UNIT
15

CHEMISTRY IN EVERYDAY LIFE

Vladimir Prelog

Prof. Vladimir Prelog was a Swiss Chemist who shared 1975 Nobel Prize for Chemistry with John W Cornforth for his work on Stereo Chemistry. He has done wide ranging research on alkaloids, antibiotics, enzymes and other natural compounds. He was distinguished for his contribution to the development of modern stereo chemistry. Prelog synthesized many natural products and worked on problems of stereo chemistry like adamenline, boromycin analoids and rifamycins

G6P3T1

Learning Objectives

After studying this unit, the students will be able to

- recognize the term drug and chemotherapy
- classify the drugs based on their properties
- describe the drug-target interaction.
- discuss some important classes of drugs.
- explain the chemistry of cleansing agents
- describe the chemicals in food
- explain the important terms in polymer chemistry.
- describe the preparation of some important synthetic polymers
- appreciate the importance of polymers in today life

INTRODUCTION

Chemistry touches every aspect of our lives. The three-basic requirement of our life: food, clothes, shelter are all basically chemical compounds. Infact, life itself is a complicated system of interrelated chemical process. In this unit, we will learn the chemistry involved in the field of medicines, food materials, cleansing agents and polymers.

15.1 Drug

The word drug is derived from the French word "*drogue*" meaning "*dry herb*". A drug is a substance that is used to modify or explore physiological systems or pathological states for the benefit of the recipient. It is used for the purpose of diagnosis, prevention, cure/relief of a disease.The drug which interacts with macromolecular targets such as proteins to produce a therapeutic and useful biological response is called medicine. The specific treatment of a disease using medicine is known as chemotherapy. An ideal drug is the one which is non-toxic, bio-compatible and bio-degradable, and it should not have any side effects. Generally, most of the drug molecules that are used now a days have the above properties at lower concentrations. However, at higher concentrations, they have side effects and become toxic. The medicinal value of a drug is measured in terms of its therapeutic index, which is defined as the ratio between the maximum tolerated dose of a drug (above which it become toxic) and the minimum curative dose (below which the drug is ineffective). Higher the value of therapeutic index, safer is the drug.

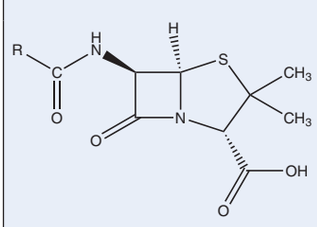
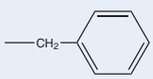
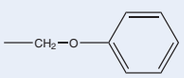
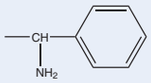
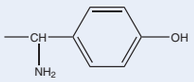
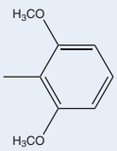
15.1.1 Classification of drugs:

Drugs are classified based on their properties such as chemical structure, pharmacological effect, target system, site of action etc. We will discuss some general classifications here.

Classification based on the chemical structure:

In this classification, drugs with a common chemical skeleton are classified into a single group. For example, ampicillin, amoxicillin, methicillin etc.. all have similar structure and are classified into a single group called penicillin. Similarly, we have other group of drugs such as opiates, steroids, catecholamines etc. Compounds having similar chemical structure are expected to have similar chemical properties. However, their biological actions are not always similar. For example, all drugs belonging to penicillin group have same biological action, while groups such as barbiturates, steroids etc.. have different biological action.

Penicillins

	R group-Drug Name				
	 Penicillin G	 Penicillin V	 Ampicillin	 Amoxicillin	 methicillin

Classification based on Pharmacological effect:

In this classification, the drugs are grouped based on their biological effect that they produce on the recipient. For example, the medicines that have the ability to kill the pathogenic bacteria are grouped as antibiotics. This kind of grouping will provide the full range of drugs that can be used for a particular condition (disease). The physician has to carefully choose a suitable medicine from the available drugs based on the clinical condition of the recipient.

Examples:

Antibiotic drugs: amoxicillin, ampicillin,cefixime, cefpodoxime, erythromycin, tetracycline etc..

Antihypertensive drugs: propranolol, atenolol, metoprolol succinate, amlodipine etc…

Classification based on the target system (drug action):

In this classification, the drugs are grouped based on the biological system/process, that they target in the recipient. This classification is more specific than the pharmacological classification.For example, the antibiotics streptomycin and erythromycin inhibit the protein synthesis (target process) in bacteria and are classified in a same group. However, their mode of action is different. Streptomycin inhibits the initiation of protein synthesis, while erythromycin prevents the incorporation of new amino acids to the protein.

Classification based on the site of action (molecular target):

The drug molecule interacts with biomolecules such as enzymes, receptors etc,, which are referred as drug targets. We can classify the drug based on the drug target with which it binds. This classification is highly specific compared to the others. These compounds often have a common mechanism of action, as the target is the same.

15.1.2 Drug–target Interaction:

The biochemical processes such as metabolism (which is responsible for breaking down the food molecules and harvest energy in the form of ATP and biosynthesis of necessary biomolecules from the available precursor molecules using many enzymes),cell-signaling (senses any change in the environment using the receptor molecules and send signals to various processes to elicit an appropriate response) etc… are essential for the normal functioning of our body. These routine processes may be disturbed by any external factors such as microorganism, chemicals etc.. or by a disorder in the system itself. Under such conditions we may have to take medicines to restore the normal functioning of the body.

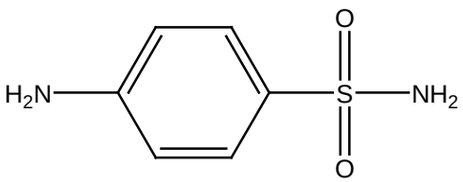
These drug molecules interact with biomolecules such as proteins, lipids, etc..that are responsible for different functions of the body. For example, proteins which act as biological catalysts are called enzymes and those which are important for communication systems are called receptors. The drug interacts with these molecules and modify the normal biochemical reactions either by modifying the enzyme activity or by stimulating/suppressing certain receptors.

Enzymes as drug targets:

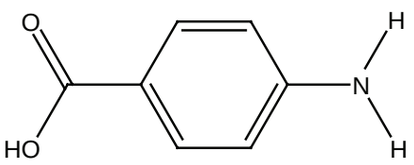
In all living systems, the biochemical reactions are catalysed by enzymes. Hence, these enzyme actions are highly essential for the normal functioning of the system. If their normal enzyme activity is inhibited, then the system will be affected. This principle is usually applied to kill many pathogens.

We have already learnt that in enzyme catalysed reactions, the substrate molecule binds to the active site of the enzyme by means of the weak interaction such as hydrogen bonding, van der Waals force etc… between the amino acids present in the active site and the substrate.

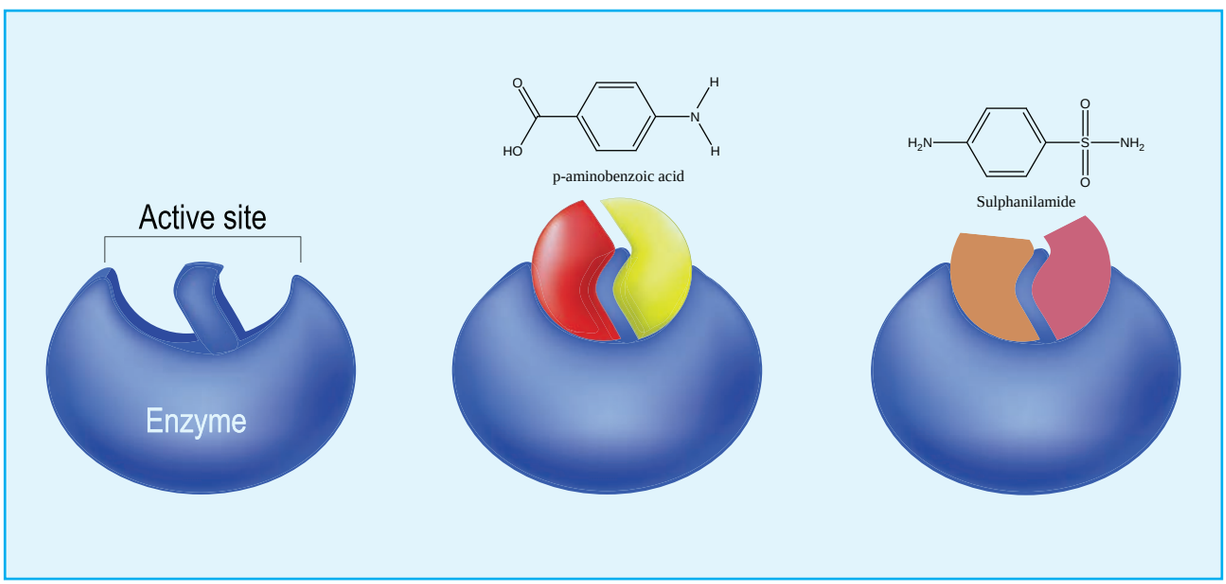
When a drug molecule that has a similar geometry (shape)as the substrate is administered, it can also bind to the enzyme and inhibit its activity.In other words, the drug acts as an inhibitor to the enzyme catalyst. These type of inhibitors are often called competitive inhibitors. For example the antibiotic sulphanilamide, which is structurally similar to *p*-aminobenzoic acid (PABA) inhibits the bacterial growth. Many bacteria need PABA in order to produce an important coenzyme, folic acid. When the antibiotic sulphanilamide is administered, it acts as a competitive inhibitor to the enzyme dihydropteroate synthase (DHPS) in the biosynthetic pathway of converting PABA into folic acid in the bacteria. It leads to the folic acid deficiency which retards the growth of the bacteria and can eventually kill them.



Sulphanilamide



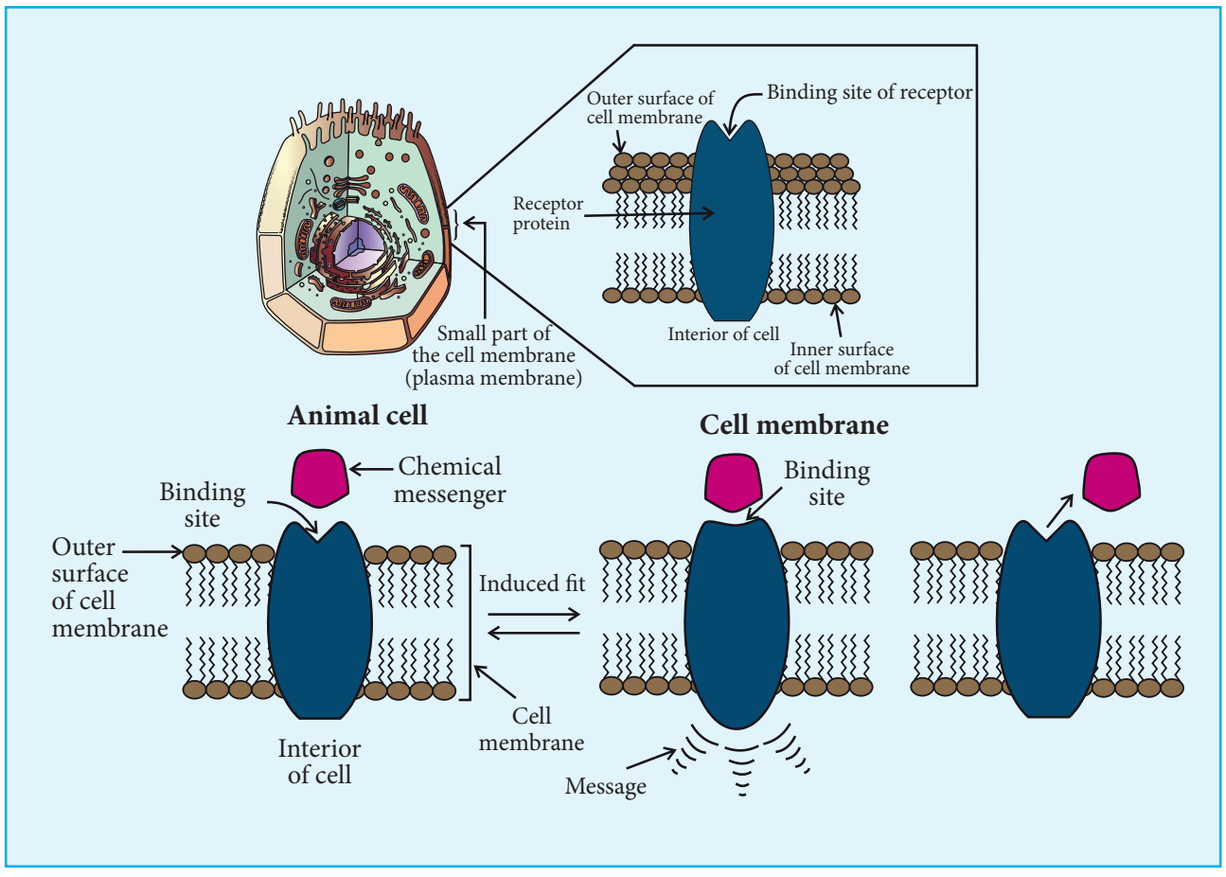
p-aminobenzoic acid



In certain enzymes, the inhibitor molecule binds to a different binding site, which is commonly referred to as allosteric site, and causes a change in its active site geometry (shape). As a result, the substrate cannot bind to the enzyme. This type of inhibitors are called allosteric inhibitors.

Receptor as drug targets:

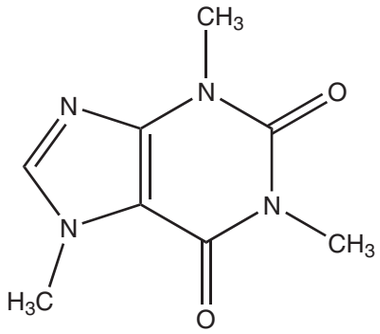
Many drugs exert their physiological effects by binding to a specific molecule called a receptor whose role is to trigger a response in a cell. Most of the receptors are integrated with the cell membranes in such a way that their active site is exposed to outside region of the cell membrane. The chemical messengers, the compounds that carry messages to cells, bind to the active site of these receptors. This brings about the transfer of message into the cell. These receptors show high selectivity for one chemical messenger over the others. If we want to block a message, a drug that binds to the receptor site should inhibit its natural function. Such drugs are called **antagonists**. In contrast, there are drugs which mimic the natural messenger by switching on the receptor. These type of drugs are called **agonists** and are used when there is lack of chemical messenger.

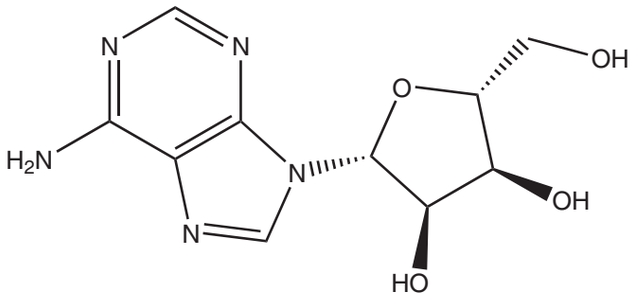


For example, when adenosine binds to the adenosine receptors, it induces sleepiness. On the other hand, the antagonist drug caffeine binds to the adenosine receptor and makes it inactive. This results in the reduced sleepiness (wakefulness).

The agonist drug, morphine, which is used as a pain killer, binds to the opioid receptors and activates them. This supress the neuro transmitters that causes pain.

Most receptors are chiral and hence different enantiomers of a drug can have different effect

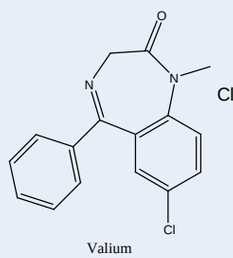
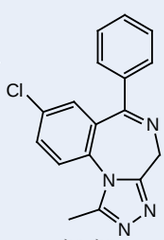
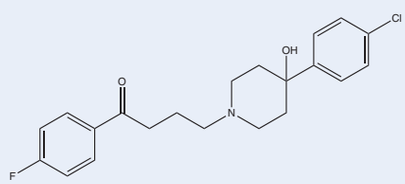


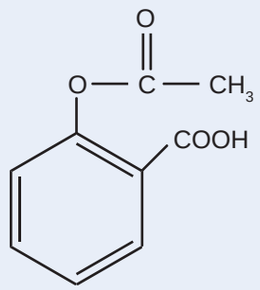
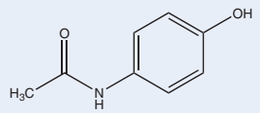
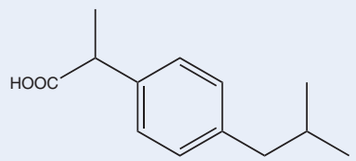
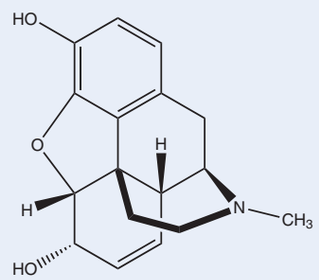
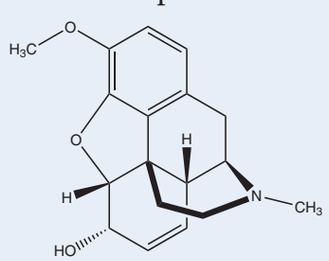


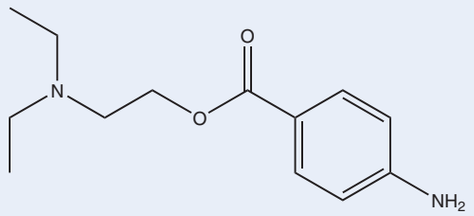
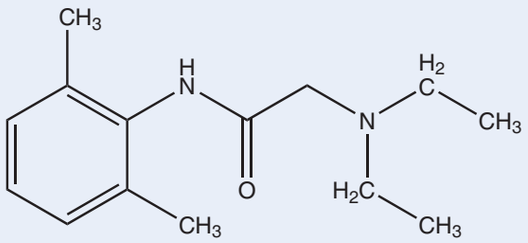
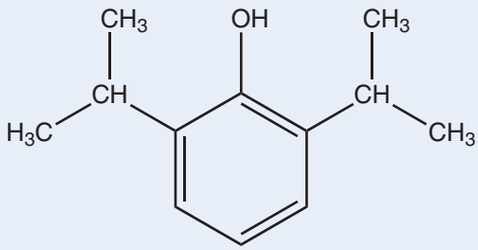
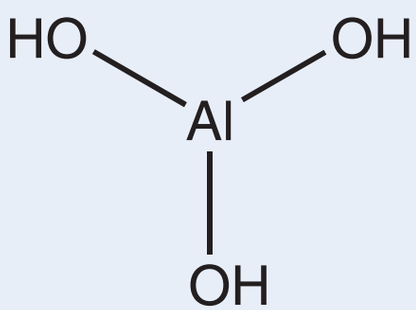
ADENOSINE

