CHEMISTRY

XII

Resource Material for Ziauddin Examination Board

BENCHMARKS

- **Students will display a sense of curiosity and wonder about the natural world and demonstrate an increasing awareness that this has lead to new developments in science and technology. They will learn from books and other sources of information and reconstruct previously learned knowledge.**

- **Students will describe and explain common properties, forms, and interactions between matter and energy; their transformations and applications in biological, chemical and physical systems.**

- **Students will demonstrate an understanding of the impact of science and technology on society and use science and technology to identify problems and creatively address them in their personal, social and professional lives. They will explain how scientists decide what constitutes scientific knowledge; how science is related to other ways of knowing; and how people have contributed to and influenced developments in science.**

CHAPTER CONTENT

S.no	Name of chapter
Chapter # 1	Organic Compound
Chapter # 2	Hydrocarbon
Chapter # 3	Alkyl halide & Amines
Chapter # 4	Alcohol , Phenol & Ether
Chapter # 5	Carbonyl compounds
Chapter # 6	Biochemistry
Chapter # 7	Analytical Chemistry
Chapter # 8	S-Block & P-Block Element
Chapter # 9	D- Block Element
Chapter # 10	Environmental Chemistry
Chapter # 11	Industrial Chemistry

CHAPTER # 1

“ORGANIC COMPOUND”

INTRODUCTION

CHAPTER CONTENT

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Sources	Coal as a source of organic compound	Characteristics of organic compound
• coal, petroleum and natural gas.	• Destructive distillation of coal	• Uses of organic compound.
• Plants & natural product of chemistry.	• Conversion of coal to petroleum	• New allotrope of carbon
• Partial & total synthesis	• Process	• Functional groups & homologous series.
• Product of biotechnology.	• Chemical reaction	• Detection of element in organic compound.

Major concepts.

- ➢ Sources of organic compound
- ➢ Coal as a source of organic compound
- ➢ Characteristics of an organic compounds

LEARNING OUTCOMES

Students will be able to	Analyzing	Understanding	Remembering
• Define organic chemistry & organic compounds.			✔
• Explain why there is such a diversity & magnitude of organic compound.	✔		
• Classify organic compounds on basis of their structure.	✔		
• Explain the use of coal as a source of both aliphatic & aromatic hydrocarbon.		✔	
• Explain the use of plants as a source of organic compound.		✔	
• Explain the organic compound are also synthesis in the lab.		✔	
• Define functional group & homologous series.			✔

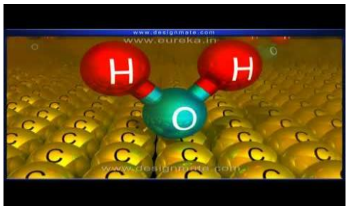
Skills	Analyzing	Applying	Understanding
• Make distinction among different organic compounds on the basis of their formula.	✔		

Society , Technology & Science.

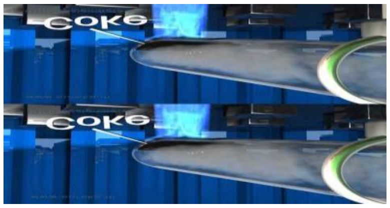
Students will be able to,

- ➢ Realize that many organic compound are obtained from plants & animals. (Understanding)
- ➢ Understand the organic compound are partially or totally synthesized in lab. (Understand)
- ➢ List many medicines obtained from plants. (Remember)

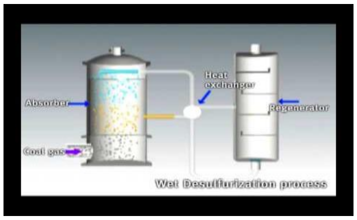
Related videos.



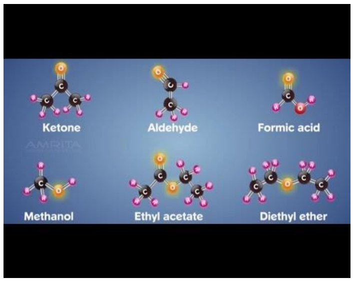
Destructive distillation of coal.



Destructive distillation of coal.

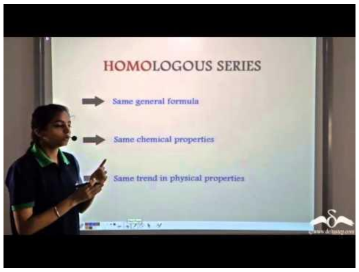


Conversion coal into petroleum.



Functional group

homologous series.



Homologous series.

(THEORY)

Organic chemistry.

Organic chemistry is the study of the synthesis, structure, reactivity and properties of the diverse group of chemical compounds primarily constructed of carbon.

Organic compound.

Organic compound, any of a large class of chemical **compounds** in which one or more atoms of carbon are covalently linked to atoms of other elements, most commonly hydrogen, oxygen, or nitrogen. The few carbon-containing **compounds** not classified as **organic** include carbides, carbonates, and cyanides.

Source of organic compound.

All organic compounds aat one time came from plants or animals. Many of our most importants substance are still derived from these sources directly or indirectly.

1) *PLANTS AND ANIMALS*

Many organic compounds are obtained directly from plant and animals sources by suitable. method of isllation.a few familiar EXAMPLE are carbohydrates (cellulose, sugar, and starches.) proteins (silk, wool, casein, and food proteins) fats and oils(cottonsed soybean oils lard, butter) alkaloids (quinine ,morphine, strychnine) hormones, vitamins, perfumes, flavors and resins.

2) ***NATURAL GAS AND PETROLEUM.***

Natural gas and petroleum are now the major sourcse of organic compounds .they are used as fuels and also, throughsynthetic organic reaction.for the production of hundreds of useful organic substances such as solvents,synthetic rubber,explosive,and plastic.

3) ***COAL***

Coal is another major sources of organic compounds.it yield coke and coal-tar on pyrolysis or destructive distillation. More then 200 organic compounds have been directly isolated from coal-tar. these coal-tar products from the starting materials for the manufacture of thousands of useful aromatic compounds, including pefumes,drugs,dyes, photographic developers, and other.

4) ***SYNTHESIS.***

Simple organic compounds derived from petroleum or coal have been converted into thousands of useful materials by synthetic mthod.many EXAMPLE might be cited of synthetic organic compounds replacing those obtained from natural sources, such as dyes, rubber, fibers, plastic ,drugs, vitamins.in many cases the synthetic materials are superior to the natural compounds replaced.for example ,synthetic dyes are superior to those of natural http://origin.in other cases the synthetic materials are entirely unknown in nature and fill the requirements not satisfied are entirely other sources.EXAMPLE.are ether .glycol, aspirin, and sulphur drugs. Synthetic organic chemistry touches almost every phase of life.

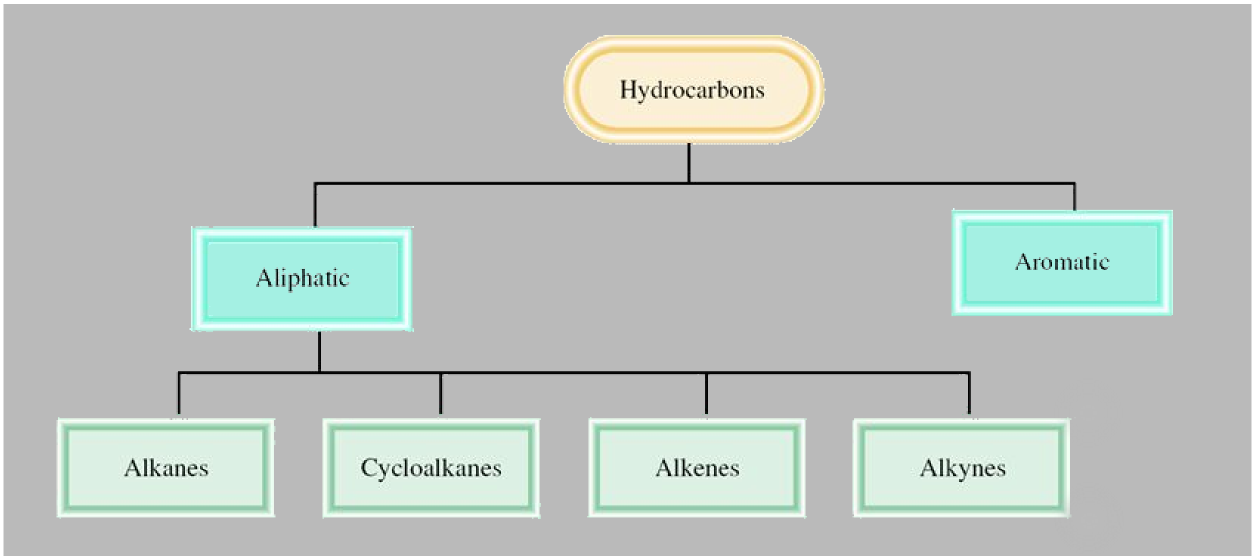
Reference page/site.
https://www.quora.com/What-are-the-organic-compounds-sources

Aliphatic Hydrocarbon Definition

An aliphatic compound or aliphatic hydrocarbon is an organic compound containing hydrogen and carbon atoms that are usually linked together in chains that are straight.

Aromatic Hydrocarbons

Aromatic Hydrocarbons are circularly structured organic compounds that contain sigma bonds along with delocalized pi electrons. They are also referred to as arenes or aryl hydrocarbons.



Reference page/site.
https://byjus.com/chemistry/aliphatic aromatic-hydrocarbons/

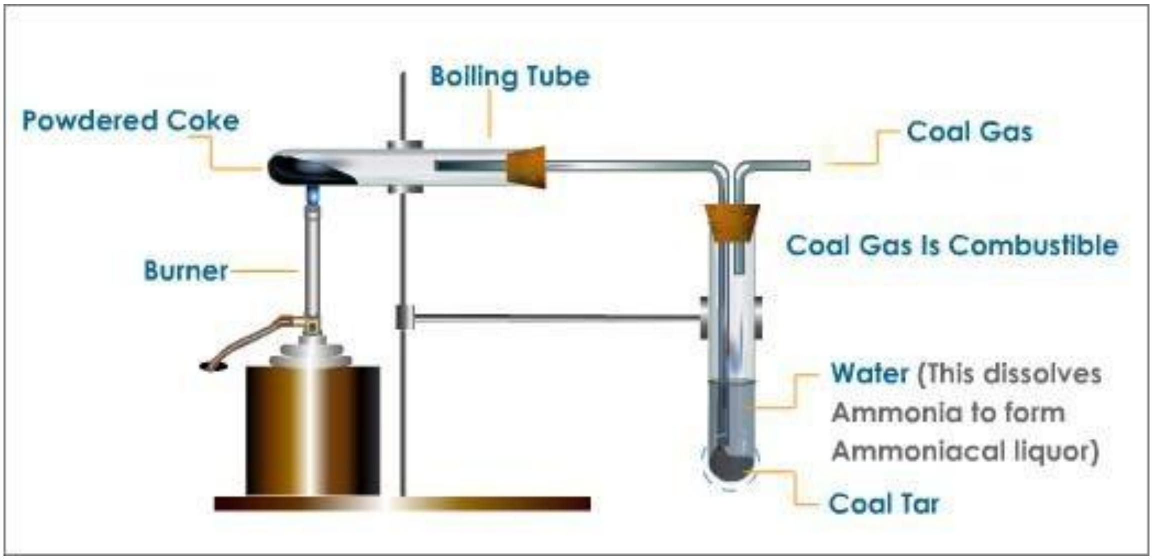
Destructive Distillation of Coal

When coal is heated without air, it does not burn but produces many by-products. This process of heating coal in the absence of air is called destructive distillation of coal.

The main by products are:

- coke
- coal tar
- amino acid liquor
- coal gas

The destructive distillation of coal can be carried out in the laboratory. The apparatus is set up as shown in the below figure.



Destructive Distillation of Coal

Finely powdered coal taken in a test tube is heated. As the coal breaks down coke, coal tar, ammonia and coal gas are produced. Coal tar collects at the bottom of the second test tube and coal gas escapes out through the side tube. The ammonia produced is absorbed in the water forming ammoniacal liquor (ammonium hydroxide). The black residue left in the 1st tube is called coke.

Coke is a fuel in its own right which can be used in homes and factories. But it is largely used as a reducing agent in the extraction of metals from their ores. It is also used in making fuel gases like water gas which is a mixture of carbon monoxide and hydrogen.

Another by product namely coal tar which is a mixture of different carbon compounds can be used to make soap, fats, dyes plastics perfumes, drugs, pesticides, explosives etc.

The other by product, ammonia is used for making fertilizers such as ammonium sulphate, ammonium superphosphate etc.

The coal gas, also called as a town gas is a mixture of hydrogen, methane and carbon monoxide which are combustible making the coal gas an excellent fuel having high calorific values.

Uses of organic compound

organic compounds have various uses in everyday lives.

though they are present almost everywhere the most common uses are

1.Preparation of wines and alcohols using fermentation sugar {ethanol}
2. Used for making soaps using hydrolysis of esters using NaOH.
3. Detergents
4. Making perfumes and essence for soaps
5.Fuel for domestic purposes {butane and iso-propane}

Allotropes of Carbon

The phenomenon by which an element can exist in more than one physical state is called allotropy. **The allotropes of carbon can be categorized into two:**

- **Amorphous Carbon Allotropes**
- **Crystalline Carbon Allotropes**

What are Allotropes of Carbon?

Carbon with atomic number 6 and represented by the symbol **'C'** in the periodic table is one of the most influential elements we see around us. Carbon is one of the elements which shows allotropy. The allotropes of carbon can be either amorphous or crystalline (Diamond, Graphite).

Table of Content

- All Carbon Allotropes
- Graphite
- Diamond
- Other Carbon Allotropes
- Silicates

Carbon due to its capability of having variable oxidation states or coordination number makes carbon one of the few elements to have multiple numbers of allotropic forms. Carbon's ability to catenate is another contributing factor. Thus, it leads to the formation of various allotropes of carbon.

How many Carbon Allotropes are there?

- Diamond: It is extremely hard, transparent crystal, with the carbon atoms arranged in a tetrahedral lattice. This allotrope of carbon is a poor electrical conductor and an excellent thermal conductor.
- Lonsdaleite: These are also called hexagonal diamond.
- Graphene: It is the basic structural element of other allotropes, nanotubes, charcoal, and fullerenes.
- Q-carbon: These carbon allotropes are ferromagnetic, tough, and brilliant crystal structure that is harder and brighter than diamonds.
- Graphite: It is a soft, black, flaky solid, a moderate electrical conductor. The C atoms are bonded in flat hexagonal lattices (graphene), which are then layered in sheets.
- Linear acetylenic carbon (Carbyne)
- Amorphous carbon
- Fullerenes, including Buckminsterfullerene, also known as "buckyballs", such as C60.
- Carbon nanotubes: Allotropes of carbon with a cylindrical nanostructure.

Let us now take a look into the more widely known allotropes of carbon:

Graphite

It is also a pure form of carbon. This allotrope of carbon is composed of flat two dimensional layers of carbon atoms which are arranged hexagonally. It is a soft, black and slippery solid. This property of graphite persists because it cleaves easily between the layers.

In each layer, each C atom is linked to three C atoms via a C-C covalent bond. Each carbon here is sp2 hybridized. The fourth bond is formed as a pi bond. Since the π-electrons are delocalized, they are mobile and can conduct electricity.

Graphite is of two forms: α and ß.

In α form, the layers are arranged in the sequence of ABAB with the third layer exactly above the first layer.

In the ß form, the layers are arranged as ABCABC.

Properties of Graphite:

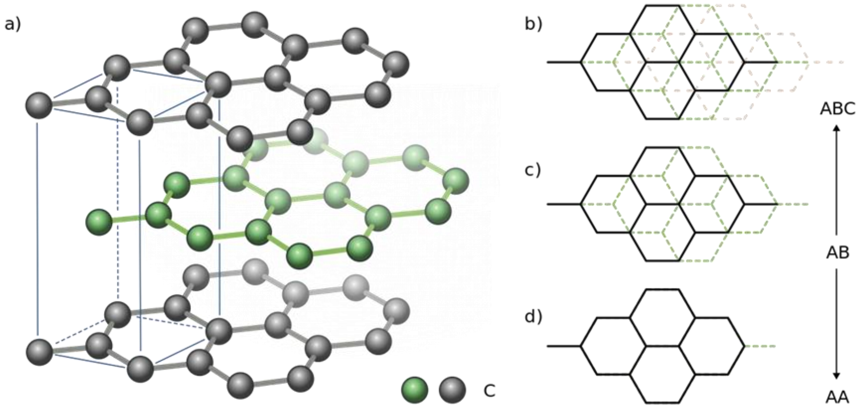
- Since the layers are stacked over each other, this carbon allotrope can act as a lubricant.
- It also has metallic lustre which helps in the conduction of electricity. It is a very good conductor of both heat and electricity
- One of the most important properties of graphite is that it is used as a dry lubricant for machines at high temperature where we cannot use oil.
- Graphite is used to make crucibles which have the property that they are inert to dilute acids as well as to alkalis.

Note: In comparison to diamond, Graphite is thermodynamically more stable.

Structure of Carbon Allotrope (Graphite):

Graphite has a unique honeycomb layered structure. Each layer is composed of planar hexagonal rings of carbon atoms in which carbon-carbon bond length within the layer is 141.5 picometers.

Out of four carbon atoms three forms sigma bonds whereas the fourth carbon forms pi-bond. The layers in graphite are held together by Vander Waal forces.

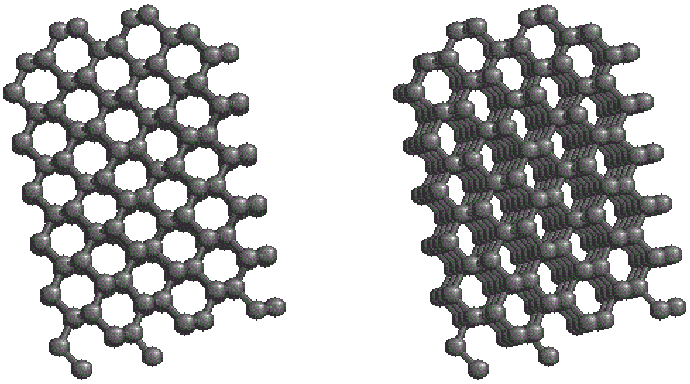


Graphite Structure – Allotropes of Carbon

Diamond

It is the purest crystalline allotrope of carbon. It has a number of carbons, linked together tetrahedrally. Each tetrahedral unit consists of carbon bonded to four carbon atoms which are in turn bonded to other carbons. This gives rise to an allotrope of carbon having a three-dimensional arrangement of C-atoms.

Each carbon is sp3 hybridized and forms covalent bonds with four other carbon atoms at the corners of the tetrahedral structure.



Structure of Diamond

Do you know why a Diamond is Hard?

It is hard because breaking a diamond crystal involves rupturing a large number of strong covalent bonds. Breaking covalent bonds is no easy task. This property makes this carbon allotrope the hardest element on earth.

Physical Properties of Diamond

- It is extremely hard
- It has a very high melting point
- It has a high relative density
- It is transparent to X-rays
- It has a high value of the refractive index
- It is a bad conductor of electricity
- It is a good conductor of heat
- It is insoluble in all solvents

Other Carbon Allotropes

Buckminsterfullerene

Buckminsterfullerene (C60) is also one of the allotropes of carbon. The structure of fullerene is like in a cage shape due to which it looks like a football.

Fullerenes

They are spheroidal molecules having the composition, C2n, where n ≥ 30. These carbon allotropes can be prepared by evaporating graphite with a laser.

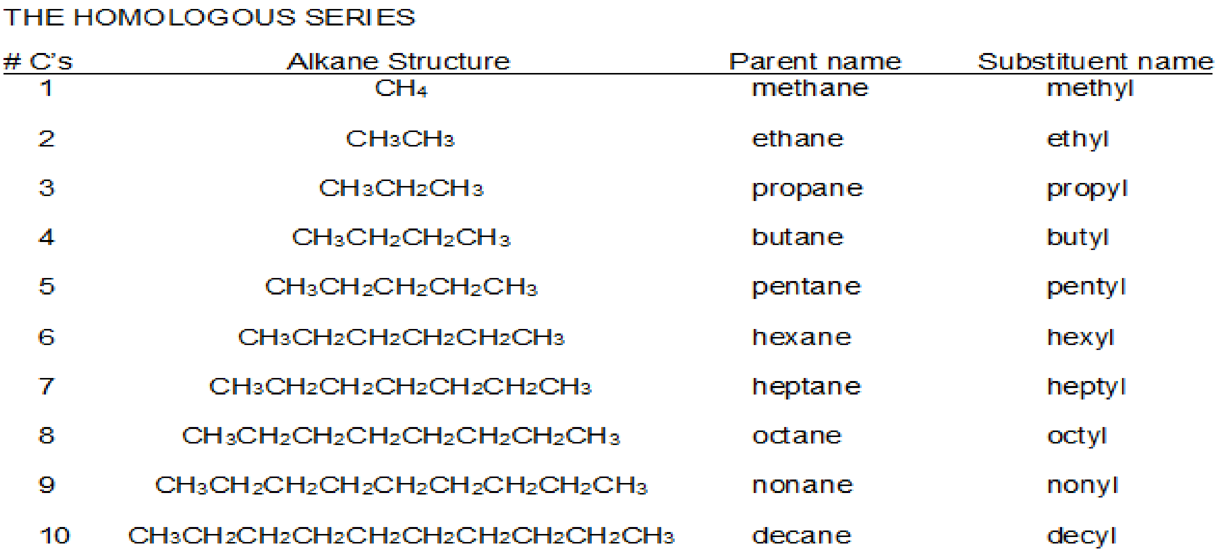
Unlike diamond, fullerenes dissolve in organic solvents. The fullerene C60 is called ‘Buckminster Fullerene’. The carbon atoms are sp2 hybridized.

Note: There are 12 five-membered rings and 20 six-membered rings in C60.

Reference page/site
https://byjus.com/jee/allotropes-of-carbon/

Functional group
A **functional group** is defined as an atom or **group** of atoms within a molecule that has similar chemical properties whenever it appears in various compounds. Even if other parts of the molecule are quite different, certain **functional groups** tend to react in certain ways,

Homologous series.
In the field of organic chemistry, a **homologous series** is a sequence of compounds with the same functional group and similar chemical properties in which the members of the **series** can be branched or unbranched.



THE HOMOLOGOUS SERIES

# C's	Alkane Structure	Parent name	Substituent name
1	CH_4	methane	methyl
2	CH_3CH_3	ethane	ethyl
3	$CH_3CH_2CH_3$	propane	propyl
4	$CH_3CH_2CH_2CH_3$	butane	butyl
5	$CH_3CH_2CH_2CH_2CH_3$	pentane	pentyl
6	$CH_3CH_2CH_2CH_2CH_2CH_3$	hexane	hexyl
7	$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$	heptane	heptyl
8	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	octane	octyl
9	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	nonane	nonyl
10	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	decane	decyl

Detection of element in organic compound.

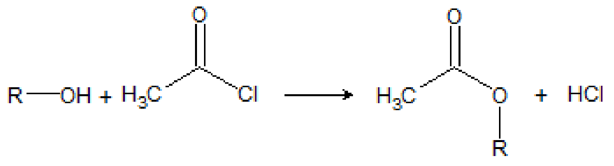
1) Alcoholic –OH group

We can detect the alcoholic group by the following tests:

- **Sodium Metal Test:** We conduct this test on the basis of the appearance of effervescence due to the liberation of hydrogen gas in reactions of sodium with alcohol.

$$2R-OH + 2Na \rightarrow 2RONa + H_2$$

- **Acetyl Chloride Test:** Acetyl chloride reacts vigorously with primary and secondary alcohols with the evolution of hydrogen chloride. The hydrogen chloride gives white fumes of ammonium chloride with ammonium hydroxide.



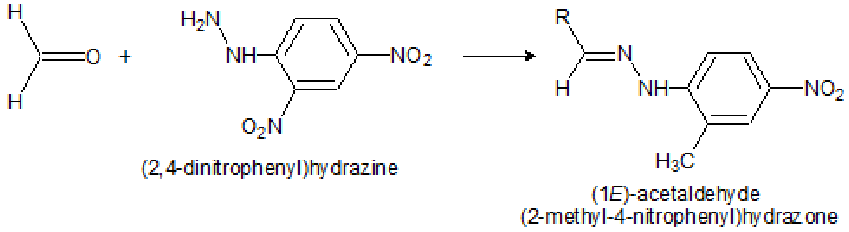
$$HCl + NH_4OH \longrightarrow NH_4Cl + H_2O$$

- **Ceric Ammonium Test:** To the sample, we add a few drops of ceric ammonium nitrate and shake well. The appearance of pink or red colour indicates the presence of an alcoholic group.

$$2ROH + (NH_4)_2Ce(NO_3)_6 \rightarrow (ROH)_2Ce(NO_3)_4 + 2NH_4NO_3$$

2) Carbonyls (Aldehydes and Ketones)

- **2,4-dinitrophenyl hydrazine test:** We add a small amount (2 drops or 0.05 – 0.1g) of the substance to 3 ml of 2,4-dinitrophenyl hydrazine reagent and shake well. A crystalline precipitate indicates the presence of a carbonyl compound. Occasionally the precipitate is oily at first but this becomes crystalline upon standing.



3) Aldehydes

- **Schiff's Test:** We dissolve the given compound in alcohol and then add 1-2ml of Schiff's reagent. The appearance of pink, red or magenta colour confirms the presence of aldehyde group.

- **Tollen's Test (Silver Mirror Test):** We add 3-4 drops of the liquid to the Tollen's reagent. We heat the container. A shining mirror precipitate confirms the presence of the aldehyde.

$$2Ag(NH_3)_2^{+} + RCHO + 3OH^{-} \rightarrow RCOO^{-} + 2Ag^{-} + 4NH_3 + 2H_2O$$

4) Carboxyl Group

We can identify Carboxylic acid by the following tests:

- **Sodium Bicarbonate test:** We add Sodium bicarbonate ($NaHCO_3$) to the 1 ml of the sample. A pinch of effervescence indicates the presence of a carboxylic group.

$$RCO_2H + NaHCO_3 \rightarrow RCOONa + CO_2 + H_2O$$

- **Ester Test:** We warm a small amount of the acid with two parts of absolute ethanol and one pare of concentrated sulphuric acid. We cool the solution and pour it continuously into aqueous Na_2CO_3 solution. A sweet, fruity smell of an ester confirms the presence of ester.

5) Amino Group

The most important basic nitrogen compounds are the primary, secondary and tertiary amines and they dissolve in mineral acids and change red litmus to blue.

- **Chemical classification of the amine function:** The classification of primary, secondary or tertiary amines is done by means of the reaction with nitrous acid.

- **Nitrous Acid Test:** We add 2g of the substance to 5 ml of 2 M HCl acid. Then, we cool it and add 2 ml of ice-cold 10% aqueous $NaNO_2$ solution slowly by means of a dropper. If we obtain a clear solution, with a continuous evolution of nitrogen gas, the substance is a primary amine.

$$RNH_2 + HONO \rightarrow ROH + H_2O + N_2$$

Reference page/site
https://www.toppr.com/guides/chemistry/organic-chemistry/qualitative-analysis-of-organic-compounds/

Student's Assessment.

- **Fehling's test is used for the detection of what?**
- **What is meant by organic compounds?**
- **What is an example of an organic chemical?**
- **What are the uses of organic compounds?**
- **Why are organic compounds useful?**
- **What organic compounds are used in medicine?**

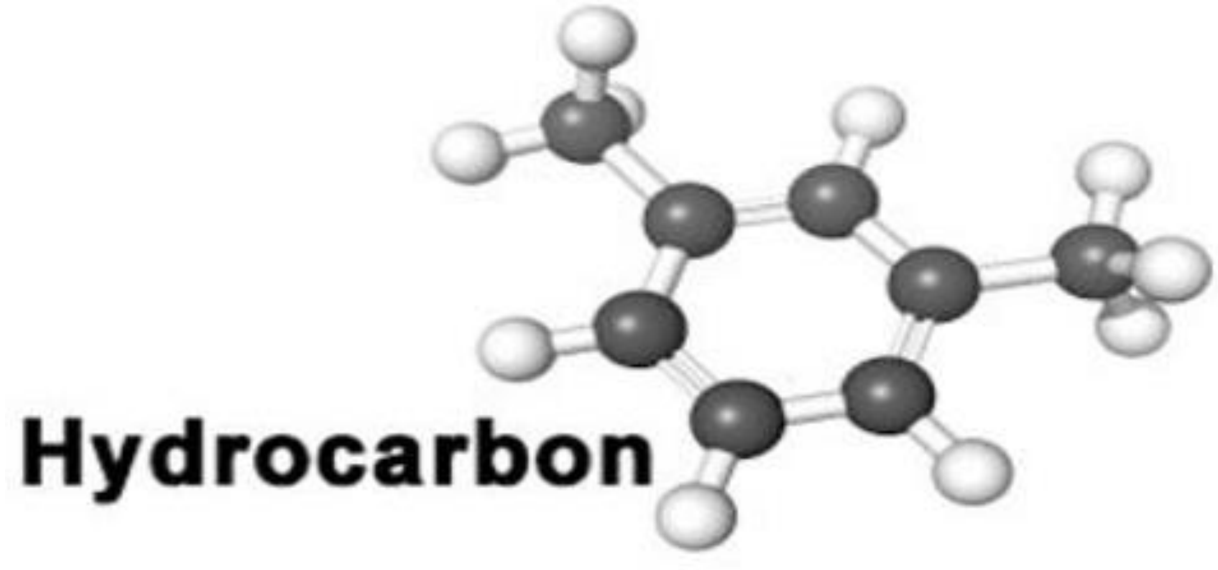
PRACTICAL # 01

- Distillation of oil from mixture of different oil sample by fractional distillation method. **(New)**
- Determination of soap number from soap sample to check the purity of soap. **(New)**

X--------X-------X

CHAPTER # 2

“HYDROCARBON”



INTRODUCTION

CHAPTER CONTENT

Alkanes & cycloalkanes	**Oxidation of organic compound**	**Isomerism**	**Benzene & substituted benzene**	**Alkene & Alkyne**
Nomenclature	Preparation of alkenes	Chiral center	Physical properties	Addition & Elimination reaction
Physical properties	Conjugation	Optical activity	MOT	Types of reaction
Structure	Dehydration of alcohol	Optical isomer	Resonance energy & stabilization	Nomenclature
Relative stability	Dehalogination of alkyl halide	Stereoisomerism	Addition & electrophilic reaction	Ozonolysis
Reactivity	Specific reactions	Structural isomerism	Substituent effects	Polymerization

Major concepts.

- Hydrocarbon
- Alkanes & cycloalkane
- Alkenes
- Alkynes
- Radical substitution reaction
- Oxidation of organic compounds
- Isomerism
- Benzene & substituted benzene.

Conceptual linkage

- This unit is built on
- Introduction to alkane & alkyl halides.
- Alkenes & Alkynes

LEARNING OUTCOMES

Students will be able to	Analyzing	Applying	Understanding
• Classify hydrocarbons as aliphatic and aromatic.			✓
• Describe nomenclature of alkanes and cycloalkanes.			✓
• Explain the shapes of alkanes and cycloalkanes exemplified by ethane and cyclopropane.		✓	
• Explain unreative nature of alkanes towards polar reagents.		✓	
• Define hemolytic and heterolytic fission, free radical initiation, propagation and termination.			✓
• Describe the mechanism of free radical substitution in alkanes exemplified by methane and ethane.			✓
• Identify organic redox reactions.			✓
• Explain what is meant by a chiral center and show that such a center gives rise to optical isomerism.			✓

• Identify chiral centers in given structural formula of a molecule.	✓		
• Explain the nomenclature of alkenes.			✓
• Explain shape of ethene molecule in terms of sigma and pi C-C bonds.			✓
• Describe the structure and reactivity of alkenes as exemplified by ethene.		✓	
• Define and explain with suitable examples the terms isomerism, stereoisomerism and structural isomerism.			✓
• Explain dehydration of alcohols and dehydrohalogenation of RX for the preparation of ethene.			✓
• Describe the chemistry of alkenes by the following reactions of ethene: Hydrogenation, hydrohalogenation, hydration, halogenation, halohydration, epoxidation, ozonolysis, and polymerization.			✓
• Explain the concept of conjugation in alkenes having alternate double bonds.			✓
• Use the IUPAC naming system for alkenes.		✓	
• Explain the shape of benzene molecule (molecular orbital aspect).			✓
• Define resonance, resonance energy and relative stability.)			✓
• Compare the reactivity of benzene with alkanes and alkenes.		✓	

- Describe what is meant by the term delocalized electrons in the context of the benzene ring.			✓
- Describe addition reactions of benzene and methyl benzene.		✓	
- Describe the mechanism of electrophilic substitution in benzene.			✓
- Discuss chemistry of benzene and methyl benzene by nitration, sulphonation, halogenation, Friedal Craft's alkylation and acylation.		✓	
- Apply the knowledge of positions of substituents in the electrophilic substitution of benzene. (Applying)		✓	
- Compare the reactivity of alkynes with alkanes. alkenes and arenes.	✓		
- Discuss the shape of alkynes in terms of sigma and pi C-C bonds.		✓	
- Describe the preparation of alkynes using elimination reactions.		✓	
- Describe acidity of alkynes.			✓
- Discuss chemistry of alkynes by hydrogenation, hydrohalogenation, hydration, bromination, ozonolysis, and reaction with metals.			✓
- Describe and differentiate between substitution and addition reactions.			✓
- Explain isomerism in alkanes, alkenes, alkynes and substituted benzene.			✓

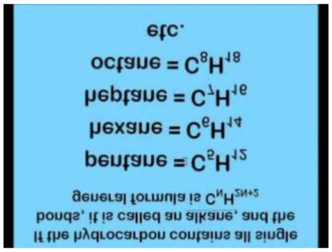
Skills	Analyzing	Applying	Understanding
- Draw different possible ring structure of benzene.			✓
- Draw straight chain of alkane, alkene & alkyne up to 10 carbon atom.			✓
- Predict the nature of molecule by their structure.		✓	

Society, technology & science

Students will be able to

- Identify and link use of various hydrocarbon used in daily life. (Understanding)
- Identify various hydrocarbon which will be important as fuel for the future energy needs of Pakistan, (understanding)

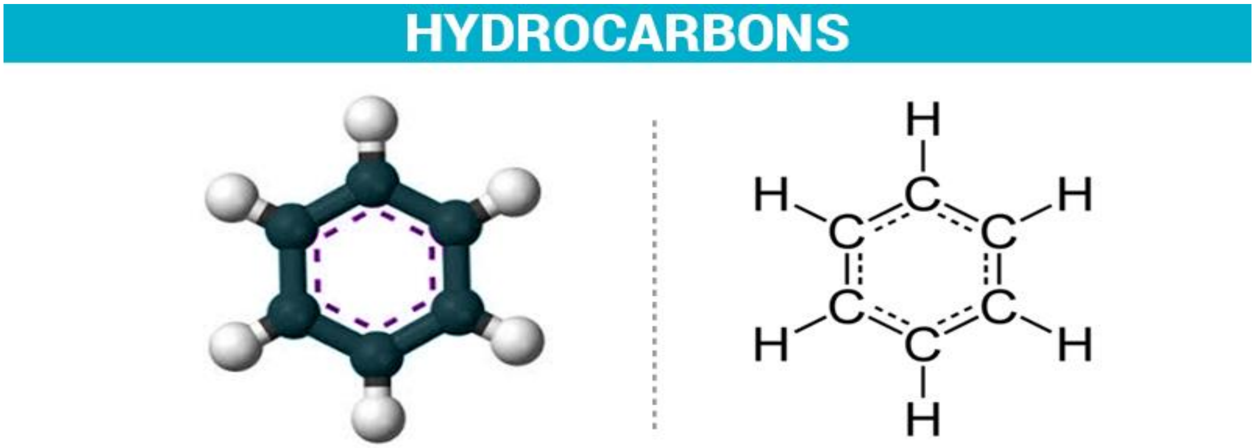
Related videos.



(THEORY)

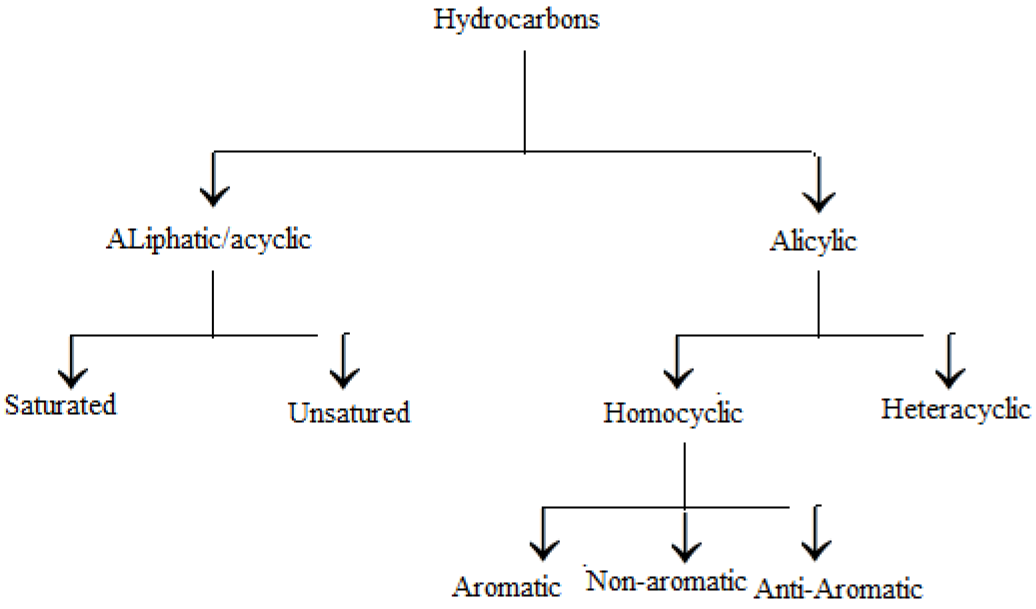
Hydrocarbon

A **hydrocarbon** is an organic chemical compound composed exclusively of hydrogen and carbon atoms. **Hydrocarbons** are naturally-occurring compounds and form the basis of crude oil, natural gas, coal, and other important energy sources.



Classification and Types of Hydrocarbons

Older chemists classified hydrocarbons as either aliphatic or aromatic. The classification was done based on their source and properties. As such, it was found out that Aliphatic hydrocarbons were derived from chemical degradation of fats or oils whereas aromatic hydrocarbons contained substances that were a result of chemical degradation of certain plant extracts. However, today we classify hydrocarbons on the basis of structure and not merely on the origin.



Classification of Hydrocarbons

Types of Hydrocarbons

- Saturated Hydrocarbons: In these compounds, carbon-carbon atoms and carbon-hydrogen atoms are held together by single bonds. These single bonded compounds are the simplest hydrocarbons. These types of hydrocarbons don't have double or triple bonds. In terms of hybridization, they have Sp^3 hybridised carbon atom with no Sp^2 or Sp hybridised Carbon atoms. They are together called as alkanes which have a general formula C_nH_{2n+2}. For example, $CH_4C_3H_6$.
- Unsaturated Hydrocarbons: These compounds consist of a single, double or a triple bond between carbon-carbon atoms. The double-bonded compounds are called alkenes and the triple bonded compounds are called alkynes. The general formula for alkenes is C_nH_{2n} and for alkynes the general formula is C_nH_{2n-2}.
- Cycloalkanes: These hydrocarbons possess one or multiple carbon rings. The hydrogen atom is attached to the carbon ring.
- Aromatic Hydrocarbons: These are also called as arenes. Arenes are compounds which consist of at least one aromatic ring.
- Aliphatic Hydrocarbons: They are straight chain structures having no rings in them.
- Alicyclic Hydrocarbons: They are hydrocarbons having a ring structure in them. The carbons atoms can be Sp, Sp^2 or Sp^3 hybridised.

Properties of Hydrocarbons

Due to their different molecular structures, the empirical formula of hydrocarbons is also different from each other. For instance, alkanes, alkynes or alkenes, the amount of bonded hydrogen decreases in alkenes and alkynes. This is mainly due to the "self-bonding" or catenation of carbon that prevents the complete saturation of the hydrocarbon by the formation of double or triple bonds. The ability of hydrocarbons to bond to themselves is known as catenation. With such capabilities, they can form more complex molecules like cyclohexane and in rare instances aromatic hydrocarbons like benzene.

Meanwhile, cracking of Hydrocarbons is a process in which heavy organic molecules are broken down into lighter molecules. This is accomplished by supplying an adequate amount of heat and pressure. Sometimes catalysts are used to speed up the reaction. This process plays a very important role in the commercial production of diesel fuel and gasoline.

Physical Properties

Alkanes with 10 C-atoms or less are generally gases at room temperatures more than 10 C-atoms, the molecules are gases or liquid. Alkanes generally having low boiling and melting points owing to their weak Vanderwal's interaction.

Boiling point depends on the following factors:

- Molecular mass
- Branching

Alkanes having high molecular mass and high boiling points. Eg: C_2H_6 has more boiling point than CH_4

Alkanes having same molecular mass but having a different number of branches, the one with less branching has more boiling point this is because of the Vanderwal's force weak on as area increases.

For example, CH_3-CH_2-CH_2-CH_3 has more Boiling point. Alkanes are very feebly soluble in water but they are soluble in non-polar solvents such as Benzene, CCl_4, etc.

Preparation of Hydrocarbons – **Alkenes**

General formula: C_nH_{2n}

Preparation Methods

Most of the reactions involving the preparation of alkenes involve elimination process. There are 3 mechanisms suggested for the elimination reactions. All these eliminations are β- eliminations.

E_2 Mechanism

- Second order kinetics.
- Single step process.
- Order & reactivity 1° > 2° > 3°

Because of steric hindrance

- More favoured in non-polar, aprotic solvents.
- Less substituted alkenes formed as a major product.

E_1 Mechanism

- Two step process.
- 1^{st} order kinetics
- Order of reactivity: 3° > 2° > 1°

Because of the stability of carbonation.

- More favoured by polar, protic solvents.
- Rearrangement possible
- Gives more substituted alkene as major products.

Hydration

(i) Acid catalysed

- Markovnikov product
- Rearrangement is possible.

(ii) Hydroboration-oxidation:

- Anti – Markonikov
- No rearrangement

(iii) Oxymercuration-Demercuration:

- Markonikov
- No rearrangement

Oxidation Reactions

- Using Baeyer's reagent
- Using hot $KMnO_4$
- Ozonolysis
- Using O_5O_4
- Addition of peroxy acid

Preparation of Hydrocarbons – Alkynes

Alkynes can be prepared from alkyl halides and alcohols.

Addition reaction:

All addition reactions in alkenes are possible.

Benzene – Preparation

- From ethyne
- From phenol
- From aniline

Chemical Properties:

Benzene generally undergoes electrophilic substitution reactions.

- Friedel Crafts alkylation, halogenation and acylation
- Nitration

Uses of Hydrocarbons

- Hydrocarbons are widely used as fuels. For example LPG (liquefied petroleum gas), CNG (Liquefied natural gas).
- They are used in the manufacturing of polymers such as polyethene, polystyrene etc.
- These organic compounds find their application in the manufacturing of drugs and dyes as a starting material.
- They serve as lubricating oil and grease.

Reference page/site
https://byjus.com/jee/hydrocarbons/

Nomenclature

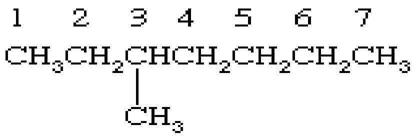
The most widely used standards for organic nomenclature evolved from suggestions made by a group of chemists assembled for that purpose in Geneva in 1892 and have been revised on a regular basis by the International Union of Pure and Applied Chemistry (IUPAC). The IUPAC rules govern all classes of organic compounds but are ultimately based on alkane names. Compounds in other families are viewed as derived from alkanes by appending functional groups to, or otherwise modifying, the carbon skeleton.

The IUPAC rules assign names to unbranched alkanes according to the number of their carbon atoms. Methane, ethane, and propane are retained for CH_4, CH_3CH_3, and $CH_3CH_2CH_3$, respectively. The *n*- prefix is not used for unbranched alkanes in systematic IUPAC nomenclature; therefore, $CH_3CH_2CH_2CH_3$ is defined as butane, not *n*-butane. Beginning with five-carbon chains, the names of unbranched alkanes consist of a Latin or Greek stem corresponding to the number of carbons in the chain followed by the suffix -ane. A group of compounds such as the unbranched alkanes that differ from one another by successive introduction of CH_2 groups constitute a homologous series.

IUPAC names of unbranched alkanes

alkane formula	name	alkane formula	name
CH_4	methane	$CH_3(CH_2)_6CH_3$	octane
CH_3CH_3	ethane	$CH_3(CH_2)_7CH_3$	nonane
$CH_3CH_2CH_3$	propane	$CH_3(CH_2)_8CH_3$	decane
$CH_3CH_2CH_2CH_3$	butane	$CH_3(CH_2)_{13}CH_3$	pentadecane
$CH_3(CH_2)_3CH_3$	pentane	$CH_3(CH_2)_{18}CH_3$	icosane
$CH_3(CH_2)_4CH_3$	hexane	$CH_3(CH_2)_{28}CH_3$	triacontane
$CH_3(CH_2)_5CH_3$	heptane	$CH_3(CH_2)_{98}CH_3$	hectane

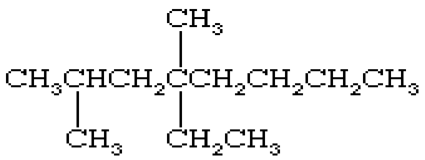
Alkanes with branched chains are named on the basis of the name of the longest chain of carbon atoms in the molecule, called the parent. The alkane shown has seven carbons in its longest chain and is therefore named as a derivative of heptane, the unbranched alkane that contains seven carbon atoms. The position of the CH_3 (methyl) substituent on the seven-carbon chain is specified by a number (3-), called a locant, obtained by successively numbering the carbons in the parent chain starting at the end nearer the branch. The compound is therefore called 3-methylheptane.



$$\overset{1}{C}H_3\overset{2}{C}H_2\underset{\displaystyle |\atop CH_3}{\overset{3}{C}H}\overset{4}{C}H_2\overset{5}{C}H_2\overset{6}{C}H_2\overset{7}{C}H_3$$

3-methylheptane

When there are two or more identical substituents, replicating prefixes (di-, tri-, tetra-, etc.) are used, along with a separate lucent for each substituent. Different substituents, such as ethyl (—CH_2CH_3) and methyl (—CH_3) groups, are cited in alphabetical order. Replicating prefixes are ignored when alphabetizing. In alkanes, numbering begins at the end nearest the substituent that appears first on the chain so that the carbon to which it is attached has as low a number as possible.


$CH_3\underset{CH_3}{CH}CH_2\overset{CH_3}{\underset{CH_2CH_3}{C}}CH_2CH_2CH_2CH_3$

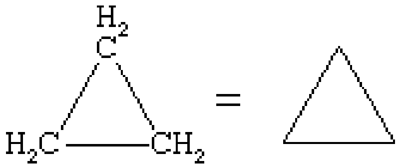
4-ethyl-2,4-dimethyloctane

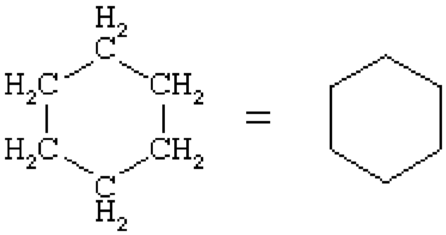
Methyl and ethyl are examples of alkyl groups. An alkyl group is derived from an alkane by deleting one of its hydrogen's, thereby leaving a potential point of attachment. Methyl is the only alkyl group derivable from methane and ethyl the only one from ethane. There are two C_3H_7 and four C_4H_9 alkyl groups. The IUPAC rules for naming alkanes and alkyl groups cover even very complex structures and are regularly updated. They are unambiguous in the sense that, although a single compound may have more than one correct IUPAC name, there is no possibility that two different compounds will have the same name.

Reference page/site
https://www.britannica.com/science/hydrocarbon#ref277891

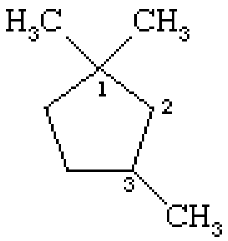
Cycloalkanes

Countless organic compounds are known in which a sequence of carbon atoms, rather than being connected in a chain, closes to form a ring. Saturated hydrocarbons that contain one ring are referred to as cycloalkanes. With a general formula of C_nH_{2n} (n is an integer greater than 2), they have two fewer hydrogen atoms than an alkane with the same number of carbon atoms. Cyclopropane (C_3H_6) is the smallest cycloalkane, whereas cyclohexane (C_6H_{12}) is the most studied, best understood, and most important. It is customary to represent cycloalkane rings as polygons, with the understanding that each corner corresponds to a carbon atom to which is attached the requisite number of hydrogen atoms to bring its total number of bonds to four.

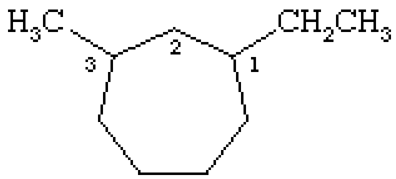

cyclopropane (C_3H_6)


cyclohexane (C_6H_{12})

In naming cycloalkanes, alkyl groups attached to the ring are indicated explicitly and listed in alphabetical order, and the ring is numbered so as to give the lowest locant to the first-appearing substituent. If two different directions yield equivalent locants, the direction is chosen that gives the lower number to the substituent appearing first in the name.



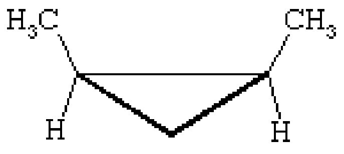
1,1,3-trimethylcyclopentane
(not 1,3,3-trimethylcyclopentane)



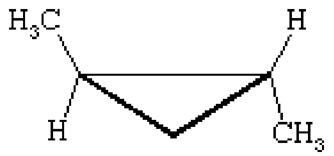
1-ethyl-3-methylcycloheptane
(not 1-methyl-3-ethylcycloheptane)

Stereoisomerism

Certain substituted derivatives of cycloalkanes exhibit a type of isomerism called stereoisomerism in which two substances have the same molecular formula and the same constitution but differ in the arrangement of their atoms in space. Methyl groups in 1,2-dimethylcyclopropane, for example, may be on the same (*cis*) or opposite (*trans*) sides of the plane defined by the ring. The resulting two substances are different compounds, each having its own properties such as boiling point



cis-1,2-dimethylcyclopropane
(bp 37° C)



trans-1,2-dimethylcyclopropane
(bp 29° C)

Cis-trans isomers belong to a class of stereoisomers known as diastereomers and are often referred to as geometric isomers, although this is an obsolete term. *Cis-trans* stereoisomers normally cannot be interconverted at room temperature, because to do so requires the breaking and reforming of chemical bonds.

