UNIT 23

INDUSTRY

Student Learning Outcomes (SLOs)

- Justify the importance and significance of industrial chemistry in various industries such as manufacturing, energy, healthcare, and environmental protection.
- Describe the chemical processes involved in industrial production, including addition and condensation polymerization, and the properties and uses of resulting materials.
- Identify the raw materials and resources used in industrial chemistry, including those readily available in the context of Pakistan.
- Explain the applications of industrial chemistry in industries such as petrochemical, cosmetics, cement, food production and more.
- Elaborate on the safety measures and precautions necessary in industrial chemical processes and facilities.

The chemical industry is the ultimate fruit of chemical research. The chemical industry provides useful and applied materials to directly consumers or to other industries.

In the large-scale production of chemicals, chemical industry plays a very important role, like in the production of plastics, synthetic fiber, and elastomers. Industrial chemists always look forward to developing new processes for the production of new materials, or improved ones. These processes are adopted due to their energy efficiency, production steps and environmental impacts. Production of fertilizers at large scale and pesticides of great variety has improved crop yields to many folds in recent history. New methods are being developed to increase and improve food and its quality. Synthetic fiber is marvelous advancement used for textiles and insulation. Pharmaceuticals is a big chemical industry. Medicines and drugs have been essential life chemicals throughout the history of mankind. New medicines for the treatment of different diseases are tailored by medicinal chemists with greater efficacy and safety. Personal care products like soaps, shampoos, skin care products, hair dyes and cosmetics are better than ever. Many chemical industries like sulphuric acid, paints, varnish, metallurgy, cement, glass, petrochemicals, ammonia, fertilizers, pesticides, food materials, etc. are inevitable for today's life.

Environmental protection aspect of chemistry known as green chemistry is working for the production of environment-friendly chemicals, development of waste management methods and recycling, biodegradable synthetic fiber etc. It not only takes care of our environment but also works to reduce footprints of environmental pollution.

23.1 Raw Materials and their Resources for Chemical Industry

Raw materials for the chemical industry are obtained from the environment. The environment is composed of the atmosphere, biosphere, hydrosphere and lithosphere.

Raw materials obtained from Atmosphere: The atmosphere is mainly composed of nitrogen, oxygen, hydrogen, carbon dioxide and noble gases. These gases are obtained from the atmosphere to produce useful industrial chemicals for example nitrogen and hydrogen are used to manufacture ammonia gas, which is in turn used for the large-scale production of urea fertilizer. Nitrogen and oxygen are used to produce nitrogen oxides and nitric acid. Oxygen is obtained from the atmosphere which is used in steel industries and in hospitals.

Raw materials obtained from the hydrosphere: Many dissolved minerals like sodium, potassium, magnesium, calcium, sulphates, chlorides and bromides are present in the ocean water and may be obtained for the manufacturing of different chemicals.

Raw materials obtained from the biosphere: Plants produce cellulose, starch, oils, alkaloids, terpenes, and raisins. Cellulose is used for making paper, starch and oils that are not only edible but also work as precursors for many chemicals and synthetic foods. Biomass is used for making biogas, bioplastics and many biochemicals. Microorganisms produce enzymes that are biocatalysts in many in-vitro preparations, such as fermentation and biotechnology. Animal and plant materials are widely used in the medicinal chemical industry.

Raw materials obtained from Lithosphere: The widest variety and mass of chemical raw materials is found in the lithosphere. Unlike other parts of environment, lithosphere resource of each geographical region is different. It is the source of elements like oxygen, silicon,

aluminium, iron, titanium and carbon etc. The most useful raw materials obtained from the Lithosphere are fossil fuels; petroleum, coal and natural gas. Others are metallurgical mineral ores containing iron, aluminium, sulphur, gold, chromium and uranium etc.

23.2 Chemical Raw Materials in Pakistan:

Among metallic ores, iron ore deposits of Pakistan are estimated to about 1.427 billion tonnes. Pakistan is an exporter of chromite, the ore of chromium. There are large reservoirs of gold and copper in Baluchistan, explored and estimated but unexploited. Pakistan has large reservoirs of natural gas and coal in Sui and Sandak. Estimated reserves of coal are 185 billion tonnes, with high sulphur content. 5.5 billion tonnes of gypsum are present which is mainly used in cement manufacturing. Other minerals include limestone, rock salt, marble and granite.

North Eastern regions of Pakistan are rich in gemstones which sometimes serve as ores for precocious metals. These gemstones include aquamarine, tourmaline, peridot, emerald, ruby, topaz, zircon, rhodochrosite etc.

23.3 Safety Measures and Precautions in Chemical Industry

To avoid accidents and to ensure the protection of workers and the environment, chemical safety is critical. The major purpose is to identify, evaluate and mitigate the adverse situations during the chemical processes. The hazards may include chemical explosive reactions, fire risks and the release of toxic gases or chemicals.

Here are some measures regarding safety in the chemical industry.

