**CHAPTER # 11**

**HYDROGEN**

**INTRODUCTION:**

Hydrogen gas was first discovered by “Cavendish” in 1766 by the action of zinc metal over dilute hydrochloric acid.

|  |  |
| --- | --- |
| **Symbol** | **H** |
| **Atomic number** | **1** |
| **Mass number (At. Mass)** |  |
| **State** | **Gas at S.T.P** |
| **Nature** | **Non-metallic** |
| **Valences** | **Monovalent** |
| **Oxidation states** | **+1, -1** |
| **Behavior** | **Reducing agent** |
| **E.C** |  |
| **% age in Earth crust** | **9th most abundant elements** |
| **Density (lightest of all gases)** |  |
| **Type of molecule** | **diatomic molecule** |
| **Molecular formula** |  |
| **Molecular mass** | **2.016 a.m.u** |
| **Meaning of Hydrogen** | **Water producer** |

**INDUSTRIAL PREPARATION OF HYDROGEN**

1. **BY PASSING STEAM OVER COKE / FROM WATER GAS:**

When steam is passed over red hot coke at about a mixture of carbon monoxide and hydrogen is obtained which is called water gas.

From water gas gas is separated by two methods.

1. **BY LIQUEFACTION: (PHYSICAL METHOD)**

When water gas is cooled upto carbon monoxide liquefies and leaving behind free gas. The remaining traces of are dissolved in solution to form sodium formate, leaving behind pure gas.

1. **BY OXIDATION: (BOSCH PROCESS) (CHEMICAL METHOD)**

In this process more steam is passed through water gas at in the presence of or catalyst dissolved in water gas oxidizes to which is soluble in water at high pressure liberating free gas.

1. **FROM NATURAL GAS: (HYDROCARBON STEAM PROCESS)**

Hydrogen is also obtained by passing steam over hydrocarbon, such as methane, in the presence of catalyst at about to produce water gas.

From water gas gas is separated by two methods.

1. **BY LIQUEFACTION:**

When water gas is cooled upto carbon monoxide liquefies and leaving behind gas. Remaining traces of are dissolved in solution to form sodium for mate leaving behind pure gas.

1. **BY OXIDATION:**

In this process more steam is passed through water gas at in the presence of iron oxide or catalyst. Carbon monoxide gas in water gas oxidizes to gas which is soluble in water under high pressure, liberating pure gas.

1. **BY CRACKING OF METHANE:**

When methane is heated above in the absence of air, decomposes to produce carbon black and gas.

* Carbon black is used in rubber industry as filler for tyres. It is also used in the preparation of inks, paints, polishes carbon paper and plastics.

1. **BY ELECTROLYSIS OF WATER:**

gas can also be prepare by the electrolysis of water. When electric current is passed through water in the presence of few drops of acid or alkali, gas is liberated at cathode and gas collects at anode.

**PHYSICALS PROPERTIES OF GAS:**

1. It is a colourless, odourless and tasteless gas.
2. It is insoluble in water.
3. It is highly inflammable and burns with blue flame. It does not supports combustion.
4. It adsorbs on the surface of some transition metals, to form interstitial hydrides.
5. It is nontoxic in nature.
6. It liquefies at and freezes at .
7. Its electronegativity is and its ionization energy is .
8. Its bond dissociation energy is .

**CHEMICAL PROPERTIES OF HYDROGEN**

1. **THERMAL STABILITY:**

Molecular Hydrogen , contains a stable covalent bond and relatively inert at ordinary temperature. Its bond energy is very high .

1. **REACTION WITH METALS:**

Hydrogen forms ionic hydrides with alkali metals and alkaline earth metals. E.g.

1. **REACTION WITH NON-METALS:**

Hydrogen reacts with many non-metals under different conditions to form addition products. **For example:**

1. **HYDROGENATION REACTIONS:**

The addition of hydrogen into other compounds is called hydrogenation reactions gives addition products with some molecular compounds, when heated in the presence of catalysts.

**For example:**

1. **AS REDUCING AGENT:**

Hydrogen shows grater affinity for oxygen and reduces many metal oxides into free metals.

**For example:**

**NASCENT HYDROGEN**

**DEFINITION:**

Hydrogen in atomic form at the time of its generation is chemically more reactive than ordinary molecular hydrogen and is called Nascent Hydrogen.

**PREPARATION:**

Nascent hydrogen is prepared by one of the following reactions:

**REASON OF HIGH REACTIVITY:**

Nascent hydrogen is chemically more reactive than molecular hydrogen because hydrogen molecule requires a very high bond dissociation energy of to break its bond into atomic hydrogen before it reacts. Nascent hydrogen is already available in atomic form and there is no need to supply extra energy to initiate the reaction.

**EVIDENCE FOR HIGH REACTIVITY:**

* Brownish coloured acidic solution does not react with gas.
* But when a piece of metal is added in acidic solution, nascent hydrogen is generated which reduces which is green in colour.

1. Similarly acidic (Pink) solution can be reduced by nascent hydrogen to the colourless solution.

**ISOTOPES OF HYDROGEN**

**DEFINITION OF ISOTOPE:**

Isotope is defined as:

“atoms of the same element having same atomic number but different mass numbers are called isotopes.”

**OR**

“atoms of the same element having same no. of protons but having different numbers of neutrons are called isotopes.”

Nearly all the elements found in nature are mixture of several isotopes. There are three isotopic forms of hydrogen, namely;

1. Protium
2. Deuterium
3. Tritium
4. **PROTIUM OR ORDINARY HYDROGEN:**

|  |  |
| --- | --- |
| **No. of protons** | **1** |
| **No. of neutrons** | **0** |
| **No. of electrons** | **1** |
| **Atomic number** | **1** |
| **Mass number** | **1** |
| **%age** |  |

1. **DEUTERIUM: (HEAVY HYDROGEN)**

|  |  |
| --- | --- |
| **Discovered in** | **1931** |
| **Discovered by** | **Urey** |
| **No. of Protons** | **1** |
| **No. of Neutrons** | **1** |
| **No. of electrons** | **1** |
| **Atomic number** | **1** |
| **Mass number** | **2** |
| **%age** | **i.e in the ratio of** |

1. **TRITIUM : (RARE HYDROGEN)**

|  |  |
| --- | --- |
| **No, of Protons** | **1** |
| **No. of Neutrons** | **2** |
| **No. of electrons** | **1** |
| **Atomic number** | **1** |
| **Mass number** | **3** |
| **%age** |  |
| **Nature** | **Radioactive** |
| **Half Life** | **12.5 years** |
| **Uses** | **As tracer in nuclear reaction** |

**CHEMICAL PROPERTIES OF WATER**

1. **REACTIONS OF WATER WITH METALS:**

Water reacts with metals in number of ways. The degree of reactivity depends upon the nature of metals and their positions in the electrochemical series.

1. **WITH MORE ELECTROPOSITIVE METALS: (WITH ALKALI AND ALKALINE EARTH METALS)**

Group I-A and II-A metals like reacts with cold water to form their hydroxides with the liberation of gas. reacts vigorously while reacts slowly.

1. **WITH LESS ELECTROPOSITIVE METALS:**

Less electropositive metals like reacts with hot water to liberate gas with the formation of their oxides. reacts with excess of steam at red heat.

1. Noble metals do not react with .
2. **REACTION OF WATER WITH NON-METALS:**
3. With chlorine: Chlorine reacts with water to form and . Hyprochlorous acid is unstable and readily liberates atomic oxygen which can bleach dyes and kill bacteria by oxidation.
4. With carbon: When steam is passed over red hot coke at , a mixture of and is obtained called water gas.
5. With Silicon: Silicon reacts with steam at very high temperature to form an oxide of silicon i.e. silica with liberation of gas.
6. With metal oxides: Metal oxides dissolve in water to form bases. E.g.
7. **REACTION WITH NON-METAL OXIDES:** Non-metallic oxides dissolve in water to produce oxy acids e.g.
8. **HYDROLYSIS OF SALTS:** Water underges hydrolysis with salts to form acidic or basic solution. E.g.

**WATER AS UNIVERSAL SOLVENT**

Water is an excellent solvent. It dissolves majority of ionic compounds and many of the covalent compounds. The great dissolving power of water is due to its large value of dielectric constant and polar nature.

In water oxygen being move electronegative than hydrogen atom, acquires a partial negative charge and hydrogen atoms get partial positive charge, so the molecule becomes polarized.

* As a result of this polar structure, water acts as an excellent solvent for ionic solutes such as salts, acids and alkalies.
* All covalent compounds containing hydroxyl group are also water soluble e.g. , and alcohols.
* Some gases are highly soluble in water such as .
* Some gases are fairely soluble in water e.g. .