Isomerism

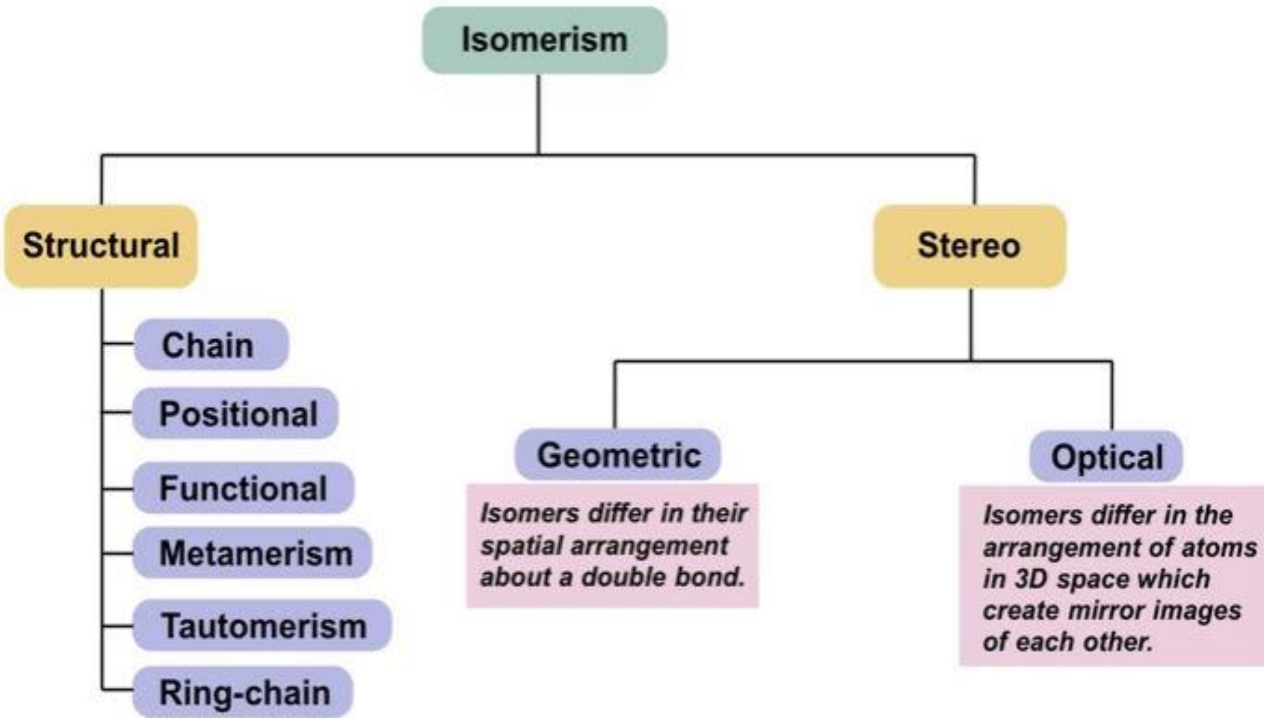
What is Isomerism?

Isomerism is the phenomenon in which more than one compounds have the same chemical formula but different chemical structures. Chemical compounds that have identical chemical formulae but differ in properties and the arrangement of atoms in the molecule are called **isomers**. Therefore, the compounds that exhibit isomerism are known as isomers.

The word "isomer" is derived from the Greek words "isos" and "meros", which mean "equal parts". This term was coined by the Swedish chemist Jacob Berzelius in the year 1830.

Types

There are two primary types of isomerism, which can be further categorized into different subtypes. These primary types are **Structural Isomerism** and **Stereoisomerism**. The classification of different types of isomers is illustrated below.



Structural Isomerism

Structural isomerism is commonly referred to as constitutional isomerism. The functional groups and the atoms in the molecules of these isomers are linked in different ways. Different structural isomers are assigned different IUPAC names since they may or may not contain the same functional group. The different types of structural isomerism are discussed in this subsection.

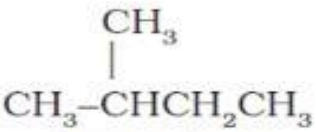
Chain Isomerism

- It is also known as skeletal isomerism.
- The components of these isomers display differently branched structures.
- Commonly, chain isomers differ in the branching of carbon

- An example of chain isomerism can be observed in the compound C_5H_{12}, as illustrated below.

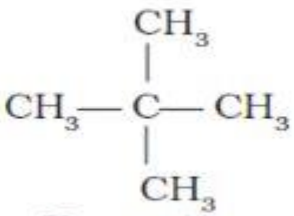
$CH_3CH_2CH_2CH_2CH_3$

Pentane



$CH_3-\overset{\overset{\displaystyle CH_3}{|}}{C}HCH_2CH_3$

Isopentane
(2-Methylbutane)

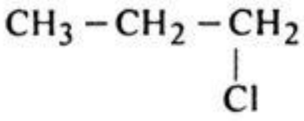


$CH_3-\underset{\underset{\displaystyle CH_3}{|}}{\overset{\overset{\displaystyle CH_3}{|}}{C}}-CH_3$

Neopentane
(2,2-Dimethylpropane)

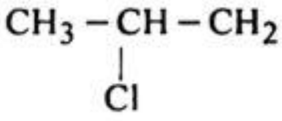
Position Isomerism

- The positions of the functional groups or substituent atoms are different in position isomers.
- Typically, this isomerism involves the attachment of the functional groups to different carbon atoms in the carbon chain.
- An example of this type of isomerism can be observed in the compounds having the formula C_3H_7Cl.



$CH_3-CH_2-\underset{\underset{\displaystyle Cl}{|}}{CH_2}$

1-Chloropropane



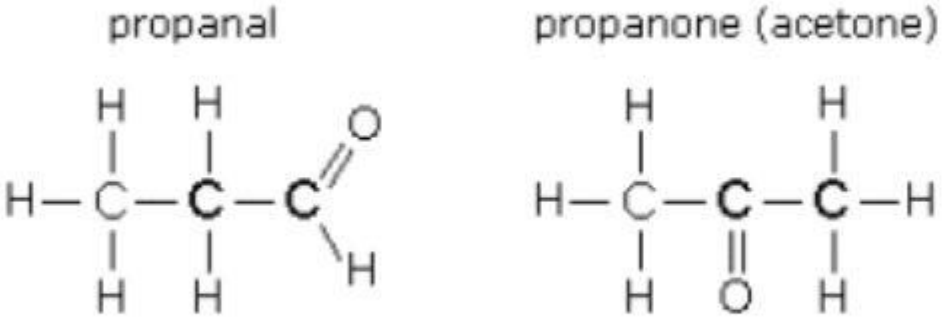
$CH_3-\underset{\underset{\displaystyle Cl}{|}}{CH}-CH_2$

2-Chloropropane

Functional Isomerism

- It is also known as functional group isomerism.
- As the name suggests, it refers to the compounds that have the same chemical formula but different functional groups attached to them.

- An example of functional isomerism can be observed in the compound C_3H_6O.



Metamerism

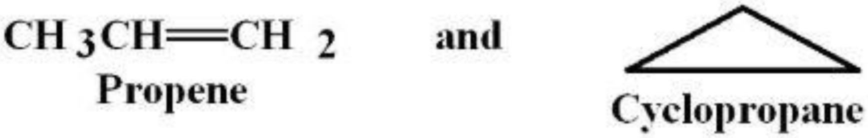
- This type of isomerism arises due to the presence of different alkyl chains on each side of the functional group.
- It is a rare type of isomerism and is generally limited to molecules that contain a divalent atom (such as sulfur or oxygen), surrounded by alkyl groups.
- Example: $C_4H_{10}O$ can be represented as ethoxyethane ($C_2H_5OC_2H_5$) and methoxy-propane ($CH_3OC_3H_7$).

Tautomerism

- A tautomer of a compound refers to the isomer of the compound which only differs in the position of protons and electrons.
- Typically, the tautomers of a compound exist together in equilibrium and easily interchange.
- It occurs via an intramolecular proton transfer.
- An important example of this phenomenon is Keto-enol tautomerism.

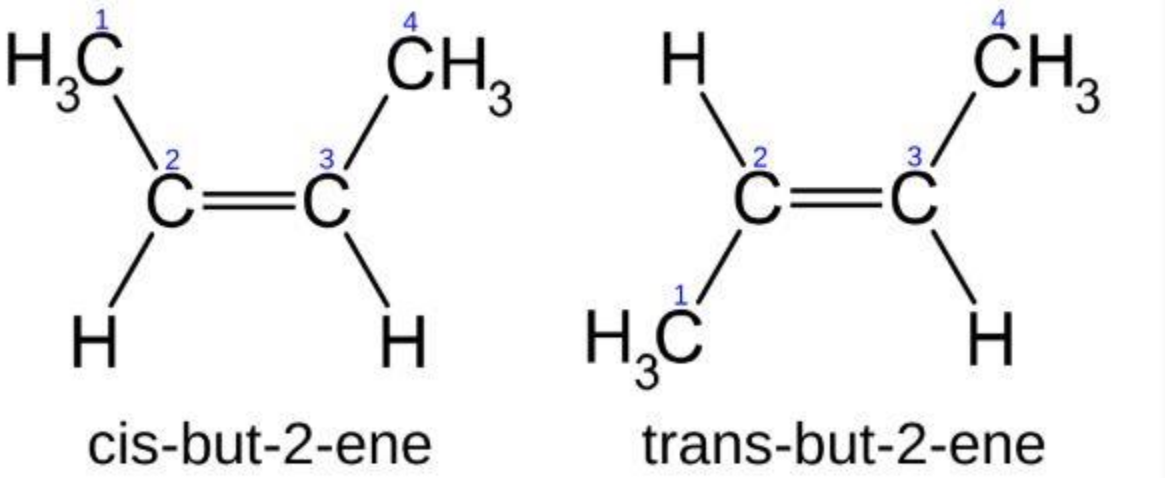
Ring-Chain Isomerism

- In ring-chain isomerism, one of the isomers has an open-chain structure whereas the other has a ring structure.
- They generally contain a different number of pi bonds.
- A great example of this type of isomerism can be observed in C_3H_6. Propene and cyclopropane are the resulting isomers, as illustrated below.



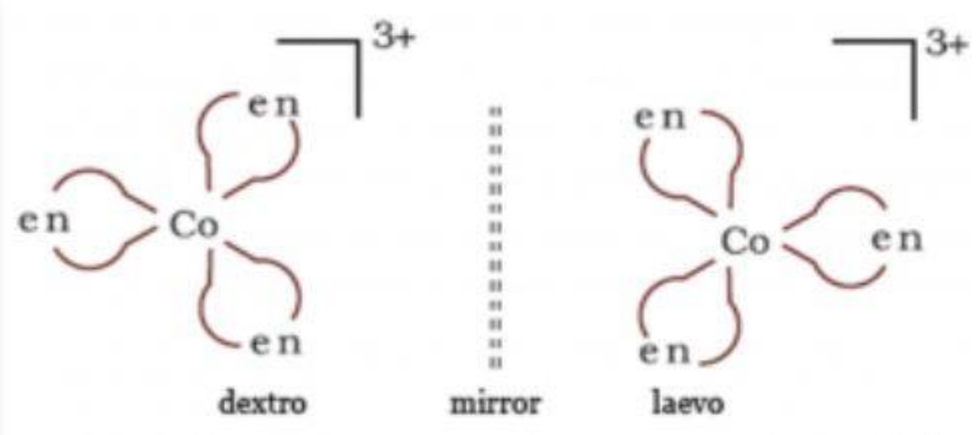
Geometric Isomerism

- It is popularly known as cis-trans isomerism.
- These isomers have different spatial arrangements of atoms in three-dimensional space.
- An illustration describing the geometric isomerism observed in the acyclic But-2-ene molecule is provided below.



Optical Isomerism

- Compounds that exhibit optical isomerism feature similar bonds but different spatial arrangements of atoms forming non-superimposable mirror images.
- These optical isomers are also known as enantiomers.
- Enantiomers differ from each other in their optical activities.
- Dextro enantiomers rotate the plane of polarized light to the right whereas laevo enantiomers rotate it to the left, as illustrated below.



Reference page/site

https://byjus.com/chemistry/isomerism/

Polymer Principles

Polymerization is the process of connecting these monomers together and creating large macromolecules of different sizes and shapes. Polymerization is similar to constructing a large building out of the same type of Lego blocks. The blocks can be connected in various ways to create a larger, more intricately shaped structure than the original Lego block on its own.

The two major types of polymerization are addition polymerization and condensation polymerization.

Addition Polymerization

Polymerization that occurs through the coupling of monomers using their multiple bonds is called **addition polymerization**. The simplest example involves the formation of polyethylene from ethylene molecules. In this reaction, the double bond in each ethylene molecule opens up, and two of the electrons originally in this bond are used to form new carbon-carbon single bonds with two other ethylene molecules.

Some common commercial addition polymers are:

- Polyethylene - films, packaging, bottles
- Polypropylene - kitchenware, fibers, appliances
- Polyvinyl chloride - pipe fittings, clear film for meat packaging

Condensation Polymerization and Hydrolysis

The chemical mechanism that cells use to make and break polymers are basically the same in all cases. Monomers are connected by a reaction in which two molecules are covalently bonded to each other through loss of a water molecule; this is called a **condensation polymerization** because the lost molecule is water. When a bond forms between two monomers, each monomer contributes part of the water molecule that is lost; one molecule provides a hydroxyl group, while the other provides a hydrogen. To make a polymer, this reaction is repeated as monomers are added to the chain one by one.

Polymers are disassembled to monomers by **hydrolysis**, a process that is essentially the reverse of the dehydration reaction. 'Hydrolysis,' from Greek, means to 'break with water.' Bonds between monomers are broken by the addition of water molecules, a hydrogen from the water attaching to one monomer and a hydroxyl attaching to the adjacent monomer.

Some common polymers in life are:

- Disaccharides and polysaccharides like maltose, sucrose, and glycogen
- All proteins made from amino acids
- Nucleic acids, like DNA and RNA, made from nucleotides

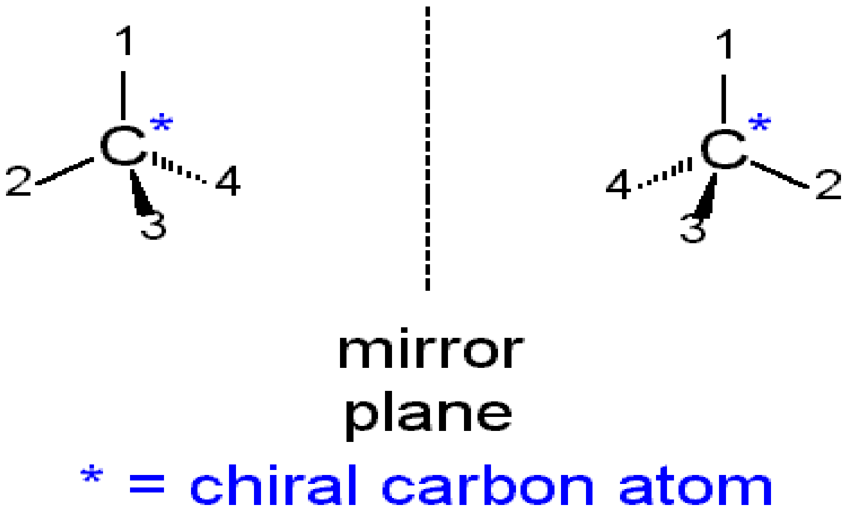
Some common commercial condensation polymers are:

- Polyurethane
- Polyethylene terephthalate (a polyester)
- Nylon 6,6

Reference page/site
https://study.com/academy/lesson/what-is-polymerization-definition-types-process-reactions.html

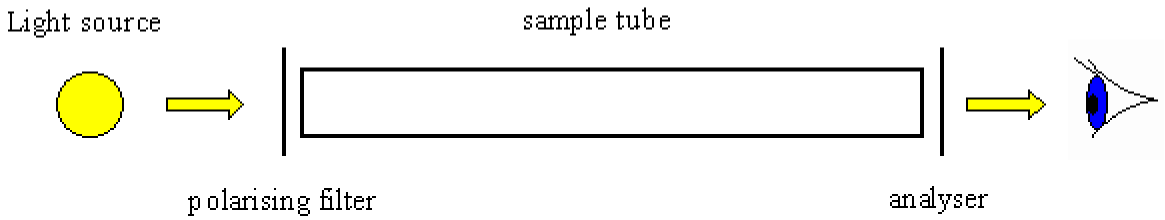
Chiral carbon

An **asymmetric carbon** atom (**chiral carbon**) is a **carbon** atom that is attached to four different types of atoms or groups of atoms.



Optical Activity

Optical activity is the ability of a chiral molecule to rotate the plane of plane-polairsed light, measured using a **polarimeter**. A simple polarimeter consists of a light source, polarising lens, sample tube and analysing lens.



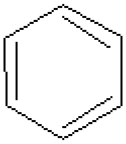
When light passes through a sample that can rotate plane polarised light, the light appears to dim because it no longer passes straight through the polarizing filters. The amount of rotation is quantified as the number of degrees that the analyzing lens must be rotated by so that it appears as if no dimming of the light has occurred.

An introduction of Benzene.

INTRODUCTION

- Molecular formula = C_6H_6
- Empirical formula = CH
- Molecular mass = 78
- Empirical formula mass = 13

- Percentage of carbon = 93.6%
- Percentage of hydrogen = 6.4%

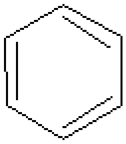


- Structural formula =
- It is an aromatic hydrocarbon.
- Physical state = liquid at room temperature.
- Melting point = 5.5°C
- Boiling point = 80°C
- It is highly inflammable.
- Benzene burns with smoke due to high percentage of carbon.
- It is insoluble in water.
- It is soluble in organic solvents.
- Benzene dissolves fats, sulphur, iodine and resins.
- Nature: (a) highly unsaturated (according to structure)
  (b) saturated (according to reactions)
- Nature of reactions:
  (a) Substitution reactions
  (b)Addition reactions (under special conditions)
- Benzene was first isolated by Faraday.
- Hoffman was the first scientist who separated benzene from coal tar.

WHAT IS THE EXACT STRUCTURE OF BENZENE?

KEKULE'S STRUCTURES FOR BENZENE

To answer this question a chemist KEKULE, in 1865 suggested the following structure for benzene.



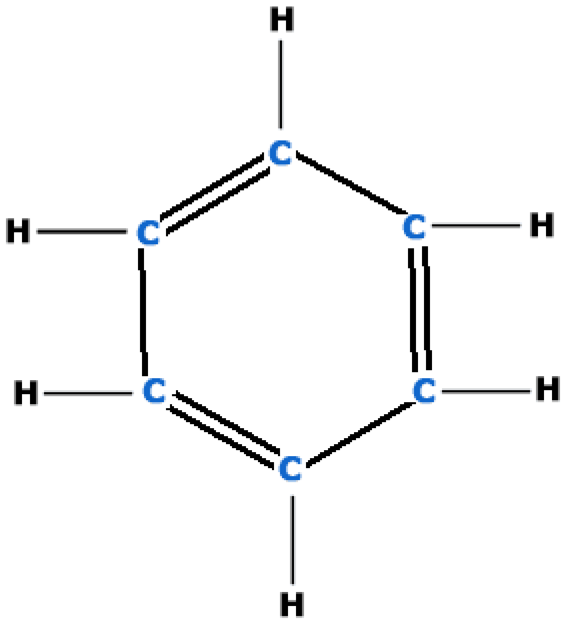
Kekule’s structure of benzene:

According to Kekule:

- Six carbon atoms in benzene are on the six corners of a regular hexagone.

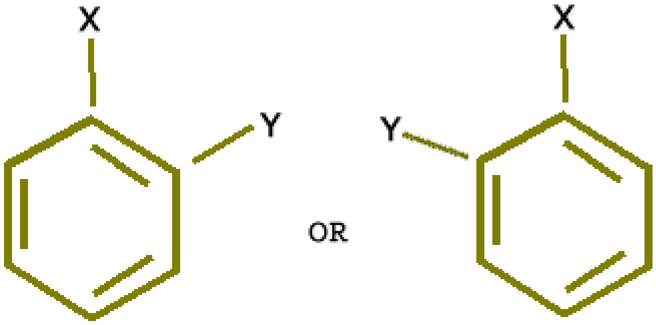
- Each C-atoms is attached with one H-atom.

- There are 3 alternate double bonds between two C-atoms to complete fourth valency of carbon i.e.

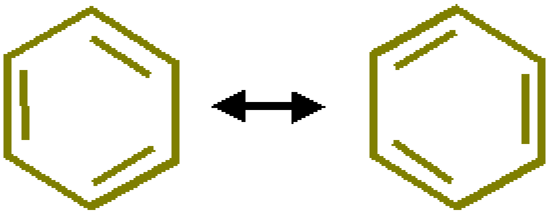


OBJECTIONS TO KEKULE'S PROPOSED STRUCTURE

There was an objection to the above mentioned structure of benzene that it must give two ortho isomers (Di substitution) but in actual practice only one ortho isomer is obtained i.e.



To answer this question Kekule extended his theory and argue that the position of double bond in benzene is not fixed but the double bond system is revolving over the hexagonal ring. He proposed following structures and said that all C-C positions have a partial double bond character.



In the extension of his theory, Kekule, explained that C-atoms in benzene were in a state of vibration and due to this vibration each pair of C-atoms has a single bond half of the time and a double bond the other half time.

Kekule's structure failed to explain why benzene with three double bonds does not undergo addition reactions like alkenes or alkynes.

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Q: Define Aromaticity?

A: The aromatic compounds containing alternate double and single bonds in a cyclic structure and resemble benzene in chemical behaviour. They undergo substitution reactions rather addition reactions. The characteristic behaviour is called **Aromaticity** or aromatic character.

Criteria of Aromaticity:

An aromatic compound is cyclic and planar.

Each atom in an aromatic cyclic ring has a p-orbital. These orbital are parallel to each other and continuous overlapping is possible around the ring.

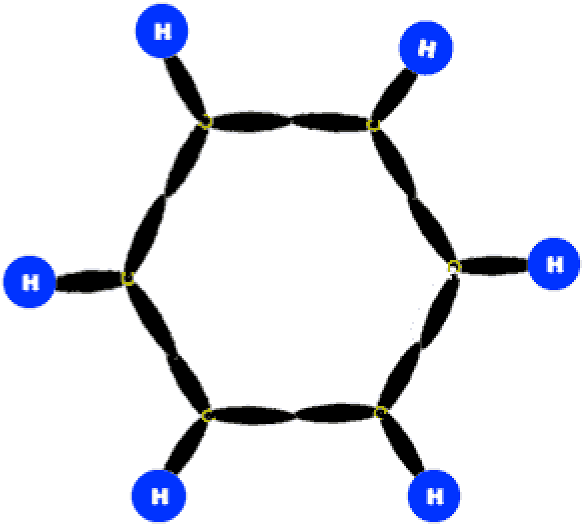
The cyclic pi-molecular orbital formed by the overlapping of p-orbital must contain **(4n+2)** pi- electrons. This is called HUCKLE RULE. Where 'n' is an integer (0,1,2,3,…)

MODERN CONCEPT OF THE STRUCTURE OF BENZENE

MOLECULAR ORBITAL TREATMENT OF BENZENE

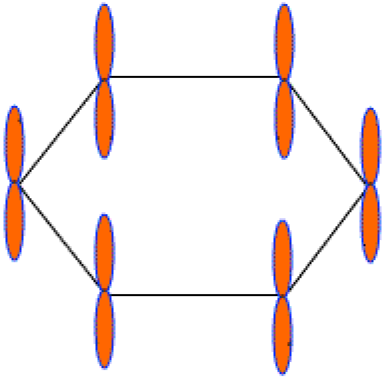
This is the most accurate concept of the structure of benzene. The structure of benzene molecule is best described in terms of molecular orbital treatment theory.

According to this theory, all the C-atoms in benzene are sp^2-hybridized. Two sp^2-hybrid orbitals of each C-atom overlap with two sp^2-hybrid orbital of two other C-atoms to form sigma bonds. In this way there are six sigma bonds are formed between six C-atoms which are 120° apart. Remaining six sp^2-orbital of six C-atoms overlap with 1s orbital of six H-atoms individually to form six sigma bonds. Since sigma bond results from the overlap of above said planar orbital, all H and C atoms are in the same plane and their generate a hexagonal ring of C-atoms.

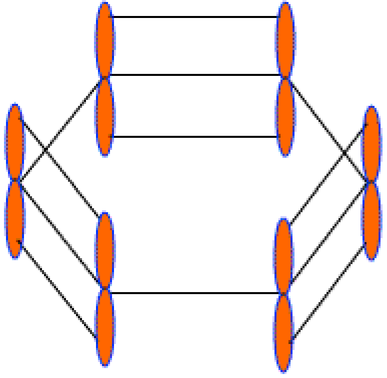


Each C-atom in benzene also has an unhybrid 2pz-orbital containing one electron. These 2pz-orbital are perpendicular to the plane of sigma bonds.

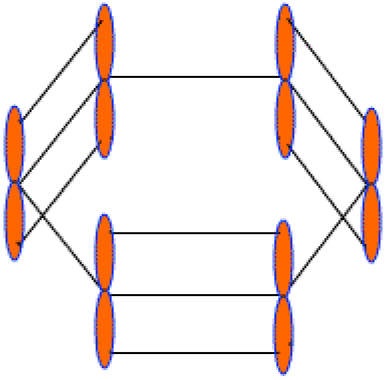
Pz orbital in benzene



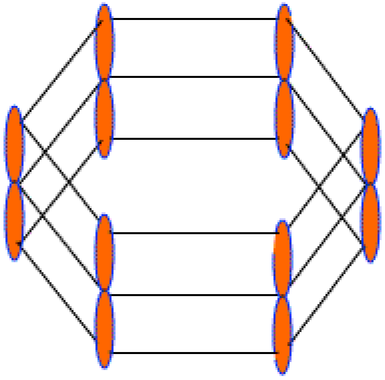
These 2pz-orbitals by lateral overlapping form three alternate pi-bonds in benzene ring.There are two possibilities of pi-bond formation in benzene.



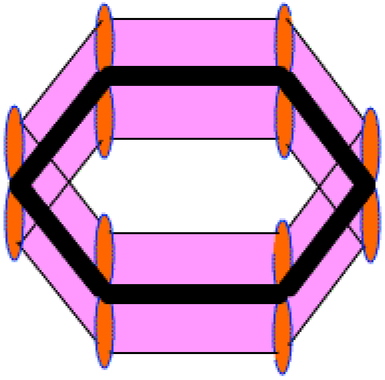
OR



Actually these 2pz-orbital produce a pi-molecular orbital containing six electrons. One half of this pi- molecular orbital lies above the plane of hexagonal ring and remaining half below the ring like a sandwich.



The overlap of these 2pz-orbital result in the formation of a fully delocalized pi-bond, which extends all over the six C-atoms of benzene nucleus. The molecular orbital approach clearly indicates that these six electrons could be found anywhere in highly delocalized manner. As a result of delocalization, a stronger pi-bond and a more stable benzene molecule is obtained which undergo substitution reactions more frequently than addition reactions.



BOND LENGTH ANALYSIS IN BENZENE

C-C length in alkane = 1.54°A
C=C length in alkene = 1.34°A
But in benzene,
C-C length = 1.397°A
C=C length = 1.397°A

This shows that in benzene single and double bonds have quite extraordinary character as they do not resemble to alkane and alkene in bond lengths.

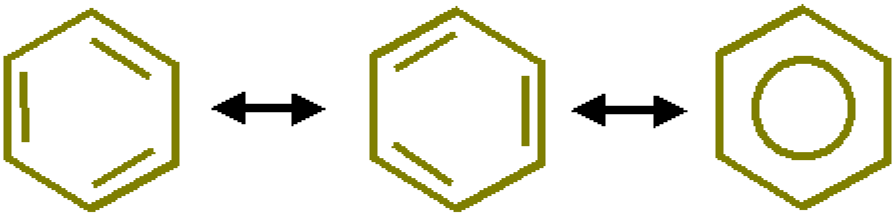
That is why benzene shows a behavior of saturated as well as an unsaturated hydrocarbon simultaneously.

MODERN REPRESENTATION OF BENZENE

With the help of molecular orbital behavior we conclude that benzene has

A regular hexagonal structure with an inscribed circle.

A hexagon with alternate double and single bonds.



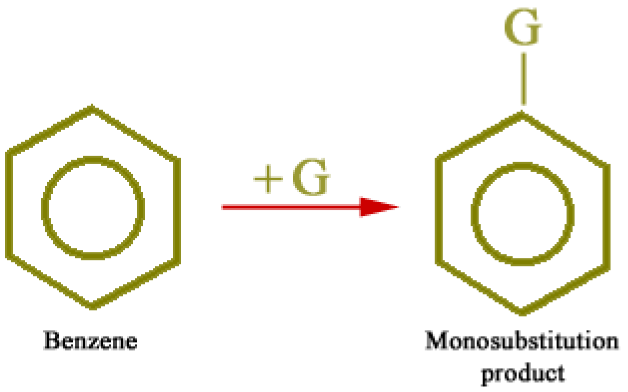
Q: Write a note on the stability of benzene ring.

A: In benzene ring pi-molecular orbital is in a state of vibration due to this vibration resonance is produced. The stability of benzene ring is due to resonance energy of the system. The resonance energy is the difference in energy content of benzene compared with that of a formal written structure. The Kekule's structure requires localization of 2p-electrons as specific pi-bonds alternately between particular C-atoms. The actual resonance hybrid structure has these electrons delocalized spread over the whole ring. Hence, pi-electrons of benzene are not readily available at particular positions as in alkenes, and so do not assist the attack of a weak electrophile in the same way as in alkenes. On the other hand the reactivity of benzene ring is also affected by the presence of annular pi-electronic cloud which acts as a repelling shield to any nucleophile attack. Thus electrophilic substitution is more common in benzene but for a powerful electrophile reagent.

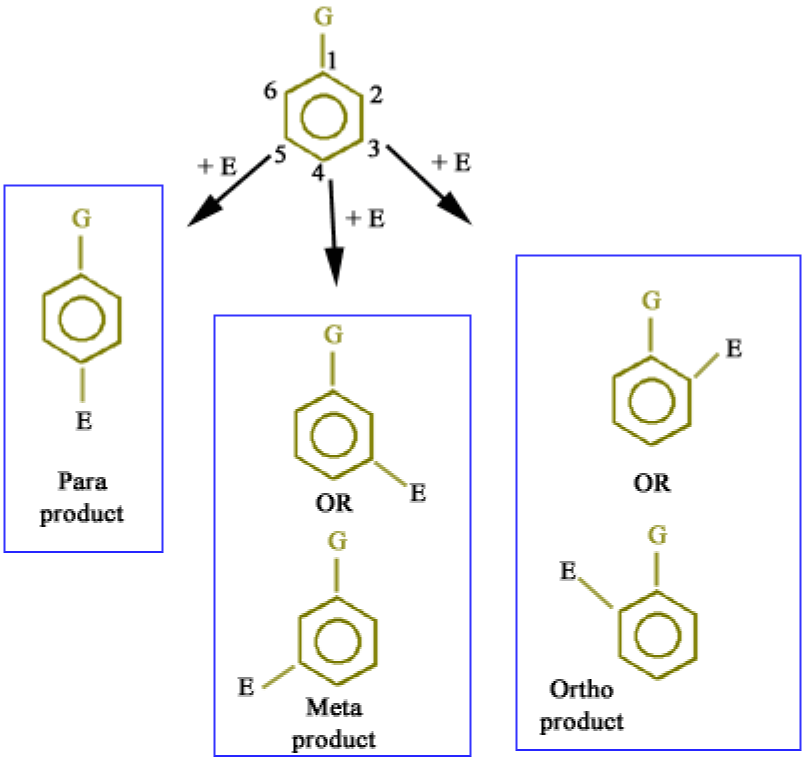
ORIENTATION IN BENZENE

ORIENTATION IN BENZENE

All hydrogen atoms of the benzene ring are equivalent. Therefore,when a group enters into the benzene ring, only one monosubstituted product (C_6H_5-G) is possible as described below:



Problem starts when another group (E^+) or second substituent enters into monosubstituted benzene and it can occupy any one of the remaining five positions as shown below:.



But which one of the five positions the new group will occupy??? Let us discuss the exact possibility.

EFFECT OF SUBSTITUENTS ON FURTHER SUBSTITUTION

Positions 2 and 6 are same (ortho product)
Positions 3 and 5 are same (meta product)
Position 4 is para position

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INFLUENCE OF SUBSTITUENT

A substituent (G) already present on the benzene ring imparts two types of influence on benzene ring for further substitution.

- **Directive effect**
- **Activity effect**

DIRECTIVE OR ORIENTATION EFFECT

The first substituent (G) may direct the next incoming group (E^+) to ortho, meta or para position, depending on the nature of the first substituent. This is called directive or orientation effect.

ACTIVITY EFFECT

The substituent already present may activate or deactivate the benzene ring towards further substitution. These effects are called the activity effects.

DIRECTIVE EFFECTS OF SUBSTITUENTS

In monosubstituted benzene, C_6H_5-G, there are five hydrogen atoms.

- Ortho = 2 positions
- Meta = 2 positions
- Para = 1 position

But, this distribution is never obtained. The products formed, in fact,is determined by the nature of the first substituent already present on the ring .

Reference page/site
https://www.citycollegiate.com/benzene3.htm

Student's Assessment

- What is aliphatic hydrocarbon used for?
- Is benzene aliphatic or aromatic?
- Is alcohol an aliphatic compound?
- What are the 4 types of hydrocarbons?
- Is aliphatic hydrocarbon dangerous?
- What products contain hydrocarbons?
- What are the effects of hydrocarbons?
- What is the main source of hydrocarbons?
- Write structures of all the alkenes which on hydrogenation give 2-methylbutane.
- How would you convert the following compounds into benzene?
  (i) Ethyne (ii) Ethene (iii) Hexane

- What effect does branching of an alkane chain has on its boiling point?
- Write chemical equations for the combustion reaction of the following hydrocarbons:
  (i) Butane, (ii) Pentene, (iii) Hexyne, (iv) Toluene
- Write the IUPAC names of the following compounds :
  (i) $CH_3\ CH = C\ (CH_3)_2$
  (ii) $CH_2 = CH – C\ \ C – CH_3$

Reference page/site
https://byjus.com/ncert-solutions-class-11-chemistry/chapter-13-hydrocarbons/

Lesson plan

https://teachers.net/lessons/posts/3339.html

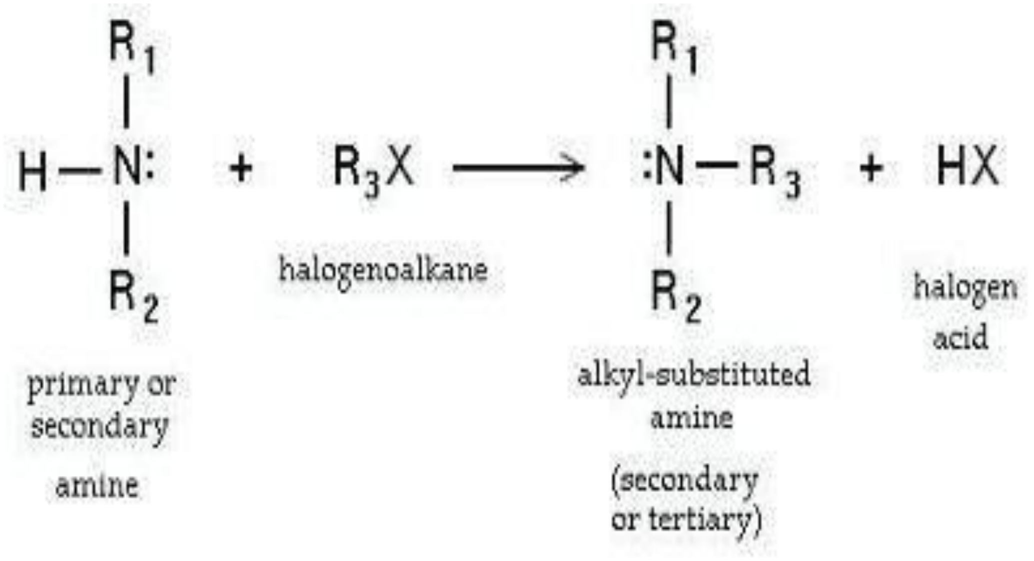
PRACTICAL # 02

- Determination of protein in meat sample. **(New)**
- Determination of fats in the sample of tallow. **(New)**

X-------X--------X

CHAPTER # 3

“ALKYL HALIDES & AMINES”



$$R_1R_2NH + R_3X \longrightarrow R_1R_2NR_3 + HX$$

INTRODUCTION

CHAPTER CONTENT

Alkyl halide	Organometallic compound	Amines
• Nomenclature	• Grignard's reagent	• Nomenclature
• Physical & chemical properties	• Preparation of Grignard's reagent	• Physical & chemical properties
• Preparation of alkyl halide	• Reactions	• Preparation of alkyl amines.
• Different types of reaction	• Chemical properties of Grignard's reagent.	• Structure of amines.
• Mechanism of reactions	• Preparation of alcohol by Grignard's reagent.	• Basicity of amine

Major concepts.

- Alkyl halide
- Organometallic compound
- Amines

Conceptual linkage

- Functional groups
- Amino acids

LEARNING OUTCOMES

Students will be able to	Analyzing	Applying	Understanding
• Name alkyl halides using IUPAC system.		✓	
• Discuss the structure and reactivity of RX.		✓	
• Describe the preparation of RX by the reaction of alcohols with HX, SOCl2 and PX3 and by radical halogenation of alkanes.		✓	
• Describe the mechanism and types of nucleophilic substitution reactions.			✓
• Describe the mechanism and types of elimination reactions.			✓
• Describe the preparation and reactivity of Grignard's Reagents.		✓	
• Discuss chemistry of Grignard's reagent by the addition of aldehydes, ketones, esters and carbon dioxide.			✓
• Discuss nomenclature, structure and basicity of amines.		✓	
• Describe the preparation of amines by alkylation of ammonia to RX and reduction of nitrites, nitro and amide functional groups.		✓	
• Discuss r eactivity of amines.		✓	
• Describe chemistry of amines by alkylation of amines with RX, reactions with aldehydes, ketones, preparation of amides and diazonium salts.	✓		
• Describe isomerism in alkyl halides and amines.			✓

Skills	Analyzing	Applying	Understanding
• Identify amines in the laboratory by carrying out appropriate test.		✓	
• Perform test to detect nitrogen in organic compounds.		✓	
• Differentiate different fruits on the basis of their basicity or acidity.	✓		

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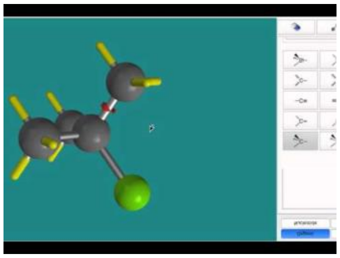
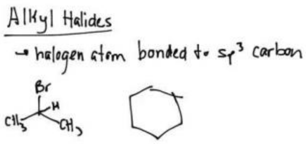
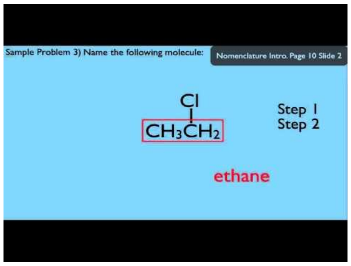
Students will be able to

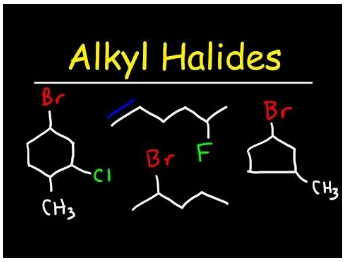
- Identify organic metallic compound in medicines.(Applying)
- Compare hemoglobin and chlorophyll. (Understanding)
- Recognize alkyl halide are precursor of many organic compound. (Applying)

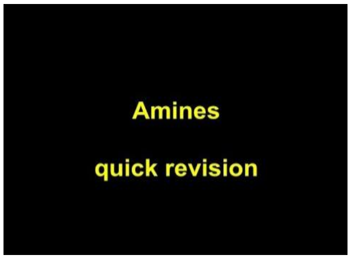
Related videos






Sample Problem 3) Name the following molecule:




Amines

quick revision

(THEORY)

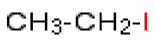
Alkyl Halide

What are Alkyl Halides?

Alkyl halides also called halo alkanes or halogenoalkanes are chemical compounds that are often derived from alkanes that contain one or more halogens. We can also say that alkyl halides are a subset of the general class of halocarbons.

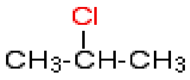
Alkyl halide or halo alkanes are formed by the replacement of hydrogen atoms in an aliphatic hydrocarbon by halogen atoms (Fluorine, chlorine, bromine or iodine). They can also be manufactured from any organic precursors such as alkanes, alkenes, or alcohols and carboxylic acids. Generally, alkyl halides contain hydrogen atoms attached to the sp^3 hybridized carbon atom of alkyl groups.

Some of the examples of Alkyl halide include;



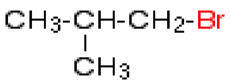
CH_3-CH_2-I

iodoethane



$CH_3-\overset{\overset{Cl}{|}}{C}H-CH_3$

2-chloropropane



$CH_3-\underset{\underset{CH_3}{|}}{C}H-CH_2-Br$

1-bromo-2-methylpropane

Classification Of Alkyl Halide

Alkyl Halide can be classified on the basis of various aspects. They are as follows.

Number of Halogen Atoms

Here, the classification mainly depends on whether they contain one, two, or more halogen atoms in their structure. Under this category we have;

1. Mono Halo alkane

Example: CH_3-CH_2-X [Where X can be Cl, F, Br or I]

2. Dihaloalkane

Example: X-CH_2-CH_2-X [Where X can be Cl, F, Br or I]

3. Trihaloalkane

Example: X-CH_2-CHX-CH_2-X [Where X can be Cl, F, Br or I]

The Position of Halogen atom Along the Chain of Carbon Atom

The classification depends on how the halogen atom is positioned on the chain of carbon atoms.

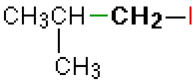
1. Primary alkyl halide
2. Secondary alkyl halide
3. Tertiary alkyl halide

Primary Alkyl Halide

In this type of halo alkanes, the carbon which is bonded to the halogen family will be only attached to one other alkyl group. It doesn't matter how much bulky group is attached to it.

Some examples of primary halo alkanes are,

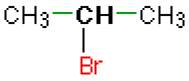
$CH_3-\mathbf{CH_2}-Br$ $CH_3CH_2-\mathbf{CH_2}-Cl$



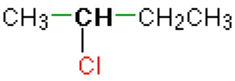
$CH_3\underset{\underset{CH_3}{|}}{C}H-\mathbf{CH_2}-I$

Secondary Alkyl Halide

In this type of halo alkanes, the carbon atom which is bonded with the halogen atom is joined directly to the other two alkyl groups which can be same or different. Some of the examples are:



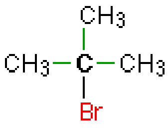
$CH_3-\underset{\underset{Br}{|}}{\mathbf{CH}}-CH_3$



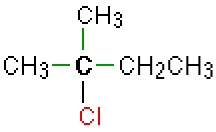
$CH_3-\underset{\underset{Cl}{|}}{\mathbf{CH}}-CH_2CH_3$

Tertiary Alkyl Halide

In this type of haloalkanes, the carbon atom which carries the halogen atom is directly bonded to three alkyl group. This alkyl group maybe with a combination of the same or different. Some examples are,



$CH_3-\overset{\overset{CH_3}{|}}{\underset{\underset{Br}{|}}{\mathbf{C}}}-CH_3$



$CH_3-\overset{\overset{CH_3}{|}}{\underset{\underset{Cl}{|}}{\mathbf{C}}}-CH_2CH_3$

Alkyl Halide Properties

Alkyl halides are colorless when they exist in pure form. But, bromides and iodides develop color when exposed to light. Many volatile halogen compounds have a sweet smell.

Boiling and Melting Points

- Methyl chloride, methyl bromide, ethyl chloride and some chlorofluoromethanes are in the form of gas at room temperature.
- Higher members are liquids or solids.
- As we know, molecules of organic halogen compounds are polar in nature.
- Due to greater polarity and greater molar mass as compared to parent hydrocarbon, the intermolecular force of attraction is stronger in halogen derivatives.
- So, the boiling points of chlorides, bromides and iodides are considerably higher than that of the hydrocarbon with the same molecular mass.
- The attraction gets stronger as the size and number of electrons increases.

- The boiling points of alkyl halides will decrease in the order RI > RBr > RCl > RF.

Density

- Bromo-derivatives, iodo-derivatives and polychloro derivatives of hydrocarbons are heavier than water.
- The density increases with an increase in the number of carbon atoms, halogen atoms and atomic mass of halogen atoms.

Solubility

- The haloalkanes are less soluble in water.
- To dissolve haloalkanes in water, energy is required to overcome the attractions between the haloalkane molecule and break the hydrogen bonds between the water molecules for haloalkanes to dissolve in water.
- Very less amount of energy is released when new attractions between the haloalkanes and the water molecules are formed. Which is not as strong as the original hydrogen bonds in water.
- So, the solubility of haloalkanes in water is less.
- But, the haloalkanes will dissolve in the organic solvent than in the water. Because of this, the complex interaction between the haloalkanes and the creative molecules has the same potential as those broken by the unique and molecular halo alkanes.

Chemical Reactions

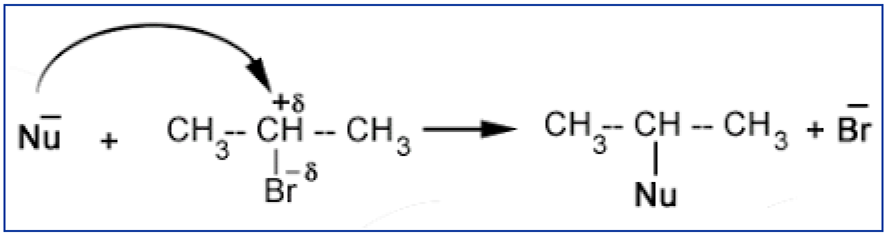
The chemical reaction of halo alkanes can be divided into three categories:

1. Nucleophilic substitution reaction
2. Elimination reaction
3. Reaction with metals

Nucleophilic Substitution Reaction

In this type of reaction, a nucleophile reacts with haloalkane which is having a partial positive charge on the carbon atom which is bonded to halogen. A substitution reaction takes place and halogen atom called leaving group leaves as halide ion. Since the substitution reaction is initiated by a nucleophile, it is called nucleophilic substitution reaction.

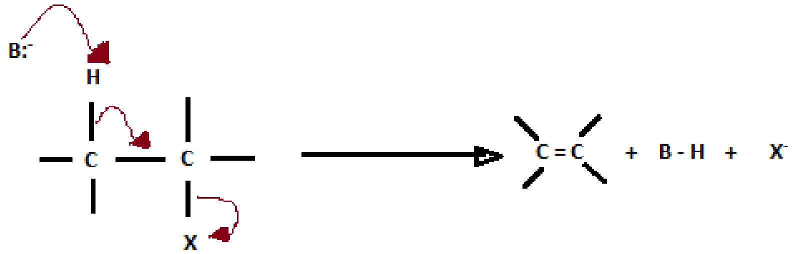
Example:



It is one of the most useful classes of organic reactions of an alkyl halide in which halogen is bonded to sp^3 hybridized carbon.

Elimination Reaction

When a haloalkane having – hydrogen atom is heated with alcoholic solution of potassium hydroxide, it will lead to the elimination of hydrogen atom from β – carbon atom and a halogen atom from the α – carbon atom. As a result, an alkene is formed as one of the products. Since β – hydrogen atom is involved in elimination, it is often called β – elimination reaction.



B = Base X = Leaving group

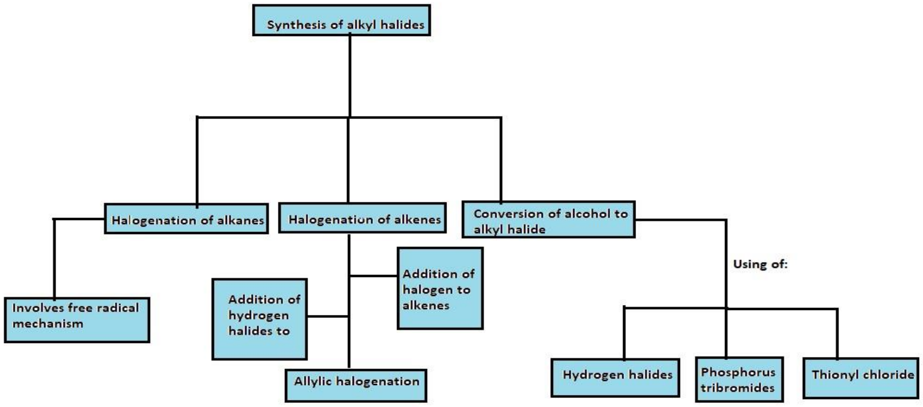
If there is any possibility of formation of more than one alkene due to the presence of more than one β – hydrogen atoms, usually one alkene is formed as the main product.

Reaction With Metals

Most organic chlorides, bromides and iodides react with certain metals to give compounds containing carbon-metal bonds. Such compounds are known as organometallic compounds. The product formed by the reaction of haloalkanes with magnesium metal in dry ether.

Meanwhile, Grignard reagents tend to react actively and can react with any source of protons leading to the formation of hydrocarbons. It is therefore essential to avoid Grignard reagent. Otherwise, this will be considered as one of the modifications to hydrocarbons.