1. **Adopting the guidelines**

By adopting the guidelines and regulations of leading regulatory bodies like OSHA (Occupational Safety and Health Administration) hazards can be avoided or reduced. They provide directions for proper storage, disposal, usage and handling of hazardous chemicals.

2. **Safety training**

By providing safety training to all workers before they are given a task regarding the process safety needed there. If duty place changes, the process hazard analysis also changes, so continual training sessions of incumbents, so that they can help themselves and others to mitigate any possible accident.

3. **Incorporating robust engineering controls**

Automatic and efficient ventilation procedures and systems, safety ensuring building structures, and automated systems of safety minimise the risks of greater damage.

4. **Proper maintenance**

The critical chemical processes need mechanical integrity and proper and timely maintenance to prevent failure and accidents.

5. **Management of change**

It is inevitable to have a clear policy for changing chemicals, procedures, equipment and personnel. This can ensure a curtailed risk of accidents due to old, expired and torn-out equipment and chemicals.

6. Hazard assessment

Conduction of hazard assessment on a regular basis, reviewing process safety after short intervals, and regular incident investigation can appreciably improve safety degrees.

7. Emergency response

The development of comprehensive and effective emergency response management in a chemical facility is the need of the day to mitigate any possible hazards.

23.4 Important Chemical Processes

Some very important chemical processes are described shortly below.

1. Polymerization

It is included in the modern chemical processes in which small precursors called monomers, are converted into long-chain molecules called polymers. More discussion on polymerization is coming ahead.

2. Calcination

Limestone is converted into calcium oxide and carbon dioxide by strong heating.

3. Reforming

Reforming is usually done with the petroleum fractions in different ways to get different type of products. For example in steam reforming saturated and unsaturated hydrocarbons, hydrogen, ammonia and methanol are prepared. During catalytic reforming, hydrocarbons are heated with the catalyst to obtain high octane gasoline.

4. Smelting

During this process metallic oxides are heated with coke to produce metals.

5. Hall & Heroult Process

Aluminium metal is obtained from its oxide.

6. Bessemer process

It is the major process in the manufacturing of steel.

7. Haber process

During this process, under the influence of catalyst, hydrogen and nitrogen gases are combined to form ammonia which is then used for making urea fertilizer.

8. Bosch process

In this process, steam is passed over red hot coke, to produce hydrogen gas on industrial-scale.

9. Farasch process

Sulphur is extracted from deep wells, with the help of superheated water and this process.

10. Down's methods

Sodium metal is obtained by electrolysis of molten halite.

11. Solvey's process

In this process, sodium carbonate or soda ash is prepared.

12. Burgius process

Lubricants and synthetic fuels are formed from coal by this process.

13. Contact process

In this process, sulphur dioxide gas is converted into sulphur trioxide gas which is further used for making sulphuric acid on the industrial scale.

You may have learned about a few of them, in the previous classes, here we shall only discuss polymerization slightly more.

23.5 Applications of Industrial Chemistry

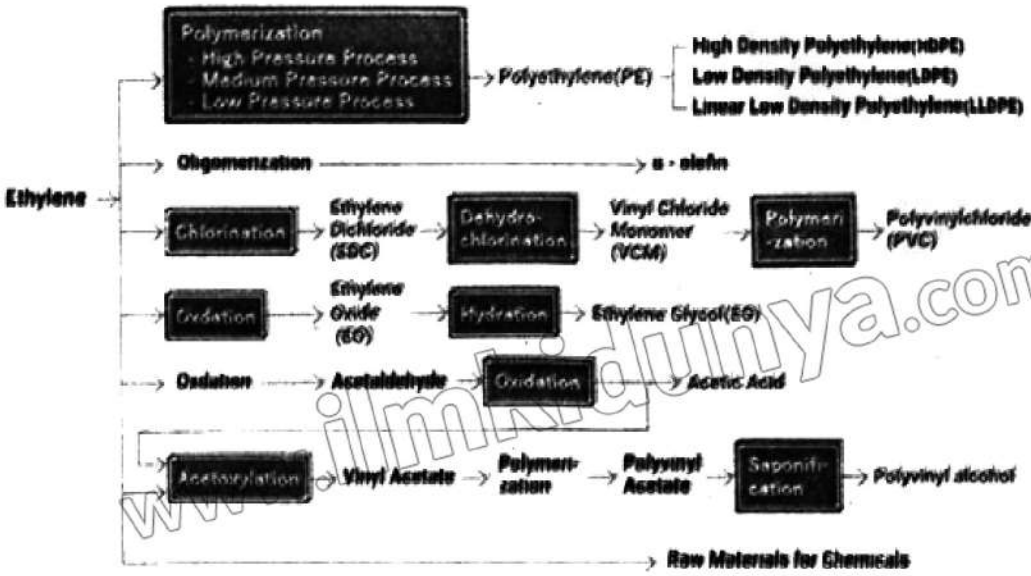
The chemical sector includes the businesses and various groups involved in creating and manufacturing industrial, specialized, and other types of chemicals.

