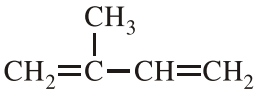
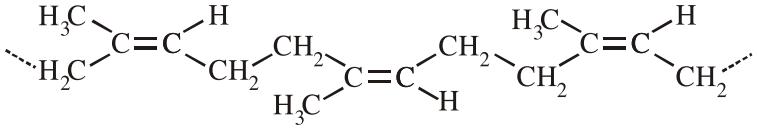


Isoprene
(2methyl buta-1,3-diene)



Natural rubber
cis-1,4-polyisoprene

Properties :

- This rubber is a natural polymer.
- Natural rubber can be streched like spring and possesses elastic property.
- In it, if force is applied, even for longer time, then retension force is maintained.
- In natural rubber, this property of elasticity is maintained at 273 to 335 K temperature.
- It becomes brittle at temperature less than 273 K.
- At temperature, higher than 335 K, it becomes fusible.
- Its water absorbing capacity is higher.
- It is soluble in non-polar solvents.
- It is non-resistant against the attack of oxidising agents

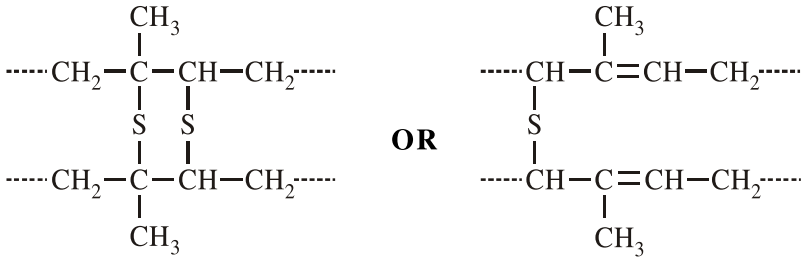
Uses :

- Natural rubber is used in many fields because of its elastic character. like in preparation of eraser, rubber band and hand gloves etc.

8.3.2 Vulcanised rubber :

Preparation :

- In 1893, Charles Goodyear discovered that mixture of natural rubber and sulphur when heated at temperature 373 to 415 K, its physical properties can be necessarily improved to a spectacular manner. This process is called vulcanisation.
- This process is slow but by adding zinc oxide as additive substance, the rate of reaction becomes fast.
- During vulcanisation process, repeating unit cis-1, 4-polyisoprene in natural rubber C2–C3 double bond of unit and adjacent $-CH_2$ groups become reactive. Therefore, bonding of these two reactive positions take place in cross through sulphur, between the two molecules of rubber and becomes hard.



Linear polymer of rubber molecules (cis-1, 4-isoprene)

Properties :

- Vulcanised rubber possesses very good elasticity.
- It does not melt (fuse) at higher temperatures and does not break at lower temperatures.
- It has very low water absorbing capacity.
- It is insoluble in organic solvents.
- It resists oxidation reaction.

Uses :

- During vulcanisation process, 5 % sulphur is used in making rubber for tyres.
- During vulcanisation process 30 % sulphur is used in making rubber for battery-cases.

8.3.3 Synthetic rubbers :

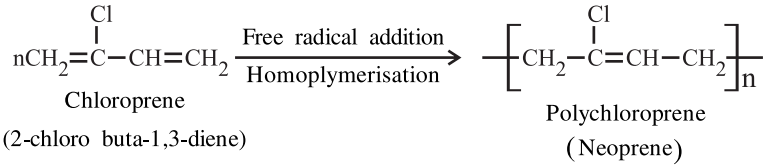
Synthetic rubber is vulcanisable rubber like polymer. On giving external stretching force, to the synthetic polymer or stretching it to twice its length, it regains its original shape and size.

Generally synthetic rubber is copolymer of buta-1,3-diene or hompolymer of buta-1,3-diene derivatives or it is a polymer of buta-1,3-diene derivatives with its unsaturated monomers.

Preparation, properties and uses of synthetic rubber :

(1) Neoprene :

Preparation : Polychloroprene (neoprene) homopolymer is obtained by addition polymerisation reaction of innumerable molecules of chloroprene (2-chloro buta-1,3-diene)



Chloroprene
(2-chloro buta-1,3-diene)

Polychloroprene
(Neoprene)

Properties :

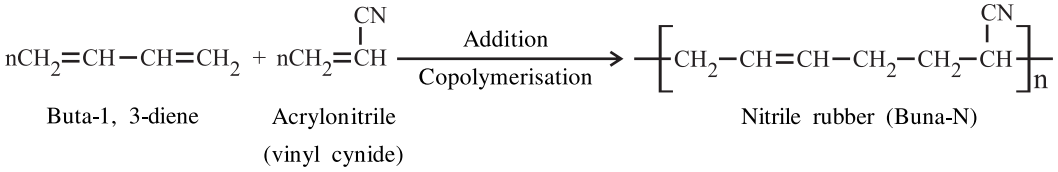
- Neoprene is a synthetic rubber of homopolymer class.
- It has superior resistance to vegetable and mineral oils.

Uses :

- Neoprene is used in conveyor belts, hose pipes, gaskets, printing rollers and as an insulator.

(2) Nitrile rubber (Buna-N)

Preparation : Nitrile rubber is obtained by addition copolymerisation reaction of mixture of two different monomers buta-1,3-diene and acrylonitrile in presence of peroxide catalyst.



Properties :

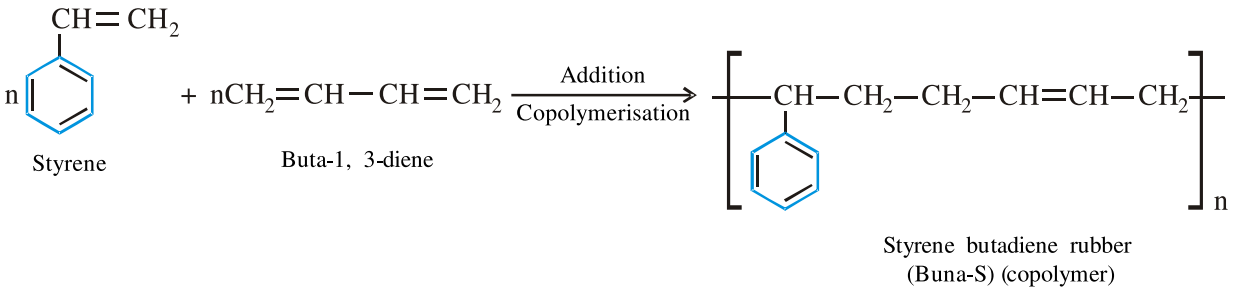
- Nitrile rubber is a copolymer obtained by addition reaction.
- Nitrile rubber has superior resistance towards lubricant oil and organic solvents.
- It does not react with petrol.

Uses :

- Nitrile rubber is used in oil seals, hose pipes and petrol tank linings.

(3) Styrene Butadiene Rubber (Buna-S, SBR)

Preparation : Two different types of innumerable molecules of styrene and buta-1,3-diene monomer joined with each other by addition copolymerisation reaction and forms copolymer named styrene butadiene rubber.



Properties :

- Styrene butadiene rubber is a copolymer obtained by addition reaction.
- It possesses good elasticity.
- At higher temperature, its shape does not change.

Uses :

- Styrene butadiene rubber is used in making tyres and footwears.

8.4 Molecular Mass of Polymers

Polymer being an amorphous solid substance; there is no regular arrangement of atoms and molecules. Number of monomers present in different molecules of same polymer means number of repeating unit is different. Thus its molecular mass is always taken as average molecular mass because of different branch lengths in any sample of polymer.

- The highly modern techniques used to determine the molecular mass of polymer are classical light scattering, Quasi-Elastic Light Scattering (QELS) and Dynamic Light Scattering (DLS).
- In determining the molecular mass of polymer substances, some chromatographic mode methods are used such as High Performance Liquid Chromatography (HPLC), Size Exclusion Chromatography (SEC), Gel-Permeation Chromatography (GPC). In addition to these Ultra-centrifuge technique is also used. To find out the molecular mass of polymer by calculation, the following symbols are used.
- Number average molecular mass = $\overline{M}_n$
- Weight average molecular mass = $\overline{M}_w$
- Number average molecular mass $\overline{M}_n = \frac{\sum_{i=1}^{\infty} N_i M_i}{\sum_{i=1}^{\infty} N_i} = \frac{\text{Total mass of polymer}}{\text{Total number of polymer molecules}}$
- Weight average molecular mass $\overline{M}_w = \frac{\sum_{i=1}^{\infty} N_i M_i^2}{\sum_{i=1}^{\infty} N_i M_i}$

  where N_i = Number of species molecules of each polymer,

  M_i = Molecular mass of each polymer species.
- **Calculation of $\overline{M}_n$:** $\overline{M}_n$ is determined by the method which depends upon the number of molecules present in the polymer sample.
- **Calculation of $\overline{M}_w$:** Molar mass of single molecule present is polymer substance and is calculated on the basis of light scattering, chromatographic and ultracentrifuge methods as indicated above.
- **PDI :** The ratio of mass and number moleular mass $\left(\overline{M}_w / \overline{M}_n\right)$ is called polydispersity Index (PDI)
- Natural polymers are generally monodispersed, therefore PDI = 1. This means is $\overline{M}_w = \overline{M}_n$.
- PDI > 1 means that $\overline{M}_w > \overline{M}_n$. Because synthetic polymer is always polydispersed.