Synthesis of Alkyl Halides

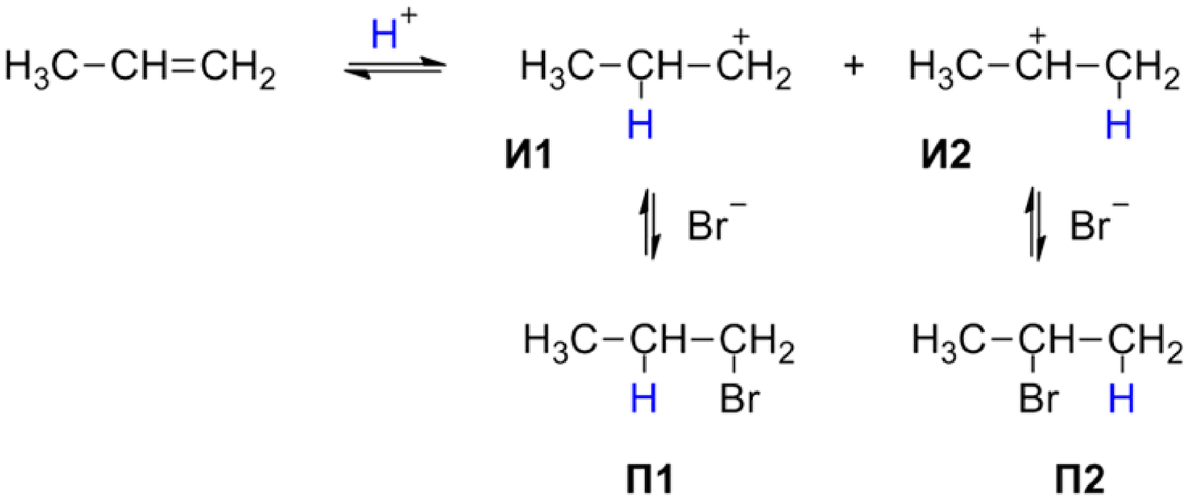


Uses of Alkyl Halide

- Many organic compounds containing halogens occur in nature and some of these are clinically useful.
- These classes of compounds find good applications in industry as well as in day to day life.
- They are used as solvents for relatively non-polar compounds and as starting materials for the synthesis of a wide range of organic compounds.
- Chlorine containing antibiotic, chloramphenicol, produced by soil microorganisms is very effective for the treatment of typhoid fever.
- Some of the fully fluorinated compounds are being considered as potential blood substitutes in surgery.
- They are used as synthon equivalents in organic synthesis.
- Previously used as refrigerants and propellants.
- They are also used in fire extinguishers

Preparation of Alkyl Halides

1. Preparation of Alkyl Halides from Alkenes



Preparation of alkyl halides from alkenes

The addition of hydrogen halides to alkenes follows either Markovnikov’s rule or exhibit Kharash effect. All the electrophilic addition reactions of alkenes following Markovnikov rule are known as Markovnikov addition reactions. A general example of such reaction is given below:

2. Preparation of Alkyl Halides from Alcohols

Alkyl halides can easily be prepared from alcohols upon the addition of halides. In this reaction hydroxyl group of alcohol is replaced with the halogen atom attached to the other compound involved. This reaction requires a catalyst for primary and secondary alcohols whereas it doesn’t require any catalyst for tertiary alcohols.

$$CH_3CH_2OH + SOCl_2 \xrightarrow{\Delta} CH_3CH_2Cl + SO_2 + HCl$$

$$CH_3CH_2OH + PCl_3 \xrightarrow{\Delta} CH_3CH_2Cl + P(OH)_3 + HCl$$

$$CH_3CH_2OH + PCl_5 \xrightarrow{\Delta} CH_3CH_2Cl + POCl_3 + HCl$$

$$CH_3CH_2OH + PBr_3 \xrightarrow{\Delta} CH_3CH_2Br + P(OH)_3 + HBr$$

Preparation of alkyl halides from alcohols

3. Preparation of Alkyl Halides by Free Radical Halogenation

A complex mixture of isomeric mono- and polyhaloalkanes upon free radical chlorination or bromination of alkanes.

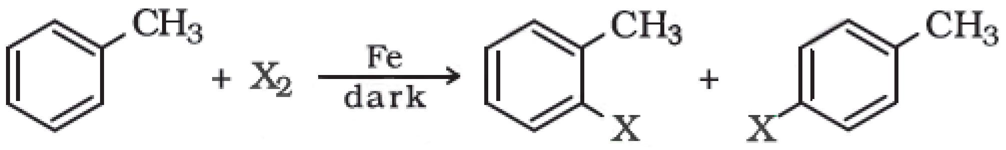
$$CH_3CH_2CH_2CH_3 \xrightarrow{Cl_2/UV light} CH_3CH_2CHCl\,CH_3 + CH_3CH_2CH_2CH_2Cl$$

Preparation of Alkyl Halides via Free Radical Halogenation

Preparation of Aryl Halides

1. Preparation of Aryl Halides via Electrophilic Substitution Reactions

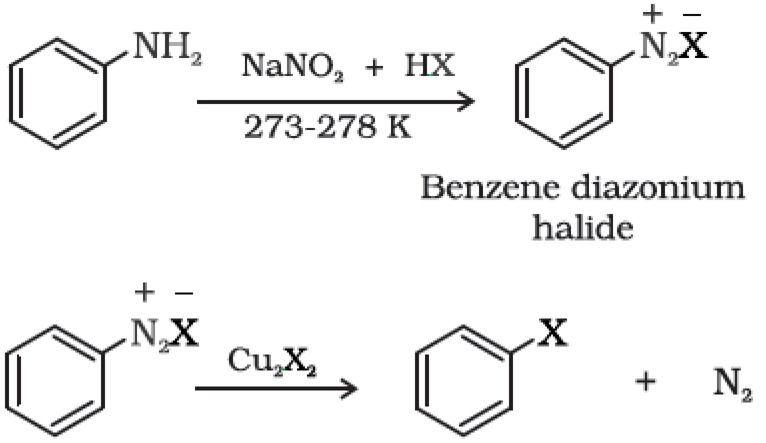
Aryl halides can be prepared by electrophilic aromatic substitution of arenes with halogens in the presence of a Lewis acid.



Preparation of aryl halides via electrophilic substitution reactions

2. Preparation of Aryl Halides through Sand Meyer's Reaction

Aryl halides can also be prepared by mixing the solution of freshly prepared diazonium salt from the primary aromatic amine with cuprous chloride or cuprous bromide.



Preparation of aryl halides through Sandmeyer's reaction

Reference page/site
https://byjus.com/jee/alkyl-halide/

Grignard reagents

Grignard reagents are formed by the **reaction** of magnesium metal with alkyl or alkenyl halides. They're extremely good nucleophiles, reacting with electrophiles such as carbonyl compounds (aldehydes, ketones, esters, carbon dioxide, etc) and epoxides.

A Grignard reagent has a formula RMgX where X is a halogen, and R is an alkyl or aryl (based on a benzene ring) group. For the purposes of this page, we shall take R to be an alkyl group (e.g., CH_3CH_2MgBr). Grignard reagents are made by adding the halogenoalkane to small bits of magnesium in a flask containing ethoxyethane (commonly called diethyl ether or just "ether"). The flask is fitted with a reflux condenser, and the mixture is warmed over a water bath for 20 - 30 minutes.

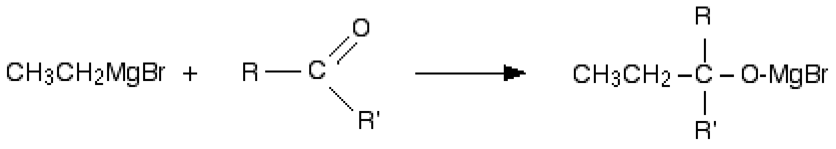
$$CH_3CH_2Br + Mg \xrightarrow{\text{ethoxyethane}} CH_3CH_2MgBr$$

Everything must be perfectly dry because Grignard reagents react with water. Any reactions using the Grignard reagent are carried out with the mixture produced from this reaction; you cannot separate it out in any way. Any excess Grignard reagent must be quenched before disposal.

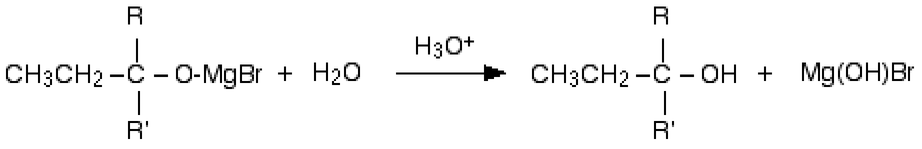
Reactions of Grignard reagents with aldehydes and ketones

These are reactions of the carbon-oxygen double bond, and so aldehydes and ketones react in exactly the same way - all that changes are the groups that happen to be attached to the carbon-oxygen double bond. It is much easier to understand what is going on by looking closely at the general case (using "R" groups rather than specific groups) - and then slotting in the various real groups as and when you need to. The "R" groups can be either hydrogen or alkyl in any combination.

In the first stage, the Grignard reagent adds across the carbon-oxygen double bond:



Dilute acid is then added to this to hydrolyze it.



$$CH_3CH_2-\underset{R'}{\overset{R}{C}}-O\text{-}MgBr + H_2O \xrightarrow{H_3O^+} CH_3CH_2-\underset{R'}{\overset{R}{C}}-OH + Mg(OH)Br$$

An alcohol is formed. One of the key uses of Grignard reagents is the ability to make complicated alcohols easily. What sort of alcohol you get depends on the carbonyl compound you started with - in other words, what R and R' are.

Reference page/site

https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Aldehydes_and_Ketones/Reactivity_of_Aldehydes_and_Ketones/Reactions_with_Grignard_Reagents

Amines

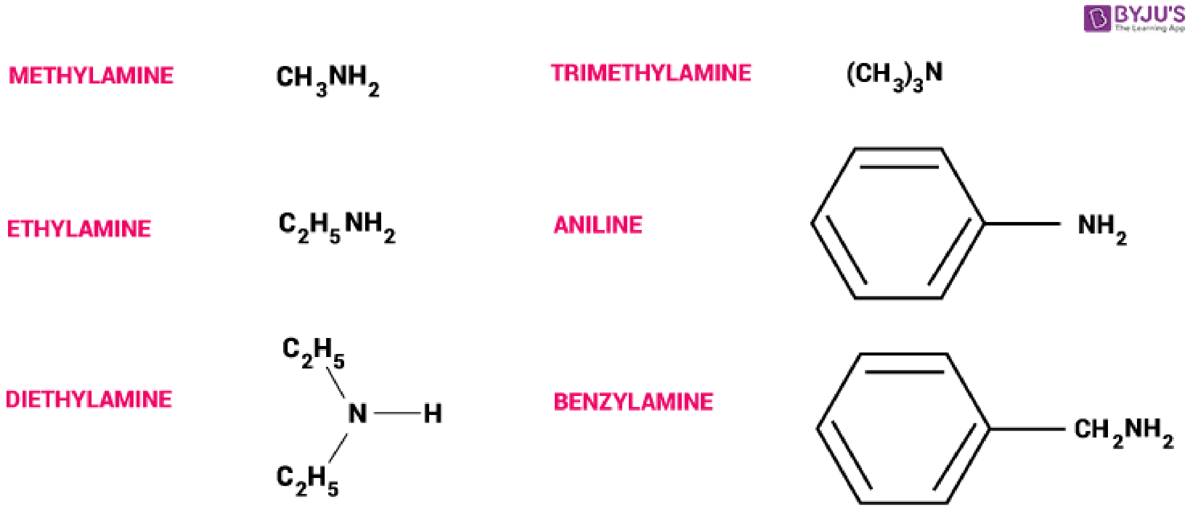
Introduction to Amines – Compounds Containing Nitrogen

Amines are one of the most important classes of organic compounds which can be derived when we replace one or more hydrogen atoms of ammonia molecules with an alkyl group.

What are Amines

An amine is generally a functional group with a nitrogen atom having a lone pair. Amines resemble ammonia structurally where nitrogen can bond up to 3 hydrogen atoms. It is also characterized by various properties that are based on carbon connectivity.

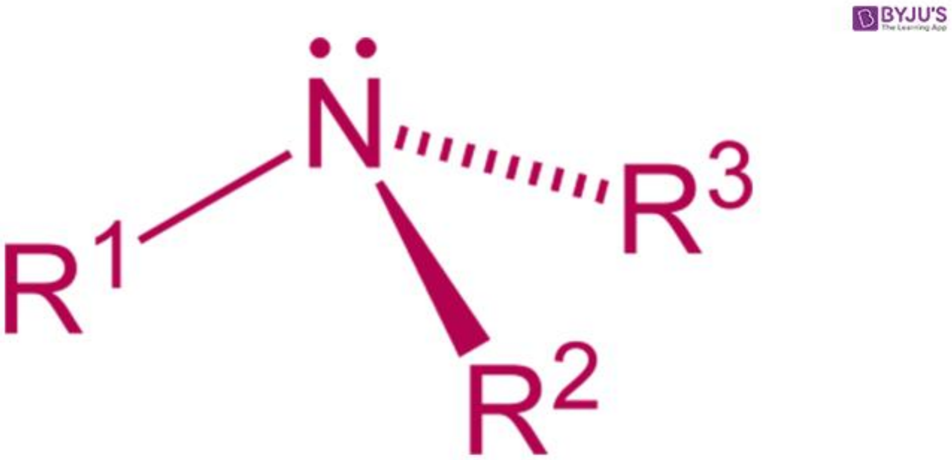
Compounds of nitrogen connected to a carbonyl group are called as amides, they have a structure R–CO–NR'R" and varies in properties with amines.



Amines are organic compounds that contain nitrogen atoms with a lone pair. Basically, they are derived from ammonia (NH3) in which one or more hydrogen atom is replaced by an alkyl or aryl group and so they are known as alkyl amines and aryl amines respectively.

Amine Structure

Nitrogen has 5 valence electrons and so is trivalent with a lone pair. As per VSEPR theory, nitrogen present in amines is sp3 hybridized and due to the presence of lone pair, it is pyramidal in shape instead of tetrahedral shape which is a general structure for most sp3 hybridized molecules. Each of the three sp3 hybridized orbitals of nitrogen overlap with orbitals of hydrogen or carbon depending upon the configuration of amines. Due to the presence of lone pair, the C-N-H angle in amines is less than 109 degrees which is a characteristic angle of tetrahedral geometry. The angle of amines is near about 108 degrees.



Occurrence of Amines

Naturally, amines occur in proteins, vitamins, hormones, etc. and they are also prepared synthetically to make polymers, drugs, and dyes.

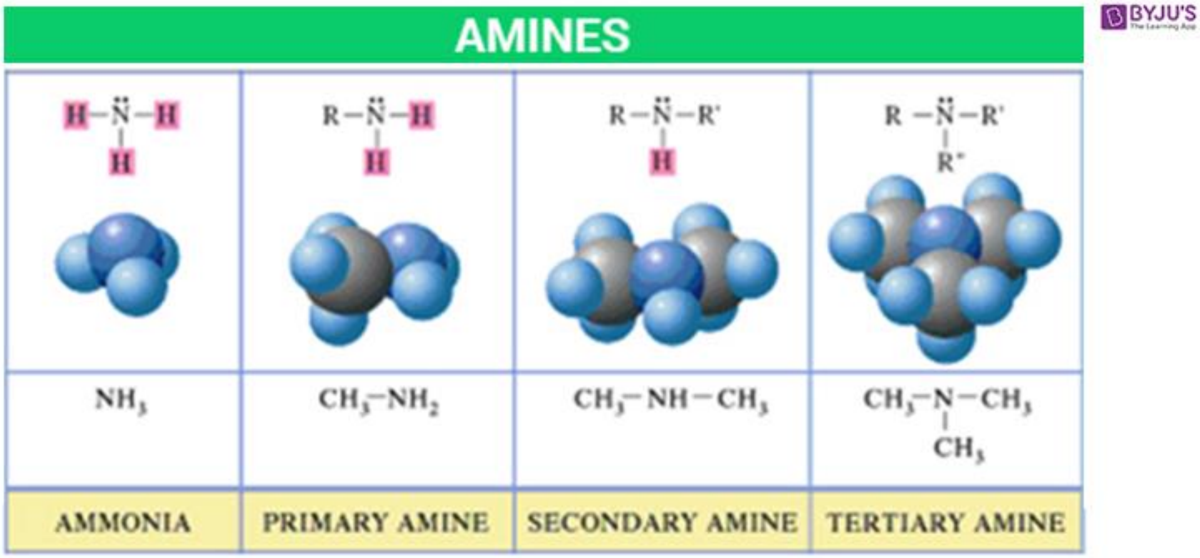
Uses of Amines

Amines have widespread application in our daily lives. Some of the uses of amines are listed below:

- It is used in water purification, medicine manufacturing and development of insecticides and pesticides.
- It is involved in the production of amino acids which is the building block of proteins in living beings. Many different varieties of vitamins are also made by amines.
- Serotonin is an important amine that functions as one of the primary neurotransmitters. It controls the feelings of hunger and is critical for the speed with which the brain operates in general.
- Pain relieving medicines such as Morphine and Demerol which are also known as analgesics are made from amines.

Types of Amines

On the basis of how the hydrogen atoms are replaced by an ammonia molecule, amines can be divided into 4 types.



1. ***Primary Amines***

   When one of the hydrogen atoms of the ammonia molecule is replaced by an alkyl or aryl group.
   Eg: Methylamine CH_3NH_2, Aniline $C_6H_5NH_2$

2. ***Secondary Amines***

   Two organic substituents replace the hydrogen atoms of the ammonia molecule forming an amine.
   Eg: Dimethylamine $(CH_3)2NH$, Diphenylamine $(C_6H_5)_2NH$

3. ***Tertiary Amines***

   When all 3 of the hydrogen atoms are replaced by an organic substituent, it could be an aryl or aromatic group.
   Eg: Trimethylamine $N(CH_3)_3$, Ethylenediaminetetraacetic acid (EDTA)

4. ***Cyclic Amines***

   These are secondary or tertiary amines in an aromatic ring structure. Eg: Piperidine $(CH_2)_5NH$, Aziridines C_2H_5N.

Basicity of Amines

Similar to ammonia, primary & secondary amines have protic hydrogens and thus they showcase a degree of acidity. Whereas teritary amines have no protic hydrogen and thus do not possess a degree of acidity.

pK_a value for primary & secondary amines is about 38, which makes them a really week acid. Whereas if we take the pK_b, it is about 4. This makes the amines much more basic than acidic. Thus an aqueous solutions of an amine strongly alkaline.

Preparation of Amines

Some of the processes for preparing primary amines are mentioned below.

Preparation of Primary Amines

Making of amines from halogen alkanes

This process will be carried out in a sealed tube. Here halogenoalkanes will be heated with the concentrated solution of ammonia in ethanol. The mixture cannot be heated under the reflux as ammonia would move out in the form of gas from a container.

$$CH_3CH_2Br + NH_3 \longrightarrow CH_3CH_2NH_3^+ Br^-$$

Now coming to the preparation of primary amine from halogen alkanes the reaction takes place in two stages. Salt will be formed at the first stage. Here ethyl ammonium bromide is the salt. It is similar to ammonium bromide expect the fact that one of the hydrogens in the ammonium atom is replaced by an ethyl group.

$$CH_3CH_2NH_3^+ Br^- + NH_3 \rightleftharpoons CH_3CH_2NH_2 + NH_4^+ Br^-$$

A reverse reaction can occur between ammonia and the salt. It is illustrated in the above reaction.

Reduction of nitriles

We can get primary amines when nitriles are reduced with lithium aluminum hydride. This method is mainly used for the preparation of amines which contains one carbon atom more than the starting amine.

Reference page/site
https://byjus.com/chemistry/amines/

Student's Assessment

- Give the reaction of alkyl halide with methanol, Aldehyde & Propanone.
- Identify the general structure for an amine.
- Identify the functional group for amines.
- Determine the structural feature that classifies amines as primary, secondary, or tertiary.

- Draw the structure for each compound and classify.
    - ethylisopropylamine
    - diethylpropylamine
- Draw the structure for *p*-ethylaniline and classify.
- Prepare tertiary alcohol from Grignard's reagent.

Reference page/site

https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Book%3A_The_Basics_of_GOB_Chemistry_(Ball_et_al.)/15%3A_Organic_Acids_and_Bases_and_Some_of_Their_Derivatives/15.10%3A_Amines_-_Structures_and_Names#:~:text=Amines%20are%20classified%20according%20to,1).

PRACTICAL # 03

- Quantitative analysis of alkyl halide sample as CFC gas in refrigerators. **(New)**

X-------X--------X

CHAPTER # 4

“ALCOHOLS, PHENOLS & ETHER”

INTRODUCTION

CHAPTER CONTENT

Alcohols	Phenols	Ethers
• Nomenclature	• Nomenclature	• Nomenclature
• Physical & chemical properties	• Physical & chemical properties	• Physical & chemical properties
• Structure of alcohol & its derivative.	• Structure of phenol & its derivative.	• Structure of ether & its derivative.
• Preparation of alcohol.	• Preparation of phenol.	• Preparation of ether.
• Chemical reactivity	• Chemical reactivity	• Chemical reactivity

Major concepts.

- Alcohol
- Phenols
- Ethers

Conceptual linkage

- Functional groups

LEARNING OUTCOMES

Students will be able to	Analyzing	Applying	Understanding
• Explain nomenclature, structure and acidity of alcohols as exemplified by ethanol.			✓
• Describe the preparation of alcohols by reduction of aldehydes, ketones, carboxylic acids and esters.		✓	
• Explain reactivity of alcohols.			✓
• Describe the chemistry of alcohols by preparation of ethers and esters, oxidative cleavage of 1, 2-diols.		✓	
• Discuss thiols (RSH).			✓
• Explain the nomenclature, structure and acidity of phenols.		✓	
• Describe the preparation of phenol from benzene sulphonic acid, chlorobenzene, acidic oxidation of cumene and hydrolysis of diazonium salts.		✓	
• Discuss the reactivity of phenol and their chemistry by electrophilic aromatic substitution, reaction with Na metal and oxidation.		✓	
• Differentiate between alcohol and phenol.			✓
• Describe isomerism in alcohols and phenols.			✓

• Identify ethers from their formula.			✓

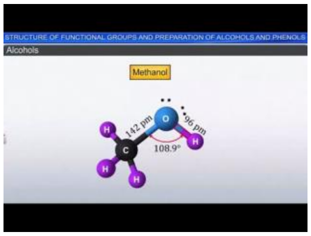
Skills	Analyzing	Applying	Understanding
• Identify alcohol using appropriate laboratory test.		✓	
• Identify alcohol using appropriate laboratory test..		✓	
• Determine the boiling point of alcohol & phenols		✓	

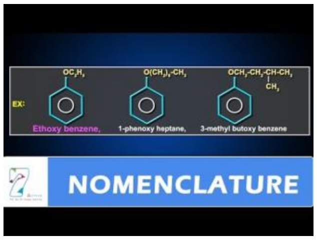
Society, Technology & Science

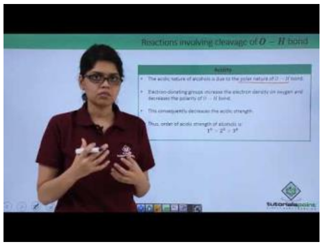
Students will be able to

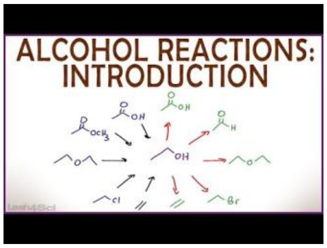
- Explain the rule of disinfectant in hygiene.(Analyzing)
- Differentiate between disinfectants & antiseptic.(Understanding)
- Recognize that ethers are used in anesthesia.(Analyzing)

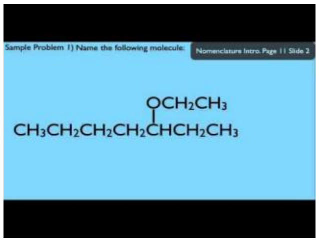
Related videos










Sample Problem 1) Name the following molecule:

$$CH_3CH_2CH_2CH_2\overset{OCH_2CH_3}{CH}CH_2CH_3$$

(THEORY)

Types of Alcohols

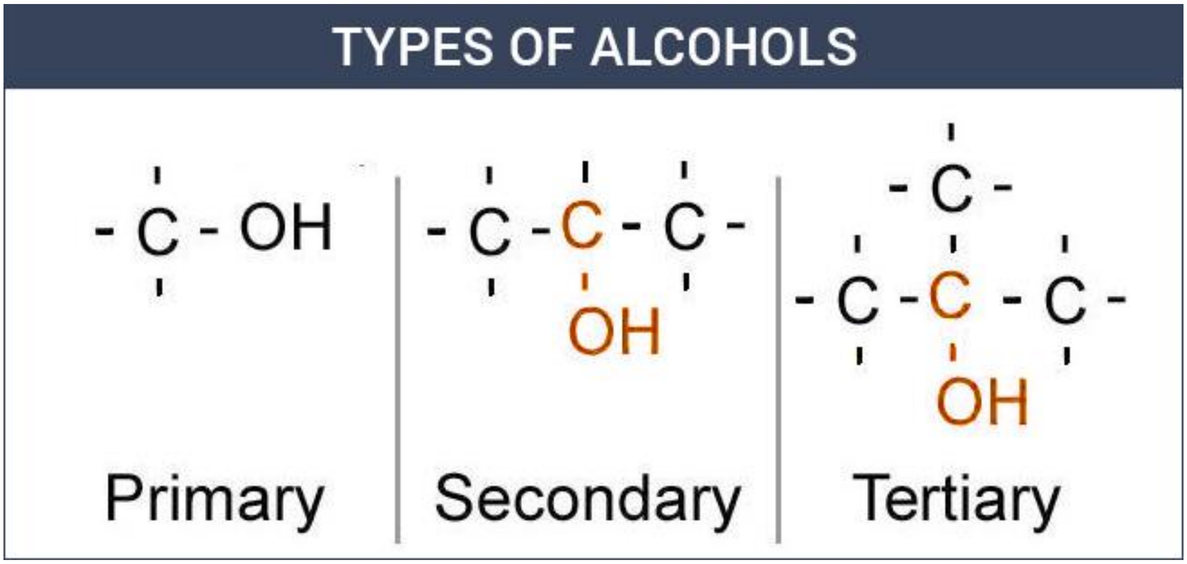
What is Alcohol?

Alcohols are those organic compounds which are characterized by the presence of one, two or more ***hydroxyl groups (−OH)*** that are attached to the carbon atom in an alkyl group or hydrocarbon chain.

Main Types of Alcohols

Alcohols are differentiated based upon the presence of hydroxyl group attached. The location of this hydroxyl group as well will change the physical and chemical properties of any alcohol.

There are three types of alcohol. Alcohols are classified as ***primary, secondary or tertiary alcohols.***

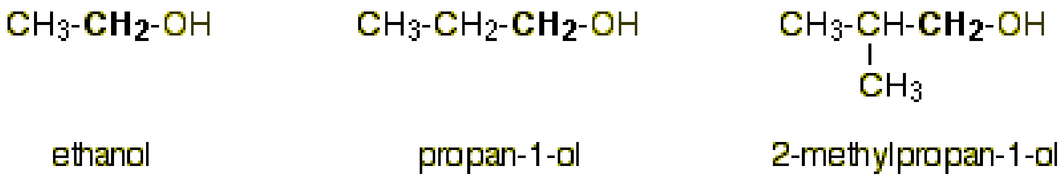


Types of Alcohols – Primary, Secondary & Tertiary Alcohols

Let us study in brief about the ***types of alcohols.***

1. Primary Alcohols

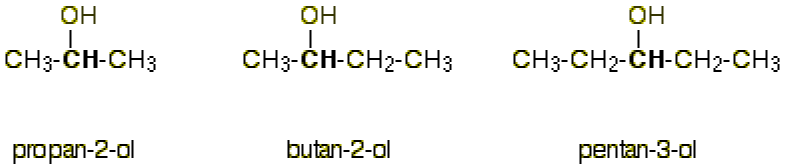
Primary alcohols are those alcohols where the carbon atom of the hydroxyl group(OH) is attached to only one single alkyl group. Some of the examples of these primary alcohols include Methanol (, propanol, ethanol, etc. The complexity of this alkyl chain is unrelated to the classification of any alcohol considered as primary. The existence of only one linkage among –OH group and an alkyl group and the thing that qualifies any alcohol as a primary.



Primary Alcohols – Examples

2. Secondary Alcohols

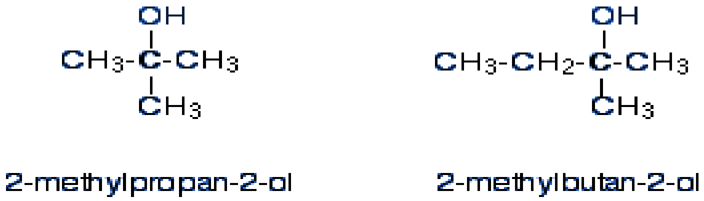
Secondary alcohols are those where the carbon atom of the hydroxyl group is attached to two alkyl groups on either side. The two alkyl groups present may be either structurally identical or even different. Some of the examples of secondary alcohols are given below-



Secondary Alcohol – Examples

3. Tertiary Alcohols

Tertiary alcohols are those which feature hydroxyl group attached to the carbon atom which is connected to 3- alkyl groups. The physical properties of these alcohols mainly depend on their structure. The presence of this -OH group allows the alcohols in the formation of hydrogen bonds with their neighbouring atoms. The bonds formed are weak, and this bond makes the boiling points of alcohols higher than its alkanes. The examples of tertiary alcohols include-



Tertiary Alcohol – Examples

Uses of Alcohols

There are several uses of alcohols. Some are listed below.

- Alcohols are consumed as ***beverages*** where the alcohols specifically consist of 3–40 percent of ethanol by volume.
- These are used as an ***anti-freezing agent*** with a mix of a solution containing ethylene glycol dissolved in water.

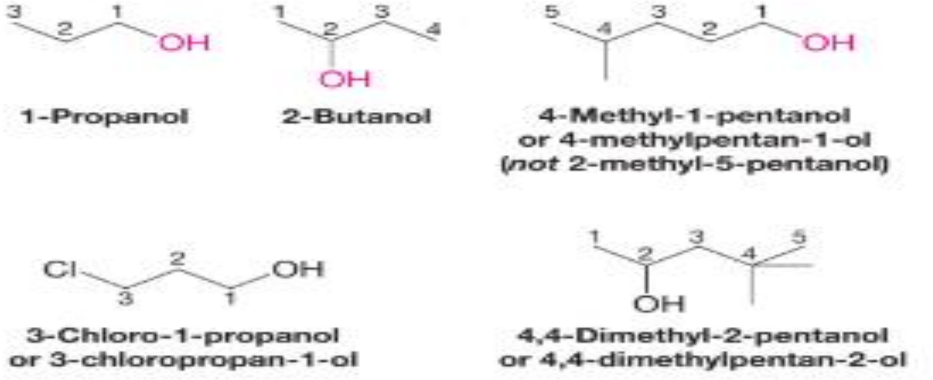
- Alcohol ethanol is used as an ***antiseptic agent***.
- Some of the alcohols are used as ***fuels*** in the internal combustion engines like the methanol.
- In the field of medicine, few of them are used as ***preservatives*** for the specimens in laboratories.

IUPAC Nomenclature for Alcohols

The following procedure should be followed in giving alcohol IUPAC substitutive names.

1. Select the longest continuous chain to which the hydroxyl group is directly attached. Change the name of the alkane corresponding to the chain by dropping the final -e and adding the suffix -ol.
2. Number the longest continuous carbon chain so as to give the carbon atom bearing the hydroxyl group the lower number. Indicate the position of the hydroxyl group by using this number as a locant.
3. Indicate the position of another substituent as a prefix by using the numbers corresponding to their positions along the carbon chain as locants.

The following example shows how the rules are applied.



1-Propanol

2-Butanol

4-Methyl-1-pentanol
or 4-methylpentan-1-ol
(*not* 2-methyl-5-pentanol)

3-Chloro-1-propanol
or 3-chloropropan-1-ol

4,4-Dimethyl-2-pentanol
or 4,4-dimethylpentan-2-ol

IUPAC Nomenclature for Alcohols

Types of Nomenclature in Alcohols

There are three systems of naming alcohols

1. **Common or trivial system**
2. **Carbonyl system and**
3. **IUPAC system**

Formula	Parent Hydrocarbon	Common name	Carbinol name	IUPAC name
CH_3-OH	Methane	Methyl alcohol	Carbinol	Methanol
CH_3-CH_2-OH	Ethane	Ethyl alcohol	Methyl carbinol	Ethanol
CH_3-CH(OH)-CH_3	Propane	Isopropyl alcohol	Dimethyl carbinol	2-Propanol
$(CH_3)_3$-C-OH	2-Methyl propane	Tert-butyl alcohol	Trimethyl carbinol	2-Methyl-2-propanol

Preparation of Alcohols

General Methods of Preparation of Alcohols

1. Hydrolysis of Halides

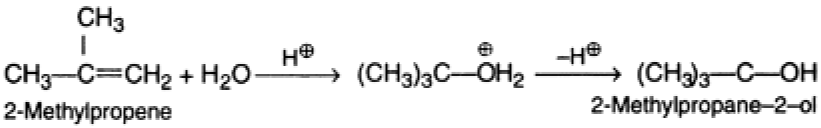
Alkyl halides when boiled with an aqueous solution of an alkali hydroxide give alcohol through nucleophilic substitution mechanism.

R-X + KOH → R-OH + KX

This general procedure produces primary and secondary alcohols. Glycerol can be synthesized from propylene by a series of reactions including the hydrolysis of a halide as one step in the process.

2. Hydration of Alkanes

Direct hydration takes place by adding water in the presence of a catalyst.



$$CH_3-\overset{\overset{CH_3}{|}}{C}=CH_2 + H_2O \xrightarrow{H^{\oplus}} (CH_3)_3C-\overset{\oplus}{O}H_2 \xrightarrow{-H^{\oplus}} (CH_3)_3-C-OH$$

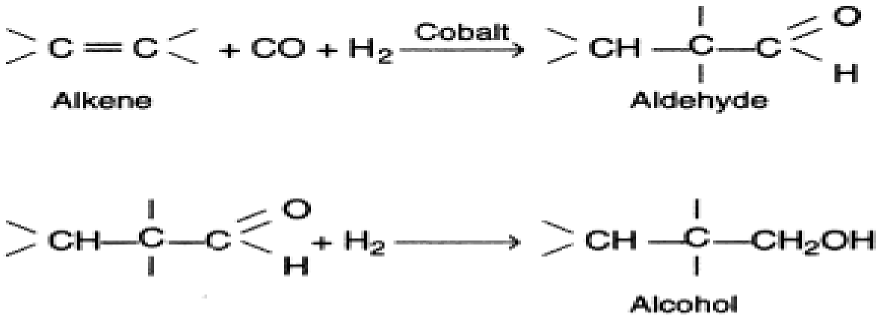
Indirect hydration is achieved by the addition of sulphuric acid to alkane followed by hydrolysis of the alkyl hydrogen sulfate.

$$\underset{\text{Ethene}}{CH_2{=}CH_2} + H_2SO_4 \longrightarrow CH_3CH_2OSO_2OH \xrightarrow[\Delta]{H_2O} \underset{\text{Ethanol}}{CH_3CH_2OH}$$

3. Hydroformylation of Alkenes

Lower molecular weight olefins react with carbon monoxide and hydrogen in the presence of a catalyst in a reaction called hydroformylation or the oxo reaction.

The resulting aldehyde is subsequently hydrogenated to form an alcohol.



Hydroformylation of Alkenes

4. Hydroboration of Alkenes

Alkenes, when treated with diborane, give alkyl boranes, R3B. Alkylboranes on oxidation with alkaline hydrogen peroxide give alcohol.

$$\underset{\text{Ethene}}{6CH_2{=}CH_2} \xrightarrow{(BH_3)_2} \underset{\text{Triethyl borane}}{2(CH_3CH_2)_3B} \xrightarrow{H_2O_2/OH^-} \underset{\text{Ethanol}}{6\,CH_3CH_2OH}$$

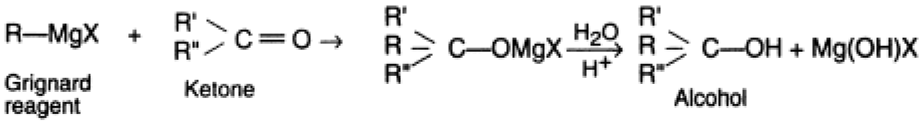
$$\underset{\text{Propene}}{6CH_3CH{=}CH_2} \xrightarrow{(BH_3)_2} \underset{\text{Tri-}n\text{-propylborane}}{2(CH_3CH_2CH_2)_3B} \xrightarrow{H_2O_2/OH^-} \underset{\text{1-Propanol}}{6CH_3CH_2CH_2OH}$$

Hydroboration of Alkenes

It is significant to note that this method always leads to anti-Markovnikov’s addition of water to alkenes.

5. Grignard Synthesis

All three types of alcohol (primary, secondary and tertiary) can be prepared from the Grignard reagents by interaction with suitable carbonyl compounds.



Grignard Synthesis

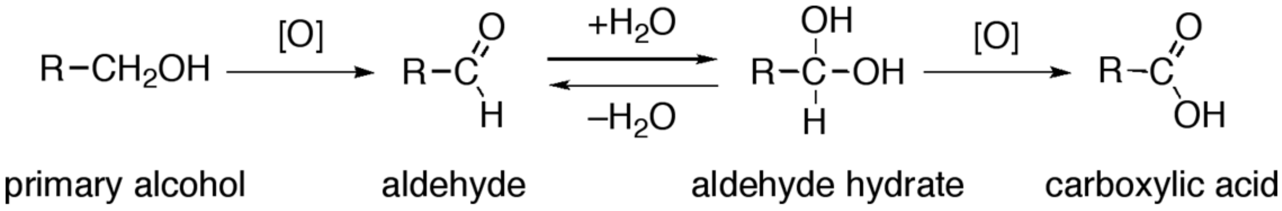
The reaction of the Grignard reagent with formaldehyde leads to primary alcohols, that with aldehydes other than formaldehyde yield secondary alcohols and that with ketones give tertiary alcohols.

Chemical Properties of Alcohols

Alcohols exhibit a wide range of spontaneous chemical reactions due to the cleavage of the C-O bond and O-H bond. Some prominent chemical reactions of alcohols are:

1. Oxidation of Alcohol

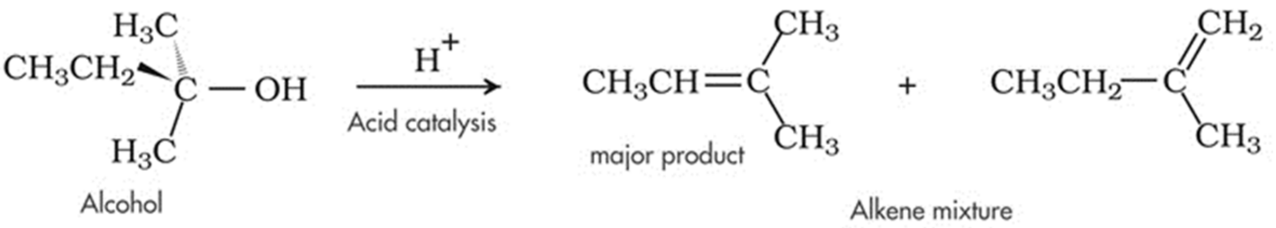
- Alcohols undergo oxidation in the presence of an oxidizing agent to produce aldehydes and ketones which upon further oxidation give carboxylic acids.



Alcohols: Physical and Chemical Properties

2. Dehydration of Alcohol

- Upon treatment with protic acids, alcohols undergo dehydration (removal of a molecule of water) to form alkenes. Dehydration of alcohol



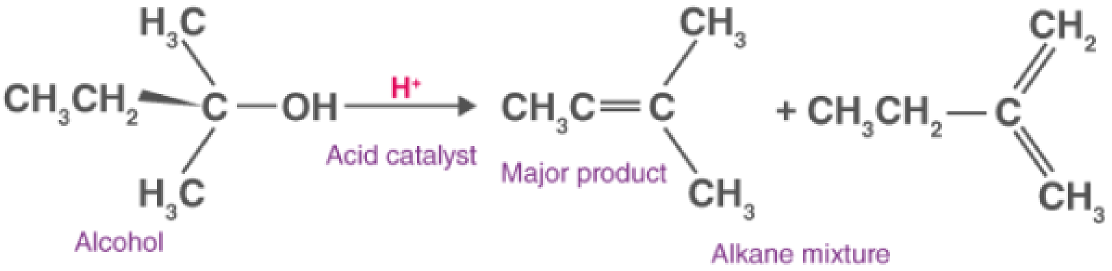
Dehydration Mechanism Steps

If either Raney-Ni, Al(i-ORr)3, or alumina are absent from the catalytic mixture, secondary alcohol dehydrogenation reaction to ketones does not occur. When the Raney-Ni is substituted with other Ni(II) salts I e. NiCl2) or complexes I e. Ni(PPh3)2Cl2), no reaction is noted.

Dehydration of alcohols follows a three-step mechanism.

1. *Formation of protonated alcohol*
2. *Formation of carbocation*
3. *Formation of alkenes*

General dehydration reaction of alcohols can be seen as,



Dehydration Reaction

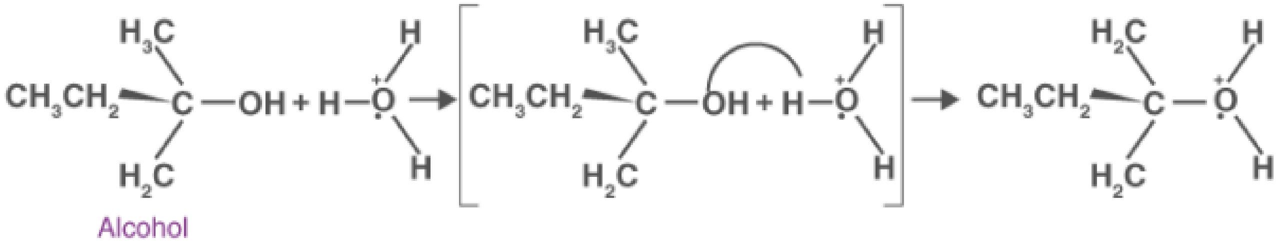
Mechanism of Dehydration of Alcohols:

Dehydration of alcohols can follow E1 or E2 mechanism. For primary alcohols, the elimination reaction follows E2 mechanism while for secondary and tertiary alcohol elimination reaction follows E1 mechanism.

Generally, it follows a ***three-step mechanism***. The steps involved are explained below.

1. Formation of protonated alcohol:

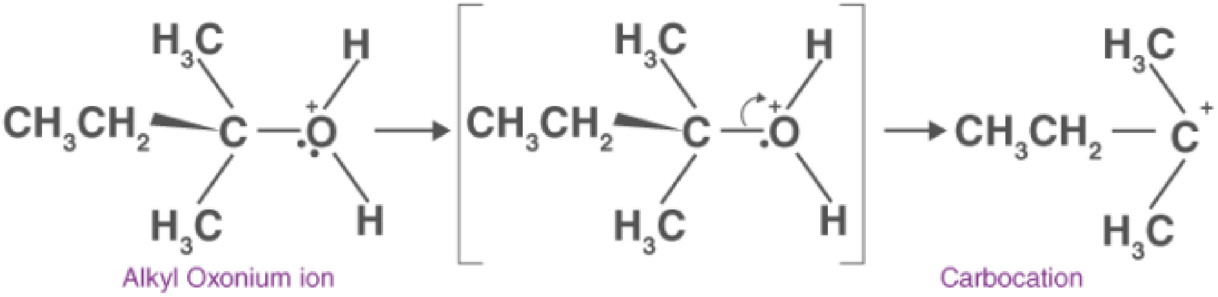
In this step, the alcohol is acted upon by a protic acid. Due to the lone pairs present on oxygen atom it acts as a Lewis base. Protonation of alcoholic oxygen takes place which makes it a better leaving group. It is a reversible step which takes place very quickly.



Formation of Protonated Alcohol

2. Carbocation formation:

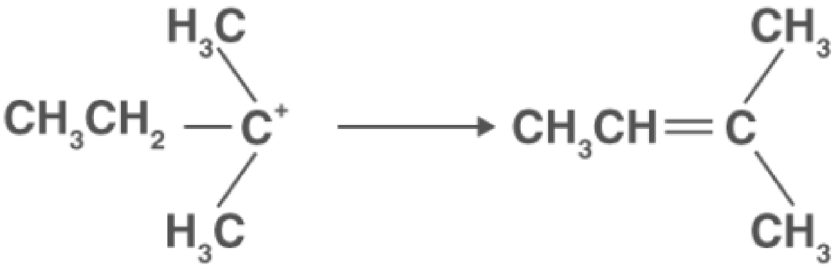
In this step, the C-O bond breaks generating a carbocation. This step is the slowest step in the mechanism of dehydration of an alcohol. Hence, the formation of the carbocation is considered as the rate-determining step.



Carbocation Formation

3. Alkene formation:

This is the last step in the dehydration of alcohols. Here the proton generated is eliminated with the help of a base. The carbon atom adjacent to the carbocation breaks the existing C-H bond to form C=C. Thus, an alkene is formed.



Alkene Formation

Reference page/site
https://byjus.com/chemistry/types-of-alcohols/#:~:text=Alcohols%20are%20those%20organic%20compounds,alkyl%20group%20or%20hydrocarbon%20chain.

Phenol - C6H6O

What is Phenol?

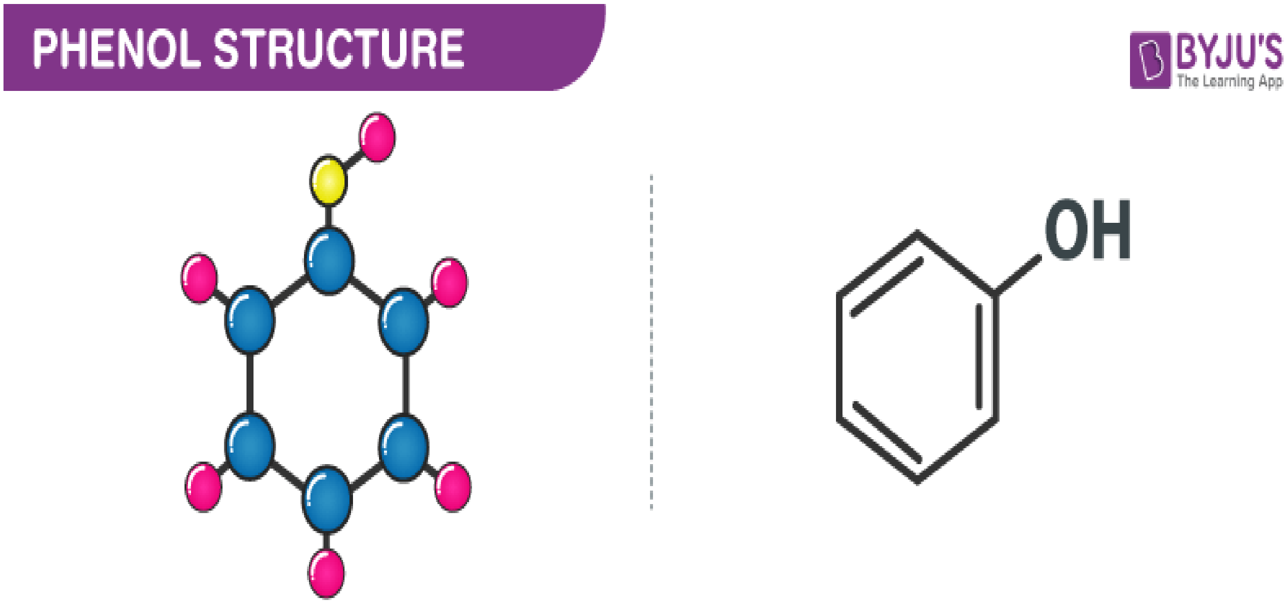
Phenol is an aromatic compound. The chemical formula of this organic compound is C_6H_6O.
It consists of a hydroxyl group and phenyl group attached to each other. It considerably dissolves in water. Earlier it was used as carbolic soap. It is mildly acidic and is corrosive to the respiratory tract, eyes, and skin.

Phenol is a crystalline solid white in color and needs to be handled with care as it can cause chemical burns. Friedlieb Ferdinand Runge discovered Phenol in the year 1834. It was extracted from coal tar. It is also known as phenolic acid. If a compound is consisting of a six-membered aromatic ring and bonded to a hydroxyl group directly, then it can be referred to as phenol.

Natural Sources of Phenols

- Phenol is a constituent of coal tar and is formed during the decomposition of organic materials. Increased environmental levels of phenol may result from forest fires. It has been detected among the volatile components from liquid manure.
- Industrial sources of phenols and other related aromatics from a petroleum refinery, petrochemicals, basic organic chemical manufacture, coal refining, pharmaceuticals, tannery and pulp, and paper mills.

Phenol Structure – C_6H_6O



Phenol Structure – C6H5OH

Nomenclature of Phenols

Phenols are organic compounds containing at least one -OH group directly attached to the benzene ring. Depending upon the number of hydroxyl groups attached to the benzene ring, phenols can be classified as monohydric, dihydric and trihydric phenols.

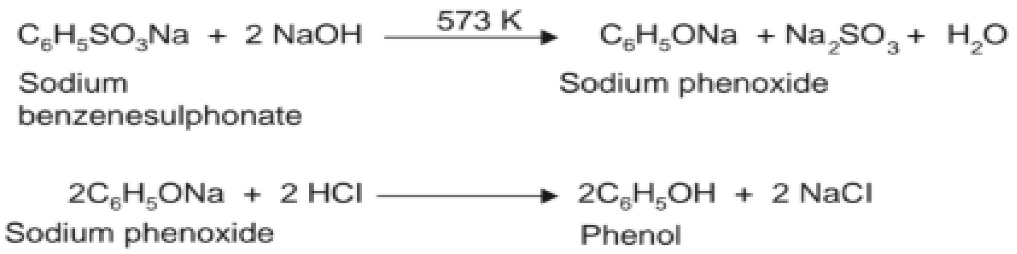
1. ***Monohydric phenols*** – The simplest member of the series is hydroxybenzene, commonly known as phenol, while others are named substituted phenols. The three isomeric hydroxyl toluenes are known as cresols.
2. ***Dihydric phenols*** – The three isomeric dihydroxy benzenes namely catechol, resorcinol, and quinol are better known by their common names.
3. ***Trihydric phenols*** – Trihydroxy phenols are known by the common names called pyrogallol, hydroxyquinol and phloroglucinol.

Synthesis of Phenols

Phenols can be synthesized by the following methods.

1. From sulphonic acids (by alkali fusion of sodium benzene sulphonate)

The first commercial process for the synthesis of phenol. Sodium benzene sulphonate is fused with sodium hydroxide at 573K to produce sodium phenoxide, which upon acidification yields phenol.