**WATER OF CRYSTALLIZATION**

**DEFINITION:**

“In the formation of crystals a definite number of water molecules become a part of it. These water molecules are called water of crystallization.”

**HYDRATES:**

Compounds which contain water molecules as a part of their crystals are called as “HYDRATES” or “HYDRATED COMPOUNDS”.

**Examples:**

1. Potash alum;
2. Blue stone;
3. Washing soda;
4. Green vitriol;
5. Epsom salt;

When crystals are heated the lose water of crystallization forming powdered substances called ANHYDROUS COMPOUND.

**HYGROSCOPIC SUBSTANCES**

**DEFINITION:**

“Substances which absorbs moisture from atmosphere when kept open are called Hygroscopic substances.”

Hygroscopic substance just become sticky or moist in open air and do not form a solution.

**Examples:**

1. Sodium nitrate;
2. Copper oxide;
3. Calcium oxide;
4. Conc. sulfuric acid;

**IMPORTANCE:**

Hygroscopic substances are commonly employed as drying agents in the laboratory. They have strong affinity for moisture or water.

**HEAVY WATER**

When a heavier isotope of hydrogen, Deutrium combines with oxygen the compound formed is Deuterium Oxide called heavy water.

Naturally occurring water contains one part of heavy water out of its seven thousand parts.

**PROPERTIES OF HEAVY WATER:**

1. Its density is slightly greater than ordinary water. It is .
2. It has low vapour pressure than ordinary water.
3. It freezing point and boiling point is .
4. Refractive index of water is much smaller than ordinary water.
5. Molecular mass of heavy water is while that of ordinary water is .

**USES:**

1. It is used as moderator in nuclear fission power reactor.
2. It is also used as a tracer in biological and chemical researches.

**SOFT WATER AND HARD WATER**

1. **SOFT WATER:**

“The water containing dissolved impurities (salts) of bicarbonates, chloride and sulphate of calcium and magnesium in small quantities which easily produces lather with soap is known as SOFT WATER.”

1. **HARD WATER:**

“The water containing dissolved impurities (salts) of bicarbonates, chlorides and sulphates of calcium and magnesium in large amounts and do not produces lather with soap easily is known as HARD WATER.”

**CAUSE OF HARDNESS:**

Rain water dissolves carbon dioxide from air. When this water passes down the layers of air, insoluble carbonates of are dissolved as bi carbonates.

Sulphates and chlorides of are also dissolved. The presence of ions in water make it hard.

**TYPES OF HARDNESS**

There are two types of hardness in water:

1. **TEMPORARY HARDNESS:**

Temporary hardness in water is due to presence of dissolved bicarbonates of calcium and magnesium.

1. **PERMANENT HARDNESS:**

Permanent hardness in water is due to presence of dissolved chlorides and sulfates of .

**METHODS OF REMOVING HARDNESS**

1. **METHODS OF REMOVING TEMPORARY HARDNESS:**
2. **BY BOILING:**

Temporary hardness of water is due to the presence of and . On heating and are decomposed to form insoluble and which can be remove easily by filteration.

1. **CLARK’S METHOD: (BY ADDING LIME WATER)**

In this method a calculated amount of slaked lime is mixed with hard water containing bicarbonates of are separated as insoluble carbonate, and are removed by filtration easily.

1. **METHODS OF REMOVING PERMANENT HARDNESS:**
2. **BY USING WASHING SODA:**

When washing soda is added to permanent hard water, insoluble and are precipitated from the soluble salts of .

1. **BY USING CAUSTIC SODA:**

When caustic soda is added to the permanent hard water, insoluble hydroxides of ions is precipitated from the salt of while is partialy soluble in water.

1. **BY USING ZEOLITE: (ION EXCHANGES METHOD)**

Zeolite or permutit is a naturally occurring Sodium aluminium silicate commonly known as Sodium zeolite. It is usually used in industry and home for softening water. As hard water is passed through it, the sodium ions will go into the solution while the unwanted ions take their place in the complex insoluble zeolite, and their hardness is removed.

**CHAPTER # 12**

**CARBON, SILICON AND THEIR COMPOUNDS**

**INTRODUCTION:**

Carbon and silicon are two important elements of group IV-A of the periodic table. Table have four electrons in their valence shell.

* Carbon is a Non-Metal.
* Silicon is a Metalloid.

**OCCURRENCE OF CARBON:**

Carbon is of Earth’s crust, half of at is in the form of carbonates. It is sixteenth most abundant element in the earth’s crust.

**FORMS OF CARBON:**

In the free state carbon occurs in the following forms:

1. Crystalline form:
2. Diamond
3. Graphite
4. Bucky balls
5. Amorphous forms:
6. Lamp black
7. Wood charcoal
8. Coad
9. Animal charcoal
10. Gas carbon

**INTRODUCTION:**

Carbon and Silicon belongs to IV-A group of the periodic table because both the elements possess four electrons in their valence shells.

Carbon is a pure non-metal and silicon is a metalloid.

**OCCURRENCE:**

Carbon is the sixteenth most abundant element in the earth crust carbon exists as free state as well as in combined state in the earth’s crust.

**FORMS OF CARBON:**

1. **CRYSTALLINE FORMS:**
2. Diamond
3. Graphite
4. Bucky balls
5. **AMORPHOUS FORMS:**
6. Coal
7. Coke
8. Charcoal
9. Carbon black

**ALLOTROPY**

**DEFINITION:**

“The existence of the same element in two or more different forms having same chemical properties but different physical properties is known as ALLOTROPY”.

The different physical forms of the same element in the same state are referred to as allotropic modification or allotropes.

**CRYSTALLINE ALLOTROPES OF CARBON:**

1. **DIAMOND:**

Diamond is one of the crystalline allotropic forms of carbon. It is found mainly in South Africa, Brazil, Australia and India.

**PROPERTIES:**

1. In pure state, diamond is transparent and bright.
2. It is the hardest natural substance known.
3. Its density is about .
4. It has a very high refractive index due to which it acquires great brilliance.
5. It is a bad conductor of electricity.
6. It has a high melting point of about .
7. Diamond may be of blue, green, yellow, red or black in colour.
8. Black coloured diamonds are called Bort or Carbondo which are of inferior qualities and are used for cutting glasses and for drilling rocks other diamonds are used as gems and precious stones.
9. **GRAPHITE:**

Graphite occurs naturally as “PLUMBAGO” an opaque black solid. It is found in Siberia, Canada and in Sri-Lanka.

**PROPERTIES:**

1. Graphite is of dark grey colour crystalline solid with dull metallic lusture.
2. It is soft and greasy to feel.
3. It is less dense than diamond and have density about .
4. It is good conductor of electricity and is used in the preparation of electrodes.
5. It leaves black mark on paper, so it is used in the manufacture of lead pencils (Graphite + clay).
6. Graphite is also used as black pigment in paints and also as neutron-moderator in nuclear reactors.
7. It has a high melting point about .
8. Sometimes graphite is mixed with oil to form a high temperature lubricant.
9. **BUCKY BALLS: (BUCKMINSTER FULLERENE)**

* In 1985, a new type of allotropic form of carbon was discovered by the vapourized graphite by two English researchers who named it bucky balls.
* It has been found that in bucky balls, carbon atoms is about forming molecules because the mass spectrum peaks correspond to cluster of carbon atoms as molecules of carbon atoms which forms a ball like football or soccer ball with highly symmetrical structure.
* Unlike diamond and graphite, bucky balls can be dissolved in organic solvents.
* Bucky balls are used as semi-conductors and lubricants.

**AMORPHOUS FORMS OF CARBON**

1. **COAL:**

The anaerobic decay of buried trees and plants under the earth’s surface at high temperature and pressure gradually and over ages converting them into and water vapours leaving behind a material containing high percentage of carbon called COAL. Following are the various stages of formation of coal.

1. Deat: , light soft brown spongy material cheap fuel, energy value .
2. Lignite: , hard, cheap fuel having energy value .
3. Sub-bituminous coal: , used in power generating stations.
4. Bituminous coal: , its destructive distillation gives coke, coal gas and coal tar.
5. Anthracite coal: hardest, driest coal, black, burns without smoke. Energy value .
6. **COKE:**

Coke is produced by heating bituminous coal to very high temperature about in the absence of air to remove all the volatile constituents present in coal. This process is called DESTRUCTIVE DISTILLATION.

* It is used as fuel and also as reducing agent in the extraction of metals especially ion.
* Coke burns in air with no smoke and leaves very little residue.