8.5 Biopolymer

- The polymer substances present in the nature such as polysaccharide, protein and nucleic acid, which are very useful for the human life are called **Biopolymer.**

8.5.1 Biodegradable polymers :

- **The degradation of those polymers which takes place mainly by enzymes, bacteria like microorganisms, hydrolysis and to some extent by oxidation are called Biodegradable polymers.**
- Biodegradable polymers are active towards environmental processes.
- Due to the easy degradation of these polymers, after there usage, there is no issue of its disposal. As a result, there is no environmental pollution.
- After the degradation of these polymers, they can be converted into the life essential products.
- During the usage, the degradation of this polymer takes place and can be used in various fields like medical and industries.
- Synthetic biodegradable polymers can be synthesized which are convenient to living system and helpful to enviornmental cycles.
- Using some aliphatic substances as monomer, many polymers are industrially prepared such as PolyHydroxy Butyrate-co-β-hydroxy Valerate (PHBV), PolyGlycolic Acid (PGA), PolyLactic Acid (PLA), Dextran, Nylon 2 Nylon 6, etc.
- The polymers present in nature are called biopolymers. They are biodegradable polymers.

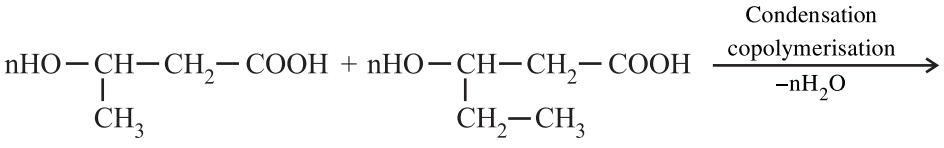
8.5.2 Non-biodegradable polymers :

- **Those synthetic polymers which do not get degraded by enzymes, bacteria like microorganism or by hydrolysis and oxidation reaction; are called non-biodegradable polymers.**
- Non-biodegradable polymer shows inertness towards the environmental process.
- As these polymers cannot be easily degraded, in everyday usage therefore disposal of polymeric waste is an acute problem. As a result environmental problems such as global warming, green house effect have been created.
- The degradation reaction does not take place; it is not converted into life essential products.
- Nowadays mostly synthesised polymer substances prepared are nonbiodegradable polymers.
- Largely used non biodegradable polymers incude polythene, polystyrene, PVC, Teflon, Orlon, Butyl rubber, Neoprene, Stryrene Butadiene Rubber, Nitrile rubber, Nylon-6, Nylon-6,6, Terylene, Bakelite, Melamine etc.

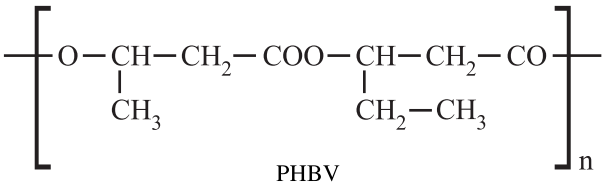
Information of some important synthetic biodegradable polymers is given below :

Poly-HydroxyButyrate-Co-β-Hydroxyvalerate (PHBV)

Preparation : PHBV is the polymer of polyester class prepared from β-hydroxy butyric acid monomer and β-hydroxy valeric acid monomer by copolymerisation condensation reaction and on release of H_2O molecule.



β-Hydroxybutyric acid β-Hydroxyvaleric acid



PHBV

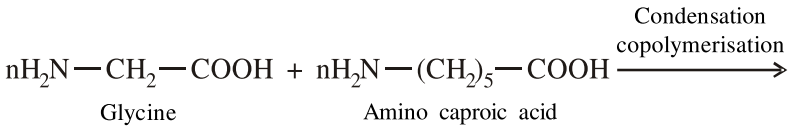
Properties :

- This polymer is of polyester class.
- It possesses biodegradable character.
- There is stiffness property of β-hydroxy butyric acid and has flexibility property of β-hydroxy valeric acid.
- PHBV also undergoes bacterial degradation in enviornmental conditions.

Uses :

- PHBV is used in special types of packaging
- In orthopaedic devices
- In capsules for filling controlled release of drugs.

Nylon-2 Nylon-6 : Nylon-2 Nylon-6 copolymer of polyamide series is obtained by condensation polymerisation reaction of two different types of monomer glycine ($H_2N–CH_2–COOH$) and amino caproic acid ($H_2N–(CH_2)_5–COOH$).



Glycine Amino caproic acid

Nylon-2 Nylon-6

- Nylon-2 Nylon-6 is a biodegradable polymer.
- Nylon-2 Nylon-6 is of polyamide class.

PGA and PLA :

- They are prepared industrially.
- They are biodegradable polymers used for post operation stiches.

Dextran :

- Dextran is the first biodegradable polyester polymer used for post operative stitches.
- It is biodegradable polymer of polyeseter class.

SUMMARY

- Our modern life style is incomplete without polymers.
- The biological requirements of human body are fulfilled by biopolymers, while physical requirements are fulfilled by natural and synthetic polymers.
- Polymer is a group of molecules having giant (macro) size and high molecular mass.
- Innumerable molecules of one type or two or more than two types simple organic molecules combine with one another and form a giant molecule (macro), is called polymer.
- The molecules of only one type which combine through chemical bond is called monomer. In polymerisation reaction, first of all two monomers combine and dimer is formed. On combining third molecule, trimer is formed. Thus by combination of one by one molecule, polymer is formed.
- In each polymer series, the definite part which is repeated and this repeating part is called "Repeating unit"
- The number of this repeating unit is called 'Degree of polymerisation' (n).
- If the value of degree of polymerisation 'n' is less than 25 ($n < 25$), then that polymer is called oligomer.
- Generally oligomer is in liquid state. Fevicol like adhesives and liquid polymers used in paint are oligomers.
- If the value of degree of polymerisation 'n' is more than 25 ($n > 25$) then that polymer is called heavy polymer. Generally heavy polymer is in solid state.
- The classification of polymers is as follows :

Polymers

On the basis of source	On the basis of structure	On the basis of polymerisation reaction	On the basis of molecular forces	On the basis of growth of polymerisation reaction
(1) Natural polymers	(1) Linear	(1) Addition polymer	(1) Elastomer	
(2) Semisynthetic polymer	(2) Branched	(2) Homopolymer	(2) Fibers	
(3) Synthetic polymers	(3) Cross linked	(3) Copolymer	(3) Thermoplastic	
		(4) Condensation polymer	(4) Thermosetting	

- Polymerisation reaction is mainly classified in to two classes (1) Addition polymerisation and (2) Condensation polymerisation.
- The addition polymerisation reaction occurs from the monomer through free radical or carbocation or carbonium ion mechanism. In both these methods, if polymer is obtained from only one type of monomer, it is called homopolymer and if polymer is obtained from two different types of monomers, it is called co-polymer.
- In the addition hompolymers obtained by addition reaction of only one monomer are included as polythene, teflon, orlon PVC, polystyrene, butyl rubber etc.
- In the addition copolymer obtained by addition reaction of two or more different monomers, styrene butadiene rubber can be included.
- The polymerisation reaction during which water, ammonia, alcohol, or hydrochloric acid is liberated and polymer is formed, then that reaction is called condensation polymerisation reaction.
- Nylon 66, nylon 6, terylene, bakelite, melamine etc can be included in the polymers obtained by condensation polymerisation.
- In the polymer obtained by polymerisation reaction, if the functional group ester (–COO–) is present, then it is called polymer of polyester class and if the functional group is amide (–CONH–), then it is called polymer of polyamide class
- Terylene is polymer of polyester class, whereas nylon 6 and nylon 6,6 is polymer of polyamide class.
- Natural rubber possesses unique property of elasticity, which cannot be destroyed at high or low temperatures, sulphur can be added to it and vulcanised rubber can be prepared.
- Vulcanised rubber maintains its property of elasticity at high or low temperatures. In addition, synthetic rubber containing more strength viz. neoprene, nitrile rubber, styrene butadiene rubber could be prepared which are inert towards the organic solvents.
- To determine molecular mass of polymer, different methods have been developed, and yet, its correct molecular mass cannot be determined because in the same polymer, the value of degree of polymerisation of its any two molecules is not same.
- To find molecular mass of polymer, in addition to colligative methods, light scattering and chromatographic methods have been proved more effective.
- To determine molecular mass of polymer, number average molecular mass $\overline{M}_n$ and mass average molecular mass $\overline{M}_w$ formulas can be used.
- The ratio of mass average molecular mass $\overline{M}_w$ and number average molecular mass $\overline{M}_n$ is called polydispersity index (PDI).