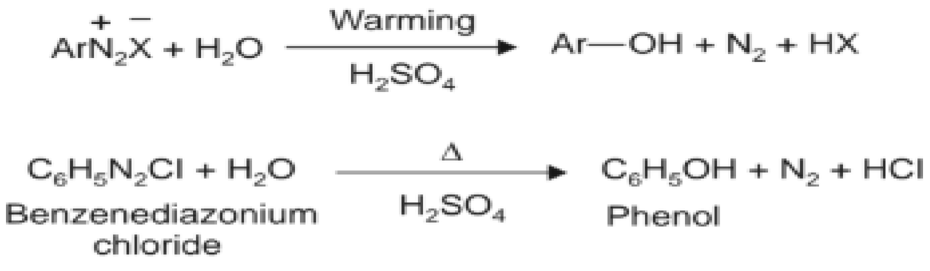
$$C_6H_5SO_3Na + 2\,NaOH \xrightarrow{573\ K} C_6H_5ONa + Na_2SO_3 + H_2O$$

$$2C_6H_5ONa + 2\,HCl \longrightarrow 2C_6H_5OH + 2\,NaCl$$

Synthesis of Phenols From Sulphonic Acids

2. From diazonium salts (by the hydrolysis of diazonium salt – laboratory method)

When a diazonium salt solution is steam distilled or is added to boiling dil.H2SO4, it forms phenol.



$$Ar\overset{+}{N}_2\overset{-}{X} + H_2O \xrightarrow[H_2SO_4]{Warming} Ar{-}OH + N_2 + HX$$

$$C_6H_5N_2Cl + H_2O \xrightarrow[H_2SO_4]{\Delta} C_6H_5OH + N_2 + HCl$$

Synthesis of Phenols From Diazonium Salts

Properties of Phenol – C_6H_6O

C_6H_6O	Phenol
Molecular Weight/ Molar Mass	94.11 g/mol
Density	1.07 g/cm^3
Melting Point	40.5 °C
Boiling Point	181.7 °C

Reactions of Phenols

A hydroxyl group is attached to an aromatic ring and it is strongly activating ortho/para director, phenols possess considerable reactivity at their ortho and para carbons toward electrophilic aromatic substitution.

1. Reactions of the Aromatic Ring

The -OH group in phenol is ortho and para directing because it increases electron density at ortho and para positions due to resonance. Thus phenol undergoes electrophilic substitution reactions.

2. Halogenation

Like $-NH_2$ group, -OH group is so much activating that it is rather difficult to prevent poly substitution.

If it is required to arrest the reaction at the mono substitution stage, the reaction should be carried out in non-polar solvents like CCl_4 and CS_2 and at lower temperatures.

C_6H_6O Uses (Phenol)

- It is used as a precursor in drugs
- It is used as an antiseptic
- It is used in the production of nylon
- It is used to preserve vaccines
- It is used in oral analgesics
- Derivatives of phenol are used in beauty products like hair color and sunscreen
- It is used in the synthesis of plastics

- It is used to produce detergents and carbonates

Reference page/site
https://byjus.com/chemistry/phenol/

Ethers

What Are Ethers?

Ethers are a class of organic compounds derived from the Latin word ‘aether’ which means ‘to ignite’. At room temperature under high-pressure ether are flammable. In ether oxygen atom bonded to two same or different alkyl or aryl groups. The general formula of ether is given as R-O-R, R-O-R’, R-O-Ar or Ar-O-Ar where R represents an alkyl group and Ar represents an aryl group.

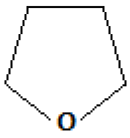
Examples:

1. $CH_3 – O – CH_3$ (Dimethyl ether)

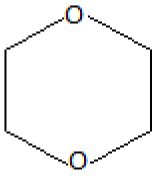
2. $(CH_3)_2CH – O – CH(CH_3)_2$ (Diisopropyl ether)

Cyclic ethers Such as

C_6H5 – O – C_6H_5 (Diphenyl ether)



Tetrahydrofuran (THF)



1,4 dioxane

Ethers can be classified into two broad categories based on the substituent group attached to its oxygen atom: symmetrical ethers and asymmetrical ethers.

Symmetrical ethers are those ethers where two identical groups are attached to the oxygen atom

Example:

$CH_3 – CH_2 – O – CH_2 – CH_3$ (Diethyl ether)

Asymmetrical ethers are those where two different groups are attached to the oxygen atom.

Example:

$CH_3 – O – CH_2 – CH_3$ (Ethyl methyl ether)

Their structure is similar to that of the structure of the alcohol. Interestingly, the structures of both ether and alcohol are similar to the structure of water molecules. This is because, in alcohol, one hydrogen atom of a water molecule is replaced by an alkyl group and in case of ethers, both hydrogen atoms of water molecules are replaced by alkyl or aryl group.

Note: Ether does not possess a hydroxyl group, unlike alcohols and phenols.

Nomenclature Of Ethers

Ethers are named simply by the names of two alkyl/aryl groups bonded to oxygen and add the word 'ether'. Those alkyl groups are listed in alphabetical order.

For example, *t*-butyl methyl ether, ethyl methyl ether

If only one alkyl/aryl group is shown in the name of a particular ether, it implies two identical groups, as in ethyl ether for diethyl ether. Naming for ethers adopted by IUPAC uses a more complex group as the root name, with the oxygen atom and the smaller group named as an alkoxy substituent. Thus, in IUPAC systems, ethers are alkoxy alkanes.

Example: ethoxyethane (diethyl ether), methoxy ethane (methyl ethyl ether), 2-methoxy-2-methylpropane (methyl tert-butyl ether), phenoxy benzene (diphenyl ether).

This IUPAC nomenclature is very useful for naming compounds with additional functional groups because these functional groups can be described in the root name.

Rules for Naming The Ether Using IUPAC Name

Rule 1: Select the longest carbon chain as the base chain and give the base name.

Rule 2: Change the name of the other hydrocarbon group ends with 'yl' change into 'oxy'.

Example: Methyl becomes methoxy and ethyl becomes an ethoxy group.

Rule 3: Alkoxy name is placed with a locator number in front of the base chain name.

Example:

1. $CH_3 – O – CH_2 – CH_2 – CH2 – CH_3$ (1 – Methoxybutane)
2. $CH_3 – CH (CH_3) – CH_2 – O – CH_2 – CH_3$ (1- Ethoxy – 2- methylpropane)

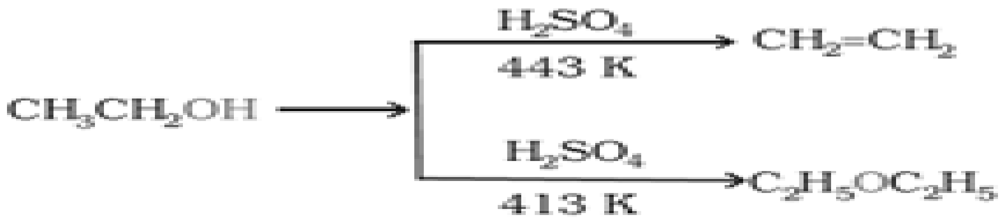
Preparation Of Ethers

Ethers can be synthesized in a number of ways. Most common industrial methods for preparing ethers are:

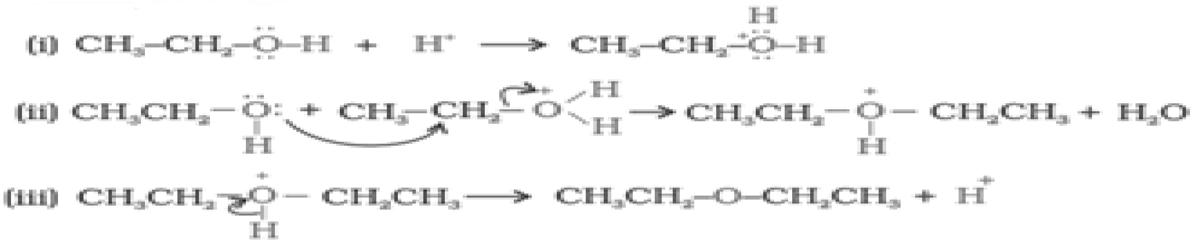
Dehydration of Alcohols

Alcohol undergoes dehydration in the presence of protic acids (sulphuric acid, phosphoric acid) to produce alkenes and ethers under different conditions. The formation of the reaction product depends on the reaction conditions.

For example, ethanol is dehydrated to ethene at 443K in the presence of sulphuric acid. On the other hand, ethanol yields ethoxyethane in the presence of sulphuric acid at 413K.



The formation of ethers by dehydration of an alcohol is a nucleophilic bimolecular reaction. That is, here the alcohol acts as a nucleophile which means it involves the attack of alcohol molecule on a protonated alcohol as shown below

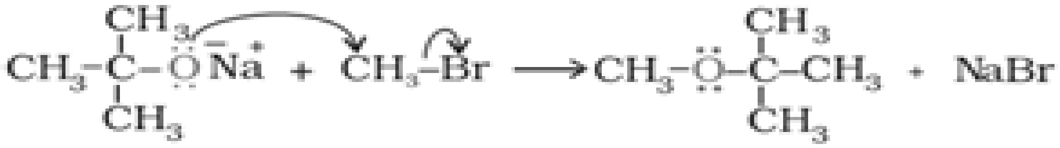


This method is used for the preparation of ethers having primary alkyl groups. To synthesize ethers in this way, the alkyl group should be unhindered and must be kept at low temperature or else the reaction will give rise to alkenes.

Williamson Synthesis

This is an important method for the preparation of symmetrical and asymmetrical ethers in laboratories. In Williamson synthesis, an alkyl halide is made to react with sodium alkoxide which leads to the formation of ether.

Example:



This reaction involves an S_N2 attack of an alkoxide ion on an alkyl halide. We know that alkoxides are very strong bases and they react steadily with alkyl halides and thus they take part in elimination reactions.

In the case of primary alkyl halides, Williamson synthesis shows higher productivity.

Alkyl Halide With Dry Silver Oxide

When alkyl halide is treated with dry silver oxide, ether is produced

$2C_2H_5Br + Ag_2O \rightarrow C_2H_5 - O - C_2H_5 + 2AgBr$

Physical Properties Of Ethers

Dimethyl ether and ethyl methyl ether are both gases at room temperature. Other lower homologues are colourless, pleasant smelling, volatile liquids with a typical ether smell.

1) **Dipole moment:** C-O-C bond angle is not 180°, dipole moments of the two C-O bonds do not cancel each other and thus ethers possess a small net dipole moment.

2) **Boiling point:** Boiling points of ether molecules are comparable to that of alkanes but they are very low compared to that of alcohols of comparable molecular mass. This is because of the presence of hydrogen bonding in alcohol.

3) **Solubility:** Ether molecules are soluble in water. This is because of the fact that like alcohol, oxygen atoms of ether can also form hydrogen bonds with a water molecule.

4) **Polarity:** Ether is less polar than esters, alcohols or amines because of oxygen atom unable to participate in the in hydrogen bonding due to the presence of bulky alkyl group on both side of the oxygen atom. but ether is more polar than alkenes.

5) **Hybridization:** In Ether oxygen atom is sp^3 hybridized with a bond angle of 109.5^0,

Uses Of Ether

- Dimethyl ether is used as a refrigerant and as a solvent at low temperature.
- Diethyl ether is a common ingredient in anesthesia used in surgeries
- Ether is used along with petrol as a motor fuel.
- Diethyl ether is a common solvent for oils, gums, resins etc.
- Phenyl ether can be used as a heat transfer medium because of its high boiling point.

Reference page/site

https://byjus.com/jee/ethers/

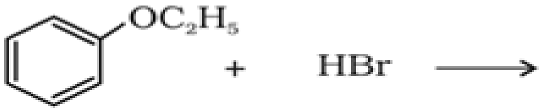
Student's assessment

- Why is C-O-C bond in dimethyl ether 111.7°?

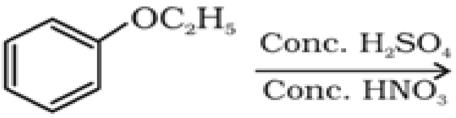
- Alcohol has a higher boiling point than ethers of comparable molecular masses. Why?
- Phenyl methyl ether reacts with HI to form phenol and iodomethane and not iodobenzene and methanol. Why?
- An ether A ($C_5H_{12}O$), when heated with excess of hot concentrated HI, produced two alkylhalides which on hydrolysis forms compounds B and C. oxidation of B gives an acid D whereas oxidation of C gave a ketone E. deduce the structures of A, B, C, D and E.
- Deduce the products of the following reactions:

(i) $CH_3-CH_2-CH_2-O-CH_3+HBr \rightarrow$

(ii)



(iii)



(iv) $(CH_3)_3C-OC_2H_5 \xrightarrow{HI}$

- Write the reactions of Williamson synthesis of 2-ethoxy-3-methyl pentane starting from ethanol and 3-methyl pentane-2-ol.
- What is phenol used for?
- Is phenol acidic or basic and why?
- What is catalytic dehydrogenation of alcohol?
- How are alkenes prepared?
- How do you convert alkanes to alkenes?
- What is the process of hydrogenation?
- What is hydrogenation and its application?

Reference page/site

https://byjus.com/chemistry/dehydration-of-alcohols/
https://byjus.com/chemistry/phenol/
https://byjus.com/jee/ethers/

Lesson plan

https://www.lessonplanet.com/search?keywords=alcohols+and+phenols

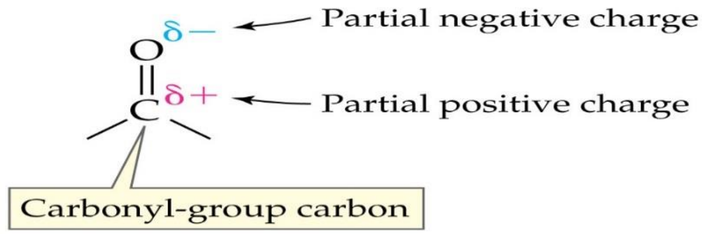
PRACTICAL # 04

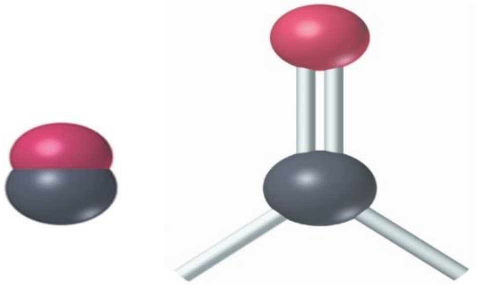
- Calculate the amount of alcohol in cough syrup. **(New)**
- Determination of alcohol in grapes sample. **(New)**
- Quantitative analysis of ether in cleaning detergents. **(New)**

X--------X_---------X

CHAPTER # 5

“CARBONYL COMPOUNDS”





INTRODUCTION

CHAPTER CONTENT

Aldehyde & Ketone	Carboxylic acid
• Relative reactivity	• Preparation of carboxylic acid
• Reduction of aldehyde & ketones	• Reaction of carboxylic acid
• Oxidation reactions	• Conversion of carboxylic acid derivative
• Nucleophilic addition reaction	• Reduction of alcohol
• Ozonolysis	• Decarboxylation reaction

Major concepts.

- Reaction of aldehyde, ketones and carboxylic acid.
- Structure of aldehyde, ketones and carboxylic acid.
- Nomenclature
- Preparation of carbonyl compound.

Conceptual linkage

This unit is built on

- Functional groups

LEARNING OUTCOMES

Students will be able to	Analyzing	Applying	Understanding
• Explain nomenclature and structure of aldehydes and ketones.		✓	
• Discuss the preparation of aldehydes and ketones by ozonolysis of alkenes, hydration of alkynes, oxidation of alcohols and Frieda! Craft's acylation of aromatics.		✓	
• Describe reactivity of aldehydes and ketones and their comparison.	✓		
• Describe acid and base catalyzed nucleophilic addition reactions of aldehydes and ketones.		✓	
• Discuss the chemistry of aldehydes and ketones by their reduction to hydrocarbons, alcohols, by using carbon nucleophiles, nitrogen nucleophiles and oxygen nucleophiles.		✓	
• Describe oxidation reactions of aldehydes and ketones.		✓	
• Describe isomerism in aldehydes and ketones			✓
• Describe preparation of carboxylic acids by carbonation of Grignard's Reagent, hydrolysis of nitriles, oxidation of primary alcohols, oxidation of aldehydes and oxidation of alkyl benzenes.		✓	

• Discuss reactivity of carboxylic acids.		✓	
• Describe the chemistry of carboxylic acids by conversion to carboxylic acid derivatives: acyl halides, acid anhydrides, esters, amides and reactions involving inter-conversion of these.	✓		
• Describe reactions of carboxylic acid derivatives.		✓	
• Describe isomerism in carboxylic acids.			✓

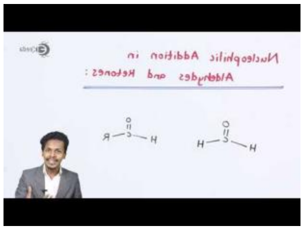
Skills	Analyzing	Applying	Understanding
• Identify aldehyde & ketones using appropriate laboratory test.		✓	
• Determine melting & boiling point of aldehyde and ketone in laboratory.		✓	
• Identify carboxylic acid by using appropriate test.		✓	
• Determine melting and boiling point of carboxylic acid in laboratory.		✓	

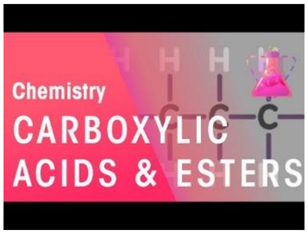
Society, Technology & Science

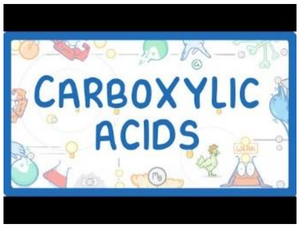
Students will be able to

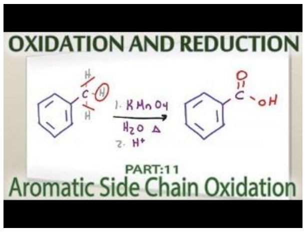
- How explain oxidation & reduction alters the structure of organic compound.(Understanding)
- Explain the need to limit exposure to formaldehyde vapors as used in adhesive, varnish, paints , foam isolation permanent press clothing.(Applying)
- Describe glucose & fructose as example of aldehyde & ketones.(understanding)
- List carboxylic acid present in fruits , vegetable & other natural products.(Applying)
- Link different carboxylic acid with their characteristics taste. (Applying)
- Recognize carboxylic acid used as preservative in food and food product. (Applying)

Related videos



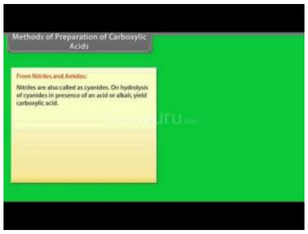






Uses of aldehyde

Uses of carboxylic acid



Uses of ketone

(THEORY)

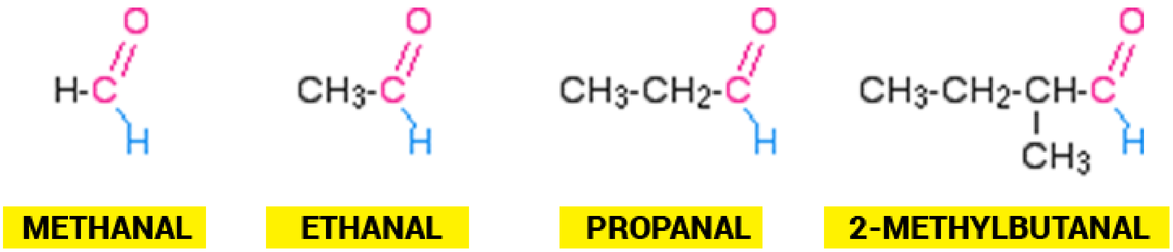
Aldehydes and Ketones

Aldehydes and ketones incorporate a carbonyl functional group, C=O. These are organic compounds with structures -CHO and RC(=O)R’ where R and R’ represent carbon-containing substituents respectively.

What are Aldehydes?

In aldehydes, the carbonyl group has one hydrogen atom attached to it together with either a 2nd hydrogen atom or a hydrogen group which may be an alkyl group or one containing a benzene ring.

Example:



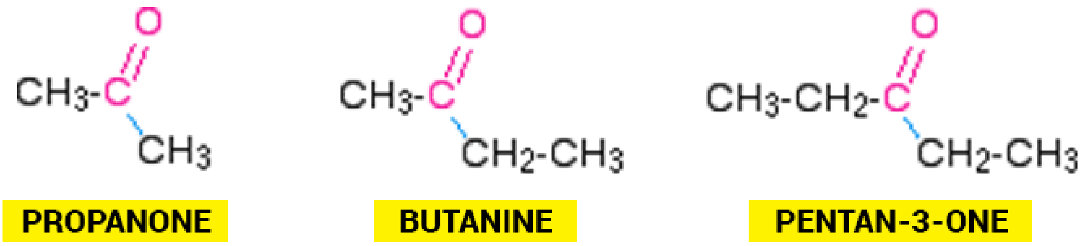
Examples of Aldehydes

One can notice that all these have the exact same end to the molecule. The only difference is the complexity of the other attached group.

What are Ketones?

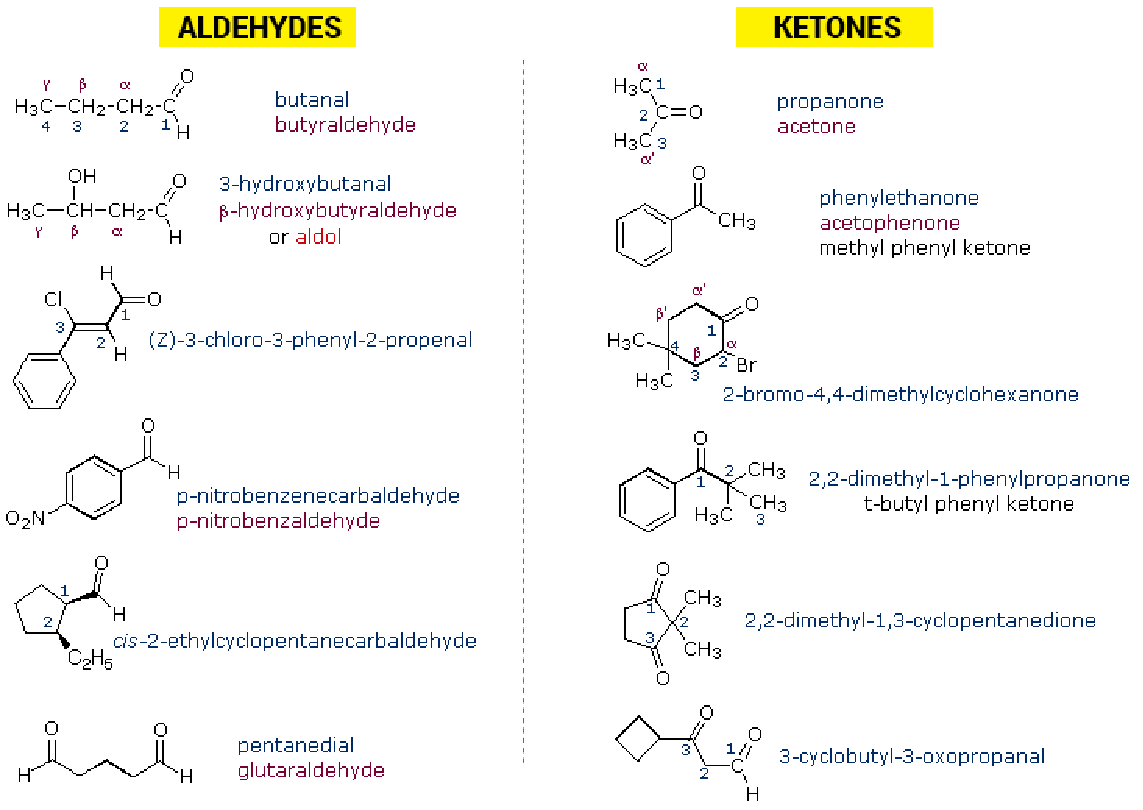
In ketones, the carbonyl group has 2 hydrocarbon groups attached to it. These can be either the ones containing benzene rings or alkyl groups. Ketone does not have a hydrogen atom attached to the carbonyl group.

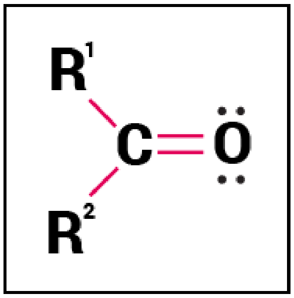
Example:



Examples of Ketones

Propane is generally written as CH3COCH3. In pentanone, the carbonyl group could be in the middle of the chain or next to the end – giving either pentan-3-one or pentan-2-one.





ALDEHYDE : R^1 AND/OR R^2 = H

KETONE : R^1 AND R^2 = ALKYL OR ARYL

Uses of Aldehydes and Ketones

Formaldehyde is the simplest aldehyde whereas acetone is the smallest ketone. There are a number of aldehydes and ketones which find application due to their chemical properties. A few uses of Aldehydes and Ketones are listed below.

1. Uses of Aldehydes

- Formaldehyde is a gas. With 40% solution in water, it forms Formalin which is used in preserving biological specimens.

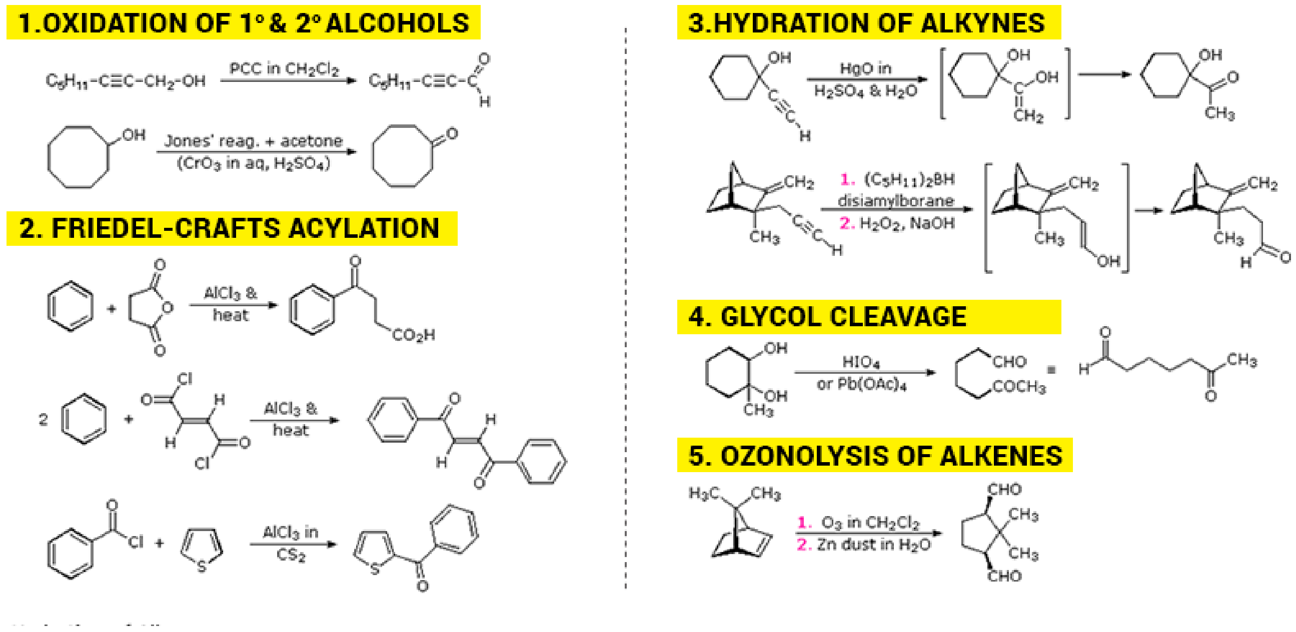
- Formaldehyde is used in embalming, tanning, preparing glues and polymeric products, as germicides, insecticides, and fungicides for plants. It is also used in drug testing and photography.
- When reacted with phenol, formaldehyde forms Bakelite, which is used in plastics, coatings, and adhesives.
- Acetaldehyde is largely used for the production of acetic acid and pyridine derivatives.
- Benzaldehyde is used in perfumes, cosmetic products, and dyes. It is added to provide almond flavour to food products and also used as a bee repellent.

2. Uses of Ketones

- The most common ketone is acetone which is an excellent solvent for a number of plastics and synthetic fibres.
- In the household, acetone is used as a nail paint remover and paint thinner.
- In medicine, it is used in chemical peeling and for acne treatments.
- Methyl ethyl ketone (MEK), chemically butanone, is a common solvent. It is used in the production of textiles, varnishes, plastics, paint remover, paraffin wax, etc.
- MEK is also used as a welding agent for plastics due to its dissolving properties.
- Cyclohexanone is another important ketone which is primarily used in the production of nylon.

Preparation of Ketones and Aldehydes

Aldehydes and Ketones are obtained from products of many reactions. Some reactions for the synthetic preparation of Aldehyde and Ketone is mention below.



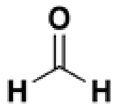
Preparation of Aldehydes and Ketones

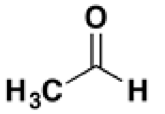
Stay tuned with BYJU'S to learn more about different types of aldehydes and ketones, their physical and chemical properties.

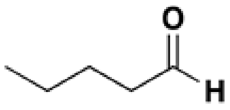
Aldehyde Nomenclature rules

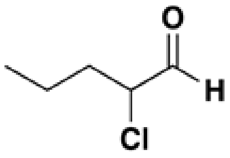
1. Aldehydes take their name from their parent alkane chains. The ***-e*** is removed from the end and is replaced with ***-al***.
2. The aldehyde funtional group is given the #1 numbering location and this number is not included in the name.
3. For the common name of aldehydes start with the common parent chain name and add the suffix ***-aldehyde***. Substituent positions are shown with Greek letters.
4. When the -CHO functional group is attached to a ring the suffix ***-carbaldehyde*** is added, and the carbon attached to that group is C1.

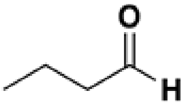
The IUPAC system names are given on top while the common name is given on the bottom in parentheses.

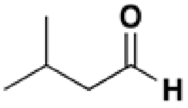

methanal
(formaldehyde)


ethanal
(acetaldehyde)


pentanal
(valeraldehyde)


2-chloropentanal
(a-chlorovaleraldehyde)

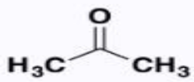

butanal
(butyraldehyde)

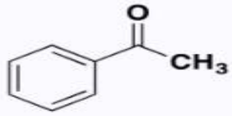

3-methylbutanal
(isovaleraldehyde)

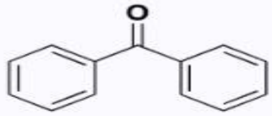
Ketone Nomenclature rules

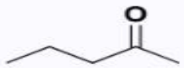
1. Ketones take their name from their parent alkane chains. The ending ***-e*** is removed and replaced with ***-one***.
2. The common name for ketones are simply the **substituent groups listed alphabetically + *ketone*.**
3. Some common ketones are known by their generic names. Such as the fact that *propanone* is commonly referred to as *acetone*.

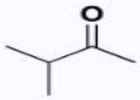
The IUPAC system names are given on top while the common name is given on the bottom in parentheses.

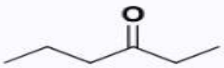

propanone
(acetone)


acetophenone
(methyl phenyl ketone)


benzophenone
(diphenyl ketone)


2-pentanone
(methyl propyl ketone)


3-methyl-2-butanone
(methyl isopropyl ketone)


3-hexanone
(ethyl propyl ketone)

Reference page/site

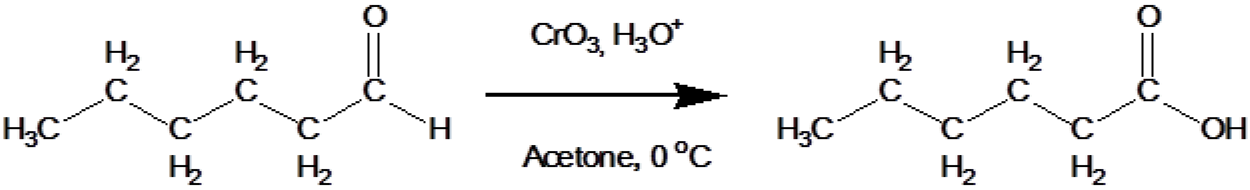
https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Aldehydes_and_Ketones/Nomenclature_of_Aldehydes_and_Ketones
https://byjus.com/chemistry/aldehydes-ketones/

Reactivity of Aldehyde & Ketones

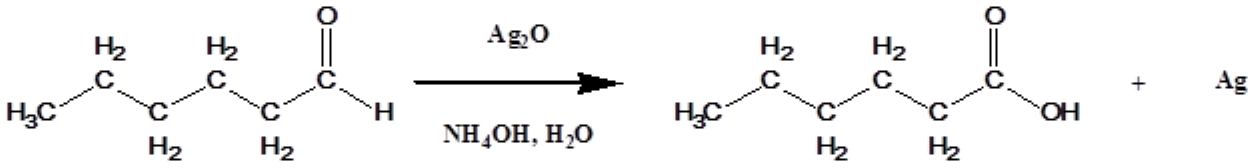
Aldehydes are typically more **reactive** than **ketones** due to the following factors. ... The carbonyl carbon in **aldehydes** generally has more partial positive charge than in **ketones** due to the electron-donating nature of alkyl groups. **Aldehydes** only have one e^- donor group while **ketones** have two.

Oxidation of Aldehydes & Ketones

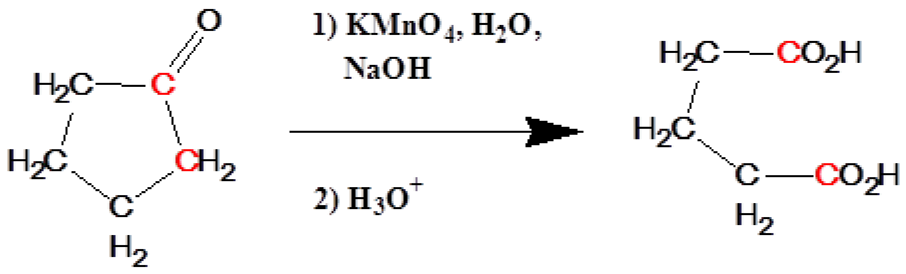
The presence of that hydrogen atom makes aldehydes very easy to oxidize. Or, put another way, they are strong reducing agents. The most common reagent for this conversion is CrO_3 in aqueous acid. This reaction generally gives good yields at room temperature.



Unfortunately, the acid condition for the previous reaction can cause unwanted side reaction. If this problem occurs it can be rectified by using a solution of sliver oxide, Ag_2O, in aqueous ammonia, also called Tollens' reagent.



Because ketones do not have that particular hydrogen atom, they are resistant to oxidation, and only very strong oxidizing agents like potassium manganate(VII) solution (potassium permanganate solution) oxidize ketones. However, they do it in a destructive way, breaking carbon-carbon bonds and forming two carboxylic acids.



Reference page/site

https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Map%3A_Organic_Chemistry_(McMurry)/19%3A_Aldehydes_and_Ketones-_Nucleophilic_Addition_Reactions/19.04%3A_Oxidation_of_Aldehydes_and_Ketones#:~:text=have%20that%20hydrogen.-,Oxidation%20of%20Aldehydes,aldehydes%20very%20easy%20to%20oxidize.&text=Because%20ketones%20do%20not%20have,potassium%20permanganate%20solution)%20oxidize%20ketones.

Isomerism in Aldehydes and Ketones

CHAIN ISOMERISM IN ALDEHYDES AND KETONES - DEFINITION

Aldehydes containing 4 or more carbons and ketones containing 5 or more carbons can exhibit chain isomerism.
Example: $CH_3-CH_2-CH_2-CHO$ and $(CH_3)_2-CH-CHO$ are chain isomers.

POSITION ISOMERISM IN ALDEHYDES AND KETONES - DEFINITION

Aromatic aldehydes and ketones having 5 or more carbon atoms can exhibit position isomerism.
Example: $CH3-CH2-CO-CH2-CH3$ and $CH3-CO-CH2-CH2-CH3$ are position isomers.

FUNCTIONAL ISOMERISM IN ALDEHYDES AND KETONES - DEFINITION

Aldehydes, ketones, unsaturated alcohols oxiranes and oxolanes, all have the same structural formula, $CnH2nO$. Thus, they can exhibit functional isomerism.
Examples: $CH3-CH2-CHO$ is an aldehyde while $CH3-CO-CH3$ is a ketone.

Reference page/site

https://www.toppr.com/content/concept/isomerism-in-aldehydes-and-ketones-257547/

Carboxylic Acid

Table of Content

Definition Structure Nomenclature Properties Uses

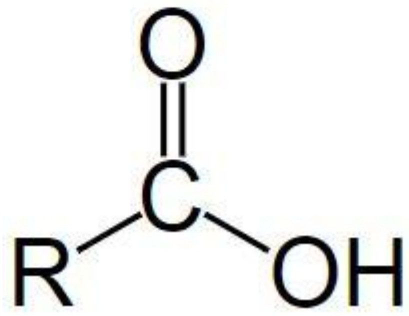
What is Carboxylic Acid?

A Carboxylic Acid is an organic compound containing a carboxyl functional group. They occur widely in nature and are also synthetically manufactured by humans. Upon deprotonation, carboxylic acids yield a ***carboxylate anion with the general formula R-COO$^-$***, which can form a variety of useful salts such as soaps.

Carboxylic Acid Structure

The ***general formula of a carboxylic acid is R-COOH***, were COOH refers to the carboxyl group, and R refers to the rest of the molecule to which this group is attached. In this carboxyl group, there exists a carbon which shares a double bond with an oxygen atom and a single bond with a hydroxyl group.

The general structure of a carboxylic acid is illustrated below.



General Structure of Carboxylic Acid

Nomenclature of Carboxylic Acids

Generally, these organic compounds are referred to by their trivial names, which contain the suffix "-ic acid". An example of a ***trivial name for a carboxylic acid is acetic acid (CH_3COOH)***. In the IUPAC nomenclature of these compounds, the suffix **"-oic acid"** is assigned.

The guidelines that must be followed in the IUPAC nomenclature of carboxylic acids are listed below.

- The suffix "e" in the name of the corresponding alkane is replaced with "oic acid".
- When the aliphatic chain contains only one carboxyl group, the carboxylic carbon is always numbered one. For example, CH_3COOH is named as ethanoic acid.

- When the aliphatic chain contains more than one carboxyl group, the total number of carbon atoms is counted and the number of carboxyl groups is represented by Greek numeral prefixes such as “di-”, “tri-“, etc.
- A carboxylic acid is named by adding these prefixes and suffixes to the parent alkyl chain. Arabic numerals are used for indicating the positions of the carboxyl group.
- The name “carboxylic acid” or “carboxy” can also be assigned for a carboxyl substituent on a carbon chain. An example of such nomenclature is the name 2-carboxyfuran for the compound 2-Furoic acid.

Carboxylic Acid Examples

Some examples describing the nomenclature of carboxylic acids as per IUPAC guidelines are provided below.

Trivial Name and Formula	**IUPAC Name of the Carboxylic Acid**
Formic acid, H-COOH	Methanoic acid
Crotonic acid, $CH_3CH=CH-COOH$	But-2-enoic acid
Carbonic acid, OH-COOH	Carbonic acid
Butyric acid, $CH_3(CH_2)_2COOH$	Butanoic acid

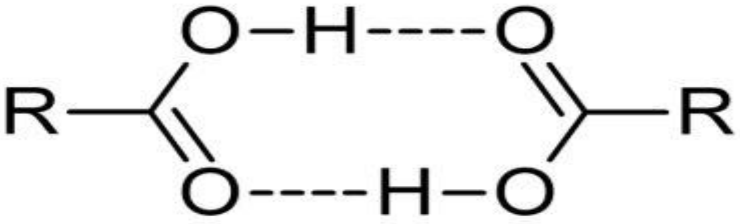
Properties of Carboxylic Acids

Most of the properties of carboxylic acids are a result of the presence of the carboxyl group. Some of the physical and chemical properties of these compounds are discussed in this subsection.

1. Physical Properties of Carboxylic Acids

- ***Carboxylic acid molecules are polar due to the presence of two electronegative oxygen atoms.***
- They also participate in hydrogen bonding due to the presence of the carbonyl group (C=O) and the hydroxyl group.
  - When placed in nonpolar solvents, these compounds form ***dimers via hydrogen bonding*** between the hydroxyl group of one carboxylic acid and the carbonyl group of

the other.



- The solubility of compounds containing the carboxyl functional group in water depends on the size of the compound. The smaller the compound (the shorter the R group), the higher the solubility.
- The boiling point of a carboxylic acid is generally higher than that of water.
- These compounds have the ability to donate protons and are therefore ***Bronsted-Lowry acids.***
- They generally have a strong sour smell. However, their esters have pleasant odors and are therefore used in perfumes.

2. Chemical Properties of Carboxylic Acids

- The ***α-carbon belonging to a carboxylic acid can easily be halogenated via the Hell-Volhard-Zelinsky reaction.***
- These compounds can be converted into amines using the Schmidt reaction.
- A carboxylic acid can be reduced to an alcohol by treating it with hydrogen to cause a hydrogenation reaction.
- Upon reaction with alcohols, these compounds yield esters.

Uses of Carboxylic Acids

- Fatty acids that are essential to human beings are made up of carboxylic acids. Examples include omega-6 and omega-3 fatty acids.
- Higher fatty acids are also used in the ***manufacture of soaps***.
- The production of soft drinks and many other food products involve the use of many carboxylic acids.
- The manufacture of rubber involves the use of acetic acid as a ***coagulant.***
- Hexanedioic acid is used in the ***manufacture of nylon-6,6***.
- Carboxylic acids have numerous applications in the rubber, textile, and leather industries.
- Ethylenediaminetetraacetic acid is a widely used ***chelating agent.***
- The synthesis of many drugs involves the use of these compounds. Therefore, carboxylic acids are very important in ***pharmaceuticals***.
- The production of many polymers involves the use of compounds containing the carboxyl functional group.

There are various methods that can be used for the preparation of Carboxylic acids.

1. By using primary Alcohols and Aldehyde. ...
2. From Alkylbenzenes. ...
3. From Nitriles and Amides. ...
4. By using Grignard Reagents. ...
5. By Acyl Halides and Anhydrides. ...
6. By using Esters.

Explain the isomerism exhibited by carboxylic acids.

Carboxylic acid can exhibit following types of isomerism:-

Chain isomerism → Chain isomerism is exhibited by the compounds which are made up of two or more carbon or other compounds with the same molecular formula but different atomic arrangements, or branches.

E.g.- $CH_3-CH_2-CH_2-COOH \leftrightharpoons CH_3-CH_{|CH_3}-COOH$

Functional isomerism → In functional isomerism, the isomer is an isomer with a different arrangement of atoms and also different functional groups.

E.g.- $CH_3-CH_2-COOH \rightleftharpoons CH_3-COO-CH_3$

Reference page/site

https://www.toppr.com/ask/question/explain-the-isomerism-exhibited-by-carboxylic-acids/
https://byjus.com/chemistry/carboxylic-acid-properties/

Student's assessment

- How are Aldehydes and Ketones Different?
- Why are Aldehydes more Reactive towards Nucleophilic Substitutions than Ketones?
- Why are the Boiling Points of Ketones Higher than those of Aldehydes?
- Please give the structure corresponding to each name:
  - butanal
  - 2-hydroxycyclopentanone
  - 2,3-pentanedione
  - 1,3-cyclohexanedione
- Give the oxidation reaction of carboxylic acid.
- Give simple chemical test of aldehyde & ketone.
- Write any five derivative of carboxylic acid.

Reference page/site

https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Aldehydes_and_Ketones/Nomenclature_of_Aldehydes_and_Ketones
https://byjus.com/chemistry/aldehydes-ketones/

Lesson plan.

https://www.lessonplanet.com/lesson-plans/aldehydes/all

https://www.scribd.com/doc/134158440/Lesson-Plan-Ketones-and-Aldehydes-docx

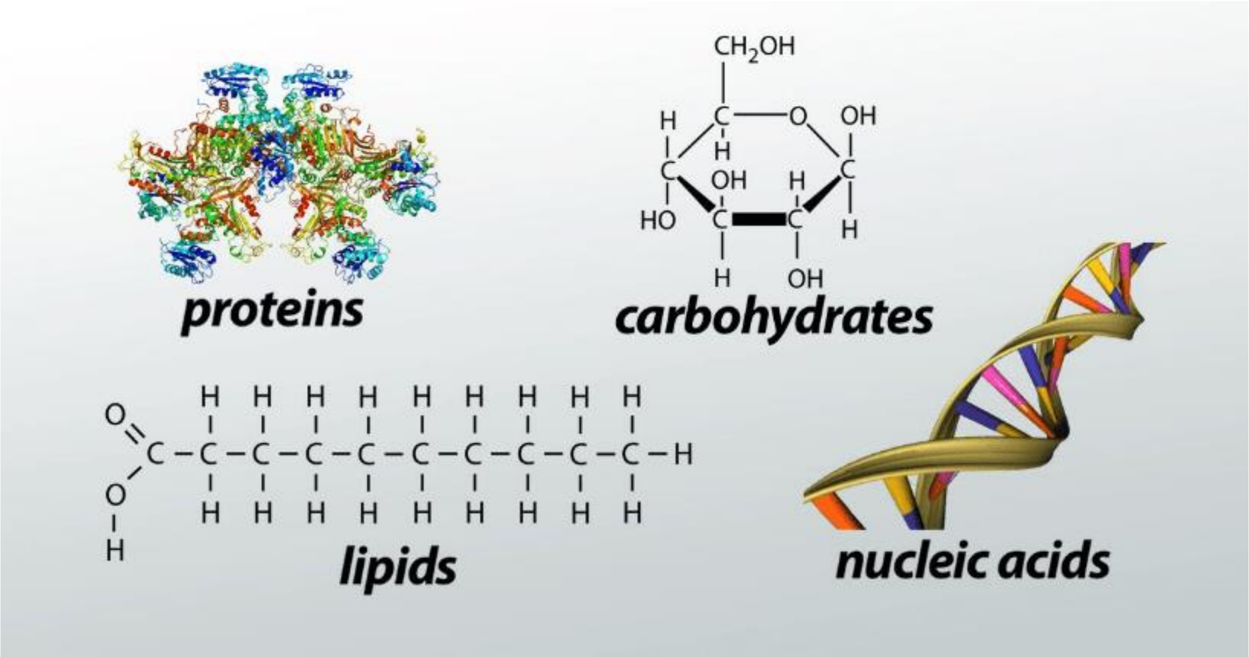
PRACTICAL # 05

- To check the quality of sugar by Tollens's or Fehling solution. **(New)**
- Determine the quantity of carboxylic acid in vinegar. **(New)**

X--------X--------X

Chapter # 6

Biochemistry



Introduction

Major Concepts

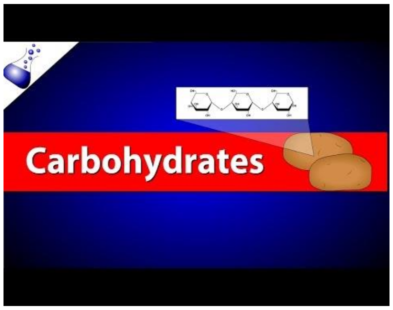
- Carbohydrates
- Proteins
- Lipids
- Minerals of Biological Significance

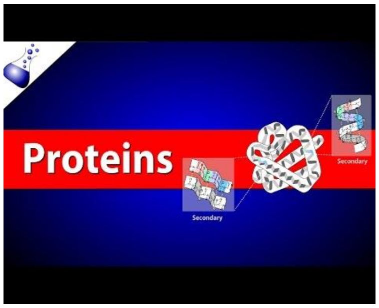
Learning outcomes

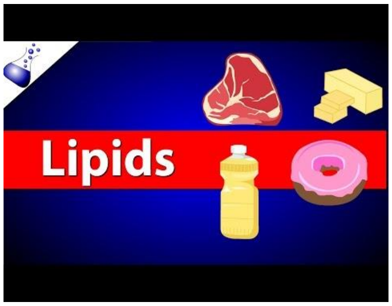
Students will be able to	Analyzing	Applying	Understanding
- Discuss the natural sources of Carbohydrates and classification based on structure.			✓
- Enlist the role of various Carbohydrates in health and diseases.		✓	
- Identify the nutritional importance and their role as energy storage		✓	
- Explain the classification of protein on the basis of structure and their functions.		✓	
- Explain classification and Functions of Lipids.		✓	
- Enlist sources and the role of Iron, Calcium, Phosphorous and Zinc in nutrition.		✓	

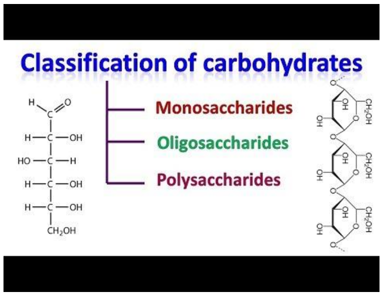
SKILLS	Analyzing	Applying	Understanding
- know Calcium as a requirement for coagulation	✓		
- •know how milk proteins can be precipitated by lowering the pH using lemon juice.	✓		

Related video

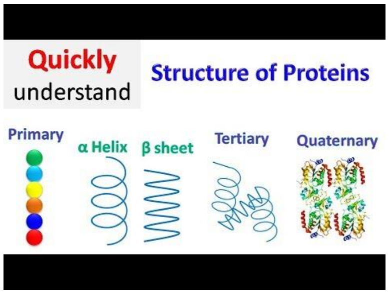




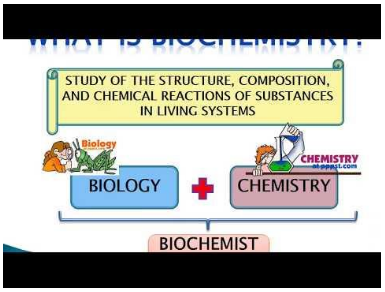




Carbohydrates classification.



Classification of proteins.



Importance of biochemistry

Chapter overview

What is Biochemistry?

The branch of science dealing with the study of all the life processes such as control and coordination within a living organism is called Biochemistry.

It mainly deals with the study of the structure and functions of the biomolecules such as the carbohydrates, proteins, acids, lipids. Hence it is also called to as Molecular biology.

What do biochemists do?

- Provide new ideas and experiments to understand how life works
- Support our understanding of health and disease
- Contribute innovative information to the technology revolution
- Work alongside chemists, physicists, healthcare professionals, policy makers, engineers and many more professionals

Importance of Biochemistry

- Biochemistry is essential to understand the following concepts.
- The chemical processes which transform diet into compounds that are characteristics of the cells of a particular species.
- The catalytic functions of enzymes.
- Utilizing the potential energy obtained from the oxidation of foodstuff consumed for the various energy-requiring processes of the living cell.
- The properties and structure of substances that constitute the framework of tissues and cells.
- To solve fundamental problems in medicine and biology.

What are Carbohydrates?

