GA POWER CAPSULE FOR CHEMISTRY FOR DEFENCE EXAMS 2018-19

ACID, BASE AND SALTS

1. Acid

- An acid is a compound, produce hydrogen ions, H+(aq), in solution, which are responsible for their acidic properties.
- According to Bronsted-Lowry theory, an acid is any species that can donate a proton to another species.
- Hydrogen ions cannot exist alone, but they exist after combining with water molecules.so, on dissolving in water yields hydronium ions (H_3O+) as the only positive ions.
- The presence of hydrogen ions make acids strong and good electrolytes.

Strong Acid:

- Examples of strong acids are: hydrochloric acid,sulphuric acid, nitric acid etc.

Weak Acid:

Examples are: acetic acid, formic acid, carbonic acid etc.

- Acids are generally sour in taste and corrosive.
- Indicators : Test whether a substance is acidic or basic. Eg: Turmeric, litmus, china rose petals (Gudhal), etc., are some of the naturally occurring indicators.
- Litmus is extracted from lichens a plant belonging to the division Thallophyta . It has a purple colour in distilled water. When added to an acidic solution, it turns red and when added to a basic solution, it turns blue.
- The solutions which do not change the colour of either red or blue litmus are known as neutral solutions. These substances are neither acidic nor basic.
- olfactory indicators:There are some substances whose odour changes in acidic or basic media.

Uses of Acids

- (i) Hydrochloric acid present in our stomach helps in the digestion of food.
- (ii) Vitamin C or ascorbic acid gives the needed nutrients for body.
- (iii) Carbonic acid is used in making carbonated beverages and fertilizers.
- (iv) Vinegar a preservative, is a dilute form of acetic acid.
- (v) Sulphuric acid is used in the manufacture of fertilizers, paints, synthetic fibres etc.
- (vi) Nitric acid is used in the preparation of aqua regia, used in the purification of precious metals like gold and silver.
- (vii) Boric acid is used to wash eyes.
- (viii) Phosphoric acid is used in making fertilizers and detergents.
- **Basicity of an acid** is defined as the no of ionizable hydrogen (H+) ions present in one molecule of an **acid**

Acids	Formulae	Basicity
Hydrochloric acid	HCL	1-Monobasic
Nitric acid	HNO_3	1-Monobasic
Carbonic acid	H_2CO_3	2-Dibasic
Sulphuric acid	H_2SO_4	2-Dibasic
Phosphorous acid	H_3PO_3	2-Dibasic
Phosphoric acid	H_3PO_4	3-Tribasic

For the acid containing the carboxylic acid, we do not count the number of hydrogen atoms but the number of carboxyl group (i.e.) -COOH

ACIDS USED IN DAY-TO-DAY LIFE

Acids are obtained from two different sources. They can be organic or mineral acids. All acids have some common characteristic properties.

Sources of the acid	Name of the acid
Vinegar	acetic acid
Citrus fruits	citric acid
Grapes, tamarind, gooseberries.	tartaric acid
Sour milk	lactic acid
Apples	malic acid
Curd	butyric acid
Tea, tomatoes	oxalic acid
Sting of red ants and bees	formic acid
Proteins	amino acids
Guava, oranges	ascorbic acid

Note: The process of dissolving an acid or a base in water is a highly exothermic one. The acid must always be added slowly to water with constant stirring.

2. Bases and Alkalis

- A Base is a substance that gives OH-ions when dissolved in water. Bases are usually metal hydroxides (MOH).
- According to Bronsted-Lowry theory, a base is a proton acceptor.
- Bases are soapy substances with a bitter taste .
- The strength of a base depends on the concentration of the hydroxyl ions when it is dissolved in water.
- Bases soluble in water are called alkalies. All alkalies are bases but all bases are not alkalies.

Strong Base:

Examples:

Sodium hydroxide: NaOH (caustic soda),, Potassium hydroxide: KOH (caustic potash), Calcium hydroxide: $Ca(OH)_2$.

Weak Base:

Examples: Magnesium hydroxide: $Mg(OH)_2$, Ammonium hydroxide: NH_4OH.

SALT

Potash alum(potassium aluminum sulfate $KAl(SO_4)_2$**)**

(i) It is used in dyeing industries to fix the dye to the fabric.

(ii) It is used for cleaning teeth.

USES OF SALTS IN INDUSTRIES:
(i) Sodium chloride is used in the manufacture of chlorine, caustic soda, washing soda and baking soda.
(ii) Ammonium salts are used as fertilizers.
(iii) Potassium nitrate is used in the manufacture of gun powder and fire works.
(iv) Silver bromide is used in photography.
(v) Potassium chlorate is used in the match industry.
(vi) Aluminium sulphate is used in preparing alums.

3. pH SCALE
The p in pH stands for 'potenz' in German, meaning power.

- The scale that measures the strength of an acid or a base is called the pH scale. This value lies between 0 and 14.
- Higher the hydronium ion concentration, lower is the pH value.
- The pH of a neutral solution is 7. Values less than 7 on the pH scale represent an acidic solution. As the pH value increases from 7 to 14, it represents an increase in OH– ion concentration in the solution, that is, increase in the strength of alkali.
- Most food crops grow best at a PH of 7-7.8.If the soil is too acidic then its pH can be raised by adding lime (or slaked lime) which neutralizes the excess acid in the soil.Similarly, if the soil is too alkaline then its pH can be lowered by adding gypsum or some other substance which can neutralize the excess alkali present in the soil.
- The medium in our stomach is highly acidic and has pH around 1.2. Our stomach produces hydrochloric acid which helps in digestion of food. Magnesium hydroxide (Milk of magnesia), a mild base, is an antacid which neutralises the excess acid.
- Tooth decay starts when the pH of the mouth is lower than 5.5.
- Acid Rain- When pH of rain water is less than 5.6, it is called acid rain.
- Gastric juice - 1.2
- Lemon Juice - 2.2
- Pure water - 7.4
- Milk of mgnesia - 10
- Sodium hydroxide solution - 14
- Note - The atmosphere of venus is made up of thick white and yellowish clouds of sulphuric acid.

STRUCTURE OF ATOM

The atomic theory of matter was first proposed by John Dalton.Fundamental particles of an atom are Electron, Proton and Neutron.

1. **Proton(p):** Discovered by E. Goldstein.

- Protons are positively charged.
- The absolute charge on the electron to be + 1.6 × 10–19 C.

2. Electron (e): Discovered by J.J. Thomson when he was studying the properties of cathode ray.

- Irish physicist George Johnstone Stoney **named** this charge '**electron**' in 1891.
- Electrons are negatively charged.
- The absolute charge on the electron to be – 1.6 × 10–19 C.
- e/m_e as: = 1.758820 × 1011 C kg–1
- The charge of an electron was measured by R. Millikan in Oil drop experiment.

3. Neutrons(n) - J. Chadwick

- It has no charge and a mass nearly equal to that of a proton.
- The mass of a neutron is taken as one unit each.

4. Atomic nucleus – Rutherford

- The fast moving alpha (α)-particles (doubly-charged helium ions) were made to fall on a thin gold foil.
- The mass of an atom is the sum of the masses of protons and neutrons present in the nucleus.

5. Valency

- The number of electrons gained, lost or shared so as to make the octet of electrons in the outermost shell, is called valency.
- The atoms of elements, having a completely filled outermost shell show little chemical activity,their valency is zero.
- An outermost-shell, which had eight electrons is said to possess an octet. Atoms would thus react, so as to achieve an octet in the outermost shell.
- The chemical behavior of an atom depend upon the number of electrons orbiting around the nucleus.

6. Atomic Number
The atomic number is defined as the total number of protons present in the nucleus of an atom. It is denoted by "Z".

7. Mass number
The mass number is defined as the sum of the total number of nucleons (protons and neutrons) present in the nucleus of an atom.

8. Isotopes

- Atoms which have the same atomic number but different mass numbers.The chemical properties of isotopes are similar but their physical properties are different.But some isotopes have special properties which find them useful in various fields. Some of them are :
- (i) An isotope of uranium is used as a fuel in nuclear reactors.
- (ii) An isotope of cobalt is used in the treatment of cancer.
- (iii) An isotope of iodine is used in the treatment of goiter

<u>Radioactive isotopes</u>
Arsenic–74 → detect tumors
Sodiun–24 → Blood clot
Iodine–131 → Activity of thyroid gland

Cobalt–60 → Treat of cancer

9. ISOBARS- Atoms of different elements with different atomic numbers, which have the same mass number, are known as isobars.

