**PERIODIC CLASSIFICATION**

**CLASSIFICATION OF ELEMENTS:**

The method of arranging similar elements in the same group and separating them from dissimilar elements is known as classification of elements.

**IDEA OF CLASSIFICATION:**

The idea of classification of elements was obtained from Dalton’s atomic theory according to which:

“The atoms of different elements possess different masses and different properties.”

**ATTEMPTS TO CLASSIFY ELEMENTS:**

The various attempts to classify elements are described as follows:

1. **DOBEREINER’S TRIADS:**

In 1829, Johann Wolfgang Dobereiner, a German Chemist, proposed his law of traids. (Triad means a group of three).

According to his law,

“The elements can be classified into group of three elements in such a way that the atomic mass of the middle element is approximately equal to the average of the atomic masses of the other two elements.”

**EXAMPLES:**

|  |  |  |  |
| --- | --- | --- | --- |
| Triad |  | Atomic mass | Arithmetic Mean |
| Lithium | 7 |  |
| Sodium | 23 |
| Potassium | 39 |
|  |  |  |  |
| Triad | Chlorine | 35.5 |  |
| Bromine | 80 |
| Iodine | 126.5 |

**DRAWBACK: -**

The law of triads was found to be valid only for few elements, hence it was rejected.

1. **NEWLAND’S LAW OF OCTAVES:**

In 1863, Newland proposed a law which he gave the name, the law of octaves. It states that,

“When the elements are arranged in the order of increasing atomic masses, every eight element starting from a given one is similar to the first.”

**EXAMPLES OF NEW LAND’S OCTAVES**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|  |  |  |  |  |  |  |
| H | Li | Be | B | C | N | O |
| F | Na | Mg | Al | Si | P | S |
| Cl | K | Ca | Cr | Ti | Mn | Fe |

**DRAWBACK:**

This law is applicable to only few elements and when applied to all elements it fails.

1. **LOTHER MEYER’S CLASSIFICATION:**

Lother Meyer, a German chemist classified the elements on the basis of a physical property of elements “ATOMIC VOLUME”

**MEYERS ATOMIC VOLUME CURVE:**

Meyer plotted a graph between the atomic volume and atomic weight. He found that elements with similar properties occupies similar positions on the curve.

**FOR EXAMPLE:**

1. Lithium, Sodium and potassium (alkali metals) appear on the peak, showing that alkali metals have large volume.
2. Fluorine, Chlorine and Bromine occur just before the peak, indicating smaller molar volume.
3. Gases, Volatile elements and elements having low m.p occupies the ascending position of the curve.
4. Elements having high m.p. are found at the descending position.

**DRAWBACK: -**

1. Meyer’s periodic table was incomplete as compared with Mendeleev’s table, published in the same year.
2. Meyer’s classification was supported by a study of various physical properties such as atomic volume, malleability, brittleness and no logical classification.

**MENDELEEV’S PERIODIC TABLE**

In 1869, Mendeleev, a Russian Chemist arranged 63 discovered elements in the sequence of their increasing atomic weights, in a tabular form which is called Mendeleev’s Periodic Table and stated a law which is called Mendeleev’s periodic law.

**MENDELEEV’S PERIODIC LAW**

“The properties of elements are the periodic functions of their atomic masses.”

**ADVANTAGES OF MENDELEEV’S PERIODIC TABLE**

1. **SYSTEMATIC STUDY OF ELEMENTS:**

Mendeleev’s periodic table helped chemists to study the elements more easily and systematically. For instance, the study of sodium metal helped chemist to a large extent to predict the properties of its group elements.

1. **PREDICATION OF PROPERTIES OF ELEMENTS:**

Mendeleev predicted the properties of those elements which were not discovered by that time and their spaces were left blank in the periodic tables. His prediction of properties proved to be remarkably accurate for example:

|  |  |  |
| --- | --- | --- |
| **PROPERTIES** | **EKA SILICON (Predicted)** | **GERMANIUM (reported)** |
| Atomic mass | 72 | 72.3 |
| Colour | Dark Grey | Greyish white |
| Boiling point | Less than |  |

1. **BLANK SPACES FOR UNDISCOVERED ELEMENTS:**

In order to maintain families of chemically similar elements, he left blank spaces in his table for undiscovered elements.

1. **DETERMINATION OF ATOMIC WEIGHT:**

The number of group of an element represents its valence. This helped Mendeleev to calculate the atomic masses of the elements from the formula.

1. **CORRECTION OF DOUBTFUL ATOMIC WEIGHTS:**

Mendeleev’s table helped to correct the doubtful atomic masses of elements. For example the atomic mass of indium was calculated to be but it was corrected to later on.

**DEFECTS IN MENDELEEV’S PERIODIC TABLE**

1. **POSITION OF HYDROGEN:**

Mendeleev’s periodic table failed to specify the position for hydrogen.

1. **POSITION OF ISOTOPES:**

Mendeleev’s periodic table also failed to specify the position for isotopes of elements.

1. **POSITION OF RAVE-EARTHS:**

Positions for rare-earths were not provided.

1. **SIMILAR ELEMENTS PLACED IN DIFFERENT GROUPS:**

Elements with many similar properties such as were placed separately.

1. **DISSIMILAR ELEMENTS PLACED IN THE SAME GROUP:**

Alkali metals were placed with coinage metals .

1. **MISFIT PAIRS OF ELEMENTS:**

Elements of higher atomic masses were placed earlier than elements of lighter atomic masses. For example:

**Q: How the defects in the Mendeleev’s Periodic Table were corrected by Moseley?**

**MOSELEY’S MODERN PERIODIC LAW**

Moseley showed in 1911 that, since the physical and chemical properties of an element depend upon the number of electrons & their arrangement in different orbitals of the atom. This idea led Moseley to predict that most of the defects of Mendeleev’s periodic table disappear, if the basis of classification of elements is changed to atomic number in place of atomic weight. Accordingly Moseley’s put forward Modern Periodic law which states as follows:

“The properties of elements are the periodic function of their atomic number, i.e. if the elements are arranged in the increasing order of their atomic number, the properties of the elements (i.e. similar elements) are repeated after definite regular intervals or periods.”

With the replacement of atomic weight by atomic number as the basis of classification of elements, many irregularities in the Mendeleev’s table disappear as shown below.

1. **POSITION OF HYDROGEN:**

The dual role of hydrogen is explained by the fact that it has one electron in its outer shell. It has equal tendency of gaining or losing one electron for assuming a stable configuration. When it loses one electron to give , it resembles alkali metals while it gains one electron to give , it resembles with halogens.

1. **ANOMALOUS PAIRS OF ELEMENTS:**

This anomaly disappears altogether & the pairs are found arranged in the table in the order in the increasing atomic numbers.