It is a group of organic compounds occurring in living tissues and foods in the form of starch, cellulose, and sugars. The ratio of oxygen and hydrogen in carbohydrates is the same as in water i.e. 2:1. It typically breaks down in the animal body to release energy.

What is the General Formula of Carbohydrates?

The general formula for carbohydrates is $C_x(H_2O)_y$.

Definition of Carbohydrates in Chemistry

Chemically, carbohydrates are defined as ***"optically active polyhydroxy aldehydes or ketones or the compounds which produce units of such type on hydrolysis".***

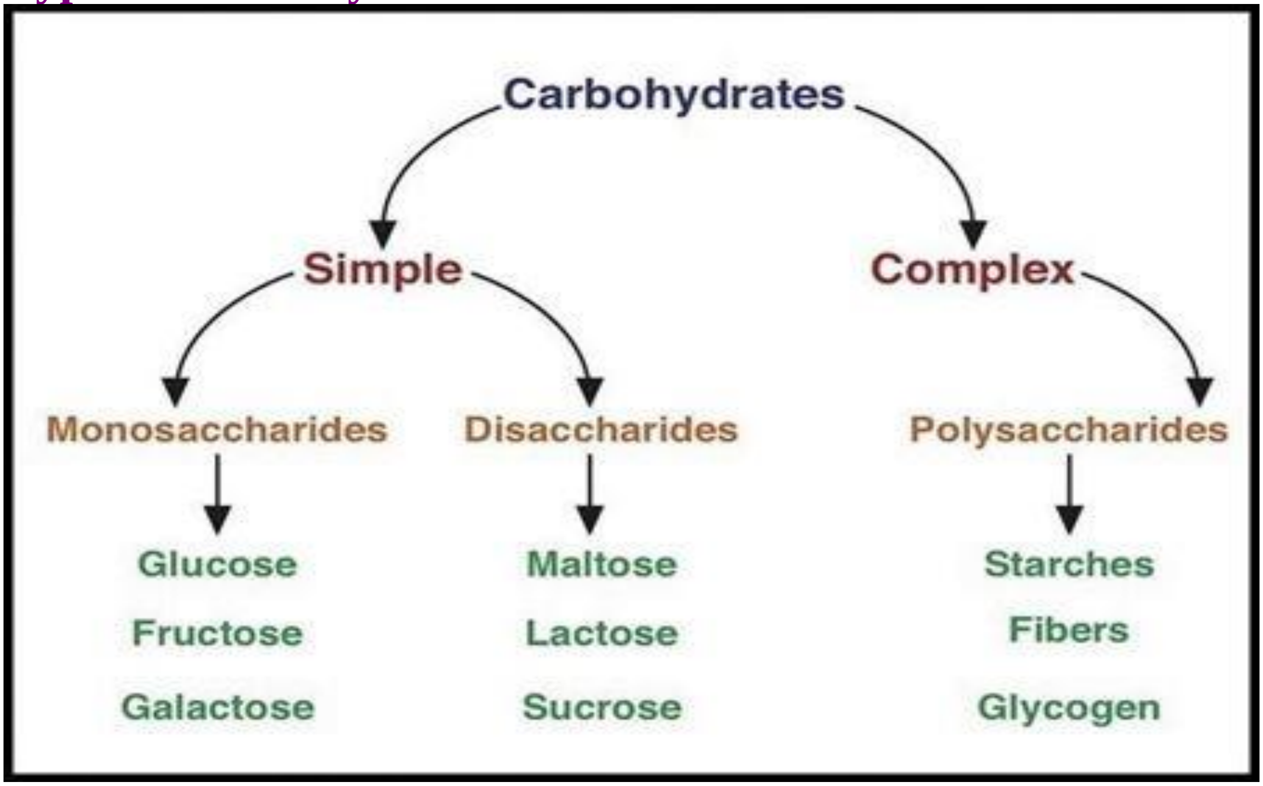
The substance most people refer to as "sugar" is the sucrose disaccharide, which is extracted either from sugar cane or beets. Sucrose is the disaccharides most sweet. It's approximately three times sweet as maltose, and six times sweet as lactos

Sources of Carbohydrates

We know carbohydrates are an important part of any human's diet. Some common sources of carbohydrates are:

1. Potatoes
2. Maze
3. Milk
4. Popcorn
5. Bread

Types of Carbohydrates



Types of Carbohydrates – Monosaccharides, Disaccharides & polysaccharides

The different types of carbohydrates can be classified on the basis of their behavior on hydrolysis. They are mainly classified into three groups:

1. ***Monosaccharides***
2. ***Disaccharides***
3. ***Polysaccharides***

1. Monosaccharides

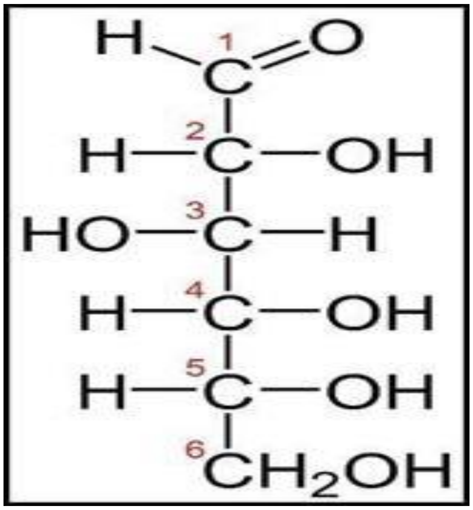
Monosaccharide carbohydrates are those carbohydrates that cannot be hydrolyzed further to give simpler units of polyhydroxy aldehyde or ketone. If a monosaccharide contains an aldehyde group then it is called aldose and on the other hand, if it contains a keto group then it is called a ketose.

Structure of Carbohydrates – Glucose

One of the most important monosaccharides is glucose. The two commonly used methods for the preparation of glucose are

- **From Sucrose:** If sucrose is boiled with dilute acid in an alcoholic solution then we obtain glucose and fructose.
- **From Starch:** We can obtain glucose by hydrolysis of starch and by boiling it with dilute H_2SO_4 at 393K under elevated pressure.

Glucose is also called aldohexose and dextrose and is abundant on earth.

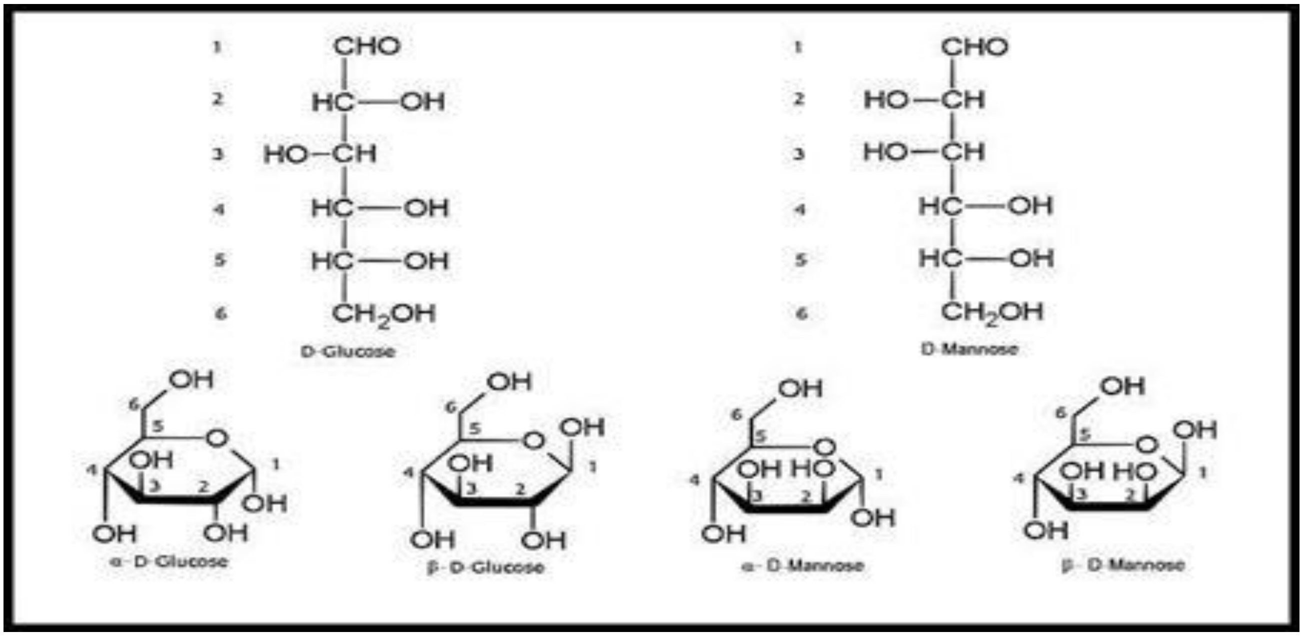


Simple Carbohydrate – Glucose

- Glucose is named as D (+)-glucose, D represents the configuration whereas (+) represents the ***dextrorotatory*** nature of the molecule.
- The ring structure of glucose can explain many properties of glucose which cannot be figured by open-chain structure.
- The two cyclic structures differ in the configuration of the hydroxyl group at C1 called anomeric carbon. Such isomers i.e. α and β form are known as anomers.

- The cyclic structure is also called pyranose structure due to its analogy with pyran.

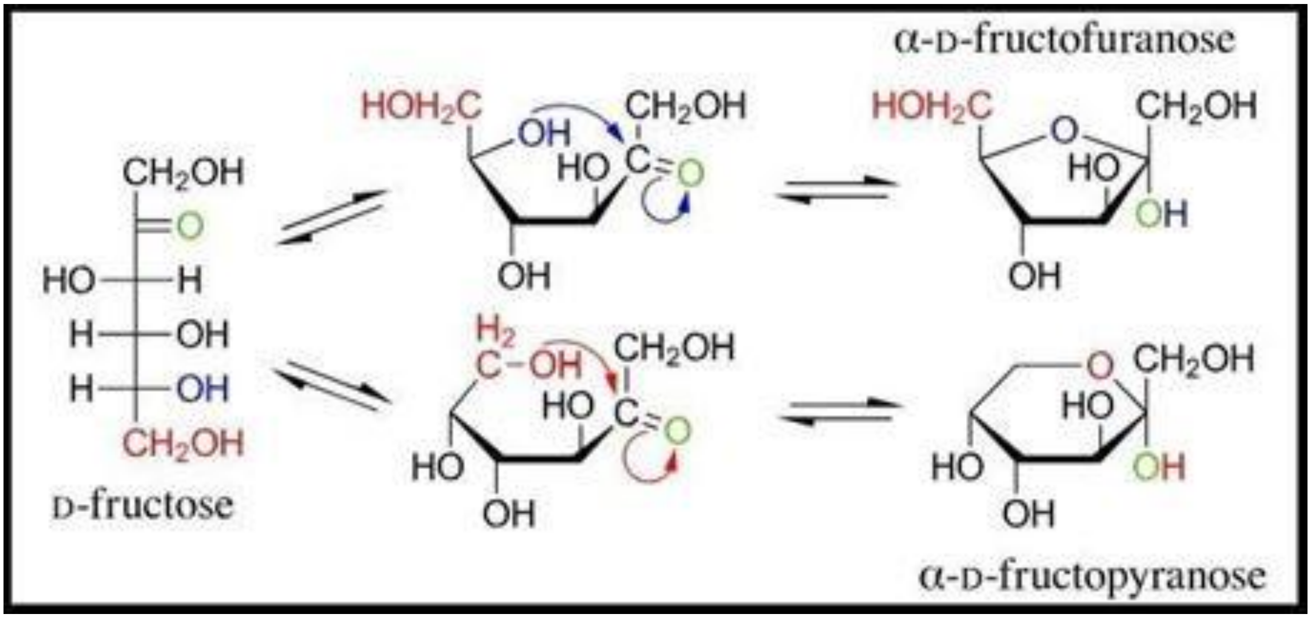
The cyclic structure of glucose is given below:



Cyclic Structure of Carbohydrates – Glucose

Structure of Carbohydrates – Fructose

It is an important ketohexose. The ***molecular formula of fructose is $C_6H_{12}O_6$ and contains ketonic functional group at carbon number 2 and has six carbon atoms in a straight chain.*** The ring member of fructose is in analogy to the compound Furan and is named as furanose. The cyclic structure of fructose is shown below:



Carbohydrate Classification – Fructose

Examples of Carbohydrates

Here are a few examples of where you'll find the most carbs:

- **Dairy Products** – Yogurt, Milk, Ice cream
- **Fruits** – Fruit juice or Whole fruit
- **Grains** – Cereal, Bread, Wheat, Rice
- **Legumes** – Plant-based proteins, Beans
- **Starchy Vegetables** – Corn, Potatoes

2. Disaccharides

- On hydrolysis, disaccharides yield two molecules of either the same or different monosaccharides.
- The two monosaccharide units are joined by oxide linkage which is formed by the loss of water molecule and this linkage is called glycosidic linkage.
- Sucrose is one of the most common disaccharides which on hydrolysis gives glucose and fructose.
- Maltose and Lactose (also known as milk sugar) are the other two important disaccharides.
- In maltose, there are two α-D-glucose and in lactose, there are two β-D-glucose which are connected by oxide bond.

3. Polysaccharides

Polysaccharides contain long monosaccharide units joined together by glycosidic linkage.

Most of them act as food storage for e.g. Starch. Starch is the main storage polysaccharide for plants.

It is a polymer of α glucose and consists of two components-Amylose and Amylopectin.

Cellulose is also one of the polysaccharides that are mostly found in plants.

It is composed of β-D- glucose units joined by a glycosidic linkage between C1 of one glucose unit and C4 of the next glucose unit.

Importance of carbohydrates

- Carbohydrates are responsible for storing chemical energy in living organisms
- They are also an important constituent for supporting the Living organisms use carbohydrates as accessible energy to fuel cellular reactions. They are the most abundant dietary source of energy (4kcal/gram) for all living beings.
- Carbohydrates along with being the chief energy source, in many animals, are instant sources of energy. Glucose is broken down by glycolysis/ Kreb's cycle to yield ATP.
- Serve as energy stores, fuels, and metabolic intermediates. It is stored as glycogen in animals and starch in plants.

- Stored carbohydrates act as an energy source instead of proteins.
- They form structural and protective components, like in the cell wall of plants and microorganisms. Structural elements in the cell walls of bacteria (peptidoglycan or murein), plants (cellulose) and animals (chitin).
- Carbohydrates are intermediates in the biosynthesis of fats and proteins.
- Carbohydrates aid in the regulation of nerve tissue and is the energy source for the brain.
- Carbohydrates get associated with lipids and proteins to form surface antigens, receptor molecules, vitamins, and antibiotics.
- Formation of the structural framework of RNA and DNA (ribonucleic acid and deoxyribonucleic acid).
- They are linked to many proteins and lipids. Such linked carbohydrates are important in cell-cell communication and in interactions between cells and other elements in the cellular environment.

What are proteins?

Proteins are complex, organic compounds composed of many amino acids linked together through peptide bonds and cross-linked between chains by sulfhydryl bonds, hydrogen bonds and van der Waals forces. There is a greater diversity of chemical composition in proteins than in any other group of biologically active compounds. The proteins in the various animal and plant cells confer on these tissues their biological specificity.

Classification of proteins

Proteins can be classified as:

(a) Simple proteins. On hydrolysis they yield only the amino acids and occasional small carbohydrate compounds. Examples are: albumins, globulins, glutelins, albuminoids, histones and protamines.

(b) Conjugated proteins. These are simple proteins combined with some non-protein material in the body. Examples are: nucleoproteins, glycoproteins, phosphoproteins, haemoglobins and lecithoproteins.

These are of following types: –

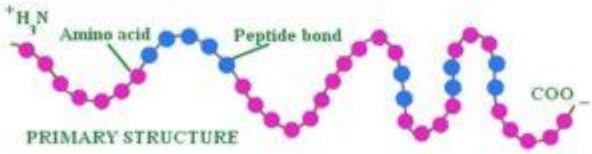
- Nucleoproteins: Combination of protein and nucleic acid
- Mucoproteins: Combination of proteins and carbohydrates (>4%)
- Glycoproteins: Combination of proteins and carbohydrates(<4%)
- Chromoproteins: Combination of proteins and coloured pigments.
- Lipoproteins: Combination of proteins and lipids.
- Metalloprotein: Combination of proteins and metal ions.
- Phosphoprotein: Combination of proteins and phosphate group.

(c) Derived proteins. These are proteins derived from simple or conjugated proteins by physical or chemical means. Examples are: denatured proteins and peptides.

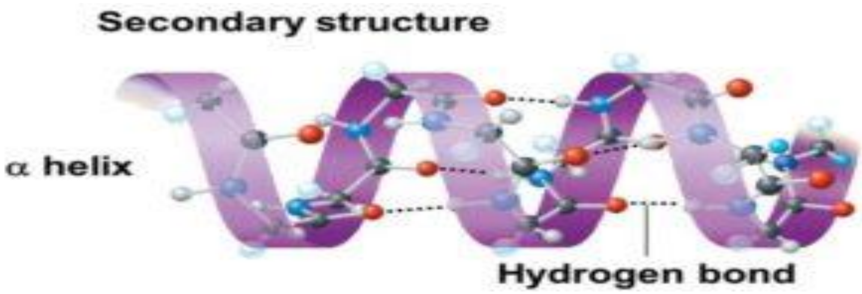
Structure of protein

Due to different rearrangement of amino acids, the structure of proteins divides into four types:

- **Primary**- the covalent linkages of the proteins



- **Secondary**- the linear peptide chains fold either into an alpha-helical structure(coiled) or a beta-pleated structure(sheets) which contain hydrogen bonds.



- **Tertiary-** The arrangement and interconnection of proteins into specific loops and bends forms the tertiary structures. This structure contains hydrogen, ionic and disulfide bonds.

Quaternary- this structure is proteins containing more than one peptide chain

Properties

- Proteins can also be characterized by their chemical reactions. Most proteins are soluble in water, in alcohol, in dilute base or in various concentrations of salt solutions.
- Proteins have the characteristic coiled structure which is determined by the sequence of amino acids in the primary polypeptide chain and the stereo configuration of the radical groups attached to the alpha carbon of each amino acid.
- Proteins are heat labile exhibiting various degrees of lability depending upon type of protein, solution and temperature profile.
- Proteins can be reversible or irreversible, denatured by heating, by salt concentration, by freezing, by ultrasonic stress or by aging.
- Proteins undergo characteristic bonding with other proteins in the so-called plastein reaction and will combine with free aldyhyde and hydroxy groups of carbohydrates to form Maillard type compounds.

Functions of Protein

Structural functions: Proteins are called as the building blocks of the body. They are an essential component of various structures in the cell and tissues. We also find these proteins in the outer membrane of all cells in the human body. We can also find structural proteins in hair, skin, and muscles. Proteins often act to strengthen these structures.

Protective: Proteins are the main constituent of antibodies that protect our body against antigens and pathogens thus preventing infections.

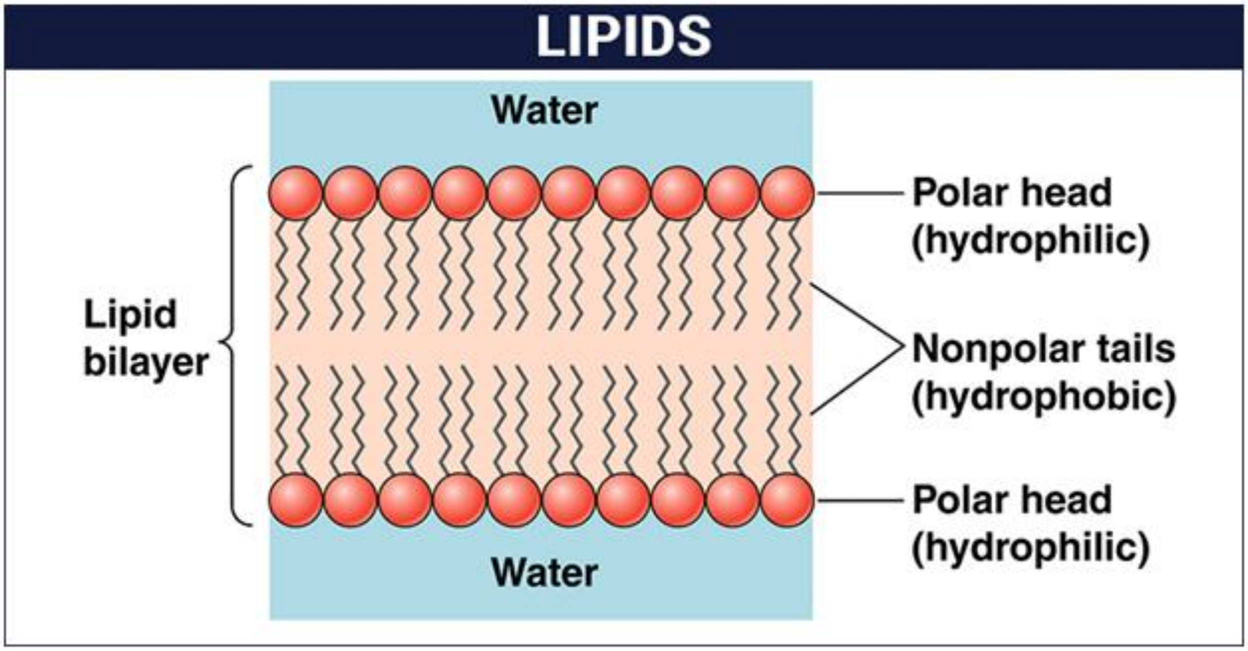
Hormonal regulation: Hormones are majorly composed of proteins. Hormones play a vital role in regulating muscle mass, sex hormones, and growth and development.

Enzymes: Proteins are called as biological buffers because they, as enzymes, regulate many different biochemical reactions that are occurring in the body.

Lipids

Lipids Definition

> ***"Lipids are organic compounds that contain hydrogen, carbon, and oxygen atoms, which forms the framework for the structure and function of living cells."***



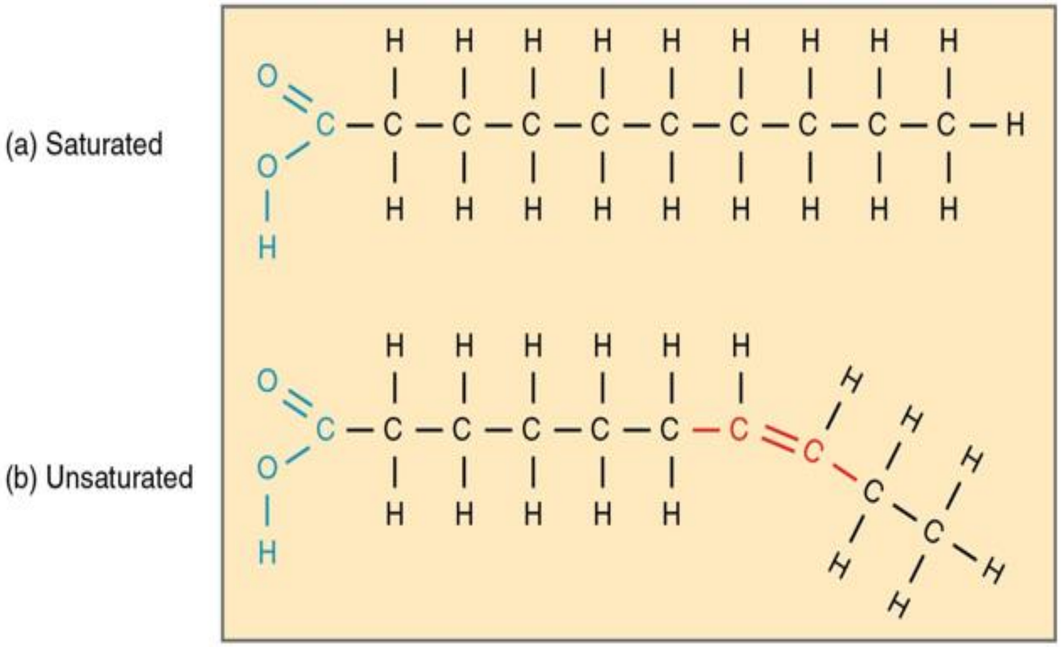
Properties of Lipids

Lipids are a family of organic compounds, composed of fats and oils. These molecules yield high energy and are responsible for different functions within the human body. Listed below are some important characteristics of Lipids.

1. Lipids are oily or greasy nonpolar molecules, stored in the adipose tissue of the body.
2. Lipids are a heterogeneous group of compounds, mainly composed of hydrocarbon chains.
3. Lipids are energy-rich organic molecules, which provide energy for different life processes.
4. Lipids are a class of compounds distinguished by their insolubility in water and solubility in nonpolar solvents.
5. Lipids are important in biological systems because they form the cell membrane, a mechanical barrier that divides a cell from the external environment

Lipid Structure

Lipids are the polymers of fatty acids that contain a long, non-polar hydrocarbon chain with a small polar region containing oxygen. The lipid structure is explained in the diagram below:



Classification of Lipids

Lipids can be classified into two major classes:

- No saponifiable lipids, and
- Saponifiable lipids.

No saponifiable Lipids

A no saponifiable lipid cannot be broken up into smaller molecules by hydrolysis, which includes triglycerides, waxes, phospholipids, and sphingolipids.

Saponifiable Lipids

A saponifiable lipid contains one or more ester groups allowing it to undergo hydrolysis in the presence of an acid, base, or enzymes. No saponifiable lipids include steroids, prostaglandins, and terpenes.

Each of these categories can be further broken down into non-polar and polar lipids.

Nonpolar lipids, such as triglycerides, are used for energy storage and fuel.

Polar lipids, which can form a barrier with an external water environment, are used in membranes. Polar lipids include glycerophospholipids and sphingolipids.

Functions of Lipids

- The majority of lipids in biological systems function either as a source of stored metabolic energy or as structural matrices and permeability barriers in biological membranes.
- Amphipathic lipids, the molecules that allow membranes to form compartments, must have been among the progenitors of living beings. This theory is supported by studies of several simple, single-cell organisms, in which up to one-third of the genome is thought to code for membrane proteins and the enzymes of membrane lipid biosynthesis.
- Lipids play several roles in organisms. Lipids make up protective barriers. They comprise cell membranes and some of the structure of cell walls in plants.
- Phospholipids form the foundation for lipid bilayers, with their amphipathic nature, that make up cell membranes. The outer layer interacts with water while the inner layer exists as a flexible oily substance.
- Lipids provide protective barriers for specialized tissues such as nerves. The protective myelin sheath surrounding nerves contains lipids.
- Lipids provide the greatest amount of energy from consumption, having more than twice the amount of energy as proteins and carbohydrates. The body breaks down fats in digestion, some for immediate energy needs and others for storage. The body draws upon the lipid storage for exercise by using lipases to break down those lipids, and eventually to make more adenosine triphosphate (ATP) to power cells.
- In plants, seed oils such as triacylglycerols (TAGs) provide food storage for seed germination and growth in both angiosperms and gymnosperms. These oils are stored in oil bodies (OBs) and protected by phospholipids and proteins called oleosins.
- Lipids give plants the necessary energy for their metabolic processes and signals between cells.

Reference pages

https://byjus.com/biology/lipids/#:~:text=There%20are%20two%20major%20types,simple%20lipids%20and%20complex%20lipids.&text=For%20eg.%2C%20fats%20and%20waxes,eg.%2C%20phospholipids%20and%20sphingolipids.

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Worksheet

Name ______________________ Date ________________________

Biomolecules

MULTIPLE CHOICE:

Circle the letter for ALL the answers that are TRUE.

THERE MAY BE MORE THAN ONE CORRECT ANSWER.

1. A _____________________ is made up of a sugar, a nitrogen base, and a phosphate group.

A. amino acid
B. nucleotide
C. phospholipid
D. glycoprotein

2. Circle the nitrogen base found in DNA but NOT RNA is _______________________

Adenine Thymine Guanine Cytosine Uracil

3. Lipids are different from other macromolecules because they ____________________

A. are hydrophobic and don't dissolve in water
B. contain carbon, hydrogen and oxygen in a ratio of 1:2:1
C. dissolve easily in water
D. form large protein molecules
E. are hydrophilic

4. Glycogen, cellulose, and starch are all ___________________.

A. proteins
B. polysaccharides
C. nucleic acids
D. lipids
E. phospholipids

5. Which 2 kinds of molecules combine to form cell membranes?

A. nucleic acids and carbohydrates
B. phospholipids and proteins
C. carbohydrates and nucleic acids
D. polysaccharides and RNA

6.Adenine, thymine, guanine, cytosine, and uracil are all _______________________

A. amino acids used to make proteins
B. carbohydrates used to make polysaccharides
C. lipids used to make phospholipids
D. nitrogen bases used to make nucleotides

7. Which part of a phospholipid molecule is NONPOLAR & HYDROPHOBIC?

A. the lipid "tails"
B. the glycerol/phosphate "head"

8. This molecule is a(n) ______________________________

A. nucleic acid
B. amino acid
C. phospholipid
D. carbohydrate

9. This molecule is ____________________

A. insulin
B. hemoglobin
C. glucose
D. a phospholipid
E. ATP

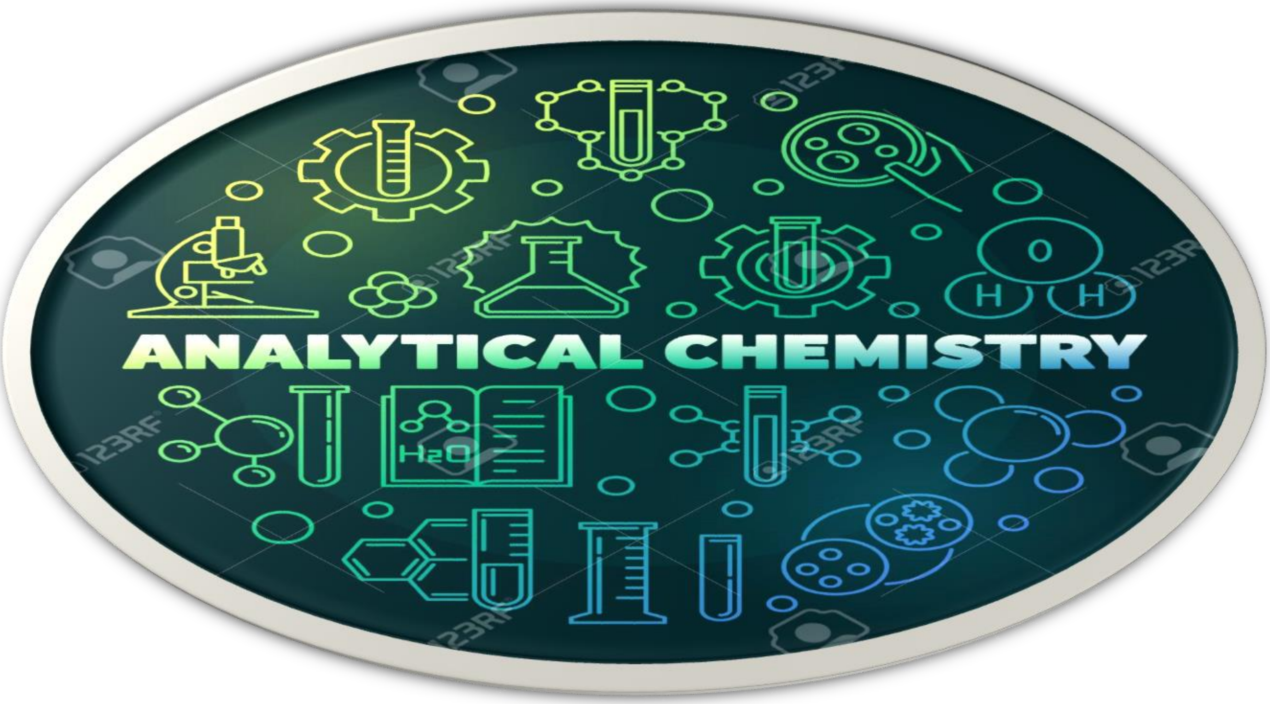
PRACTICAL # 06

- Determine the quantity of protein & glucose in human blood sample. **(New)**

X---------X--------X

Chapter # 7

Analytical chemistry



Introduction

Major concept

- Analytical chemistry
- Classical method of analysis
- Modern method of analysis

Conceptual linkage

Structure of atom and molecule

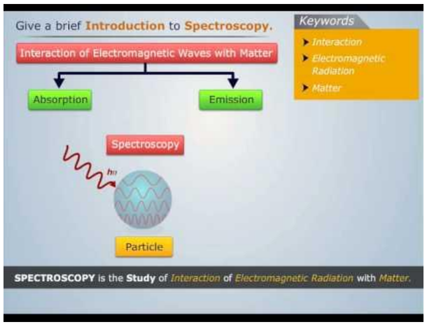
Learning outcomes

Students will be able to	Analyzing	Applying	Understanding
• Compare the classical method of analysis with modern methods.			✔
• Discuss the procedure of combustion analysis.			✔
• Define spectroscopy and discuss its applications in analytical Chemistry.		✔	
• State the regions of electromagnetic spectrum used in IR and UV/vis spectroscopy.		✔	

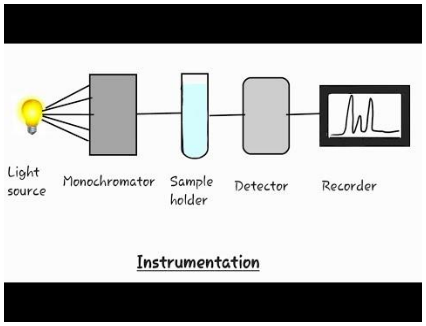
- Explain the origin of IR absorption of simple molecules.	✔		
- Predict whether a given molecule will absorb in the unVisible region.	✔		
- Predict the color of a transition metal complex from its UV/visible spectrum.	✔		
- Outline in simple terms the principles of proton NMR spectroscopy.		✔	
- Describe standard scales used in proton NMR.		✔	
- Outline the use of MS in determination of relative isotopic masses and isotopic abundance.		✔	
- Define and explain atomic emission and atomic absorption spectrum.			✔

SKILLS	Analyzing	Applying	Understanding
- Calculate the average atomic mass of an element from isotopic data.		✔	
- Calculate percentage of C, H and 0 from given data and determine empirical and molecular formula.		✔	

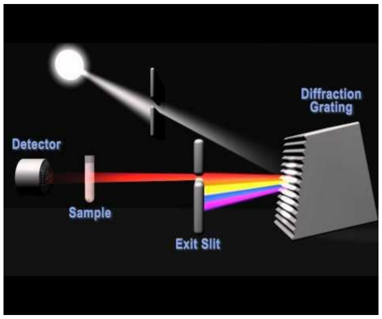
Reference videos



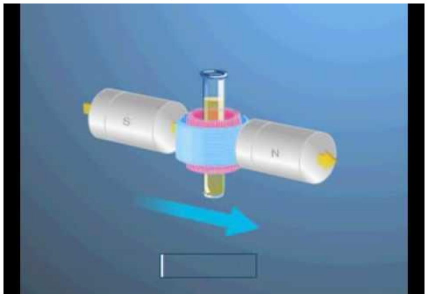
Spectroscopy



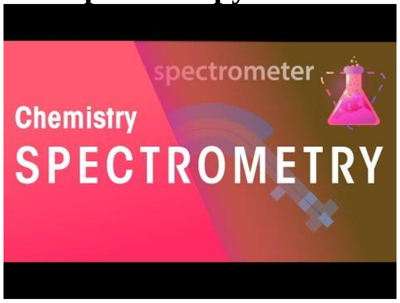
UV Spectroscopy



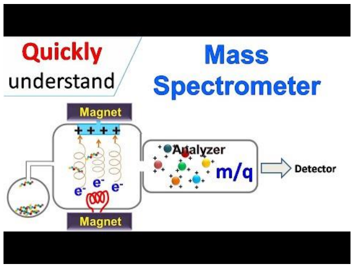
how spectroscopy work?



NMR Spectroscopy



Spectrometery



mass spectroscopy

Chapter overview

What is Analytical Chemistry?

Analytical chemistry is the branch of chemistry that deals with the analysis of different substances. It involves the **separation, identification, and the quantification of matter.** It involves the use of classical methods along with modern methods involving the use of scientific instruments.

Analytical chemistry involves the following methods:

- The *process of separation* isolates the required chemical species which is to be analyzed from a mixture.
- The *identification of the analyte substance* is achieved via the method of qualitative analysis.
- The *concentration of the analyte* in a given mixture can be determined with the method of quantitative analysis.

Today, the field of analytical chemistry generally involves the use of modern, sophisticated instruments. However, the principles upon which these instruments are built can be traced to more traditional techniques.

Methods Used in Analytical Chemistry

The methods used to determine the identity and the quantity of the analytes in the field of analytical chemistry can be broadly divided into classical and instrumental methods.

1.Classical Methods

- There exist many classical methods of checking for the presence or absence of a particular compound in a given analyte. One such example is the acid test for gold.
- Another example of a classical method for qualitative analysis is the Kastle-Meyer test which employs phenolphthalein as an indicator to check for the presence of hemoglobin in the given analyte.
- Flame tests can be used to check for the presence of specific elements in an analyte by exposing it to a flame and observing the change in the color of the flame.
- Gravimetric analysis is a classical method of quantitative analysis, which can be used in analytical chemistry to determine the amount of water in a hydrate by heating it and calculating the weight of the water lost.
- One of the better-known classical methods of quantitative analysis is volumetric analysis (also known as titration). In the titration method, a reactant is added to the analyte till an equivalence point is obtained.

2. Instrumental Methods

- Spectroscopy involves the measurement of the interaction between electromagnetic radiation and the atoms or molecules belonging to a sample.

- With the help of electric fields and magnetic fields, the method of mass spectroscopy is used to measure the ratio of the mass of the molecule to its charge.
- A common instrumental method used in the field of analytical chemistry is electrochemical analysis. In this method, the analyte is placed in an electrochemical cell and the voltage or the current flowing through it is measured.
- The interaction between the analyte and energy in the form of heat is studied in the discipline of analytical chemistry known as calorimetry. A calorimeter is an instrument that is used to measure the heat of a chemical reaction.
- It can be noted that even biological measurements are made with the help of this branch of chemistry, and this field is known as bioanalytical chemistry.

Branches of Analytical Chemistry

Two sub-branches come under analytical chemistry namely quantitative analysis and qualitative analysis which can be explained as follows. These two methods form the backbone of many educational labs of analytical chemistry.

3. Quantitative Analysis

Quantitative Analysis is a method of determining the absolute or relative quantity regarding the concentration of one or more substances present in a sample or compound.

For example, Take a sample of an unknown solid substance. The chemists first use “qualitative” methods to identify what type of compound is present in the sample; then he adopts the quantitative analysis procedure to determine the exact amount or the quantity of the compound present in the sample.

Some of the Quantitative analysis techniques include Gravimetric Analysis and Volumetric analysis.

2. Qualitative Analysis

Quality means the standard or the feature of one substance. Hence Qualitative analysis method deals with the determination of the quality of a particular compound, irrespective of its quantity or concentration. In simpler words, the qualitative analysis does not measure the amount of the substance but measures the quality of that material. One of the best examples of this type of method is the observation of a chemical reaction, whether there will be a change in colour or not.

The qualitative analysis method can be measured in different ways such as Chemical tests, flame tests, etc. Several such tests are widely used in salt analysis (identification of the cation & anion of inorganic salts).

4. Importance of Analytical Chemistry

Analytical chemistry is the branch which is taught in almost all schools and colleges. But the applications of it are made in pharmaceutical industries, food factories, chemical industries, agricultural industries and in scientific laboratories. The tools used for this purpose are quite expensive which one cannot afford at home.

Applications of Analytical Chemistry

Some important applications of this branch of chemistry are listed below.

- The shelf lives of many medicines are determined with the help of analytical chemistry.
- It is used to check for the presence of adulterants in drugs.
- Soil can be tested to check for appropriate concentrations of minerals and nutrients that are necessary for plant growth.
- It is employed in the process of chromatography where the blood samples of a person are classified

What is Spectroscopy?

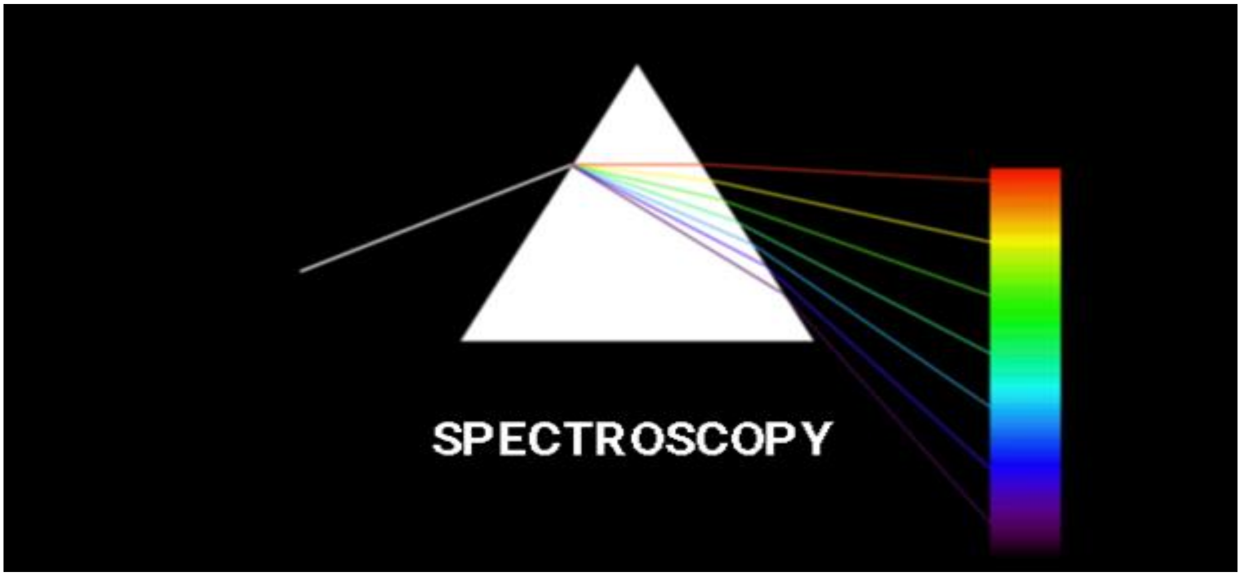
Spectroscopy means the dispersion of light into component colors. In simple words, it is a method to measure how much light is absorbed by a chemical substance and at what intensity of light passes through it.

As per analytical science, every element or compound has unique characteristic spectrum. Each compound absorbs and disperses light over a certain range of wavelength.

Type of interaction between light and material:

In spectroscopy, the type of interaction between light and the material is usually -:

- Absorption spectroscopy
- Emission spectroscopy
- Elastic scattering
- reflection spectroscopy
- Impedance spectroscopy
- Inelastic scattering
- Coherent or resonance spectroscopy



In Chemistry, Spectroscopy helps to study or analyze various chemical compounds or elements, whereas, in Physics, it helps to determine the makeup of the atmospheres of planets.

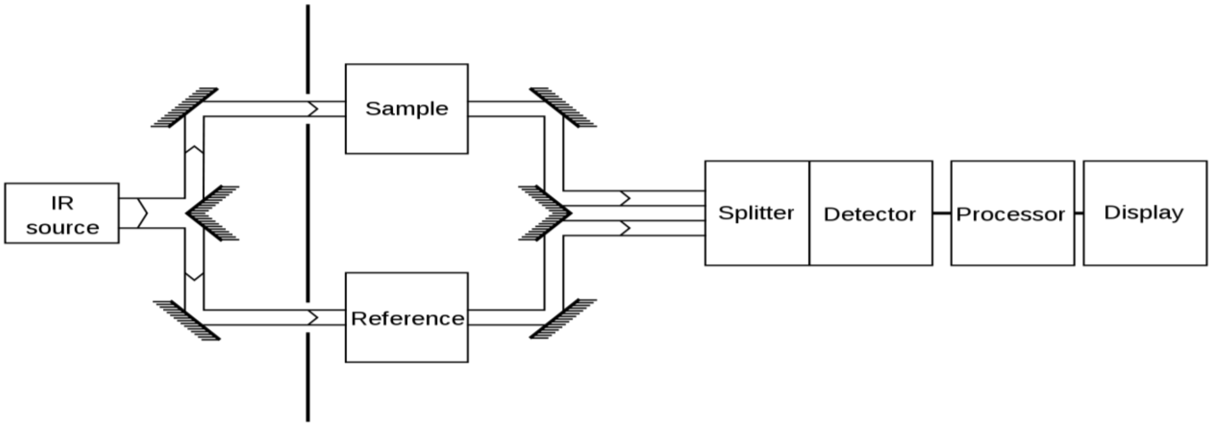
Spectroscopic method

- IR Spectroscopy (Infrared spectroscopy)
- Ultra- Violet/visible
- Nuclear magnetic resonance (NMR)
- Atomic Emission and absorption
- Mass spectrometry

Infrared Spectroscopy:

The type of spectroscopy which deals with the infrared region of the electromagnetic spectrum is Infrared Spectroscopy.

The rays of the infrared region have longer wavelength whereas having a lower frequency than light. Infrared spectroscopy is based on absorption spectroscopy.



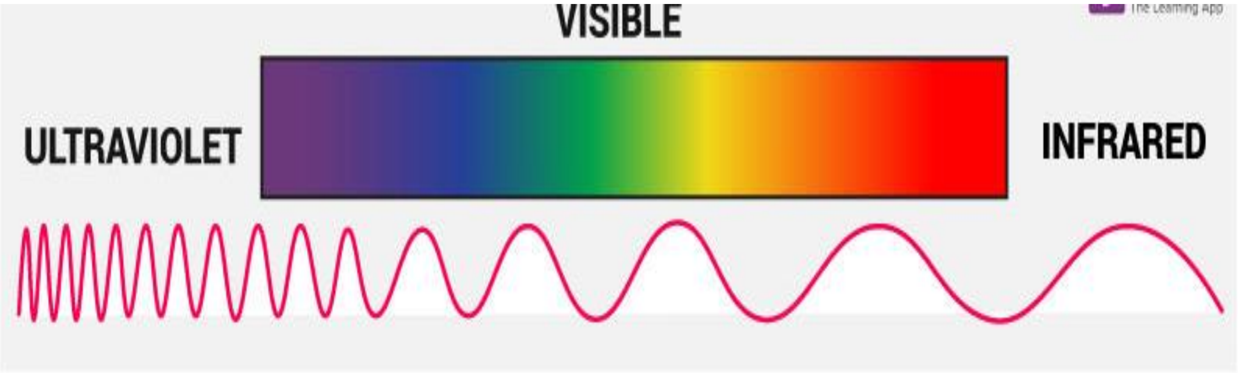
IR Spectroscopy

IR spectroscopy (which is short for infrared spectroscopy) deals with the infrared region of the electromagnetic spectrum, i.e. light having a longer wavelength and a lower frequency than visible light. Infrared Spectroscopy generally refers to the analysis of the interaction of a molecule with infrared light.

What is IR Spectroscopy?

An IR spectrum is essentially a graph plotted with the infrared light absorbed on the Y-axis against. Frequency or wavelength on the X-axis. An illustration highlighting the different regions that light can be classified into is given below.

IR Spectroscopy detects frequencies of infrared light that are absorbed by a molecule. Molecules tend to absorb these specific frequencies of light since they correspond to the frequency of the vibration of bonds in the molecule.



UV-Visible Spectroscopy

The Principle of UV-Visible Spectroscopy is based on the absorption of ultraviolet light or visible light by chemical compounds, which results in the production of distinct spectra.

Spectroscopy is based on the interaction between light and matter. When the matter absorbs the light, it undergoes excitation and de-excitation, resulting in the production of a spectrum.

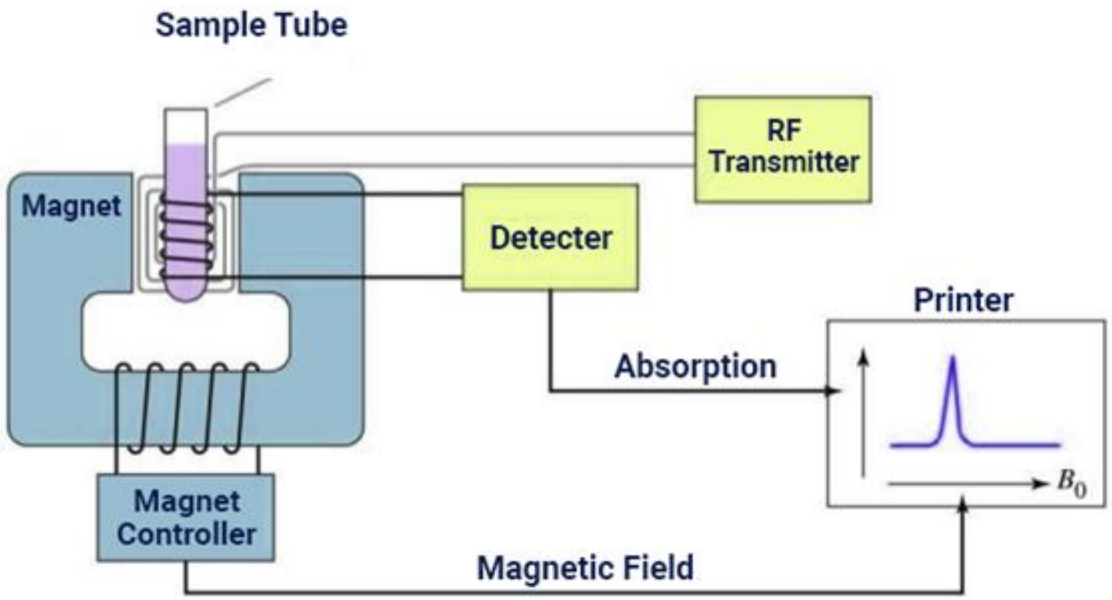
When matter absorbs ultraviolet radiation, the electrons present in it undergo excitation. This causes them to jump from a ground state (an energy state with a relatively small amount of energy associated with it) to an excited state (an energy state with a relatively large amount of energy associated with it).

It is important to note that the difference in the energies of the ground state and the excited state of the electron is always equal to the amount of ultraviolet radiation or visible radiation.

NMR Spectroscopy (Nuclear Magnetic Resonance)

Nuclear magnetic resonance (NMR) spectroscopy is the study of molecules by recording the interaction of radiofrequency (Rf) electromagnetic radiations with the nuclei of molecules placed in a strong magnetic field.
Zeeman first observed the strange behavior of certain nuclei when subjected to a strong magnetic field at the end of the nineteenth century, but the practical use of the so-called ***"Zeeman effect"*** was only made in the 1950s when NMR spectrometers became commercially available.

It is a research technique that exploits the magnetic properties of certain atomic nuclei. The NMR spectroscopy determines the physical and chemical properties of atoms or molecules.