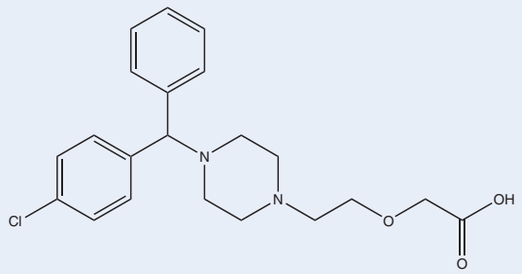
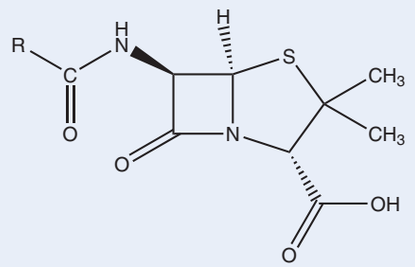
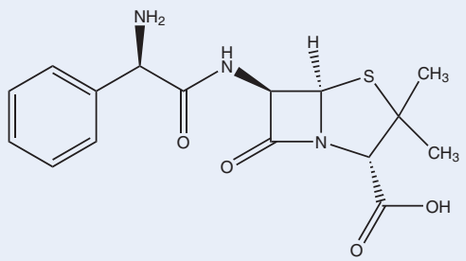
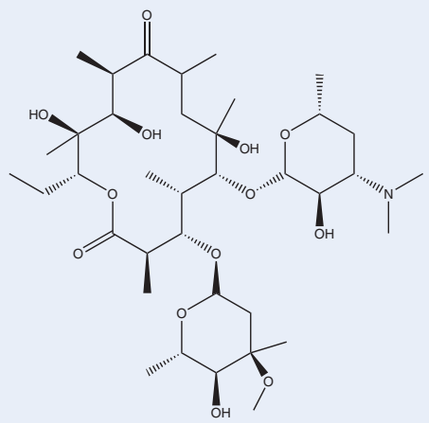
Therapeutic action of Different classes of Drugs:

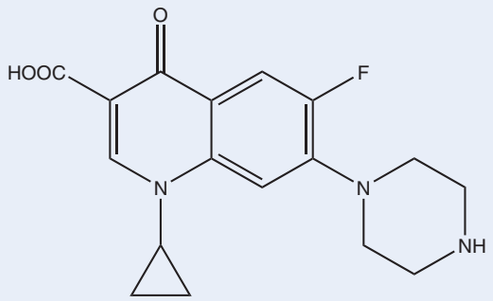
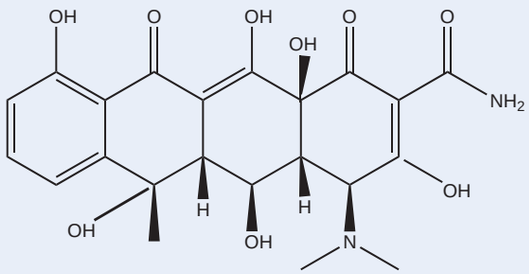
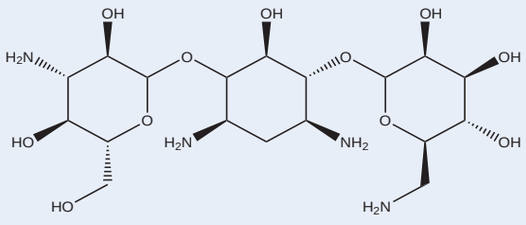
The developments in the field of biology allowed us to understand various biological process and their mechanism in detail. This enabled to develop new safer efficient drugs. For example, to treat acidity, we have been using weak bases such as aluminium and magnesium hydroxides. But these can make the stomach alkaline and trigger the production of much acid. Moreover, This treatment only relives the symptoms and does not control the cause. Detailed studies reveal that histamines stimulate the secretion of HCl by activating the receptor in the stomach wall. This findings lead to the design of new drugs such as cimetidine, ranitidine etc.. which binds the receptor and inactivate them. These drugs are structurally similar to histamine.In this section, we shall discuss the therapeutic action of a few important classes of drugs.

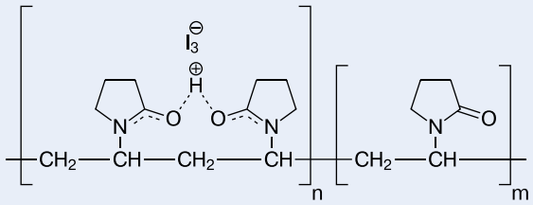
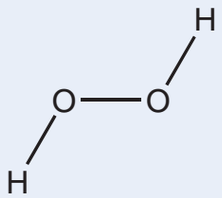
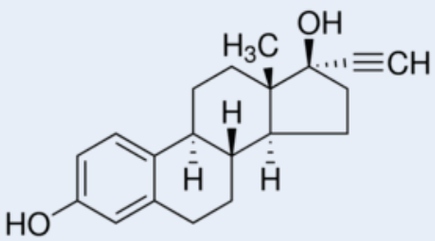
Class of Drugs	Mode of action	Chemical structure of some important structures
1) Tranquilizers They are neurologically active drugs. **i) Major tranquilizers:** Haloperidol, clozapine **ii) Minor tranquilizers:** Diazepam (Valium), alprazolam	Acts on the central nervous system by blocking the neurotransmitter dopamine in the brain **Uses** Treatment of stress, anxiety, depression, sleep disorders and severe mental diseases like schizophrenia	 Valium  alprazolam  Haloperidol

2) Analgesics (Non – narcotic) Analgesics reduce the pain without causing impairment of consciousness. **i) Anti-inflammatory drugs** **Example** Acetaminophen or paracetamol, Ibuprofen, Asprin. **ii) Antipyretics** Example **Salicylates** Acetylsalicylic acid (aspirin), **Acetaminophen or Paracetamol** **iii) Nonsteroidal anti-inflammatory drugs (NSAIDs)** Ibuprofen	They alleviate pain by reducing local inflammatory responses **Uses** Used for short-term pain relief and for modest painlike headache, muscle strain, bruising, or arthritis. These drugs have many other effects such as reducing fever (antipyretic) and preventing platelet coagulation. Due to this property, aspirin finds useful in the prevention of heart attacks Reduces fever by causing the hypothalamus to override a prostaglandin-induced increase in temperature..	 Acetylsalicylic acid (aspirin)  Paracetamol  Ibuprofen
3) **Opioids (Narcotic Analgesics)** **Examples** Morphine, codeine	Relive pain and produce sleep. These drugs are addictive. In poisonous dose,these produces coma and ultimately death. **Uses** Used for either short-term or long-term relief of severe pain. Mainly used for post operative pain, pain of terminal cancer.	 Morphine  codeine

4) Anaesthetics i) Local anaesthetics Examples **Ester-linked local anaesthetic** - Procaine **Amide-linked local anaesthetic** - Lidocaine	It causes loss of sensation, in the area in which it is applied without losing consciousness. They block pain perception that is transmitted via peripheral nerve fibres to the brain **Uses** They are often used during minor surgical procedures.	 Procaine  Lidocaine
ii) General anaesthetics Example **Intravenous general anaesthetics**– Propofol **Inhalational general anaesthetics**- Isoflurane	Cause a controlled and reversible loss of consciousness by affecting central nervous system **Uses** They are often used for major surgical procedures.	 Propofol
5) Antacids **Examples** Milk of Magnesia, Sodium bicarbonate, calcium bicarbonate, aluminium hydroxide Ranitidine, Cemitidine Omeprazole, rabeprazole	Neutralize the acid in the stomach that causes acidity. **Uses** To relieve symptoms such as burning sensation in the chest/ throat area (heart burns) caused by acid reflux.	 aluminium hydroxide

6) Antihistamines Examples Cetirizine, levocetirizine, desloratadine, brompheniramine Terfenadine	Block histamine release from histamine-1 receptors **Uses** To provide relief from the allergic effects	 Cetirizine
7) Antimicrobials i) Beta-Lactams Examples Penicillins, ampicillin, cephalosporins, carbapenems, and monobactams	Inhibits bacterial cell wall biosynthesis **Uses** To treat skin infections, dental infections, ear infections, respiratory tract infections, pneumonia, urinary tract infections, and gonorrhoea	 Penicillins  Ampicillin
ii) Macrolides Examples Erythromycin, azithromycin	Targets bacterial ribosomes and prevent protein production **Uses** To treat respiratory tract infections, genital, gastrointestinal tractand skin infections	 Erythromycin

iii) Fluoroquinolones Examples Clinafloxacin, ciprofloxacin, levofloxacin	Inhibits bacterial enzyme DNA gyrase **Uses** To treat urinary tract infections, skin infections, and respiratory infections (such as sinusitis, pneumonia, bronchitis), pulmonary infections in cystic fibrosis	 Ciprofloxacin
iv) Tetracyclines Examples Doxycycline, minocycline, oxytetracycline	Inhibit the bacterial protein synthesis via interaction with the 30S subunit of the bacterial ribosome **Uses** Used in the treatment of peptic ulcer disease, infections of the respiratory tract, cholera, acne vulgaris.	 Oxytetracycline
v) Aminoglycosides Examples Kanamycin, gentamicin, neomycin	Bind to the 30S subunit of the bacterial ribosome, thus stopping bacteria from making proteins **Uses** Used to treat infections caused by gram-negative bacteria	 Kanamycin

8) Antiseptics Examples Hydrogen peroxide, povidone-iodine, benzalkonium chloride	Stop or slow down the growth of microorganisms – Applied to living tissue **Uses** To reduce the risk of infection during surgery and other procedures	 Povidone-iodine
9) Disinfectants Examples Chlorine compounds, alcohol, Hydrogen peroxide.	Stop or slow down the growth of microorganisms – Generally used on inanimate objects	 Hydrogen peroxide
10) Antifertility drugs **Example** **Synthetic oestrogen** - Ethynylestradiol, Menstranol **Synthetic Progesterone** - Norethindrone, Norethynodrel	These synthetic hormones that suppresses ovulation/ fertilisation. **Uses** Used in birth control pills.	 Ethynylestradiol

15.2 Food additives:

Have you ever noticed the ingredients that is printed on the cover of the packed food materials such as biscuits, chocolates etc...You might have noticed that emulsifiers such as 322, 472E, dough conditioners 223 etc… are used in the preparation, in addition to the main ingredients such as wheat flour, edible oil, sugar, milk solid etc… Do you think that these substances are necessary? Yes. These substances enhance the nutritive, sensory and practical value of the food. They also increase the shelf life of food. The substances which are not naturally a part of the food and added to improve the quality of food are called food additives.

15.2.1 Important categories of food additives

- Aroma compounds
- Food colours
- Preservatives
- Stabilizers
- Artificial Sweeteners
- Antioxidants
- Buffering substances
- Vitamins and minerals

Advantages of food additives:

1. Uses of preservatives reduce the product spoilage and extend the shelf-life of food
2. Addition of vitamins and minerals reduces the mall nutrient
3. Flavouring agents enhance the aroma of the food
4. Antioxidants prevent the formation of potentially toxic oxidation products of lipids and other food constituents

15.2.2. Preservatives:

Preservatives are capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food by growth of microorganisms. Organic acids such as benzoic acid, sorbic acid and their salts are potent inhibitors of a number of fungi, yeast and bacteria. Alkyl esters of hydroxy benzoic acid are very effective in less acidic conditions. Acetic acid is used mainly as a preservative for the preparation of pickles and for preserved vegetables. Sodium metasulphite is used as preservatives for fresh vegetables and fruits. Sucrose esters with palmitic and steric acid are used as emulsifiers. In addition that some organic acids and their salts are used as preservatives. In addition to chemical treatment, physical methods such as heat treatment (pasteurisation and sterilisations), cold treatment (chilling and freezing) drying (dehydration) and irradiation are used to preserve food.

15.2.3. Antioxidants:

Antioxidants are substances which retard the oxidative deteriorations of food. Food containing fats and oils is easily oxidised and turn rancid. To prevent the oxidation of the fats and oils, chemical BHT(butylhydroxy toluene), BHA(Butylated hydroxy anisole) are added as food additives. They are generally called antioxidants. These materials readily undergo oxidation by reacting with free radicals generated by the oxidation of oils, thereby stop the chain reaction of oxidation of food. Sulphur dioxide and sulphites are also used as food additives. They act as anti-microbial agents, antioxidants and enzyme inhibitors.

15.2.4 Sugar Substituents:

Those compounds that are used like sugars (glucose, sucrose) for sweetening, but are metabolised without the influence of insulin are called sugar substituents. Eg. Sorbitol, Xylitol, Mannitol.

15.2.5 Artificial sweetening agents:

Synthetic compounds which imprint a sweet sensation and possess no or negligible nutritional value are called artificial sweeteners. Eg. Saccharin, Aspartame, sucralose, alitame etc…

15.3 Cleansing agents:

Soaps and detergents are used as cleansing agents. Chemically soap is the sodium or potassium salt of higher fatty acids. Detergent is sodium salt of alkyl hydrogen sulphates or alkyl benzene sulphonic acids.

15.3.1 Soaps:

Soaps are made from animal fats or vegetable oils. They contain glyceryl esters of long chain fatty acids. When the glycerides are heated with a solution of sodium hydroxide they become soap and glycerol. We have already learnt this reaction under the preparation of glycerol by saponification. Common salt is added to the reaction mixture to decrease the solubility of soap and it helps to precipitate out from the aqueous solution. Soap is then mixed with desired colours, perfumes and chemicals of medicinal importance.

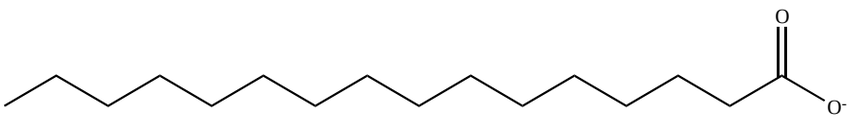
Total fatty matter:

The quality of a soap is described in terms of total fatty matter (TFM value). It is defined as the total amount of fatty matter that can be separated from a sample after splitting with mineral acids., Higher the TFM quantity in the soap better is its quality.

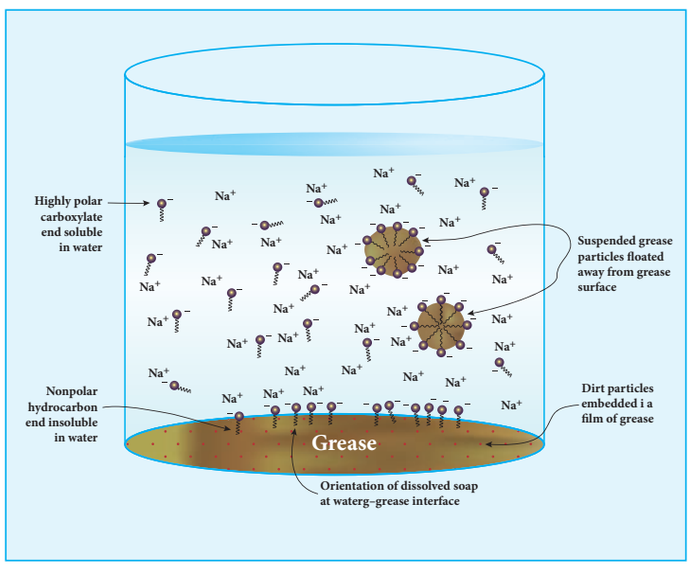
As per BIS standards, Grade-1 soaps should have 76% minimum TFM, while Grade-2 and 3 must have 70 and 60% , minimum respectively. The other quality parameters are lather, moisture content,mushiness, insoluble matter in alcohol etc..

The cleansing action of soap:

To understand how a soap works as a cleansing agent, let us consider sodium palmitate an example of a soap. The cleansing action of soap is directly related to the structure of carboxylate ions (palmitate ion) present in soap. The structure of palmitate exhibit dual polarity. The hydrocarbon portion is non polar and the carboxyl portion is polar.



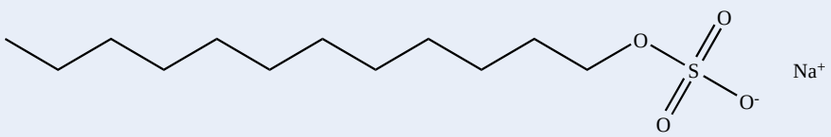
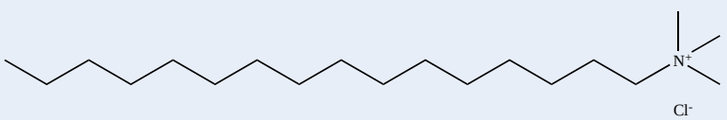
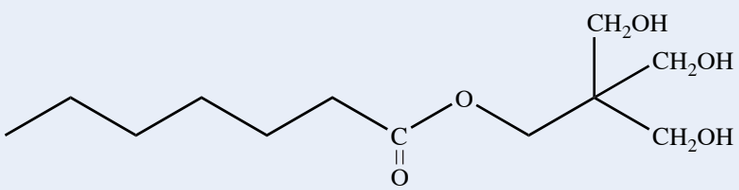
The nonpolar portion is hydrophobic while the polar end is hydrophilic. The hydrophobic hydro carbon portion is soluble in oils and greases, but not in water. The hydrophilic carboxylate group is soluble in water. The dirt in the cloth is due to the presence of dust particles intact or grease which stick. When the soap is added to an oily or greasy part of the cloth, the hydrocarbon part of the soap dissolve in the grease, leaving the negatively charged carboxylate end exposed on the grease surface. At the



same time the negatively charged carboxylate groups are strongly attracted by water, thus leading to the formation of small droplets called micelles and grease is floated away from the solid object. When the water is rinsed away, the grease goes with it. As a result, the cloth gets free from dirt and the droplets are washed away with water. The micelles do not combine into large drops because their surfaces are all negatively charged and repel each other. The cleansing ability of a soap depends upon its tendency to act as a emulsifying agent between water and water insoluble greases.