10. Isotones – atoms having same number of neutrons.

11. Isoelectronics – atoms/molecules/ions containing sae number of electrons.

12. Mass defect - The mass defect is the difference between the rest mass of a nucleus and the sum of the rest masses of its constituent nucleons.

13. Binding Energy

- The binding energy of a nucleus is the energy required to separate a nucleus into its constituent parts.
- For heavier nuclei, energy is released when they break up (fission).
- For lighter nuclei, energy is released when they fuse together (fusion).
- Nuclear particles are held together by a nuclear strong force.A stable nucleus remains forever, but as the ratio of N/Z gets larger, the atoms decay. Elements with Z > 82 are all unstable.
- As the heavier atoms become more unstable, particles and photons are emitted from the nucleus and it is said to be radioactive. All elements with A > 82 are radioactive.

Examples are:

Alpha particles - (2 proton and 2 neutron) least penetrating
beta-minus particles - (electron) penetrating
beta- plus particles - (positron) penetrating
Gamma rays - most penetrating, high electromagnetic radiation.

Half-Life period - The half half-life of an isotope is the time in which one one- half of its unstable nuclei will decay.
$N = N_0(1/2)^n$, Where n is number of half-lives

SOME COMMON ELEMENTS & COMPOUNDS

1. **Carbon:**

The three states of carbon are diamond, amorphous, and graphite.

- Carbon exhibits allotropy and shows maximum catenation.
- Carbon occurs both in free state as diamond, coal etc. and also in the combined form as CO_2.
- Diamond is one of the allotropic forms of carbon and is the purest form of natural carbon. It is the hardest natural substance.
- Graphite is also an allotropic form of carbon, which is very soft and slippery. Graphite are prepared artificially by Acheson process.
- Fullerene (C_{60}) looks like a soccer ball. It contains 20 six membered and 12 five membered rings of carbon atoms.
- Graphene is an allotrope of carbon. It is a strong substance and used as a conducting material for touch screen, LCD and LED

2. Compounds of Carbon

Carbon monoxide (CO)

- Carbon monoxide (CO) combines with haemoglobin to form carboxyhaemoglobin which is not able to absorb oxygen and as a result of this, suffocation takes place (Asphyxia).
- The death of persons in closed rooms with wood, coal or coke fires and in closed bathrooms with gas geyser is due to the formation of carbon monoxide.

Carbon dioxide (CO_2)

- 0.03-0.05 percent in atmosphere.
- Solid CO_2 is known as dry ice. It is used in refrigerators under the name drikold. It is used in transport of perishable food materials as it provides cold as well as the inert atmosphere.

Carbides

They are the compounds of carbon with metals or electronegative elements.

- Destructive distillation of coal gives products like coal gas, gas carbon, coal tar and ammonical liquor.
- Lamp Black is also known as Soot.

3. Nitrogen:

- Nitrogen is a neutral gas and is neither combustible nor a supporter of combustion.
- In air (79% by volume). In combined state, nitrogen is found as nitrates (Chile salt petre—sodium nitrate ($NaNO_3$), Indian salt petre—potassium nitrate (KNO_3)

4. Compounds of Nitrogen

Ammonia

- It is prepared from nitrogen and hydrogen by Haber's process. It has pungent odour.
- Ammonia is used in manufacturing fertilizers and explosives etc.
- Nitrogen fixation involves the fixation of atmospheric nitrogen into nitrate by lightning and by nitrogen fixing bacteria called **Rhizobia.**

Oxygen:

- Oxygen is an important constituent of atmosphere (21% by volume). Supporter of combustion.
- **Liquid oxygen** mixed with freshly divided carbon, is used in place of dynamite in coal mining.
- **Ozone(O_3) -** It protects the life on the earth by not allowing UV rays to reach the Earth.The common refrigerants, chlorofluorocarbons deplete this ozone layer.
- Its bleaching action is due to its oxidizing action.
- Ozone is also used as a germicide and disinfectant, for sterilizing water.

Phosphorus (P):

- It is highly reactive non-metal, so it occurs only in combined state.

- Phosphorus is an essential constituent of bones, teeth, blood and nerve tissues. Bone ash contains about 80% of phosphorus.

Sulphur (S):
- It occurs in free state in volcanic region.
- Rhombic sulphur is the most stable form at ordinary temperature and all other forms gradually change into this form.

Compounds of Sulphur
- **Sulphuric acid** is also known as **oil of vitriol** or **king of chemicals.** It has a great affinity for water and thus it acts as a powerful dehydrating agent. Corrosive action of sulphuric is due to its dehydrating action.
- **Hypo** (Sodium thiosulphate) It is mainly used in photography as a fixing agent. It is used to remove undecomposed silver halide on photographic paper or film.

Halogens:
Halogens are highly reactive elements and therefore, they do not exist in free state but exist only in combined form.
Halogens have highest electron affinity so they act as strong oxidizing agent.
Their oxidizing power decreases from fluorine to iodine.

Chlorine:
Chlorine was first discovered by Scheele (1774)
Chlorine is used as a germicide, disinfectant, oxidizing agent, bleaching agent in paper and textile industry.
Chlorine being an acidic gas turns moist blue litmus paper to red and then bleaches it.

Iodine (I_2)
Chile saltpeter or **caliche** contains iodine as sodium iodate (5-20%).
It turns starch solution blue. Solution of KI/I_2 is used in the treatment of goiter. It is used as an antiseptic as tincture of iodine.

Noble Gases
- Helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe) and radon (Rn) are known as inert gases or noble gases or rare gases.
- These elements have completely filled valence shell.
- It atmosphere, argon is most abundant noble gas but in universe, helium is most abundant gas.
- Natural gas in the most important source of helium.
- The mixture of helium and oxygen is used for artificial breathing of asthama patients.
- 85% helium + 15% hydrogen is used for filling in balloons and airships.
- Mixture of helium and oxygen is used for respiration by sea divers.
- Helium is used as pressuring agent in rockets to expel liquid oxygen and liquid hydrogen.
- Xe is also known as stranger gas and Xe-Kr is used in high intensity photographic flash tubes.
- Radon is used in the preparation of ointment for the treatment of cancer.

Water (H2O):
- Water is called the "Universal Solvent".
- Hardness of water –
  Temporary hardness - Water is said to be temporarily hard when it contains bicarbonates of calcium and magnesium (or hydrogen carbonates). This type of hardness can be easily removed by boiling.
  Permanent hardness - Water is said to be permanently hard when it contains sulphates and chlorides of calcium and magensium.
  This hardness cannot be removed by boiling.
- **Degree of Hardness -** It is defined as the number of parts of $CaCO_3$ or equivalent to various calcium or magnesium salts present in 10^6 parts of water by mass.
- Heavy water is prepared either by prolonged electrolysis or by fractional distillation of ordinary water. Heavy water (D_2O) is colourless, tasteless and odourless liquid. Fission in uranium-235 is brought by slow speed neutron. Heavy water is used for this purpose in nuclear reactors as moderators.

Hydrochloric Acid (HCL):
- Hydrochloric acid is prepared by dissolving hydrogen chloride gas in water.
- It reacts with metals to form their respective chlorides and liberates hydrogen.
- Hydrochloric acid is used in the production of dyes, drugs, paints, photographic chemicals and in the preparation of aqua-regia. Aqua regia is a mixture of nitric acid and hydrochloric acid, optimally in a molar ratio of 1:3. Aqua regia is a yellow-orange fuming liquid because it can dissolve the noble metals gold and platinum

Nitric Acid (HNO_3):
It is manufactured by the Ostwald's Process by the reaction of ammonia and air in presence of platinum as catalyst.
- Nitric acid is colourless in pure form. Commercial nitric acid is yellowish due to the presence of dissolved nitrogen dioxide.
- Nitric acid is a strong monobasic acid. It ionizes in water readily.
- Nitric acid is a strong oxidizing agent. When it undergoes thermal decomposition, it yields nascent oxygen.

