite path called orbits.
- ▶ Presence of Protons was observed by Goldstein in 1896 in a discharge tube with a perforated cathode. Experiments carried out by Lord Rutherford showed that positive particles produced in a discharge tube containing hydrogen gas are same as protons.
- ▶ **Mass Number** is the sum of



John Dalton - English chemist. Best known for his contribution in modern atomic theory, and his research into colour blindness.

number of protons and neutrons present in the nucleus of an atom.

- ▶ **Atomic Number** is derived from Nuclear charge of atom, hence it will be the number of protons.
- ▶ Electron is the fundamental particle of matter or nature.
- ▶ Heaviest sub-atomic particle is Neutron
- ▶ Electrons and positrons have same mass and opposite charges.
- ▶ Neutrons and Antineutrons have no charge and no mass.
- ▶ The dual nature of electron was proposed by **Victer de-Broglie**.
- ▶ The dual nature of electrons was experimentally provided by I.H. Germer.
- ▶ The radius of nucleons of an atom varies in the order 10^{-13} cm.
- ▶ Isotopes are the different types of atoms of the same element having same atomic number

Particle	Discoverer	Charge
electron	J.J. Thomson	-ve
proton	Rutherford	+ve
neutron	J. Chadwick	no charge
nucleus	Rutherford	+ve

- ▶ The smallest atom known is Helium.
- ▶ The simplest atom is Hydrogen.
- ▶ The most abundant element in the Universe is Hydrogen (2nd Helium)

and different mass numbers.

- ▶ Isotopes differ in the no. of neutrons.
- ▶ Protium, Deuterium and Tritium are the Isotops of Hydrogen.
- ▶ Protium has no neutron.
- ▶ Deuterium has one neutron.
- ▶ Tritium has two neutrons.
- ▶ Isobars are atoms of different elements having same mass number and different atomic numbers.
Eg: Argon - 40 and Calcium 40
- ▶ **Isotones** : are atoms of different elements having different atomic numbers, and mass numbers, but they should have **same number of neutrons**
eg: ${}^3_1\text{H}$ and ${}^4_2\text{He}$, both contain two neutrons.
- ▶ **Nuclear Isomers** : These are the different types of atoms of the same element having different radioactivity constants.
- ▶ The term 'isotope' was introduced by Soddy.
- ▶ **Allotropes** are different forms of the same element with different physical appearances.
eg: Red phosphorus and white phosphorus oxygen and ozone.
- ▶ The most complex atom available from earth is **Uranium - 238**



The structure of atom was discovered by **Niels Bohr** (Danish physicist).

- ▶ Valency is the combining capacity of one atom to another.
- ▶ Noble gases have zero valency.
- ▶ Hydrogen shows univalency.
- ▶ Sodium and Potassium show univalency.
- ▶ The common valency of carbon is four.
- ▶ Hydrogen produces largest number of compounds (2nd - Carbon)
- ▶ Cathode rays are discovered by **Julius Plucker**.
- ▶ Anode rays are discovered by **Goldstein**.
- ▶ Neutron was discovered by **James Chadwick**.

- ▶ Cathode rays are used in Television.
- ▶ The atomic size is about 10^5 times larger than the nuclear size.
- ▶ Wavelength of violet (VIBGYOR) is $3800\text{\AA} - 4300\text{\AA}$.
- ▶ Wavelength of Red is $6500\text{\AA} - 7600\text{\AA}$
- ▶ The most valid atomic theory was "Wave mechanical model of atom" suggested by **Max Planck**.
- ▶ Spectroscope is an instrument which analyses the wavelength of emitted radiations.
- ▶ The radioactive liquid element is Francium.
- ▶ The radioactive gaseous element is Radon.
- ▶ The atomic number is first calculated by Moseley.
- ▶ The most reactive element - Fluorine

The nucleus

The nucleus is at the centre of the atom and contains the protons and neutrons. Protons and neutrons are collectively known as nucleons.

Atom: The smallest particle of a carbon 12 element

Atomic Mass Unit (amu): One twelfth of a mass of a Carbon-12 atom; a unit used for stating atomic and formula weights

Atomic Number: number of protons in the nucleus; defines the identity of element.

Atomic Orbital: Where electrons are revolving and are the strongest of any place in the atom.

Atomic Radius: Radius of an atom.

Atomic Weight: Weighted average of the masses of an element; The relative masses of atoms of different elements.

Avogadro's Number: The number (6.022×10^{23}) of atoms, molecules or particles found in 1 mole of any compound.

Atom Structure

Atom comprises a nucleus containing protons and neutrons and electrons which revolve around it. The protons are positively charged, electrons are negatively charged. The neutrons have no charge. **Atomic Number** is the number of protons (positively charged mass units) in the nucleus of an atom.