15.3.2 Detergents:

Synthetic detergents are formulated products containing either sodium salts of alkyl hydrogen sulphates or sodium salts of long chain alkyl benzene sulphonic acids. There are three types of detergents.

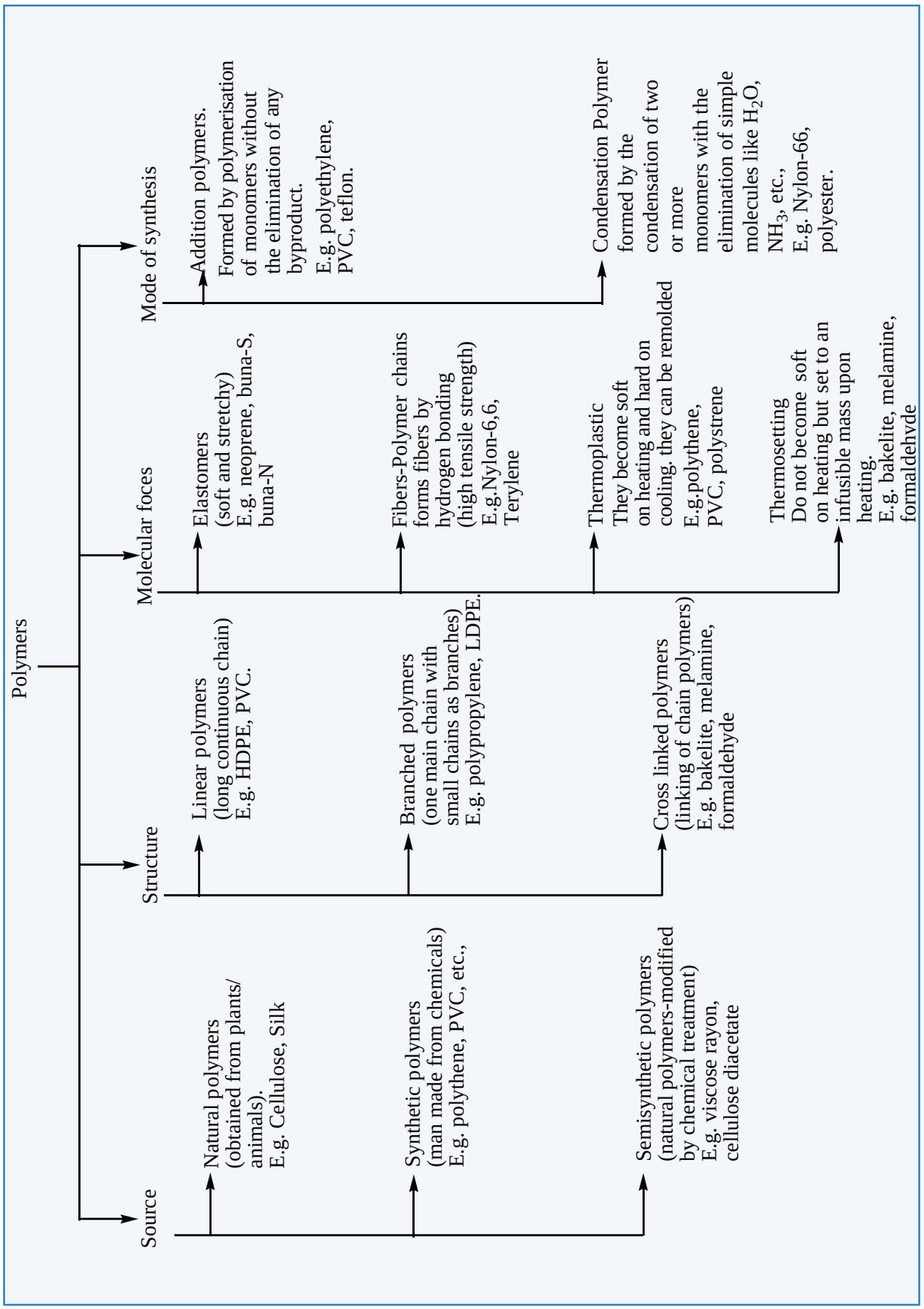
Detergent Type	Example
Anionic detergent	Sodium Lauryl sulphate (SLS) 
Cationic detergent	n-hexaadecyltrimethyl ammonium chloride  *N,N,N*-trimethylhexadecan-1-aminium chloride
Non-ionic detergent	Pentaerythrityl stearate.  3-hydroxy-2,2-bis(hydroxymethyl)propyl heptanoate

Detergents are superior to soaps as they can be used even in hard water and in acidic conditions. The cleansing action of detergents are similar to the cleansing action of soaps.

15.4 Polymers

The term Polymer is derived from the Greek word 'polumeres' meaning "having many parts". The constitution of a polymer is described in terms of its structural units called monomers. Polymers consists of large number of monomer units derived from simple molecules. For example: PVC(Poly Vinyl Chloride). is a polymer which is obtained from the monomer vinyl chloride. Polymers can be classified based on the source of availability, structure, molecular forces and the mode of synthesis. The following chart explain different classification of polymers.

15.4.1 Classification of Polymers:



15.4.2 Types of polymerisation

The process of forming a very large, high molecular mass polymer from small structural units i.e., monomer is called polymerisation. Polymerisation occurs in the following two ways

i. Addition polymerisation or chain growth polymerisation
ii. Condensation polymerisation or step growth polymerisation

Addition polymerisation

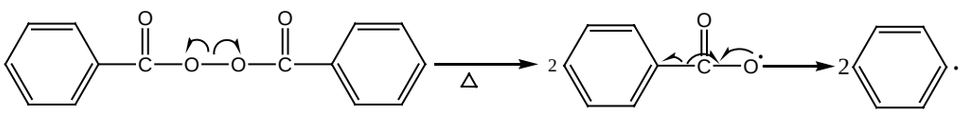
Many alkenes undergo polymerisation under suitable conditions. The chain growth mechanism involves the addition of the reactive end of the growing chain across the double bond of the monomer. The addition polymerisation can follow any of the following three mechanisms depending upon the reactive intermediate involved in the process.

i. Free radical polymerisation
ii. Cationic polymerisation
iii. Anionic polymerisation

Free radical polymerisation

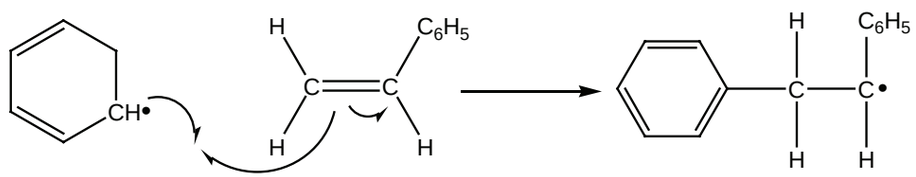
When alkenes are heated with free radical initiator such as benzyl peroxide, they undergo polymerisation reaction. For example styrene polymerises to polystyrene when it is heated to ionic with a peroxide initiator. The mechanism involves the following steps.

1. initiation – formation of free radical



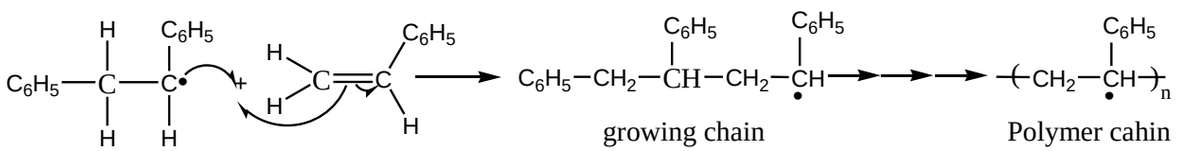
benzoyl peroxide — phenyl free radical + $2CO_2$

2. Propagation step



phenyl free radical — Styrene (monomer) — Stabilised radical

The stabilized radical attacks another monomer molecule to give an elongated radical

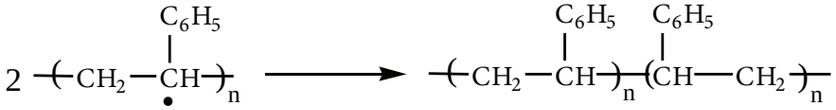


monomer — growing chain — Polymer cahin

Chain growth will continue with the successive addition of several thousands of monomer units.

Termination

The above chain reaction can be stopped by stopping the supply of monomer or by coupling of two chains or reaction with an impurity such as oxygen.



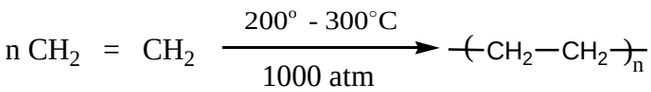
15.4. 3 Preparation of some important addition polymers

1. Polythene

It is an addition polymer of ethene. There are two types of polyethylene i) HDPE (High Density Polyethylene) ii) LDPE (Low Density polyethylene).

LDPE

It is formed by heating ethene at 200° to 300° C under oxygen as a catalyst. The reaction follows free radical mechanism. The peroxides formed from oxygen acts as a free radical initiator.



ethene Polythene

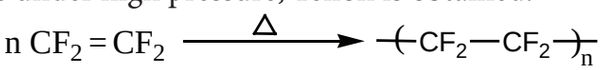
It is used as insulation for cables, making toys etc…

HDPE

The polymerization of ethylene is carried out at 373K and 6to7 atm pressure using Zeiglar – Natta catalyst $[TiCl_4+(C_2H_5)_3Al]$ HDPE has high density and melting point and it is used to make bottles, pipe etc..,

Preparation of Teflon (PTFE)

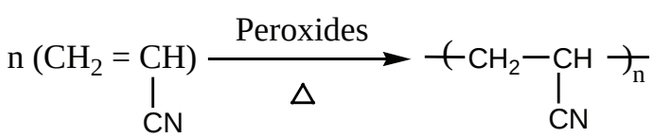
The monomer is tetrafluroethylene. When the monomer is heated with oxygen (or) ammonium persulphate under high pressure, Teflon is obtained.



It is used for coating articles and preparing non – stick utensils.

I. Preparation of Orlon (polyacrylonitrile – PAN)

It is prepared by the addition polymerisation of vinylcyanide (acrylonitrile) using a peroxide initiator.



Prop - 2-enenitrile PAN

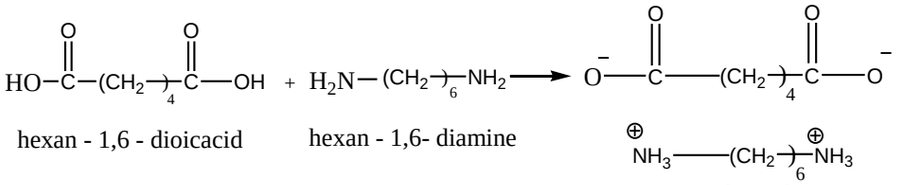
It is used as a substitute of wool for making blankets, sweaters etc…

Condensation polymerisation

Condensation polymers are formed by the reaction between functional groups an adjacent monomers with the elimination of simple molecules like H_2O, NH_3 etc…. Each monomer must undergo at least two substitution reactions to continue to grow the polymer chain i.e., the monomer must be at least bi functional. Examples : Nylon– 6,6, terylene….

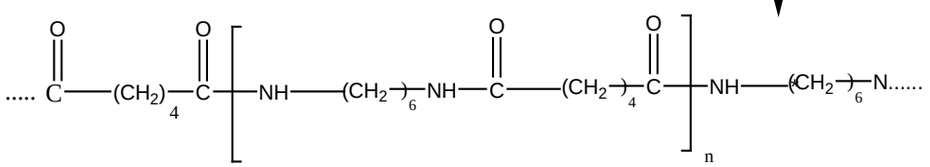
Nylon – 6,6

Nylon – 6,6 can be prepared by mixing equimolar adipic acid and hexamethylene – diamine to form a nylon salt which on heating eliminate a water molecule to form amide bonds.



hexan - 1,6 - dioicacid hexan - 1,6- diamine

Nylon salt

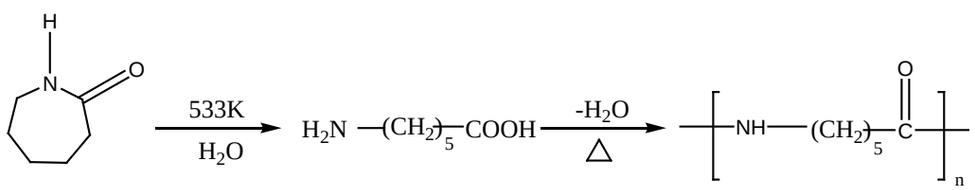


Poly (hexamethyleneadipamide)
Nylon 6,6

It is used in textiles, manufacture of cards etc…

Nylon – 6

Capro lactam (monomer) on heating at 533K in an inert atmosphere with traces of water gives Є-v amino carproic acid which polymerises to give nylon – 6

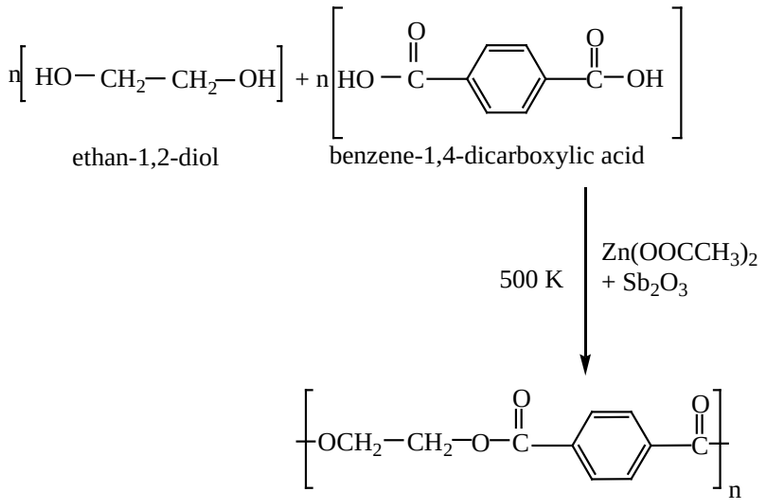


Nylon -6

It is used in the manufacture of tyrecards fabrics etc….

II. Preparation of terylene (Dacron)

The monomers are ethylene glycol and terepathalic acid (or) dimethylterephthalate. When these monomers are mixed and heated at 500K in the presence of zinc acetate and antimony trioxide catalyst, terylene is formed.



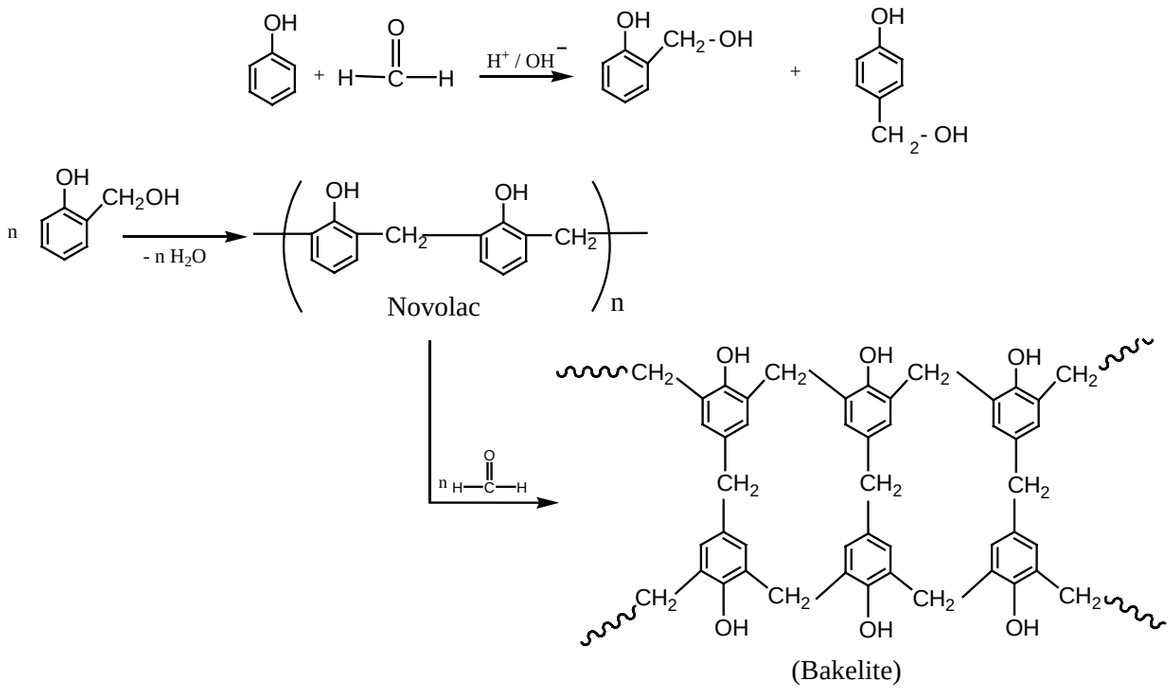
Terylene (an polyester)

It is used in blending with cotton or wool fibres and as glass reinforcing materials in safety helmets.

Preparation of Bakelite

The monomers are phenol and formaldehyde. The polymer is obtained by the condensation polymerization of these monomers in presence of either an acid or a base catalyst.

Phenol reacts with methanal to form ortho or para hydroxyl methylphenols which on further reaction with phenol gives linear polymer called novolac. Novalac on further heating with formaldehyde undergo cross linkages to form backelite.