BAKING SODA
- Chemically Baking soda is sodium hydrogen carbonate, $NaHCO_3$.
- Baking soda is manufactured by Solvey's process

USES
1. Used for cooking of certain foods.
2. For making baking power (a mixture of sodium hydrogen carbonate and tartaric acid). On heating

during baking, baking soda gives off carbon dioxide. It is this carbon dioxide which raises the dough. The sodium carbonate produced on heating the baking soda gives a bitter taste. Therefore, instead of using the baking soda alone, baking powder is used. The tartaric acid present in it neutralises the sodium carbonate to avoid its bitter taste.

3. In medicines Being a mild and non-corrosive base, baking soda is used in medicines to neutralise the excessive acid in the stomach and provide relief. Mixed with solid edible acids such as citric or tartaric acid, it is used in effervescent drinks to cure indigestion.
4. In soda acid fire extinguishers.

WASHING SODA

- Chemically, washing soda is sodium carbonate decahydrate, $Na_2CO_3.10H_2O$.
- Washing soda is manufacturing by Solvey's process.

USES

1. It is used in the manufacture of caustic soda, glass, soap powders, borex and in paper industry.
2. For removing permanent hardness of water.
3. As a cleansing agent for domestic purpose.

PLASTER OF PARIS

- Plaster of paris, also called POP.
- Chemically, it is $2CaSO_4.H_2O$ or $CaSO_4.1/2H_2O$ (calcium sulphate hemi hydrate)
- Gypsum, ($CaSO_4.H_2O$) is used as the raw material

USES

4. In making casts for manufacture of toys and statues.
5. In hospitals for making plaster casts to hold fractured bones in place while they set. It is also used for making casts in dentistry.
6. For making the surface of walls and ceiling smooth.
7. For making 'chalk' for writing on blackboard.
8. For making fire proof materials.

BLEACHING POWDER

- Bleaching is a process of removing colour from a cloth to make it whiter.
- Chemically, it is calcium oxychloride,$CaOCl_2$.
- It is manufactured by Hasen-Clever Method.

USES

1. For bleaching of cotton, linen and wood pulp.
2. In making wool unshrinkable.
3. Used as disinfactant and germicide for sterilization of water.
4. For the manufacture of chloroform.
5. Used as an oxidizing agent in chemical industry.

CHEMISTRY IN EVERYDAY LIFE

Synthetic Materials

The materials created by man using the natural materials, are known as synthetic materials.

Cement

- It was discovered by an English Mason, Joseph Aspdin in 1824. He called it Portland cement because he thought that it resembled the limestone found in Portland.
- **Approximate Composition of Portland cement**

Calcium oxide (CaO)	60-70%
Silica (SiO_2)	20-25%
Alumina (Al_2O_3)	5-10%
Ferric oxide (Fe_2O_3)	2-3%

- Raw materials are limestone (provides lime), clay (provides alumina and silica), gypsum (reduces the setting time of cement).
- When water is mixed with cement and left as such for sometime, it becomes a hard mass. This is know as setting of cement. It is an exothermic process, therefore cement structures have to be cooled upto 7 days by sprinkling water.
- Mortar is a mixture of cement, sand and water. It is used for plastering walls and binding bricks and stones.
- Concrete is a mixtures of cement, sand, gravel or small pieces of stone and water. It is used for the construction of floors.
- The structure having iron rods embedded in wet concrete, is known as **reinforced concrete**.

Glass ($Na_2O.CaO.6SiO_2$)

- It is a supercooled liquid of silicates.
- Raw material used for the formation of glass are sodium carbonate, calcium carbonate and sand.
- Finely powdered mixture known as **batch**, is mixed with cullet (broken glass pieces) and then fused in a tank furnace at 1673 K. After few hours, molten glass is obtained.
- Molten glass is cooled slowly and uniformly. The process of slow and uniform cooling is known as **Annealing**
- Different addition may produce different coloured glasses.

Substance used	Colour of glass
Cuprous oxide	Red
Cupric oxide	Peacock blue
Potassium dichromate	Green or Greenish yellow
Ferrous oxide	Green
Ferric oxide	Brown
Manganese dioxide	Light pink, in excess black
Cobalt oxide	Blue
Gold chloride	Ruby
Cadmium	Yellow
Carbon	Amber colour

Variety of glass and **Uses**

- **Soft glass** - It is a mixture of sodium or calcium silicates. It is used in making window glass, mirrors and common glass wares etc.

- **Hard glass** - It is a mixture of potassium and calcium silicates. It is more resistant to the action of acids for making hard glass apparatus.
- **Flint glass** - It is mainly a mixture of sodium, potassium and lead silicates. It is used in making bulbs and optical instruments.
- **Pyrex glass** (Borosilicate glass) - It is used in making pharmaceutical containers, lab apparatus and over ware.
- **Quartz glass** (Silica glass) - It is used in the preparation of chemical apparatus and optical instrument.
- **Crookes glass -** It is used for making lenses for spectacles.
- **Photochromatic glass -** On exposure to bright light, photochromatic glass darkens temporarily. So, it is very useful as a Sun shield.
- **Safety glass -** The three layers are joined together by the action of heat and pressure. It does not break easily under impact and is used in auto vehicle wind shield.
- **Optical glass -** It is used for making lenses for microscope, telescope and spectacles.
- **Glass fibres** - used as insulating material in oven, refrigerator etc.
- **Optical fibres -** are extensively used in telecommunication surgical operations etc. Optical fibres can transmit images round corners.
- **Lead crystal glass -** Lead glass has a high refractive index. So, it is used for making expensive glass ware.
- **Etching of glass -** Glass is attacked by hydrofluoric acid (HF), therefore it is used in the etching of glass.

CHEMICALS IN AGRICULTURE

Fertilizers

- Urea is the best fertilizer as it leaves only carbon dioxide after ammonia, has been assimilated by plants.
- It has 46.6% mitrogen and it does not alter the pH of the soil.
- Mixture of $Ca(CN)_2$ and C is known as **nitrolim**. Commerically, calcium nitrate is known as Norvegian salt petre.
- The mixture of nitrogenous, phosphatic and potash fertilizers in suitable amounts, is called **NPK fertilizers.**

Pesticides

Pesticides are the chemicals which are applied to crops, e.g. DDT and **malathion**.

Difethialone

Vitamin K has been suggested and +successfully used, as antidote for pets or humans accidentally or intentionally exposed to anticoagulant poisons.

Chemicals in medicines

Analgesics (Pain relievers)

These reduce pain. Aspirin and paracetamol are non-narcotic analgesics. Aspirin reduces fever, prevents platelet coagulation.

Narcotic analgesics are chiefly used for the relief of post operative pain, cardiac pain and pains of terminal cancer and in child birth.

Polymerization

- Polymers are defined as high molecular mass macromolecules, which consist of repeating structural units derived from the corresponding monomers.
- Polymers occur in nature also. Cotton, for example, is a polymer called cellulose. Cellulose is made up of a large number of glucose units.

On the basis of intermolecular forces Polymers are classified as:

1. Elastomers- rubber, buna-S, buna-N, neoprene etc.
2. Fibres – polyamides (nylon 6, 6), polyesters (Terylene), etc.
3. Thermoplastic polymers - Such plastic which gets deformed easily on heating and can be bent easily are known as thermoplastics. Polythene and PVC, Polythene, Polystyrene, Polyvinyls, etc.
4. Thermosetting Polymers - some plastics which when moulded once, can not be softened by heating. These are called thermosetting plastics.eg: bakelite, melamine etc.

Few important polymers are:

(a)Polythene

(i)Low density polythene-polymerisation of ethene under high pressure in the presence of traces of dioxygen or a peroxide initiator (catalyst).

(ii)High density Polythene - polymerisation of ethene in the presence of a catalyst such as triethylaluminium and titanium tetrachloride (Ziegler-Natta catalyst).

(b)Polytetrafluoroethene (Teflon)- Teflon is manufactured by heating tetrafluoroethene with a free radical or persulphate catalyst at high pressures.

(c)Polyacrylonitrile - polymer of acrylonitrile in presence of a peroxide catalyst.

Condensation Polymerisation

(a)Polyamides - possess amide linkages

(i) Nylon 6, 6 - prepared by the condensation polymerization of hexamethylenediamine with adipic acid under high pressure and at high temperature

ii) Nylon 6 - obtained by heating caprolactum with water at a high temperature.