1. **CHARCOAL:**

“The residue left after heating to high temperature organic substances like wood, nutshells, bones sugar etc. in the absence of air is called charcoal.”

1. Wood charcoal: It is the most common charcoal prepared by burning wood in the limited supply of air. It contains impurities such as sulphur. It is mainly used as domestic fuel.
2. Animal charcoal: It is produced when animal bones and refuse are heated in the limited supply of air. It contains high percentage of calcium phosphate as impurity. It is used in sugar industry to remove brown colours of cane sugar and also decolorizing petroleum.
3. Sugar charcoal: It is formed by dehydration of carbohydrates by concentrated .
4. Activated charcoal: it is the charcoal that has been thoroughly treated and cheaned by heating with super-heated steam. It has more adsorbing power. It is used in gas mask for absorbing poisonous gases and in sugar mills for decolorizing sugar juice and sugar cane.
5. **CARBON BLACK (SOOT):**

It is prepared by heating methane to high temperature in limited supply of air. It is used in black shoe polishes, printer’s ink, type-writing papers and in rubber tyre industry as filler to increase the strength, hardness and elasticity of rubber.

**CHEMICAL PROPERTIES OF CARBON**

Chemically carbon is not very reactive element. All the allotropes of carbon have similar chemical properties.

1. **COMBUSTION:**

1. **COMBINATION REACTIONS:**
2. **AS REDUCING AGENT:**

Carbon is a powerful reducing agent because it has greater affinity for oxygen. It reduces many oxides. This reduction occurs at very high temperature to from of gas. For Examples:

1. **REACTIONS WITH STRONG OXIDIZING AGENTS:**

Carbon reacts with strong oxidizing agents like hot and concentrated nitric acid and concentrated sulphuric acid and gets oxidized and liberate gas.

**SILICA**

Silica occurs naturally in three main crystalline forms namely quartz, tridymite and crystobalite. The most common of three is quartz.

**PREPARATION:**

1. It is prepared by heating silicon in air or oxygen.
2. It can also be prepare by in hydrated form as a gelatinous precipitate by warming Sodium silicate with conc. solution.

**PROPERTIES:**

1. Because of its structure, is non-volatile and hard.
2. Its melting point is about .
3. When cooled, it forms glass-like solid, known as fused silica (also called quartz glass), which has very low co-efficient of expansion hence is heat resistant.

**STRUCTURE:**

Silica exists in a colourless crystalline form when pure. It is a macromolecular compound with silion and oxygen atom linked together covalently in tetrahedral units.

**USES:**

1. Sand is widely used in making cement, concrete, glass and refractory silica bricks.
2. Fused silica (quartz glass) is used in making optical lenses and prisms, heat resisting articles.
3. Large quartz crystals are used in the manufacture of lenses of optical instruments.
4. Powdered quartz is used is the making of Silicon Carbide , Silicon tetraflouride , Sodium Silicate and Silica bricks.
5. Kieselguhr absorbs liquids readily and is used as absorbent of nitroglycerine (explosive) in the manufacture of dynamite.
6. It is also used in medicines for making dry antiseptic dressings.

**SODIUM SILICATE**

**PREPARATION:**

Sodium Silicate is prepared by heating a mixture of silica and Sodium carbonate.

**PROPERTIES:**

1. It is glass like solid.
2. Its melting point is .
3. It dissolves in hot water forming a thick syrup like liquid called WATER GLASS.

**USES:**

It is used for:

1. Fire proofing wood and textiles.
2. Soap making.

**SILICA GEL**

**PREPARATION:**

when an acid is mixed in aqueous solution of sodium silicate (water glass), a gel is formed. When dehydrated by heating a hard porous mass is left which is called silica gel.

**PROPERTIES:**

1. It is hard transparent solid.
2. It absorbs moisture and other volatile substances. On heating the vapours are lost and can be recovered.

**USES:**

Silica gel is used as:

1. Drying agent in medicine, small bags of silica gel are kept in medicines packing to prevent the medicines being spoiled by water vapours in the atmosphere.
2. It is also used to recover valueable vapours from industrial effluents and in the refining of petroleum.

**CHAPTER # 14**

**SULPHUR AND ITS COMPOUNDS**

**EXTRACTION OF SULPHUR BY FRASCH’S METHOD:**

**INTRODUCTION:**

Underground deposits of sulfur present at depth are the major sources of sulphur. The method used for its extraction is FRASCH’S method, developed by an American Engineer, Herman Frasch.

**BASIC PRINCIPLE:**

The working principle is based on the melting of sulfur deposites underground and then pumped to the surface.

**DETAILS OF THE PROCESS:**

1. First of all a hole of about in diameter is drilled through the soil layers to the sulphur bed and three concentric pipes arsunk into a sulfur bearing rock, through a bore.
2. Super-heated steam at under a pressure of is pumped down through the outermost pipe to the sulphur bed to melt sulphur forming an emulsion which collects in a pool at the bottom.
3. The compressed hot air at a pressure of is blown down the innermost pipe, which pushes the molten sulphur up the surface of ground which is collected in big wooden basins. Sulphur is then allowed to solidify and is pure.

**PHYSICAL PROPERTIES OF SULPHUR:**

1. Sulphur is a yellow solid.
2. It is insoluble in water but soluble in carbon disulphide .
3. It is non-metallic element.
4. It is bad conductor of electricity and heat.
5. Its boiling point is about .

**CHEMICAL PROPERTIES:**

1. **REACTION WITH METALS:**

Sulfur combines with many metals directly to form their respective sulphides may even react sulfur without much more heating, when both are in finely divided form.

6. **REACTION WITH NON-METALS:**
7. **WITH OXYGEN:**
8. **WITH HYDROGEN:**
9. **WITH CARBON:**
10. **WITH CHLORINE:**
11. **WITH FLUORINE:**
12. **WITH CONCENTRATED ACIDS:**

Sulphur is readily oxidized when warmed with conc. Sulphuric acid to produce gas and also with cons. Nitric acid to produce gas.



**USES OF SULPHUR:**

1. It is used in the manufacture of sulfuric acid, sulfur di oxide and carbon disulphide.
2. It is used for the manufacture of calcium and magnesium hydrogen sulphates and also used for bleaching wood pulp.
3. Sulphur is used in volcanizing rubber.
4. It is used for disinfecting houses and for dirty vines. It also helps to kill fungi and insects.

**ALLOTROPIC FORMS OF SULPHUR**

Sulphur exists in three allotropic form.

1. Rhombic sulphur
2. Monoclinic Sulphur
3. Plastic Sulphur

**RHOMBIC SULPHUR:**

1. **PREPARATION:**

Rhombic Sulphur is prepared by slow evaporation of the solution of ordinary sulphur in carbon disulphide or which is filtered first to remove insoluble impurities present in sulphur. The filtrate on evaporation produces octahedral crystal of rhombic sulphur.

1. **STRUCTURE:**

Rhombic Sulphur consists of molecules. These molecules consists of 8 sulfur atoms bound to each other through single covalent bond.

1. **PROPERTIES:**
2. It is the most stable crystalline form of sulphurat ordinary conditions.
3. Free sulphur exists in nature as rhombic sulphur.
4. It is obtained as pale yellow crystals, giving lemon yellow powder.
5. Its m.p is .
6. Its density is at .
7. It is insoluble in water but soluble in , benzene, , turpentine etc.

**MONOCLINIC SULPHUR:**

1. **PREPARATION:**

Monoclinic Sulphur is obtained by slow cooling molten sulphur until a crust is formed on the surface of the molten sulphur pierce two holes through the crost and pour off the remaining molten sulphur from inside on removing the crust the long needle shaped crystals of monoclinic sulfur are formed on the side of the dish.

1. **STRUCTURE:**

Monoclinic Sulphur also consists of molecules. The only difference is the shapes of crystals molecules unite together to give needle shaped crystals.

1. **CHARACTERISTICS:**
2. Monoclinic Sulphur is another crystalline form of sulphur. It is stable between and it changes slowly to Rhombic Sulphur at ordinary temperature.
3. It consists of dark yellow transparent needl;e like crystals.
4. Its m.p is .
5. It density is .
6. It is soluble in but insoluble in water.

**INTER CONVERSION OF :**

Below the rhombic sulphur is stable and above monoclinic sulphure is stable. Thus the temperature at which both forms coexist equilibrium is called transition temperature. The transition temperature is .

**PLASTIC SULPHUR:**

1. **PREPARATION:**

When molten or liquid sulfur is heated carefully upto its boiling point of about and then quickly dropped in ice-cold water, it turns into long, elastic soft, sticky, rubber like yellow ribbons of plastic sulphur which looks as if it is made up of plastic material.