1. Petrochemicals

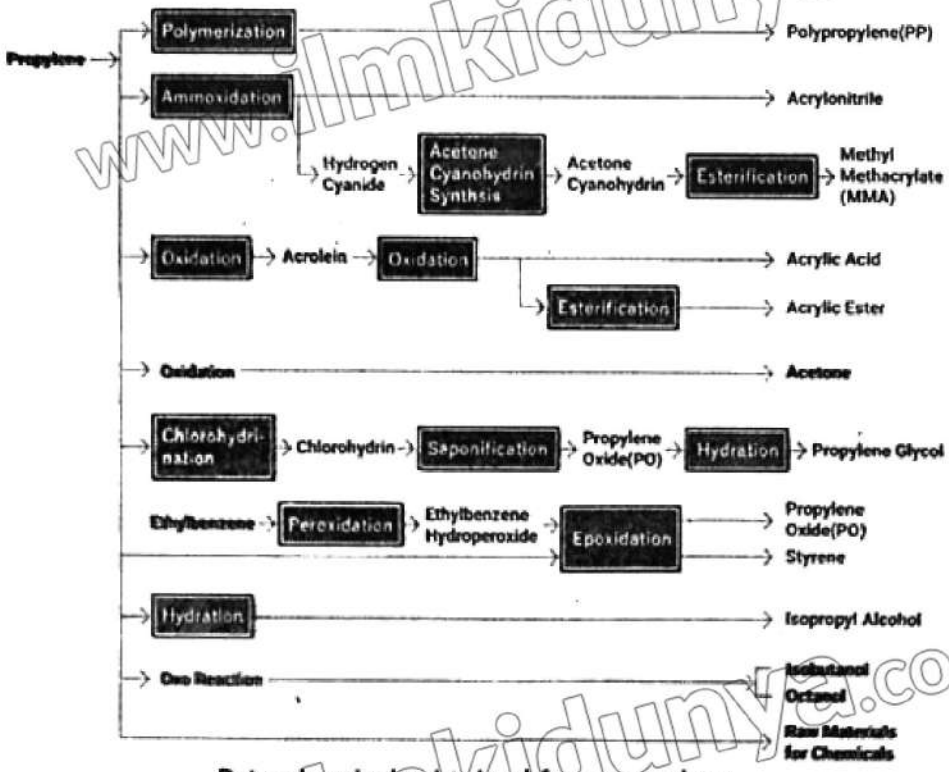
Those compounds which are derived from petroleum and it's fractions are called petrochemicals. Examples of petrochemicals are wide spread and highly applied such as insulation, soap, detergents, paints, fertilizers, rubber, coating, cosmetics and textile etc. There are three types of petrochemicals based on starting materials.

a. Olefins

Major olefins are ethene, propene and butadiene. Each one of them is used to prepare lots of petrochemicals.



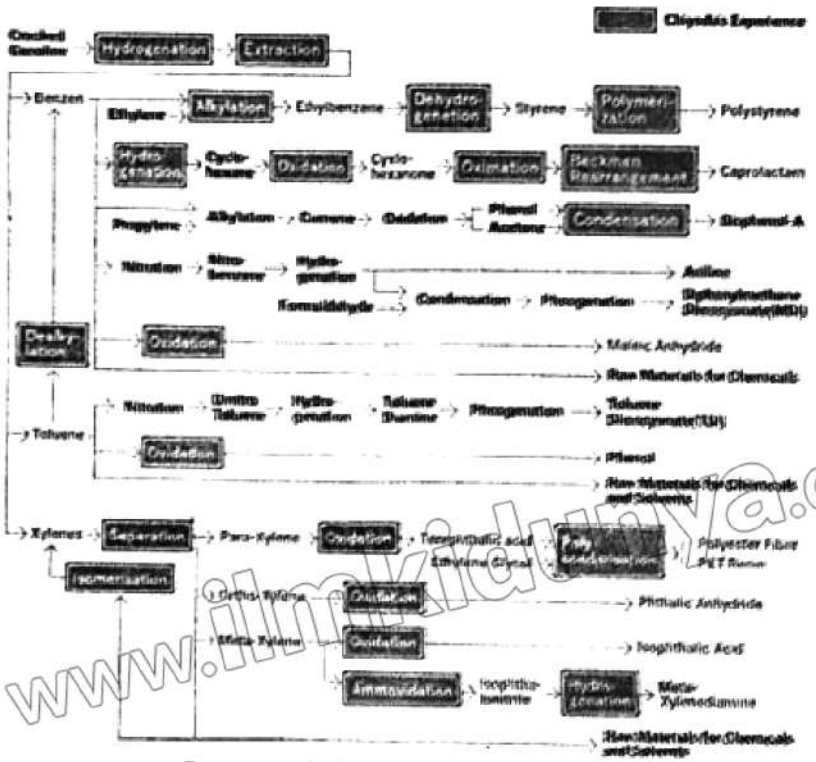
Petrochemicals obtained from ethylene



Petrochemicals obtained from propylene

2. Aromatics

Aromatics include benzene, toluene and xylenes etc. These are used to prepare lots of other compounds and polymers, as shown in the flow sheet.