(b)Polyesters - polycondensation products of dicarboxylic acids and diols. Polyester is another synthetic fibre. Fabric made from this fibre does not get wrinkled easily. It remains crisp and is easy to wash. So, it is quite suitable for making dress material.

Eg: Terylene is the best known example of polyesters. It is prepared by ethylene glycol and terephthalic acid.It can be drawn into very fine fibres that can be woven like any other yarn.

(c)Phenol - formaldehyde polymer (Bakelite and related polymers)
Prepared by the condensation reaction of phenol with formaldehyde in the presence of either an acid or a base catalyst.
The initial product could be a linear product – Novolac used in paints. Novolac on heating with formaldehyde undergoes cross linking to form an infusible solid mass called bakelite. It is used for making combs, phonograph records, electrical switches and handles of various utensils.

Eg. Melamine – Melamine formaldehyde polymer is formed by the condensation polymerisation of melamine and formaldehyde. Melamine is a versatile material. It resists fire and can tolerate heat better than other plastics. It is used for making floor tiles, kitchenware and fabrics which resist fire. It is used in the manufacture of unbreakable crockery.

Copolymerisation.

Natural rubber - Natural rubber may be considered as a linear polymer of isoprene (2-methyl-1, 3-butadiene) and is also called as cis - 1, 4 - polyisoprene.

Vulcanisation of rubber-This process consists of heating a mixture of raw rubber with sulphur and an appropriate additive at a temperature range between 373 K to 415 K so that rubber gets stiffened.

Synthetic Rubbers -
(i) Neoprene - by the free radical polymerisation of chloroprene.
Rayon - rayon or artificial silk. Although rayon is obtained from a natural source, wood pulp, yet it is a man-made fibre.
Nylon - Nylon is also used for making parachutes and ropes for rock climbing. A nylon thread is actually stronger than a steel wire.

CLASSIFICATION OF ELEMENTS

Mendeleef's Periodic Table (1869)
States that,"the physical and chemical properties of elements are the periodic function of their atomic masses."

Modern Periodic Law
"The physical and chemical properties of the elements are periodic function of their atomic numbers."

Long Form of Periodic Table
Long form of periodic table or Bohr's table is based on **Bohr-Burry concept** of electronic configuration. It contains 7 periods (horizontal rows) and 18 groups.

Periodic Properties
The properties which are repeated at regular intervals are known as periodic properties, i.e. periodic properties show a regular order along a group and period. Some important periodic properties are

Ionisation enthalpy
It is the minimum energy required to remove an electron from an isolated gaseous atom of an element to form a positive ion.

Electron gain enthalpy
It is the energy released by an element when an extra electron is added to its neutral gaseous atom.

Electronegativity
It is the ability of an atom to attract the shared pair of electrons towards it.

Metallic character
It is the tendency of an element to form cation by the loss of electrons.

CHEMICAL REACTIONS AND EQUATION

Physical Change
- The change that only affect physical properties, but the chemical compositions remains unchanged, are called **physical change**.
- These can be reversed by changing the conditions of temperature and pressure, boiling, cutting of trees, dissolving common salt in water burning of wax.

Chemical Change
- The change which affect the composition as well as chemical properties of matter and result in the formation of a new substance is called a chemical change.
- Chemical changes are generally irreversible. Some examples of chemical changes are burning of candle (gases), photosynthesis, ripening of fruits, electrolysis of water.
- A chemical reaction involves bond breaking or bond formation between any two atoms to produce new substances.

Types of Chemical Reactions

Exothermic and Endothermic Reactions
Reactions in which heat is released along with the formation of products, are called **exothermic reactions**. Burning of fuel is an example of exothermic reaction.
Reactions in which heat is absorbed, are known as **endothermic reactions.**

Oxidation and Reduction
- Oxidation is removal of electrons.
- Reduction is the addition of electrons.
- Oxidation means
  (a) addition of oxygen

(b) removal of hydrogen.
- Reductions means
  (a) Removal of oxygen.
  (b) Addition of hydrogen.
- The substance that causes oxidation is called the oxidizing agent.
- The substance that causes reduction is called the reducing agent.

Oxidising agent
1. Acceptors of electrons.
2. It is a substance which removes the electron from an atom.
3. It brings about oxidation.

Reducing agent
1. Donors of electrons.
2. It is a substance which adds electrons to an atom.
3. It brings about reduction.

REDOX REACTION
A reaction which involves oxidation and reduction occurring simultaneously together are called redox reaction. Photosynthesis in plants digestion of food in animals; dry and wet batteries and corrosion of metals are diverse examples of oxidation and reduction reactions.

Electrolysis
- Electrolysis is carried out in an electrolytic cell.
- A simple electrolytic cell consists of two copper strips dipping in an aqueous solution of copper sulphate.
- On applying DC voltage to the two electrodes, copper metal is deposited on cathode and copper is dissolved at anode.
- Used In the purification of impure metals.
- In the extraction of metals
- The blocks used in typing industries are prepared by electrolysis.
- Steel is coated with zinc metal during the process of galvanization.

Batteries
These convert chemical energy into electrical energy. Mainly two types of batteries are used, i.e. primary and secondary.

Primary Batteries
In the primary batteries, reaction occurs only once and after a period of time battery becomes dead.

Dry Cell or Leclanche Cell
It consists of a zinc container that acts as anode and the cathode is a carbon (graphite) rod surrounded by powdered manganese dioxide and carbon.
A moist paste of ammonium chloride (NH_4CI) and zinc chloride ($ZnCI_2$) is used as an electrolyte. Dry cell is commonly used in our transistors and clocks.

Mercury Cell
It is commonly used in low current devices such as hearing aids, watches etc.
The electrolyte is a past of potassium hydroxide (KOH) and zinc oxide (ZnO).

Secondary Batteries

Lead Storage Battery
It consists of a lead as anode and a grid of lead packed with lead dioxide (PbO_2) as cathode.
A 38% solution of sulphuric acid is used as an electrolyte. On charging the battery, the reaction is reversed and lead sulphate gives lead on anode and cathode is converted into lead dioxide respectively.

Nickel Cadmium Cell
It has longer life that the lead storage cell. It consists of a cadmium as anode and nickel dioxide as cathode. The electrolyte is a potassium hydroxide (KOH) solution.

Fuel Cells
Fuel cells convert energy from the combustion of fuels such as hydrogen, carbon monoxide, methane directly into electrical energy
A fuel cell with hydrogen and oxygen has been used for electric power in Apollo Space Programme.

Corrosion
- When iron is exposed to moist air for a long period of time, its surface acquires a coating of brown flaky substance called **rust**.
- Rust is mainly hydrated iron (III) oxide ($Fe_2O_3.xH_2O$).
- In corrosion, a metal is oxidized by the loss of electrons to oxygen and form oxide.
- The rusting of iron can be prevented by painting, oiling and greasing, galvanizing (by coating iron objects with zinc), chrome plating etc.

Catalysis
- A catalyst is a substance which alter the rate of reaction.
- The catalyst itself does not alter during the reaction.
- The phenomena in which the rate of reaction is altered by the presence of a substance (**catalyst**) is known as catalysis.
- Catalysts are specific in their action.
- A catalyst does not change the equilibrium state of a reversible reaction, only brings it quickly.
- The main function of a catalyst in a reaction is to decrease the activation energy.

Applications of Catalysts in Industrial Processes
- Haber process for ammonia—Iron is used as a catalyst and molybdenum is used as a promoter of catalyst iron.
- Contact process for sulphuric acid—Vanadium pentoxide is used as a catalyst.
- Ostwald process for nitric acid—Platinum gauze is used as a catalyst.
- Deacon process for chlorine—Cupric chloride is used as a catalyst.

- Synthesis of petrol—Nickel, iron, cobalt and alumina is used as a catalyst.

Enzyme Catalysis

The increase in the rate of reaction by the enzymes is known as enzyme catalysis. They are biocatalysts, all are proteins in nature.

The rates of enzymatic reactions are very much affected by pH change.