1. **POSITION OF RARE EARTHS:**

Moseley’s periodic law justifies the separate position of Rare Earths as they possess same properties.

1. **POSITION OF ISOTOPES:**

Since isotopes of the same element possess the same atomic number, all of them should occupy one and the same place in the periodic table.

**MODERN PERIODIC LAW AND PERIODIC TABLE**

In 1913, Henry Moseley, a British Physicist, found that it is not the atomic weight but the atomic number which is the fundamental property of an atom which is most suitable for the arrangement of elements.

**MODERN PERIODIC LAW**

“The physical and chemical properties of elements are the periodic function of their atomic numbers.”

**MODERN PERIODIC TABLE**

In order to prepare modern periodic table the International Union of Pure and Applied Chemistry (IUPAC) in 1892 recommended to arrange the elements in the ascending order of their atomic number instead of atomic weight to prepare periodic table.

Modern periodic table (which is also called long form of periodic table) consists of Group and periods.

**PERIODS**

Horizontal rows of elements in the periodic table are called periods. There are seven periods in the Modern periodic table.

**PERIOD – 1:** This period corresponds to filling up of K-Shell. It is the shortest period and contains only 2 elements with electronic configuration .

**PERIOD – 2:** This period corresponds to filling up of L-Shell. In this period electron occupy 2s and 2p orbitals. Therefore, it contains 8 elements from to . It is called first short period.

**PERIOD – 3:** This period corresponds to the filling up of M-Shell. In this period 3s and 3p orbitals are being filled. It start from Na and ends at Ar. This period also contains 8 elements and is called second short period.

**PERIOD – 4:** This period corresponds to the filling up of N-Shell. It starts with filling of 4s orbital followed by 3d and 4p orbital. It contains 18 elements. It is called first long period.

**PERIOD – 5:** This corresponds to the filling up of O-Shell. It starts with the filling of 5s orbital followed by 4d and 5p. it contains 18 elements. It is called second long period.

**PERIOD – 6:** This period includes 2 elements of s-block with configuration . 10 elements of d-block with configuration elements of f-block with configuration (Lanthanides). This is an exceptional case where electrons are accommodated in 4f orbitals after 5d electrons.

**PERIOD – 7:** This period includes 2 elements of s-block with configuration . 10 elements of d-block with configuration and 14 elements of f-block with configuration (Actinides). This is also an exceptional example where electrons are accommodated in 5f orbitals after 6d acquires one electron.

General characteristics of periods

1. Each period starts with an alkali metal (except 1st periods) and ends at noble gas (except 7th period).
2. The number of valance electrons increases while we move across the period.
3. Metallic character decreases from left to right.
4. Non-metallic character increases from left to right.
5. In a period number of shell remains the same.
6. Atomic volume decreases from left to right.

**GROUPS**

The vertical columns of elements arranged in the periodic table are called groups. These groups are designated by Roman numerals and a letter either A or B.

**GROUP I-A:**

The members of this group are called alkali metals. Their valence shell electronic configuration is (where n is the no. of shell).

**GROUP II-A:**

The members of this group are called alkaline earth metals. Their valence shell electronic configuration is (where n is the no. of shell).

**GROUP III-A:**

The members of this group are called Boron family. Their valence shell electronic configuration is .

**GROUP IV-A:**

The members of this group are called Carbon family. Their valence shell electronic configuration is .

**GROUP V-A:**

The members of this group are called Nitrogen family. Their valence shell electronic configuration is .

**GROUP VI-A:**

The members of this group are called Oxygen family. Their valence shell electronic configuration is .

**GROUP VII-A:**

The members of this group are called Carbon family. Their valence shell electronic configuration is .

**ZERO-GROUP OR GROUP VIII-A:**

Members of this group are called Noble gases. Their valence shell electronic configuration is .

**PERIODICITY**

**DEFINITION:**

“The repetition of the similar physical and chemical properties of elements after specific intervals due to repetition of similar valence shell electronic configuration is called periodicity.”

**CAUSE OF PERIODICITY:**

Chemical properties of elements depends upon the number of valence electrons, hence elements with similar valence shell configuration tend to show similar chemical properties thus,

“The cause of periodicity of properties is the repetition of similar valence shell electronic configuration after regular intervals of 2, 8, 8,18 and 32 in atomic number.”

On this basis, now modern periodic law may be restated as:

“The physical and chemical properties of elements are a periodic function of the electronic configuration of their atoms which vary with increasing atomic number in a periodic manner.”

**TYPES OF ELEMENTS BASED ON ELECTRONIC CONFIGURATION**

On the basis of electronic configuration, the periodic table has been divided into s, p, d and f-blocks, which contains following types of elements.

1. Representative or Typical Elements.
2. Nobles Gases.
3. Outer transition elements (d-block elements).
4. Inner transition elements (f-block elements).
5. **REPRESENTATIVE OR TYPICAL ELEMENTS: -**

All elements of sub-group A of the periodic table are called representative or typical elements. They include metals, non-metals and metalloids. These include elements of s and p blocks.

1. **S-BLOCK ELEMENTS:**

The elements of I-A and II-A belong to s-block. The valence shell configuration of s-blocks is where ‘n’ is the period number.

1. **P-BLOCK ELEMENTS:**

The elements in which p orbitals are being progressively filled are called p-block elements. The elements of the group III-A, IV-A, V-A, VI-A and VII-A are the members of p-block. The valence shell configuration of these elements ranges from where ‘n’ is the period number.

1. **THE NOBLE GASES:**

In the periodic table, the noble gases are found at the end of each period in zero group. With the exception of Helium (z = 2), all the noble gases have outer electronic configuration of . No atom has a complete outer shell with the exception of noble gases.

1. **D-BLOCK ELEMENTS: (OUTER TRANSITION ELEMENTS)**

The elements in which the last electron enters (n-1)d orbitals in which the last or outer transition elements or d-block elements. The valence shell electronic configuration of these elements ranges from .

These elements are placed in the middle of periodic table between s and p block elements they consist of 4 series of 10 elements.

* 1st series of d-block from .
* 2nd series of d-block from .
* 3rd series of d-block from .
* 4th series of d-block from onwards in complete.

1. **F-BLOCK ELEMENTS: (INNER TRANSITION ELEMENTS)**

The elements in which the last electron enters (n-2)f orbital are called f-block elements or inner transition elements. They have outer electronic configuration: .

f-block elements consist of two series of 14 elements each:

* 1st series of f-block from .
* 2nd series of f-block from .