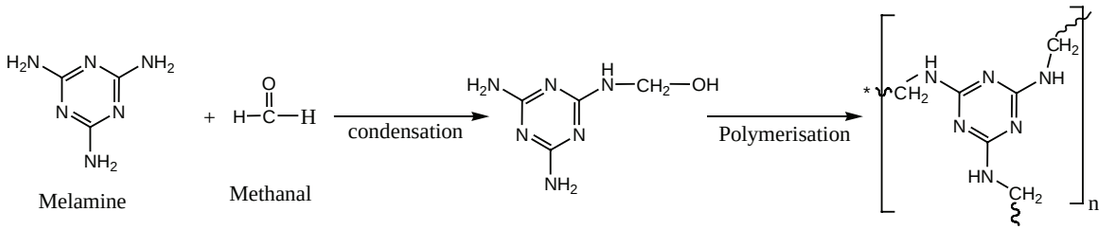
(Bakelite)

Uses:

Navolac is used in paints. Soft backelites are used for making glue for binding laminated wooden planks and in varinishes, Hard backelites are used to prepare combs, pens etc..

Melamine (Formaldehyde melamine):

The monomers are melamine and formaldehyde. These monomers undergo condensation polymerisation to form melamine formaldehyde resin.

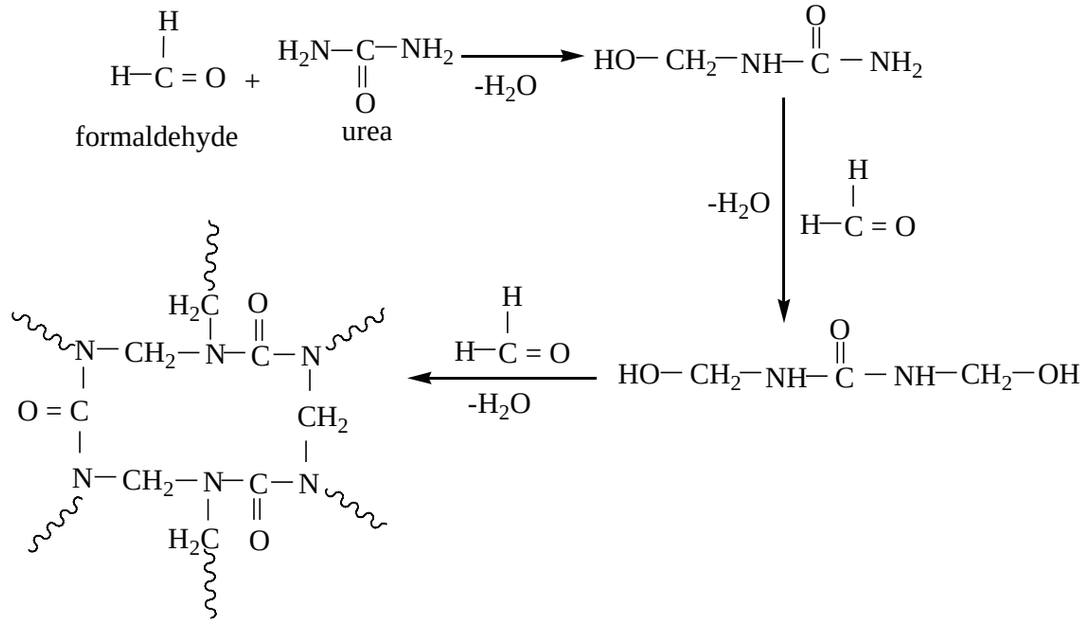


Melamine Methanal

Uses: It is used for making unbreakable crockery Melamine-formaldehyde polymer

Urea formaldehyde polymer:

It is formed by the condensation polymerisation of the monomers urea and formaldehyde.



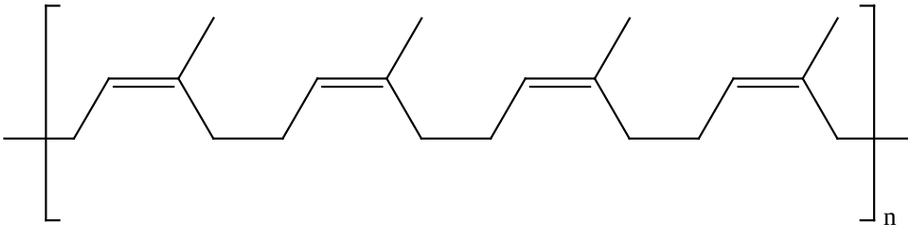
urea formaldehyde polymer

15.4.4 Co-polymers:

A polymer containing two or more different kinds of monomer units is called a co-polymer. For example, SBR rubber(Buna-S) contains styrene and butadiene monomer units. Co-polymers have properties quite different from the homopolymers.

15.4.5 Natural and Synthetic rubbers:

Rubber is a naturally occurring polymer. It is obtained from the latex that excludes from cuts in the bark of rubber tree (Ficus elastic). The monomer unit of natural rubber is cis isoprene (2-methyl buta-1,3-diene). Thousands of isoprene units are linearly linked together in natural rubber. Natural rubber is not so strong or elastic. The properties of natural rubber can be modified by the process called vulcanization.



cispolyisoprene

Vulcanization: Cross linking of Rubber

In the year 1839, Charles Good year accidently dropped a mixture of natural rubber and sulphur onto a hot stove. He was surprised to find that the rubber had become strong and elastic. This discovery led to the process that Good year called vulcanization.

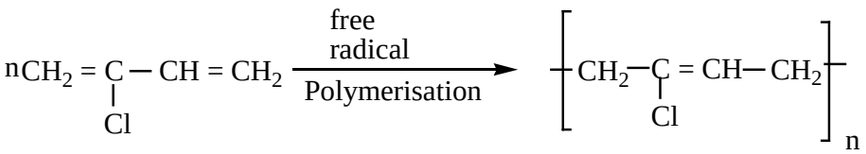
Natural rubber is mixed with 3-5% sulphur and heated at 100-150˚C causes cross linking of the cis-1,4-polyisoprene chains through disulphide (-S-S-) bonds. The physical properties of rubber can be altered by controlling the amount of sulphur that is used for vulcanization. In sulphur rubber, made with about 1 to 3% sulphur is soft and stretchy. When 3 to 10% sulphur is used the resultant rubber is somewhat harder but flexible.

Synthetic rubber:

Polymerisation of certain organic compounds such as buta-1,3-diene or its derivatives gives rubber like polymer with desirable properties like stretching to a greater extent etc., such polymers are called synthetic rubbers.

Preparation of Neoprene:

The free radical polymeristion of the monomer, 2-chloro buta-1,3-diene(chloroprene) gives neoprene.

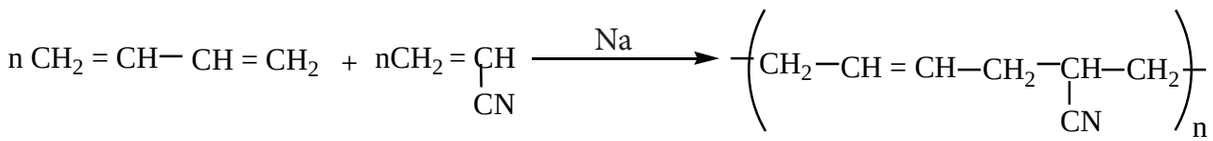


It is superior to rubber and resistant to chemical action.

Uses: It is used in the manufacture of chemical containers, conveyer belts.

Preparation of Buna-N:

It is a co-polymer of acrylonitrile and buta-1,3-diene.

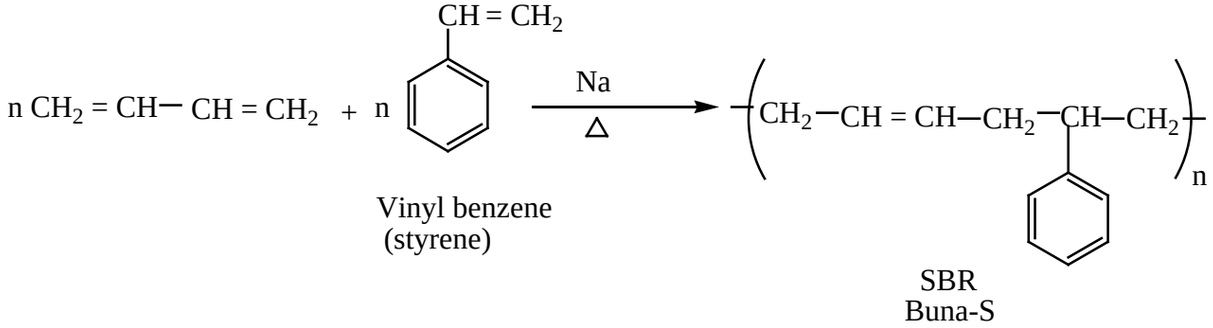


Vinyl cyanide Buna-N

It is used in the manufacture of hoses and tanklinings.

Preparation of Buna-S:

It is a co-polymer. It is obtained by the polymerisation of buta-1,3-diene and styrene in the ratio 3:1 in the presence of sodium.



15.4.6 Biodegradable Polymers

The materials that are readily decomposed by microorganisms in the environment are called biodegradable. Natural polymers degrade on their own after certain period of time but the synthetic polymers do not. It leads to serious environmental pollution. One of the solution to this problem is to produce biodegradable polymers which can be broken down by soil micro organism.

Examples:

Polyhydroxy butyrate (PHB)

Polyhydroxy butyrate-co-A- hydroxyl valerate (PHBV)

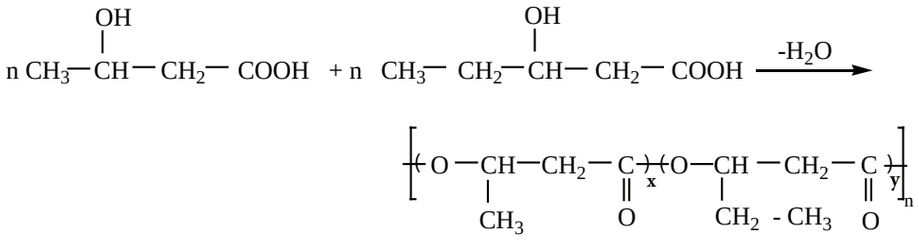
Polyglycolic acid (PGA), Polylactic acid (PLA)

Poly (∈ caprolactone) (PCL)

Biodegradable polymers are used in medical field such as surgical sutures, plasma substitute etc… these polymers are decomposed by enzyme action and are either metabolized or excreted from the body.

Preparation of PHBV

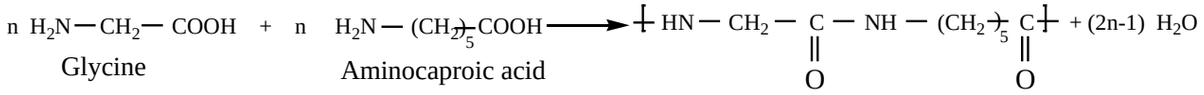
It is the co – polymer of the monomers 3 – hydroxybutanoic acid and 3-hydroxypentanoic acid. In PHBV, the monomer units are joined by ester linkages.



Uses : It is used in ortho paedic devices, and in controlled release of drugs.

Nylon– 2-Nylon -6

It is a co – polymer which contains polyamide linkages. It is obtained by the condensation polymersiation of the monomers, glycine and E - amino caproic acid.



Nylon -2-nylon - 6

EVALUATION

C7M1B1

Choose the correct answer:

1. Which of the following is an analgesic?

   a) Streptomycin b) Chloromycetin c) Asprin d) Penicillin

2. Antiseptics and disinfectants either kill or prevent growth of microorganisms. Identify which of the following statement is not true.

   a) dilute solutions of boric acid and hydrogen peroxide are strong antiseptics.

   b) Disinfectants harm the living tissues.

   c) A 0.2% solution of phenol is an antiseptic while 1% solution acts as a disinfectant.

   d) Chlorine and iodine are used as strong disinfectants.

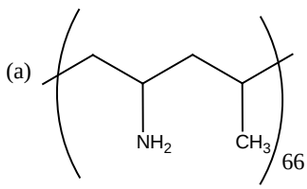
3. Drugs that bind to the receptor site and inhibit its natural function are called

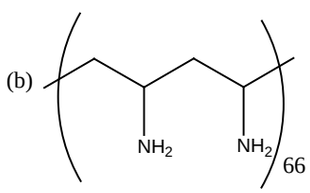
   a) antagonists b) agonists c) enzymes d) molecular targets

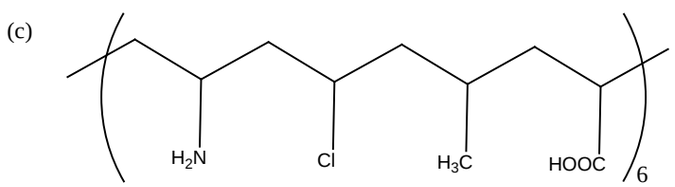
4. Aspirin is a/an

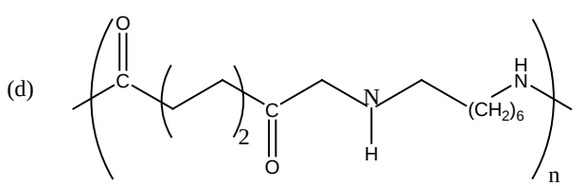
   a) acetylsalicylic acid b) benzoyl salicylic acid c) chlorobenzoic acid d) anthranilic acid

5. Which one of the following structures represents nylon 6,6 polymer?









6. Natural rubber has

a) alternate cis- and trans-configuration b) random cis- and trans-configuration

c) all cis-configuration d) all trans-configuration

7. Nylon is an example of

a) polyamide b) polythene c) polyester d) poly saccharide

8. Terylene is an example of

a) polyamide b) polythene c) polyester d) polysaccharide

9. Which is the monomer of neoprene in the following?

a) $CH_2-\underset{\underset{Cl}{|}}{C}-CH=CH_2$ b) $CH_2=CH-C\equiv CH$

c) $CH_2=CH-CH=CH_2$ d) $CH_2=\underset{\underset{CH_3}{|}}{C}-CH=CH_2$

10. Which one of the following is a bio-degradable polymer?

a) HDPE b) PVC c) Nylon 6 d) PHBV

11. Non stick cook wares generally have a coating of a polymer, whose monomer is

a) ethane b) prop-2-enenitrile c) chloroethene d) 1,1,2,2-tetrafluoroethane

12. Assertion: 2-methyl-1,3-butadiene is the monomer of natural rubber

Reason: Natural rubber is formed through anionic addition polymerisation.

a) If both assertion and reason are true and reason is the correct explanation of assertion.

b) if both assertion and reason are true but reason is not the correct explanation of assertion.

c) assertion is true but reason is false. d) both assertion and reason are false.

13. Which of the following is a co-polymer?

a) Orlon b) PVC c) Teflon d) PHBV

14. The polymer used in making blankets (artificial wool) is

a) polystyrene b) PAN c) polyester d) polythene

15. Regarding cross-linked or network polymers, which of the following statement is incorrect? (NEET)

a) Examples are Bakelite and melamine

b) They are formed from bi and tri-functional monomers

c) They contain covalent bonds between various linear polymer chains

d) They contain strong covalent bonds in their polymer chain

Short Answer Questions

1. What are antibiotics?
2. Name one substance which can act as both analgesic and antiphyretic
3. Write a note on synthetic detergents
4. How do antiseptics differ from disinfectants?
5. What are food preservatives?
6. What are drugs? How are they classified
7. How the tranquilizers work in body.
8. Write the structural formula of aspirin.
9. Explain the mechanism of cleansing action of soaps and detergents
10. Which sweetening agent are used to prepare sweets for a diabetic patient?
11. What are narcotic and non – narcotic drugs. Give examples
12. What are anti fertility drugs? Give examples.
13. Write a note on co –polymer
14. What are bio degradable polymers? Give examples.
15. How is terylene prepared?
16. Write a note on vulcanization of rubber
17. Classify the following as linear, branched or cross linked polymers

    a) Bakelite b) Nylon-6,6 c) LDPE d) HDPE

VOLUME II

ANSWERS

UNIT 8

MCQ

1. $Ag_2C_2O_4 \rightleftharpoons 2Ag^+ + C_2O_4^{2-}$

$[Ag^+] = 2.24\times10^{-4} \text{ mol } L^{-1}$

$[C_2O_4^{2-}] = \frac{2.24\times10^{-4}}{2} \text{ mol } L^{-1}$

$= 1.12\times10^{-4} \text{ mol } L^{-1}$

$K_{sp} = [Ag^+]^2 [C_2O_4^{2-}]$

$= (2.24\times10^{-4} \text{ mol } L^{-1})^2 (1.12\times10^{-4} \text{ mol } L^{-1})$

$= 5.619\times10^{-12} \text{ mol}^3 L^{-3}$

[Option (d)]

2. iii) 75 ml $\frac{M}{5}$ HCl + 25ml $\frac{M}{5}$ NaOH

No of moles of HCl = $0.2\times75\times10^{-3} = 15 \times 10^{-3}$

No of moles of NaOH = $0.2 \times 25 \times 10^{-3} = 5 \times 10^{-3}$

No of moles of HCl after mixing = $15 \times 10^{-3} - 5 \times 10^{-3}$

$= 10 \times 10^{-3}$

$\therefore$ concentration of HCl = $\frac{\text{No of moles of HCl}}{\text{Vol in litre}}$

$= \frac{10\times10^{-3}}{100\times10^{-3}} = 0.1M$

for (iii) solution, pH of 0.1M HCl = $-\log_{10}(0.1)$

$= 1.$

[Option (d)].