Some important enzyme catalysis reactions are as follows

- Starch $\xrightarrow[H_2O]{\text{Diastase}}$ Maltose
- Maltose $\xrightarrow[H_2O]{\text{Maltase}}$ Glucose
- Glucose $\xrightarrow{\text{Zymase}}$ Ethyl alcohol
- Sucrose $\xrightarrow{\text{Invertase}}$ Glucose + Fructose
- Urea $\xrightarrow[H_2O]{\text{Urease}}$ Ammonia + Carbon dioxide

MATTER AND ITS NATURE

- Matter can exist in three states-
  I. Solid
  II. Liquid
  III. Gas.
- The forces of attraction between the particles(inter-molecular force) are maximum in solids, intermediate in liquids and minimum in gases. The spaces in between the constituent particles and kinetic energy of the particles are minimum in the case of solids, intermediate in liquids and maximum in gases.
- The states of matter are inter-convertible. The state of matter can be changed by changing temperature or pressure.
- The process of melting, that is, change of solid state into liquid state is also known as fusion.
- Evaporation is a surface phenomenon. Particles from the surface gain enough energy to overcome the forces of attraction present in the liquid and change into the vapour state. The rate of evaporation depends upon the surface area exposed to the atmosphere, the temperature, the humidity and the wind speed. Evaporation causes cooling.
- Burning of coal, wood or leaves is a chemical change. Explosion of a firework is a chemical change. If you leave a piece of iron in the open for some time, it acquires a film of brownish substance. This substance is called rust and the process is called rusting. The process of rusting can be represented by the following equation: Iron (Fe) + Oxygen (O_2, from the air)water (H_2O) rust (iron oxide-Fe_2O_3) For rusting, the presence of both oxygen and water (or water vapour) is essential. It is a chemical change.
- Prevent iron articles from coming in contact with oxygen, or water, or both. One simple way is to apply a coat of paint or grease. Another way is to deposit a layer of a metal like chromium or zinc on iron. This process of depositing a layer of zinc on iron is called galvanisation.
- Stainless steel is made by mixing iron with carbon and metals like chromium, nickel and manganese. It does not rust.

Solution

- A solution is a homogeneous mixture of two or more substances. The major component of a solution is called the solvent, and the minor, the solute. Lemonade, soda water etc. are all examples of solutions. We can also have solid solutions (alloys) and gaseous solutions (air).
- The solute particles cannot be separated from the mixture by the process of filtration. The solute particles do not settle down when left undisturbed, that is, a solution is stable.
- The concentration of a solution is the amount of solute present per unit volume or per unit mass of the solution/solvent. A suspension is a heterogeneous mixture.
- Colloids are heterogeneous mixtures in which the particle size is too small to be seen with the naked eye, but is big enough to scatter light.
- The particles are called the dispersed phase and the medium in which they are distributed is called the dispersion medium.

Metals & Nonmetals

- Metals are generally **good conductors of heat and electricity**.
- Silver is the best conductor of heat followed by copper.
- Mercury offers a very high resistance to the passage of electric current.
- Metals are generally **hard** but sodium and potassium are so **soft** that they can be easily cut with a knife.
- Metals are malleable and ductile. Gold and silver are most malleable and best ductile metals.
- Metals are solids at room temperature except mercury (mp – 39°C) which is liquid, caesium (mp 28.4°C) and gallium (mp 29.8°C) are liquid above 30°C.
- Metals are electropositive in nature, they ionize by the loss of electrons and form positive ions.
- Almost all the metal oxides are basic in nature but zinc oxide and aluminium oxide are amphoteric.
- Lithium, sodium, potassium, rubidium and caesium are alkali metals. Alkali metals are stored under kerosene or liquid paraffins to protect them from action of air.
- Metallic sodium is prepared by the electrolysis of molten mixture of 40% sodium chloride and 60% calcium chloride in a **Down's cell**.
- **Sodium bicarbonate**($NaHCO_3$), baking soda is used in effervescent drinks and fruit salts in fire extinguishers and it is also used in the form of sesquicarbonate. It is used for wool washing.
- **Sodium carbonate** ($Na_2CO_3.10H_2O$) washing soda is used in the manufacturing of glass, soap, washing powder and for softening hard water.
- Mixture of sodium carbonate and potassium carbonate is known as **fusion mixture**.

- **Sodium sulphate** ($Na_2SO_4.10H_2O$) is Glauber's salt. It is used as purgative.
- **Sodium thiosulphate** ($Na_2S_2O_3.5H_2O$) or **Hypo** It is used in the photography as a fixing agent.
- **Potassium superoxide** (KO_2) used in space capsules, submarines and breathing masks as it produces oxygen and removes carbon dioxide and carbon monoxide.
- **Potassium** cyanide (KCN) is used in the extraction of silver, gold and as a germicide in agriculture. KCN is more poisonous than sodium cyanide.
- Potassium hydroxide (KOH) is known as caustic potash used in the preparation of soft soap. Its aqueous solution is known as **potash lye.**
- **Potassium carbonate** (K_2CO_3) is potash or pearl ash.

De-icing of Roads after snowfall
De-icing in the process of removing ice from a surface by using salts on the surface. Now-a-days, liquid $CaCI_2$ and $MgCI_2$ are also used for this purpose.

Alkaline Earth Metals and their Compounds
Beryllium, magnesium, calcium, strontium, barium and radium are collectively known as alkaline earth metals. Be $(OH)_2$ is amphoteric in nature. Mg $(OH)_2$ is called **milk of magnesia** and used as an **antacid.**

Calcium oxide (CaO) is also called **quick lime**. It is used in the manufacturing of glass, calcium chloride, cement, bleaching power, calcium carbide, slaked lime, in the extraction of iron and as a drying agent for ammonia and alcohol.

Calcium hydroxide, slaked lime [$Ca(OH_2)$] is used in the manufacturing of caustic soda, sodalime and for softening of hard water.

Calcium sulphate, gypsum ($CaSO_4.2H_2O$) loses a part of its water of crystallization when heated upto 120°C to from $[CaSO_4]_2.H_2O$ which is known as **plaster of Paris**.

Plaster of Paris is a white powder, which sets into hard mass on wetting with water and it is used in making statues, toys, etc., in medical applications of setting fractured bones in right positions and indentistry.

Some Important Metals and their Uses

Boron (B)
It is a semimetal (metalloids). In the nature, it occurs in combined state as borax.
Boron and boron carbide rods are used to control the nuclear reactions.
Boron carbide (B_4C) is hardest, known as an artificial substance after diamond and is known as **Norbia.**
Orthoboric acid (H_3BO_3) is used as an antiseptic and eye wash under the name boric lotion.

Aluminium (Al)
It is a third most abundant element of Earth's crust. It is extracted from bauxite ($AI_2O_3.2H_2O$). Aluminium powder is used in fireworks, flash light powder, thermite welding.

Ammonal (a mixture of aluminium powder and ammonium nitrate) is used as an explosive.
Ruby and sapphire are essentially AI_2O_3. Ruby is red due to the presence of Cr and sapphire is blue due to Fe and Ti. Emerald is green, it contains Ca/Cr and aluminium silicates (AI_2SiO_3).

Tin (Sn)
The important ore of tin is cassiterite (SnO_2) or tin stone. In cold countries, white tin is converted to grey tin (powder), the process is known as **tin disease** or **tin plague.** Tin plating is done to prevent the rusting of iron. Tin amalgam is used in making mirrors. Pentahydrate of stannic chloride ($SnCI_4.5H_2O$), is called butter of tin used as mordant in dyeing.

Lead (Pb)
Lead is mainly found in the form of sulphide ore called **galena** (PbS). Red lead (minium or sindhur) is Pb_3O_4 used for making protective paint for iron and in match industry.

Zirconium (Zr)
It is used for making core of nuclear reactors and for making pumps, valves and heat exchangers.

Vanadium (V)
Vanadium pentoxide (V_2O_5) is a very good catalyst for manufacturing of sulphuric acid by contact process.

Tungsten
Tungsten filaments are used in electric bulbs. Calcium tungstate is used in X-ray tube.

Iron (Fe)
It is extracted from its haematite ore.

Cast iron It is the most impure form of iron and contains 2.5–4% carbon.

Wrought iron or **Malleable iron** is the most purest form of iron and contains minimum amount of carbon (0.12–0.5%)
Iron (II) is present in haemoglobin (blood).

Mild steel contain 0.25%–0.5% carbon while hard steels contains 0.5%–1.5% carbon. Soft steels contain carbon upto 0.25%.