**ADVANTAGES AND DISADVANTAGES OF THE PERIODIC CLASSIFICATION**

* **ADVANTAGES: -**

1. It is based on the most fundamental property (i.e. atomic number) of elements. This is why it has no problem for the position of isotopes of elements.
2. It divides the elements into four block i.e. s-block, p-block, d-block and f-block.
3. It draws a clear line between metals, non-metals and metalloids.
4. The position of elements in the periodic table indicates their electronic configuration.
5. It can help to predict new elements and their properties before their discoveries.
6. It makes the study of the properties of the elements and their compounds simple and easy.

* **DISADVANTAGES: -**

1. Position of Hydrogen and Helium has still not been decided.
2. Lanthanides and actinides have still not been adjusted in the main body of the periodic table.
3. Group VIII-B consists of three columns.
4. Some properties such as specific heat of elements have no relationship with the periodic classification.

**HYDROGEN**

**INTRODUCTION: -**

Hydrogen was discovered by Cavendish in 1766 when he treated a metal with dilute acid.

Hydrogen exists in the gaseous state in nature at normal temperature and pressure. It is the lightest element in nature. Its molecule is . Its atomic number is one and atomic mass is 1.008. it occurs in the free states as well as in the combined state in nature.

**POSITION OF HYDROGEN IN PERIODIC TABLE**

Hydrogen is the first element of the periodic table. It resembles with alkali metals of group I-A, halogens of group VII-A and elements of group IV-A. this makes its position in the periodic table anomalous.

1. **POSITION OF HYDROGEN WITH ALKALI METALS (I-A GROUP)**
2. **SIMILARITIES: -**
3. Like alkali metals, hydrogen has one electron in its outer most shell.
4. Lake alkali metals, hydrogen lose one electron to form uni-positive ion.
5. Like alkali metals, hydrogen shows oxidation state and one valence.
6. Both hydrogen and alkali metals combine with halogen to form halides, e.g. HCL, NaCl, etc.
7. Compounds such as halides of both hydrogen and alkali metals ionize in aqueous solution to form positive ions such as etc.
8. Like alkali metals, hydrogen is liberated as cathode when fused halides of alkali metals and hydrogen halid are electrolyzed.
9. **DISSIMILARITIES: -**
10. Hydrogen is a gas whereas alkali metals are solids.
11. Hydrogen exists as whereas alkali metals exist in monoatomic form.
12. Hydrogen needs only one electron to complete its valence shell whereas alkali metals need seven electrons to complete their valence shells.
13. Oxides of hydrogen i.e. is neutral whereas oxides of alkali metals such as is basic.
14. The outermost shell of hydrogen atom is half filled with one electron while alkali metals do not.
15. Hydrogen forms hydride on by gaining an electron whereas alkali metals do not.
16. Hydrogen forms covalent compounds as well as ionic compounds, while alkali metals form only ionic compounds.
17. **POSITION OF HYDROGEN WITH HALOGENS: (VII-A GROUP)**
18. **SIMILARITIES: -**
19. Hydrogen is a gas like most of the halogens.
20. Hydrogen is stable in the form of diatomic molecules like halogens.
21. Hydrogen like halogens requires only one electron to complete outer most shell.
22. Binary compounds of both hydrogen and halogen with alkali metals have same structures. E.g. both have cubic structure.
23. Both hydrogen and halogen gains one electron to form univalent an ions like .
24. Both hydrogen and halogen react with carbon and silicon to form similar compounds like .
25. **DISSIMILARITIES: -**
26. Hydrogen is a gas whereas some of the halogen are liquid and solid at ordinary temperature.
27. Hydrogen has only one electron in its valence shell whereas halogens have seven.
28. A hydride ion is unstable in water, whereas a halide ion is water stable Hydride ion reacts with water liberating gas.
29. Oxide of hydrogen i.e. is neutral whereas oxide of halogen such as is acidic.
30. The outermost shell of hydrogen atom is considered to be half-filled and halogens are not.
31. Hydrogen preferably forms covalent molecules whereas halogens mostly form ionic compounds.
32. **POSITION OF HYDROGEN WITH CARBON FAMILY: (IV-A GROUP)**
33. **SIMILARITIES: -**
34. The valence shell of hydrogen is half filled like those of group IV-A elements.
35. Hydrogen forms covalent bond by sharing of electrons like members of group IV-A.
36. Thermodynamic properties such as ionization potential and electron affinity of hydrogen are similar to those of group IV-A elements.
37. Hydrogen can form an ion like .
38. **DISSIMILARITIES: -**
39. Hydrogen is a gaseous elements while carbon family elements are solids.
40. It exists as diatomic molecule, but members of group IV as monoatomic form.
41. Hydrogen has 1 valence electron while group IV-A elements have 4 valence electrons.
42. Valence shell of hydrogen consists of s-orbital only while valence shell of group IV-A elements consists of s & p orbitals.
43. It shows mono valence and group IV-A elements shows tetra valence.
44. Hydrogen exhibit isotropy while group IV-A elements do not.
45. Hydrogen does not exhibit allotropy, but group IV-A elements do exhibit allotropy.

**INDUSTRIAL PREPARATION OF HYDROGEN**

On the industrial scale, hydrogen is produced by a number of methods.

1. **ELECTROLYSIS OF WATER: -**

In this method, electricity is passed through water containing a small amount of an electrolyte, hydrogen is obtained at cathode while at anode oxygen is obtained.

In this method, hydrogen (also oxygen) is obtained in the purest form.

1. **FROM WATER GAS / STEAM & COKE PROCESS: -**

When steam is passed over red hot coke at a mixture of carbon monoxide and hydrogen is obtained this is known as water gas.

Water Gas

**SEPARATION OF HYDROGEN FROM WATER GAS:**

1. The water gas is mixed with steam and passed over catalyst at a temperature of .
2. is separated by dissolving it in KOH:
3. Or by dissolving in at high pressure:
4. **LIQUEFACTION METHOD:**

The water gas is cooled down to the temperature where carbon monoxide becomes liquid and free hydrogen gas is separated. The traces of gas is removed by passing the mixture through solution, which absorbs forming sodium formula.

1. **STEAM AND METHANOL PROCESS:**

In this process, a mixture of steam and vapours of methanol is heated at a temperature of about . Hydrogen is obtained along with carbon dioxide.

1. is separated by dissolving in :
2. **CRACKING OF HYDROCARBON:**

When methane or other hydrocarbons are heated at high temperature in the absence of oxygen, hydrogen gas is obtained with other compounds products. The process is known as cracking or pyrolysis or thermal decomposition.

Carbon black is used in the manufacture of tyres as fillers, paints, plastic etc.