- The polydispersity index of natural polymer or biopolymers is PDI = 1, while for synthetic polymers it is PDI > 1.
- Polymers found in living beings are biopolymers. The decomposition of biopolymer by microorganisms like bacteria is possible. While using them, its transformation occurs in simple components and so they are called biodegradable polymers. Biodegradable polymers are friends of environment.
- The polymers which are not decomposed by microorganisms like bacteria, and the simple components are not obtained during their use, are called non-biodegradable polymers. Many problems are created in the environment by use of non-degradable polymers.
- To care of environmental problems, it is necessary to increase the use of biodegradable polymers. In some synthetic biodegradable polymers, PHBV, PGA, PLA, dextran, nylon-2 nylon-6 are included.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Those simple organic molecules which chemically combine with one another and form a polymer, is called .....

(A) Monomer (B) Tetramer (C) Dimer (D) Trimer

(2) The number 'n' of repeating unit in polymer molecule is called .....

(A) Degree of polymerisation (B) Oligomer

(C) Heavy polymer (D) Repeating unit

(3) Which functional group is present in polyester ?

(A) –COO– (B) $–CH_2–CH_2–$ (C) –CONH– (D) $–CH_2–CN$

(4) What type of polymer can be considered novolac ?

(A) Linear (B) Branched (C) Cross linked (d) (A) and (B)

(5) Which of the following substances is an elastomer ?

(A) Nylon 6 (B) Nylon 6,6

(C) Vulcanised rubber (D) Melamine

(6) Which of the following polymers is obtained by condensation polymerisation ?

(A) PVC (B) Polythene (C) Polystyrene (D) Nylon 6,6

(7) Light Scattering method is used .....

(A) to find concentration (B) to find molecular mass of polymer

(C) to test elements (D) to find number of molecules

(8) HDP is used in preparation of .....

(A) Light and soft devices (B) Hard and durable devices

(C) Cotton and wool (D) Light and cheap devices

(9) Which monomer is used for preparation of orlon ?

(A) $CF_2=CF_2$ (B) $CH_2=CH-CN$ (C) $CH_2=CHCl$ (D) $CH_2=CH-OH$

(10) From the following ..... is the example of biopolymer ?

(A) Teflon (B) Neoprene (C) Nylon-6,6 (D) DNA

(11) Which of the following two monomers are used in preparation of nylon-6,6 ?

(A) Hexamethylene diamine and ethylene glycol

(B) Adipic acid and hexamethylene diamine

(C) Dimethyl terphthalate and ethylene glycol

(D) Adipic acid and ethylene glycol

(12) ..... possesses biodegradable property

(A) PTFE (B) PAN (C) SBR (D) PHBV

(13) Which choice is correct for synthetic polymer substance ?

(A) $\overline{M}_n = \overline{M}_w$ (B) $\overline{M}_n \geq \overline{M}_w$ (C) $\overline{M}_w > \overline{M}_n$ (D) $\overline{M}_w < \overline{M}_n$

(14) Which is the formula to find mass average molecular mass ?

(A) $\overline{M}_w = \dfrac{\sum_{i=1}^{\infty} N_i^2 \cdot M_i}{\sum_{i=1}^{\infty} N_i \cdot M_i}$ (B) $\overline{M}_w = \dfrac{\sum_{i=1}^{\infty} N_i M_i}{\sum_{i=1}^{\infty} N_i}$

(C) $\overline{M}_w = \dfrac{\sum_{i=1}^{\infty} N_i M_i}{\sum_{i=1}^{\infty} N_i^2}$ (D) $\overline{M}_w = \dfrac{\sum_{i=1}^{\infty} N_i M_i^2}{\sum_{i=1}^{\infty} N_i M_i}$

(15) What can be obtained by ultracentrifuge method in polymer chemistry ?

(A) Concentration (B) Molecular mass (C) Precipitation (D) Solution

2. Write answers of the following questions in brief :

(1) Give definitions :

(i) Degree of polymerisation

(ii) Repeating unit.

(2) Give examples of natural polymer.

(3) When is called that the condensation polymer has occurred ?

(4) What is meant by addition polymerisation reaction ?

(5) Mention the types of addition reaction on the basis of their methods.

(6) Mention the uses of high density polythene (HDP).

(7) Upto which temperature the layer of teflon does not decompose ?

(8) What type of polymer is polystyrene ?

(9) Which rubber is used in place of natural rubber ?

(10) Give equation of chemical reaction for preparation of nylon 6.

(11) Mention repeating unit of bakelite.

(12) What is PDI ?

(13) What is meant by biopolymer ?

(14) Give example of natural elastomer.

(15) The capsules used for filling controlled drugs is prepared from which polymer ?

(16) Mention the repeating unit in PTFE.

3. Answer the following questions :

(1) Give information about semisynthetic polymer substances.

(2) What are oligomers and heavy polymers ?

(3) Explain elastomers.

(4) Mention characteristics of thermoplastic polymers.

(5) Explain the preparation of any one polymer obtained by addition co-polymerisation reaction.

(6) Give properties and uses of nylon-6,6.

(7) How is melamine prepared ?

(8) Give difference between natural rubber and vulcanised rubber.

(9) Mention methods to find molecular mass of polymer.

(10) Mention the formulas of weight average molecular mass and number average molecular mass.

(11) Give differences between biodegradable and non-biodegradable polymers.

(12) Mention characteristics of PGA, PLA, dextran.

4. Answer the following questions in detail :

(1) Give classification of polymers and give one example of each.

(2) What is meant by monomer, polymer and degree of polymerisation? Explain with example.

(3) Explain condensation polymerisation reaction.

(4) Explain steps of free radical addition polymerisation reaction.

(5) Mention preparation, properties and uses of high density polythene (HDP).

(6) Explain stepwise polymerisation reaction.

(7) Mention properties and uses of bakellite.

(8) Write a note on vulcanised rubber.

(9) Write a note on 'PHBV'

(10) Explain oligomer and heavy polymer.

Unit 9

Chemistry in Everyday Life

9.1 Introduction

Development of chemistry improves quality of human life. Contribution of chemistry is seen in each and every field of human life. Some compounds, such as foods, clothes, potable water, abode, soaps, detergents, drugs, dyes etc. which we are using regularly are mostly made from organic compounds. Moreover, fertilizers and pesticides used in agriculture, polymers, oils, papers, glass, cement, various types of fuels etc. are gifts of chemistry. Synthesis of creative and destructive explosives used in security of nation have become possible through chemistry. In this way, directly or indirectly, chemistry is closely associated with our everyday life. In this unit, we will understand uses of chemistry in three important areas – drugs, foods and cleansing agents.

9.2 Drugs

Up to 19th century, plant based natural drugs were used in crude form e.g., powder or boiled drink of bark, roots and leaves of tree etc. available in nature. The bark of cinchona tree and quinine obtained from it, were used for malaria; but for certain diseases no natural or synthetic drug was available during 19th century. Research about applications of such compounds resulted in chemical compounds which were used for treatment of diseases in 20th century. In 1904, a German chemist Paul Ehrlich realized that certain chemicals were more toxic to disease causing organisms to human cells, so these chemicals could be used to control or cure infectious diseases. Ehrlich found certain dyes that used to stain bacteria to make them more visible under a microscope. These dyes stain the nerve cells of bacteria. From this, the idea arose in his mind that if it can be made toxic for organisms, then they

could be used as effective drug for these microorganisms. In this way Ehrlich synthesized arsenic containing compounds (Salvarsan and neo salvarsan) for skin disease like syphilis and for sleeping sickness. For this Ehrlich was awarded the Nobel prize in 1908. Ehrlich gave chemotherapy term for such compounds used in treatment of diseases. Thus, treatment of diseases in which parasites live (virus, fungi, yeast, bacteria, protozoa, worm) are killed and their growth is inhibited by chemicals in body is called **chemotherapy.** Due to successive efforts of Ehrlich about chemotherapy, he is known as father of chemotherapy.

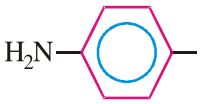
9.3 Classification of Drugs

Due to development of chemistry, many drugs are synthesized for various diseases. These drugs can be classified in four types as follows.