Compound obtained from benzene

3. Synthesis gas

It is usually known as syn gas, actually a mixture of carbon monoxide, hydrogen gas, nitrogen, *hydrocarbons* etc. It's is used to prepare many useful compounds like acetic acid, ammonia,urea, SNG, biofuels like methanol and ethanol. It is also used to capture carbon dioxide to reduce greenhouse effect to avoid global warming. Synthesis gas is used to generate electricity and heat through combined heat and power (CHP) systems.

Cosmetics

Cosmetics are mixtures of chemical compounds derived from natural and synthetic both. Cosmetics have many purposes, including personal and skin care, conceal spots and enhance natural looks. Makeup can also add colour to face, or change the appearance of the face completely. Few examples include lipstick, mascara, nail polish, creams, colours and dyes etc.

1. Nail polish

There is no fixed single formula of nail polish. However, there are a number of ingredients that may be used. The basic components include;

a. **Film forming agent:** Nitrocellulose, cellulose acetate, cellulose acetate butyrate, vinyl polymers, acrylates, maliec acid, monobutyl ester, and zein(protein) etc. depending on brand.
b. **Resins and plasticizers:** castor oil, amyl and butyl stearate and mixes of fatty acids and glycerol etc.
c. **Solvents:** Ethyl acetate, butyl acetate, acetone, toluene and isopropyl alcohol etc.
d. **Colouring agents:** Iron oxides, colour lakes, mica, titanium dioxide, carmine, ultramarine, manganese violet etc.

Manufacturing method

i. Pigments like nitrocellulose and plasticizer are mixed and ground in a "two-roll" differential speed mill to produced fine dispersion of the color.
ii. When properly and fully milled, the mixture is removed from the mill in the form of sheets and then broken down into small chips for mixing with the solvent.
iii. The mixture is cooled slightly before the addition of such other materials as perfumes, moisturizers and cooling agents.
iv. The mixture is then pumped into smaller drums, and then trucked to a production line. The finished nail polish is pumped into explosion proof pumps, and then into smaller bottles suitable for the consumer market.

2. Lipstick

Raw materials

Waxes: bees wax, carnauba wax, candlila wax
Oils: linolin oil, castor oil, and vegetable oils
Natural ingredients: butter, natural pigments, fruit based chemicals
Pigments: both natural and synthetic
Alcohols: *isopropyl alcohol*
Preservatives: antioxidants

Manufacturing

The raw materials firstly are melted and mixed separately due to heterogeneous ingredients. Initially three mixtures are prepared separately. One contains solvents, the other contains oils in the third one contains fats and waxy materials.Secondly the solvent mixture and oils are mixed with the colour pigments. After the pigment mass ground and mixed, it is added to the hot wax mass untill a uniform colour is obtained. The lipstick mass is made free from air. The melted mass is transferred into a mould "upside down". The lipstick is cooled, separated from mould and sealed from the bottom.Then the lipsticks are passed through the flame to seal pinholes and improve the finish. Lastly the lipstick is caped now it is ready for labelling and packaging.

3. CEMENT

Cement is a very useful material used to glue bricks and stones together in construction after mixing with water, sand and crush etc. It is a dirty green coloured powder.

Raw materials:

1. Lime stone(almost 65% of cement)
2. Gypsum (2-3%)
3. Clay or shale(20-30%)
4. Supplementary ingredients (fly ash, silica fumes, iron ore or mill scale, bauxite etc. in minor amounts according to typeof cement and its applications)

Process

Step 1: Mining: Usually cement industry is installed where the raw materials are nearby and there is no need for large expenses on the transport. Raw materials are dug, extracted,and transported to the factory by trucks.

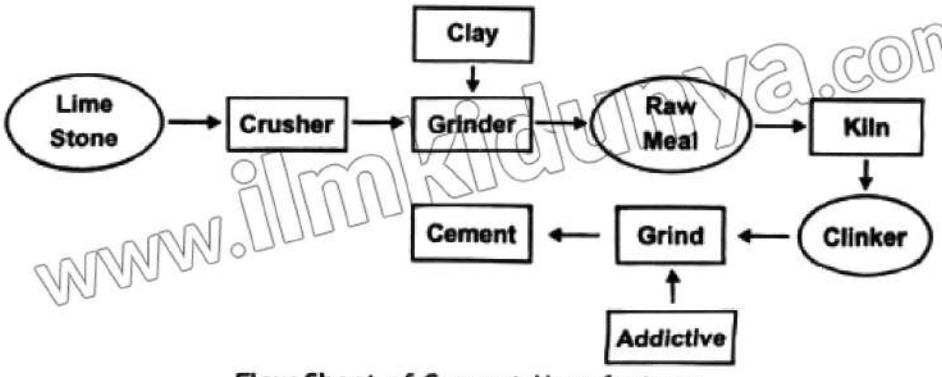
Step 2: Crushing: These raw materials reach in the factory in the form of big stones. They are crushed to small pebbles and then ground to fine powder.