Atomic Number = Number of protons
or
= Number of electrons (for a neutral atom)

Atomic Mass or mass number

Mass Number = Number of protons + number of neutrons
(ie, number of nucleons)

- ▶ The densest element - Osmium
- ▶ The lightest element - Hydrogen
- ▶ The lightest metal - Lithium
- ▶ Actinometer is used to measure the intensity of radiation.

Chemical bonds

- Union of the atoms of two or more elements by mutual attraction is called chemical bond.
- ▶ The bond formed by the transfer of electrons from one atom to another is called ionic bond or electrovalent bond.
 - ▶ In covalent bonds the atoms are linked together by the sharing of electrons between the atoms.
 - ▶ Vander Waals bonds act between molecules which are brought close together. They are the weakest bonds.
 - ▶ The attractive force which binds the hydrogen atom of one molecule with the electronegative atom of another molecule is called hydrogen bond.
 - ▶ In co-ordinate bond the

electrons are shared and the shared pair of electrons are derived from only one atom.

Pauli's Exclusion Principle

This principle states that no two electrons in atom can have the same set of all the four quantum numbers.

Hund's Rule of maximum Multiplicity

This rule states that pairing of electrons in the orbitals of a particular sub-shell does not take place until all the orbitals of the sub shell are singularly occupied. The singly occupied orbitals must have the electrons with parallel spins.

Aufbau principle

According to this principle, electrons are filled in various orbitals in the increasing order of their energies.

- Electrons have negative charge, protons have positive charge and neutrons are chargeless particles.

Octet Rule

For an atom to be stable, there must be 8 electrons in the out-

ermost shell. This rule is called Octet Rule.

Rutherford's Atom Model

In this model, the electrons were assumed to be revolving around the nucleus in well-defined orbits just like the planets move around the sun in fixed orbits in solar system. The orbital revolution is not expected to be stable. To remain in a circular orbit the electron would need to undergo acceleration. Therefore it will radiate energy. The loss in energy would lead to the shrinking of the size of the orbit or it will hit the nucleus. Such an atom cannot expect to be stable.

Properties of Compounds

- ▶ Compound is a pure substance that is composed of two or more elements chemically combined in definite and constant proportions.
- ▶ The separation of a compound into its elements by chemical means is called analysis.
- ▶ The formation of a compound by the union of elements is called synthesis.
- ▶ The common refrigerents are Ammonia and Freon.
- ▶ Non stick kitchen vessels are coated with Teflon.
- ▶ Teflon is chemically Tetra flouroethylene
- ▶ Photographic films are coated with Silver Bromide.
- ▶ Artificial rain is done by using Silver Iodide.

- ▶ Phosphine (PH_3) has the smell of rotten fish.
- ▶ Hydrogen sulphide gas has the smell of rotten egg.
- ▶ Bleaching Powder is chemically calcium chloride hypochlorite (CaOCl_2).
- ▶ Bleaching Powder is a mixed salt.
- ▶ Egg shell, Marble, Limestone etc contain Calcium Carbonate.
- ▶ Coral reefs are made of calcium carbonate.
- ▶ Green house effect is created by Carbondioxide, methane, watervapour etc.
- ▶ Dry ice is solid Carbondioxide.
- ▶ Zinc Phosphide and Arsenic sulphide are used as Rat poison (rodenticide)
- ▶ Laughing gas is Nitrous Oxide.
- ▶ Benzyl chloride is used as tear gas.
- ▶ Sodium peroxide is used as airpurifier in Submarines.
- ▶ Tin Amalgam ($\text{Sn} + \text{Hg}$) is used to coat on mirror.
- ▶ Paper is chemically cellulose.
- ▶ The most abundant carbohydrate (organic compound) present in nature is cellulose.
- ▶ Cellulose is not absorbed by human body, due to the absence of cellulase in body.
- ▶ Rust is chemically hydrated ferric oxide. ($\text{Fe}_2\text{O}_3 \cdot x \cdot \text{H}_2\text{O}$)
- ▶ Freezing mixture contains calcium chloride and sodium chloride.
- ▶ The gas responsible for Bhopal gas tragedy was methyl isocyanate (MIC).
- ▶ Fluorosis is due to the excess intake of Fluoride salts along with drinking water.
- ▶ Fluorosis is first reported in

Properties of Fundamental Particles

Sub - Atomic Particles

1. **Positrons** : Discovered by Anderson, these are positive counterparts of electrons. Highly unstable and combine with electrons producing γ - rays.
2. **Neutrinos and Anti-neutrinos** : Postulated by Fermi, these are particles of zero mass and zero charge.
3. **Pi- mesons (pions) and mu-mesons (muones)** : Postulated by Yukawa, these are particles having a mass intermediate between that of the electron and the proton.
4. **Neutral Mesons (π)** : Postulated by Kemmer to account for the binding forces that of the nucleons (protons + neutrons.)