1. **THERMAL DECOMPOSITION OF AMMONIA:**

Catalytic decomposition of ammonia to about produces a mixture of gas and gas. gas can be separated from the mixture by cooling it to where gas liquefies leaving free gas.

1. **BY ELECTROLYSIS OF BRINE:**

Hydrogen is obtained as by product in the manufacture of Sodium hydroxide and Chlorine by electrolysis of Brine (28% saturated solution of in water).

**ELECTROLYTIC REACTION:**

**Ionization:**

**Cathode reaction:**

**Anode reaction:**

**Overall reaction:**

**ATOMIC AND NASCENT HYDROGEN**

**ATOMIC HYDROGEN: -**

The hydrogen in the atomic form formed by thermal decomposition or electrical dissociation of ordinary molecular hydrogen is called Atomic Hydrogen.

**NASCENT HYDROGEN:**

The hydrogen in the atomic form at the time of its generation from a chemical reaction is called Nascent Hydrogen.

**PREPARATION OF ATOMIC HYDROGEN:**

Atomic hydrogen is prepared by thermal decomposition under reduced pressure.



**PROPERTIES OF ATOMIC HYDROGEN:**

1. It is much more reactive than molecular hydrogen.
2. It has very short life and quickly combine itself. To from molecular hydrogen .
3. It behaves as a strong reducing agent and combines with metals and non-metals at ordinary temperature.

**REACTION OF ATOMIC HYDROGEN:**

1. **WITH METALS:**
2. **WITH NON-METALS:**
3. **REDUCTION OF METAL OXIDE:**

**USES OF ATOMIC HYDROGEN:**

1. It is a powerful reducing agent i.e. why it is used in metallurgy for extraction of metals e.g.
2. It is used to prepare atomic hydrogen torch to attain a temperature of which is employed in welding purpose. Heat produced by atomic hydrogen is not by burning hydrogen but from recombination of hydrogen atoms.

* **ATOMIC HYDROGEN IS MORE REACTIVE THAN MOLECULAR HYDROGEN:**

Atomic hydrogen is much more reactive than molecular hydrogen. In molecular hydrogen two atoms of hydrogen are held together by a strong covalent bond having energy . For molecular hydrogen to react, it is the prerequisite to dissociate into atoms, for which high energy is required. Thus molecular hydrogen is less reactive. On the other hand, for atomic hydrogen to react there is no such condition. It is in the atomic form and thus, ready to take part in the reaction. It reacts with room temperature or even below it.

**BINARY COMPOUNDS OF HYDROGEN**

**HYDRIDE:**

“Binary compounds of hydrogen with other elements are called hydrides.”

Hydrogen combines with almost all the elements (except VIII-A group) to form hydrides. This is because of its middle order of E.N of hydrogen which is .

**CLASSIFICATION OF HYDRIDES:**

On the basis of nature of bonds in hydrides, they have been classified into:

1. Ionic Hydrides.
2. Covalent Hydrides.
3. Complex Hydrides.
4. Interstitial or Metallic Hydrides.
5. Polymeric Hydrides.
6. Borderline Hydrides.

**IONIC OR SALT LIKE OR SALINE HYDRIDES**

**DEFINITION: -**

These are the hydrides in which hydrogen is present as hydride ion in combination with electropositive metals.

**NATURE:**

In ionic hydride formation metal loses electron(s) and acquire positive charge while hydrogen becomes negatively charged by accepting electron . Thus these hydrides are ionic or salt like in nature.

**EXAMPLES OF IONIC HYDRIDES:**

Hydrides of group I-A; e.g.

Hydrides of group II-A; e.g.

**PREPARATION:**

1. **HYDRIDES OF GROUP I-A METALS:**
2. **HYDRIDES OF GROUP II-A METALS:**

Except Beryllium and Magnesium all alkaline earths forms Ionic hydrides.

**PROPERTIES:**

1. These hydrides are white, crystalline, salt like solids.
2. Their melting and boiling points are high.
3. They ionize to give negatively charged ion .
4. They react with water and produce gas.
5. They also produce hydrogen with acids.
6. They also react with alcohol liberating gas.
7. They are powerful reducing agent in metallurgical processes.

**COVALENT HYDRIDES**

**DEFINITION:-**

“Hydrogen combines with non-metals in which the atoms are linked to hydrogen through the shared pair of electron or covalent bonds such hydrides are called Hydrides.”

**NATURE:**

These hydrides are covalent in nature and more volatile than ionic hydrides.

**ELEMENTS WHICH FORM COVALENT HYDRIDES:**

Non-metallic elements of III-A, IV-A, V-A, VI-A and VII-A shared electrons with hydrogen to form these hydrides.

**PREPARATION: -**

1. **By direct combination of elements:**
2. **By hydrolysis of compounds like carbides:**

**PROPERTIES: -**

1. They are colourless gases (except water).
2. Their melting and boiling points are low.
3. The stability of hydride of elements increases with the increase in electronegativity of the central atom.
4. Hydrides of III-A and IV-A are neutral, while those of group VI-A and VII-A are acidic.

**COMPLEX HYDRIDES**

**DEFINITION: -**

The elements of III-A form covalent hydrides combine with ionic hydrides to form complex hydrides such as .

**EXAMPLES:**

Lithium Boro hydride

Sodium Alumino hydride

**PREPARATION:**

These hydrides are formed when ionic hydrides of I-A group and covalent hydrides of III-A unite.

**PROPERTIES:**

1. They are white crystalline solids.
2. They are power full reducing agents.
3. They are tetrahedral in structure.
4. They produce when react with water:

**INTERSTITIAL OR METALLIC HYDRIDES**

**DEFINITION:**

These hydrides are formed by the absorption of hydrogen in the interstitial spaces (empty spaces between atoms in the crystal lattice) of transition metals crystal.

**NATURE:**

They are non-stoichiometric compounds and do not obey the laws of chemical combination. Actually, they are not real chemical compounds. They are physical combinations.

**EXAMPLES:**

Titanium hydride

Vanadium hydride

**POLYMERIC HYDRIDES**

**DEFINITION:**

Beryllium and Magnesium form hydrides of formula in which a large number of these molecules are polymerize to give compounds of very high molecular mass. These hydrides are called polymeric hydrides.

**STRUCTURES: -**

**PROPERTIES:**

1. They are white Non-Volatile solids.
2. They liberate when reacts with water:

**BORDERLINE HYDRIES**

**DEFINITION:**

The hydrides of group I-B, II-B and Indium and Thallium of group III-A are called border line hydrides.

**EXAMPLES:**

**ISOTOPES OF HYDROGEN**

**DEFINITION:**

“Atoms of the same elements having same atomic number but different mass number are known as ISOTOPES.”

**OR**

“Atoms that have the same number of protons but different number of neutrons in their nuclei are called ISOTOPES.”