Step 3: Homogenisation: Raw materials are mixed in proper percentages, mixed thoroughly to get a homogeneous powder.

Step 4: Clinkerization: In this process, calcium oxide reacts with silica, alumina, and iron oxide to form the aluminates, silicates and ferrites in a rotary kiln, whitch operates at a temeperature around 1400 °C to 1450 °C. These are the main components of the clinker(small semi round pebbles).

Step 5: Cement grinding: These clinkers are then ground in the ball mill together with gypsum(for the increase in setting time) and other additives to produce cement.

Step 6: Packing: Usually 50 kg bags are made. But open trucking is also done based on demand.



Flow Sheet of Cement Manufacture

23.7 Industrial Chemistry in Food Production

1. **Food additives and preservatives**
   - Anti-caking agents are used to stop ingredients from becoming lumpy.
   - Antioxidants prevent foods from oxidising, or becoming rancid.
   - Artificial sweeteners sweetens with out sugar.
   - Food acids maintain the correct acid level.
   - Synthetic colours enhance food colour.
   - Sodium benzoate is usually used as food preservative.

2. **Fermentation**

A process which makes use of microorganisms and their enzymes for converting raw materials into finished edible products such as vinager, wine etc.

3. **Food processing**

Food Processing is the technique of transforming food items into a form that can be consumed. It can cover the processing of raw materials into food through different physical and chemical steps.

4. **Purification**

Many food or beverage products use a purification step to remove colourful contaminants, unwanted taste and odour.

5. **Food packaging**

Food packaging is the crucial step and uses specialized techniques to avoid biological and chemical attacks and contamination.

6. **Food waste management**

The chemical treatment of waste refers to reducing its hazardous nature by using some specific chemicals such as acids, bases, oxidizers, reducers, etc.

KEY POINTS

1. In the large scale production of chemicals chemical industry plays a very important role, like in the production of plastics, synthetic fibre, and elastomers etc.
2. Raw materials for the chemical industry is obtained from atmosphere, biosphere, hydrosphere and lithosphere.
3. To avoid accidents and to ensure protection of workers and environment, chemical safety is critical.
4. Polymerization is a process in which small molecules like ethene, propylene, butadiene, vinyl alcohol, vinyl chloride, styrene etc. Under a set of conditions link together to form long chain, high molecular weight compounds, called polymers.
5. There are two types of polymerization reactions ; addition polymerization and condensation Polymerization.
6. Those compounds which are derived from petroleum and it's fractions are called petrochemicals. They have thee major classes; olefin based, aromatics and synthesis gas based.
7. Cosmetics have many purposes, including personal and skin care, conceal spots and enhance natural looks.
8. Cement is a very useful material used to glue bricks and stones together in construction after mixing with water, sand and crush etc.
9. Industrial chemistry has got its applications in food industry.

References:

1. Ullmann's Encyclopedia of Industrial Chemistry
2. Principles of Industrial Chemistry by Chris A. Clausen

EXERCISE

1. Multiple Choice Questions (MCQs)

i. Industrial chemistry is very important in the field of:
   a) Medicines b) Cement c) Glass d) All of them
ii. Halite (rock salt) in Pakistan is obtained from:
   a) Lithosphere b) Hydrosphere c) Biosphere d) Atmosphere
iii. The methods and applications to avoid accidents in chemical industry is termed as:
   a) Security b) Hazard analysis c) Chemical safety d) Protection
iv. Butadiene is included in the class:
   a) Olefins b) Aromatics c) Petroleum d) Syn gas
v. Polyvinyl chloride (PVC) is a polymer:
   a) Addition b) Substitution c) Reduction d) Condensation
vi. Nylon 6'6 preparation needs:
   a) Adipic acid b) Hexamethylene diamine
   c) Citric acid d) Both a and b
vii. The percentage of gypsum in cement is :
   a) 2-3% b) 1-5% c) 20% d) 65%
viii. Vinegar is made by:
   a) Addition Polymerization b) Condensation Polymerization
   c) Fermentation d) Pasteurization

2. Short Answer Questions

i. What are the petrochemicals? Explain their classes.
ii. What useful products are obtained from ethylene?
iii. Enlist useful products obtained from benzene and it's derivatives.
iv. How does chemical industry get raw materials for production of useful stuff?
v. Explain the addition polymerization with an example.
vi. Explain condensation Polymerization with an example.
vii. How is the Kevlar prepared? What are it's uses?
viii. Write the raw materials used in nail polish.
ix. Enlist of raw materials used for making lipstick.
x. Write down the method for the preparation of lipstick.

3. Long Answer Questions

i. Write a detailed note on cement.
ii. Write the involvement of industrial chemistry in food production and preservation.
iii. Write a detailed account of petrochemicals.