Stainless steel is an alloy of iron (Fe), chromium (Cr) and nickel (Ni). Ferric chloride ($FeCI_3$) is used as stypic to stop bleeding from a cut. Ferrous sulphate ($FeSO_4$) is used in making blue black ink.

Copper, Silver and Gold (Cu, Ag and Au)
These are called coinage metals. Silver is used as amalgam for filling teeth and in silvering mirrors. Silver bromide (AgBr) is used in photography. $AgNO_3$ is called **lunar caustic** used in preparing marking inks and hair dyes.
$CuSO_4.5H_2O$ is called **blue vitriol** or **nila thotha** and $CuFeS_2$ is called fool's gold.

Mercury (Hg)
Mercuric sulphide (HgS) is used as a cosmetic in Ayurvedic medicine as Makardhwaja.

Zinc (Zn)
It is used in galvanization to prevent rusting of iron. Zinc sulphide is used in the preparation of X-ray screens.
Zinc oxide is known as **philosopher's wool**. Zinc sulphate ($ZnSO_4.7H_2O$) is white vitriol.

Metallurgy
The process of extraction of metals from their ores is called metallurgy.

Minerals, Ores and Gangue
The natural substance in which metals and other impurities found in combined state, are called minerals.
The minerals from which metal can be extracted conveniently and beneficially, are called ores. **Gangue or matrix** are the impurities associated with the ore.

Metal	Ores	Chemical composition
Sodium	Rock salt Chile salt petre Borax	NaCI $NaNO_3$ $Na_2B_4O_7.10H_2O$
Potassium	Carnallita Sylvine	KCI. $MgCI_2.6H_2O$ KCI
Magnesium	Carnallite Magnesite Asbestos	KCI.$MgCI_2.6H_2O$ $MgCO_3$ $CaSiO_3.3MgSiO_3$
Calcium	Lima stone Gypsum Fluorspar	$CaCO_3$ $CaSO_4.2H_2O$ CaF_2
Aluminium	Bauxite Cryolite Feldspar	$AI_2O_3.2H_2O$ Na_3AIF_6 $KAISi_3O_8$
Manganese	Pyrolusite Manganite Manganese blende	MnO_2 $Mn_2O_3.H_2O$ MnS
Iron	Haematite Magnetite Iron pyrites Siderite	Fe_2O_3 Fe_3O_4 FeS_2 $FeCO_3$
Copper	Copper glance Copper pyrites Malachite Azurite	Cu_2S $CuFeS_2$ $Cu(OH)_2.CuCO_3$ $2CuCO_3.Cu(OH)_2$
Silver	Silver glance Horn silver Ruby Silver	Ag_2S AgCI $Ag_2S.Sb_2S_3$
Gold	Calverite Sylvanite	$AuTe_2$ $AuAgTe_4$
Zinc	Zinc blende Calamine Zincite Franklinite	ZnS $ZnCO_3$ ZnO $ZnO.Fe_2O_3$
Mercury	Cinnabar	HgS
Tin	Cassiterite	SnO_2
Lead	Galena Cerrusite Anglesite	PbS $PbCO_3$ $PbSO_4$

Some Important Alloys and their Uses

Non-Metals
These may be solid, liquid or gas (bromine is the only liquid non-metal).
These are soft, non-lustrous, brittle, non-sonorous and non-conductor of heat and electricity. These have low melting and boiling points. These from oxides with oxygen which are generally acidic. Their examples include noble gases, i.e. helium (He), neon (Ne), argon (Ar), krpton (Kr), xenon (Xe) and some other p-block elements like chlorine (CI_2), bromine (Br_2) and phosphorus (P) etc.

Alloys are homogeneous mixtures of metals and cannot be separated into their components by physical methods.
Pure metals have poor mechanical properties. Hence, they are not used in their pure form in industry. Their properties are modified by adding other elements.

Characteristics of alloys:
Alloys are harder and tougher than the base metal and are resistant to corrosion.
They are inert to commonly used chemicals and are magnetisable and ductile.
Alloy is considered as a mixture because it shows the properties of its constituents and can have variable composition.

Amalgams:
Alloys of mercury with other metals like sodium, potassium,gold and zinc...etc are called amalgams.
Amalgams stored in iron bottles as iron cannot form amalgam with mercury.

Rold Gold is a metal, such as brass, coated with a thin layer of gold, usually of above 9 carat purity.

Brass
Composition- zinc 30%, copper 70%
uses- In making of utensils, pipes and radiator statues etc.

Yellow Brass
composition - Cu 67%, Zn 33%
uses - Hardware items

Bronze
Composition - Copper 90%, Tin 10%

uses - In making of coins, ornaments, utensils and statues.

Stainless steel
composition - Fe 82%,(Ni + Cr) 18
uses - In making of surgical instruments, watches and utensils etc.

Magnalium
composition- Al 95% ,Mg 5%
uses - In making light articles and physical balance etc.

Duralumin
composition- Al 95%, Cu 4% ,Mn 0.5%
uses -In making parts of aeroplane and ship etc.

Alnico
composition - Al 8-12% , Ni 15-26% , Co 5-24% ,Cu 6%
Remaining: Fe, Tl
uses - It is useful in making of magnets.

German silver
composition - Cu 60% ,Zn 20%, Ni 20%
uses - It is useful in electroplating and making of utensils.

sterling Silver
composition - silver 92.5%, copper 7.5%
uses - jewelry, art object

Gun metal
composition - Cu 88%, Sn 10%,Zn 2%
uses - It is useful in making of guns, machine parts and canons.etc

Solder metal
composition - Pb 50%, Sn 50%
uses - It is mainly useful to join electric wires.

Bell Metal-
composition - copper - 77%, tin - 23%
uses- casting of bells

coin metal -
composition - copper 75%, nickel 25%
uses - U.S coins

wood's metal
composition - Bi 50%, Pb 25%, Sn 12.5%, Cd 12.5%
uses - fuse plugs, automatic sprinklers.

Monel
composition - Ni 67%,and copper, with small amounts of iron, manganese, carbon, and silicon.
uses - It is resistant to corrosion and acids and thus used for making valves, pumps, shafts, fittings, fasteners, and heat exchangers.
Plumber's solder
composition - Pb 67%, sn 33%
uses- soldering joints.

CHEMICAL BONDING

Chemical Bonding
Constituents (atoms, molecules or ions) of different elements except noble gases, do not have complete octet so they combine with other constituent atoms by chemical bonds to achieve complete (stable) octet. The process of their combination is called chemical bonding. Chemical bonding depends upon the valency of atoms.

Types of Chemical Bond
They are divided in the following types depending upon the mode electron transferred or shared electrons or forces of attraction
- Electrovalent or ionic bond
- Covalent bond
- Coordinate or dative covalent bond
- Hydrogen bond
- van der Waals' forces

Electrovalent Bond
The bond formed by the transfer of electrons from one atom to another is called electrovalent bond and the compound is called **electrovalent compound** or **ionic compound**. These bonds are formed between metals and non-metals.
These conduct electricity when dissolved in water and also soluble in water. These are insoluble in organic solvents like alcohol etc.

Some Electrovalent Compounds (Ionic Compounds)

Name	Formula	Ions present
Aluminium oxide (Alumina)	AI_2O_3	AI^{3+} and O^{2-}
Ammonium chloride	NH_4CI	NH_4^+ and CI^-
Calcium chloride	$CaCI_2$	Ca^{2+} and CI^-

Covalent Bond
The bond is formed by the sharing of electrons between two atoms of same (or different) elements, is called covalent bond.
Covalent bond may be single, double or triple depends upon the number of sharing pairs of electrons.
Covalent compounds are usually liquids or gases having low melting point and boiling point. These do not conduct electricity and are insoluble in water but dissolve in organic solvent.

Some Covalent Compounds

Name	Formula	Element's part
Alcohol (Ethanol)	C_2H_5OH	C, H and O
Ammonia	NH_3	N and H
Acetylene (Ethyne)	C_2H_2	C and H

Coordinate or Dative Bond
The bond is formed by one sided sharing of one pair of electrons between two atoms. The necessary condition for the formation of coordinate bond is that octet of one atom should be complete, having atleast one lone pair of electrons and other atom should have a deficiency of atleast one pair of electrons.

The atom having complete octet which provides the electron pair for sharing, is known as **donor**. The other atom which accept the electron pair, is called the **acceptor**.