3. $BaSO_4 \rightleftharpoons Ba^{2+} + SO_4^{2-}$

$K_{sp} = (s)\ (s)$

$K_{sp} = (s)^2$

$= (2.42\times10^{-3} \text{ g } L^{-1})^2$

$= \left(\frac{2.42\times10^{-3} \text{ g } L^{-1}}{233 \text{g mol}^{-1}}\right)^2$

$= (0.01038\times10^{-3})^2$

$= (1.038\times10^{-5})^2$

$= 1.077\times10^{-10}$

$= 1.08\times10^{-10} \text{ mol}^2 \text{ } L^{-2}$

[Option (c)]

4. $Ca(OH)_2 \rightleftharpoons Ca^{2+} + 2OH^-$

Given that pH=9

pOH=14-9=5

$[pOH = -\log_{10}[OH^-]]$

$\therefore [OH^-] = 10^{-pOH}$

$[OH^-] = 10^{-5} \text{ M}$

$K_{sp} = [Ca^{2+}][OH^-]^2$

$= \frac{10^{-5}}{2} \times (10^{-5})^2$

$= 0.5\times10^{-15}$

[Option (a)]

5. $\underset{\text{acid 1}}{H_2O} + \underset{\text{base 1}}{H_2O} \rightleftharpoons \underset{\text{acid 2}}{H_3O^+} + \underset{\text{base 2}}{OH^-}$

$\underset{\text{acid 1}}{HF} + \underset{\text{base 1}}{H_2O} \rightleftharpoons \underset{\text{acid 2}}{H_3O^+} + \underset{\text{base 2}}{F^-}$

$\therefore$ Conjugate bases are OH^- and F^- respectively

i.e.,[Option (c)]

6. Basic buffer is the solution which has weak base and its salt

$$\underset{200\,ml}{NH_4OH} + \underset{100\,ml}{HCl} \longrightarrow \underset{Salt}{NH_4Cl} + H_2O + \underset{(100\,ml\ weak\ base)}{NH_4OH}$$

i.e.,[Option (c)]

7. $BF_3 \rightarrow$ elctron deficient $\rightarrow$ Lewis acid

$PF_3 \rightarrow$ electron rich $\rightarrow$ lewis base

$CF_4 \rightarrow$ neutral $\rightarrow$ neither lewis acid nor base

$SiF_4^- \rightarrow$ neutral $\rightarrow$ neither lewis acid nor base

[option (b)]

8. $BF_3 \rightarrow$ elctron deficient $\rightarrow$ Lewis acid

$PF_3 \rightarrow$ electron rich $\rightarrow$ lewis base

$CO \rightarrow$ having lone pair of electron $\rightarrow$ lewis base

$F^- \rightarrow$ unshared pair of electron $\rightarrow$ lewis base

[option (a)]

9. $HCOONa + H\cdot OH \rightleftharpoons \underset{\text{strong base}}{NaOH} + \underset{\text{weak acid}}{H\text{-}COOH}$

Basic in nature.

$$C_6H_5NH_3Cl^- + H\cdot OH \rightleftharpoons \underset{acidic}{H_3O^+} + C_6H_5\text{-}NH_2 + Cl^-$$

$$KCN + H - OH \rightleftharpoons \underset{\text{strong base}}{KOH} + \underset{\text{weak acid}}{HCN}$$

basic

[option (b)] basic, acidic, basic is correct.

10. $C_5H_5N + H\text{-}OH \rightleftharpoons C_5H_5\overset{+}{N}H + OH^-$

$$\frac{\alpha^2 C}{1-\alpha} = K_b$$

$$\alpha^2 C \approx K_b$$

$$\alpha = \sqrt{\frac{K_b}{C}} = \sqrt{\frac{1.7\times10^{-9}}{0.1}}$$

$$= \sqrt{1.7}\times10^{-4}$$

Percentage of dissociation $= \sqrt{1.7 \times 10^{-4} \times 100}$

$= 1.3 \times 10^{-2} = 0.013\ \%$

[Option (b)]

11. $pH = -\log_{10}[H^+]$

$\therefore [H^+] = 10^{-pH}$

Let the volume be x mL

$V_1M_1 + V_2M_2 + V_3M_3 = VM$

$\therefore$ x mL of 10^{-1}M + x mL of 10^{-2}M + x mL of 10^{-3} M

= 3x mL of $[H^+]$

$$\therefore [H^+] = \frac{x[0.1+0.01+0.001]}{3x}$$

$$= \frac{0.1+0.01+0.001}{3}$$

$$= \frac{0.111}{3}$$

$= 0.037$

$= 3.7 \times 10^{-2}$

[Option (a)]

12. $AgCl_{(s)} \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

$\underset{0.1\ M}{NaCl} \longrightarrow \underset{0.1\ M}{Na^+} + \underset{0.1\ M}{Cl^-}$

$K_{sp} = 1.6 \times 10^{-10}$

$K_{sp} = [Ag^+][Cl^-]$

$K_{sp} = (s)(s+0.1)$

$0.1 >>> s$

$\therefore s + 0.1 \simeq 0.1$

$$\therefore S = \frac{1.6 \times 10^{-10}}{0.1} = 1.6 \times 10^{-9}$$

[Option (b)]

13. $PbI_2(s) \rightleftharpoons Pb^{2+}(aq) + 2I^-(aq)$

$K_{sp} = (s)(2s)^2$

$3.2 \times 10^{-8} = 4s^3$

$$s = \left(\frac{3.2 \times 10^{-8}}{4}\right)^{1/3}$$

$= (8 \times 10^{-9})^{1/3}$

$= 2 \times 10^{-3}$M [Option (a)]

14. Addition of salt KY (having a common ion Y^-) decreases the solubility of MY and NY_3 due to common ion effect.

Option (a) and (b) are wrong.

For salt MY , $MY \rightleftharpoons M^+ + Y^-$

$K_{sp} = (s)(s)$

$6.2 \times 10^{-13} = s^2$

$\therefore s = \sqrt{6.2 \times 10^{-13}} \simeq 10^{-7}$

for salt NY_3,

$NY_3 \rightleftharpoons N^{3+} + 3Y^-$

$K_{sp} = (s)(3s)^3$

$K_{sp} = 27s^4$

$$s = \left(\frac{6.2 \times 10^{-13}}{27}\right)^{1/4}$$

$s. \simeq 10^{-4}$

The molar solubility of MY in water is less than of NY_3

[Option (d)]

15. x ml of 0.1 M NaOH + x ml of 0.01 M HCl

No of moles of NaOH = $0.1 \times x \times 10^{-3} = 0.1x \times 10^{-3}$

No of moles of HCl = $0.01 \times x \times 10^{-3} = 0.01x \times 10^{-3}$

No of moles of NaOH after mixing = $0.1x \times 10^{-3} - 0.01x \times 10^{-3}$

$= 0.09x \times 10^{-3}$

$$\text{Concentration of NaOH} = \frac{0.09x \times 10^{-3}}{2x \times 10^{-3}} = 0.045$$

$[OH^-] = 0.045$

$P^{OH} = -\log(4.5 \times 10^{-2})$

$= 2 - \log 4.5$

$= 2 - 0.65 = 1.35$

$pH = 14 - 1.35 = 12.65$

16. $K_a = 1\times10^{-3}$

$pH = 4$

$\frac{[salt]}{[Acid]} = ?$

$pH = pK_a + \log\frac{[Salt]}{[Acid]}$

$4 = -\log_{10}(1\times10^{-3}) + \log\frac{[Salt]}{[Acid]}$

$4 = 3 + \log\frac{[Salt]}{[Acid]}$

$1 = \log_{10}\frac{[Salt]}{[Acid]}$

$\Rightarrow \frac{[Salt]}{[Acid]} = 10^1$

i.e., $\frac{[Acid]}{[Salt]} = \frac{1}{10}$

1:10

[Option (d)]

17. $\underset{10^{-5}m}{KOH} \rightarrow \underset{10^{-5}m}{K^+} + \underset{10^{-5}m}{OH^-}$

$[OH^-] = 10^{-5}M.$

$pH = 14 - pOH$

$pH = 14 - \left(-\log\left[OH^-\right]\right)$

$= 14 + \log[OH^-]$

$= 14 + \log 10^{-5}$

$= 14 - 5$

$= 9.$

[Option (a)]

18. $\underset{\text{acid 1}}{H_3PO_4} + \underset{\text{base 1}}{H-OH} \rightleftharpoons \underset{\text{acid 2}}{H_3O^+} + \underset{\text{base 2}}{H_2PO_4^-}$

$\therefore H_2PO_4^-$ is the conjugate base of H_3PO_4

[Option (c)]

19. HPO_4^{2-} can have the ability to accept a proton to form $H_2PO_4^-$.

It can also have the ability to donate a proton to form PO_4^{-3}

[Option (c)]

20. $pH = -\log_{10}[H^+]$

$\therefore [H^+] = 10^{-pH}$

$= 10^0 = 1$

$[H^+] = 1M$

The solution is strongly acidic

[Option (b)]

21. According to Henderson equation

$pH = pK_a + \log\frac{[salt]}{[acid]}$

ie. $-\log[H^+] = -\log K_a + \log\frac{[salt]}{[acid]}$

$-\log[H^+] = \log\frac{[salt]}{[acid]} \times \frac{1}{K_a}$

$\log\frac{1}{[H^+]} = \log\frac{[salt]}{[acid]} \times \frac{1}{K_a}$

$\therefore [H^+] = K_a\frac{[acid]}{[salt]}$

[option (a)]

22. $h = \sqrt{\frac{K_h}{K_a.K_b}}$

[Option (c)]

23. $K_h = \frac{K_w}{K_b} = \frac{1\times10^{-14}}{1.8\times10^{-5}}$

$= 0.55\times10^{-9}$

$= 5.5\times10^{-10}$

[option (b)]

Key answer for short answer question

8. Concentration of HNO_3 = 0.04M

$[H_3O^+]=0.04 \text{ mol dm}^{-3}$

$pH=-\log[H_3O^+]$

$=-\log(0.04)$

$=-\log(4\times10^{-2})$

$=2-\log4$

$=2-0.6021$

$=1.3979 = 1.40$

14. $Ba(OH)_2 \rightarrow Ba^{2+}+2OH^-$

$1.5\times10^{-3}M \qquad 2\times1.5\times10^{-3}M.$

$[OH^-] = 3\times10^{-3}M$

$[\because pH+pOH=14]$

$pH= 14-pOH$

$pH= 14- \left(-\log [OH^-]\right)$

$= 14+ \log [OH^-]$

$=14+\log(3\times10^{-3})$

$=14 + \log 3 + \log 10^{-3}$

$= 14 + 0.4771 - 3$

$=11+0.4771$

$pH=11.48$

15. Number of moles of $HNO_3 = 0.05 \times 50 \times 10^{-3}$

$=2.5 \times 10^{-3}$

Number of moles of $KOH = 0.025 \times 50 \times 10^{-3}$

$= 1.25 \times 10^{-3}$

Number of moles of HNO_3 after mixing

$= 2.5 \times 10^{-3} - 1.5 \times 10^{-3}$

$= 1.25 \times 10^{-3}$

$\therefore$ concentration of $HNO_3 = \dfrac{\text{Number of moles of } HNO_3}{\text{Volume is litre}}$

After mixing, total volume = 100 ml = 100×10^{-3}L

$\therefore [H^+]=\dfrac{1.25\times10^{-3}\text{moles}}{100\times10^{-3}\text{L}}$

$=1.25\times10^{-2}$ moles L^{-1}

$pH = -\log [H^+]$

$pH = -\log(1.25\times10^{-2}) = 2 - 0.0969$

$= 1.9031$

16. Given

$K_a=10^{-9}$

$c=0.4M$

$pH=-\log[H^+]$

$[H^+]=\sqrt{K_a \times c.}$

$=\sqrt{10^{-9}\times0.4}$

$=2\times10^{-5}$

$\therefore pH= -\log(2\times10^{-5})$

$=5-\log2$

$=5-0.3010$

$=4.699.$

17. $h = \sqrt{K_h} = \sqrt{\dfrac{K_W}{K_aK_b}} = \sqrt{\dfrac{1\times10^{-14}}{1.8\times10^{-5}\times1.8\times10^{-5}}}$

$= \sqrt{\dfrac{1}{1.8}\times10^{-4}}$

$= 0.7453\times10^{-2}$

$pH = \frac{1}{2} pK_w + \frac{1}{2} pK_a - \frac{1}{2} pK_b$

Given that $K_a = K_b = 1.8 \times 10^{-5}$

if $K_a = K_b$, then, $pK_a = pK_b$

$\therefore pH = \frac{1}{2} pK_w = \frac{1}{2} (14) = 7$

19. Given that $K_{sp} = 1 \times 10^{-12}$

$$\underset{s}{Ag_2CrO_4}(s) \rightleftharpoons \underset{2s}{2Ag^+_{(aq)}} + \underset{s}{CrO_4^{-2}}(aq)$$

$$\underset{0.01M}{AgNO_3}(s) \rightleftharpoons \underset{0.01M}{Ag^+_{(aq)}} + \underset{0.01M}{NO_3^-}(aq)$$

$$K_{sp} = [Ag^+]^2\,[CrO_4^{2-}]$$

$$\begin{bmatrix} [Ag^+] = 2s + 0.01 \\ 0.01 >> 2S \\ \therefore\ [Ag^+] = 0.01M \\ [CrO_4^{2-}] = s \end{bmatrix}$$

$$1 \times 10^{-12} = (0.01)^2\ (s)$$

$$(s) = \frac{1 \times 10^{-12}}{(10^{-2})^2} = 1 \times 10^{-8}\,M$$

20. $\underset{s}{Ca_3(PO_4)_2} \rightleftharpoons \underset{3s}{3Ca^{2+}} + \underset{2s}{2PO_4^{3-}}$

$K_{sp} = [Ca^{2+}]^3[PO_4^{3-}]^2$

$K_{sp} = (3s)^3(2s)^2$

$K_{sp} = 27s^3.4s^2$

$K_{sp} = 108s^5$

21. $CaF_2(s) \rightleftharpoons Ca^{2+}_{(aq)} + 2F^-(aq)$

$[F^-] = 2\,[Ca^{2+}] = 2 \times 3.3 \times 10^{-4}M$

$= 6.6 \times 10^{-4}M$

$K_{sp} = [Ca^{2+}][F^-]^2$

$= (3.3 \times 10^{-4})(6.6 \times 10^{-4})^2$

$= 1.44 \times 10^{-10}$

22. $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

x= solubility of AgCl in 1M $AgNO_3$

$$\underset{1M}{AgNO_3}(aq) \rightleftharpoons \underset{1M}{Ag^+}(aq) + NO_3^-(aq)$$

$[Ag^+] = x + 1 \simeq 1M \qquad (\because x << 1)$

$[Cl^-] = x$

$K_{sp} = [Ag^+][Cl^-]$

$1.8 \times 10^{-10} = (1)(x)$

$x = 1.8 \times 10^{-10}\,M$

23. $Ag_2CrO_4(s) \rightleftharpoons 2Ag^+_{(aq)} + CrO_4^{2-}(aq)$

$K_{sp} = [Ag^+]^2[CrO_4^{2-}]$

$= (5 \times 10^{-5})^2(4.4 \times 10^{-4})$

$= 1.1 \times 10^{-12}$

24. $\underset{s}{Hg_2Cl_2} \rightleftharpoons Hg_2^{2+} + \underset{2s}{2Cl^-}$

$K_{sp} = [Hg_2^{2+}][Cl^-]^2$

$= (s)(2s)^2$

$K_{sp} = 4s^3$

25. $\underset{x}{Ag_2CrO_4} \rightleftharpoons \underset{2x}{2Ag^+} + \underset{x}{CrO_4^{2-}}$

x is the solubility

of Ag_2CrO_4 in 0.1M K_2CrO_4

$$\underset{0.1M}{K_2CrO_4} \rightleftharpoons \underset{0.2\ M}{2K^+} + \underset{0.1\ M}{CrO_4^{2-}}$$

$[Ag^+] = 2x$

$[CrO_4^{2-}] = (x + 0.1) \approx 0.1 \qquad \because x << 0.1$

$K_{sp} = [Ag^+]^2[CrO_4^{2-}]$

$1.1 \times 10^{-12} = (2x)^2(0.1)$

$1.1 \times 10^{-12} = 0.4x^2$

$$x^2 = \frac{1.1 \times 10^{-12}}{0.4}$$

$$x = \sqrt{\frac{1.1 \times 10^{-12}}{0.4}}$$

$$x = \sqrt{2.75 \times 10^{-12}}$$

$x = 1.65 \times 10^{-6}M$

26. When two are more solution are mixed, the resulting concentrations are differnet from the original.

Total volume = 0.250L

$$\underset{0.1\ M}{Pb(NO_3)_2} \rightleftharpoons \underset{0.1\ M}{Pb^{2+}} + \underset{0.2\ M}{2NO_3^-}$$

Number of moles

Pb^{2+} = molarity × Volume of the solution in lit

$= 0.1 \times 0.15$

$$[Pb^{2+}]_{mix} = \frac{0.1 \times 0.15}{0.25} = 0.06\ M$$

$$\underset{0.2\ M}{NaCl} \rightleftharpoons \underset{0.2\ M}{Na^+} + \underset{0.2\ M}{Cl^-}$$