(1) On the basis of pharmacological effect : Drugs can be classified on basis of their pharmacological effect. This classification is most useful for doctors because they are known as drugs for specific treatment. For example, body pain relieving drugs can be classified as analgesic drugs and the drugs, killing or inhibiting the growth of microorganisms that cause harmful effect on wound or injury can be classified as antiseptic drugs.

(2) On the basis of drug action : Drugs can affect particular biochemical process. Drugs can be classified on the basis of specific action of them. Some problems occur in body due to release of histamine such as common cold, acidity, swelling, redness of skin and itching. Therefore, the drugs used to stop the release of histamine are classified as separate class of antihistamines.

(3) On the basis of chemical structure of drugs : Drugs can be classified on the basis of chemical structure. Drugs containing similar chemical structure are included in same class. Mostly, drugs containing similar chemical structure have similar drug action. e.g., sulphonamides have common structure as follows :



where, R = aromatic or heterocyclic group

(4) On the basis of molecular targets of drugs : Drugs usually interact with biomolecules such as carbohydrates, lipids, proteins and nucleic acids. These biomolecules are called target molecules of drugs. Similar target molecules containing drugs can be put in the same class.

9.4 Working Mechanism of Drugs

Macromolecules perform various functions in the body. For example, some proteins perform the role of biological catalysts in the body called **enzymes.** Some proteins are crucial to communication system in the body called **receptors.** Nucleic acids have coded genetic information for the cell. Lipid and carbohydrates are structural parts of the cell membrane.

Enzymes and receptors play an important role in our body. If these two substances show negative effect, then various systems get disturbed in our body, as a result a human being suffers from various diseases. We use specific drugs for protection of these diseases. These drugs stop negative effect of enzymes and receptors by interacting with them.

9.4.1 Drug-Enzyme Interaction :

Detailed information about enzymes is given in unit-7. Generally substrate is bound with active site of enzyme. At the end of this reaction product is formed and enzyme is obtained in original form. Information about lock and key model of enzyme, which explains the mechanism of enzyme can be found in unit-2 and 7. Drugs stop this reaction of enzymes; for this, drugs stop the substrate from binding with active site of enzyme. These drugs are called **enzyme inhibitors.** Drugs stop the substrate to bind with active site of enzymes in two ways.

(1) Drugs compete with natural substrate for their attachment on the active site of enzymes as shown in Fig. 9.1; such drugs are called **competitive inhibitors.**

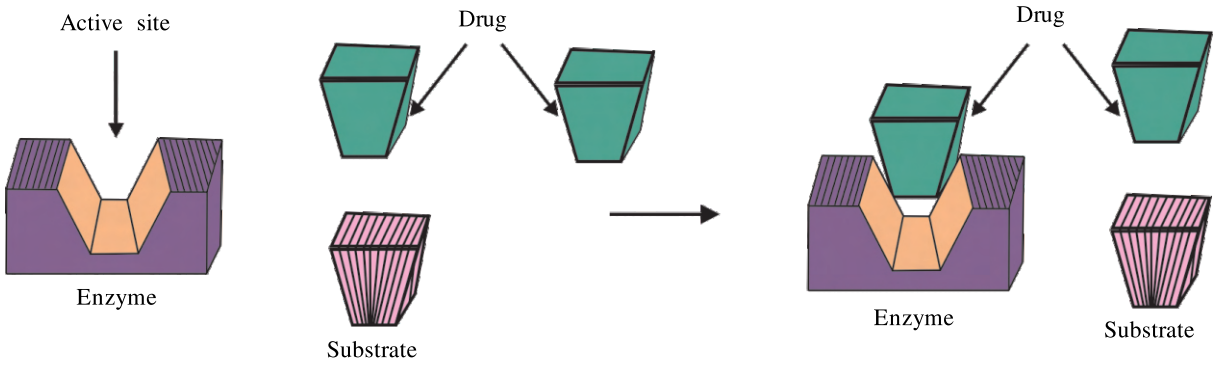


Fig. 9.1 Competition between drugs and substrate for binding with active site of enzyme

(2) Some drugs do not bind to the active site of enzyme but bind to a different site. This site is called **allosteric site.** This type of binding of drug with enzyme results in the change in shape of active site as shown in Fig. 9.2, therefore substrate cannot bind with it. If the binding between enzyme and drug is formed by strong covalent bond then it cannot be broken easily, so this enzyme is blocked permanently when body degrades the enzyme-inhibitor complex, and new enzyme is synthesised.

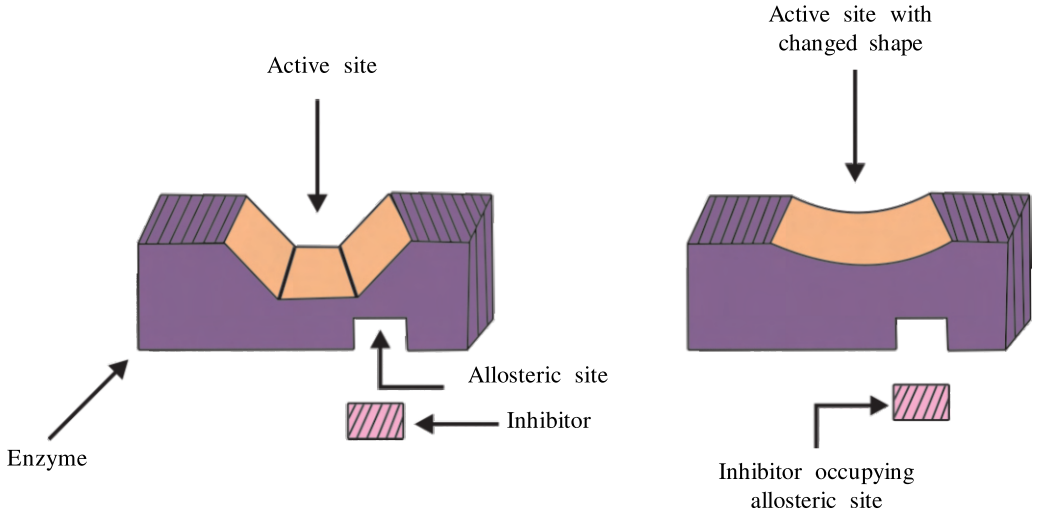


Fig. 9.2 Change in shape of active site of enzyme and allosteric site

9.4.2 Drug-Receptor Interaction :

Receptors are made from proteins. They play key role in communication process of body. Most of receptors are embedded in cell membrane as shown in Fig. 9.3.

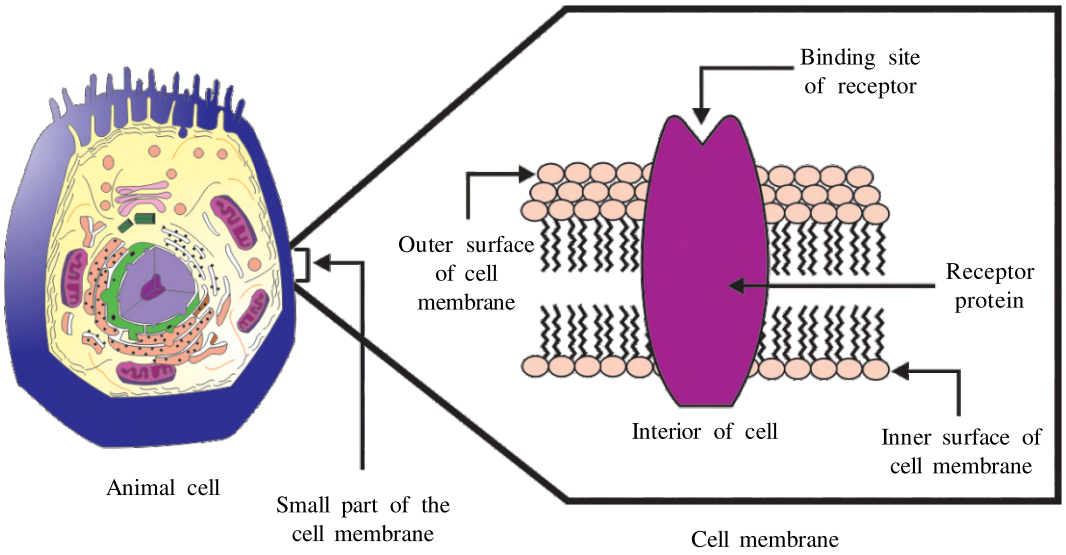


Fig. 9.3 Receptor in membrane of animal cell

Small active part of receptor is present on outside region of cell membrane. It is called binding site. In the body, message between two neurons or that between neurons to muscles is communicated through certain chemicals. These chemicals are called **chemical messengers.** When a chemical messenger comes near the binding site of receptor, then the receptor changes shape of its binding site to accept chemical messenger. Messenger gives its message to cell, and it moves away from receptor. Thus, messenger gives message to the cell without entering into the cell as shown in Fig. 9.4