PROJECT

Prepare a report on the Impact of Artificial Intelligence (AI) on Various Industries.

Glossary

Acid dissociation constant: K_a is termed as the acid dissociation constant. It is a measure of the extent to which an acid is ionized or dissociated at the equilibrium state.

Acid strength: The degree to which different Bronsted acids give off protons is called acid strength.

Acylation: The reaction in which the acyl group is introduced in the benzene ring when acyl chloride (ethanoyl chloride) is reacted with benzene in the presence of a catalyst, aluminium chloride, is called acylation.

Addition polymers: Addition polymers are formed by combining alkene monomers, resulting in just one huge molecule.

Alkaline earth metals: The elements in Group 2 of the Periodic Table are referred to as the alkaline earth metals.

Alloying: Alloying is the process of combining a metal with one or more other elements to enhance its properties such as strength, ductility, corrosion resistance, and hardness.

Ampere: The SI Unit of current is the ampere, which is the amount of current flowing when one coulomb passes a given point in one second.

Anode: The electrode at which oxidation occurs is called the anode.

Antiviral drugs: Antiviral drugs are a class of medicines particularly used to treat viral infections.

Artificial organ: An artificial organ is a biological device or tissue created by scientists to replace, replicate, or augment a functional naturally occurring organ.

Assumptions : Assumptions are the basic convictions or declarations accepted without evidence.

Atomic absorption spectrum: An atomic absorption spectrum is observed when free atoms in the ground state absorb specific wavelengths of light and get excited to higher energy levels.

Atomic emission spectroscopy: Atomic emission spectroscopy is a powerful technique to quantify the elements by the measurement of the specific wavelength of light emitted from a pre-excited sample.

Begging the Question: Asking a question that begs an answer is referred to as "begging the question,"

Biodegradable polymers: The polymers which can be decomposed by the action of microorganisms are called biodegradable polymers.

BOD: The biological oxygen demand (BOD) is the amount of oxygen used to decompose the organic matter in a sample of water over a specified time period, usually 5 days, at a specified temperature.

Buffer solution: A buffer solution is a solution, the pH of which does not change significantly when a small amount of acid or base is added to it.

C-13 NMR: C-13 NMR is based on the magnetic properties of the C-13 nuclei.

Carbocation: A carbon atom which is attached with three atoms or a group of atoms and possesses a unit positive charge is known as carbocation.

Carbohydrates: Carbohydrates have the general formula $C_x(H_2O)_y$

Carbonyl compounds: Carbonyl compounds are a class of organic substances characterized by the presence of a carbonyl group (C=O).
Cathode: The electrode at which reduction occurs is called the cathode.
Cement: Cement is a very useful material used to glue bricks and stones together in construction after mixing with water, sand crush etc.
Ceramics: Ceramics include materials like cement, glass, and clay minerals such as porcelain.
Chiral molecules: Chiral molecules are those having carbon atoms bonded to four different atoms or groups of atoms.
Chiral: All objects that are non-super imposable on their mirror images are called chiral.
Claims: A claim is a declaration or proposition that represents the central idea or stance of a debate.
Common ion effect: The phenomenon in which the degree of ionization or solubility of an electrolyte is suppressed by the addition of a highly soluble electrolyte containing a common ion is called the common ion effect.
Competitive inhibitor: A competitive inhibitor is a molecule that is similar to the substrate and competes with it for the active site on the enzyme.
Complex compound: A complex compound or coordination compound is formed between transition metals and ligand(s).
Conclusion: The conclusion is the final statement that naturally follows from the initial statements. It represents the ultimate goal of the argument.
Condensation polymers: Condensation polymers are formed by the combination of monomers with the elimination of simple molecules such as H_2O.
Confirmation bias: The tendency of people to process information by searching for or interpreting information that is consistent with their existing beliefs.
Coordination number: The number of coordinate covalent bonds formed by metal ions with ligands is called coordination number.
Coordination sphere: The central atom or ion with ligand(s) is. called coordination sphere.
Coulomb: The SI unit of charge is the coulomb (C).
Counterclaims: A counterclaim is a statement that opposes the main claim.
Dependant variable: The variable that is affected by changes in the independent variable and this is usually plotted on the y-axis.
Disproportionation reaction: A redox reaction in which the same element is oxidized and reduced simultaneously.
Drug action: Drug action refers to certain biochemical or physiological effects that the drug produces in the body to produce a therapeutic response.
electrochemical cells: Devices, which convert electrical energy into chemical energy and vice versa, are known as electrochemical cells.
Electrochemical series; A list of arrangement of elements in the order of their standard electrode potential with reference to standard hydrogen electrode is called electrochemical series.
Electrolysis: Electrolysis is the process by which chemical reactions are stimulated by an external electrical current.
Electrolytic cell: Electrolytic cell is a device that converts electrical energy to chemical energy by electrolysis.

Electromotive force: The force with which electrons are pushed to flow through the wire from the anode to the cathode is called the electromotive force or emf.