No.of moles $Cl^- = 0.2 \times 0.1$

$$[Cl^-]_{mix} = \frac{0.2 \times 0.1}{0.25} = 0.08\ M$$

Precipitation of $PbCl_2$ (s) occurs if

$[Pb^{2+}][Cl^-]^2 > K_{sp}$

$[Pb^{2+}][Cl^-]^2 = (0.06)(0.08)^2$

$= 3.84 \times 10^{-4}$

Since ionic product $[Pb^{2+}][Cl^-]^2 > K_{sp}$, $PbCl_2$ is precipitated

27. $Al(OH)_3 \rightleftharpoons Al^{3+}(aq) + 3OH^-(aq)$

$K_{sp} = [Al^{3+}][OH^-]^3$

$Al(OH)_3$ precipitates when

$[Al^{3+}][OH^-]^3 > K_{sp}$

$(1 \times 10^{-3})[OH^-]^3 > 1 \times 10^{-15}$

$[OH]^3 > 1 \times 10^{-12}$

$[OH^-] > 1 \times 10^{-4} M$

$[OH^-] = 1 \times 10^{-4} M$

$POH = -\log_{10}[OH^-] = -\log(1 \times 10^{-4}) = 4$

pH = 14-4= 10

Thus, Al $(OH)_3$ precipitates at a pH of 10

Evaluate yourself

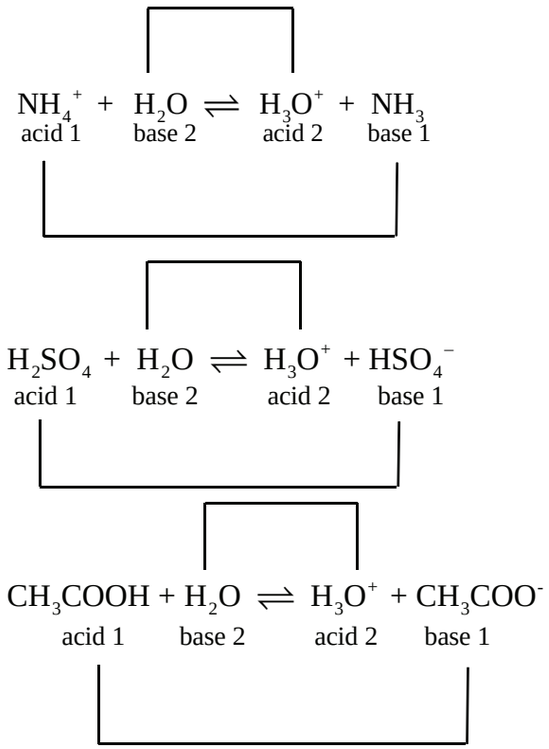
Key

Evaluate yourself – 1

acid : (i) HNO_3 iii) H_3PO_3 iv) CH_3COOH

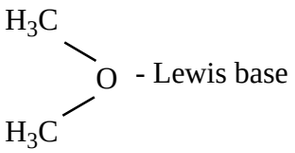
base : ii) Ba $(OH)_2$

Evaluate yourself – 2



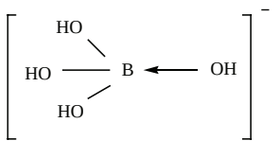
Evaluate yourself – 3

i) CaO - Lewis base ; CO_2 -Lewisacid

ii)  - Lewis base

$AlCl_3$ - Lewis acid

Evaluate yourself – 4

 ; electron pair acceptor - Lewis acid

Evaluate yourself – 5

Given solution is neutral

$\therefore [H_3O^+] = [OH^-]$ Let $[H_3O^+] = x$; then $[OH^-] = x$

$K_w = [H_3O^+][OH^-]$

$4 \times 10^{-14} = x \cdot x$

$x^2 = 4 \times 10^{-14}$

$x = \sqrt{4 \times 10^{-14}} = 2 \times 10^{-7}$

Evaluate yourself – 6

a) Answer

$$\underset{10^{-8}\ M}{H_2SO_4} \xrightarrow{H_2O} \underset{2\times10^{-8}}{2H_3O^+} + \underset{10^{-8}\ M}{SO_4^{2-}}$$

In this case the concentration of H_2SO_4 is very low and hence $[H_3O^+]$ from water cannot be neglected

$\therefore [H_3O^+] = 2\times10^{-8}$ (from H_2SO_4) + 10^{-7} (from water)

$=10^{-8}(2+10)$

$=12\times10^{-8} = 1.2 \times10^{-7}$

$pH = -\log_{10}[H_3O^+]$

$= -\log_{10}(1.2\times10^{-7})$

$=7 - \log_{10}1.2$

$=7 - 0.0791 = 6.9209$

b) Answer

pH of the solution = 5.4

$[H_3O^+]$ = antilog of (-pH)

= anitlog of (-5.4)

= antilog of $(-6 + 0.6) = \bar{6}.6$

$= 3.981\times10^{-6}$

i.e., 3.98×10^{-6} mol dm^{-3}

c) Answer

No of moles of HCl $= 0.2\times 50 \times 10^{-3} = 10 \times 10^{-3}$

No of moles of NaOH $= 0.1 \times 50 \times 10^{-3} = 5 \times 10^{-3}$

No of moles of HCl after mixing $= 10 \times 10^{-3} - 5 \times 10^{-3}$

$= 5 \times 10^{-3}$

after mixing total volume = 100mL

$\therefore$ Concentration of HCl in moles per litre = $\frac{5\times10^{-3}\text{mole}}{100 \times 10^{-3}\text{L}}$

$[H_3O^+] = 5\times10^{-2}$ M

$pH = -\log(5 \times 10^{-2})$

$= 2 - \log 5$

$= 2 - 0.6990$

$= 1.30$

Evaluate yourself - 7

$$\alpha = \sqrt{\frac{K_b}{C}} = \sqrt{\frac{1.8\times10^{-5}}{6\times10^{-2}}}$$

$= \sqrt{3 \times 10^{-4}}$

$= 1.732 \times 10^{-2}$

$= \frac{1.732}{100} = 1.732\%$

Evaluate yourself – 8

a) Answer

Dissociation of buffer components

$$NH_4OH\ (aq) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

$$NH_4Cl \rightarrow NH_4^+ + Cl^+$$

Addition of H+

The added H^+ ions are neutralized by NH_4OH and there is no appreciable decrease in pH.

$$NH_4OH(aq) + H^+ \rightarrow NH_4^+(aq) + H_2O(l)$$

Addition of OH^-

$$NH_4^+(aq) + OH^-(aq) \rightarrow NH_4OH\ (aq)$$

The added OH^- ions react with NH_4^+ to produce unionized NH_4OH. Since NH_4OH is a weak base, there is no appreciable increase in pH

b) Answer

pH of buffer

$$\underset{0.4-\alpha}{CH_3COOH(aq)} \rightleftharpoons \underset{\alpha}{CH_3COO^-(aq)} + \underset{\alpha}{H^+(aq)}$$

$$\underset{0.4}{CH_3COONa(aq)} \longrightarrow \underset{0.4}{CH_3COO^-(aq)} + \underset{0.4}{Na^+(aq)}$$

$$[H^+] = \frac{K_a[CH_3COOH]}{[CH_3COO^-]}$$

$[CH_3COOH] = 0.4 - \alpha \simeq 0.4$

$[CH_3COO^-] = 0.4 + \alpha \simeq 0.4$

$$\therefore [H^+] = \frac{K_a(0.4)}{(0.4)}$$

$[H^+] = 1.8\times10^{-5}$

$\therefore pH = -\log(1.8\times10^{-5}) = 4.74$

Addition of 0.01 mol HCl to 500ml of buffer

$$\text{Added } [H^+] = \frac{0.01 \text{ mol}}{500 \text{ mL}} = \frac{0.01 \text{ mol}}{1/2 \text{ L}}$$

$= 0.02M$

$$\underset{0.4-\alpha}{CH_3COOH(aq)} \rightleftharpoons \underset{\alpha}{CH_3COO^-(aq)} + \underset{\alpha}{H^+(aq)}$$

$$\underset{0.4}{CH_3COONa} \rightarrow \underset{0.4}{CH_3COO^-} + \underset{0.4}{Na^+}$$

$$\underset{(0.02)}{CH_3COO^-} + \underset{0.02}{HCl} \rightarrow \underset{0.02}{CH_3COOH} + \underset{0.02}{Cl^-}$$

$\therefore$ $[CH_3COOH] = 0.4 - \alpha + 0.02 = 0.42 - \alpha \simeq 0.42$

$[CH_3COO^-] = 0.4 + \alpha - 0.02 = 0.38 + \alpha \simeq 0.38$

$$[H^+] = \frac{(1.8 \times 10^{-5})(0.42)}{(0.38)}$$

$[H^+] = 1.99 \times 10^{-5}$

$pH = - \log (1.99 \times 10^{-5})$

$= 5 - \log 1.99$

$= 5 - 0.30$

$= 4.70$

Evaluate yourself – 9

a) answer

$$pOH = pK_b + \log \frac{[salt]}{[base]}$$

We know that

$pH + pOH = 14$

$\therefore 9 + pOH = 14$

$\Rightarrow pOH = 14 - 9 = 5$

$$5 = 4.7 + \log \frac{[NH_4Cl]}{[NH_4OH]}$$

$$0.3 = \log \frac{[NH_4Cl]}{0.1}$$

$$\frac{[NH_4Cl]}{0.1} = \text{antilog of } (0.3)$$

$[NH_4Cl] = 0.1M \times 1.995$

$= 0.1995\ M$

$= 0.2M$

Amount of NH_4Cl required to prepare 1 litre 0.2M solution = Strength of NH_4Cl × molar mass of NH_4Cl

$= 0.2 \times 53.5$

$= 10.70\ g$

10.70 g ammonium chloride is dissolved in water and the solution is made up to one litre to get 0.2M solution. On mixing equal volume of the given NH_4OH solution and the prepared NH_4Cl solution will give a buffer solution with required pH value (pH = 9).

b)answer

$$pH = pK_a + \log \frac{[salt]}{[acid]}$$

$$4 = 3.75 + \log \frac{[\text{sodium formate}]}{[\text{formic acid}]}$$

[Sodium formate] = number of moles of HCOONa

$= 0.6 \times V \times 10^{-3}$

[formic acid] = number of moles of HCOOH

$= 0.8 \times 100 \times 10^{-3}$

$= 80 \times 10^{-3}$

$$4 = 3.75 + \log \frac{0.6V}{80}$$

$$0.25 = \log \frac{0.6V}{80}$$

$$\text{antilog of } 0.25 = \frac{0.6V}{80}$$

$0.6V = 1.778 \times 80$

$= 1.78 \times 80$

$= 142.4$

$$V = \frac{142.4\ mL}{0.6} = 237.33mL$$

Evaluate yourself - 10

Sodium carbonate is a salt of weak acid, H_2CO_3 and a strong base, NaOH, and hence the solution is alkaline due to hydrolysis.

$$Na_2CO_3(aq) \rightarrow 2Na^+(aq) + CO_3^{2-}(aq)$$

$$CO_3^{2-}(aq) + H_2O(l) \rightleftharpoons HCO_3^- + OH^-$$

i) $$h = \sqrt{\frac{K_w}{K_a \times C}}$$

$$= \sqrt{\frac{1 \times 10^{-14}}{5.5 \times 10^{-11} \times 0.05}}$$

$h = 6.03 \times 10^{-2}$

Given that $pK_a = 10.26$

$pK_a = -\log K_a$

i.e., K_a = antilog of $(-pK_a)$

= antilog of (-10.26)

= antilog of (-11 + 0.74)

$= 10^{-11} \times 5.5$

[antilog of 0.74 = 5.49 $\simeq$ 5.5]

ii) $K_h = \frac{K_w}{K_a} = \frac{1 \times 10^{-14}}{5.5 \times 10^{-11}}$

$= 1.8 \times 10^{-4}$

iii) $pH = 7 + \frac{pK_a}{2} + \frac{\log C}{2}$

$= 7 + \frac{10.26}{2} + \frac{\log 0.05}{2} = 7 + 5.13 - 0.65$

$= 11.48$

Unit 9 Electro Chemistry

1. 1F = 96500 C = 1 mole of e^- = 6.023×10^{23} e^-

$\therefore$ 9650 C = $\frac{6.22 \times 10^{23}}{96500} \times 9650 = 6.022 \times 10^{22}$

Option (C)

2. $Mn^{2+} + 2e^- \rightarrow Mn \ (E^\circ_{red}) = -1.18V$

$2\left[Mn^{2+} \rightarrow Mn^{3+} + e^-\right] (E^\circ_{ox}) = -1.51V$

$3Mn^{2+} \rightarrow Mn + 2Mn^{3+} \quad E^\circ_{cell} = ?$

$E^\circ_{cell} = (E^\circ_{ox}) + (E^\circ_{red})$

$= -1.51 - 1.18$ and non spontaneous

$= -2.69V$

Since E° is –ve ΔG is +ve and the given

forward cell reaction is non – spontaneous.

(Option (b))

3. Anodic oxidation: (Reverse the given reaction)

$(E^\circ_{ox}) = 0.76V$ cathodic reduction

$\therefore E^\circ_{cell} = (E^\circ_{ox}) + (E^\circ_{red})$

= 0.76 + 0.34 = 1.1V

(Option (c))

4. $\Lambda = \frac{\kappa}{M} \times 10^{-3} \ mol^{-1} \ m^3$

$= \frac{5.76 \times 10^{-3} \ S \ c \ m^{-1} \times 10^{-3}}{0.5} mol^{-1} \ m^3$

$= \frac{5.76 \times 10^{-3} \times 10^{-3} \times 10^6}{0.5} \ S \ cm^{-1} mol^{-1} \ cm^3.$

$= 11.52 \ S \ cm^2 \ mol^{-1}$

(Option (b))

5. $(\Lambda_\infty)_{HoAC} = \left[(\Lambda^\circ)_{HCl} + (\Lambda^\circ)_{NaOAC}\right] - (\Lambda^\circ)_{NaCl}$

$= (426.2 + 91) - (126.5)$

$= 390.7$

(Option (c))

6. 1F = 96500 C = charge of 1 mole of e^- = $charge\ of\ 6.022 \times 10^{23}$ e^-

(Option (b))

7. $7MnO_4^- + 5e^- \rightarrow Mn^{2+} + 4H_2O$

5 moles of electrons i.e., 5F charge is required.

(Option (a))

8. m=ZIt

$= \frac{40 \times 3.86 \times 2500}{2 \times 96500}$

= 2g

41min 40sec = 2500 seconds

$Z = \frac{m}{n \times 96500} = \frac{40}{2 \times 96500}$

(Option (b))

9. m=ZIt (mass of 1 mole of Cl_2 gas = 71)

$t = \frac{m}{ZI}$ ($\therefore$ mass of 0.1mole of Cl_2 gas = 7.1 g mol^{-1})

$= \frac{7.1}{\frac{71}{2 \times 96500} \times 3} (2\ Cl^- \rightarrow Cl_2 + 2e^-)$

$= \frac{2 \times 96500 \times 7.1}{71 \times 3}$

= 6433.33sec

=107.2 min

(Option (b))

10. $Q = It$

$= 1A \times 60S$

$96500\ C\ \text{charge} \equiv 6.022 \times 10^{23}\ \text{electrons}$

$60\ C\ \text{charge} \equiv \frac{6.022 \times 10^{23}}{96500} \times 60$

$= 3.744 \times 10^{20}\ \text{electrons}$

(Option (C))

11. In general, specific conductance of an electrolyte decreases with dilution. So, 0.002N solution has least specific conductance.

(Option (b))

12. Charging : anode : $PbSO_4(s) + 2e^- \rightarrow Pb\ (s) + SO_4^{-2}(aq)$

Cathode : $PbSO_4(s) + 2H_2O\ (l) \rightarrow PbO_2\ (s) + SO_4^{-2}(aq) + 2e^-$

(Option (C))

13. Option (a) I and IV

14. $E^o_{Zn^{2+}|Zn} = -0.76V$ and $E^o_{Fe^{2+}|Fe} = -0.44V$ Zinc has higher negative electrode potential than iron, iron cannot be coated on zinc.

Option (d)

15. Both are false

i) Dry air has no reaction with iron

ii) Rust has the composition $Fe_2O_3 . x\ H_2O$

(Option (d))

16. (Option (a))

17. $\alpha = \frac{\Lambda}{\Lambda_o} = \frac{6}{400}$

$K_a = \alpha^2 C$

$= \frac{6}{400} \times \frac{6}{400} \times \frac{1}{36}$

$= 6.25 \times 10^{-6}$

Option (b)

18. $R = \rho . \frac{l}{A}$

$\text{cell constant} = \frac{R}{\rho}$

$= \kappa . R \left(\frac{1}{\rho} = \kappa \right)$

$= 1.25 \times 10^{-3}\ \Omega^{-1} cm^{-1} \times 800\ \Omega$

$= 1\ cm^{-1}$

Option (c)

19. Option (d)

20. $E_{cell}=E^{o}_{cell}-\frac{0.0591}{2}\log\frac{[zn^{2+}]}{[Cu^{2+}]}$

$E_1=E^{o}_{cell}-\frac{0.0591}{2}\log\frac{10^{-2}}{1}$

$E_1=E^{o}_{cell}+0.0591.....(1)$

$Zn(s) \rightarrow Zn^{2+}(aq)+2e^{-}$

$Cu^{2+}(aq)+2e^{-} \rightarrow Cu(s)$

$Zn(s)+Cu^{2+}(aq) \rightarrow Zn^{2+}(aq)+Cu(s)$

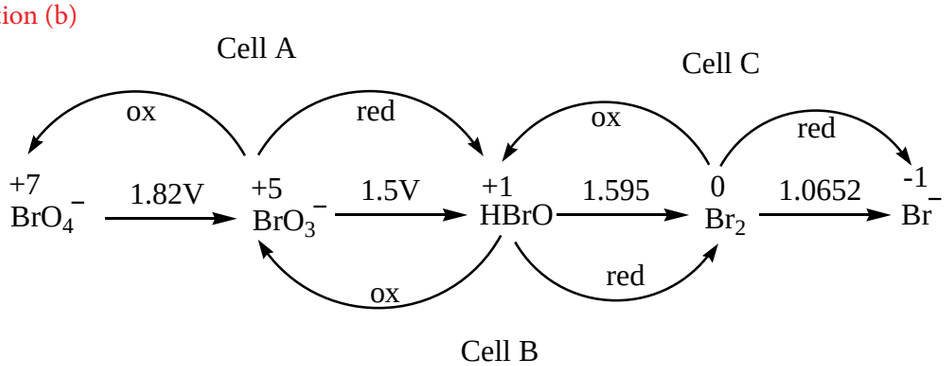
$E_2=E^{o}_{cell}-\frac{0.0591}{2}.\log\frac{1}{10^{-2}}$

$E_2=E^{o}_{cell}-0.0591.....(2)$

$\therefore E_1>E_2$

Option (b)

21.