1. **STRUCTURE:**

The plastic sulphur is not composed of rings but is composed of extremely long zig-zag chains of sulfur atoms coiled up.

1. **PROPERTIES:**
2. It is non-crystalline form of sulphur and it is considered as a super coaled form of sulphur.
3. It is light yellow or amber coloured, soft, sticky, elastic rubber like material.
4. Its density is .
5. At , it changes to pale yellow liquid.
6. It is insoluble in water as well as carbon disulphide.

**INDUSTRIAL PREPARATION OF SULPHURIC ACID**

On the large scale sulphuric acid is manufactured by two methods, the contact process and the lead chamber process. The contact process is the most recent and gives the sulphuric acid of highest purity.

**CONTACT PROCESS**

**INTRODUCTION:**

This method was developed in Germany in the early 19th century, but came into operation from 1912. Now a days is mainly produced by Contact Process.

**RAW MATERIALS:**

1. Sulphur or Iron Pyrite.
2. Air (for oxygen).
3. Water.
5. (Catalyst).

**PRINCIPLE:**

**PRINCIPLE INVOLVES:**

1. Production of .
2. Oxidation of into in presence of .
3. Absorbtion of into to get Oleum.
4. Absorbtion of oleum in water to get .

**PROCEDURE WITH PLANT**

1. **PRODUCTION OF IN SULPHUR OR PYRITE BURNER:**

In this chamber, sulphur or iron pyrite is burnt in air to get .

1. **PURIFICATION OF GASES:**

Purification unit consists of following chambers:

* Dust remover: Dust particles are removed by gravity separation method.
* Scrubbing tower: Steam is injected from top of tower to dissolve soluble gases.
* Drying tower: is sprayed from top to dissolve absorb moisture from gases.
* Arsenic purifier: in this tower Arsenic oxide is absorbed by precipitated .
* Thyndall box: Impurities are further checked by thyndall effect.

1. **OXIDATION OF INTO IN CONTACT TOWER:**

The purified gases obtained in above step is heated in preheater and then oxidized catalytically in CONTACT TOWER according to following reaction:

Since the reaction is exothermic and reversible the favourable conditions for obtaining maximum yield of are:

1. Excess of .
2. Low temperature
3. High pressure
4. **ABSORBTIONS IN ABSORBTION TOWERS:**
5. The gas produced in contact tower is not directly dissolved in water, as it is less soluble in water, therefore, gas is first dissolved in producing a very thick liquid called .
6. Oleum is the diluted with appropriate amount of water to get sulphuric acid of desired concentration.

The Sulphuric acid obtained in the contact process is pure.

**PHYSICAL PROPERTIES OF SULPHURIC ACID:**

1. Pure conc. Sulphuric acid is a colourless, odourless, viscous oily liquid, often called oil of vitrial.
2. Its melting point is while its boiling point is .
3. Conc. has specific gravity about , while dilute sulphuric acid has specific gravity about .
4. It is corrosive and is hygroscopic as it absorbs water vapours from surrounding and becomes diluted. It is therefore used as drying agent.

**CHEMICAL PROPERTIES OF**

Sulphuric acid behave in three different ways:

1. As an acid.
2. As an oxidizing agent.
3. As drying or dehydrating agent.
4. **AS AN ACID:**
5. **IONIZATION:**
6. **REACTION WITH ALKALIES:**

Sulphuric acid reacts with alkalies (base) to give two types of salts: hydrogen sulphate and sulphate e.g:

1. **REACTION WITH METAL OXIDES:**

also reacts with metal oxides to form salt and water e.g:

1. **REACTION WITH CARBONATES AND BICARBONATES:**

liberates gas when treated with metal bicarbonates and carbonates e.g:

1. **As a Oxidizing agent:**

Sulphuric acid acts as an oxidizing agent. The oxidizing properties of depends upon:

1. Concentration of acid.
2. Nature of metal or reducing agent.
3. Temperature.

**OXIDATION OF METALS:**

1. Diluted oxidizes less electropositive metals like to their sulphate salts and liberated gas.
2. Hot and conc. oxidizes some metals to their sulphates liberating gas.
3. Reactive metals with conc. form different products. reacts with conc. to liberate gas.

**OXIDATION OF NON-METALS**

Hot and conc. Sulphuric acid oxidizes non-metals into their oxides or oxyacids and liberates gas.



**OXIDATION OF OTHER COMPOUNDS**

**AS DEHYDRATING OR DRYING AGENT**

The removal of water molecule from a substance is called dehydration and the regent used to extract water molecules from various substances is called dehydrating agent sulphuric acid has a great affinity for water, so conc. is used as a dehydrating agents for dehydration of as many substance like, glucose sucrose, ethanol, formic acid, oxalic acid and hydrated copper sulphate.

**USES OF SULPHURIC ACID:**

Sulphuric acid is the most important chemical compound and is extensively used in industries. The progren and prosperity of any nation can be estimated in terms of amounts of sulphuric acid consumed annually. It is therefore, barometer of industrial and economic progress of a country. It’s important uses are as follows.

It is used:

1. In the manufacture of fertilizers especially dihydrogen calcium phosphate (super phosphate) and ammonium sulphate .
2. In the manufacture of Rayon, papers, plastics and detergents.
3. In the manufacture of paints and pigments.
4. In making cellulose film and all kinds of man-made fabrics.
5. In steel pickling and cleaning.
6. As drying, dehydrating and oxidizing agent.
7. In motor batteries and lead accumulators.
8. Electrolytic refining of metals by electrolysis.
9. As a catalyst in no. of chemical processes.
10. For refining of petroleum.

**CHAPTER # 13**

**AMMONIA**

**PREPARATION OF AMMONIA**

* **LABORATORY PREPARATION:**

**BY HEATING A MIXTURE OF AMMONIUM CHLORIDE AND SLAKED LIME:**

In the laboratory ammonia is prepared by heating any ammonium salt with a nonvolatile base. Usually, ammonium chloride and dry slaked lime are used. Ammonia gas is collected by the downward displacement of air because it is lighter than air. Ammonia is prepared by the downward displacement of air because it is lighter than air.

* **INDUSTRIAL PREPARATION:**

**NAME OF METHOD:**

Ammonia is prepared on large scale by “Haber-Bosch Process” (developed by Haber and Bosch).

**RAW MATERIALS:**

1. Nitrogen gas
2. Hydrogen gas
3. Iron oxide containing a little Molybdenum and Aluminium Sulphate (catayst)

**PRINCIPLE OR BASIS:**

The principle involves the direct union of pure . The reaction takes place according to following equation:

The above reaction is reversible, exothermic and is accompanied by decrease in volume of product. Le-Chatelier’s Principle suggests following conditions to increase the yield of ammonia.

1. combines in the ratio of by volume.
2. Temperature should be as low as practicable Optimum temperature is .
3. 200 atmospheric pressure favours the forward reaction.
4. Iron oxide and aluminium sulphate are used as catalyst.

**PROCESS:**

The purified mixture of in the proportion of by volume is allowed to pass through compressor where they are compressed to 200 atmospheric pressure and then they are passed over iron oxide and aluminium sulphate in catalyst chamber at where gas is formed. By the spray of water, ammonia solution is obtained.

**PROPERTIES OF AMMONIA:**

1. **PHYSICAL PROPERTIES:**

|  |  |
| --- | --- |
| Colour | Colourless gas |
| Smell | Characteristic strong pungent smell |
| Taste | Alkaline taste |
| Solubility | Highly soluble in water |
| Density | Lighter than air |
| Nature | Basic gas as it turns red litmus blue |
| B.P & F.P |  |

1. **CHEMICAL PROPERTIES:**
2. **REACTION WITH WATER:**

Ammonia is very soluble in water and reacts with water to form, ammonium hydroxide.

1. **REACTION WITH OXYGEN:**
2. Ammonia does not burn in air but it burns readily in oxygen with greenish yellow flame to form nitrogen gas and water vapours.
3. However in the presence heated Platinum catalyst ammonia reacts with excess of air (oxygen) to produce nitric oxide i.e. Nitrogen (II) oxide gas instead of nitrogen gas.
4. **REACTION WITH ACIDS:**

Since ammonia is a base, so it reacts, with acids to form ammonium salts.

1. **REACTION WITH CHLORINE :**

When ammonia reacts with chlorine, it first reduces chlorine to produce hydrogen chloride and nitrogen. Then hydrogen chloride reacts with excess of ammonia to produce dense white fumes of ammonia chloride.

The overall reaction can be describe as:

1. **AS REDUCING AGENT:**

Ammonia is not a strong reducing agent. However it reduces heated copper oxide to free copper metal with the evolution of gas and water.