Enzymes: Enzymes are biocatalysts which alter the speed of metabolic activities in the living bodies.

Equivalence point: The equivalence point is the point at which indicator changes its colour and the point at which neutralisation takes place.

Error: Error is the difference between the value or quantity obtained in an experiment and the value accepted in the experiment or in the literature.

Falling Occam's Razor: If there are two possible explanations for the same event, you should choose the more straightforward one.

Faraday (F). It corresponds to the charge carried by one mole of electrons and amounts to 96487 C.

Fertilizers: Fertilizers, are natural or artificial substances containing elements that improve plant growth and productivity.

Fibrous proteins: Proteins that are made up of elongated or fibrous polypeptide chains are called fibrous proteins.

Fridel-Craft acylation: The introduction of the acyl group in the benzene ring when it is heated with chloroalkane in the presence of aluminium chloride (Lewis acid) is called Fridel-Craft acylation.

Fridel-Craft alkylation: The introduction of an alkyl group in a benzene ring when it is heated with chloroalkane in the presence of aluminium chloride (Lewis acid) is called Fridel-Craft alkylation.

Fungicides: Fungicides are pesticides that kill or prevent the growth of fungi and their spores.

Galvanic or voltaic cell: An electrochemical cell in which a spontaneous redox reaction produces an electric current is known as a galvanic or voltaic cell.

Genetic engineering: Genetic engineering also called genetic modification is a technique used to change an organism`s genes using technology.

Geometric isomerism: Geometric isomerism is also called cis-trans isomerism

Globular proteins: Proteins that are water-soluble and possess a shape like a sphere or a globe upon folding are called globular proteins.

Glycogen: Glycogen is a type of stored glucose molecule made up of a large number of connected glucose molecules.

Halogenoalkanes: Halogenoalkanes also known as alkyl halides are compounds in which one hydrogen atom of alkanes has been replaced by a halogen atom.

Hasty Generalizations: A hasty generalization fallacy is a claim made on the basis of insufficient evidence.

Herbicides: Herbicides are chemicals used to control unwanted plants also called weeds.

Independent variable: It is manipulated or controlled by the individual who is doing an experiment. It is plotted on the x-axis.

Insecticides: Insecticides are chemicals used to control insects.

Ionic product of water: The product of the concentration of H^+ and OH^- ions in pure water at room temperature (298 k) is called an ionic product of water.

IR spectroscopy: The spectroscopy that makes use of the interaction of infrared radiations with organic molecules.

Isomerism: The phenomenon which gives different structural formulae to organic compounds with the same molecular formulae is called isomerism.

Ligand: A ligand is an atom or group of atoms which are electron-rich and have the ability to donate lone pairs of electrons to the transition metal ions, making dative covalent bonds with them.

Lipids: Lipids are naturally occurring heterogeneous groups of organic compounds of animals and plants origin, which are soluble in organic solvents.

Material: A material is a substance or mixture that makes up an object.

Metabolite: A metabolite is a biologically active form of a drug or substance produced by the body's metabolic processes.

Metallurgy: The process of separating materials from ores and alloying them is known as metallurgy.

Naphthols: Naphthols are derivatives of naphthalene and consist of a naphthalene ring system bonded to a hydroxyl group.

Nematicide: A nematicide is a type of pesticide used to kill plant-parasitic nematodes.

Nernst equation: The Nernst equation is a mathematical expression that relates the standard electrode potential (E°) to the actual electrode potential (E) under non-standard conditions, taking into account the concentrations of the reactants and products.

**Nernst`s law:** Nernst`s law states that a solute is distributed between two layers of immiscible solvents so that the ratio of its concentration in each solvent is equal to its solubility.

NMR spectroscopy: NMR spectroscopy or magnetic resonance spectroscopy (MRS), is a spectroscopic technique based on re-orientation of atomic nuclei with non-zero nuclear spins in an external magnetic field.

Non-specific reactions: The reactions that occur without specificity to a particular substrate are called non-specific reactions.

Nuclear spin flipping: Nuclear spin flipping is a quantum mechanical phenomenon where certain atomic nuclei absorb energy from an external magnetic field, leading to a change in their spin state.

Nucleic acids: Naturally occurring biomolecules that serve as the primary information-carrying molecules in cells are called nucleic acids.

Nucleophilic substitution reaction: The reaction in which the halogen atom of an alkyl halide is substituted or replaced by a strong nucleophile is known as a nucleophilic substitution reaction.

Oligosaccharides: Carbohydrates which upon hydrolysis form 2 to 10 molecules of monosaccharides or simple sugars are called oligosaccharides.

Opiates: Opiates, also called opioids are a class of drugs that include the illegal drug heroin, synthetic opioids such as fentanyl, and legal prescription pain relievers such as oxycodone, hydrocodone, codeine, morphine, and many others.

Optical isomers: Optical isomers rotate the plane of polarized light either clockwise or anticlockwise.