NMR Spectroscopy Instrumentation

It relies on the phenomenon of nuclear magnetic resonance and provides detailed information about the structure, dynamics, reaction state, and chemical environment of molecules.

Atomic emission and absorption spectroscopy.

What is emission spectrum?

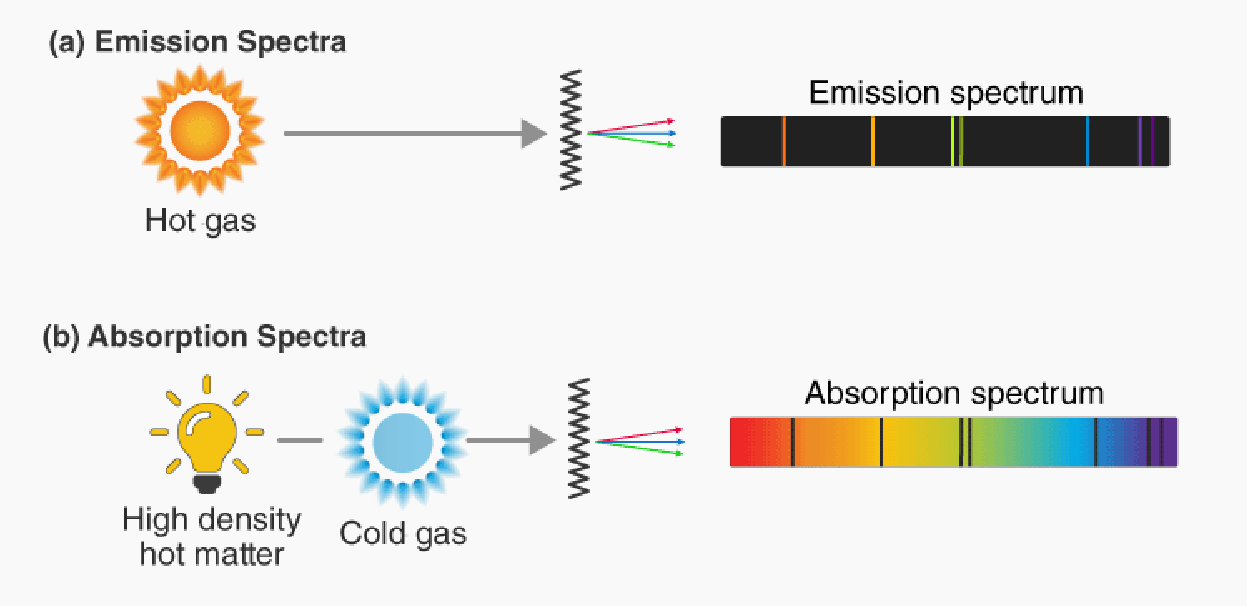
When energy is absorbed by electrons of an atom, electrons move from lower energy levels to higher energy levels. However, these electrons have to emit energy to return to their ground state from the excited state which is unstable. The frequencies of light emitted in such cases form the emission spectrum.

What is absorption spectrum?

On the other hand, an absorption spectrum is constituted by the frequencies of light transmitted with dark bands when energy is absorbed by the electrons in the ground state to reach higher energy states.

Difference Between Emission and Absorption Spectra

The emission and absorption spectra difference is provided here. These two topics are one of the most interesting concepts in physics. Learn their differences in-details given in the table provided below.



What is Mass Spectrometry?

Mass spectrometry is an analytical method useful for calculating the mass-to – charge ratio (m / z) of one or more molecules in the sample. Such measurements may also often be used to determine the precise molecular weight of the sample components. Mass spectrometry is an analytical method to find the molecular mass of a compound and indirectly helped to prove the identity of isotopes.

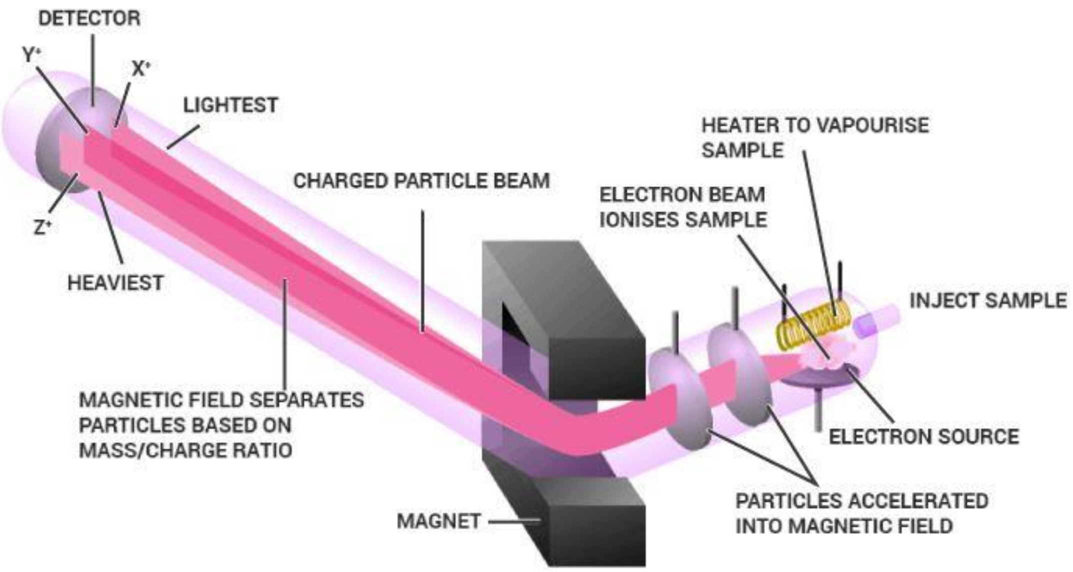
5. Principle of Mass Spectrometry

Based on Newton's second law of motion and momentum, a mass spectrometer uses this property of matter to plot ions of varying masses on a mass spectrum. From the law, we infer how much mass is relevant to the inertia and acceleration of a body. This principle is applied to the aspect where ions with different mass to charge ratios are deflected by different angles in an electric or magnetic field.

2. Mass Spectrum

A mass spectrum is a graph obtained by performing mass spectrometry. It is a relation between the mass to charge ratio and ion signal.

MASS SPECTROMETRY



Reference pages

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https://byjus.com/chemistry/analytical-chemistry/
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https://chem.libretexts.org/Courses/Northeastern_University/10%3A_Spectroscopic_Methods/10.1%3A_Overview_of_Spectroscopy

Worksheet

1. https://study.com/academy/practice/quiz-worksheet-atomic-spectra-characteristics-types.html

2. Choose an answer and hit ‘next’. You will receive your score and answers at the end.

Question 1 of 3

1,Which of the following does NOT describe an atomic spectrum?

○ Light that contains patterns characteristic of the elements present in a gas

○ Something we can use to figure out what elements are present in the sun

○ A mixture of light of different wavelengths

● A full rainbow, such as would be contained inside purely white light

2 What is the name of the equipment used to split the sun’s light into its various colors to analyze it?

○ A splitter

○ A spectrometer

○ A half-wave plate

○ A gyroscope

3.Which of the following is an example of an absorption spectrum?

○ 

○ 

○ 

○ 

Lesson plan

https://www.mrl.ucsb.edu/sites/default/files/mrl_docs/ret_attachments/curriculum/spectrscopy%20lesson%20plan.pdf

PRACTICAL # 07

- Analyze the sample of salt to determine the nitrogenous compound. **(New)**
- Analyze the purity of water. **(New)**

X---------X--------X

CHAPTER # 08

“S & P – BLOCK ELEMENTS”

INTRODUCTION

CHAPTER CONTENT

Reaction of representive element	**Chemical behaviour of halogens**	**Compounds of S & P block element**
Reactions of S & P block element with, • Oxygen • Water • Halogens • Nitrogen • Hydrogen • Alcohol • Acids	• Bond Enthalpies in Halogens • Strength of Halogens as Oxidizing Agents: F>Cl>Br>I 13.6.3 • The Acidity of Hydrogen Halides. • Halide Ions as Reducing Agents and their relative Strength	• Sodium hydroxide • Washing soda • Chlorine gas • Nitric acid • Sulphuric acid • Bleaching powder • Aqua regia • Boric acid

Major concepts.

- Representive element
- Behaviour of halogens
- Description of group I-A to VIII-A
- Diagonal relationship of representative elements

Conceptual Linkages

This unit is built on
- Periodic Table
- Periodicity of Properties

LEARNING OUTCOMES

Students will be able to	Analyzing	Understanding	Applying
• Recognize the demarcation of the Periodic Table into s block, p block, d block, and f block.		✓	
• Describe how physical properties like atomic radius, ionization energy, electronegativity, electrical conductivity and melting and boiling points of elements change within a group and within a period in the Periodic Table.	✓		
• Describe reactions of period 3 elements with water, oxygen and chlorine.			✓
• Describe physical properties and acid-base behavior of oxides, chlorides and hydroxides of period 3 elements.			✓
• Describe reactions of oxides and chlorides of period 3 elements with water.			✓
• Explain the trends in physical properties and oxidation states in groups I, II, IV and VII of the Periodic Table.	✓		
• Describe reactions of Group I elements with water, oxygen and chlorine.			✓
• Explain effect of heat on nitrates, carbonates and hydrogen carbonates of Group I elements.			✓
• Describe reactions of Group II elements with water, oxygen and nitrogen.			✓
• Discuss the trend in solubility of the hydroxides, sulphates and carbonates of Group II elements.			✓
• Discuss the trends in thermal stability of the nitrates and carbonates of Group II elements.	✓		

- Differentiate beryllium from other members of its group.	✓		
- Describe reactions of Group IV elements with water.			✓
- Discuss the chlorides and oxides of group IV elements			✓
- Explain the relative behaviour of halogens as oxidizing agents and reducing agents.			✓
- Compare the acidity of hydrogen halides.	✓		
- Distinguish between an oxide and a peroxide.		✓	
- Write representative equations for the formation of oxides and sulphides.			✓
- Compare the outermost s and p orbital system of an element with its chemical properties.	✓		

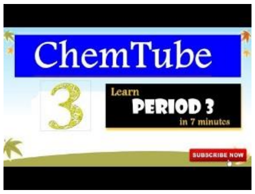
Skills	**Analyzing**	**Applying**	**Understanding**
- Perform flame tests and explain the appearance of colors in the flame.	✓		
- Analyze acidic and basic Ions using various tests.	✓		

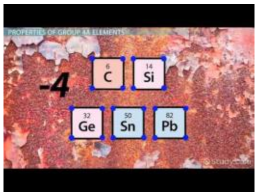
Society , Technology & Science.

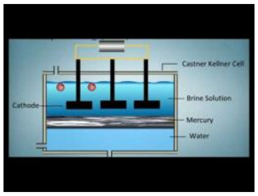
Students will be able to,

- Describe how the food and beverage industry uses steel, tin, aluminum and glass for canning purposes. (Analyzing)
- Explain how certain elements are mined and extracted from the earth. (Applying)
- Relate the properties of the halogens to their important commercial uses. (Applying)
- Explain that iodine deficiency leads to goiter. (Understanding)
- Explain the applications of bleaching powder. (Understanding)
- Explain fluoride toxicity and deficiency. (Understanding)

Related videos.







Sodium hydroxide

Sodium carbonate

Sulphuric acid

(THEORY)

Chapter overview

This chapter describes and explains the trends in atomic and physical properties of the Period 3 elements from sodium to argon. It covers ionization energy, atomic radius, electronegativity, electrical conductivity, melting point and boiling point.

Electronic structures

Across Period 3 of the Periodic Table, the 3s and 3p orbitals fill with electrons. Below are the abbreviated electronic configurations for the eight Period 3 elements:

Na	[Ne] $3s^1$
Mg	[Ne] $3s^2$
Al	[Ne] $3s^2\ 3p_x^1$
Si	[Ne] $3s^2\ 3p_x^1\ 3p_y^1$
P	[Ne] $3s^2\ 3p_x^1\ 3p_y^1\ 3p_z^1$
S	[Ne] $3s^2\ 3p_x^2\ 3p_y^1\ 3p_z^1$
Cl	[Ne] $3s^2\ 3p_x^2\ 3p_y^2\ 3p_z^1$
Ar	[Ne] $3s^2\ 3p_x^2\ 3p_y^2\ 3p_z^2$

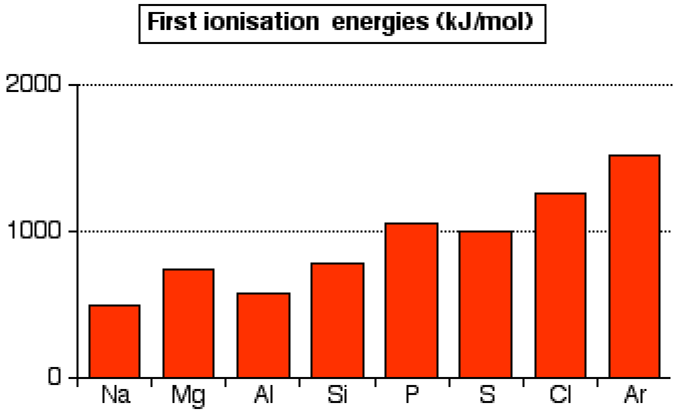
In each case, [Ne] represents the complete electronic configuration of a neon atom.

First Ionization Energy

The first ionization energy is the energy required to remove the most loosely held electron from one mole of gaseous atoms to produce 1 mole of gaseous ions each with a charge of +1.

The molar first ionization energy is the energy required to carry out this change per mole of XX.

The pattern of first ionization energies across Period 3



There is a general upward trend across the period, but this trend is broken by decreases between magnesium and aluminum, and between phosphorus and sulfur.

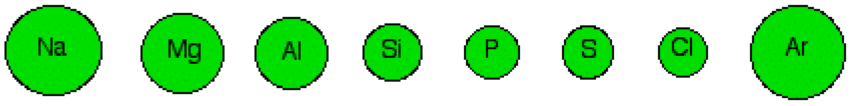
Explaining the pattern

First ionization energy is dependent on four factors:

- the charge on the nucleus;
- the distance of the outer electron from the nucleus;
- the amount of screening by inner electrons;
- Whether the electron is alone in an orbital or one of a pair.

Atomic radius

The diagram below shows how atomic radius changes across Period 3.



The figures used to construct this diagram are based on:

- metallic radii for Na, Mg and Al;
- covalent radii for Si, P, S and Cl;
- The Vander Waals radius for Ar (which forms no strong bonds).

It is appropriate to compare metallic and covalent radii because they are both being measured in tightly bonded circumstances. These radii cannot be compared with a van der Waals radius, however, making the diagram deceptive. The general trend towards smaller atoms across the period is not broken at argon. For convenience and clarity, argon is ignored in this discussion.

Explaining the Trend

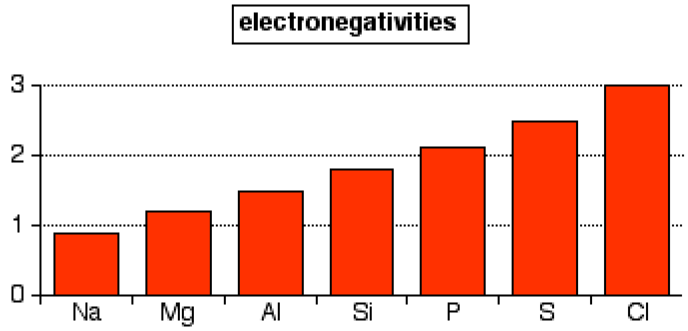
A metallic or covalent radius is a measure of the distance from the nucleus to the bonding pair of electrons. From sodium to chlorine, the bonding electrons are all in the 3-level, screened by the electrons in the first and second levels. The increasing number of protons in the nucleus across the period attracts the bonding electrons more strongly. The amount of screening is constant across Period 3.

Electronegativity

Electronegativity is a measure of the tendency of an atom to attract a bonding pair of electrons. The Pauling scale is most commonly used. Fluorine (the most electronegative element) is assigned a value of 4.0, and values decrease toward cesium and francium which are the least electronegative at 0.7.

The trend

The trend across Period 3 looks like this:



Argon is not included; because it does not form covalent bonds, its electronegativity cannot be assigned.

Explaining the Trend

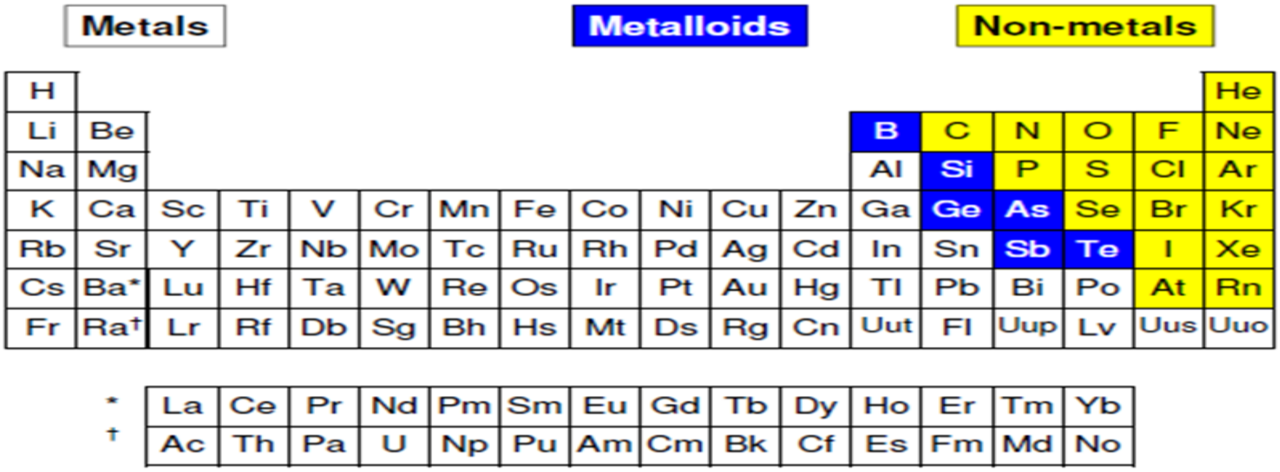
The explanation is the same as that for the trend in atomic radii. Across the period, the valence electrons for each atom are in the 3-level. They are screened by the same inner electrons. The only difference is the number of protons in the nucleus. From sodium to chlorine, the number of protons steadily increases and so attracts the bonding pair more closely.

Physical Properties

This section discusses electrical conductivity and the melting and boiling points of the Period 3 elements. An understanding of the structure of each element is necessary for this discussion.

Structures of the elements

The structures of the elements vary across the period. The first three are metallic, silicon is network covalent, and the rest are simple molecules.



Metals

Metalloids

Non-metals

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba*	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra†	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus	Uuo

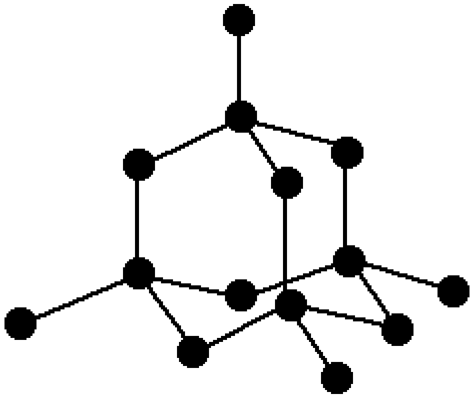
*	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
†	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No

Three metallic structures

Sodium, magnesium and aluminum all have metallic structures. In sodium, only one electron per atom is involved in the metallic bond, the single 3s electron. In magnesium, both of its outer electrons are involved, and in aluminum all three are involved. One key difference to be aware of is the way the atoms are packed in the metal crystal. Sodium is 8-coordinated with each sodium atom interacting with only 8 other atoms. Magnesium and aluminum are each 12-coordinated, and therefore packed more efficiently, creating less empty space in the metal structures and stronger bonding in the metal.

A network covalent structure

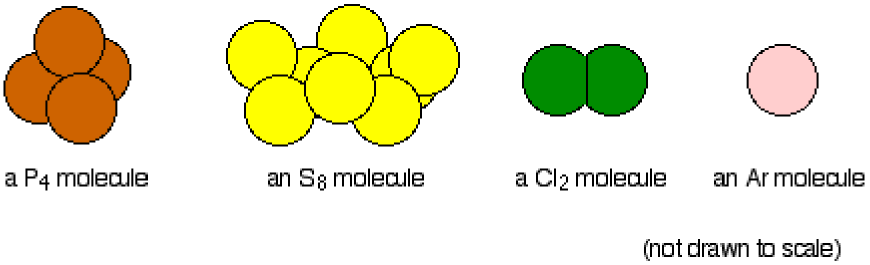
Silicon has a network covalent structure like that of diamond. A representative section of this structure is shown:



The structure is held together by strong covalent bonds in all three dimensions.

Four simple molecular structures

The structures of phosphorus and sulfur vary depending on the type of phosphorus or sulfur in question. In this case, white phosphorus and one of the crystalline forms of sulfur—rhombic or monoclinic—are considered. These structures are shown below:



Aside from argon, the atoms in each of these molecules are held together by covalent bonds. In the liquid or solid state, the molecules are held in close proximity by van der Waals dispersion forces .

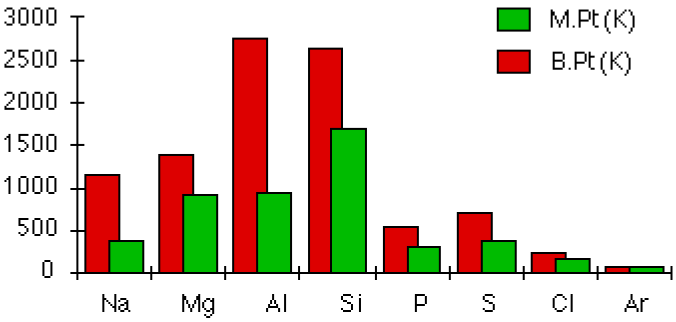
Electrical conductivity

- Sodium, magnesium and aluminum are good conductors of electricity. Conductivity increases from sodium to magnesium to aluminum.
- Silicon is a semiconductor.
- Phosphorus, sulfur, chlorine, and argon are nonconductive.

The three metals conduct electricity because the delocalized electrons (as in the "sea of electrons" model) are free to move throughout the solid or the liquid metal. Semiconductor chemistry for substances such as silicon is beyond the scope of most introductory level chemistry courses. The other elements do not conduct electricity because they are simple molecular substances. without free, delocalized electrons..

Melting and boiling points

The chart shows how the melting and boiling points of the elements change as you go across the period. The figures are plotted in kelvin rather than °C to avoid showing negative temperatures.



The metallic structures

Melting and boiling points increase across the three metals because of the increasing strength of their metallic bonds. The number of electrons which each atom can contribute to the delocalized "sea of electrons" increases. The atoms also get smaller and have more protons as you go from sodium to magnesium to aluminum. The attractions and therefore the melting and boiling points increase because:

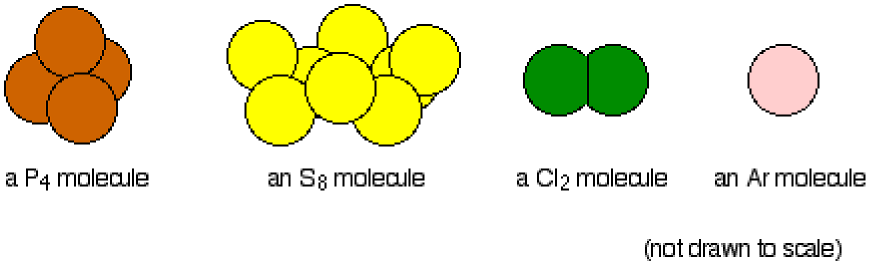
- The nuclei of the atoms are more positively charged.
- The "sea" is more negatively charged.
- The "sea" is progressively nearer to the nuclei and thus is more strongly attracted.

Silicon

Silicon has high melting and boiling points due to its network covalent structure. Melting or boiling silicon requires the breaking of strong covalent bonds. Because of the two different types of bonding in silicon and aluminum, it makes little sense to directly compare the two melting and boiling points.

The four molecular elements

Phosphorus, sulfur, chlorine and argon are simple molecular substances with only van der Waals attractions between the molecules. Their melting or boiling points are lower than those of the first four members of the period which have complex structures. The magnitudes of the melting and boiling points are governed entirely by the sizes of the molecules, which are shown again for reference:



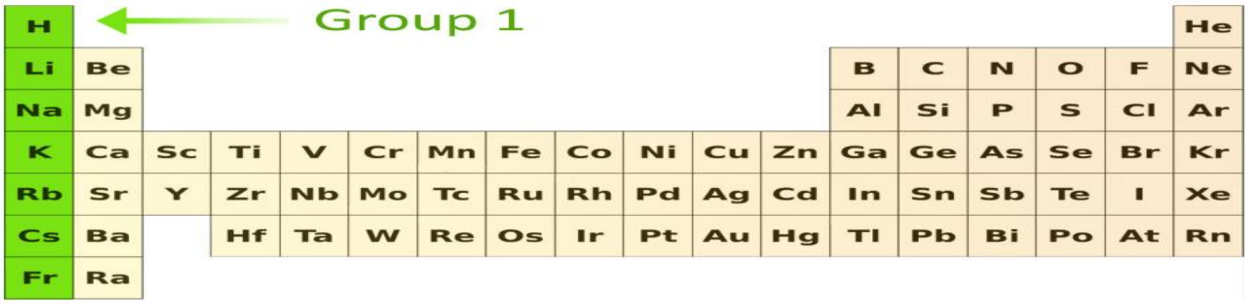
- Phosphorus: Elemental phosphorus adopts the tetrahedral P_4 arrangement. Melting phosphorus breaks no covalent bonds; instead, it disrupts the much weaker van der Waals forces between the molecules.
- Sulfur: Elemental sulfur forms S_8 rings of atoms. The molecules are bigger than phosphorus molecules, and thus the van der Waals attractions are stronger, leading to a higher melting and boiling point.
- Chlorine: Chlorine, Cl_2, is a much smaller molecule with comparatively weak van der Waals attractions, and thus chlorine will have a lower melting and boiling point than sulfur or phosphorus.
- Argon: Elemental argon is monatomic . The scope for van der Waals attractions between argon atoms is very limited and so the melting and boiling points of argon are lower again.

Elements of Group 1: Alkali Metals

Did you know that the elements in the periodic table are further classified on the basis of their properties? Well, depending on the nature of the reaction that the metals display, some of the metals are called Alkali metals. Making such classification is sometimes vital to the understanding of different elements.

It also helps us in determining the expected outcome of a given element, based on its placement in the periodic table. Hence, studying alkali metals and their properties is very interesting and stimulating to the overall knowledge of the periodic table. Let us understand more about these metals.

Alkali Metals List



H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra																

Included in Group 1 of the periodic table, the following are the alkali metals:

- Lithium
- Sodium
- Potassium
- Rubidium
- Cesium

Alkali Metals Properties

The general electronic configuration of elements of group 1 is ns^1. They have a strong tendency to donate their valence electron in the last shell to form strong ionic bonds. They have the least nuclear charge in their respective periods. As we move down the group, the atomic radius increases. Therefore, the nuclear charge decreases. Caesium is the most metallic element in the group.

Alkali Metals Reactivity with Water

Alkali metals derive their classification because of the results of their reaction with water. Alkaline metals when reacting with water produce an alkaline solution, along with the release of hydrogen gas. The following chemical equations demonstrate how various metals react with water:

$$\text{lithium} + \text{water} \rightarrow \text{lithium hydroxide} + \text{hydrogen}$$
$$2\,Li(s) + 2\,H_2O(l) \rightarrow 2\,LiOH\,(aq) + H_2(g)$$

sodium + water → sodium hydroxide + hydrogen

$$2\,Na(s) + 2\,H_2O(l) \rightarrow 2\,NaOH\,(aq) + H_2(g)$$

potassium + water → potassium hydroxide + hydrogen

$$2\,K(s) + 2\,H_2O(l) \rightarrow 2\,KOH\,(aq) + H_2(g)$$

All elements in a particular group react in an analogous manner.

How Do Alkali Metals React Otherwise?

As alkali metals are the most reactive group of metals in the periodic table, each of these metals is capable of reacting with different elements to produce different results. Following chemical equations demonstrate some of the ways in which they react:

potassium + oxygen → potassium oxide

$$4\,K(s) + O_2(g) \rightarrow 2\,K_2O(s)$$

sodium + chlorine → sodium chloride

$$2\,Na(s) + Cl_2(g) \rightarrow 2\,NaCl(s)$$

potassium + chlorine → potassium chloride

$$2\,K(s) + Cl_2(g) \rightarrow 2\,KCl\,(s)$$

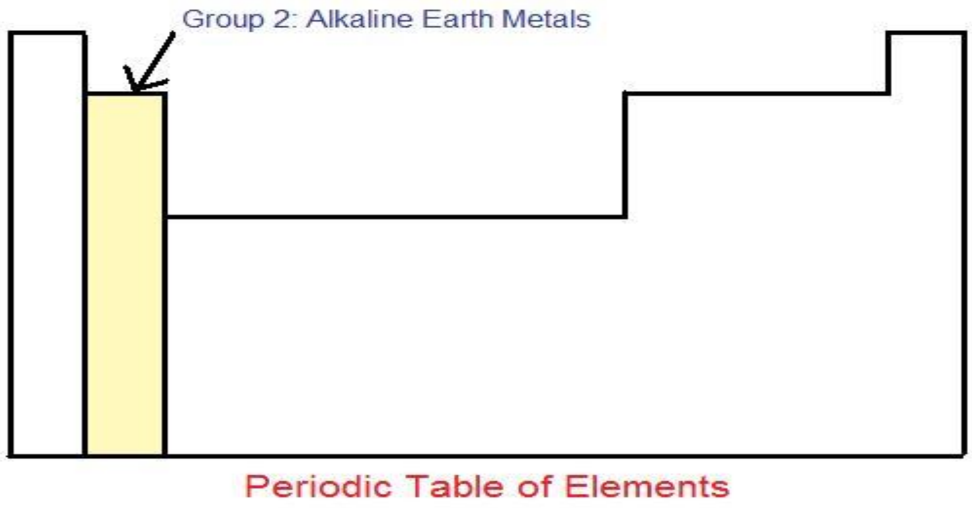
All alkalis manifest themselves as a white solid in their compound form that is capable of being dissolved in water. Most of these compounds are ionic in nature.

Group 2: General Properties :

The elements in the group include beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), and radium (Ra).

Introduction

Group 2 contains soft, silver metals that are less metallic in character than the Group 1 elements. Although many characteristics are common throughout the group, the heavier metals such as Ca, Sr, Ba, and Ra are almost as reactive as the Group 1 Alkali Metals. All the elements in Group 2 have two electrons in their valence shells, giving them an oxidation state of +2. This enables the metals to easily lose electrons, which increases their stability and allows them to form compounds via ionic bonds. The following diagram shows the location of these metals in the Periodic Table:



The table below gives a detailed account of the descriptive chemistry of each of the individual elements. Notice an increase down the group in atomic number, mass, and atomic radius, and a decrease down the group for ionization energy. These common periodic trends are consistent across the whole periodic table.

	Atomic #	Mass (g)	Oxidation State(s)	Electron Configuration	Atomic Radius (pm)	Ionization Energy (kJ/mol)	Melting Point	Boiling Point	Flame Color	Magnetic Order	Crystal Structure
Be	4	9.012	+2	$1s^2 2s^2$	105	899.5	1560 K	2742 K	None	Diamagnetic	Hexagonal
Mg	12	24.31	+1, +2	$[Ne]3s^2$	150	737.7	923 K	1363 K	Bright White	Paramagnetic	Hexagonal
Ca	20	40.08	+2	$[Ar]4s^2$	180	589.8	1115 K	1757 K	Orange/ Red	Diamagnetic	Face Centered Cubic
Sr	38	87.62	+2	$[Kr]5s^2$	200	549.5	1042 K	1655 K	Scarlet	Paramagnetic	Face Centered Cubic
Ba	56	137.3	+2	$[Xe]6s^2$	215	502.9	1000 K	2170 K	Green	Paramagnetic	Body Centered Cubic
Ra	88	226.0	+2	$[Rn]7s^2$	215	509.3	973 K	2010 K	~	Non-magnetic	Body Centered Cubic

Alkaline Earth Metal Reactions

The reactions of the alkaline earth metals differ from those of the Group 1 metals. Radium is radioactive and is not considered in this section.

- **Reactions with Hydrogen**: All the alkaline earth metals react with hydrogen to create metallic hydrides. Below is an example of a reaction of this type:

  $$Ca(s)+H_2\ (g)\rightarrow CaH_2\ (s)(Group\ 2.1)$$

- **Reactions with Oxygen:** The alkaline earth metals react with oxygen to produce metal oxides. An oxide is a compound containing oxygen in a -2 oxidation state. The following is an example reaction of an alkaline earth metal with oxygen (beryllium does not react with oxygen, but the other metals react in this manner):

  $$Sr(s)\ +O_2\ (g)\rightarrow SrO_2\ (s)(Group\ 2.2)$$

- **Reactions with Nitrogen**: These reactions cannot occur in ordinary condition; extremely high temperatures are required. A theoretical reaction of an alkaline earth metal with nitrogen would proceed in the following manner:

  $$3Mg(s)\ +N(g)\rightarrow Mg_2\ N_2\ (s)(Group\ 2.3)$$

- **Reactions with Halogens**: Alkaline earth metals react with halogens to form metal halides. A halide is a compound containing an ionic halogen. A reaction of this type between magnesium and chlorine is given below:

  $$Mg(s)+Cl2(g)\rightarrow MgCl2(s)(Group\ 2.4)$$

- **Reactions with Water**: Beryllium does not react with water; however, magnesium, calcium, strontium, and barium do react to form metal hydroxides and hydrogen gas. The reaction of barium and water is illustrated in the following equation:

  $$Ba(s)\ +\ 2H_2O(l)\rightarrow Ba(OH)_2(aq)+H_2\ (g)(Group\ 2.5)$$

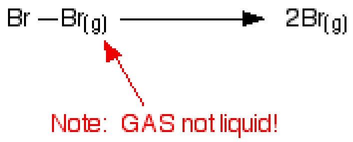
Reference page/site
https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Modules_and_Websites_(Inorganic_Chemistry)/Descriptive_Chemistry/Elements_Organized_by_Period/Period_3_Elements/Physical_Properties_of_Period_3_Elements

Bond enthalpies (bond energies or bond strengths)

Bond enthalpy is the heat required to break one mole of a covalent bond to produce individual atoms, starting from the original substance in the gas state, and ending with gaseous atoms. For chlorine, $Cl_2(g)$, it is the heat energy required to carry out this change per mole:

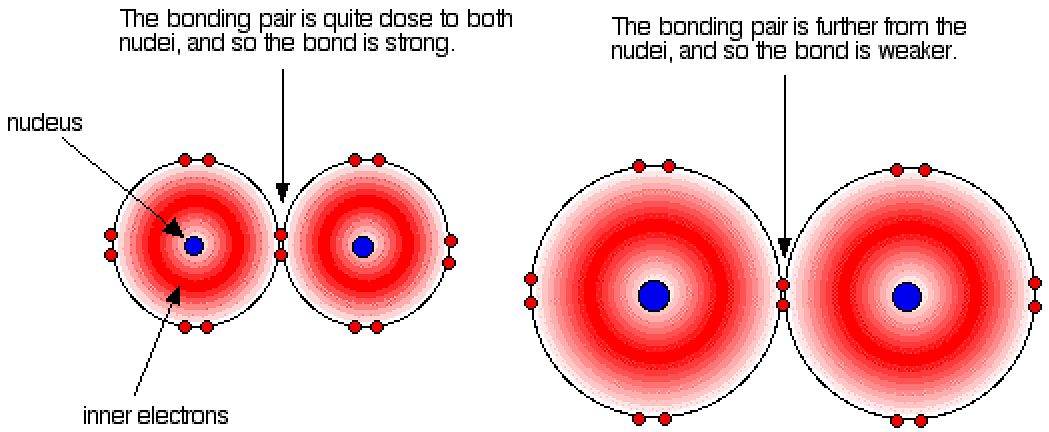
$$Cl-Cl_{(g)} \longrightarrow 2Cl_{(g)}$$

Below is the same reaction with bromine:

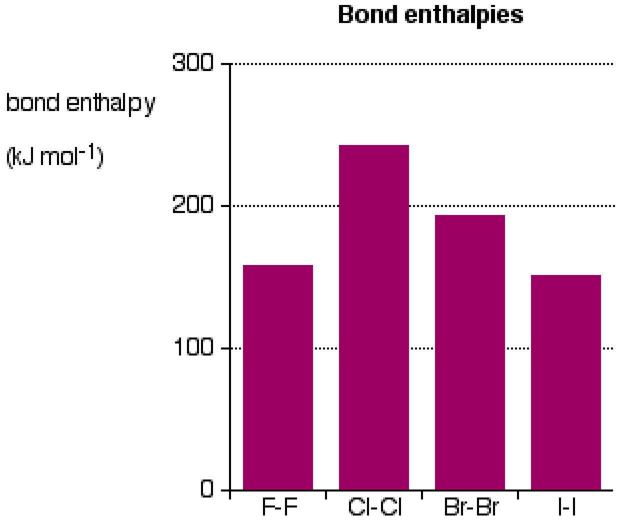


Bond enthalpy in the halogens, $X_2(g)$

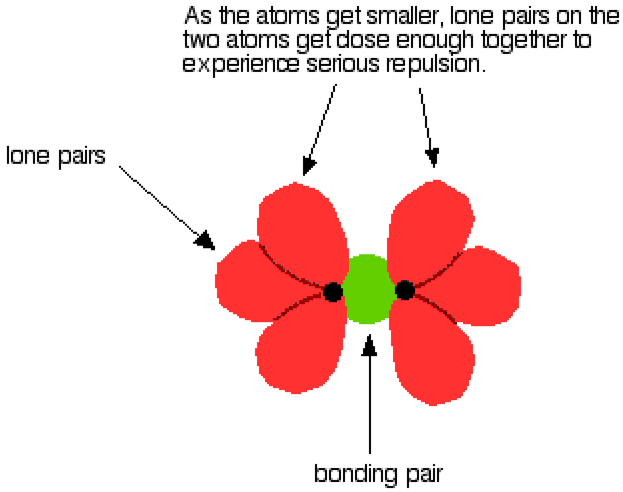
A covalent bond occurs because the bonding electron pair is attracted to both the nuclei at either side of it. It is that attraction which holds the molecule together. The size of the attraction depends, among other things, on the distances from the bonding pair to each of the two nuclei.



As mentioned before, the bonding pair feels a net attraction of 7+ from both ends of the bond. As the atoms get larger down the group, the bonding pair is progressively farther from the nuclei; it is reasonable to expect the bond strength to decrease. The figure below shows the actual bond enthalpies of the diatomic halogens:



The bond enthalpies of the Cl-Cl, Br-Br and I-I bonds decrease as predicted, but the F-F bond enthalpy deviates significantly. Because fluorine atoms are so small, a strong bond is expected; in fact, it is remarkably weak. In addition to the bonding electrons between the two atoms, each atom has 3 non-bonding pairs of electrons in the outer level—lone pairs. If the bond length is very short (as is the case with F-F), the lone pairs on the two atoms close enough together to cause a significant amount of repulsion.



In the case of fluorine, this repulsion is great enough to counteract much of the attraction between the bonding pair and the two nuclei; this weakens the bond.

Reference page/site

https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Modules_and_Websites_(Inorganic_Chemistry)/Descriptive_Chemistry/Elements_Organized_by_Block/2_p-Block_Elements/Group_17%3A_The_Halogens/0Group_17%3A_Physical_Properties_of_the_Halogens/Physical_Properties_of_the_Group_17_Elements#:~:text=A%20covalent%20bond%20occurs%20because,at%20either%20side%20of%20it.&text=The%20figure%20below%20shows%20the,F%2DF%20bond%20enthalpy%20deviates%20significantly.

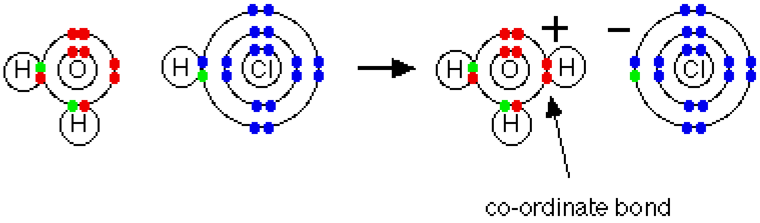
The acidity of the hydrogen halides

Hydrogen chloride as an acid

By the Bronsted-Lowry definition of an acid as a proton donor, hydrogen chloride is an acid because it transfers protons to other species. Consider its reaction with water.

Hydrogen chloride gas is soluble in water; its solvated form is hydrochloric acid. Hydrogen chloride fumes in moist air are caused by hydrogen chloride reacting with water vapor in the air to produce a cloud of concentrated hydrochloric acid.

A proton is donated from the hydrogen chloride to one of the lone pairs on a water molecule.



A coordinate (dative covalent) bond is formed between the oxygen and the transferred proton.

The equation for the reaction is the following:

$$H_2O + HCl \rightarrow H_3O^+ + Cl^-$$

The H_3O^+ ion is the hydroxonium ion (also known as the hydronium ion or the oxonium ion). This is the normal form of protons in water; sometimes it is shortened to the proton form, H^+(aq), for brevity.

When hydrogen chloride dissolves in water (to produce hydrochloric acid), almost all the hydrogen chloride molecules react in this way. Hydrochloric acid is therefore a strong acid. An acid is strong if it is fully ionized in solution.

Reference page/site
https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Modules_and_Websites_(Inorganic_Chemistry)/Descriptive_Chemistry/Elements_Organized_by_Block/2_p-Block_Elements/Group_17%3A_The_Halogens/1Group_17%3A_General_Reactions/The_Acidity_of_the_Hydrogen_Halides

CHEMISTRY OF SODIUM HYDROXIDE

Commercial name : caustic soda

On industrial scale sodium hydroxide can be prepared by the following methods.

1) Castner - Kellner Process.
2) Gibb's Method.
3) Nelson's Method.

Castner - Kellener Process

Principle

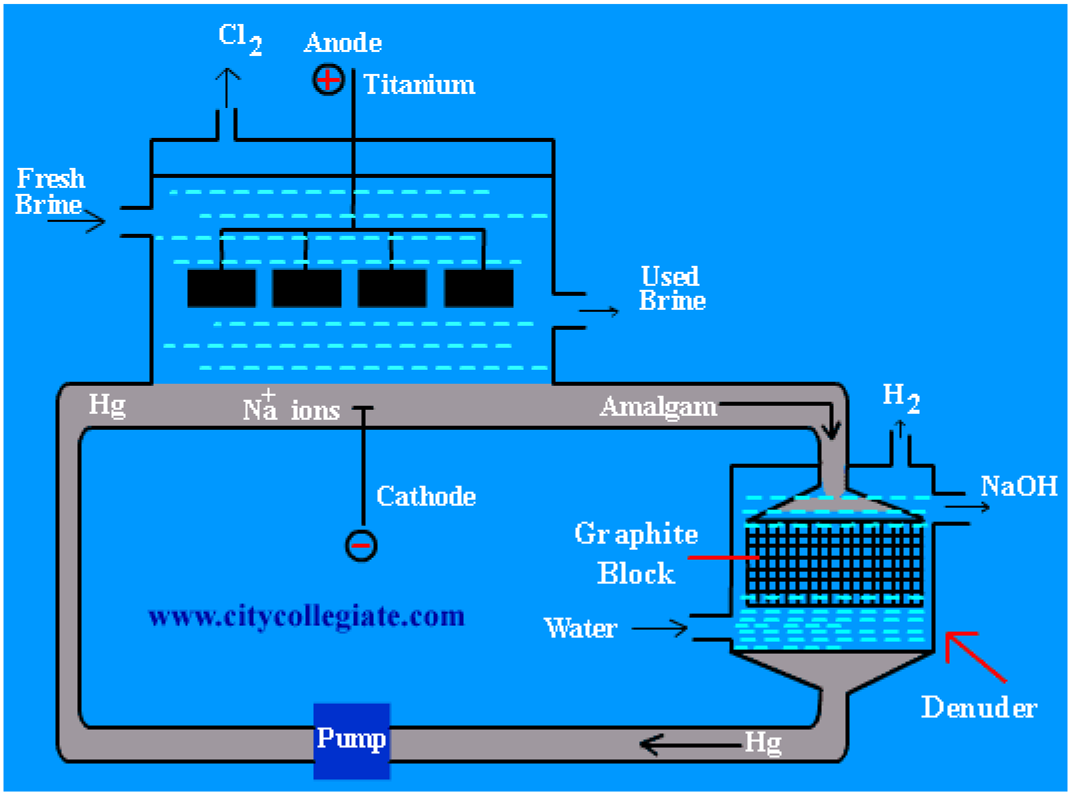
In castner-kellner method NaOH is prepared by the electrolysis of aqueous solution of NaCl(Brine).

Concentration of brine

25 % mass/mass
i.e. 25 gm of NaCl is dissolved in 75 gm of water.

Castner-kellner cell

It is a rectangular tank of steel.
Inside of tank is lined with "ebonite".
Anode is made of titanium.
Flowing layer of mercury (Hg) at the bottom of tank serves as cathode.



Details of process

Ionization of NaCl

$$2NaCl \rightarrow 2Na^+ + 2Cl^-$$

When electric current is passed through brine, +ve and -ve ions migrate towards their respective electrodes. Na^+ions are discharged at mercury cathode. The sodium deposited at mercury forms SODIUM AMALGAM. Chlorine produced at the anode is removed from the top of the cell.

Reaction at cathode

$$2Na^+ + 2e^- \rightarrow 2Na$$

Na forms amalgam.

$$Na + Hg \rightarrow Na/Hg$$

Na^+ ions are discharged in preference to H^+ ions due to high over voltage.

Na+/Na: E.P. = -2.71 volt

H+/H : E.P. = 0.00 volt

Reaction at anode

$$2Cl^- \rightarrow Cl_2 + 2e^-$$

Formation of NaOH

Amalgam moves to another chamber called "denuder", where it is treated with water to produce NaOH which is in liquid state. Solid NaOH is obtained by the evaporation of this solution.

$$2Na/Hg + 2H_2O \rightarrow 2NaOH + H_2 + 2Hg$$

Advantages of castner's process

NaOH obtained is highly pure.

The process is very efficient.

Possible reaction between NaOH and Cl_2 is avoided as NaOH is obtained in a separated chamber.

Disadvantages

High electricity consumption.

Environmental pollution due to escape of Hg vapours.

Reference page/site

http://www.citycollegiate.com/sblock3.htm

CHEMISTRY OF SODIUM CARBONATE (Na_2CO_3)

Soda Ash

INDUSTRIAL PREPARATION OF SODIUM CARBONATE

On industrial scale sodium carbonate is prepared by Ammonia Solvay Process.

Raw Materials

1. Sodium Chloride
2. Lime Stone ($CaCO_3$)
3. Ammonia

Details of the process

At first stage a saturated solution of sodium chloride is prepared which is also known "BRINE".

Composition of solution of NaCl (brine) is 28% m/m.

Steps of preparation

Ammoniation of Brine

In this stage saturated brine is allowed to flow down an ammoniating tower. This tower is fitted with mushroom shaped baffles. These baffles control the flow of brine and ensure the proper mixing and saturation of ammonia.

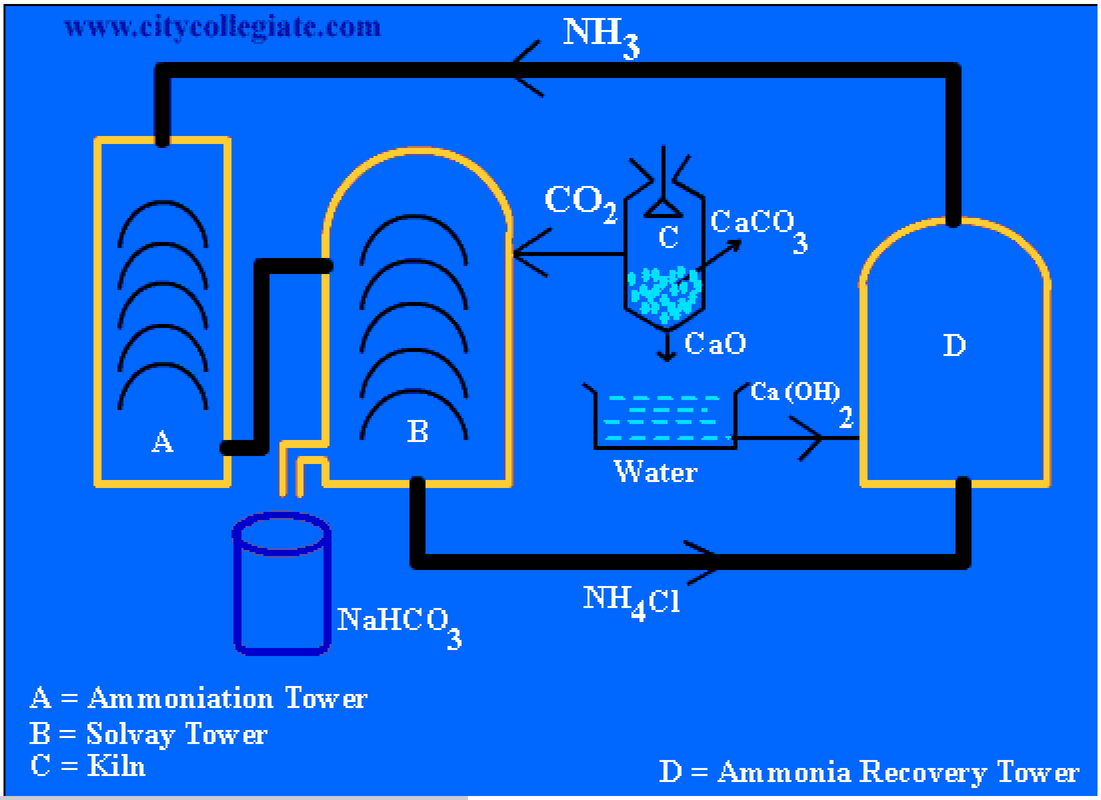
Carbonation of ammoniated brine

In the second step, ammoniated brine is allowed to trickle down a carbonating tower known as Solvay tower. This tower is also fitted with baffle plates. Here brine is mixed with carbon dioxide gas, produced by heating lime stone in a separate chamber called "**kiln**".

$$CaCO_3 \rightarrow CaO + CO_2$$

the baffle plates ensure the flow of solution and breaks up carbon dioxide into small bubbles to produce good conditions for reaction.