1. **REACTION WITH CARBON DIOXIDE :**

Ammonia reacts with at high temperature about under pressure to produce Urea Which is an important fertilizer.

**USES:**

1. Aqueous ammonia is used in softening of temporary hard water.
2. It is used as solvent in lounderies for removing grease and oil stains.
3. Liquid ammonia is used as cooling agent in some refrigerators.
4. Ammonia is used in the manufacture of nitric acid in Ostwald’s method and in the manufacture of sodium carbonates (washing soda) by solvay process.
5. The biggest use of ammonia is in the manufacture of nitrogenous fertilizers, like urea, ammonium sulphate, ammonium nitrate, ammonium phosphate etc.

**NITRIC ACID**

**INTRODUCTION:**

Nitric acid is a very important acid which is used extensively in the laboratories and in industries. It was first prepared by Glavber in 1685 from sulphuric acid and potassium nitrate. The early al-chemists used the acid for separating gold from silver, silver being soluble in this acid while gold is insoluble. As a result of corrosive action on many metals, the acids was previously known as aqua fortis meaning strong water.

**PREPARATION:**

1. **LABORATORY PREPARATION:**

Nitric acid is prepared in the laboratory by heating solid Potassium nitrate with conc. Sulphuric acid.

Note that all glass apparatus must be used in this preparation because vapours of nitric acid formed will rapidly attack corcks, rubber and other materials.

1. **INDUSTRIAL PREPARATION OF NITRIC ACID BY OSTWALD’S PROCESS:**
2. **NAME OF METHOD:**

Now a days Nitric acid is manufactured on large scale by Ostwald’s process.

1. **RAW MATERIALS:**

* Ammonia
* Air or Oxygen
* Water
* Platinum Gauze (Catalyst)

1. **PRINCIPLE:**

The principle involves catalytic oxidation of ammonia into nitric oxide which is further oxidized to nitrogen dioxide which on absorption in water gives nitric acid.

1. **DIFFERENT STEPS OF PROCESS:**

The process is carried out in a large plant, which has three main parts.

1. **AMMONIA-OXIDATION CONVERTER / CATALYST CHAMBERS:**

A mixture of ammonia gas and air is passed over platinum gauze used as catalyst at in ammonia conuerter where ammonia is oxidized into Nitric Oxide.

1. **OXIDATION OR COOLING TOWER:**

Nitric Oxide so obtained is cooled below and then combines with more oxygen to form Nitrogen dioxide.

1. **ABSORPTION TOWER:**

Nitrogen dioxide is dissolved in water forming Nitric Acid which is pure.

**PROPERTIES:**

1. **PHYSICAL PROPERTIES:**
2. Nitric acid is a colourless fuming liquid with sharp chocking smell. It has sour taste. Although it is colourless when pure, it tends to turn yellowish after sometimes due to decomposition of some acid into which then dissolves in the acid and turns it yellowish.
3. The boiling point of pure nitric acid is . The density of pure nitric acid is ordinary nitric acid has specific gravity ordinary nitric acid has specific gravity and boils at .
4. It is miscible in water in all proportion conc. nitric acid is unstable and decomposes in sunlight or on heating.
5. **CHEMICAL PROPERTIES:**

* **AS AN ACID:**

Nitric acid is a strong monobasic acid in its aqueous solution ionizes completely in water as:

1. **REACTION WITH ALKALI:**
2. **REACTION WITH BASIC (METALLIC) OXIDES:**
3. **REACTION WITH CARBONATES AND BI CARBONATES:**
4. **REACTION WITH METAL IN DILUTED FORM:**

* **AS OXIDIZING AGENT:**

Nitric acid acts as a powerful oxidizing agent because it is an electron acceptor and has nitrogen at its highest oxidation state and can undergo reduction in many ways.

The oxidizing property of nitric acid depends upon the following factors.

1. Concentration of the acid.
2. Nature of the reducing agent.
3. Temperature.

Due to these factors nitric acid gives variety of reduction products, such as etc.

1. **REACTION WITH NON-METALS:**

Hot conc. Nitric acid reacts with many non-metals and oxidizes them into their oxides or oxy-acids and itself is reduced to gas.

* **REACTION WITH CARBON:**

Carbon oxides to liberate gas on heating with conc.

Similarly silicon oxidizes to

* **REACTION WITH SULPHUR:**

Sulphur oxides first into gas and then to sulphuric acid, on heating with conc. nitric acid.

* **REACTION WITH PHOSPHOROUS:**

Red phosphorous oxidizes to phosphoric acid on heating with conc. nitric acid.

* **REACTION WITH IODINE:**

Iodine is oxidized to hydro iodic acid when heated with nitric acid.

1. **REACTION WITH METALS:**

Conc. as well as dil. Nitric acid oxidizes many metals. Conc. liberates gas, while the reaction of dil. depends upon the nature of the reducing agent.

* **REACTION WITH COPPER:**
* **REACTION WITH LEAD:**
* **REACTION WITH ZINC:**
* **REACTION WITH SOME REDUCING AGENTS:**

Nitric acid which is a strong oxidizing agent also undergoes redox reactions with some common reducing agents like etc.

* **REACTION WITH :**

Conc. nitric acid oxidizes to sulphur while itself is reduced to gas.

* **REACTION WITH :**

Ferrous sulphate reacts with conc. nitric acid and oxidizes to ferric sulphate in the presence of sulphuric acid. While is reduced to gas.

* **REACTION WITH :**

Sulphur dioxide oxidizes to sulphuric acid on heating with conc. .

* **NITRATION REACTION (AS NITRATING AGENT):**

Hot conc. nitric acid reacts with organic compounds like benzene to replace hydrogen atom by the nitro group to form substituted product, nitro benzene . the substitution of group in organic compound is called nitration.

**AQUA REGIA:**

The noble metals like gold and platinum which are not soluble in conc. Nitric acid. However they are dissolved in a mixture of conc. and conc. taken in the ratio of . This mixture is called aqua regia or royal water. Aqua regia dissolves gold due to liberation of nascent chlorine which forms gold chloride with it, which is soluble.

**USES:**

Nitric acid is an important chemical compound.

1. Large amount of nitric acid is used in the manufacture of fertilizers, such as etc.
2. Used in the manufacture of cellulose, lacquers and smokeless gun powder.
3. Used in the manufacture of dyes and explosives such as nitro glycerol and trinitrotoluene (T.N.T) which are powerful explosives.
4. Used as a powerful oxidizing agent in the production of important polymers like nylon and terylene.
5. Used as laboratory reagent.
6. Used as nitrating agent and in the formation of aqua regia which dissolves noble metals and also for producing etching designs on copper plates.

**OZONE**

**INTRODUCTION:**

Ozone is a pale blue poisonous gas with a sharp, irritating odour. It is an allotropic form of oxygen with molecular formula ozone was first discovered by Schonbein in 1839. However in 1886 J.Soret demonstrated that Ozone was actually an allotrope of Oxygen .

**PREPARATION:**

Ozone can be prepared from oxygen by passing electric discharge through oxygen gas. The apparatus used for ozone preparation is known as OZONIZER.

**PHYSICAL PROPERTIES:**

1. Ozone is a pale-blue gas at ordinary condition.
2. Ozone has a sharp, irritating smell like gas.
3. Ozone is very poisonous gas at concentration parts per million . Exposure to to in air produces headache, burning of eye and irritation to the respiratory passages.
4. Pure ozone can be obtained as blue liquid by cooling ozonized oxygen to .
5. It is only slightly soluble in water but dissolve in turpentine oil readily.

**CHEMICAL PROPERTIES:**

Ozone is chemically more reactive than ordinary diatomic molecular oxygen. It acts as powerful oxidizing agent because it dinociates readily forming atomic oxygen.

;

It oxidizes:

1. **into :**
2. **into :**
3. **into :**
4. **into :**

**USES:**

1. It is sometimes used in water treatment instead of chlorine.
2. It is used as bleaching agent.
3. It is largely used in the preparation of pharmaceuticals, synthetic lubricants and other commercially usefully organic compounds.

**IMPORTANCE:**

Ozone is an important component of the upper atmosphere, where it serves to screen out the ultra-violet radiation of the sun. In this way ozone protects the earth from the harmful effects of high energy rays.

**HYDROGEN PEROXIDES:**

**INTRODUCTION:**

Oxygen can combine with hydrogen to form two major oxides, (water) and (hydrogen peroxides). The nard was first to prepare by the action of dilute sulphuric acid on and named its Oxygenated water.

**LABORATORY PREPARATION:**

In laboratory it is prepared by the action of dilute sulphuric acid on (Barium peroxide).