Bonding between A and B is predominantly
– Ionic if there is large difference in electronegativity.
– Covalent if both A and B have approximately same value of electronegativity.
– Coordinate if lone pair on A (or B) is donated to electron deficient B (or A).

Compounds Containing Ionic and Covalent Bonds

Name	Formula
Potassium cyanide	KCN
Sodium hydroxide	NaOH
Calcium carbonate	$CaCO_3$

Compounds Containing Covalent and Coordinate Bonds

Name	Formula
Carbon monoxide	CO
Ozone	O_3
Dinitrogen oxide	N_2O
Dinitrogen trioxide	N_2O_3
Nitric acid	HNO_3

Compounds Containing Electrovalent, Covalent and Coordinate Bonds

Name	Formula
Ammonium chloride	NH_4Cl
Ammonium bromide	NH_4Br

Hydrogen Bond
The electrostatic force of attraction between hydrogen atom (which is covalently bonded to a highly electronegative atom) and any other electronegative atom which is present in the same or different molecules, is known as hydrogen bond.
It is maximum in the solid state and minimum in the gaseous state.

- **Intermolecular H-bonding** (e.g. HF, water (H_20) molecule) It occurs between different molecules of a compound and results in increasing solubility in water and high boiling point.
- **Intramolecular H-bonding** (e.g. o -nitrophenol) It occurs within different parts of a same molecule and results in decreasing solubility in water and low boiling point.
- Molecules having O—H, N—H or H—F bond show abnormal properties due to H-bond formation. For example
- Glycerol is viscous and has very high boiling point due to the presence of intermolecular H-bonding.
- H-bonding also plays an important role in biological system and stability of proteins and nucleic acids.

van der Waals' Forces
The ability of geckos (lizard) which can hang on a glass surface using only one toe to climb on sheer surfaces had been attributed to the van der Waals' forces between these surfaces and their foot-pads.

ATMOSPHERIC POLLUTION

Atmospheric pollution
The substance which causes pollution is known as pollutant. Pollutants are of two types
— **Primary pollutants** persist in the environment in the form, they are produced, e.g. sulphur dioxide (SO_2), nitrogen dioxide (NO_2) etc.
— **Secondary pollutants** are the products of reaction of primary pollutants, e.g. peroxyacetye nitrate (PAN), ozone (O_3), aldehyde etc.

Major Gaseous Air Pollutants
Major gaseous air pollutants are oxides of sulphur, nitrogen, carbon and hydrocarbons.

Sulphur dioxide (SO_2)
It is highly toxic for both animals and plants, bronchitis, asthma, emphysema. It also causes eye and throat irritation and breathlessness.
Sulphur dioxide reduces the rate of formation of chloroplast and thus, causes chlorosis. SO_2 is highly corrosive and damage buildings, marbles (Taj Mahal) and textiles.
SO_2 is oxidized to SO_3 which reacts with water to give H_2SO_4. H_2SO_4 remains suspended in the air as droplets or come down in the form of acid rain.

Oxides of nitrogen
Among the oxides of nitrogen, nitric oxide (NO), a colourless, odourless gas and nitrogen dioxide (NO_2), a brown gas with pungent odour act as tropospheric pollutants.
NO_2 is highly toxic for living tissues causes leaf fall. It is a corrosive oxide and helps in the formation of smog.
In the presence of oxygen, NO_2 reacts with water or moisture and produces nitric acid (HNO_3) which is an important factor for making acid rain.

Carbon monoxide (CO)
From more stable carboxyhaemoglobin complex with haemoglobin due to which the delivery of oxygen to the organs and tissues is blocked.

Hydrocarbons
Out of the hydrocarbons, methane (CH_4) is the most abundant hydrocarbon pollutant. Higher concentrations of hydrocarbons given carcinogenic effect, i.e. are cancer producing. They cause ageing of plants, breakdown of plant tissues and shedding of leaves.

Consequences of Atmospheric Pollution
Green house gases such as carbon dioxide, methane and water vapours trap the heat radiated from Earth. This leads to an increase in Earth's temperature. This heating up of Earth and its objects due to the trapping of infrared radiation by green house gases in the atmosphere, is called **green house effect.**

Green house effect is very essential for the existence of life because in its absence, Earth would be converted into extremely cold planet. When concentration of green house gases increases, green house effect also increases. This is known as **global warming.**

Acid rain

It is caused by the presence of oxides of nitrogen and sulphur in the air. These oxides dissolve in rain water and from nitric acid and sulphuric acid respectively. The rain carrying acids, is called acid rain.

Particulates

Diseases caused by particulate

Diseases	Cause
Pneumoconiosis	Due to inhalation of coal dust
Silicosis	Due to inhalation of free silica (SiO_2)
Black lung disease	Found in workers of coal mines
White lung disease	Found in textile workers
Byssinosis	Due to inhalation of cotton fibre dust

Smog

It is two types:

Classical smog

These occur in cool, humid climate. Sulphur dioxide (SO_2) and particulate matter from fuel combustion are the main components of classical smog.

Photochemical smog

These occur in warm, dry and sunny climate. It consists of a mixture of primary pollutants (nitrogen oxides and carbon monoxides) and secondary pollutants (ozone, formaldehyde).

Peroxyacetyl nitrate (PAN) and aldehydes present in smog causes irritation in eyes. PAN has the highest toxicity to plants. It attacks younger leaves and causes bronzing and glazing of their surfaces.

Stratospheric Pollution

In stratosphere, ozone layer absorbs the ultraviolet radiation of the Sun which are harmful to living organisms.

Depletion of ozone layer causes skin cancer and cataract in human and reduction of planktons in ocean and depletion of plants.

Depletion of ozone layer is caused by **chlorofluoro carbons** which are used in refrigeration, fire extinguishers and aerosol sprayers.

In stratosphere, the depletion of ozone layer leading to ozone hole has been mainly observed in the stratosphere of Antarctica.

The formation of this hole occur due to the accumulation of special clouds in the region called **Polar Stratospheric Clouds** (PSCs) and inflow of chlorofluoro carbons (CFCs).

Water pollution

In some part of India, drinking water is contaminated by the impurities of arsenic, fluoride, uranium, etc.

In water, some dissolved Oxygen (DO) is also present. For a healthy aquatic life, the optimum value of DO is 5-6 ppm. If DO is below 5 ppm, the growth of fishes is inhibited.

Biochemical Oxygen Demand (BOD) is the total amount of oxygen (in mg) required by microbes to decompose the organic matter present in 1L of water sample while **Chemical Oxygen Demand** (COD) refers to the total amount of oxygen (in ppm) consumed by the pollutants in a water sample.

$$\text{BOD} = \frac{\text{Amount of oxygen required (in mg)}}{\text{Volume of water sample (in L)}}$$

For clean water, BOD is less than 5 ppm while for highly polluted water, it is 17 ppm or more.

PROPERTIES OF GASES

1. Properties of Gases

- Gas has no definite volume or shape.
- The other outstanding characteristic of gases is their low densities, compared with those of liquids and solids.
- All gases expand equally due to equal temperature difference.
- **Diffusion of gases:** The phenomenon in which a substance mixes with another because of molecular motion, even against gravity- is called diffusion.
- **The pressure of a gas:** The molecules of a gas, being in continuous motion, frequently strike the inner walls of their container
- Temperature and Temperature Scales: Temperature is defined as the measure of average heat. Temperature is independent of the number of particles or size and shape of the object.
- **Compressibility:** Particles of a gas have large intermolecular spaces among them. By the application of pressure much of this space can be reduced and the particles be brought closer. Hence the volume of a gas can be greatly reduced. This is called compressing the gas.

Gas Laws

- All gases, irrespective of their chemical composition, obey certain laws that govern the relationship between the volume, temperature and pressure of the gases. A given mass of a gas, under definite conditions of temperature and pressure, occupies a definite volume.
  When any of the three variables is altered, then the other variables get altered. Thus these Gas laws establish relationships between the three variables of volume, pressure and temperature of a gas.
- **Boyle's Law:** "The product of the volume and pressure of a given mass of dry gas is constant, at constant temperature".
- **Charles' Law:** "At constant pressure, the volume of a given mass of gas increases or decreases by 1/273 of its original volume at 32°F, for each degree centigrade rise or lowering in temperature."
- **Pressure Law:** Volume remaining constant, the pressure of a given mass of gas increases or decreases by a constant fraction (=1/273) of its pressure at 0°C for each degree Celsius rise or fall of temperature.