**ISOTOPES OF HYDROGEN:**

There are three isotopes forms of hydrogen namely,

Protium, Deuterium, Tritium

**PROTIUM: -**

It is also known as ordinary hydrogen. It contains one proton in the nucleus and one electron in its valence shell. It has atomic number and atomic mass number . Naturally free occurring hydrogen contain protium.

**DEUTERIUM: -**

It is also called Heavy Hydrogen. It contains one proton one neutron and one electron in its valence shell. It has atomic number and atomic mass number . It is present in naturally occurring hydrogen to the extent of about , i.e. in the ratio of .

**TRITIUM: -**

It is also called radioactive hydrogen. It contains in the nucleus and one electron in its valence shell. It has atomic number and atomic mass number . It occurs in very small quantities in the naturally occurring hydrogen to the extent of about . It is radioactive form of hydrogen and has a half-life of years.

**SEPARATE POSITION OF HYDROGEN**

1. Hydrogen resembles and at the same time differs from the elements of group I-A (Alkali metals) Group IV-A (Carbon family) & Group VII-A (Halogens). Therefore it is not justifiable to place it along with the elements of any one of the above mentioned groups.
2. The atomic structure of hydrogen (having one proton in the nucleus & one electron outside) differs so markedly from other elements that it is describable to give it a special place in the periodic table & not associate it with any particular group.

**ATOMIC HYDROGEN IS MORE REACTIVE THAN THE MOLECULAR HYDROGEN (GIVE REASON)**

**REASON:**

Atomic Hydrogen is more reactive than the molecular Hydrogen. In molecular hydrogen two atoms of hydrogen are held together by a strong covalent bond having energy . For molecular hydrogen to react, it is the prerequisite to dissociate into atoms, for which high energy is required. Thus molecular hydrogen is less reactive. On the other hand for atomic hydrogen to react there is no such condition. It is in the atomic form, & thus, ready to take part in the reaction. It reacts at room temperature or even below it.

**s-Block Elements**

**INTRODUCTION: -**

Elements are classified into s, p, d and f block elements on the basis of their electronic configuration.

Elements in which the outermost s-orbital possesses electrons are called s-block elements. They include electropositive metals of group I-A (i.e. alkali metals) and II-A (i.e. alkaline earth metals).

**GROUP I-A: (LITHIUM FAMILY)**

The group I-A consists of Lithium Sodium, rubidium, cesium and francium. These elements are known as alkali metals as their hydroxides are water solute and form strong bases (alkalis). The electronic configuration of alkali metals are given below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ELEMENT** | **SYMBOL** | **Atomic No. (Z)** | **ELECTRONIC CONFIGURATION** | **PRINCIPAL OXIDATION STATE** |
| Lithium | Li | 3 |  | +1 |
| Sodium | Na | 11 |  | +1 |
| Potassium | K | 19 |  | +1 |
| Rubidium | Rb | 37 |  | +1 |
| Cesium | Cs | 55 |  | +1 |
| Francium | Fr | 87 |  | +1 |

**GROUP II-A: (BERYLLIUM FAMILY)**

The group II-A consists of beryllium, magnesium, calcium strontium, barium and radium. These elements are known as alkaline earth metals as they are alkaline and their compounds are found in earth’s crust.

**GROUP TRENDS IN S-BLOCK ELEMENTS**

1. **ATOMIC RADIUS:**

Atomic Radii is defined as the distance between nucleus and a point where electron density is effectively zero.

* Atomic Radii of alkali metals and alkaline earth metals increases from top to bottom in a group this increase is due to addition of shells in a period by increasing atomic number, but they decrease from I-A group to II-A group due to increase in nuclear charge.

1. **IONIC RADII:**

Ionic radii of s-block elements increases from top to bottom in a group. This increase is due to addition of shell in a group by increasing atomic number, but they decreases from I-A group to II-A group due to increased nuclear change.

1. **IONIZATION POTENTIAL: (IONIZATION ENERGY)**

Ionization energy is the amount of energy which is required to remove valence electron from an atom of an element in gaseous state. I.P value depends upon.

|  |  |
| --- | --- |
| Atomic size | Inverse relation |
| Nuclear charge | Direct relation |

Ionization energy decreases from top to bottom in a group with the increase in size of atom. But I.P value increases from alkali metals to alkaline earth metals. Higher ionization energy of alkaline earth metals is due to the increased nuclear charge.

1. **HYDRATION ENERGY:**

The amount of heat evolved when one mole of metal ion forms an aqueous solution is called heat of hydration or hydration energy. It depends upon charge density (charge to size ratio) move the charge density more will be the hydration energy of metal ions.

* Hydration energy decreases from top to bottom in a group.
* But it increases from alkali metals to alkaline earth metals due to increase in charge density.

1. **ELECTRODE POTENTIAL:**

The potential difference created between the element (electrode) and a solution of its salt (electrolyte) is called Electrode Potential. The elements with high negative electrode (reduction) potentials are easily oxidized and behave as powerful reducing agents.

The s-block elements are powerful reducing agent due to their high negative aqueous electrode (reduction) potential. E.g.



The reduction (electrode) potential of alkaline earth metals are lower than those of alkali metals. Hence they are less electropositive and weaker reducing agents than the alkali metals.

Alkali (and alkaline earth) metals have high negative values of aqueous electrode (reduction) potential due to which they cannot be used in voltaic cells based on water as solvent because of their rapid oxidation by that solvent.

1. **DENSITIES:**

Densities of s-block elements are less in the respective periods. This is because of,

1. Their large atomic volume.
2. Their smaller nuclear mass.

* Down the group I-A and II-A densities increases due to increase in atomic weight.
* Group II-A elements are more denser than group I-A elements due to greater atomic weight and smaller volume.

1. **HARDNESS, MELTING POINT AND BOILING POINT:**

* S-block elements are less hard and have relatively low Boiling point and Melting point. Down the group in I-A & II-A group, hardness M.P and B.P decreases , because due to the increase in atomic radii, there are less number of atom per unit volume, so less number of electron are available for interaction, so hardness M.P and B.P decreases.
* Alkaline earth metals are more harder having high M.P and B.P than the alkali metals. This is because there is greater interaction among alkaline earth metals due to:

1. Their small atomic size permitting close packing.
2. Presence of an extra valence electron for interaction, producing greater binding force, which keeps the atoms held together.