Oxidation half-cell: Half-cell, in which oxidation occurs is called an oxidation half-cell or anode half-cell.

Oxidation: A reaction in which a substance loses electrons is called oxidation.

oxidizing agent: *An oxidizing* agent is a substance that accepts electrons and causes oxidation, therefore, its oxidation state decreases.

Partition coefficient: The partition coefficient (K_{pc}) is defined as the ratio of the concentrations of a solute in two different immiscible solvents in contact with each other when equilibrium has been established at a particular temperature.

Pesticides: The chemical substances used in agriculture to control or kill pests including insects, fungi, rodents and weeds are called pesticides.

Petrochemicals: The compounds which are derived from petroleum and its fractions are called petrochemicals.

pH scale: the pH scale is a numerical scale that shows the acidic or alkaline strength of a solution.

pH: The pH of a solution is the logarithm to base 10 of the reciprocals of the numerical value of the hydrogen ion concentration.

Phenols: Phenols are compounds that contain a hydroxyl group (-OH) attached to an aromatic ring (benzene ring).

Polyamide: A polyamide is produced by the condensation of diamines and dicarboxylic acids.

Polyesters: Polyesters are produced by the condensation of diols and dicarboxylic acids.

Polymerization: The reaction by which monomers are converted into polymers is known as polymerization.

Polymers: Polymers are high molecular weight compounds whose structures are made up of a large number of simple repeating units.

Polysaccharides: The Carbohydrates upon hydrolysis form hundreds to thousands of units of simple sugars are called polysaccharides.

Premises: Premises are the statements or reasons that provide the foundation for the claim.

Proteins: Proteins are complex nitrogenous substances that produce amino acids on complete hydrolysis.

Qualitative data: Qualitative data in chemistry refers to non-numeric information derived from observations about chemical characteristics and reactions.

Quantitative data: Quantitative data refers to numerical measurements that are obtained from experiments.

Random error: Random error is the random difference between the observed value and the true value.

Rebuttals: A rebuttal challenges and opposes an opposing viewpoint, offering proof or logic to undermine or disprove it.

Recycling: Recycling is the process of collecting, and processing materials that would otherwise be discarded as waste, converting them into new products.

Reducing agent: A reducing agent is a substance that causes reduction through the loss of electrons.

Reduction half-cell: Half-cell, in which reduction occurs is called a reduction half-cell or *cathode half-cell.*

Reduction: A reaction in which a substance gains electrons is called reduction.

Retention time: Retention time is the time taken for a sample molecule to travel through the column, from the time it is inserted into the machine to the time it is detected.

Rf (retardation factor) value: Rf value of a compound is the ratio of the distance travelled by the solute to the distance travelled by the solvent.

Roasting: The concentrated ore is heated in air below its melting point and converted into oxide. This process is called roasting.

Smelting: The method to reduce metal ions to free metal is called smelting.

SN_1: SN_1 is a unimolecular nucleophilic substitution reaction that occurs in two steps.

SN_2: SN_2 is a bimolecular nucleophilic substitution reaction which occurs in a single step.

Solubility Product: It is defined as the product of the equilibrium concentrations of ions, each raised to a power which is equal to the coefficient of the ion in the balanced chemical equation.

Spectroscopy is a technique used for structural elucidation of the molecule. It is based on the interaction of atoms or molecules and light.

Standard electrode potential: The standard electrode potential is defined as the tendency of a half-cell reaction to undergo reduction relative to the standard hydrogen electrode.

Stereoisomers: Stereoisomers are those molecules which have the same chemical formulae, same structural formulae but different arrangements of atoms in space. The phenomenon of the existence of such molecules is called stereoisomerism.

Steroids: Steroids are organic compounds with a typical molecular structure containing four fused rings of carbon atoms (three six-membered and one five-membered).

Straw Man Fallacy: The straw man fallacy occurs when someone distorts or exaggerates another's claim and then attacks the distorted version of the claim instead of refuting the original claim.

Substrate molecule: The alkyl halide molecule on which nucleophile attacks is called a substrate molecule.

Systematic error: Systematic error is a consistent or proportional difference between the observed and true values of something.

Terpenes: Lipids containing isoprene units (five-carbon units) are called terpenes or isoprenoids.

Therapeutic window: The therapeutic window, also known as the therapeutic range or therapeutic index, indicates the range of drug concentrations in the body that bring about the desired therapeutic effects with minimum adverse effects.

Titration: Titration is a technique used in neutralisation reactions between acids and alkalis to determine the concentration of the unknown solution.

TLC: Thin-layer chromatography (TLC) separates substances based on how they interact with different surfaces. In TLC, substances move across a thin layer on a plate.

UV-spectroscopy: UV-spectroscopy is the technique in which the UV and visible light absorption by any compound is measured. Its typical range of wavelength is from 200 nm-800nm.

X-ray crystallography: It is a method that uses X-rays to find out the detailed structure of a crystal, including the arrangement of its atoms and molecules.

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