**INDUSTRIAL PREPARATION:**

Hydrogen peroxide on large scale is usually manufactured by the oxidation of isopropyl alcohol with oxygen under reduced pressure

from the mixture can be separated by fractional distillation, under reduced pressure.

**PHYSICAL PROPERTIES:**

1. Pure hydrogen peroxide is a pale blue syrupy liquid.
2. It mixes with water to give solution which is slightly acidic.
3. It boils at with slight decomposition at .
4. Its freezing point is .

**CHEMICAL PROPERTIES:**

1. **DECOMPOSITION:**

It decomposes in the presence of as catalyst.

Decomposition of can be retarted (slowed down) by using glycerine.

1. **AS OXIDIZING AGENT:**

Hydrogen peroxide is an strong oxidizing agent because it can readily oxygen or accept electrons.

**EXAMPLES:**

1. With : (in acidic medium)
2. With :
3. **AS REDUCING AGENT:**

Hydrogen peroxide in the form of aqueous solution with can also behave as a reducing agent For Example:

1. **WITH : (IN ACIDIC MEDIUM)**
2. **WITH :**

**USES OF :**

1. As antiseptic: is used as a mild antiseptic in mouth wash as well as for cleaning wounds.
2. As bleaching agents: is used as bleaching agent in bleaching delicate materials like silk, wool, feathers and human hairs. It removes unwanted calour from fabrics, hair or other material.
3. As Restoring Paintings: Liquid is used for restoring paintings.
4. As fuel component: Liquid is used for providing oxygen for burning fuel in space rockets. It is also used for burning diesel oil in engines of submerged submarines which cannot use air.
5. Synthetic application: It is also used in the preparations of:
6. Sodium (III) chlorate .
7. Some Organic compounds which are used for initiating polymerization reaction.

**CHAPTER # 15**

**HALOGENS**

**INTRODUCTION:**

* Halogens are the elements of VII-A group of the periodic table.
* They includes Fluorine , Chlorine , Bromine , Iodine and Astatine .
* These elements are known as halogens a name derived from Greek word meaning “Salt producing” (Halo means Salt, Gene means producing), because these elements combine readily with metals to form salts.
* These are strong oxidizing agents.
* The last member of the family is Astatine, which is radioactive, shows different behavior and is rather unstable (astatos = unstable).
* They exhibit variable oxidation states in their compounds except Fluorine which shows an oxidation state-1 always.
* Halogens exist as diatomic molecules .
* Fluorine and chlorine are gases is of pale yellow in colour, chlorine is of greenish yellow gas or pale green in colours. Bromine is volatile reddish brown liquid. Iodine is shiny black solid that sublimes readily.

**PREPARATION OF CHLORINE**

**LABORATORY METHOD:**

Chlorine is usually prepared in the laboratory from hydrochloric acid. When conc. is gently heated with chlorine gas is produced.

**PROCEDURE:**

In this method is taken in round bottomed flask with conc. , fitted with a cork, containing a delivery tube. On gentle heating greenish yellow chlorine gas comes out which is collected by the upward displacement of air in a gas jar through the delivery tube.

Since it is a poisonous gas so efficient ventilation in the laboratory in necessary.

**INDUSTRIAL PREPARATION OF GAS:**

On large scale chlorine gas is manufactured by the electrolysis of sodium chloride solution in two types of cells.

1. Nelson’s cell
2. Castner Kellner’s cell

**NELSON’S CELL**

**CONSTRUCTION:**

1. Nelson’s cell consists of a U-Shaped perforated steel vessel, which acts as cathode.
2. The graphite anode is dipped in the salt solution, taken in the U-Shaped vessel.
3. The U-tube is separated form anode by as bestose layer or diaphragm, deposited on inner wall of the perforated U-tube.
4. The U-tube is known as anode compartment and this U-tube is fixed in an outer compartment, known as cathode compartment.

**WORKING:**

On passing electric current through the solution, chlorine gas is produced at anode, which rises into the dome at the top of the anode and is drawn away. metal is produced at cathode which interacts with water of the solution seeping through the diaphragm to release hydrogen gas with the formation of sodium hydroxide soln which is collocted at the bottom of the cathode compartment in a catch basin.

**Cell reactions:**

Ionization:

At Cathode:

At Anode:

Overall reaction

**CASTNER-KELLNER’S CELL**

**CONSTRUCTION:**

1. Castner Kellner’s cell consists of two compartment first cell is called Electrolyzer and second cell is called soda cell or denuder.
2. First cell consists of a steel tank. A number of graphite or titanium blocks acts as anode and a stream of mercury flowing across the bottom of the cell acts as cathode. (It is called moving mercury cathode).

**WORKING:**

On passing electric current, chlorine is discharged at the anode and sodium at cathode, where it is dissolved in the to form sodium amalgam. The sodium amalgam is removed from the cell.

The following reactions take place

Ionization:

Anode Reaction:

Cathode Reaction:

**REACTIONS IN SODA CELL:**

The sodium amalgam flows into a separate chamber called soda cell. In this cell the amalgam mixed with water, producing sodium hydroxide and releases gas pure mercury is regenerated and recycled through mercury pump.

**ADVANTAGES OF PROCESS:**

1. The process is very efficient.
2. The process gives product of high purity.
3. The possible reaction between and gas is avoided by obtained and gas in the separate chambers.

**DISADVANTAGES OF THE PROCESS:**

1. The process consumer large amount of current.
2. Inspite of strict control, some mercury vapours escape from the factory. This mercury contaminates sea water. As a result mercury becomes part of tissues of marine animals and plants resulting in pollution of food chain.

**PHYSICAL PROPERTIES OF CHLORINE GAS:**

1. Chlorine is greenish yellow gas.
2. It has sharp, pungent disagreeable and irritating checking smell.
3. It produces inflammation in the nose and throat, if inhaled in considerable quantity and cause congestion in the lung tissues.
4. It is fairly soluble in water and its solution is called chlorine water.
5. Its density is at S.T.P.
6. It is times heavier than air.
7. It shows variable oxidation states in its compounds. Such as (the most common oxidation state),.
8. Its boiling point is .
9. Its freezing point is .

**CHEMICAL REACTIONS OF CHLORINE GAS:**

1. **REACTION WITH HYDROGEN:**

Chlorine undergoes addition reaction with Hydrogen gas quickly in the presence of sunlight to form Hydrogen Chloride gas.

1. **REACTION WITH METALS:**

Practically all metals (except noble metals) combines with chlorine gas on heating to form their chlorides e.g:

1. **REACTION WITH NON-METALS:**
2. **WITH PHOSPHOROUS:**
3. **WITH SULFUR:**
4. **ADDITION REACTIONS:**

* is a poisonous gas and is used as a chemical weapon in wars.

1. **SUBSTITUTION REACTIONS:**

Chlorine undergo addition reactions with a lot of compounds. E.g.

**WITH METHANE:**

Chlorine undergoes substitution reactions with methane in the presence of sunlight. It is an example of photochemical chain reaction.

1. **WITH ALKALIES LIKE :**
2. When chlorine gas is passed through caustic soda solution in cold, then sodium hypochlorite and chloride are formed.
3. If excess of gas is passed through hot solution of , sodium chlorate is produced.
4. **REACTION WITH AMMONIA:**

Chlorine reacts with ammonia violently to form nitrogen and hydrogen chloride. Hydrogen chloride then combines with excess of ammonia to produce white fumes of .

1. **REACTION WITH LIME WATER:**

Chlorine reacts with lime water in three ways.

1. **WITH COLD AND DILUTE LIME WATER IN EXCESS:**

When is reacted with excess of cold and dilute lime water, calciumhypochlorite is produced.

1. **WITH HOT LIME WATER IN EXCESS OF CHLORINE:**

When excess of is reacted with hot lime water calcium chlorate is produced.

1. **PASSING GAS OVER DRY SLAKED LIME:**

When gas is passed over dry slaked lime at about , bleaching powder is produced.

1. **WITH WATER (BLEACHING ACTION):**

Chlorine in the presence of water acts as powerfull oxidizing agent and bleaching agent, due to the formation of hypochlorous acid, reacts with water and undergoes auto redox reaction forming hypochlorous acid and hydrochloric acid.

The reaction proceeds as,

1. **OXIDATION OF :**
2. **OXIDATION OF SULPHUROUS ACID:**

The reaction occurs as:

**USES OF CHLORINE:**

The production and consumption of on large scale make it one of the most important chemical of chemical industry and national economy.