**COMPARES OF ALKALI METALS AND ALKALINE EARTH METALS**

1. **SIMILARITIES: -**
2. Both alkali and alkaline earth metals are s-block elements which have valence electrons in s-orbitals.
3. Both alkali and alkaline earth metals are strongly electropositive.
4. Both alkali metals and alkaline earth metals are highly reactive.
5. Both alkali metals and alkaline earth metals do not occur in Free State in nature.
6. Both alkali metals and alkaline earth metals are prepared by the electrolysis of their fused chlorides.
7. The hydroxides of both families are strong bases.
8. All elements on reacting with water give hydrogen gas.

**DIFFERENCES:**

|  |  |
| --- | --- |
| **ALKALI METALS** | **ALKALINE EARTH METALS** |
| Alkali metals are highly electropositive. | Alkaline earth metals are less electropositive than the alkali metals. |
| They are lighter than water, e.g. specific gravity of and that of . | They are heavier than water, e.g. specific gravity of and that of . |
| Alkali metal hydroxides are strongly basic, except that of . | Alkaline earth metals hydroxides are less basic. |
| The decompose water vigorously at room temperature, forming strong alkalis. | They form weak bases on heating with water. |
| Alkali metal carbonates, sulphates and phosphates are water soluble . | Alkaline earth metals carbonates, sulphates and phosphates are water insoluble . |
| Alkali metals nitrates on heating give nitrites and oxygen | Alkaline earth metals nitrates on he gives oxides, Nitrogen dioxide and Oxygen. |
| They do not form carbides directly. | They form stable carbides on with carbon. |

**CHEMICAL REACTIONS OF s-BLOCK ELEMENTS**

1. **REACTION WITH HALOGENS:**
2. **Alkali metals:**

e.g.

1. **Alkaline earth metals:**

e.g.

1. **REACTION WITH OXYGEN:**

The alkali metals and alkaline earth metals directly combine with oxygen producing a variety of oxides e.g. normal oxides , peroxides and super oxides .

1. **REACTION WITH HYDROGEN:**

1. **REACTION WITH NITROGEN:**
2. **Formation of alkali metal Nitrides:**

e.g.

1. **Formation of Alkaline earth Nitrides:**

e.g.

1. **REACTION WITH WATER:**

Most of the alkali and alkaline earth metals react with water violently and explosively.

e.g.

Magnesium reacts with steam

And,

* form a protective coating of hydrated metal oxide on their surface by the action of water and protected from extensive corrosion by water. Magnesium only reacts with boiling water.

**DIAGONAL RELATIONSHIP**

The element of the second period belonging to the I-A group is similar in behavior to the elements of the II-A group in the third period. This is called the “DAGONAL RELATIONSHIP”. It can be show as follows:

|  |  |  |
| --- | --- | --- |
|  | **I-A** | **II-A** |
| **Second period** | Li  Na | Be  Mg |
| **Third period** |

Thus resembles move to than .

**DIAGONAL RELATIONSHIP BETWEEN :**

1. Both have approximately same ionic size.
2. Both are more electropositive than and less electropositive than .
3. On heating in air, both form normal oxides whereas other alkali metals form higher oxides.
4. Both gives only monoxides .
5. Carbonates and phosphates of both are insoluble in water where as those of other alkali metals are water soluble.
6. Carbonates of both are unstable and decompose to form oxides, whereas other alkali metals, carbonates are stable.
7. The nitrates of both decompose to form along with oxides.

**EXTRACTION OF SODIUM BY DOWN’S PROCESS**

**ORE USED:**

Halite or rock salt .

**RAW MATERIALS:**

Fused Sodium Chloride

Fused Calcium Chloride

**BASIC PRINCIPLE:**

Electrometallurgy

**CONSTRUCTION OF DOWN’S CELL:**

Down’s cell is an outer steel tank lined with fire bricks. The cell is fitted with a central graphite anode which projects up from the base of the cell. It is surrounded by a circular steel cathode. The two electrodes are separate by a cylindrical iron gauze from one another to prevent the mixing of sodium metal depositing at cathode and chlorine liberating at anode.

**WORKING:**

Sodium Chloride melts at . Electrolysis at the temperature causes many difficulties. To lower the melting point of sodium chloride, calcium chloride is added to it. The electrolytic mixture containing and melts at about .

**ELECTROLYTIC REACTIONS:**

The following reactions take place.

**IONIZATION:**

**ANODE REACTION:**

**CATHODE REACTION:**

**OVER ALL REACTION:**

**PHYSICAL PROPERTIES OF SODIUM:**

1. It is a silvery white, soft metal.
2. Its density is . it is lighter than water.
3. Its melting point is .
4. Its boiling point is .
5. Its blue vapors burn with a golden yellow flame.
6. It is good conductor of heat and electricity.

**CHEMICAL REACTIONS OF SODIUM**

1. **REACTION WITH AIR:**
2. **At ordinary temperature:**
3. **On heating with Oxygen:**
4. **REACTION WITH WATER:**

Sodium reacts with water rigorously. It is a highly exothermic reaction and thus the formed catch fire.

1. **REACTION WITH HALOGENS:**

1. **REACTION WITH SULPHUR:**
2. **AS REDUCING AGENT:**

It reduces metal oxides to metal and acts reducing agent.

1. **REACTION WITH HYDROGEN:**

It forms sodium hydride at

1. **REACTION WITH ALCOHOL:**

Sodium reacts with alcohols to form sodium alkoxides. This reaction is similar to that of water but less exothermic.

e.g.

1. **REACTION WITH ACETYLENE:**

Hen acetylene is passed over heated sodium, both mono substituted and disubstituted acetylides are formed.

Di-Sodium acetylide

Mono Sodium acetylide

**ALLOY OF SODIUM:**

1. **Sodium amalgam:**

It is an alloy of sodium with mercury metal.

1. **Sodium-lead Alloy:**

It is an alloy of sodium with lead metal.

In both these alloys the reactivity of sodium is decreased. These alloys are used as reducing agents.

**AMMONIA SOLVAY’S PROCESS**

**INTRODUCTION:-**

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

**RAW MATERIALS: -**

1. Saturated solution of .
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 impurity:

1. **CARBONATION:**

The ammonical brine is passed to carbonating tower (Solvay Tower) where is pumped in at the bottom 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 bicarbonate is filtered off washed with a little water and dried, whereas filtrates is sent to ammonia recovery tower.

1. **CALCINATION OF SODIUM BICARBONATE:**

Sodium bicarbonate 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:**

As ammonia is much more costly than sodium carbonate or sodium bicarbonate 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 are recovered and recycled.

**CHEMICAL REACTION OF SODIUM CARBONATE:**

1. **HYDROLYSIS:**

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

Weak acid

Strong alkali

1. **REACTION WITH :**

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

1. **ACTION OF DILUTE ACIDS:**

On treating with dilute acids it produces carbon dioxide.