$(E_{cell})_A=-1.82+1.5=-0.32V$

$(E_{cell})_B=-1.5+1.595=+0.095V$

$(E_{cell})_c=-1.595+1.0652=-0.529V$

$\therefore$ The species undergoing disproportionation is $HBrO$ (Option D)

Short answer

8. Given

$C = 0.01M$ $\quad \lambda^{o}_{cation} = 248.2\ S\ cm^2\ mol^{-1}$

$K= 1.5\times10^{-4}\ S\ cm^{-1}$ $\quad \lambda^{o}_{anion} = 51.8\ S\ cm^2\ mol^{-1}.$

1. Molar conductivity

$\Lambda^{\circ}_{m} = \frac{K(sm^{-1})\times10^{-3}}{C\ (in\ M)}\ mol^{-1}\ m^3$ $\quad K = 1.5\times10^{-4}S\ cm^{-1}$

$= \frac{1.5\times10^{2}\times10^{-3}}{0.01}\ S\ mol^{-1}\ m^2$ $\quad 1\ cm^{-1} = 10^{2}m^{-1}$

$= 1.5\times10^{-3}\ S\ m^2\ mol^{-1}$ $\quad = 1.5\times10^{2}$

2. Degree of dissociation $\alpha = \frac{\Lambda^{\circ}}{\Lambda^{\circ}_{\infty}}$

$\Lambda^{o}_{\infty}=\lambda^{o}_{cation}+\lambda^{o}_{anion}$

$= (248.2+51.8)\ S\ cm^2\ mol^{-1}$

$= 300\ S\ cm^2\ mol^{-1}$

$= 300\times10^{-14}\ s\ m^2\ mol^{-1}$

$$\alpha = \frac{1.5\times10^{-3}\ \text{S m}^2\ \text{mol}^{-1}}{300\times10^{-4}\ \text{S m}^2\ \text{mol}^{-1}}$$

$$\alpha = 0.05$$

$$K_a = \frac{\alpha^2 c}{1-\alpha}$$

$$= \frac{(0.05)^2(0.01)}{1-0.05}$$

$$= \frac{25\times10^{-4}\times10^{-2}}{95\times10^{-2}}$$

$$= 0.26\times10^{-4}$$

$$= 2.6\times10^{-5}.$$

13. Given

$I = 1.608A$; $t = 50\ \text{min} = 50\times60 = 3000S$

$V = 250\ \text{mL}$

$C = 0.5\ \text{M}$

$\eta = 100\%$

Calculate the number of faradays of electricity passed through the $CuSO_4$ solution

$\Rightarrow Q = It$

$Q = 1.608\times3000$

$Q = 4824C$

$\therefore$ number of Faradays of electicity $= \frac{4824\ \text{C}}{96500\ \text{C}} = 0.05\text{F}$

Electrolysis of $CuSO_4$

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s).$

The above equation shows that 2F electricity will deposit 1 mole of Cu^{2+} to Cu.

$\therefore$ 0.05F electricity will

deposit $\frac{1\text{mol}}{2\text{F}}\times0.05\text{F} = 0.025\ \text{mol}$

Initial number of molar of Cu^{2+} in 250 ml of solution $= \frac{0.5}{1000\ \text{mL}}\times250\text{mL}$

$= 0.125\ \text{mol}$

$\therefore$ number of moles of Cu^{2+} after electrolysis $= 0.125 - 0.025$

$= 0.1\ \text{mol}$

$\therefore$ Concentration of $Cu^{2+} = \frac{0.1\ \text{mol}}{250\ \text{mL}}\times1000\ \text{mL}$

$= 0.4\ \text{M}$

14. Required half cell reaction

$2\,Br^- \rightarrow Br_2 + 2e^-$ $\quad (E^\circ_{ox}) = -1.09V$

$2\,Fe^{3+} + 2e^- \rightarrow 2Fe^{2+}$ $\quad (E^\circ_{red}) = +0.771V$

$2Fe^{3+} + 2Br^- \rightarrow 2Fe^{2+} + Br_2$ $\quad (E^\circ_{cell}) = ?$

$$E^{\circ}_{cell} = \left(E^{\circ}_{ox}\right) + \left(E^{\circ}_{red}\right)$$
$$= -1.09 + 0.771$$
$$= -0.319V$$

E°_{cell} is – ve; ΔG is +ve and the cell reaction is non spontaneous. Hence Fe^{3+} cannot oxidises Br^{-} to Br_2 .

15. $\left(E^{\circ}_{ox}\right)_{Fe|Fe^{2+}} = 0.44V$ and $\left(E^{\circ}_{red}\right)_{Cu^{2+}|Cu} = 0.34V$.

These +ve emf values shows that iron will oxidise and copper will get reduced i.e., the vessel will dissolve. Hence it is not possible to store copper sulphate in an iron vessel.

16. Metals having higher oxidation potential will liberate H_2 from H_2SO_4 . Hence, the metal M_1 having $+ xV,$ oxidation potential will liberate H_2 from H_2SO_4 .
17. oxidation potential of M_1 is more +ve than the oxidation potential of Fe which indicates that it will prevent iron from rusting
18. Cell reactions:

Oxidation at anode: $Cd\,(s) \rightarrow Cd^{2+}(aq) + 2e^{-}$ $\qquad \left(E^{\circ}_{ox}\right)_{Cd|Cd^{2+}} = 0.4V$

Reduction at cathode: $Cu^{2+}(aq) + 2e^{-} \rightarrow Cu\,(s)$ $\qquad \left(E^{\circ}_{red}\right)_{Cu^{2+}|Cu} = 0.34V$

$$Cd(s) + 2e^{-} \rightarrow Cd^{2+}(aq) + Cu(s)$$
$$E^{\circ}_{cell} = \left(E^{\circ}_{ox}\right) + \left(E^{\circ}_{red}\right)_{cathode}$$
$$= 0.4 + 0.34$$
$$= 0.74V.$$

emf is +ve, so ΔG is (-)ve, the reaction is feasible.

19. Oxidation at anode:

$2H_2(g) + 4OH^{-}(aq) \rightarrow 4H_2O\,(l) + 4e^{-}$

1 mole of hydrogen gas produces 2 moles of electrons at 25^0C and 1 atm pressure, 1 mole of hydrogen gas occupies = 22.4 litres

$$\therefore \text{ no. of moles of hydrogen gas produced} = \frac{1 \text{ mole}}{22.4 \text{ litres}} \times 44.8 \text{ litres}$$
$$= 2 \text{ moles of hydrogen}$$

$\therefore$ 2 of moles of hydrogen produces 4 moles of electron i.e., 4F charge.

We know that $Q = It$

$$I = \frac{Q}{t}$$
$$= \frac{4F}{10 \text{ mins}}$$
$$= \frac{4 \times 96500 \text{ C}}{10 \times 60 \text{ s}}$$
$$I = 643.33 \text{ A}$$

Electro deposition of copper

$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$

2F charge is required to deposit

1 mole of copper i.e., 63.5 g
If the entire current produced in the fuel cell ie., 4 F is utilised for electrolysis, then
2× 63.5 i.e., 127.0 g copper will be deposited at cathode.

20. $Ni^{2+}(aq) + 2e^{-} \rightarrow Ni\ (s)$

$Cr^{2+}(aq)+3e^{-} \rightarrow Cr\ (s)$

The above reaction indicates that 2F charge is required to deposit 58.7g of Nickel form nickel nitrate and 3F charge is required to deposit 52g of chromium.

Given that 2.935 gram of Nickel is deposited

$\therefore$ The amount of charge passed through the cell $= \frac{2F}{58.7g} \times 2.935g$

$= 0.1F$

$\therefore$ if 0.1F charge is passed through chromium nitrate the amount of chromium deposited

$= \frac{52g}{3F} \times 0.1F$

$= 1.733g$

21. Given that

$\left[Cu^{2+}\right] = 0.1M$

$E^{\circ}_{Cu^{2+}|Cu} = 0.34$

$E_{cell} = ?$

Cell reaction is

$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu\ (s)$

$$E_{cell} = E^{o} - \frac{0.0591}{n} \log \frac{[Cu]}{\left[Cu^{2+}\right]}$$

$$= 0.34 - \frac{0.0591}{2} \log \frac{1}{0.1}$$

$$= 0.34 - 0.0296$$

$$= 0.31V$$

22. oxidation at anode

$Mg \rightarrow Mg^{2+} + 2e^{-}$.....(1) $\left(E^{o}_{ox}\right) = 2.37V$

Reduction at cathode

$Ag^{+} + e^{-} \rightarrow Ag$ ..... (2) $\left(E^{o}_{red}\right) = 0.80V$

$\therefore\ E^{o}_{cell} = \left(E^{o}_{ox}\right)_{anode} + \left(E^{o}_{red}\right)_{cathode}$

$= 2.37 + 0.80$

$= 3.17V$

Overall reaction

Equation (1) + 2 × equation $(2) \Rightarrow$

$Mg + 2Ag^{2+} \rightarrow Mg^{2+} + 2Ag$

$\Delta G^\circ = -nfE^\circ$

$= -2 \times 96500 \times 3.17$

$= -611810$ J

$\Delta G^o = -6.12 \times 10^5$ J

$W = 6.12 \times 10^5$ J

$\Delta G^o = -2.303\ RT \log^K C$

$\Rightarrow \log K_c = \dfrac{6.12 \times 10^5}{2.303 \times 8.314 \times 298}$

K_c = Antilog of (107.2)

23. Electrolysis of water

At anode:

$2H_2O \rightarrow 4H^+ + O_2 + 4e^-$.....(1)

At cathode:

$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

Overall reaction $6H_2O \rightarrow 4H^+ + 4OH^- + 2H_2 + O_2$

(or)

Equation (1) +(2) $\times 2 \Rightarrow 2H_2O \rightarrow 2H_2 + O_2$

$\therefore$ According to faradays Law of electrolysis, to electrolyse two mole of Water $(36g \simeq 36\ mL\ of\ H_2O)$, 4F charge is required alternatively, when 36 mL of water is electrolysed, the charge generated = 4×96500 C.

$\therefore$ When the whole water which is available on the lake is completely electrolysed the amount of charge generated is equal to $\dfrac{4 \times 96500\ C}{36\ mL} \times 9 \times 10^{12} L$

$= \dfrac{4 \times 96500 \times 9 \times 10^{12}}{36 \times 10^{-3}} C$

$= 96500 \times 10^{15}$ C

$\therefore$ Given that in 1 second, 2×10^6 C is generated therefore, the time required to generate

96500×10^{15} C is $= \dfrac{1\ S}{2 \times 10^6 C} \times 96500 \times 10^{15} C$

$= 48250 \times 10^9$ S

$\therefore$ Number of years $= \dfrac{48250 \times 10^9}{365 \times 24 \times 60 \times 60}$

$= 1.5299 \times 10^6$ years

1 year = 365 days

$= 365 \times 24$ hours

$= 365 \times 24 \times 60$ min

$= 365 \times 24 \times 60 \times 60$ sec.

Unit 10 Surface Chemistry

S.No.	Answers
1.	(c) $\frac{x}{m}=k.p^{1/n}$ $\Rightarrow \log(\frac{x}{m})=\log k+\frac{1}{n}\log p$ $y=c+mx$ $\quad m=\frac{1}{n}$ and $c=\log k$
2.	The incorrect statement is option (b) Physisorption is an exothermic process. Hence increase in temperature decreases the physisorption.
3.	(d) Adsorption leads to decrease in randomness (entropy).i.e. $\Delta S< 0$ for the adsorption to occur, ΔG should be -ve. We know that $\Delta G=\Delta H-T\Delta S$ if ΔS is -ve, $T\Delta S$ is +ve. It means that ΔG will become negative only when ΔH is -ve and $\Delta H>T\Delta S$

4.	(c) dispersion medium-gas dispersed phase-liquid	13.	pyroxylin(nitro cellulose)
5.	(a) (Hardy-Schulze rule)	14.	(d) Both reactant and catalyst are in same phase. i.e(l)
6.	(b)	15.	(a)
7.	(b) Emulsion dispersed phase Dispersion medium -liquid	16.	(a) coagulating power $\alpha\frac{1}{\text{coagulation value}}$
8.	(b) Gel-butter	17.	(d) ΔS is -ve
9.	(d) As_2S_3 is a -vely charged colloid. It will be most effectively coagulated by the cation with greater valency. i.e., Al^{3+}.	18.	(d)
10.	(b)	19.	(a)
11.	(d) Tyndall effect-scattering of light	20.	(d)
12.	(b)		

Unit 11 Alcohols and Ethers

Key answer

1. $2\ R - OH + 2Na \rightarrow 2\ RONa + H_2\uparrow$ 2 moles of alcohol gives 1 mole of H_2 which occupies 22.4L at 273K and 1 atm

$$\therefore \text{ number of moles of alcohol} = \frac{2 \text{ moles of R - OH}}{22.4\,\text{L of } H_2} \times 560 \text{ mL}$$

$$= 0.05 \text{ moles}$$

$$\therefore \text{ no. of moles} = \frac{\text{mass}}{\text{molar mass}}$$

$$\Rightarrow \text{ molar mass} = \frac{3.7}{0.05} = 74 \text{ g mol}^{-1}$$

General formula for R - OH $C_n\ H_{2n+1}$ - OH

$$\therefore n(12) + (2n+1)(1) + 16+1=74$$

$$14n = 74 - 18$$

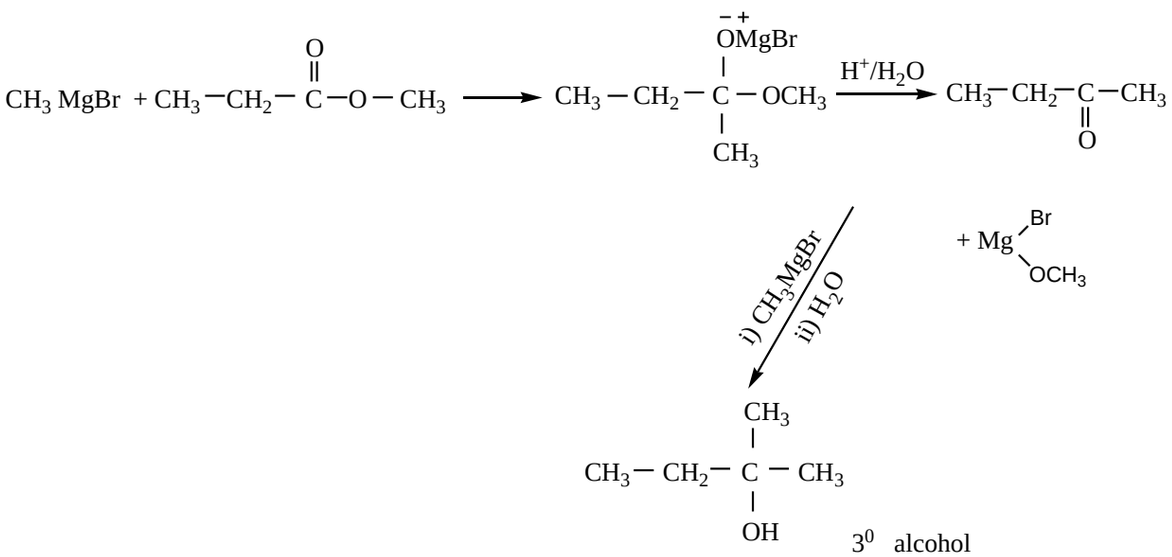
$$14n = 56$$

$$\therefore n = \frac{56}{14} = 4$$

The 2° alcohol which contains 4 carbon is $CH_2CH(OH)CH_2CH_3$

Option (a)

2.

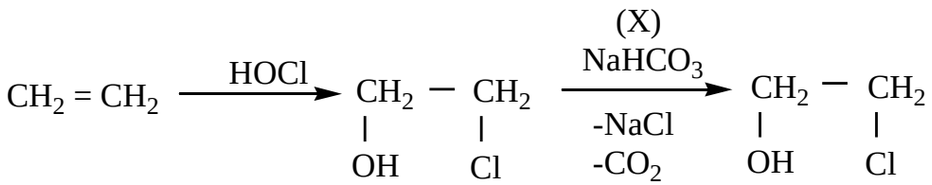


Option (c)

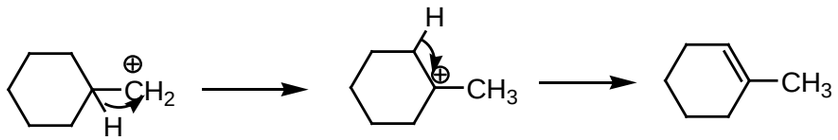
3. Hydro boration – Anti markownikoft product i.e., $CH_3 - CH_2 - CH - CH_2 - CH_2 - OH$

Option (a)

4.



5. (c) 4 – nitrophenol
6. Option (b) saytzeff rule

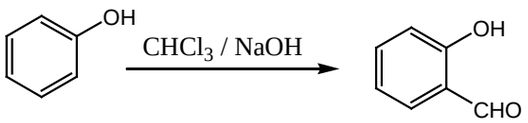


major product

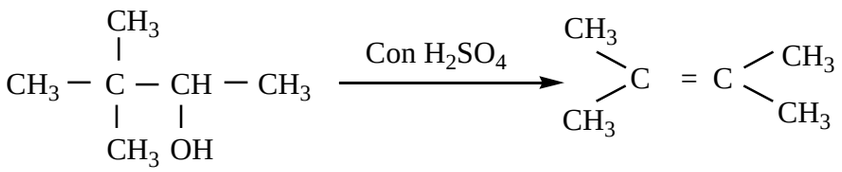
7. Carbolic acid is

   a) phenol

8. Riemer – Tiemann reaction (option (c))



9.

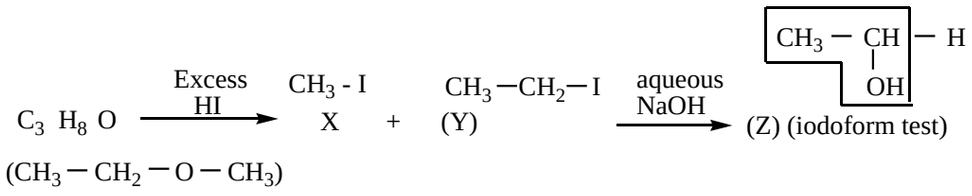


Option (b)

10. Option (a)
11. Option (a)
12. $CH_3 - CH_2 - OH \xrightarrow{PCl_5} CH_3 - CH_2 - Cl \xrightarrow{ale.KOH} CH_2 = CH_2 \xrightarrow{H_2SO_4/H_2O} CH_3 - CH_2 - OH$

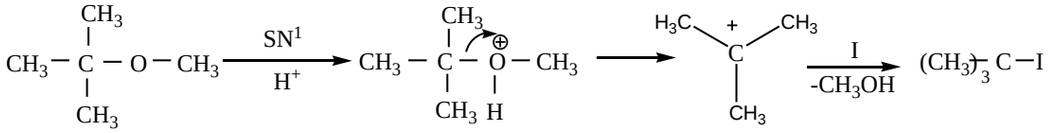
    (Z) ethanol

13. Cyclic alcohol → sodium cyclic alkoxide → williamson ether synthesis option (c)
14. Option (d) phenol
15. Option (A)
16. Option (c)
17. Option (d)
18. Option (C)
19.