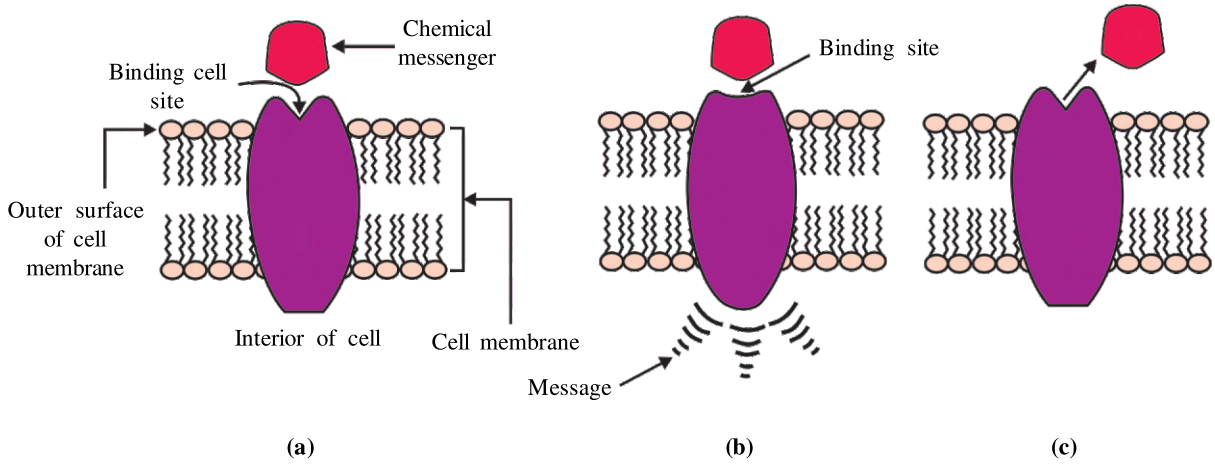


Fig. 9.4 (a) Receptor receiving chemical messenger

(b) Shape of the receptor changed for attachement of messenger

(c) Receptor regains structure after removal of chemical messenger

Many receptors are present in body. They interact with various chemical messengers. Receptors react with specific messenger due to specific shape of its binding site. Instead of messengers, drugs bind to receptor site and stop communication process of cell. These drugs are called **antagonists.** Sometimes, due to defect in natural chemical messenger, the communication process is stopped. At this time, if the messenger shaped drug is used, then receptor accept it, and under the impression of natural messenger the communication process occurs. These drugs are called **agonists.**

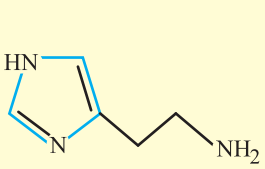
9.5 Therapeutic Action of Different Classes of Drugs

Let us discuss therapeutic action of some important classes of drugs :

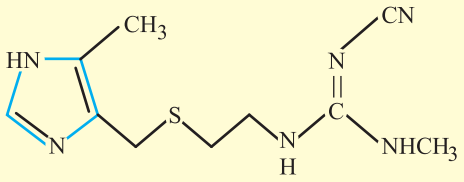
(1) Antacids : Due to overeating or indigestion, much acid is released in stomach. It is known as acidity. Acidity causes irritation and pain in stomach. In severe cases, ulcers are developed in stomach. Sodium hydrogen carbonate or mixture of aluminium hydroxide and magnesium hydroxide are used as **antacids** for treatment of acidity. Metal hydroxides are insoluble so they do not increase the pH higher than neutral value in stomach. While excessive sodium hydrogen carbonate can make the stomach fluid alkaline; due to this side effects can occur in stomach. Antacids give relief only from the symptoms but they do not control the causes, so they are not called drugs.

(2) Antihistamines : In our body, release of histamine stimulates the secretion of pepsin and hydrochloric acid in stomach, therefore, acidity develops in stomach. The drug cimetidine (Tegamet) prevents the interaction of histamine with the receptors present in stomach wall. It results in release of lesser amount of acid. Thus, this drug acts like antacid and prevents the causes of release of acid. Moreover, similar type of drug- ranitidine (zantac) is more used nowadays.

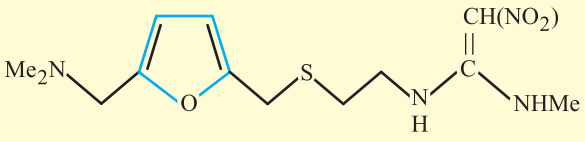
(For information only)



Histamine



Cimetidine



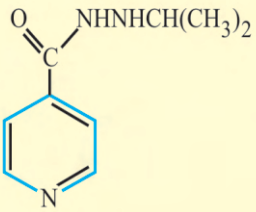
Ranitidine

Histamine causes common cold, redness of skin and allergy like itching in body. For this synthetic drugs brompheniramine (Dimetapp) and terfenadine (seldane) are used as antihistamines. These drugs are also known as **antiallergenic drugs.** These drugs prevent interaction between histamine in binding with receptor. Thus, these drugs protect the body from negative effect of histamine. We cannot use the antacids as antiallergenic drugs or antiallergenic drugs as antacids because both types of drugs work on different receptors.

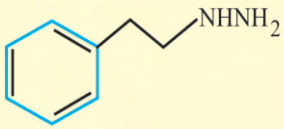
(3) Neurologically active drugs : Tranquilizers and analgesics are neurologically active drugs. These drugs affect mainly the message transfer mechanism between nerve and receptor.

(A) Tranquilizers : Tranquilizers are a class of chemical compounds used in treatment of stress, mild and severe mental diseases. They relieve anxiety, stress, irritability or excitement. They are essential components in sleeping pills. There are various types of tranquilizers. Their functions are also different. For example, noradrenaline is one of the neurotransmitter that means neuro messenger. It changes the mood of person. If the level of noradrenaline is low for some reason then the message signal sending activity becomes slow, due to this person feels depressed. In such situation antidepressant drugs are required. These drugs inhibit catalytic effect of enzyme for degradation reaction of noradrenaline. Thus, these drugs act as enzyme inhibitors. Therefore important neurotransmitter noradrenaline is released and after a long period it activates its receptor. Thus, person comes out of depression gradually. Iproniazid and phenelzine are this type of drugs.

(For information only)



Iproniazid



Phenelzine

Some tranquilizers namely chlordiazepoxide and meprobamate are relatively mild tranquilizers. They relieve tension. Equanil drug relieves from depression and hypertension.

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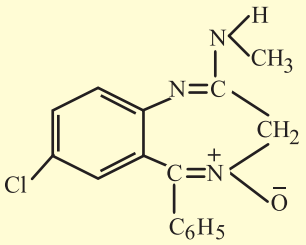
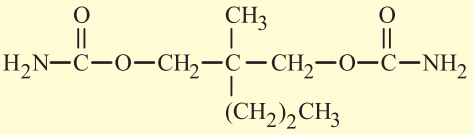
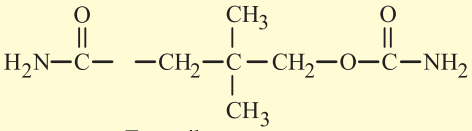


Chlordiazepoxide

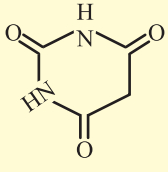


Meprobamate

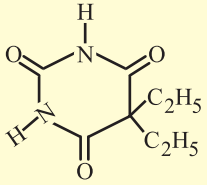


Equanil

(For information only)



Barbituric acid



Veronal

Derivatives of barbituric acid such as veronal, amytal, nembutal, luminal, seconal are important tranquilizers. These barbituric acid derivatives are called barbiturates. They are sedatives (sleep producing agents).

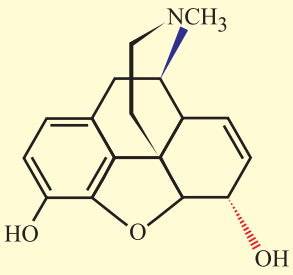
(B) Analgesic drugs : Physical pain reducing compounds are known as **analgesic drugs.** These drugs can be classified in to two classes as follows :

(i) Non-narcotic analgesic drugs

(ii) Narcotic analgesic drugs

(i) Non-narcotic analgesic drugs : Aspirin and paracetamol are well known examples of non-narcotic analgesic drugs. Due to these drugs, a person does not suffer from sleepiness or excitement, so they are called **non-narcotic analgesic drugs.** In body, released prostaglandins chemical causes inflammation and pain in the tissue. Aspirin inhibits synthesis of prostaglandins in body, which results in removal of pain in body. These drugs relieve from skeletal pain such as that caused by arthritis. These drugs reduce body temperature which means they are fever relievers. Therefore, these drugs are known as **antipyretics.** Aspirin prevents coagulation of blood, due to this it is more useful to patient of heart diseases.