1. It is used in the manufacture of chloroform , carbontetrachloride , and production of Sulphumonochloride .
2. It is used in the manufacture of vinyl chloride and poly vinyl chloride .
3. It is used in the preparation of D.D.T and hexachlorocydohexane; effective pesticides.
4. It is used in the preparation of Bleaching powder which is used in bleaching cotton, liner and clothes.
5. It is used for sterilizing drinking water and disinfecting drainages and sewers to kill bacteria.
6. It is used is the production of some poisonous gases of warfare such as phosgene , chloropicrin and mustard gas .
7. Chlorine is used extensively in the production of dyes, drugs, explosives etc.
8. It is also used in the layes test for the identification of bromide and iodide ions.

**HYDROCHLORIC ACID**

**LABORATORY PREPARATION:**

The most common laboratory method for the preparation of hydrochloric acid, is by the action of Conc. on common salt .

**METHOD:**

1. In this method, common salt is placed in a round bottom flask, fitted with a thistle funnel and a delivery tube.
2. Concentrated is added from the thistle funnel over common salt, thistle funnel should be dipped in .
3. The reaction starts at once with effervescence to liberate gas.
4. When gas evolution slakens, the flask is gently heated to get faster supply of gas, which is collected through the delivery tube in gas jar by the upward displacement of air.

**INDUSTRIAL PREPARATION:**

1. **BY DIRECT COMBINATION OF AND :**

Hydrochloric acid is commercially prepared in the pure state by the direct combination of hydrogen and chlorine gas.

The reaction is strongly exothermic. The gas mixture is burnt in brick lined furnace, using water cooled iron nozzle. A small excess of gas is usually used to minimize corrosion. Gases from the furnace are absorbed in water.

1. **BY HYDROLYSIS OF :**

Hydrochloric acid from the chlorides of non-metals, such as is obtained by the action of with water.

1. **BY ACTION OF ON AND :**

Hydrochloric acid can also be obtained by the action of chlorine over hydrogen compounds.

**PROPERTIES:**

1. **PHYSICAL PROPERTIES:**
2. Hydrogen chloride is a colourless gas with strong acidic odour and acidic taste.
3. It is highly soluble in water to form hydrochloric acid.
4. It is slightly heavier than air and fumes strongly in moist air.
5. **CHEMICAL PROPERTIES:**
6. **REACTION WITH WATER:**
7. **REACTION WITH ALKALIES:**
8. **REACTION WITH AMMONIA:**
9. **REACTION WITH LESS ELECTROPOSITIVE METALS:**
10. **REACTION WITH METAL CARBONATES AND BICARBONATES:**
11. **REACTION WITH AND (PRECIPITATION):**

**USES:**

1. Hydrochloric acid is used for the picking of iron and steel that is to remove the rust from the metal surface.
2. It is used in the manufacture of dyes, plastics, medicines, rubber, chlorides etc.
3. It is used as chemical reagent in the Laboratory.
4. It is used to remove deposits from sanitary wares and floors.

**BLEACHING POWDER**

**INTRODUCTION:**

Bleaching powder is a mixed salt of calcium with chloride and oxychloride. Professor Odling suggested the formula of bleaching powder as,

On the basis of the available percentage of chlorine.

**PREPARATION:**

1. **LABORATORY PREPARATION:**

In the laboratory bleaching powder is prepared by shaking a small quantity of slaked lime, with chlorine in a jar, a white powder is produced.

1. **COMMERCIAL PREPARATION:**

On large scale bleaching powder is prepared by Hasenclever process. The Hasenclever plant consists of four, iron cylinder 2 to 3 meter long in which chlorine gas is passed in the opposite direction to come in contact with slacked lime which is blown from top of the cylinders by means of compressed air and is allowed to fall. Chlorine is completely absorbed in the upper cylinders where fresh slacked lime enters. The reaction occurs to form bleaching powder.

An off white amorphous powder (bleaching powder) with the smell of chlorine is removed dried and packed in wooden vats and kept in the dark for some time. It is stored in well-ventilated rooms.

**PROPERTIES:**

1. **PHYSICAL PROPERTIES:**
2. Bleaching powder is yellowish white amorphous powder.
3. It is soft powder.
4. It gives a strong smell of chlorine.
5. **CHEMICAL PROPERTIES:**
6. **REACTION WITH WATER:**

Bleaching powder is generally used with reasonable quantity of water. In water, it liberates gas on reaction.

It also decomposes into and in presence of excess of water and acts as strong bleaching agent.

1. **REACTION WITH STRONG ACIDS:**

Bleaching powder reacts with strong acids like to liberate gas.

1. **REACTION WITH IN THE PRESENCE OF MOISTURE (WITH WEEK CARBONIC ACID):**

Bleaching powder reacts slowly with carbon dioxide of air in the presence of moisture in the air to hypochlorous acid which oxidizes and destroys impurities in the surrounding atmosphere.

1. **REACTION WITH AMMONIA:**

When bleaching powder is treated with solution of ammonia, gas evolver.

**USES:**

1. Bleaching powder is used for sterilization of drinking water and disinfecting drainages and sewers.
2. It is used for bleaching of cotton, linen and paper pulp.
3. It is used for the quick preparation of gas which is a powerful oxidizing agent.
4. It is also used to prepare hypochlorous acid .

**CHAPTER 18**

**CHEMICAL INDUSTRIES**

**AMMONIA SOLVAY’S PROCESS**

**INTRODUCTION:**

The method commonly used for the preparation of sodium bi carbonate and sodium carbonate was designed by a Belgian engineer Solvay and is called Solvay’s process.

**RAW MATERIALS:**

1. Saturated solution of NaCl (Brine)
2. Ammonia
3. Lime stone
4. Water

**STEPS OF MANUFACTURING:**

1. **AMMONIATION OF BRINE:**

Ammonia gas containing a little is passed through brine to saturate it.

Salts of magnesium and calcium are precipitated as carbonates, if present as impurities:

1. **CARBONATION:**

The ammonical brine is passed to carbonating tower (solvay tower) where is pumped in at the bottom of the of the tower following reactions take place,

* required in this step is obtained by heating calcium carbonate in a special kiln called lime kiln.

1. **FILTRATION:**

The solid sodium bi carbonate is filtered off, washed with a little water and dried, whereas filtrate is sent to ammonia recovery tower.

1. **CALCINATION OF SODIUM BI CARBONATE:**

Sodium bi carbonate obtained in the above step is heated to get anhydrous sodium carbonate i.e. soda ash.

Carbon dioxide obtained here is recycled for carbonation. If washing soda i.e. is required then dissolved soda ash in hot water and crystallize by cooling as .

1. **RECOVERY OF AMMONIA:**

An ammonia is much more costly than sodium carbonate or sodium bi carbonate therefore it is recovered in ammonia recovery tower by the following processes.

**ADVANTAGES OF SOLVAY’S PROCESS:**

1. It employs cheap materials.
2. The consumption of fuel is much less, since there is no solution to evaporate.
3. No harmful by products are produced.
4. A pure product is obtained.
5. Raw materials and are recovered and recycled.

**CHEMICAL REACTIONS OF SODIUM CARBONATE:**

1. **HYDROLYSIS:**

Hydrolysis of sodium carbonate produces strong alkali. That is why aqueous solution of sodium carbonate is alkaline in nature.

1. **REACTION WITH :**

When is passed through a cold solution of sodium carbonate, sodium bi carbonate is formed.

1. **ACTION OF DILUTE ACIDS:**

On treating with dilute acid it produces carbon dioxide.

1. **PRECIPITATION OF INSOLUBLE METALLIC CARBONATES:**

Precipitation of metallic carbonates are occurs when aqueous solution of sodium carbonate is mixed with the solution containing metallic cation.

**USES:**

1. Soda ash is used in the manufacture of glass enamels, soaps and paper.
2. It is used for water softening.
3. Sodium carbonate is marketed as washing soda.
4. It is used as a common laboratory reagent.
5. It is used in the smelting of iron ores of high sulphur content.

**SODIUM HYDROGEN CARBONATE**

**PROPERTIES OF SODIUM HYDROGEN CARBONATE:**

1. **PHYSICAL PROPERTIES:**
2. It is white non-crystalline compound.
3. It’s taste is bitter, although commonly known as meetha (sweet) soda.
4. It is soluble in water, but its solubility is less than that of sodium carbonate.
5. It is weekly alkaline and its solution changes red litmus to blue.
6. **CHEMICAL PROPERTIES:**
7. When heated, it loses carbon dioxide and changes to sodium carbonate.
8. With acids it forms salts and water. Carbon dioxide is also given out.

**USES OF SODIUM HYDROGEN CARBONATE:**

1. It is used as baking powder .
2. Used in fire extinguishers to get gas for extinguishing fire.
3. Used as an anti-acid (medicine) to cure acidity (hyper acidity).
4. Used in preparation of effervescent drinks and fruit salts.
5. Used in the textile, tanning, paper, ceramic’s industries.