- **Avogadro's Law:** This is quite intuitive: the volume of a gas confined by a fixed pressure varies directly with the quantity of gas. Equal volumes of gases, measured at the same temperature and pressure, contain equal numbers of molecules. Avogadro's law thus predicts a directly proportional relation between the number of moles of a gas and its volume.
- **Gay-Lussac's Law:** When different gases react with each other chemically to produce gaseous substances, then under the same condition of temperature and pressure, the volume of the reacting gases and product gases bear a simple ration among one another.
- **Avogadro Number:** From Avogadro's hypothesis, we know equal volume of all gases contain equal number of molecules at normal temperature and pressure.
  The number is known as Avogadro Number and is equal to6.06X1023.
- **The ideal gas equation of state:** If the variables P, V, T and n (the number of moles) have known values, then a gas is said to be in a definite state, meaning that all other physical properties of the gas are also defined. The relation between these state variables is known as an equation of state.
- An ideal gas is an imaginary gas that follows the gas laws and has 0 volume at 0 K i.e., the gas does not exist.

ORGANIC CHEMISTRY

Organic chemistry is defined as the study of hydrocarbons and their derivatives. Most atoms are only capable of forming small molecules. However one or two can form larger molecules.
Urea was the first organic compound prepared in laboratory. It was prepared by Wohler (1828) from inorganic compound i.e. ammonium cyanate.
Acetic acid was the first organic compound synthesized from the elements by **Kolbe**.

Functional group is responsible for the chemical properties of the molecules ex. OH is alcoholic group

Isomers Compounds having the same molecular formula but different structures, e.g. C_2H_6O can have the structure, i.e. CH_3OCH_3 (dimethyl ether) and C_2H_5OH (ethanol).

Hydrocarbons
These are the compounds of only carbon and hydrogen.
Saturated hydrocarbons They contain only single bonds. These are also called **alkanes** or **paraffins** and have general formula C_nH_{2n+2}. Methane is the first member of this group.

Unsaturated hydrocarbons They have general formula C_nH_{2n} for alkene and C_nH_{2n-2} for alkynes. These have atleast one double (=) or triple (≡) bond and are called **alkenes** and **alkynes** respectively.

Aromatic hydrocarbons They have ring structure with alternate double bonds and (4n + 2) πe^- (Huckel's rule) e.g. benzene.

Important Hydrocarbons and their Uses
Methane (CH_4) It is also known as marsh gas or damp fire. Natural gas contains mainly 90% methane along with ethane, propane, butane etc. Rice agriculture is a big source of atmospheric methane.
- It is the cause of occurrence of the explosions in mines.
- It is used as a fuel gas in making carbon black.

Biogas
Produced during decay of biomass in the absence of oxygen. Methane (75%) is the main constituent of biogas).
Ethane (C_2H_6)
Natural gas contains approx. 10% ethane. Its hexachloro derivative C_2CI_6 is used as an artificial camphor.
Butane (C_4H_{10})
It is the main constituent of LPG (liquefied petroleum gas).
Ethylene ($CH_2 = CH_2$)
In World war | (1914-18), it was used for the manufacturing of mustard gas (poisonous gas). It is used as an anesthetic for the preservation and artificial ripening of green fruits.
Acetylene (CH ≡ CH)

Benzene (C_6H_6)
It is the simplest aromatic hydrocarbon. It was discovered by Faraday in 1825. It is also used as a motor fuel under the name benzol.

Toluene ($C_6H_5CH_3$)
It is used as a commercial solvent in the manufacturing of explosive (TNT), drugs (chloramines-T) and dyestuffs. Used in the manufacturing of saccharin and printing inks. toluene is used as antifreeze.
Naphthalene ($C_{10}H_8$)
It is used for preventing moths in clothes, as an insecticide.

Halogen Derivatives of Hydrocarbons

Chloroform ($CHCl_3$)
- It was discovered by **Sir James Young Simpson**.
- It is stored in closed dark coloured bottles completely filled because it is oxidized by air in the presence of sunlight to an extremely poisonous gas phosgene ($COCl_2$).
- It reacts with conc. HNO_3 and form chloropicrin ($CI_3C - NO_2$). Chloropicrin is an insecticide and also used as poisonous gas at the time of war.
- The major use of chloroform today is in the production of the Freon refrigerant, R-22.

Iodoform (CHI_3)
It is used as an antiseptic due to liberation of free iodine.

Carbon tetrachloride (CCI_4)
used as a fire extinguishers under the name pyrene.
Dichloro diphenyl trichloro ethane (DDT)
It was the first chlorinated organic insecticides and originally prepared in 1873.

Alcohols
Methyl alcohol (CH_3OH)
- It is also known as wood spirit or wood naphtha.

- Methyl alcohol is poisonous in nature and when taken internally it can cause blindness and even death.
- It is used for denaturing alcohol (methylated spirit is denatured ethyl alcohol).

Ethyl alcohol (C_2H_5OH)
It is simply known as alcohol, spirit of wine or grain alcohol.

Glycerol $(CH_2OH.CHOH.CH_2OH)$
- It is an important trihydric alcohol known as glycerine.
- It is sweet in taste and very hygroscopic in nature. It is used in the manufacturing of cosmetics and transparent soaps.

Phenol (C_6H_5OH)
It is a monohydric benzene derivative. It is commonly known as carbolic acid or benzenol.

Methyl isocyanate (CH_3NCO)
Leakage of this gas is responsible for Bhopal gas tragedy.

Coal
- It is believed that is was formed by (carbonization). Different varieties of coal are anthracite (90% carbon), bituminous (70% carbon), lignite (40% carbon) and peat (10-15% carbon).
- On heating at 1270-1675 K in the absence of air, coal decomposes and gives the following products.
- **Coke** is the solid residue left after the distillation.
- **Coal tar** It is a mixture of about 700 substances.
- Now-a-days bitumen, a petroleum product, is used in place of coal tar for metalling the roads.
- The most significant characteristics of Indian coal are its high ash content, entrained gasifires and low sulphur content.
- The process of separation of various constituents/ fractions of petroleum is known as **refining**.
- **Knocking -** In a petrol engine, vapours of petrol and air are first compressed to a small volume and then ignited by a spark. If the quality of petrol is not good, it leads to the pre-ignition of fuel in the cylinder. This gives rise to a metallic sound known as knocking. Tetraethyl lead (TEL) and Benzene – Toluene – Xylene (BTX) are common antiknock compounds.
- **Octane number -** The antiknocking property of petrol is measured in terms of octane number. Higher the octane number, better is the quality of fuel. Gasoline used in automobiles has an octane number 80 or higher while in aeroplane, it has an octane number 100 or over higher.

Fuels:
- **Producer gas** is a mixture of carbon monoxide and nitrogen. Water gas in mixture of carbon monoxide and hydrogen.
- **Coal gas** is a mixture of hydrogen, methane, carbon monoxide, ethane, acetylene, carbon dioxide, nitrogen and oxygen.
- **Oil gas** and petrol gas is a mixture of methane, ethylene and acetylene etc., and is obtained by cracking of kerosene.
- **LPG** (Liquefied Petroleum Gas) the mixtures of hydrocarbons such as propane, propene, n-butane, isobutene and various butane with small amount of ethane.The major sources of LPG are natural gas.
- **CNG** (Compressed Natural Gas) It is highly compressed from of natural gas, octane rating of CNG is 130.
- **Gasohol+** It is a mixture of ethyl alcohol (10%) and petrol (90%).

Flame:
It is the hot part of fire and has three parts.
- **Innermost region of flame** It is black because of the presence of unburned carbon particles.
- **Middle region** It is yellow luminous due to partial combustion of fuel.
- **Outermost region** It is blue (non-luminous) due to complete combustion of fuel. It is the hottest part of flame and is used by the Goldsmith to heat the gold.

Rocket Fuel:
- The fuel used in rockets is called rocket propellant.
- **Liquid propellants** are alcohol, liquid hydrogen, liquid ammonia (NH_3), kerosene oil etc.
- **Solid propellants** are polybutadiene and acrylic acid used along with oxidizers such as aluminium per chlorate, nitrate or chlorate.