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

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

**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 smeeting of iron over of high sulpher content.

**LARGE SCALE MANUFACTURE OF CAUSTIC SODA**

On commercial scale, caustic soda is manufactured by two methods:

1. Castner Kellner’s Cell Method.
2. Nelson’s Cell Method.

**CASTNER KELLNER’S CELL METHOD**

**INTRODUCTION:**

Sodium hydroxide is largely manufactured by the electrolysis of brain. The cell commonly used for the electrolysis is “CASTNER KELLNER’S CELL”.

**CONSTRUCTION OF CELL:**

1. The electrolytic cell consists of a steel tank.
2. A number of graphite or titanium blocks act as anode.
3. 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 dissolves in the mercury to form sodium amalgam. The sodium amalgam is removed from the cell.

The following reactions taken place:

**IONIZATION:**

**ANODE REACTION:**

**CATHODE REACTION:**

**FORMATION OF :**

The sodium amalgam flows into a separate chamber called soda cell. In this cell the amalgam is mixed with water, producing sodium hydroxide and hydrogen. Pure mercury is regenerated during the process.

The regenerated mercury is recirculate.

**ADVANTAGES OF THE PROCESS:**

1. The process is very efficient.
2. The process given product of high purity.
3. The possible reaction between is avoided by obtained in the separate chambers.
4. Discharge of ions in preference to ions.

**DISADVANTAGES OF THE PROCESS:**

1. The process a consumer large amount of electricity.
2. In spite 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.

**CHEMICAL REACTION OF SODIUM HYDROXIDE**

1. **REACTION WITH CARBON DIOXIDE:**

Sodium hydroxide absorbs carbon dioxide from atmosphere and produces sodium carbonate.

1. **REACTION WITH ACIDS:**

Sodium hydroxide is an strong alkali and reacts with inorganic as well as organic acids to produce corresponding salt and water.

1. **REACTION WITH AMMONIUM SALTS:**

On heating sodium hydroxide reacts with ammonium salts and liberates ammonia.

1. **REACTION WITH CARBON:**

Sodium hydroxide is a very stable compound and cannot be converted directly into the oxide. On strong heating with carbon, it produces sodium, hydrogen and carbon monoxide.

1. **REACTION WITH ALUMINUM:**

Aluminum reacts with aqueous solution of sodium hydroxide to produce hydrogen.

1. **REACTION WITH CHLORINE:**

* When chlorine is passed through a hot concentrated solution of sodium hydroxide, sodium chloride and sodium chlorate are obtained.
* When chlorine is passed through cold and dilute sodium hydroxide solution, sodium chloride and sodium hypochlorite are formed:

1. **REACTION WITH SALTS:**

On treating with solutions of some salts, it produces precipitates of metallic hydroxides or oxides.

Blue ppt

Raddish brown ppt

White ppt

Brown ppt

1. **REACTION WITH ZINC SALTS:**

precipitates out Zinc hydroxides from aqueous of Zinc salts.

Tetro hydroxo zincate (II) ion

The zinc hydroxide precipitate is amphoteric, re-dissolve in excess of due to formation of complex an ion to produce zincate ion:

e.g.

1. **REACTION WITH PHOSPHORUS:**

Phosphorus reacts with sodium hydroxide to produce phosphine.

phosphine

Sodium hypophosphite

1. **REACTION WITH SAPONIFICATION:**

On boiling sodium hydroxide reacts with fat to produce soap (sodium salt of fatly acids).

**USES OF SODIUM HYDROXIDE:**

It is used in:

1. Soap manufacturing.
2. Paper rubber industry.
3. To open blocked drains and pipes.
4. Production of ray on in textile.
5. Petroleum industry for refining.

**BAKING SODA**

Sodium bicarbonate or sodium hydrogen carbonate is commonly known as baking soda having composition .

**PREPARATION:**

It is prepared by carbonation of saturated sodium carbonate solution.

**PROPERTIES OF SODIUM BI CARBONATE:**

1. **EFFECT OF HEAT:**

On heating aqueous solution of sodium bicarbonate produces sodium carbonate and .

1. **HYDROLYSIS:**

Hydrolysis of sodium carbonate produces strong alkali i.e. this iswhy aqueous solution of sodium bicarbonate is alkaline in nature.

Strong alkali

1. **ACTION OF DILUTE ACID:**

On heating with dilute acids it produce carbon dioxide.

**USES OF BAKING SODA:**

1. It is used as a source of carbon dioxide in fire extinguishers.
2. It is used in baking.
3. It is used for the treatment of hyperacidity in the stomach.

**EPSOM SALT**

**INTRODUCTION:**

Magnesium Sulphate occurs in nature as kieserite . The hepta hydrated is the best known from of magnesium sulphate.

**PREPARATION:**

It is prepared by treating with dilute . Crystals or Epsom salt are obtained on evaporating and then colling this solution.

**PROPERTIES:**

1. It is a colorless crystalline solid.
2. It is soluble in water.
3. It crystalizes from its conc. Solution at .
4. It loses six water molecules on heating at .

It is completely dehydrated at .

It decomposes on strong heating.

**USES:**

1. It is used in medicines.
2. It is used in ceramics, cement, paper, dyeing and soap industries.
3. It is used in manufacture of paints.
4. It is used for loading and mordanting cotton textile goods.

**GYPSUM**

Calcium sulphate occurs in nature as dehydrate salt called gypsum. It is abundantly found in Pakistan.

**PREPARATION:**

1. It can be prepared by the action of dilute sulphuric acid on marble chips.
2. It can also be prepared by the action of dilute sulphuric acid on calcium chloride.

**PROPERTIES:**

1. It is sparingly soluble in water.
2. It produces permanent hardness in water.
3. At gypsum loses molecule of water of crystallization to form calcium sulfate hemi hydrate or commonly known as plaster of Paris.

**OR**

1. At , it loses all the water of crystallization and gives anhydrous calcium sulphate.
2. when mixed with water, sets in about 5 minutes to a hard mass. This setting occurs with slight expansion. This property permits to use in the preparation of moulds in surgery.

**BLEACHING POWDER**

**COMPOSITION:**

Bleaching powder is a mixed salt of calcium with chlorine and oxy chloride, , chemically called calcium chloro hypo chlorite.

**PREPARATION:**

It can be prepared by the reaction of chlorine gas on calcium hydroxide (Slaked lime).

**PROPERTIES:**

1. It is a white amorphous powder which gives smell of chlorine.
2. In the presence of water, it decomposed to calcium chloride and calcium hypochlorite and acts as a strong bleaching agent.
3. When bleaching powder is treated with strong solution of ammonia, nitrogen gas is evolved.
4. It reacts with slowly and liberates hypro chlorous acid.