(For information only)



Morphine

(ii) Narcotic analgesic drugs : When morphine and many of its homologues are used as drugs, then they relieve pain and produce sleep. Due to these drugs, excitement occurs before sleep. It is called euphoria. If a person starts enjoying this situation frequently, then person has to take it regularly and becomes an addict. This is the most negative side of such drugs. These drugs produce excitement and sleep. Due to this, they are called **narcotic analgesic drugs.** If large amount of morphine is used, then it acts as poison instead of drug. Large amount of morphine produces stupor, coma, convulsions and ultimately death. These drugs are used when there is no option for them. Many efforts have been made to find out alternative of morphine and these efforts are continuing till today.

(4) Antimicrobial drugs : Diseases occur in human being and animals due to different types of microorganisms such as bacteria, virus and fungi. The drugs which are used to prevent and to inhibit the pathogenic action of these microorganisms are called **antimicrobial drugs.** The specific chemical is used to prevent and to inhibit the pathogenic action of bacteria, fungi, virus and other parasite is called antibacterial agent, antifungal agent, antiviral agent and antiparasitic agent, respectively. Generally, antibiotics, antiseptics and disinfectants are called antimicrobial drugs.

(A) Antibiotics : The chemical substances produced by living organisms to inhibit the growth or to kill microorganisms are called **antibiotics,** e.g., penicillin, tetracycline, chloramphenicol, etc. Penicillin produced by microorganisms is first antibiotic that acts as drug. In 1945, Alexander Fleming, Howard Florey and Ernst Boris Chain were awarded the Nobel prize in the field of physiology and medicine, to encourage their joint efforts in this field. Antibiotics that kill microorganisms are called **microbicidal** and antibiotics that inhibit the growth of microorganisms are called **microbiostatic.** For example, penicillin, aminoglycosides, ofloxacin etc. are bactericidal and erythromycin, tetracycline, chloramphenicol etc. are bacteriostatic.

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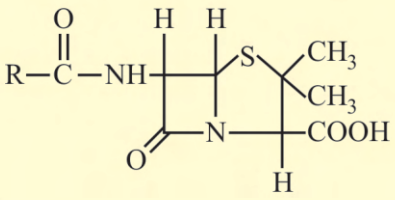
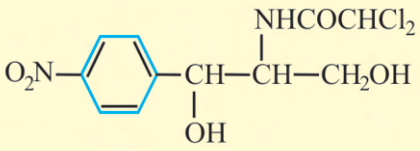


General structure of Pencillin



Chloramphenicol

Nomenclature methods of antibiotics is also interesting. Names of some antibiotics were derived from the names of bacteria, e.g., Pencillin from penicillium notatum, streptomycin from streptomyces griseus. Some names were decided from name of place from where soil samples were first collected e.g., Angolamycin from Angola. Some names were decided from name of laboratory or factory, e.g., Hemycin from Hindustan Antibiotics Ltd. Some names were derived from the names of relatives, patients, secretary of discoverer-scientist. e.g., Halinin from name of a scientist's wife, seramycetin from name of mother-in-law, vernamycin from name of secretary, bacitracin from a patient named Tarcey (microorganisms were collected from wound of Tracey).

(B) Antiseptics and disinfectants : Antiseptics and disinfectants are such chemicals that kill or inhibit the growth of microorganisms. **Antiseptics are useful in making tissues free from microorganisms.** Antiseptics are used in making mouth free from microorganisms by gargling and they can be used by applying on wounds. Potassium permanganate, furacine and soframycine are the examples of antiseptics. Like antibiotics it does not take them in abdomen. Dettol used as an antiseptic is a mixture of chloroxylenol and terpineol. Bithionol is added to soaps to develop the antiseptic properties. Iodine is a powerful antiseptic. Its 2-3 % solution prepared in alcohol-water mixture is known as tincture of iodine. It is applied on wounds for making them free from microorganisms. Dilute aqueous solution of boric acid act as weak antiseptic. It is used as washing solution for eyes to free them from microorganisms.

Generally, **disinfectants are applied to inanimate objects for making them free from microorganisms.** 0.2 to 0.4 ppm concentration containing aqueous solution of chlorine and very low concentration of sulphur dioxide can act as disinfectants. Activity of disinfectants is expressed by **phenol coefficient.** If the value of this coefficient is 10, then it means it has 10 times more disinfectant activity than phenol. Generally, this type of activity is checked on salmonella typhosa bacteria. Same compound acts as antiseptic or disinfectant at its different concentrations. e.g., 0.2% of phenol solution acts as antiseptic and 1% of phenol solution acts as disinfectant.

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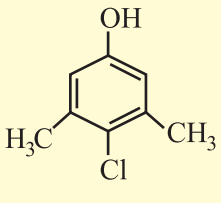
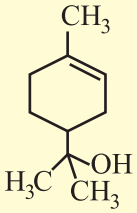
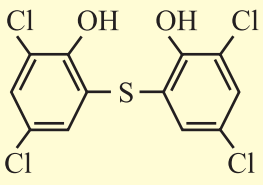


Chloroxylenol



Terpineol



Bithionol

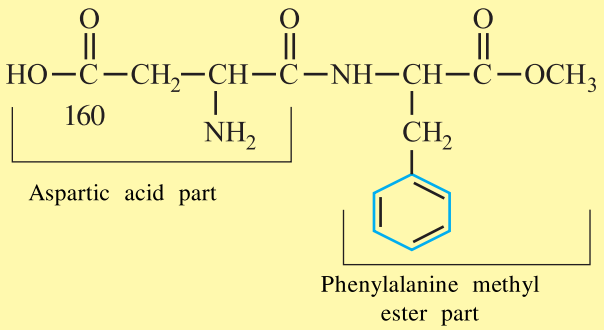
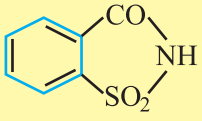
(5) Antifertility drugs : Average human life has increased due to modern drugs and good health, therefore, population increases. Increased population causes social problems such as limited resources of foods, clothes and abode, pollution and unemployment. Due to this, each and every person has to worry about how to control the population. For this, remedies should be used to control births. The chemicals used for prevention of impregnation are called **antifertility drugs.** Estrogen and progesterone possess this type of ability. For this, mixture of estrogenic and progestogenic compounds are used in pill form. They are known as antifertility pills or birth control pills. Females can take these pills in orally. In such type of compounds, mixture of mestranol (estrogenic) and norethindrone (progestogenic) is used.

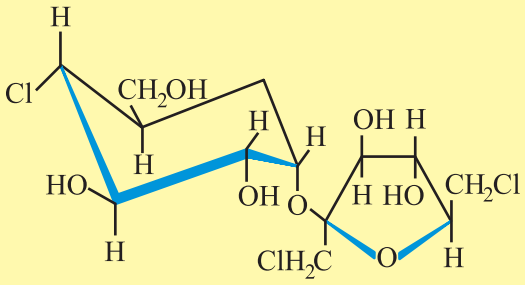
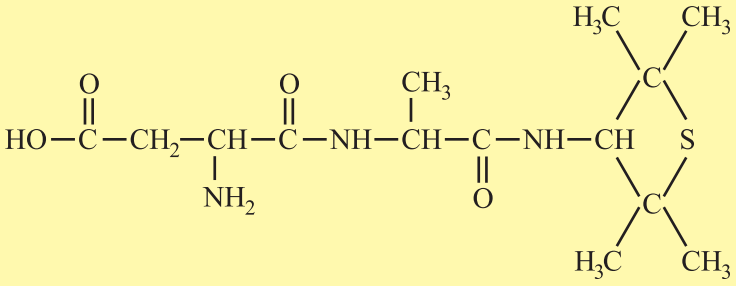
9.6 Chemicals in Food

Specific chemicals are added to foods for their preservation, enhancing their appeal and improving nutritive value in them. These compounds are food colours, flavours and sweeteners, fat and stabilising agents, antioxidants, preservatives, nutritional supplements such as minerals, vitamins and aminoacids. Let us study about some important compounds in this topic.