**PROPERTIES OF SODIUM HYDROXIDE**

1. **PHYSICAL PROPERTIES:**
2. It is a white crystalline solid.
3. It melts at to a clear liquid, and at , it decomposes.
4. It density is .
5. It is highly soluble in water and liberate large amount of heat.
6. **CHEMICAL PROPERTIES:**

The chemical reactions of are following:

1. **REACTION WITH ACIDS:**

It reacts with acids to form salt and water. For example,

3. **REACTION WITH AMMONIUM SALTS:**

When reacts with ammonium salts, liberating ammonia gas on warming. For example,

2. **REACTION WITH CARBON DIOXIDE:**

It absorbs carbon dioxide to produce sodium carbonate and water.

1. **REACTION WITH CHLORINE GAS:**

The reaction of sodium hydroxide with chlorine gas results in the formation of sodium salt of oxy acids such as,

1. **REACTION WITH METALS:**

Sodium hydroxide dissolves certain metals like zinc, tin, aluminium etc to liberate gas.

**USES OF SODIUM HYDROXIDE:**

1. It is used in the manufacture of soap and petroleum industry.
2. It is used in textile and paper industries.
3. It is used in bleaching and dyeing process as well as for mercerizing the cotton cloth.
4. It is used in purification of bauxite.
5. It is used in manufacture of artificial silk.

**FOOD PRESERVATION**

**INTRODUCTION:**

Food whether grown on trees e.g. fruits, in the ground as plants e.g. vegetables, cereals etc. or as animals e.g. mutton, beef etc. above the ground do not last forever. Fruits, vegetables and cereal grains begin to deteriorate once they are harvested. Similarly meat begins to deteriorate in quality soon after slaughter of the animal.

In this modern world, the food needs to be stored or supplied to distant areas, it is therefore necessary to prevent the food from being destroyed or spoiled.

**CAUSES OF FOOD SPOILAGE:**

The food may subject to several decay mechanisms. For example:

* Moisture.
* Biological attack by pests.
* Disease or decay micro-organisms.
* Chemical reactions.
* Physical changes.

The producer and processor therefore want to prevent or minimize changes of spoilage of the foods.

1. **MOISTURE:**

The agricultural products of law moisture contents such as corn and soyabean when exposed to higher humidity take up enough moisture contents to permit the growth of moulds and bacteria.

1. **MICROBIAL ACTIVITIES:**

There are several kinds of food which tend to spoil by microbial attack. Fish, poultry and dairy products are specifically spoiled by microbial growth.

1. **CHEMICAL CHANGES:**

The chemical changes brought by enzymes are responsible for food spoilage. There enzymes may have their origin in the food material or may be produced by yeast, moulds and bacteria which contaminate the product. The chemical and biochemical changes renders the fats and oil rancid and are also responsible for browning of fruits and vegetables.

**FOOD PRESERVATION METHODS**

There are numerous methods of preservation of foods. Some of the most widely used ones are described here.

1. **REMOVAL OF MOISTURE:-**

This method of preservation of food relates with removal of water or drying process. The products that needs to be dried are the various pastes, milk, coffee and tea, some vegetable, fruits, meat and eggs.

1. **ADDITION OF SALT AND SUGAR:-**

As a means of chemical preservation, sugar and salt are added to many sausages to increase their shelf life. The sugar and salt bind the water, which helps the microrganisms to grow. The inhibition in growth of microbes by this way retards the process of food spoilage. The water binding agents are known as humectants.

1. **TEMPERATURE CONTROL:**

One of the controlling factor for preservation of food is temperature. Environmental conditions related to temperature though not destroy organisms however it prevents their growth. Refrigeration and freezing of foods in this respect lowers the environmental temperature to levels which do not allow the growth of many destructive organisms.

1. **PRESERVATION BY STORAGE:**

Many types of fresh such as fruits, vegetables, meats, fish etc. when required to be stored for long term are preserved by heat treatment employing various methods. Amongst these methods canning and irradiation are noteworthy.

1. **CANNING:**

The preservation of food by sealing into air tight containers is called canning. This method is widely used for food preservation. The containers may be metal which is often plastic-lined aluminum or special strength glass/. The raw food is packed into the container sealed and the whole package is used to cook the food and sterilize both the container and the contents.

1. **IRRADIATION:**

The process of passing radiation through any substance is called irradiation. The radiation is comprised of alpha , beta and gamma rays.

Radiation can be used to preserve food such as meat, potatoes and onions etc without causing undesirable protein denaturation or appreciably altering the taste. The process leaves no residual radioactivity in the food. There is a little loss of vitamins in all foods by the recommended doses than that seen with canning, freezing or drying.

1. **PRESERVATION BY CHEMICAL ADDITION:**

Certain chemical substances are added in small proportions to preserve food. In this regard commonly used food additions are salts of calcium, magnesium, potassium and sodium.

1. The use of sodium sulphite and potassium meta-bi-sulphite is to prevent the growth of micro-organisms.
2. Sodium di hydrogen phosphate is incorporated to improve the texture and magnesium hydroxide reduce the acidity in foods.
3. Addition of common salt preserves meat and fish items.
4. Propionic acid, benzoic acid and their salts prevents the bread and cheese from moulds and yeasts.
5. Dry fruits, Jam and jellies are preserved by addition of sulphur dioxide or salts of sulphurous acid.

**SOAPS**

**DEFINITION: -**

The sodium and potassium salts of fatly acids used for cleansing purpose are called soaps.

**Examples:**

1. Potassium palmitate
2. Sodium stearate
3. Sodium palmitate
4. Potassium oleate

**RAW MATERIALS:**

1. **TALLOW:** It is the main fatly materials used in soap making Vegetable oil like linseed oil or palm oil and animal fat can also be used in place of tallow.
2. **CAUSTIC SODA OR CAUSTIC POTASH:**

**MANUFACTURE OF SOAP: (SAPONIFICATION)**

Large units known as kettles are used for preparation of soap now a days. Animal fat or vegetable oil is placed in large tank and alkali is added.

The mixture is mixed with steam and boiled during reaction using a steam coil.

The chemical process for the preparation of soap is called saponification. The reaction is represented by the following equation.

**SEPARATION OF GLYCERINE: (SALTING OUT)**

Salt is added to the soap and glycerine mixture. Salt solution with glycerine settles down as it is heavier than soap. This process is called salting out.

The salt water glycerine solution is drained from the tank and glycerine as a by product is separated.

**TYPES OF SOAP:**

**LAUNDRY SOAP:**

Soap precipitated is mixed with resin, some more caustic soda solution is added and mixture is boiled.

To increase its weight sodium silicate is added which also makes it less soluble. Washing soda and sodium phosphate are added to improve washing quality. It is now moulded into soap cake or blocks.

**TOILET SOAP:**

Good quality fat and edible oils are used for toilet soap. Soap is passed through hot heavy rollers to remove the moisture colour and perfumes are added to it and casted into soap cakes.

**KITCHEN SOAPS:**

The soaps containing finely divided sand, washing soda are called kitchen soaps. It is used in kitchen for washing utensils.

**SHAVING CREAM:**

Good quality animal fat or edible oil is saponified using caustic potash . Some extra amount of stearic acid is added to prevent it from quick drying.

**PLASTICS**

**DEFINITION:**

Plastics are high molecular compounds formed as a result of polymerization or poly condensation of simple molecules.

**CLASSIFICATION:**

Plastics are divided into two basic types:

1. Thermoplastics.
2. Thermosetting plastics.

**THERMOPLASTICS:**

On heating these plastics become soft. On cooling they regain their rigidity they can be heated and cooled repeatedly without any change in composition. Such plastics are easily moulded into shapes.

**Examples:**

Cellulose nitrate, cellulose a cetate and vinyl polymers are examples of this class.

**THERMOSETTING PLASTICS:**

Thermosetting plastics becomes soft on heating on further heating, they become permanently hard. They cannot be softened again. They are practically insoluble in all organic solvents and water.

**Examples:**

Bakelite, epoxes resins (araldite and adhesives)

**Some common plastics and their uses:**

1. **POLYTHENE (POLYETHYLENE):**

It is the polymer of ethane.

It is most commonly used in the preparation of polythene bags and plastic bottles.

1. **POLY VINYL CHLORIDE:**

It is the polymer of vinyl chloride:

1. **BAKELITE:**

It is the polymer of phenol and form aldehyde.

It is used to manufacture components of switches, electric board sheets, camera, radio, telephone etc.