India in 1938 in Nellore Dist of AP.

- ▶ Copper oxychloride is used as fungicide in pepper plants.
- ▶ Silver iodide is used to make artificial rain
- ▶ Acid rain is caused by the pollution of environment due to nitrogen oxide and sulphur dioxide.
- ▶ Aluminium is used to make CDs.
- ▶ Aluminium and its compounds are amphoteric.
- ▶ Oxides are binary compounds of Oxygen and metals or non metals.
- ▶ Acidic oxides show the properties of Acids. eg: Carbon dioxide, sulphur dioxide, phosphorus pentoxide etc.
- ▶ Basic oxides are generally metallic oxides. eg: Calcium oxide, Sodium peroxide, magnesium oxide, etc.
- ▶ Neutral oxides are neither acidic nor basic. eg: 1. Nitrous oxide (N_2O)
2. Carbon monoxide (CO)
- ▶ Amphoteric oxides are showing both the properties of acids and bases. eg: Aluminium oxide
Zinc oxide, Water

- ▶ Aspirin is called **Wonder Drug**.
- ▶ Aspirin is chemically Acetyl Salicylic Acid.
- ▶ Ordinary Portland Cement (OPC) contains the major component Calcium oxide (Lime)
- ▶ White paints are made by using Titanium dioxide.
- ▶ The whitest compound ever known is Titanium dioxide.
- ▶ Titanium is referred as **wondermetal**. Titanium is used to make Air Crafts.
- ▶ Nitrous oxide is used as an anaesthetic
- ▶ Tranquilizers are chemicals used as medicine for mental disorder.
- ▶ Barbituric Acid and its salts are used as Tranquilizers.
- ▶ Sodium compound used in respiratory equipments and submarine is sodium peroxide.
- ▶ Sweetest sugar is Fructose (present in Fruits).
- ▶ Honey contains Glucose and Fructose
- ▶ Rocket propellant contains fuel and oxidiser.
- ▶ Rocket fuel is liquid Hydrogen. (LHG)
- ▶ Fuel of the future is Hydrogen.

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| <ul style="list-style-type: none"> ▶ Analgesics are the drugs used for relieving pain.
eg: Aspirin ▶ Antipyretics are the chemicals used to bring down body temperature. eg: Paracetamol, Aspirin ▶ Disinfectants: Chemical used to kill micro-organisms. eg: Phenol ▶ Antibiotics: Chemicals extracted from microorganisms (fungi, mold, bacteria) and can be used to destroy some other microorganisms.
eg: Streptomycin, Penicillin, Chloroamphenicol. ▶ Antiseptics : Chemicals that can be applied to living tissues to destroy microorganisms.
eg: Dettol ▶ The element which is used to coat the photocopying drum of Xerox is selenium. ▶ Silicon, Germanium etc used in the manufacture of transistors and IC chips due to their semi conductivity. ▶ Water gas a mixture of Carbon monoxide and Hydrogen is used as Industrial fuel. ▶ Producer gas a mixture of Carbon monoxide and Nitrogen is used as 'Industrial Fuel'. ▶ Coke is the refined form of coal (contains the element carbon) ▶ Bathing salt is sodium carbonate used to reduce the hardness of water. ▶ Baking Powder is mixture of sodiumbicarbonate and Tartaric Acid salt. ❑ Hydrogen sulphide is a gas with the smell of rotten egg. ❑ Coral reefs are made of calcium carbonate. ❑ Impure sodium carbonate obtained in the industrial process is called black ash. | <ul style="list-style-type: none"> ❑ Flint glass contains lead chromate. Lead chromate is used as pigments called chrome yellow. ❑ Rising of dough in the process of manufacture of bread is through the action of carbon dioxide. ❑ The gas responsible for green house effect is carbon dioxide. ❑ Ferromagnetic powder is coated in tape recorders. ❑ Dry ice is solid carbon dioxide. ❑ Carbon dioxide is used in fire extinguishers. ❑ Cryolite is a double fluoride of aluminium and sodium. ❑ Silver halides are used in photographic plates because they are readily reduced by light. | <ul style="list-style-type: none"> ❑ Rat poison is zinc phosphide. ❑ The aluminium compound used in fire extinguishers is alum. ❑ Calcium compound used in freezing mixture is calcium chloride. ❑ The chemical used as a 'fixer' in photography is sodium thiosulphate. ❑ Liquid sodium is employed as a coolant in nuclear reactors. ❑ Diffusion of light in the atmosphere takes place due to water vapour. ❑ Ferrous sulphate crystals are known as 'Green vitriol'. ❑ The main constituents of pearl are calcium carbonate and magnesium carbonate. |
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