(1) Artificial sweetening agents : Many people suffer from fatness or obesity. Obesity causes many diseases. To reduce the obesity, use of non-caloric artificial sweeteners instead of sugar in food has increased. Aspartame, saccharin, sucrolose and alitame are well known artificial sweetening agents. Their sweetness values are 160, 550, 600, 2000 times more, respectively than that of sucrose but they give less calories to body. Aspartame is used only for cold foods and soft drinks because they are unstable at cooking temperature. Appearance and taste of sucrolose are like sugar. It is stable at cooking temperature. Structures of important artificial sweeteners are given in table 9.1

Table 9.1 Artificial sweeteners

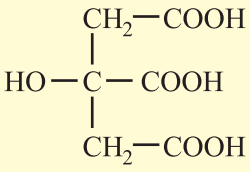
Artificial sweetener	Structural formula (For information only)	Sweetness value in comparison to sucrose
Aspartame		160
Saccharin		550

Sucrolose		600
Alitame		2000

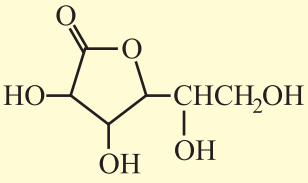
(2) Food preservatives : The chemicals used to prevent food from spoiling by microorganisms like fungi or to preserve food for a long time, are called **food preservatives.** Generally, we use table salt, table sugar and vegetable oil as food preservative in daily life for domestic purposes. Moreover, sodium benzoate, sodium metasulphite and salts of propionic acid or sorbic acid are used as preservatives in food industry.

(3) Antioxidants : Addition of some chemical compounds to food causes slow activity of oxygen; so that the food is preserved for a long time. These types of chemical compounds are called **antioxidants.** Antioxidants are more active towards oxygen. Due to this, the foods are preserved. Citric acid, ascorbic acid, butylated hydroxy toluene (BHT) and butylated hydroxy anisole (BHA) are important antioxidants.

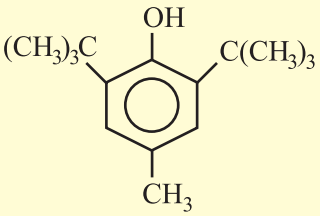
(For information only)



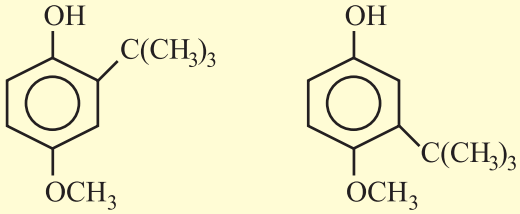
Citric acid



Ascorbic acid



Butylated hydroxy toluene (BHT)



Butylated hydroxy anisole (BHA)
(BHA is mixture of two isomers)

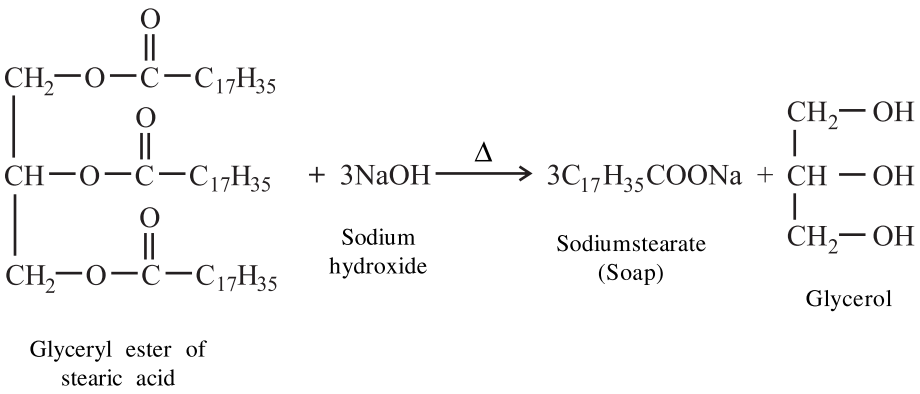
(4) Food colours : Some chemical compounds added to food are dyes and as a result food becomes colourful. These type of chemical compounds are called **food colours.** β-carotene, caramel, tetrazine, arneto are food colours.

9.7 Cleansing Agents

The chemical compounds used to remove dirt or oily materials from surfaces are called **cleansing agents.** These compounds also improve cleansing property of water.

9.7.1 Soap :

Soap is sodium or potassium salt of fatty acid (stearic acid, oleic acid, palmitic acid). Vegetable oils or animal fats are glyceryl ester of the fatty acids. They are heated with aqueous solution of sodium hydroxide or potassium hydroxide which results in formation of sodium salt of fatty acid and glycerol. This reaction of formation soap is called **saponification.**



We use various types of soaps every day, for example, bath soap, washing soap, shaving soap, medicated soap, etc. In preparation of these types of soaps, some specific chemicals are additionly added to main reactants (fats and alkali). For preparation of bath soap, fat or oil having good quality and potassium hydroxide as alkali are used, because this type of soap is soft and they make the soap smooth in comparison to sodium soap. Care should be taken about the removal of excess alkali during preparation of bath soap. Moreover, colours and fragrant materials are also added to it. Glycerol is added during preparation of shaving soap, due to this, soap and its foam do not dry up rapidly. Additionally rosin is added while preparing them. It forms sodium rosinate which foams well. Deodorants are added during preparation of medicated soap. It prevents the body odour due to sweat. **Quality of bath soap can be decided on the basis of presence of TFM (Total Fatty Matters).** If a soap has high proportion of TFM, then its quality is good. Very low proportion TFM containing soap makes skin dry and produces burning sensation. BIS (Bureau of Indian Standards) has established standard values of TFM for deciding the quality of bath soap. As per BIS, grade-1 is given to soap if it contains 76 % or more TFM, grade-2 is given to soap if it contains 65 % or more but less than 76 % of TFM, grade-3 is given to soap if it contains 60 % or more but less than 65 % of TFM. The percentage value of TFM or grade of soap is compulsory to mention on bath soaps. Dear students, kindly read this information on wrapper of a soap that you use and decide its quality yourself.

Limitations of soap :

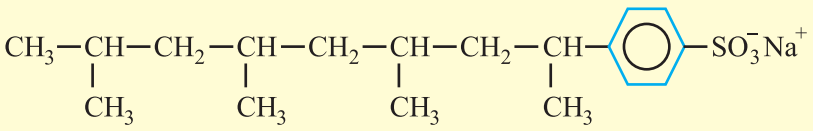
- Soap is converted to free fatty acids in acidic medium. This fatty acid is insoluble in water and it does not act as cleansing agent.

$$\underset{\text{(Soap)}}{C_{17}H_{35}COONa} + H^+ \rightarrow \underset{\text{Fatty acid}}{C_{17}H_{35}COOH} + Na^+$$

- Soap does not produce foam with hard water, because it reacts with calcium and magnesium present in hard water and forms calcium and magnesium salts of fatty acid. Thus, soap is wasted when it is used with hard water, and does not satisfy the purpose of cleanliness.

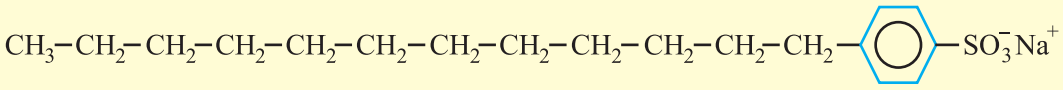
9.7.2 Synthetic Detergents :

To combat with the limitations of soap, the compounds are developed possessing similar cleanliness ability of soap called synthetic detergents. **Chemically synthetic detergents are sodium salts of organic sulphonic acid.** Synthetic detergents show the cleanliness ability in acidic medium or even with hard water. Sodium salts of branched alkyl benzene sulphonate (ABS) and linear alkyl benzene sulphonate (LAS) are examples of synthetic detergents. These detergents contain 10 to 14 carbon atoms in chain attached to aromatic ring.



Branched sodium dodecylbenzene sulphonate

(ABS detergent)



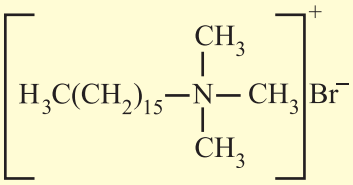
Linear sodium dodecylbenzene sulphonate

(LAS detergent)

Classification of Detergents : Detergents are classified into three categories depending upon the structural position of their molecules in aqueous medium (i) anionic detergents (ii) cationic detergents and (iii) non-ionic detergents.

(i) Anionic detergents : The detergents which are in negative ion (anionic) form in their aqueous solutions are called anionic detergents. They are effective also in dilute acidic medium. These type of detergents are used more for domestic purposes. ABS and LAS are **anionic detergents.**

(ii) Cationic detergents : The detergents which are in positive ion (cationic) form in their aqueous solution are called cationic detergents. These type of detergents being germicidal are used in hospitals and in preparation of cosmetics. Cetyl trimethyl ammonium bromide and its similar quaternary amines are **cationic detergents.** They are used in hair conditioner.