**USES:**

1. It is used to bleach cotton, lines and wood pulp.
2. It is used as a disinfectant and germicide.
3. It is used as an oxidizing agent in many chemical industries.

**INDUSTRIAL PREPARATION OF SULPHURIC ACID**

**INTRODUCTION:**

Sulphuric acid is the most important chemical in the chemical industry. It is therefore call “The King of the Chemicals”. Now a days it is prepared commercially by two methods.

1. Contant Process.
2. Lead Cambers Process.

**CONTACT PROCESS**

The process was discovered early in the 19th century but it was successfully operated in 1901 and then it has been used.

**RAW MATERIALS:**

1. Sulpher or Iron Pyrite.
2. Air.
3. Water
4. .
5. .

**PRINCIPLE:**

The basic principal involves following steps:

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

**PROCEDURE (WITH PLANT)**

1. **PRODUCTION OF IN SULPHER OR PYRITE BORNER:**

In this chamber Sulfer or iron Pyrite is burnt to get .

1. **PURIFICATION UNITS:**

The purification unit consists of following towers:

1. **DUST REMOVER:**

Burner gases are passed through dust remover where dust particles are settled down by gravity method.

1. **SCRUBBING TOWER:**

In this tower gases are washed by a spray of water from the top gas is insoluble in water at this temperature. The soluble impurities are removed.

1. **DRYING TOWER:**

The moisture of gases is removed by conc. in drying tower.

1. **ARSENIC PURIFIER:**

Dry gases are now passed over precipitated ferric hydroxide in arsenic purifier where arsenic oxide is absorbed in are removed.

1. **THYNDALL BOX:**

In this box impurities of are further checked by thyndall effect.

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

The purified so obtained is oxidized catalytically in contact tower according to bthe reaction.

Le-Chatelier suggests following favorable conditions for the maximum yield of .

1. Oxygen required for the oxidation of sulpher dioxide must be in excess.
2. As the reaction is exothermic, the temperature must be low. A temperature of give the maximum yield of .
3. High pressure favours the reaction. A pressure of is applied.
4. **ABSORBTION TOWERS:**

gas so formed is passed in absorbtion tower where it is absorbed in conc. to form Oleum.

Oleum is then diluted with water to any desired concentration.

**PHYSICAL PROPERTIES OF :**

1. Sulphuric acid is colourless, odourless oily liquid.
2. Its melting point is and boiling point is .
3. It is hygroscopic in a nature.
4. It causes severe burns when comes in contact with skin.
5. Its various forms of sulphuric acid are:
6. Dilute containing and density is .
7. Conc. of laboratory grade containing and density is .
8. having density .
9. Fuming Sulphuric acid containing dissolved leaving density .

**CHEMICAL PROPERTIES OF SULPHURIC ACID**

The chemical properties of are divided into following sets:

1. Acidic properties.
2. Oxidizing properties.
3. Dehydrating properties.
4. Sulphonating properties.
5. **ACIDIC PROPERTIES:**

It is strong acid, because it reacts with water to form oxonium ion (i.e. it provides ion). It is diprotic acid because it loses second ion after the loss of first ion. Due to loss of two ion, it forms two ionic species and acts as diprotic acid.

1. **IONIZATION:**
2. **REACTION WITH BASES:**
3. **ACTION ON METALLIC CARBONATES & BICARBONATES:**
4. **REACTION WITH METALS IN DELUTE FORM:**
5. **OXIDIZING PROPERTIES:**

Sulphuric acid acts as a powerful oxidizing agent and oxidizes a number of non-metals, metals and compounds.

1. **OXIDATION OF NON-METALS:**

Hot and concentrated oxidizes non-metals like:

While itself reduces to .



1. **OXIDATION OF METALS:**

* Hot and conc. oxidizes metals to metal sulphate and itself reduces to .

e.g.

1. **WITH ALUMINIUM AND IRON:**

e.g.

1. **ACTION OF CONC. ON ZINC:**

conc. oxidizes zinc to while itself reduces to .

1. **OXIDATION OF COMPOUNDS:**
2. **OXIDATION OF HALIDES:**

oxidizes halides (halogen acids) to from free halogens and itself reduces to .

1. **OXIDATION OF FERRUS SULPHIDE:**

oxidizes to elemental sulphur and itself reduces to .

1. **OXIDATION OF HYDROGEN SULPHIDE:**

oxidizes to elemental sulphur and itself reduces to .

1. **DEHYDRATING PROPERTIES:**

The removal of water molecule from a substance is called dehydration. Sulphuric acid has a great affinity for water molecules from many compounds. Thus it acts as a Dehydrating Agent and can extract water molecules from many compounds to form different products.

1. **SULPHONATING PROPEERTIES:**

The reaction in which one or more hydrogen atom of an organic compound is replaced by same number of sulphonic acid group is called sulphonation reaction. Sulphuric reacts with many organic compounds and acts as sulphonating agent.

* **WITH METHANE:**

Methane sulphonic acid

Methane

* **WITH ETHANE:**

Ethane sulphonic acid

Ethane

* **WITH BENZENE:**

**ELECTRONIC STRUCTURE OF :**

**GEOMETRICAL STRUCTURE OF :**

* The high boiling point and viscosity of are due to the presence of hydrogen bonding which link the molecule in large aggregates.

**USES OF SULPHURIC ACID:**

Sulphuric acid is used in many industries and is known as “King of Chemicals”. The progress and prosperity of a country acid used there. As it is used in the following industries therefore a country should produce a large quantity of sulphuric acid.

It is used:

1. In manufacture of fertilizers like super phosphate and .
2. In manufacture of detergents.
3. In making dyes, explosives paints etc.
4. In making chemicals like .
5. In petroleum refinery.
6. In coal-tar industry.
7. In storage batteries.
8. In silver and gold plating.
9. As common laboratory agent.
10. As drying and dehydrating agent.
11. In qualitative salt analysis as group reagent.

**PREPARATION OF BY OSTWALD’S PROCESS**

**INTRODUCTION:**

Nitric acid is preferably manufactured on large scale through oxidation of ammonia by Ostwald’s process.

**RAW MATERIALS:**

1. Ammonia
2. Air
3. Water
4. Platinum Gauze as catalyst

**BASIC PRINCIPLE:**

The principle involves 3 steps ammonia is oxidized to in the presence of catalyst at . then combines with oxygen of air forming which is dissolved in water to produce .

**PLANT USED:**

1. convertor or catalyst chamber.
2. Oxidation Chamber.
3. Absorbtion Towers.

**DETAILS OF PROCEDURE:**

1. **OXIDATION OF IN AMMONIA CONVERTOR:**

1 part by volume of mixed with