Flow Chart



Chemistry of Solvay tower

CO_2 reacts with ammonia to form ammonium carbonate.

$$2NH_3 + CO_2 + H_2O \rightarrow (NH4)_2CO_3$$

Ammonium carbonate further reacts with CO_2 to form ammonium bicarbonate.

$$(NH4)_2CO_3 + CO_2 + H_2O \rightarrow 2NH_4HCO_3\ (aq.)$$

Ammonium bicarbonate then react with NaCl to form sodium bicarbonate.

$$NH_4HCO_3 + NaCl \rightarrow NaHCO_3 + NH_4Cl$$

Due to exothermic nature of above reactions, solubility of $NaHCO_3$ increases. To counter this effect , lower part of Solvay tower is cooled , ppt of $NaHCO_3$ are separated by vacuum filtration and washed to remove ammonium salts.

Conversion of $NaHCO_3$ to $Na_2\ CO_3$

Dry sodium bicarbonate is heated in rotary furnace called "**CALCINER**" to give anhydrous sodium carbonate or soda ash. Carbon dioxide is recirculated to carbonation tower.

$$2NaHCO_3 \rightarrow Na_2\ CO_3 + CO_2 + H_2\ O$$

Ammonia recovery process

When $CaCO_3$ is heated, CaO is obtained along with CO_2. CaO is treated with water to form $Ca(OH)_2$.

$$CaO + H_2\ O \rightarrow Ca(OH)_2$$

Quick lime is heated with $NH_4\ Cl$ to form NH_3 and calcium chloride (by product). Ammonia is used again in this process.

$$2NH_4\ Cl + Ca(OH)_2 \rightarrow CaCl2 + 2NH_3 + 2H_2\ O$$

Reference page/site

https://www.citycollegiate.com/sblock2.htm

Laboratory and industrial preparation of chlorine gas

LABORATORY METHOD www.citycollegiate.com

In laboratory Cl_2 gas is prepared by heating a mixture of NaCl , MnO_2 with conc. H_2SO_4.

$$4NaCl + 4H_2SO_4 + MnO_2 \rightarrow 4NaHSO_4 + MnCl_2 + 2H_2O + Cl_2$$

SECOND METHOD

Chlorine may also be obtained by heating manganese dioxide with concentrated hydrochloric acid

$$MnO_2 \cdot + 4HCl \cdot \rightarrow MnCl_2 + 2H_2O + Cl_2$$

INDUSTRIAL PREPARATION

On industrial scale Cl_2 is obtained by the electrolysis of aqueous solution of NaCl called Brine.

$$NaCl + H_2O \rightarrow Cl_2 + H_2 + 2NaOH$$

IONIZATION OF NaCl www.citycollegiate.com

$$NaCl \rightleftharpoons Na^+ + Cl^-$$

REACTION AT ANODE

Cl^- ions are collected at anode and form chlorine gas

$$2Cl^- \rightarrow Cl_2 + 2e^-$$

REACTION AT CATHODE www.citycollegiate.com

Na^+ ions are collected at cathode where they are mixed with water to produce sodium hydroxide and liberate hydrogen gas.

$$2Na^+ + 2H_2O + 2e^- \rightarrow 2NaOH + H_2$$

OVERALL REACTION

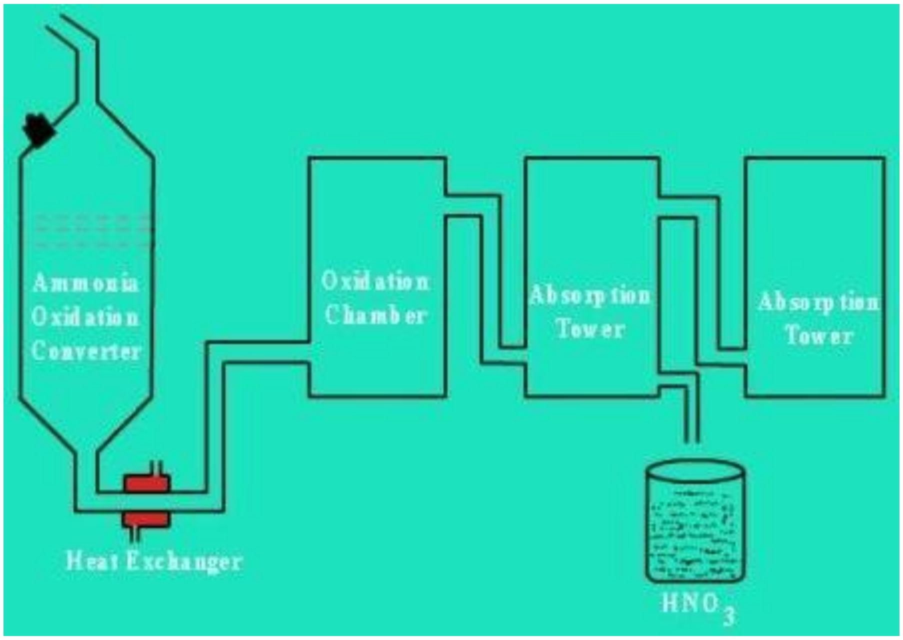
$$\begin{array}{c} 2Na^+ + 2H_2O + 2e^- \rightarrow 2NaOH + H_2 \\ 2Cl^- \rightarrow Cl_2 + 2e^- \\ \hline 2Na^+ \; 2Cl^- + 2H_2O \rightarrow 2NaOH + Cl_2 + H_2 \end{array}$$

Ostwald Process

Ostwald process is one of the most common methods or chemical process used for the manufacturing of nitric acid. The process was developed in the year 1902 by a German chemist named Wilhelm Ostwald. He was later awarded the Nobel Prize in 1909 for his research.

The Principle and Mechanism Behind Ostwald's Process

Before we get into the different steps, let us quickly understand the principle or mechanism behind the Ostwald process. The conversion of ammonia to nitric acid simply occurs as a result of oxidation. This particular oxidation reaction gives us the corresponding nitric oxide. Further, when the nitric oxide is oxidized nitrous gases are formed and those gases can trap water molecule. As a result, we obtain nitric acid. Catalytic oxidation involving O_2 is used where ammonia will give rise to the product.



While carrying out the process, there are specific reaction chambers where ammonia is fed from one direction and air through a different path. There are possibilities of side reactions occurring as well. If we go for subsequent ammonia oxidation, we will get some other reactions. It happens usually in the case of dinitrogen. The removal of dinitrogen creates ammonia. If we try to oxidize the ammonia, it will also give back the dinitrogen. There can be other oxidized forms as well.

In all these, optimizing the reaction condition becomes very important, otherwise, many gases can be formed together with the desired NO. It is, therefore, necessary to avoid side reactions.

Moving on, the next stage involves the oxidation of NO_2 which can also dimerize to give N_2O_4. The reaction in this stage is only favoured at low temperatures.

Meanwhile, the Ostwald process is also closely related to Born Haber's cycle or process.

Ostwald Process for making Nitric Acid

Step 1 – Catalytic Oxidation Reaction

Primary Oxidation (Formation of Nitric Acid)

The main goal in this process is the conversion of ammonia into nitric acid. The process begins in a catalyst chamber where one ammonia part and eight oxygen parts are introduced by volume. The chamber temperature is around 600°C. This chamber uses a catalyst-like platinum gauze or copper and nickel can also be used.

The oxidation of ammonia takes place and it is converted into nitric oxide (NO). The process is reversible and exothermic. The change in temperature encourages a forward reaction.

$4NH_3 + 5O_2 \leftrightarrow 4NO + 6H_2O$ | H -24.8 Kcal/mol

Secondary Oxidation (Formation Of Nitrogen Dioxide)

The nitric oxide gas produced by oxidation of ammonia is in a very hot state. It is passed through a heat exchanger in which the temperature of nitric oxide is lowered to 150ºC. After cooling, nitric oxide is transferred to another oxidizing tower where nitrogen dioxide (NO2) is oxidized at about 50ºC.

$2NO + O_2 \leftrightarrow 2\ NO_2$

Step 2 – Absorption of No_2 (Formation of HNO_3)

In a special absorption tower containing water, the nitrogen dioxide from the secondary oxidation chamber is introduced. NO_2 gas is passed through a tower where it absorbs the water. Nitric acid is then obtained through this process.

$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

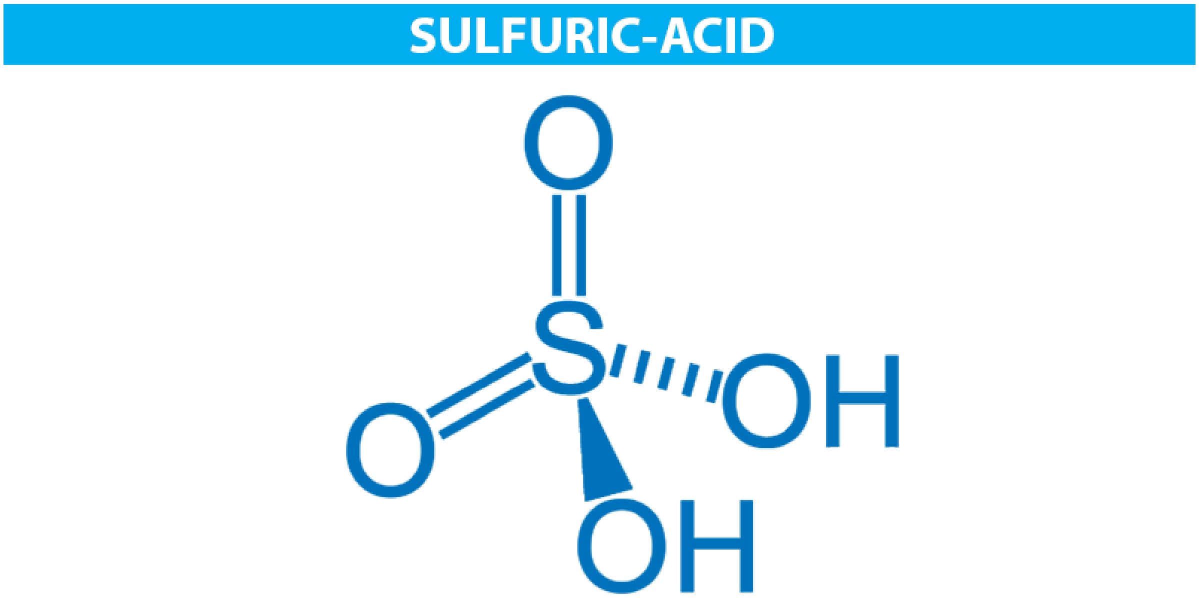
Nitric acid that is obtained is very dilute. NO is recycled to increase the concentration level which is generally kept around 68 per cent. The acid-in-water solution can also be dehydrated by distillation with sulfuric acid. Here, the pressure is kept between 4–10 standard atmospheres and the temperature is set at 870–1,073 K.

This reaction is exothermic as there is a release of energy. However, since the water and oxygen are constantly added to this cycle as reactants, the increasing concentration will create optimal equilibrium conditions.

Sometimes when producing nitric acid by the Ostwald process can be dangerous due to unfavourable conditions that may arise. More significantly, the concentration and corrosive behaviour of nitric acid can be a safety hazard.

Reference page/site
https://byjus.com/jee/ostwald-process/

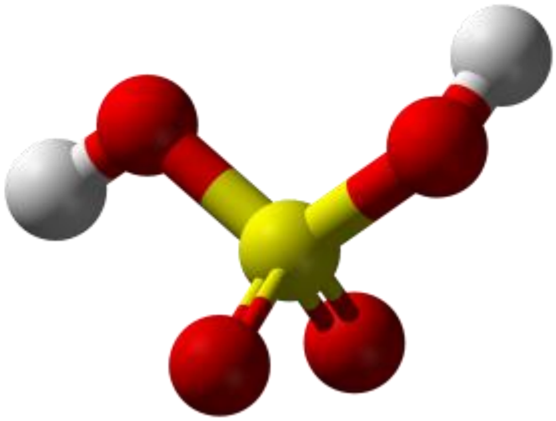
Preparation of Sulphuric Acid by Contact process



Sulphuric acid – H2SO4

We will first start by addressing the question of what is sulphuric acid. Well, sulphuric acid is basically an oxidizing agent, a strong mineral acid, and a dehydrating agent. Sulphuric acid has the chemical formula **H_2SO_4**.

The acid is a colorless liquid. It is soluble in water and generally releases heat on contact. Further, the acid is corrosive in nature to metals and tissues. It will even char wood and most other organic matter on contact, but chances of objects catching fire are null. The acid has a density of 15 lb/gal. Exposure to the acid can result in adverse health effects from inhalation. It depends on the rate of exposure and concentration.



Sulfuric Acid

Sulfuric Acid 3D ball Structure

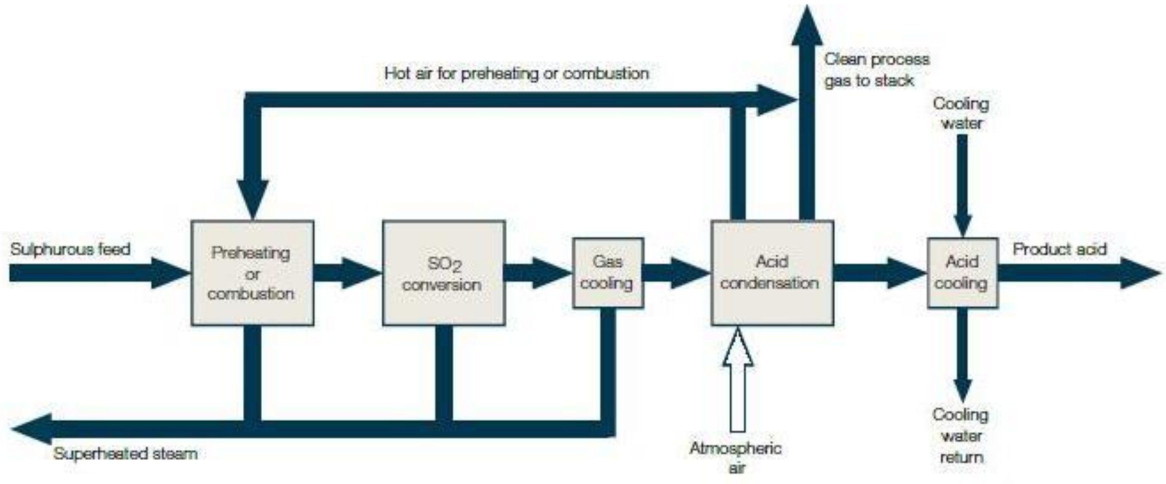
That being said, the acid is usually manufactured using a method known as the contact process. Earlier, in this process, a chemical element known as platinum was first used as a catalyst. Later, an inorganic compound known as vanadium oxide replaced platinum due to cost constraints.

In any case, today we will be looking at the contact process in detail.

Contact process for manufacturing of sulphuric acid:

Steps involved in the manufacturing of sulphuric acid are as stated below:

1. Preparation of sulfur dioxide.
2. Conversion of sulfur dioxide into sulfur trioxide.
3. Conversion of sulfur trioxide formed into concentrated H_2SO_4.



Step 1: Preparation of sulphur dioxide:

SO_2 is prepared by burning sulphur in the presence of excess air so that the product combines with oxygen which is helpful for the next stage.

$S(s) + O_2\ (g) \rightarrow SO_2(g)$

Step 2: Preparation of sulphur trioxide:

Sulphur trioxide is formed when sulphur dioxide reacts with oxygen in a ratio of 1:1 at a temperature of 400°C – 450°C and a pressure of 1-2 atm in the presence of V_2O_5 as a catalyst. This reaction is reversible in nature.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Step 3: Preparation of concentrated sulphuric acid:

The sulphur trioxide formed is first made to react with concentrated sulphuric acid. Sulphur trioxide cannot be dissolved in water directly as it leads to the formation of fog. The product obtained after this reaction is known as oleum. The oleum obtained is then dissolved in water to obtain concentrated sulphuric acid.

$$H_2SO_4 + SO_3(g) \rightarrow H_2S_2O_7(l)$$

$$H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4$$

Uses of Sulphuric Acid

In Industries:

- Up to 50 percent of this liquid manufactured is used in the production of phosphoric acid which is in turn used to make phosphate fertilizers.
- It is used in the manufacturing of metals such as copper, zinc etc.
- 5 percent of the produced acid is used in the making of fibers.

In Domestic Environments:

- Used in acidic drain cleaners.
- Due to its strong dehydrating property, it can be used to remove tissue paper.

As a Catalyst:

- Used as a catalyst in the manufacturing process of nylon.
- Used in the Manheim process in the manufacturing of HCl.
- Used in petroleum refining.

Reference page/site

https://byjus.com/chemistry/mass-production-of-sulphuric-acid/

BLEACHING POWDER

Chemical name : Calcium chloro hypo chloride.
Commercial name : Bleaching powder.
Chemical formula : $Ca(OCl)Cl.H_2O$ or $CaOCl_2.H_2O$.It is a dirty white amorphous powder with pungent smell of chlorine gas.

Industrial Preparation of Bleaching Powder

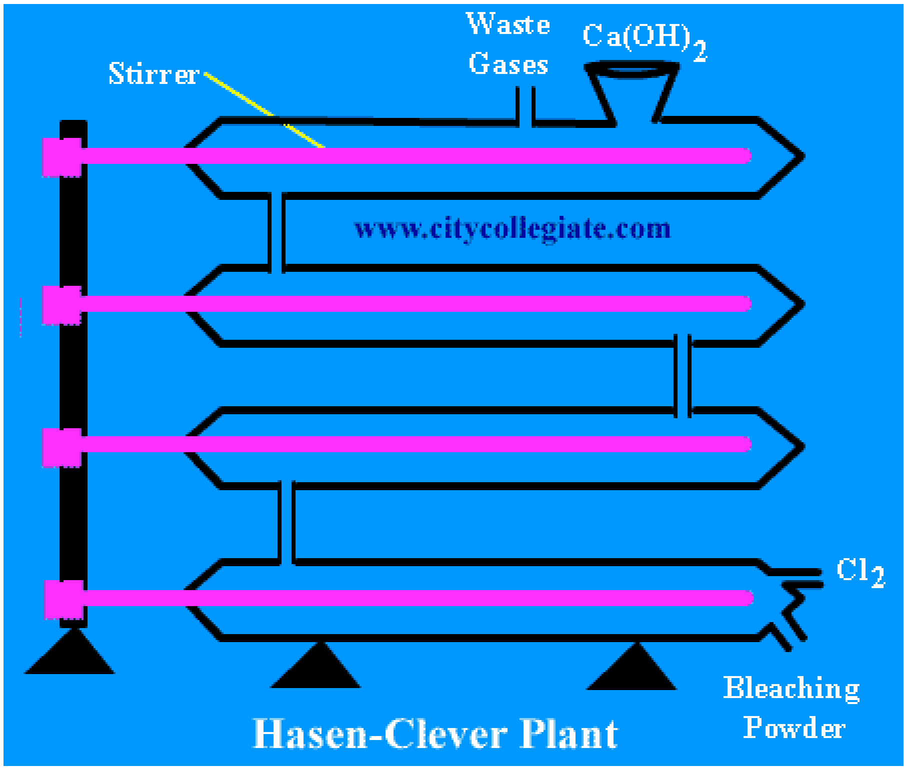
On industrial scale it is prepared by "**Hasen-Clever Method**".

Raw Material

1. **Slaked lime $Ca(OH)_2$**
2. **Chlorine gas**

Hasen-Clever Plant

The plant consists of four cylinder of castiron. Each cylinder is about 2 to 3m long .Each cylinder is provided with a stirrer to ensure the mixing of substances. There is an inlet in the upper most cylinder for $Ca(OH)_2$. The bottom cylinder has an inlet for Cl_2 and outlet for bleaching powder. Each cylinder is connected to the other by means of pipes.



Procedure

Slaked lime is introduced in the first cylinder with the help of compressed air .Cl_2 gas is introduced from the lower most cylinder .In tjis way these two substances meet, when proper saturation is reached, the product is separated from the last cylinder as bleaching powder.$Ca(OH)_2 + Cl_2 \rightarrow Ca(OCl)Cl.H_2O$

Properties

It is a strong bleaching agent.Due to liberation of chlorine gas in aqueous solution it decolorize different fabrics. It is also an anti-septic.

Chemical properties

Reaction with water:

$Ca(OC)Cl + H_2O \rightarrow Ca(OH)_2 + Cl_2$

With HCl:

$Ca(OCl)Cl + 2HCl \rightarrow CaCl_2 + Cl_2 + H_2O$

With CO_2:

$2Ca(OCl)Cl + CO_2 + H_2O \rightarrow CaCO_3 + CaCl_2 + 2HOCl$

Uses

As oxidizing and bleaching agent it is used in textile and other industries. It is also used in the purification of drinking water.

Reference page/site

https://www.citycollegiate.com/bleaching_powderIX.htm

Aqua Regia Definition

Aqua regia is a mixture of hydrochloric acid (HCl) and nitric acid (HNO_3) at a ratio of either 3:1 or 4:1. It is a reddish-orange or yellowish-orange fuming liquid. The term is a Latin phrase, meaning "king's water". The name reflects the ability of aqua regia to dissolve the noble metals gold, platinum, and palladium.

Aqua Regia Uses

Aqua regia is useful to dissolve gold and platinum and finds application in the extraction and purification of these metals. Chloroauric acid may be made by using aqua regia to produce electrolytes for the Wohlwill process. This process refines gold to extremely high purity (99.999%). A similar process is used to produce high-purity platinum.

Aqua regia is used to etch metals and for analytic chemical analysis. The acid is used to clean metals and organics from machines and laboratory glassware. In particular, it's preferable to use aqua regia rather than chromic acid to clean NMR tubes because chromic acid is toxic and because it deposits traces of chromium, which ruin NMR spectra.

Reference page/site

https://www.thoughtco.com/definition-of-aqua-regia-604788#:~:text=Aqua%20regia%20is%20a%20mixture,gold%2C%20platinum%2C%20and%20palladium.

Preparation of Boric Acid

One of the simplest methods of preparing boric acid is by reacting borax with any mineral acid (hydrochloric acid, for instance). The chemical equation for this reaction can be written as:

$$Na_2B_4O_7.10H_2O + 2HCl \rightarrow 4H_3BO_3 + 5H_2O + 2NaCl$$

Boric acid can also be prepared from the hydrolysis of diborane and trihalides of boron (such as boron trichloride or boron trifluoride).

Properties of Boric Acid – H_3BO_3

H_3BO_3	Boric Acid
Molecular Weight/ Molar Mass	61.83 g·mol−1
Density	1.435 g/cm3
Boiling Point	158 °C
Melting Point	300 °C

Under standard conditions for temperature and pressure (STP), boric acid exists as a white, crystalline solid that is fairly soluble in water. The solubility of H3BO3 in water is temperature-dependent. At a temperature of 25 degrees Celsius, the solubility of boric acid in water is 57 grams per litre. However, when the water is heated to 100 degrees Celsius, the solubility of this compound increases to approximately 275 grams per litre. It can also be noted that boric acid is sparingly soluble in pyridine and slightly soluble in acetone. The conjugate base of boric acid is the borate anion.

Structure of H_3BO_3 Molecules

Each boric acid molecule features boron-oxygen single bonds. The boron atom occupies the central position and is linked to three hydroxide groups. The overall molecular geometry of boric acid is trigonal planar. The structure of H_3BO_3 molecules is illustrated below.

What are the Uses of Boric Acid?

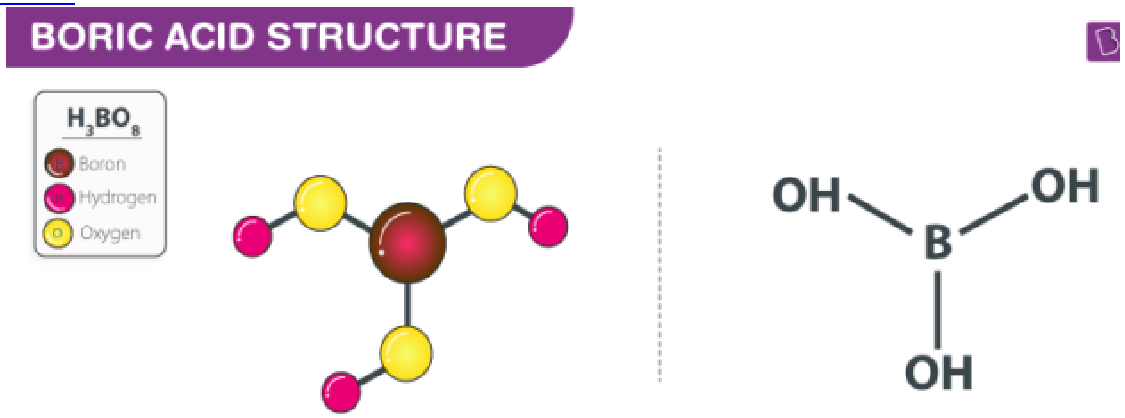
The uses of boric acid are listed below.

- It is used in the manufacture of textile fiberglass

- It is used in the production of the flat panel display
- It is used to neutralize the active hydrofluoric acid
- It is used by blacksmiths as welding flux
- It is used in electroplating
- It is used in the jewelry industry
- It is used in the manufacture of silly putty
- It is used as an Insecticidal
- It is used as an antiseptic and antibacterial
- It is used on carrom boards as a dry lubricant
- It is used as a neutron poison in some nuclear plants
- It is used to preserve grains like wheat and rice

Reference page/site

https://byjus.com/chemistry/boric-acid/#:~:text=Boric%20acid%2C%20often%20known%20as,precursor%20to%20other%20chemical%20compounds.



Structure of Boric acid

Student's Assessment.

- What quality unifies all of the elements grouped in the s-block?
- What is the ending of the electron configuration of each element in group 3?
- What is the valence electron configuration of each element in group 2?
- Why does the s-block span two groups of elements?
- What is the formula for bleaching powder?
- Is bleaching powder acidic or basic?
- What is the pH value of bleaching powder?
- What is the importance of sodium hydroxide?

- Can you mix sodium hydroxide and bleach?
- Is boric acid the same as borax?
- What is boric acid used for?
- How do you neutralize boric acid?
- What exactly is boric acid?
- Is boric acid soluble in acetone?
- How Sulphuric acid is produced?
- What type of acid is sulfuric acid H_2SO_4?
- What is the pH of Sulphuric acid?
- Will sulfuric acid dissolve metal?
- Is H_2SO_4 a Monoprotic acid?

PRACTICAL # 08

- How to make sodium extract by sodium metal.
- Determination of crystal of Epsom salt in hydrated salt.

X--------X-------X

CHAPTER # 09

“D – BLOCK ELEMENTS”

(Outer Transition Metals)”

INTRODUCTION

CHAPTER CONTENT

Characteristics of Transition Elements	Chemistry of Some important Transition Elements
Binding Energy	Oxidation States
Variable Oxidation States	Extraction process
Magnetic Behaviour	Electrolysis of metal
Catalytic Activity	Chemical properties of metal
Alloy formation	Nomenclature of co-ordination compound

Major Concepts

- Transition Elements
- Coordination Compounds
- The Chemistry of Some Specific Transition Metals

Conceptual Linkages

This unit is built on

- Periodic Table
- Periodicity of Properties
- Metals and Metalloids

LEARNING OUTCOMES

Students will be able to	Analyzing	Understanding	Applying
• Describe electronic structures of elements and ions of d-block elements.			✓
• Explain why the electronic configuration for chromium and copper differ from those assigned using the Aufbau principle.	✓		
• Describe important reactions and uses of Vanadium, Chromium, Manganese, Iron and Copper. Explain shapes, origin of colors and nomenclature of coordination compound		✓	
• Relate the coordination number of ions to the crystal structure of the compound of which they are a part.			✓
• Define an alloy and describe some properties of an alloy that are different from the metals that compose it.	✓		
• Describe the reactions of potassium dichromate with oxalic acid and Mohr's salt.			✓
• Describe the reactions of potassium manganate VII with ferrous sulphate, oxalic acid and Mohr's salt.		✓	

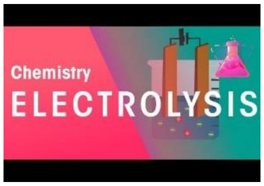
Skills	Analyzing	Understanding	Applying
• Calculate concentration of iron (II) ions in solution by titration with KMnO4.		✓	
• Explain the reaction of hexaaquacopper (II) ions with iodide and determine the concentration of copper (II) ions in the solution.		✓	

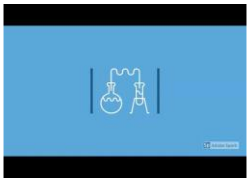
SOCIETY, TECHNOLOGY AND SCIENCE:

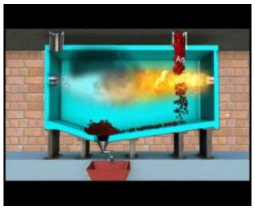
Students will be able to:

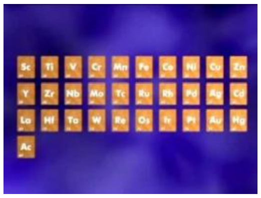
- Compare properties of Brass, Bronze and their constituent elements. (Applying)
- Identify that certain transition metal compounds are used in paints (understanding)

Related Videos









Chapter overview

(THEORY)

General characteristics of d-block elements

1 Atomic and Ionic Radii

The atomic and ionic radii of transition elements are smaller than those of p- block elements and larger than those of s-block elements. The atomic and ionic radii of first transition elements are given in the List.

Element and Atomic (pm) radii

Sc – 144 Ti – 132 V – 122 Cr - 118 Mn - 117

Fe - 117 Co - 116 Ni - 115 Cu - 117 Zn - 125

The atomic radii of first transition series decreases from Sc to Cr and remains almost constant till Cu and then increases towards the end. This can be explained based on two effects namely screening and the nuclear charge effect. These two effects oppose each other resulting in increase in nuclear charge. Hence very slight variation in the atomic radii from Cr to Cu is observed.

It has been observed that Zirconium and Hafnium have almost equal atomic radii. This is because of lanthanide contraction.

2 Metallic character

All the transition elements are metals, since the number of electrons in the outermost shell is very small, being equal to 2.They are hard, malleable and

3. Formation of coloured ions

Most of the transition metal compounds are colored in their solid or solution form. The colour of transition metal ions is due to the presence of unpaired electrons in it and the energy gap between two energy levels in the same d-subshell being small. Hence very small amount of energy is required for excitation of electrons from one energy level to the other. The energy can be easily provided by the visible light. The colour observed corresponds to the complementary colour of the light absorbed.

It may be noted that Zinc, Cadmium and Mercury salts do not form any colored compounds because of the absence of vacant d orbitals to which electrons can be excited. $Sc3+$ ions are also colorless because of the absence of d-electrons.

4 Catalytic Properties

Most of the transition metals and their compounds are used as catalyst.

The catalytic activity of transition metals is due to the following reasons.

i) They show a variety of oxidation states and thereby can form intermediate products with various reactants.

ii) They are also capable of forming interstitial compounds which can adsorb and activate the reacting species.

Some examples of catalyst are

i) Iron / molybdenum act as catalyst in the synthesis of ammonia by Haber's Process.

ii) Vanadium pentoxide ($V2O5$) is used for catalytic oxidation of $SO2$ to $SO3$

iii) $TiCl4$ is employed as a catalyst in the manufacture of polythene.

5 Variable oxidation states

All transition elements exhibit variety of oxidation states (or) variable valences in their compounds. This property is due to the following reasons.

i) These elements have several (n - 1) d and ns electrons.

ii) The energies of (n - 1) d and ns orbitals are fairly close to each other.

Salient features of oxidation states of transition elements

1. The elements which exhibit the maximum number of oxidation states occur either in or near the middle of the series. For example , in the first transition series manganese exhibits maximum number of oxidation states (+2 to +7).
2. The elements in the beginning of the series exhibit fewer oxidation states because they have less number of d-electrons which they can lose or contribute for sharing. The elements at the end of the series exhibit fewer oxidation states, because they have too many d electrons and hence fewer vacant d-orbitals can be involved in bonding.
3. The transition elements in lower oxidation states (+2 and +3) generally form ionic bonds and in higher oxidation state form covalent bonds.
4. The highest oxidation state shown by any transition metal is +8. For example, ruthenium and osmium show highest oxidation states of +8 in some of their compounds.
5. Some transition metals show oxidation state of zero in their compounds. Ni(CO)4 and Fe(CO)5 are common examples.

6 Magnetic Properties

The magnetic properties of a substance are determined by the number of unpaired electrons in it. There are two main type of substances.

i) Paramagnetic substances

The paramagnetic character arises because of the presence of unpaired electrons. Paramagnetic substances are the substances which are attracted by magnetic field.

ii) Diamagnetic Substances

Diamagnetic character arises because of the absence of unpaired electrons.

Diamagnetic substance are the substances which are repelled by the magnetic field.

Most of the transition elements and their compounds are paramagnetic and are attracted by magnetic field. Greater the number of unpaired electrons in the substance greater is the paramagnetic character, The magnetic character of a substance is expressed in terms of magnetic moments. The magnetic moment can be calculated using the relation

$$n(n + 2)\text{BM (Bohr Magneton)}$$

n = number of unpaired electrons

Example

Ti^{+3} - The number of unpaired electrons is 1. Hence

1(1+ 2)BM = 3 = 1.732 B.M

Larger the value of magnetic moment, the greater is the paramagnetic character.

In addition to paramagnetic and diamagnetic substance, there are a few substances such as iron which are highly magnetic as compared to ordinary metals. These substances are called ferromagnetic substances

7 Complex formation

The cations of d-block elements have strong tendency to form complexes with certain molecules (e.g. CO, NO, NH3....etc) or ions (e.g. F-, Cl-, CN- ....etc) called ligands. Their tendency to form complexes is due to two reasons.

Small size and high positive charge density.

Presence of vacant (n-1) d orbitals which are of appropriate energy to accept lone pair and unshared pair of electrons from the ligands for bonding with them.

Examples of some complex compounds are,

[Cu(NH3)4]2+, [Ag(NH3)2]+, [Fe(CN)6]4-,....etc.

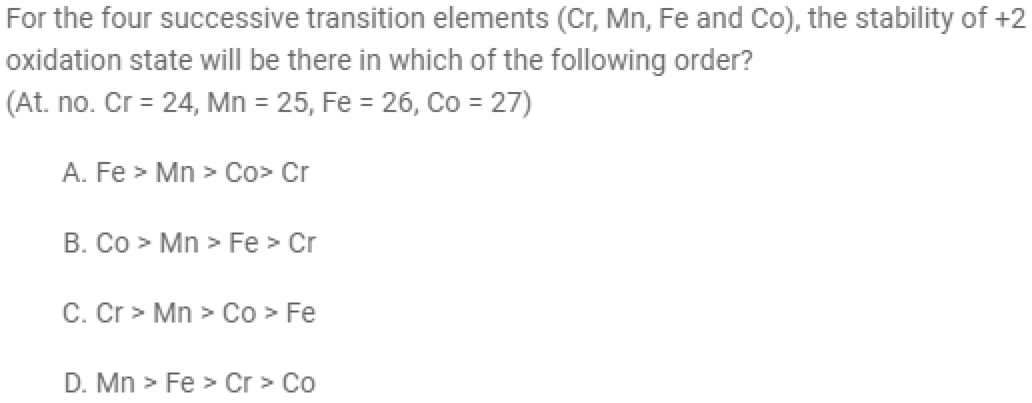
8 Formation of alloys

Transition metals form alloys with each other. This is because they have almost similar size and the atoms of one metal can easily take up positions in the crystal lattice of the other. Eg. Alloys of Cr-Ni, Cr-Ni-Fe, Cr-V-Fe, Mn-Fe......etc.

Reference page/site

https://www.brainkart.com/article/General-characteristics-of-d-block-elements_2837/

Oxidation state



For the four successive transition elements (Cr, Mn, Fe and Co), the stability of +2 oxidation state will be there in which of the following order?
(At. no. Cr = 24, Mn = 25, Fe = 26, Co = 27)

A. Fe > Mn > Co> Cr

B. Co > Mn > Fe > Cr

C. Cr > Mn > Co > Fe

D. Mn > Fe > Cr > Co

Naming Coordination Compounds

The set of rules for naming a coordination compound is:

1. When naming a complex ion, the ligands are named before the metal ion.
2. Write the names of the ligands in the following order: neutral, negative, positive. If there are multiple ligands of the same charge type, they are named in alphabetical order. (Numerical prefixes do not affect the order.)
3. Multiple occurring monodentate ligands receive a prefix according to the number of occurrences: di-, tri-, tetra-, penta-, or hexa. Polydentate ligands (e.g., ethylenediamine, oxalate) receive bis-, tris-, tetrakis-, etc.
4. Anions end in -ido. This replaces the final "e" when the anion ends with "-ate" (e.g, sulfate becomes sulfato) and replaces "-ide" (cyanide becomes cyanido).
5. Neutral ligands are given their usual name, with some exceptions: NH_3 becomes ammine; H_2O becomes aqua or aquo; CO becomes carbonyl; NO becomes nitrosyl.
6. Write the name of the central atom/ion. If the complex is an anion, the central atom's name will end in -ate, and its Latin name will be used if available (except for mercury).
7. If the central atom's oxidation state needs to be specified (when it is one of several possible, or zero), write it as a Roman numeral (or 0) in parentheses.
8. End with "cation" or "anion" as separate words (if applicable).

Example:

Write a proper chemical name for each of the following coordination compounds:

a. $[NiCl_4]^{2-}$

b. $Pt(NH_3)_2Cl_4$

c. $[Pt(NH_3)_2Cl_2]Cl_2$.

Solution:

a. Tetrachloridonickelate (II) ion. The complex ion, an anion, is inside the parentheses. We have to add the suffix -ate in the name of the metal.

b. Diamminetetrachloroplatinum (IV). This is a neutral molecule. The total charge on the ligands is -4. Therefore, the platinum oxidation number is +4.

c. Diamminedichloroplatinum (II) chloride. Here, the number of ions and atoms are the same. However, the brackets as well as the different oxidation number of the platinum result in a very different name.

Reference page/site
https://courses.lumenlearning.com/introchem/chapter/naming-coordination-compounds/#:~:text=The%20set%20of%20rules%20for,are%20named%20in%20alphabetical%20order.

Important use of transition element

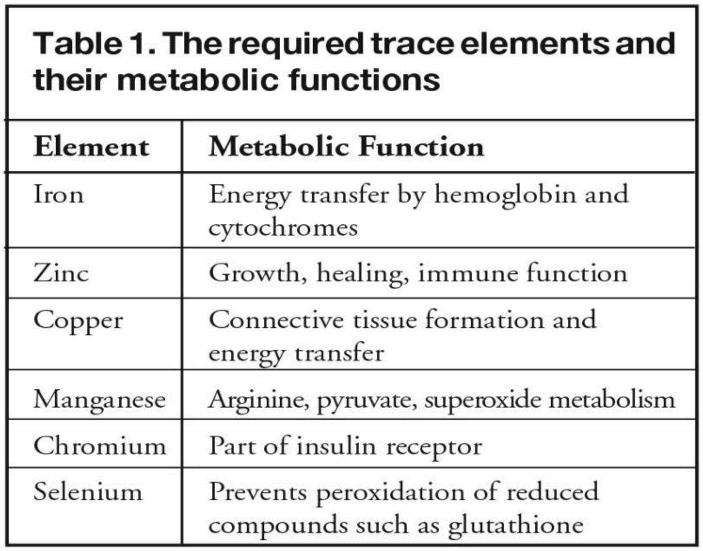


Table 1. The required trace elements and their metabolic functions

Element	Metabolic Function
Iron	Energy transfer by hemoglobin and cytochromes
Zinc	Growth, healing, immune function
Copper	Connective tissue formation and energy transfer
Manganese	Arginine, pyruvate, superoxide metabolism
Chromium	Part of insulin receptor
Selenium	Prevents peroxidation of reduced compounds such as glutathione

Industrial Application of Alloys

Alloys have been used in industries for a long time. Few widely used applications are:

- Stainless Steel is used in wire and ribbon forms for applications, such as screening, staple, belt, cable, weld, metalizing, catheter, and suture wire.
- Alloys of Gold and Silver are used in the preparation of jewelry. White Gold, which is an alloy of Gold, Silver, Palladium, and Nickel is used as cheap alternative of Platinum. A wide selection of alloys is used in welding applications by numerous industries.
- Some alloys function as corrosion-resistant materials and are used in moisture rich-environments.
- High temperature alloys have been used for many aerospace and petrochemical applications. In addition, they have been used for welding wire, where elevated temperatures and harsh environments are routinely encountered. These alloys have been used in applications where corrosion resistance and high strength must be maintained at elevated temperatures.

- Magnetic alloys are used for magnetic cores and dry reed switches. Quality control measures include magnetic testing to maintain consistently high standards of uniformity and performance.

- Alloys are also used to produce internal and external leads.

- Nickel-Chromium, Nickel-Chromium-Iron, and Iron-Chromium-Aluminum alloys have been used for high-temperature heating elements.

- Some alloys are used as resistance elements to control or measure electric current. Applications have included wire-wound resistors, rheostats, potentiometers, and shunts.

- Thermocouple alloys have found a wide-range of use in temperature sensing and control.

- Alloys are also used as thermostat metals, radio and electronic devices, precision devises in aircraft controls, telecommunications, automotive applications.

Reference page/site
https://www.globalspec.com/reference/46879/203279/industrial-application-of-alloys

Alloy steels

This type of metal contains multiple elements to enhance various properties. Metals such as manganese, titanium, copper, nickel, silicon, and aluminium may be added in different proportions.
This improves steel's hardenability, weldability, corrosion resistance, ductility and formability.
Applications for alloy steels are electric motors, bearings, heating elements, springs, gears, and pipelines.

- **Stainless steel**: Stainless steel contains high amounts of chromium. This is why it has 200 times higher resistance to corrosion than mild steel. It makes it the ideal candidate to manufacture kitchen utensils, piping, surgical and dental equipment. Also, as no coating is necessary, you can have a metallic look like you want with the right surface finish.

- **Tool steel:** Tool steels are used for making cutting and drilling tools. Their high hardness make them an ideal choice for these applications. They contains molybdenum, vanadium, cobalt, and tungsten as constituent metals.

METALLURGY OF COPPER

IMPORTANT ORES OF COPPER

Copper pyrite or chalcopyrite ($CuFeS_2$).
Chalocite (Cu_2S) or copper glance.
Malachite green [$CuCO_3.Cu(OH)_2$].
Azurite blue [$2CuCO_3.Cu(OH)_2$].
Bornite ($3Cu_2S.Fe_2S_3$) or peacock ore.
Melaconite (CuO) etc.

EXTRACTION OF COPPER FROM SULPHIDE ORE

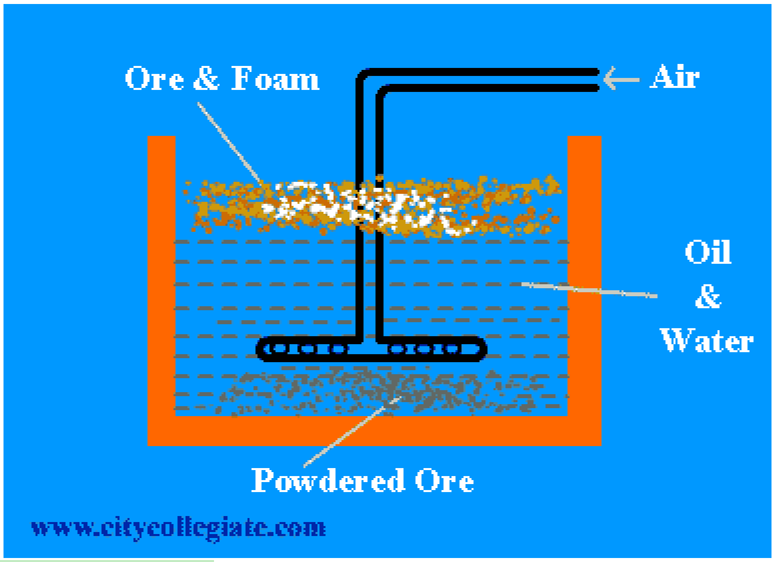
Large amount of copper are obtained from copper pyrite ($CuFeS_2$) by smelting. Ores containing 4% or more copper are treated by smelting process. Very poor ores are treated by hydro-metallurgical process.

EXTRACTION OF COPPER BY SMELTING PROCESS

Following steps are involved in the extraction of copper.

CONCENTRATION

The finely crushed ore is concentrated by Froth-Floatation process. The finely crushed ore is suspended in water containing a little amount of pine oil. A blast of air is passed through the suspension. The particles get wetted by the oil and float as a froth which is skimmed. The gangue sinks to the bottom.



ROASTING

The concentrated ore is then roasted in a furnace in the presence of a current of air. Sulphur is oxidized to SO_2 and impurities of arsenous and antimony are removed as volatile oxides.

The following reaction takes place.

$$2CuFeS_2 + O_2 \rightarrow Cu_2S + 2FeS + SO_2$$
$$S + O_2 \rightarrow SO_2$$

$$\mathbf{4As + 3O2 \rightarrow As2O3}$$

$$\mathbf{4Sb + 3O2 \rightarrow 2Sb2O3}$$

Cuprous sulphide and ferrous sulphide are further oxidized into their oxides.

$$\mathbf{2Cu2S + 3O2 \rightarrow 2Cu2O + 2SO2}$$

$$\mathbf{2FeS + 3O2 \rightarrow 2FeO + 2SO2}$$

SMELTING

The roasted ore is mixed with coke and silica (sand) SiO2 and is introduced in to a blast furnace. The hot air is blasted and FeO is converted in to ferrous silicate (FeSiO3).

$$\mathbf{FeO + SiO2 \rightarrow FeSiO3}$$

$$\mathbf{Cu2O + FeS \rightarrow Cu2S + FeO}$$

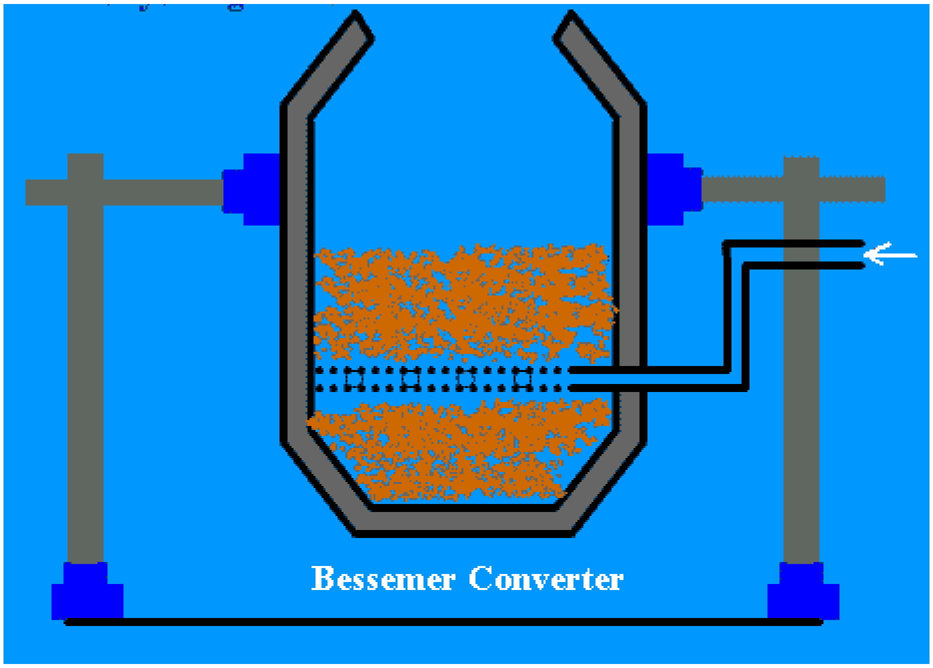
FeSiO3 (slag) floats over the molten matte of copper.

BESSEMERIZATION

Copper metal is extracted from molten matte through bessemerization . The matte is introduced in to Bessemer converter which uphold by tuyers. The air is blown through the molten matte. Blast of air converts Cu2S partly into Cu2O which reacts with remaining Cu2S to give molten copper.

$$\mathbf{2Cu2S + 3O2 \rightarrow 2Cu2O + 2SO2}$$

$$\mathbf{2Cu2O + Cu2S \rightarrow 6Cu + SO2}$$



The copper so obtained is called "Blister copper" because, as it solidifies, SO2 hidden in it escapes out producing blister on its surface.

IMPURITIES IN BLISTER COPPER AND THEIR EFFECTS

Blister copper is 99% pure. It contains impurities mainly iron but little amount of As, Zn, Pb, Ag and Au may also be present. These impurities adversely affect the electrical as well as mechanical properties of copper. Therefore, they must be removed.

REFINING OF COPPER

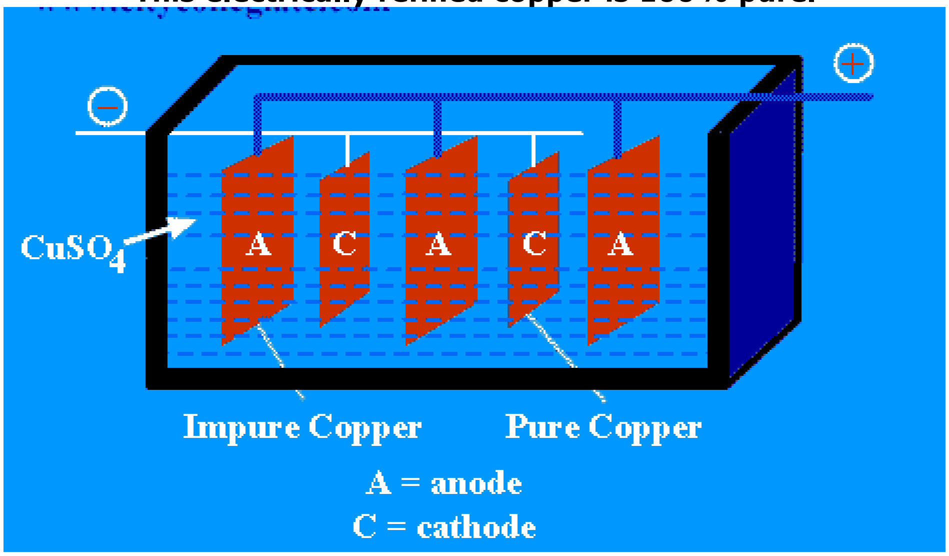
Blister copper is refined by electrolysis. Blocks of blister copper are used as anodes and thin sheets of pure copper act as cathodes. The cathode plates are coated with graphite in order to remove depositing copper. The electrolyte is copper sulphate (CuSO4) mixed with a little amount of H2SO4 to increase the electrical conductivity. Optimum potential difference is 1.3 volt for this electrolytic process. During electrolysis, pure copper is deposited on the cathode plates and impurities which are soluble and fall to the bottom of the cell as anode mud or sludge.