Option (D)

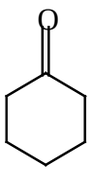
20.



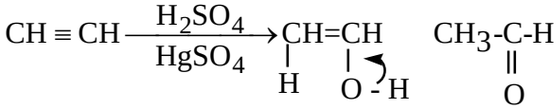
21. Option (b) SN^2 reaction
22. Violet color option (b)

Unit 12 Carbonyl Compounds and Carboxylic Acids

Key Answers



1. Option (b)
2. (d)
3. (c)
4. (b)



(X)

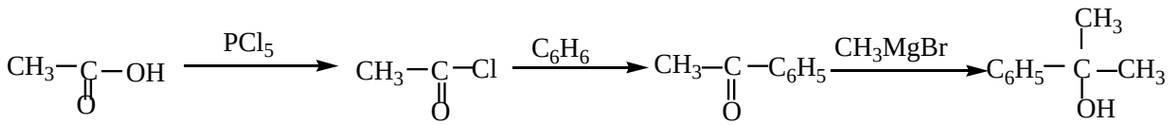
(x) reduces tollens reagent and Fehling solution and it also answers iodoform test.

5) (c)

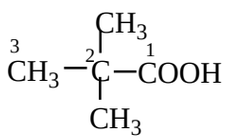
X-HCHO

$Y\text{-}(CH_2)_6N_4$

6)



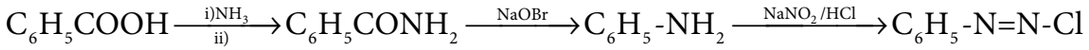
7)



8) (a)

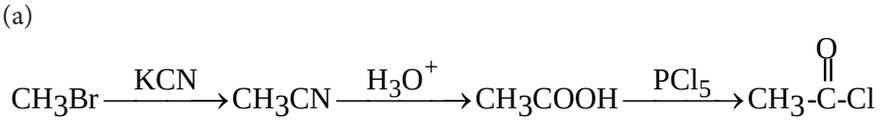
-I effect increases the acidity. If electronegativity is high, -I effect is also high.

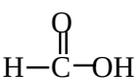
9) (c)



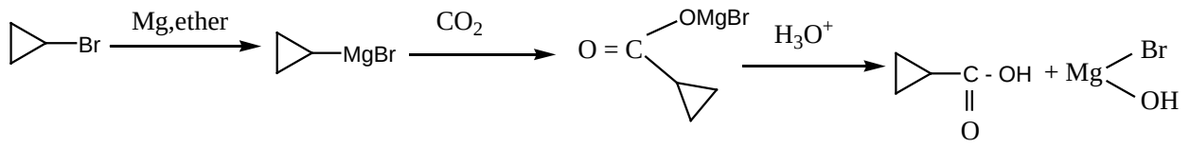
(A) (B)

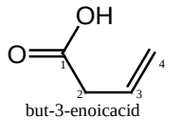
10. (c)
11. (a)



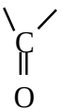
12. (a) formic acid 

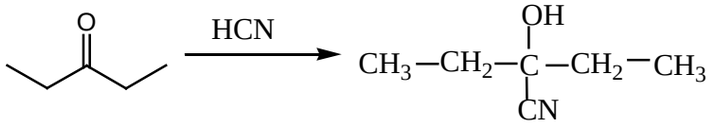
13. (b)

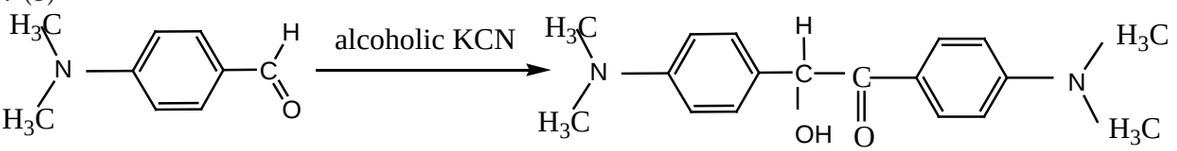


14. (a) 

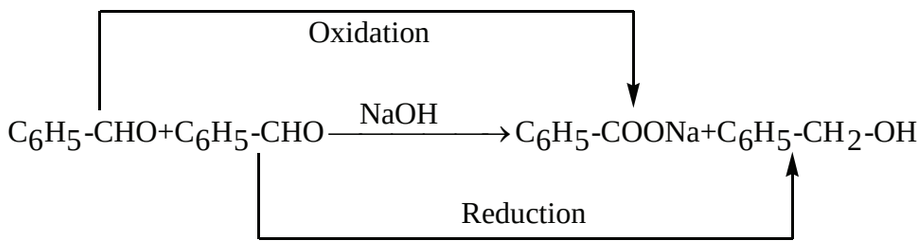
but-3-enoicacid

15. (d)  group is reduced to CH_2 - (Wolff-kishner reduction)

16. (a) 

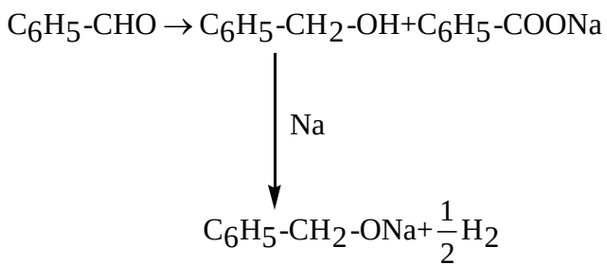
17. (b) 

18. (b) Cannizaro reaction

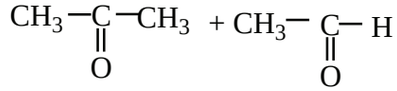
19 (a) 

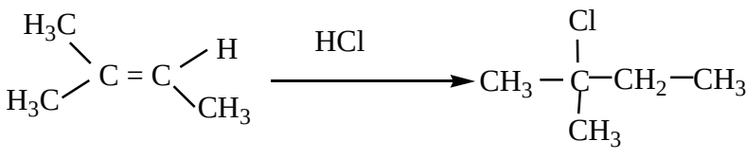
20(b). Fehling's solution

21. (c)



22. (d) Wolf kisher reduction

23. (c) 

alkene 

24.(d) formation of intermolecular H-bonding

Unit – 13 Organic Nitrogen compounds

1. Option (a)
2. Option (b)
3. Option (a) only primary amides undergo hoffmann bromamide reaction
4. Option (d) both are wrong
5. $CH_3CH_3Br \xrightarrow{\text{aq NaOH}} CH_3CH_2\text{-}OH \xrightarrow{KMnO_4} CH_3\text{-}COOH \xrightarrow{NH_3} CH_3CONH_2 \xrightarrow{Br_2/NaOH} CH_3\text{-}NH_2$

   Option (c)
6. Option (c) 3° nitroalkane
7. Option (c)
8. Option (c) Suhiff's base
9. Option (b) p – nitrosation takes places, the product is $(CH_3)_2N$–C$_6$H$_4$–NO

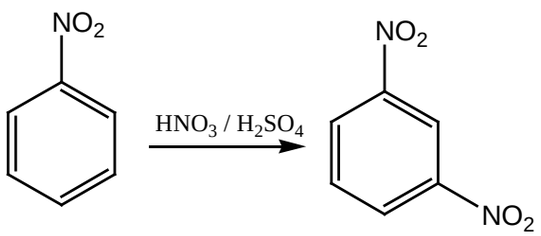
10. $C_6H_5NH_2 + CH_3COOCOCH_3 \longrightarrow C_6H_5NHCOCH_3$

    acetanilide

11. Option (d)
12. Option (a)
13. Option (a)

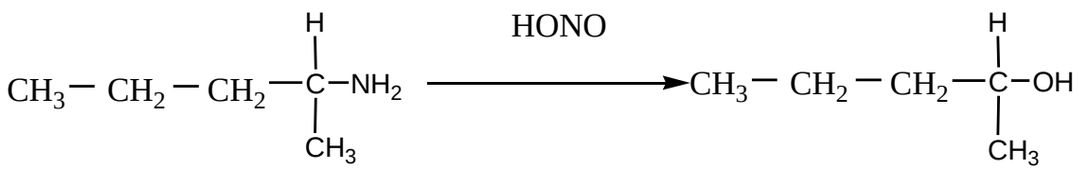
$$C_6H_5NO_2 \xrightarrow{Fe/HCl} C_6H_5NH_2 \xrightarrow{NaNO_2\ /\ Hcl} C_6H_5\text{-}N_2Cl \xrightarrow{H_2O} C_6H_5\text{-}OH + N_2\uparrow + HCl$$

14. (d)



1,3 - dinitrobenzene

15. (b)



16. Option (b) blue solution

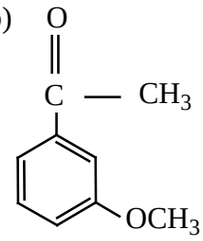
17. (d) triethyl amine (3° amine)

18. Option (b) CH_3 is a+I group, all other – I group. +I group increase the electron density on NH_2 and hence increases the basic nature.

19. Option (a) Ethanol, ammonium hydroxide

20. Option (d)

21. b)



22. (b) $C_6H_5COONH_4 \xrightarrow[\text{Heat}]{P_2O_5} C_6H_5\text{-}C \equiv N \xrightarrow{LiAlH_4} C_6H_5CH_2NH_2 \xrightarrow{HNO_2} C_6H_5CH_2OH$

23. Option (a)

Unit 9 Electro chemistry

1. (c) 2. (b) 3. (c) 4. (b) 5. (c) 6. (b) 7. (a) 8. (b) 9. (b) 10. (c) 11. (b) 12. (c)
13. (a) 14. (d) 15.(d) 16. (a) 17. (b) 18. (c) 19.(d) 20. (b) 21.(d) 22. (a) 23. (b) 24. (a)
25. (a)

Unit 10 – Surface Chemistry

1. (c) 2.(b) 3.(d) 4. (c) 5. (a) 6. (b) 7. (b) 8.(b) 9.(d) 10.(b) 11. (d) 12. (b)
13. (d) 14. (d) 15. (a) 16. (a) 17. (d) 18. (d) 19. (a) 20. (d)

Unit – 11 – Alcohols and Ethers

1. (a) 2. (c) 3. (a) 4. (c) 5. (c) 6.(b) 7.(a) 8.(c) 9.(b) 10.(a) 11.(a) 12.(d)
13. (c) 14. (d) 15. (a) 16.(c) 17.(d) 18.(c) 19.(d) 20.(a) 21.(b) 22. (b)

Unit – 12 Carbonyl Compounds and Carboxylic Acids

1. (b) 2. (d) 3. (c) 4. (b) 5. (c) 6. (a) 7.(a) 8.(a) 9. (c) 10. (c) 11. (a) 12.(a)
13. (b) 14. (a) 15. (d) 16. (a) 17.(b) 18.(b) 19. (a) 20.(b) 21. (c) 22. (d) 23.(c) 24. (d)

Unit – 13 Organic Nitrogen compounds

1. (a) 2. (b) 3. (a) 4. (d) 5. (c) 6. (c) 7.(c) 8.(c) 9. (b) 10. (d) 11. (d) 12.(a)
13. (a) 14. (d) 15. (b) 16. (b) 17.(d) 18.(b) 19. (a) 20.(d) 21. (b) 22.(b) 23.(a) 24. (b)
25. (b)

Unit – 14 Bio molecules

1. (c) 2. (d) 3. (b) 4. (a) 5. (a) 6. (c) 7. (a) 8. (c) 9. (d) 10. (d) 11. (d) 12. (d)
13. (a) 14. (c) 15. (c) 16. (d) 17. (d) 18. (d) 19. (c) 20. (b) 21. (a) 22. (c) 23. (b)
24. (d) 25. (d)

Unit – 15 Chemistry in Action

1. (c) 2. (a) 3. (a) 4. (a) 5.(d) 6.(c) 7. (a) 8. (c) 9. (a) 10.(d) 11. (d) 12. (c)
13.(d) 14.(b) 15. (d)

Glossary - கலைச்சொற்கள்

Absorption	உட்கவர்தல்
Acid Anhydride	அமிலநீரிலி
Active Sites	கிளர்வு மையங்கள்
Acylation	அசைலேற்றம்
Adhesives	ஒட்டும் தன்மையுடைய பொருள்
Adsorbate	பரப்புகவரப்பட்ட பொருள்
Adsorbent	பரப்புகவர்பொருள்
Adsorption	பரப்புகவர்தல்
Aldol Condensation	ஆல்டால்குறுக்கம்
Alkylation	ஆல்கைலேற்றம்
Analgesic	வலிநிவாரணி
Anesthetic	மயக்கமருந்து
Anode	நேர்மின்முனை
Antacid	அமிலநீக்கி
Antagonists	எதிர்வினையூக்கி
Antibiotics	எதிர்உயிரிகள்
Antiseptic	புரைதடுப்பான்
Anxiety	பதற்றம்
Auto Catalyst	தன் வினைவேகமாற்றி
Basicity	காரத்தன்மை
Benzoylation	பென்சாயிலேற்றம்
Biological Specimen	உயிரியல் மாதிரிகள்
Bromination	புரோமினேற்றம்
Carrier Proteins	கடத்துபுரதங்கள்
Catalytic Poison	வினைவேகமாற்றியின் நச்சு
Cataphoresis	மின்முனைக் கவர்ச்சி
Cathode	எதிர்மின்முனை
Cell Constant	கலமாறிலி
Cell Membrane	செல்சவ்வு

Chemisorption	வேதிப்பரப்புகவர்ச்சி
Cinnamon	லவங்கப்பட்டை
Coagulation	கூழ்மவீபடிவாதல்
Coal Tar	நிலக்கரித்தார்
Co-Enzyme	நொதிசெயல் உயர்த்தி
Concentration Cell	செறிவு மின்கலன்
Conductance	மின் கடத்துத்திறன்
Convulsions	வலிப்பு
Coupling Reaction	இணைப்புவினை
Current Efficiency	மின்னாற் வீழ்படிவாக்குத்திறன்
Decarboxylation	கார்பாக்ஸில் நீக்கம்
Dehydration	நீர்நீக்கம்
Dehydrogenation	ஹைட்ரஜன் நீக்கம்
Denaturation	இயல்பு நீக்கம்
Desorption	பரப்பு நீக்குதல்
Detergents	அழுக்கு நீக்கிகள்
Dialysis	கூழ்மபிரிப்பு
Diazotisation	டையசோஆக்கல்
Disinfectant	தொற்றுநீக்கி
Double Decomposition	இரட்டைச் சிதைவு
Drugs	பலபடிகள்
Electrochemical Equivalent	மின்வேதிச் சமானநிறை
Electrochemical Series	மின்வேதி வரிசை
Electrode	மின்முனை
Electrode Potential	மின்முனை மின்னழுத்தம்
Electrolysis	மின்னாற்பகுத்தல்
Electrolyte	மின்பகுளி
Electromotive Force	மின்னியக்குவிசை
Electrophilic Substitution	எலக்ட்ரான் கவர்பதிலீடு
Electroplating	மின்முலாம்பூசுதல்
Emulsions	பால்மங்கள்

Enzymes	நொதிகள்
Equivalent Conductance	சமானகடத்துத்திறன்
Esterification	எஸ்டராக்கல்
Fatty Acids	கொழுப்பு அமிலங்கள்
Fermentation	நொதித்தல்
Filterability	வடிபடும்தன்மை
Flavoring Agents	வாசனைப்பொருள்
Food Preservatives	உணவு பாதுகாப்பான்
Gel	களிமம் (களி)
Genetic Information	மரபுவழி தகவல்
Half-Cell Reaction	அரைக் கலவினை
Heterogeneity	பலபடித்தானதன்மை
Heterogeneous Catalyst	பலபடித்தான வினைவேகமாற்றி
Homogeneous Catalyst	ஒருபடித்தான வினைவேகமாற்றி
Induced Catalyst	தூண்டப்பட்ட வினைவேகமாற்றி
Infinite Dilution	முடிவிலா நீர்த்தல்
Inhibitor	வினைவேகதளர்த்தி
Isotherm	சமவெப்பநிலைக்கோடு
Lyophilic Sol	கரைப்பான் விரும்பும்கூழ்மங்கள்
Lyophobic Sol	கரைப்பான் வெறுக்கும்கூழ்மங்கள்
Miscelles	இணைவுக்கூழ்மம்
Mixed Ethers	கலப்பினஈதர்கள்
Molar Conductance	மோலார் கடத்துத்திறன்
Nitration	நைட்ரோஏற்றம்
Non-Spontaneous Process	தன்னிச்சையற்ற செயல்முறை
Nucleophilic Addition	கருகவர்சேர்ப்பு
Nucleophilic Substitution	கருகவர்பதிலீடு
Ozonolysis	ஓசோனேற்றம்
Peptisation	கூழ்மமாக்கல்
Perfumes	வாசனை திரவியங்கள்
Physisorption	இயற்பரப்புக் கவர்ச்சி

Potential Gradient	மின்னழுத்த வேறுபாடு
Primary Amine	ஓரிணைய அமீன்
Primary Cell	முதன்மை மின்கலன்
Promoter	வினைவேக உயர்த்தி
Receptors	உணர்வேற்பி
Redox Reaction	ஆக்ஸிஜனேற்ற ஒடுக்கவினை
Resins	பிசின்
Resistance	மின்தடை
Rusting	துருப்பிடித்தல்
Sacrificial Protection	தன்னிழப்பு பாதுகாப்பு
Salt Bridge	உப்புப்பாலம்
Scattering Of Light	ஒளிச்சிதறல்
Secondary Amine	ஈரிணைய அமீன்
Secondary Cell	இரண்டாம்நிலை மின்கலன்
Sedimentation	படிவாதல்
Silver Mirror	வெள்ளிஆடி சோதனை
Solvation	கரைபானேற்றம்
Specific Conductance	நியமகடத்துத்திறன்
Specific Resistance	நியமமின்தடை
Spectator Ions	மின்வேதி வினையுறா அயனிகள்
Spontaneous Process	தன்னிச்சை செயல்முறை
Stress	மன உளைச்சல்
Stupor	மதி மயக்கம்

Chemistry Volume-II – Class XII

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