ELECTROCHEMICAL CHANGES DURING ELECTROLYSIS

Cu ➔ Cu+2 + 2e- (at the anode)

Cu+2 +2e-➔ Cu (at the cathode)

This electrically refined copper is 100% pure.



Reference page/site
https://www.citycollegiate.com/dblock4.htm

Chemical reactions

Reactions with oxygen

The group 1 elements react quickly with oxygen in the air at room temperature. Most transition elements react slowly, or not at all, with oxygen at room temperature. Some transition metals react with oxygen on heating, for example:

copper + oxygen → copper oxide

$$2Cu(s) + O_2(g) \rightarrow 2CuO(s)$$

Reactions with water

The group 1 elements react vigorously with cold water. Most transition elements react slowly with cold water, or not at all.

Iron reacts with water and oxygen at room temperature to form hydrated iron(III) oxide, or rust.

For more information on rusting, visit the **Using materials** study guide.

Reactions with halogens

The group 1 elements react vigorously with the halogens. Some transition elements also react with halogens, for example:

iron + chlorine → iron(III) chloride

$$Fe(s) + Cl_2(g) \rightarrow FeCl_3(s)$$

Reference page/site
https://www.bbc.co.uk/bitesize/guides/z97yw6f/revision/3

Student's assessment.

- What do you mean by d-d transition?
- What are transition elements and why are they called so?
  What is meant by transition elements?
- How reactive are transition elements?
- Naming Coordination Compounds from formulas: Give a systematic name for each of the following compounds:
  - $[Ag(NH3)_2]Br$
  - $Ni(CO)_4$
  - $K2[Cd(CN)_4]$
  - $[Co(H2O)_6][Ag(CN)_2]^3$
  - $[CoCl3Br_3]^{-4}$
  - $[Ni(en)(NH3)2]^{+2}$.
- Why d-block element show coloured property.
- Describe some alloy of aluminium.

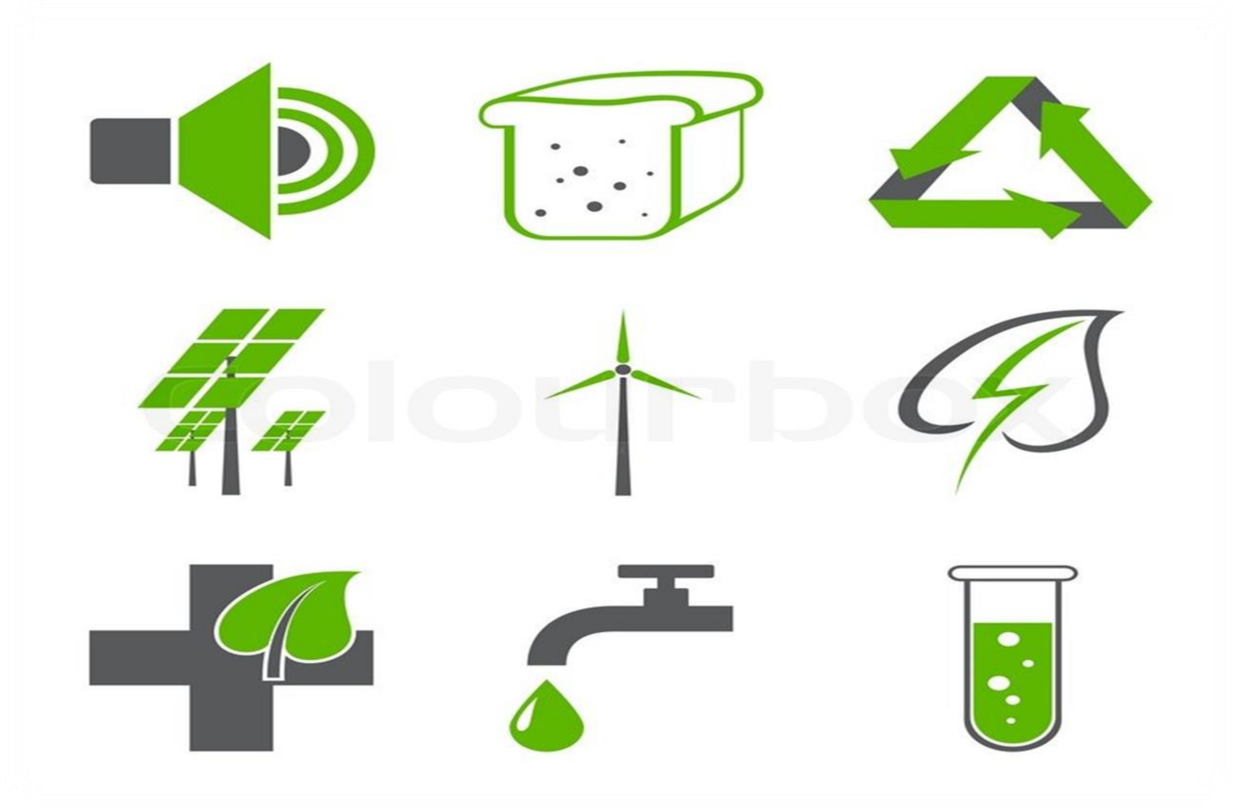
PRACTICAL # 09

- Identify the metal by performing flame test.
- How to apply tin layer on metallic surface by mechanical & electroplating method.

X-------X-------X

CHAPTER # 10

“ENVIROMENTAL CHEMISTRY”



INTRODUCTION

CHAPTER CONTENT

Chemistry of the Troposphere	**Chemistry of the Stratosphere**	**Water Pollution and Water Treatment**
Chemical Reactions in the Atmosphere	Production and Destruction of Ozone	Types of Water Pollutants
2 COx, N1Ox, VOCs, SOx ,		Suspended Solids and Sediments
Automobile, Pollutants and the Catalytic Converter		Dissolved Solids
Industrial Smog		Thermal Pollution
Photochemical Smog		
Global Warming and Climate Change		
Acid Rain		

Major Concepts

- Chemistry of the Troposphere
- Chemistry of the Stratosphere
- Water Pollution and Water Treatment
- Green Chemistry

Conceptual Linkages

The unit is built on

- Composition of Atmosphere
- Layers of Atmosphere
- Air Pollutants
- Ozone

LEARNING OUTCOMES

Students will be able to	**Analyzing**	**Understanding**	**Applying**
• Recognize various chemical reactions occurring in the atmosphere.		✔	
• Recognize that the release of COx, SOx, NOx, VOCs are associated with the combustion of hydrocarbon based fuels.			✔
• . Outline problems associated with release of pollutants including acid rain and the formation by free radical reactions of hazardous inorganic and organic compounds e.g., PAN.	✔		
• Describe causes and impacts of urban smog.	✔		

• Explain greenhouse effect and global warming as resulting in climate change.	✔		
• Explain the build up to and recognize the adverse effects of ozone in the troposphere.			✔
• Describe the role of CFCs in destroying ozone in the stratosphere.			✔
• Describe the role of ozone in the stratosphere in reducing the intensity of harmful UV radiation reaching the earth.		✔	
• List possible alternatives to the use of CFCs.			✔
• Recognize and describe various water pollutants			✔
• Explain the various parameters of water analysis.			✔
• List some major products of the petrochemicals industry, together with their uses.			✔

Skills	Analyzing	Applying	Understanding
• Estimate chloride ions in tap water using titration technique.		✔	

Society , Technology & Science.

Students will be able to,

- Describe how properties of gases promote greenhouse effect. (Analyzing)
- Make connections between Halons and CFCs and their effects on ozone depletion. (Analyzing) Predict effects of radiation pollution. (Applying)
- Explain the need to work in a well-ventilated area when working with toxic solvents as used in adhesives. (Applying) Describe how rain water seepage through hazardous wastes dumpsites can dissolve and reach drinking water supplies. (Applying)
- Describe three ways in which water is purified naturally. (Applying)
- Explain how photochemical reactions contribute to air pollution. (Applying)
- Identify ways in which air pollution resulting from auto exhausts can be alleviated. (Applying)
- Recognize the use of catalytic converters in reducing pollutant emissions from petrol driven cars. (Analyzing)
- Differentiate between ozone at the earth's surface and ozone formation and depletion in the atmosphere. (Applying)
- Realize that dumping waste water from household and industry without treatment to the rivers and creeks is dangerous for the environment.(Understanding)

Related videos.

(THEORY)

Chapter overview

Chemistry of the Troposphere

A lot of chemistry happens in Earth's atmosphere; there are many different kinds of chemicals in the air. Those chemicals often combine with each other in chemical reactions, making new and different chemicals. This is called "atmospheric chemistry".

Earth's atmosphere has different layers. The lowest layer is called the troposphere. We live in the troposphere. This page explains about atmospheric chemistry in the troposphere.

Most of the gas in our atmosphere is nitrogen. About 4/5ths of the air is nitrogen. What about the other 1/5th? Almost all of it is oxygen, the stuff in the air we need to breathe. There are also very small amounts of a bunch of other chemicals.

Have you heard of greenhouse gases? They are kinds of gases that trap the heat from sunlight in our atmosphere. Earth would be very cold if we didn't have any greenhouse gases. Carbon dioxide and methane are two very important greenhouse gases.

Some of the chemicals in the air come from pollution. When we burn coal in a factory or gasoline in our cars, we make air pollution. Coal and oil have sulfur in them. When they burn, they make chemicals called sulfur oxides. These can turn into sulfuric acid when they mix with water droplets in the air. These droplets of acid can fall to the ground as acid rain. Cars and trucks also give off chemicals called nitrogen oxides. Nitrogen oxides combine with other chemicals to make smog. They also help make nitric acid, which is another acid in acid rain.

Nature also does things to change the chemistry of the troposphere. Volcanoes, lightning, and wildfires all add chemicals to the air or change the ones that are already there. Energy from sunlight can make chemical reactions happen, changing one gas into another. Some chemicals move in cycles between the atmosphere, living creatures, and the oceans. The Carbon Cycle and the Nitrogen Cycles are two important cycles that change the chemistry of the atmosphere.

This table (below) describes some of the chemicals in the troposphere, and some of the chemical reactions that happen in the air:

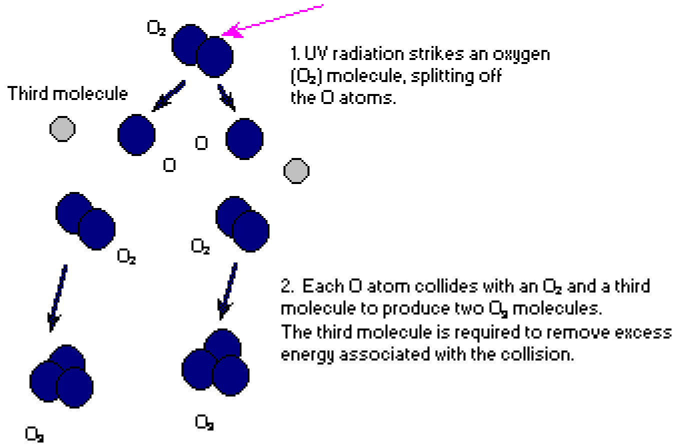
Chemical	**Formula**	**Role in Tropospheric Chemistry**
Carbon dioxide	CO_2	Carbon dioxide is a kind of greenhouse gas. When we breathe, we take in oxygen and breathe out carbon dioxide. Plants and some kinds of microbes use carbon dioxide during photosynthesis to make food. Burning fuels also puts carbon dioxide into the atmosphere.
Carbon monoxide	CO	When things burn, they mostly make carbon dioxide. Sometimes they make carbon monoxide, too. Carbon monoxide is a poisonous gas. Volcanoes and car enginesmake carbon monoxide.
Hydrocarbons	C_xO_y	Hydrocarbons are chemicals made up of hydrogen and carbon atoms. When fuel burns, it puts some hydrocarbons into the air. Hydrocarbons help to make smog, a kind of air pollution.
Methane	CH_4	Methane is a kind of greenhouse gas.
Nitrogen	N_2	Most of the gas in Earth's atmosphere is nitrogen. About 4/5ths of the air is nitrogen. The nitrogen cycle explains how nitrogen moves around in the environment. When fuel burns hot, like it does in the engine of a car, nitrogen combines with oxygen to make nitrogen oxides.
Nitrogen Oxides	NO & NO_2	Nitrogen oxides are a kind of pollution. Burning fuels like gasoline in air makes nitrogen oxides. Most nitrogen oxides come from cars and trucks. They help to make smog. They also mix with water droplets in the air to make nitric acid. Nitric acid is a part of acid rain.
Nitric Acid	HNO_3	Nitric acid is part of acid rain. Nitric acid forms when nitrogen oxides mix with water droplets in the air. Nitrogen oxides are a kind of pollution that comes from the engines of cars and trucks.
Oxygen & Ozone	O_2 & O_3	About 1/5th of the gas in the atmosphere is oxygen. When you breathe, your body uses the oxygen to keep you alive. Ozone is a special kind of oxygen that has three atoms instead of two.
PAN(Peroxyacytyl nitrate)	$C_2H_3O_5N$	PAN is a kind of air pollution. Smog has PAN in it. PAN forms when nitrogen dioxide, oxygen, and Volatile Organic Compounds (VOCs) get together.
Smog	-	Smog is a mixture of smoke and fog. Photochemical smog is a kind of air pollution. It has nitrogen oxides, ozone, VOCs, and PAN in it.
Photodissociation	-	When a photon of sunlight breaks apart a molecule.
Sulfur Oxides	SO_2 & SO_3	Sulfur dioxide and sulfur trioxide are types of pollution. People make them when we burn coal and oil. Volcanoes also give off sulfur oxides. Sulfur dioxide mixes with water droplets in the air to make sulfuric acid. Sulfuric acid is in acid rain.

Chemical	Formula	Role in Tropospheric Chemistry
Sulfuric Acid	H_2SO_4	Sulfuric acid is in acid rain. Sulfuric acid in the air is made when sulfur dioxide gasmixes with water droplets. The sulfur dioxide gas comes from volcanoes and from coal and oil that people burn for fuel.

Chemistry of the Stratosphere

Ozone Formation and Destruction

Stratospheric ozone (O3) is produced by the combination of an oxygen atom (O) with an oxygen molecule (O2). The basic steps to formation are:



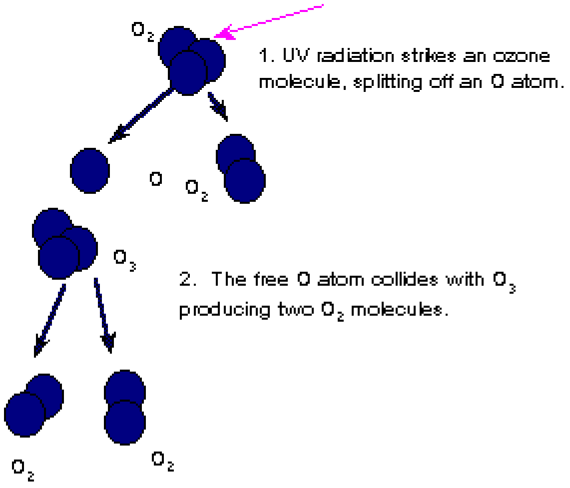
In the above diagram, oxygen atoms are represented as dark blue circles. This reaction is written in chemical equations as

$$O2 + UV \Rightarrow O + O$$

$$2\ O + 2\ O2 + \text{third molecule} \Rightarrow 2\ O3 + \text{third molecule}$$

$$\text{Net Reaction: } 3\ O2 + UV \Rightarrow 2\ O3$$

UV radiation is also involved in the destruction of O3.



1. UV radiation strikes an ozone molecule, splitting off an O atom.

2. The free O atom collides with O_3 producing two O_2 molecules.

This destruction is expressed as

$$O3 + UV \Rightarrow O + O2$$

$$O + O3 \Rightarrow 2\ O2$$

$$\text{Net Reaction: } 2\ O3 + UV \Rightarrow 3\ O2$$

UV radiation plays a crucial role in the formation and destruction of ozone. UV amounts are greatest in the tropical regions, thus it is not suprising that most of the destruction and production of ozone occurs in the tropical stratosphere.

In 1970 Dr. P. Crutzen proposed the following catalytic reaction that results in the destruction of O3.

$$X + O3 \Rightarrow XO + O2$$

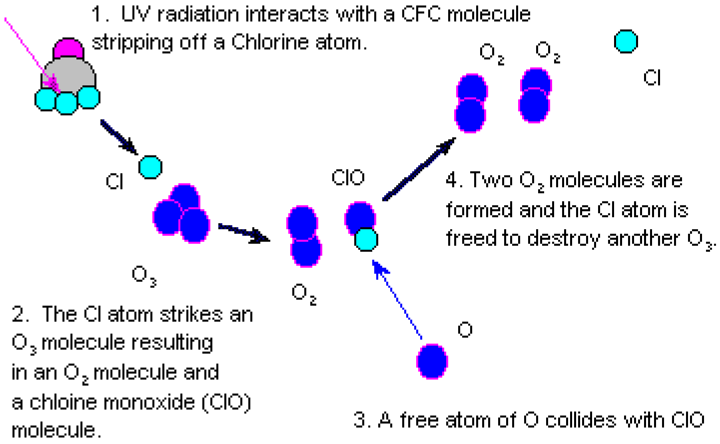
$$O3 + UV \Rightarrow 2\ O2$$

$$O + XO \Rightarrow X + O2$$

$$\text{Net Reaction: } 2\ O3 + UV \Rightarrow 3\ O2$$

In this sequence of reactions, X is an atom or molecule that acts as a catalyst to convert O3 to O2. Note that X does not change in the net reaction and so it can continue to destroy O3 molecules. The important radicals represented by X include chlorine (Cl), hydroxyl (OH), nitric oxide (NO), and bromine (Br). There is a delicate balance between the production and destruction of O3, resulting in what is referred to as an O3 shield that protects us from high energy UV radiation. This natural balance has recently been disrupted by human activities.

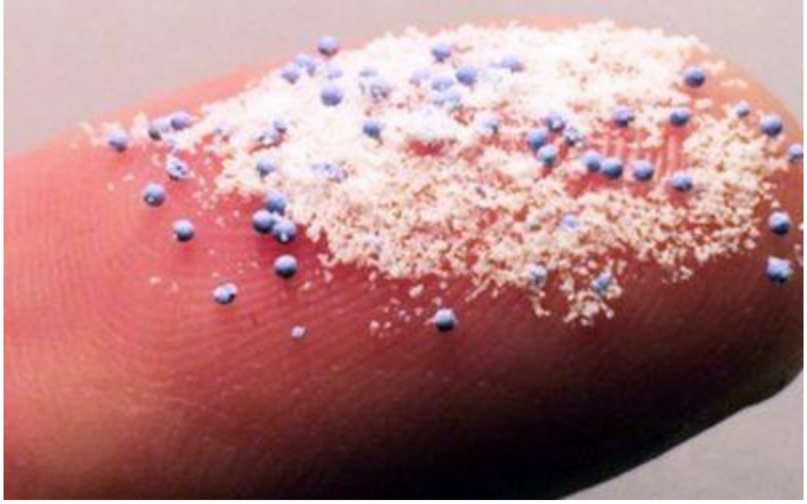
One molecule that can serve as the catalyst molecule X is chlorine (Cl). But how does Cl get into the stratosphere? In the 1930s useful chemical compounds known as chlorofluorocarbons (CFCs) were produced for use in refrigeration, air conditioning, solvents, aerosol spray cans, and Styrofoam™ puffing agents. They are very stable in the troposphere with lifetimes of approximately 100 years. This long lifetime allows CFCs that are emitted near the surface to be carried by the winds upward. In the stratosphere CFCs are dissociated by UV light producing chlorine atoms. The destruction of O3 then follows with the following chemical reactions:



WHAT ARE THE
TYPES OF WATER POLLUTION

Water pollution can come from a number of different sources. If the pollution comes from a single source, such as an oil spill, it is called point-source pollution. If the pollution comes from many sources, it is called nonpoint-source pollution.

Most types of pollution affect the immediate area surrounding the source. Sometimes the pollution may affect the environment hundreds of miles away from the source, such as nuclear waste, this is called transboundary pollution.



MICROPLASTIC

PRODUCT REVIEW The Giant Issue of Microplastics First, we will have a look at the background story on micro-plastics, and then we will go into detail on how the situation regarding micro-plastics in our environment impacts us today.   What are micro-plastics?...

What are micro-plastics?

A micro-plastic is any piece of plastic smaller than 5mm in diameter.

MICROBIOLOGICAL WATER POLLUTION

Microbiological water pollution is usually a natural form of water pollution caused by microorganisms. Many types of microorganisms live in water and cause fish, land animals and humans to become ill. Microorganisms such as:

- **Bacteria**
- **Viruses**
- **Protozoa**

Serious diseases such as cholera come from microorganisms that live in water. These diseases usually affect the health of people in poorer countries, as they do not have the facilities to treat polluted water.

CHEMICAL WATER POLLUTION

- Industrial and agricultural work involves the use of many different chemicals that can run-off into water and pollute it. Metals and solvents from industrial work can pollute rivers and lakes. These are poisonous to many forms of aquatic life and may slow their development, make them infertile or even result in death.
- Pesticides are used in farming to control weeds, insects and fungi. Run-offs of these pesticides can cause water pollution and poison aquatic life. Subsequently, birds, humans and other animals may be poisoned if they eat infected fish.
- Petroleum is another form of chemical pollutant that usually contaminates water through oil spills when a ship ruptures. Oil spills usually have only a localized effect on wildlife but can spread for miles. The oil can cause the death of many fish and stick to the feathers of seabirds causing them to lose the ability to fly.

NUTRIENTS AND THEIR EFFECT ON WATER

Nutrients are essential for plant growth and development. Many nutrients are found in wastewater and fertilisers, and these can cause excess weed and algae growth if large concentrations end up in water.

- This can contaminate drinking water and clog filters.
- This can be damaging to other aquatic organisms as the algae use up the oxygen in the water, leaving none for the surrounding marine life.

SUSPENDED MATTER

Some pollutants do not dissolve in water as their molecules are too big to mix between the water molecules. This material is called **particulate matter** and can often be a cause of water pollution.

- The suspended particles eventually settle and cause a thick silt at the bottom. This is harmful to marine life that lives on the floor of rivers or lakes.
- Biodegradable substances are often suspended in water and can cause problems by increasing the amount of anaerobic microorganisms present.
- Toxic chemicals suspended in water can be harmful to the development and survival of aquatic life.

GROUNDWATER POLLUTION

A lot of the Earth's water is found underground in soil or under rock structures called aquifers. Humans often use aquifers as a means to obtain drinking water, and build wells to access it. When this water becomes polluted it is called **groundwater pollution**.

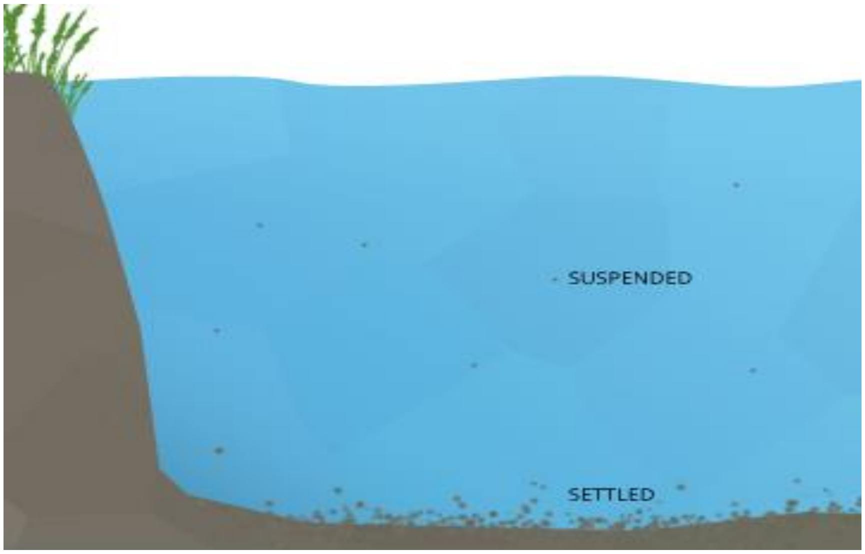
Groundwater pollution is often caused by pesticide contamination from the soil, this can infect our drinking water and cause huge problems.

What are Suspended Solids sediments ?

Both organic and inorganic particles of all sizes can contribute to the suspended solids concentration.

Total suspended solids (TSS) are particles that are larger than 2 microns found in the water column. Anything smaller than 2 microns (average filter size) is considered a dissolved solid. Most suspended solids are made up of inorganic materials, though bacteria and algae can also contribute to the total solids concentration [3].

These solids include anything drifting or floating in the water, from sediment, silt,and sand to plankton and algae [1]. Organic particles from decomposing materials can also contribute to the TSS concentration. As algae, plants and animals decay, the decomposition process allows small organic particles to break away and enter the water column as suspended solids [17]. Even chemical precipitates are considered a form of suspended solids [20]. Total suspended solids are a significant factor in observing water clarity [3]. The more solids present in the water, the less clear the water will be.



Some sediment will settle to the bottom of a body of water, while others remain suspended.

Some suspended solids can settle out into sediment at the bottom of a body of water over a period of time [3]. Heavier particles, such as gravel and sand, often settle out when they enter an area of low or no water flow. Although this settling improves water clarity, the increased silt can smother benthic organisms and eggs [1]. The remaining particles that do not settle out are called colloidal or nonsettleable solids [4]. These suspended solids are either too small or too light to settle to the bottom.

Settleable solids are also known as bedded sediments, or bedload [37]. These sediments can vary from larger sand and gravel to fine silt and clay, depending on the flow rate of water. Sometimes these sediments can move downstream even without rejoining the suspended solids concentration. When settleable solids are moved along the bottom of a body of water by a strong flow, it is called bedload transport [7]

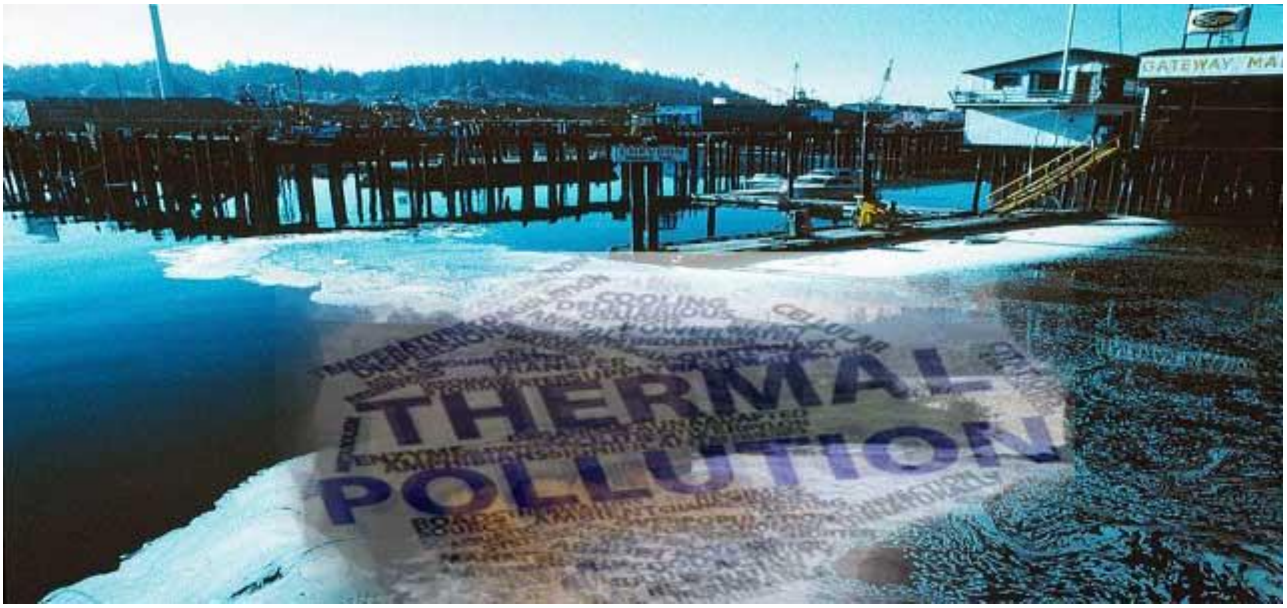
HOW DO THESE SOLIDS END UP DISSOLVED IN WATER?

These minerals can originate from a number of sources, both natural and as a result of human activities. Mineral springs contain water with high levels of dissolved solids, because the water has flowed through a region where the rocks have a high salt content. The water in the Prairie provinces tends to have high levels of dissolved solids, because of high amounts of calcium and magnesium in the ground.

These minerals can also come from human activities. Agricultural and urban runoff can carry excess minerals into water sources, as can wastewater discharges, industrial wastewater and salt that is used to de-ice roads.

Thermal Pollution: Source, its harmful effects and preventive measures

Thermal pollution is the degradation of water quality by any process that changes ambient water temperature. A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers.



Thermal Pollution: Sources, its harmful effects and Preventive measures

What is Thermal Pollution?

The term thermal pollution has been used to indicate the detrimental effects of heated effluent discharge by various power plants. It denotes the impairment of quality and deterioration of aquatic and terrestrial environment by various industrial plants like thermal, atomic, nuclear, coal-fired plants, oil field generators, factories, and mills.

What are the sources of Thermal Pollution?

1. Nuclear Power Plant
2. Coal-fired power Plant
3. Industrial Effluents
4. Domestic Sewage
5. Hydro-electric power
6. Thermal Power Plant

Definition of green chemistry

Green chemistry is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Green chemistry applies across the life cycle of a chemical product, including its design, manufacture, use, and ultimate disposal. Green chemistry is also known as sustainable chemistry.

Green chemistry:
Prevents pollution at the molecular level
Is a philosophy that applies to all areas of chemistry, not a single discipline of chemistry
Applies innovative scientific solutions to real-world environmental problems
Results in source reduction because it prevents the generation of pollution
Reduces the negative impacts of chemical products and processes on human health and the environment
Lessens and sometimes eliminates hazard from existing products and processes
Designs chemical products and processes to reduce their intrinsic hazards

Reference page/site

https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_(Brown_et_al.)/18%3A_Chemistry_of_the_Environment/18.4%3A_Chemistry_of_the_Troposphere
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Student's Assessment.

- Greenhouse effect leads to global warming. Which substances are responsible for greenhouse effect?
- Ozone is a toxic gas and is a strong oxidizing agent even then its presence in the stratosphere is very important. Explain what would happen if ozone from this region is completely removed?
- what could be the harmful effects of improper management of industrial and domestic solid waste in a city?
- why does water covered with excessive algal growth become polluted?

PRACTICAL # 10

- Determine the pollution of different places or areas by using simple gravimetric method.

X--------X-------X

CHAPTER # 11

“INDUSTRIAL CHEMISTRY”

INTRODUCTION

CHAPTER CONTENT

UNIT DESCRIPTION
▪ Introduction to the Chemical Process Industry and Raw Materials used
▪ Safety Considerations in Process Industries
▪ Dyes
▪ Pesticides
▪ Petrochemicals
▪ Synthetic Polymers (PVC and Nylon)
▪ Cosmetics: Lipsticks, Nail Varnish and Remover, hair Dyes
▪ Adhesives

Major Concepts

- Introduction to Chemical Industry
- Pharmaceutical Industry
- Pesticides
- Synthetic Polymers (PVC and Nylon)
- Cosmetics: Lipstick, Nail Polish and Remover, Perfumes
- Adhesive

Conceptual Linkages

This unit is built on

- Basic Metallurgical Operations

LEARNING OUTCOMES

Students will be able to	Analyzing	Understanding	Applying
• Discuss the importance of the chemical industries in the economy of Pakistan.	✓		
• Describe the raw materials available in Pakistan for various chemical industries.			✓
• Describe the chemical processes of addition and condensation polymerization.		✓	
• Interpret difference between petrochemical and chemicals derived from them.		✓	
• Describe the fractional distillation and refining of Petroleum		✓	
• List the various raw materials for Petrochemical industry.	✓		
• Identify the important fractions.	✓		
• Describe the basic building block processes in Petrochemical technology.		✓	
• List some major petrochemicals.			✓
• Discuss types and applications of hair dyes.			✓
• Describe the formation and uses of PVC and Nylon. (Applying)			✓
• Describe preparation and applications of various cosmetics like nail varnish, nail polish remover and lipsticks.		✓	

Describe types and applications of synthetic adhesives.		✔	.

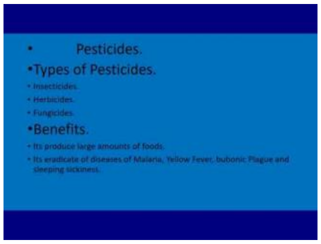
Skills	Analyzing	Applying	Understanding
• List the safety measures and precautions in process industries.	✓		
• List various petrochemicals and their functions.		✔	

Society , Technology & Science.

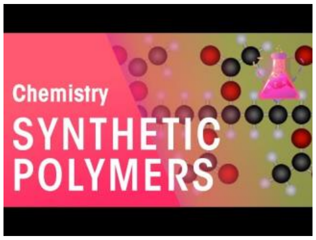
Students will be able to,

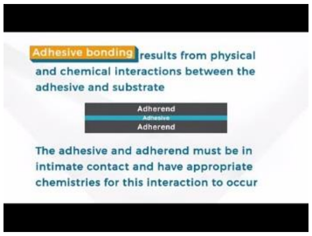
- Identify risks associated with the manufacturing of chemicals. (Evaluating)
- Trace the development and uses of different synthetic fibers. (Applying)

Related videos.



- Pesticides.
- Types of Pesticides.
- Insecticides.
- Herbicides.
- Fungicides.
- Benefits.
- Its produce large amounts of foods.
- Its eradicate of diseases of Malaria, Yellow Fever, bubonic Plague and sleeping sickiness.





Adhesive bonding results from physical and chemical interactions between the adhesive and substrate

The adhesive and adherend must be in intimate contact and have appropriate chemistries for this interaction to occur

(THEORY)

Chapter overview

Chemical process industry

An industry, abbreviated CPI, in which the raw materials undergo chemical conversion during their processing into finished products, as well as (or instead of) the physical conversions common to industry in general.

In the chemical process industry the products differ chemically from the raw materials as a result of undergoing one or more chemical reactions during the manufacturing process. The chemical process industries broadly include the traditional chemical industries, both organic and inorganic; the petroleum industry; the petrochemical industry, which produces the majority of plastics, synthetic fibers, and synthetic rubber from petroleum and natural-gas raw materials; and a series of allied industries in which chemical processing plays a substantial part. While the chemical process industries are primarily the realm of the chemical engineer and the chemist, they also involve a wide range of other scientific, engineering, and economic specialists.

Chemical raw materials classification

1, chemical raw materials can generally be divided into two categories according to the material source of organic chemical raw materials and inorganic chemical raw materials.

(1) organic chemical raw materials

Alkanes and their derivatives, alkynes and derivatives, quinones, aldehydes, alcohols, ketones, phenols, ethers, anhydrides, esters, organic acids, carboxylic acids Salts, carbohydrates, heterocycles, nitriles, haloids, amine acyls and the like.

(2) Inorganic Chemical Materials

Inorganic chemical products are the main raw material containing sulfur, sodium, phosphorus, potassium, calcium and other chemical minerals (see inorganic salt industry) and coal, petroleum, natural gas and air, water and so on. In addition, by-products and waste from many industrial sectors are also raw materials for inorganic chemicals such as coke oven gas for the coking process in the iron and steel industry. The ammonia contained therein can be recovered from sulfuric acid to make ammonium sulfate, chalcopyrite, Sulfur dioxide from the smelter waste gas from mines and sphalerites can be used to produce sulfuric acid and the like.

2, according to the production process to points, can be divided into the starting material, the basic raw materials and intermediate materials.

(1) starting material

Starting materials are raw materials required for chemical production such as air, water, fossil fuels (ie coal, oil, natural gas, etc.), sea salt, various minerals, agricultural products (such as starchy foods or wild plants, Prime wood, bamboo, reed, straw, etc.).

(2) basic raw materials

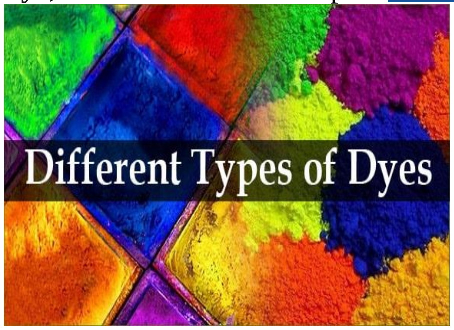
The basic raw materials are processed starting materials, such as calcium carbide and various organic and inorganic materials listed above.

(3) the middle of raw materials

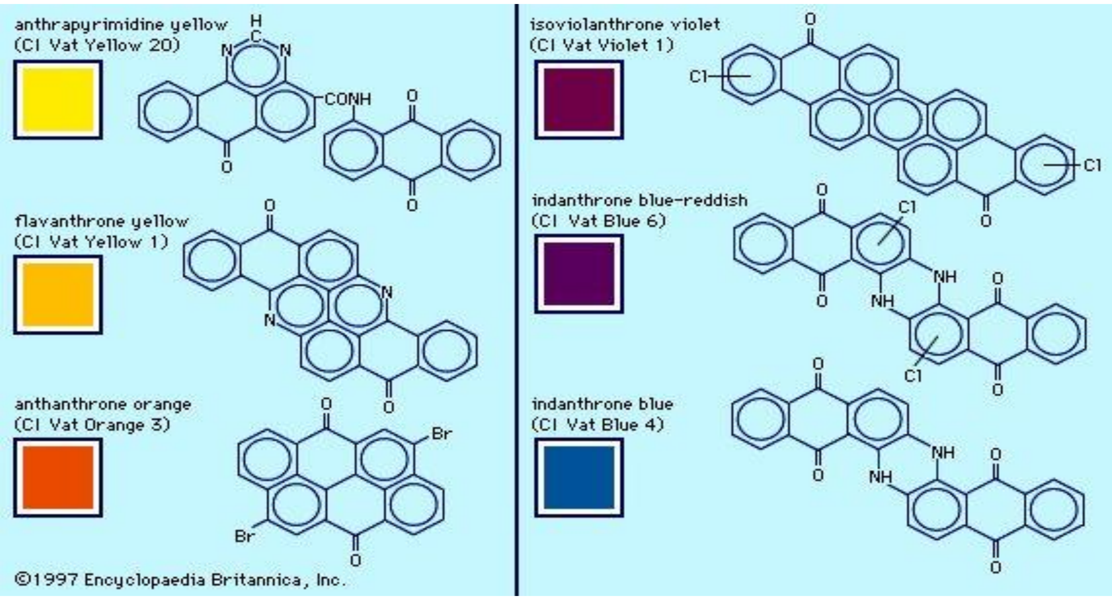
The middle of raw materials, also known as intermediate, generally refers to the complex organic chemical production, the use of basic raw materials to produce products, but not end-use products, but also need further processing. For example, the production of dyes, plastics and pharmaceuticals of various organic compounds: methanol, acetone, vinyl chloride and so on.

Dyes :

Dye, substance used to impart colour to textiles, paper, leather,



and other materials such that the colouring is not readily altered by washing, heat, light, or other factors to which the material is likely to be exposed. Dyes differ from pigments, which are finely ground solids dispersed in a liquid, such as paint or ink, or blended with other materials. Most dyes are organic compounds (i.e., they contain carbon), whereas pigments may be inorganic compounds (i.e., they do not contain carbon) or organic compounds. Pigments generally give brighter colours and may be dyes that are insoluble in the medium employed.



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What are Pesticides?

Pesticides are chemical substances that are meant to kill pests. In general, a pesticide is a chemical or a biological agent such as a virus, bacterium, antimicrobial, or disinfectant that deters, incapacitates, kills, pests.

This use of pesticides is so common that the term pesticide is often treated as synonymous with plant protection product. It is commonly used to eliminate or control a variety of agricultural pests that can damage crops and livestock and reduce farm productivity. The most commonly applied pesticides are insecticides to kill insects, herbicides to kill weeds, rodenticides to kill rodents, and fungicides to control fungi, mold, and mildew.

A Brief History

Pesticides are not recent inventions! Many ancient civilizations used pesticides to protect their crops from insects and pests. Ancient Sumerians used elemental sulfur to protect their crops from insects. Whereas, Medieval farmers experimented with chemicals using arsenic, lead on common crops.

The Chinese used arsenic and mercury compounds to control body lice and other pests. While, the Greeks and Romans used oil, ash, sulfur, and other materials to protect themselves, their livestock, and their crops from various pests.

Meanwhile, in the nineteenth century, researchers focused more on natural techniques involving compounds made with the roots of tropical vegetables and chrysanthemums. In 1939, Dichloro-Diphenyl-Trichloroethane (DDT) was discovered, which has become extremely effective and rapidly used as the insecticide in the world. However, twenty years later, due to biological effects and human safety, DDT has been banned in almost 86 countries.

Definition of Pesticides

The Food and Agriculture Organization (FAO) has defined pesticide as:

any substance or mixture of substances intended for preventing, destroying, or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals, causing harm during or otherwise interfering with the production, processing, storage, transport, or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances that may be administered to animals for the control of insects, arachnids, or other pests in or on their bodies.

Types of Pesticides

These are grouped according to the types of pests which they kill:

Grouped by Types of Pests They Kill

1. Insecticides – insects
2. Herbicides – plants
3. Rodenticides – rodents (rats & mice)
4. Bactericides – bacteria
5. Fungicides – fungi
6. Larvicides – larvae

Based on how biodegradable they are:

Pesticides can also be considered as:

- **Biodegradable:**
- The biodegradable kind is those which can be broken down by microbes and other living beings into harmless compounds.
- **Persistent:**
- While the persistent ones are those which may take months or years to break down.

Another way to classify these is to consider those that are chemical forms or are derived from a common source or production method.

Chemically-related pesticides:

- ***Organophosphate:***

  Most organophosphates are insecticides, they affect the nervous system by disrupting the enzyme that regulates a neurotransmitter.

- ***Carbamate:***

  Similar to the organophosphorus pesticides, the carbamate pesticides also affect the nervous system by disrupting an enzyme that regulates the neurotransmitter. However, the enzyme effects are usually reversible.

- ***Organochlorine insecticides:***

  They were commonly used earlier, but now many countries have been removed Organochlorine insecticides from their market due to their health and environmental effects and their persistence (e.g., DDT, chlordane, and toxaphene).

- ***Pyrethroid:***

  These are a synthetic version of pyrethrin, a naturally occurring pesticide, found in chrysanthemums(Flower). They were developed in such a way as to maximise their stability in the environment.

- ***Sulfonylurea herbicides:***

  The sulfonylureas herbicides have been commercialized for weed control such as pyrithiobac-sodium, cyclosulfamuron, bispyribac-sodium, terbacil, sulfometuron-methyl Sulfosulfuron, rimsulfuron, pyrazosulfuron-ethyl, imazosulfuron, nicosulfuron, oxasulfuron, nicosulfuron, flazasulfuron, primisulfuron-methyl, halosulfuron-methyl, flupyrsulfuron-methyl-sodium, ethoxysulfuron, chlorimuron-ethyl, bensulfuron-methyl, azimsulfuron, and amidosulfuron.

- ***Biopesticides:***

  The biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals.

Examples of pesticides

Examples of pesticides are fungicides, herbicides, and insecticides. Examples of specific synthetic chemical pesticides are glyphosate, Acephate, Deet, Propoxur, Metaldehyde, Boric Acid, Diazinon, Dursban, DDT, Malathion, etc.

Benefits of Pesticides

The major advantage of pesticides is that they can save farmers. By protecting crops from insects and other pests. However, below are some other primary benefits of it.

- Controlling pests and plant disease vectors.
- Controlling human/livestock disease vectors and nuisance organisms.
- Controlling organisms that harm other human activities and structures.

Petrochemical

Petrochemicals are chemicals derived from petroleum or natural gas. They are an essential part of the chemical industry as the demand for synthetic materials grows continually and plays a major part in today's economy and society.[2] Petrochemicals are used to manufacture thousands of different products that people use daily, including plastics, medicines, cosmetics, furniture, appliances, electronics, solar power panels, and wind turbines.[3]

. Important Petrochemicals

99% of all plastics are created from oil and natural gas It is one of the most important of all the petrochemicals simply because it is used in the production of plastics.[4] Other important petrochemicals include:

- **Ethylene**: Used in paper, consumer electronics, detergents, footwear, and adhesives
- **Propylene**: Used in paints, furniture, textiles, pharmaceuticals, and food packaging
- **Benzene**: Creates pharmaceuticals, furniture, electronics, and food packaging
- **Methanol**: Used in thermal insulation and building construction
- **Toluene**: Creates inks and sports equipment

Types of Synthetic Polymers

Low Density Polyethylene

Low Density Polyethylene (LDPE) polymers are among the most common types of synthetic organic polymers, which are often found in households. LDPE is a thermoplastic made from the monomer ethylene. One of the first polymers to be created, it was produced in 1933 by Imperial Chemical Industries using a high pressure process via free radical polymerization. It is manufactured the way method today. LDPE is commonly recycled, with the number 4 as its recycling symbol. Despite competition from more modern polymers, LDPE continues to be an important plastic grade.

- ## High Density Polyethylene

High Density Polyethylene (HDPE) or polyethylene high-density (PEHD) is a polyethylene thermoplastic made from petroleum. It takes 1.75 kilograms of petroleum (in terms of energy and raw materials) to make one kilogram of HDPE. HDPE is commonly recycled, with the number 2 as its recycling symbol.

- ## Polypropylene

Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications, including packaging and labeling, textiles, stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes. An additional polymer made from the monomer propylene, it is rugged and unusually resistant to many chemical solvents, bases, and acids.

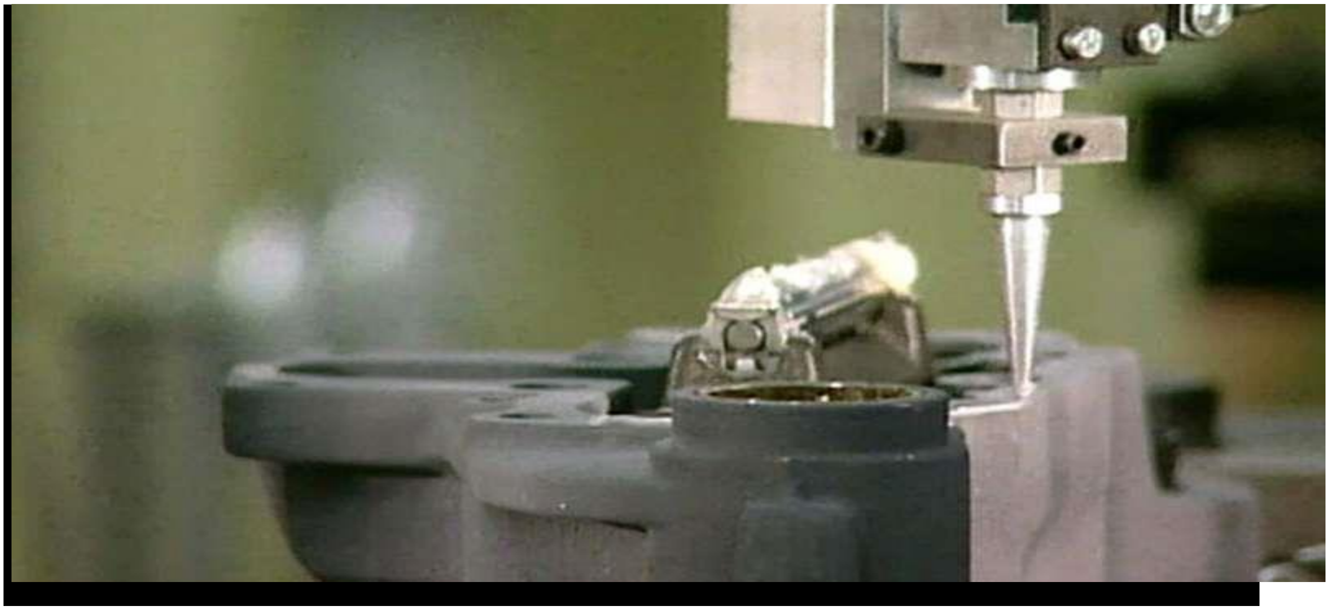
- ## Polyvinyl Chloride

Polyvinyl Chloride (PVC) is the third-most widely produced plastic, after polyethylene and polypropylene. PVC is used in construction because it is cheaper and stronger than more traditional alternatives such as copper or ductile iron. It can be made softer and more flexible by adding plasticizers, the most popular of which are phthalates. In this form, PVC is used in clothing and upholstery, electrical cable insulation, inflatable products, and many applications in which it replaces rubber.

- ## Polystyrene
- Polystyrene (PS) is an aromatic polymer made from the monomer styrene, a liquid petrochemical. One of the most popular plastics, PS is a colorless solid that is used, for example, in disposable cutlery, plastic models, CD and DVD cases, and smoke detector housings. Products made from foamed polystyrene include packing materials, insulation, and foam drink cups. Its very slow biodegradation is a focus of controversy, and it can often be found littered outdoors, particularly along shores and waterways.
- ## Nylon

Nylon, a family of synthetic polymers known generically as polyamides, was first produced on February 28, 1935 by Wallace Carothers at DuPont's research facility. Nylon is one of the most commonly-used polymers. The amide backbone present in nylon causes it to be more hydrophilic than the polymers discussed above. Notice that your nylon clothing will absorb water, for instance; this is because nylon can engage in hydrogen bonding with water, unlike the purely hydrocarbon polymers that make up most plastics.

Adhesive



Adhesive, any substance that is capable of holding materials together in a functional manner by surface attachment that resists separation. “Adhesive

Adhesion

In the performance of adhesive joints, the physical and chemical properties of the adhesive are the most important factors. Also important in determining whether the adhesive joint will perform adequately are the types of adherend (that is, the components being joined—e.g., metal alloy, plastic, composite material) and the nature of the surface pretreatment or primer. These three factors—adhesive, adherend, and surface—have an impact on the service life of the bonded structure. The mechanical behaviour of the bonded structure in turn is influenced by the details of the joint design and by the way in which the applied loads are transferred from one adherend to the other.

Adhesive Materials

Virtually all synthetic adhesives and certain natural adhesives are composed of polymers, which are giant molecules, or macromolecules, formed by the linking of thousands of simpler molecules known as monomers.

Reference page/site
https://www.britannica.com/technology/dye
https://byjus.com/chemistry/pesticides/
https://energyeducation.ca/encyclopedia/Petrochemical
https://courses.lumenlearning.com/introchem/chapter/types-of-synthetic-organic-polymers/
https://www.britannica.com/technology/adhesive/Synthetic-adhesives

Student's Assessment.

- What separation technique is used when a separation operation is accompanied by chemical reaction that facilitates separation?
- Chemical reactions require feed mixtures from non-renewable resources like coal, petroleum. What is used in place of non-renewable sources?
- What are Pesticides? Explain it in your words.

"THANK YOU"