Cetyltrimethyl
ammonium bromide

(iii) Non-ionic detergents : The detergents which are neither in cationic nor in anionic form in their aqueous solution are called **non-ionic detergents.** They are used for cleaning the glass and ceramic wares. Polyethylene glycol and ester of stearic acid are these type of detergents.

$$CH_3(CH_2)_{16}COOH + HO(CH_2CH_2O)_nCH_2CH_2OH \xrightarrow{-H_2O} CH_3(CH_2)_{16}COO(CH_2CH_2O)_nCH_2CH_2OH$$

Stearic acid — Polyethylene glycol — Non-ionic detergents

Biosoft and Biohard Detergents : Detergents used in everyday life are collected through gutters in the sewage farm. Microorganisms degrade organic compounds of sewage farm. Due to this degradation, organic compounds are converted into simple inorganic molecules and ions. The detergents easily degraded by microorganism are called **biosoft detergents.** The detergents not easily degraded or very slowly degraded by microorganisms are called **biohard detergents.** LAS is easily degraded by microorganisms because it contains linear alkyl group, therefore it is known as biosoft detergents; while ABS contains branched alkyl group so it is not degraded by microorganisms, therefore it is known as biohard detergent. Biohard detergents cause water pollution.

SUMMARY

- Directly or indirectly, chemistry is closely associated with our everyday life. By now we have understood applications of chemistry in drugs, foods and cleansing agents.

Drugs

- Research about applications of chemical compounds resulted in chemical compounds which were used for treatment of diseases during the twentieth century.
- The treatment in which diseases causing parasites (virus, fungi, yeast, bacteria, protozoa, worm) are killed and inhibited their growth by chemicals in body is called chemotherapy.
- Ehrlich has synthesized arsenic containing compounds for skin diseases like syphilis and for sleeping disorder. For this work Ehrlich was awarded the Nobel prize in 1908.
- Due to successive efforts of Ehrlich about chemotherapy, he is known as father of chemotherapy.
- Drugs can be classified (1) on the basis of pharmacological effect (2) on the basis of drug action (3) on the basis of chemical structure of drugs and (4) on the basis of molecular targets of drugs.
- Enzymes and receptors play an important role in our body. Drugs stop negative effect of enzymes and receptors by interacting with them.

Therapeutic action of different classes of drugs

Sr.	Drug	Uses	Example	Note
(1)	Antacids	Prevents acidity	Sodium hydrogen carbonate, mixture of aluminium hydroxide and magnesium hydroxide	Give relief only for the symptoms but do not control the causes
(2)	Antihistamine Drugs	In treatment of acidity	As antacids : cimetidine, ranitidine. As antiallergenic drugs : brompheniramine, terfenadine	Act as antihistamine drugs, the antacids cannot be used as antiallergenic drugs or the antiallergenic drugs cannot be used as antacids.
(3)	Neurologically Active Drugs			They affect mainly the message transfer mechanism between nerve and receptor.
	(A) Tranquilizers	Relief from anxiety, stress, irritability.	Iproniazid, phenelzine, chlordiazepoxide, meprobamate, derivatives of barbituric acid such as veronal, amytal, nembutal, luminal, seconal	These drugs are sedative (sleep producing)
	(B) Analgesic drugs (i) Non-Narcotic	In treatment of body pain, fever, coagulation of blood	Paracetamol, aspirin	Patient does not suffer from sleepiness or excitement.
	(ii) Narcotic	In treatment of body pain	Morphine	Patient suffers from sleepiness and excitement
(4)	Antimicrobial Drugs (A) Antibiotics	To prevent and inhibit the growth of microorganism	Penicillin, tetracycline chloramphenicol, amino glycosides, ofloxacin, erythromycin	To prevent and to inhibit the pathogenic action of microorganisms

	(B) Antiseptic Drugs	In making tissues free from micro-organisms	Potassium permanganate, tincture iodine, furacine, soframicine, boric acid, 0.2% aqueous solution of phenol	
	(C) Disinfectants	In making inanimate objects free from micro organism	Chlorine water having 0.2 to 0.4 ppm concentration, dilute solution of sulphur dioxide, 1% of aqueous solution of phenol	
(5)	Antifertility Drugs	Prevention of impregnation	Mixture of mestranol (estrogenic) and norethin-drone (progestogenic)	These drugs are for females, these pills are taken orally.

Food

- Specific chemicals are added to food for their preservation, enhancing their appeal and improving nutritive value.

Some important compounds are added to food

Sr.	Compounds	Examples	Importance
(1)	Artificial sweetening agents	Aspartame, saccharin, sucrolose, alitame	Their sweetness is higher than table sugar but they give less calories to body
(2)	Food preservatives	Table salt, table sugar, vegetable oil, sodium benzoate, sodium meta-bisulphite, salt of propionic acid, salt of sorbic acid	To prevent food from spoilage by microorganisms
(3)	Antioxidants	Citric acid, ascorbic acid, butylated hydroxy toluene (BHT), butylated hydroxy anisole (BHA)	They cause slow activity of oxygen and resulting food is preserved for long time.
(4)	Food colours	β-Carotene, caramel, tetrazine, arneto	They make food colourful.

Cleansing Agents

- The chemical compounds used to remove dirt or oily materials from surfaces are called cleansing agents.
- Soaps and synthetic detergents are important cleansing agents.

- Vegetable oil or Animal fat + Sodium hydroxide or Potassium hydroxide $\xrightarrow[\text{Saponification}]{\Delta}$ Sodium salt of fatty acid (Soaps) + Glycerol
- Soaps produce insoluble compounds in acidic medium and with hard water. In these cases soap is wasted and it does not satisfy the purpose of cleansing.
- Sodium salt of organic sulphonic acid is called synthetic detergents. e.g., sodium salts of branched alkyl benzene sulphonate (ABS) and linear alkyl benzene sulphonate (LAS).

Synthetic detergents

Anionic detergents e.g.,	Cationic detergents e.g.,	Non-ionic detergents e.g.,
• Sodium salt of branched alkyl benzene sulphonate • Sodium salt of linear alkyl benzene sulphonate	• Cetyl trimethyl ammonium bromide	• Ester formed from the polyethylene glycol and stearic acid

- The detergents easily degraded by microorganism are called biosoft detergents e.g., LAS detergents.
- The detergents not easily degraded or very slowly degraded by microorganisms are called biohard detergents. e.g., ABS detergents. These detergents cause water pollution.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Who is known as the father of chemotherapy ?

(A) Alexander Fleming (B) Howard Florey

(C) Paul Ehrlich (D) Ernst Boris Chain

(2) What are the drugs called that kill or inhibit the growth of microorganisms which cause bad effect to wounds or injury ?

(A) Tranquilizers (B) Antibiotics (C) Antiseptics (D) Disinfectants

(3) Which statement is true from the following ?

(A) Drugs bind to receptor site instead of messengers and stop communication process of cell are called agonists.

(B) The receptors which accept drugs in impression of natural messenger and communication process occurs are called antagonists.

(C) Drugs bind to different sites instead of active site of enzyme; this site is called allosteric site.

(D) Drugs helped in binding of substrate with active site of enzyme are called enzyme inhibitors.

(4) Which type of class of drugs does ranitidine belong to ?

(A) Antihistamines (B) Neurologically active drugs

(C) Antimicrobial drugs (D) Antifertility drugs.

(5) Which of following solutions acts as disinfectant ?

(A) Aqueous solution containing 1 % of phenol

(B) Aqueous solution containing 0.2 % of phenol

(C) Aqueous solution containing 2-3 % of iodine

(D) Dilute aqueous solution of boric acid

(6) Which order from the following is true on the basis of sweetness values ?

(A) Aspartame > Sucrolose > Alitame > Saccharine

(B) Aspartame > Saccharine > Sucrolose > Alitame

(C) Alitame > Sucrolose > Saccharine > Aspartame

(D) Saccharine > Aspartame > Alitame > Sucrolose

(7) Which of the following two pairs are proper ?

(a) Food preservative - Sodium benzoate

(b) Antioxidant - Propionic acid

(c) Food colour - β-carotene

(d) Artificial sweetening agent-Arneto

(A) a, b (B) a, c (C) a, d (D) b, d

(8) LAS is .....

(A) Cationic detergent (B) Nonionic detergent

(C) Biosoft detergent (D) Biohard detergent

(9) ABS is .....

(A) Anionic detergent (B) Cationic detergent

(C) Nonionic detergent (D) Biosoft detergent

(10) Which of the following drugs is analgesic drug ?

(A) Barbiturates (B) Penicillin (C) Ranitidine (D) Paracetamol

2. Write the answers of the following questions in brief :

(1) Which chemical produced in body causes inflammation or pain in the tissue ?

(2) What is tincture of iodine ?

(3) Write the example of weak antiseptic.

(4) Write the example of powerful antiseptic.

(5) How can the activity of disinfectant be expressed ?

(6) Mention the name of artificial sweetening agent which is stable at cooking temperature.

(7) Which compound is added in shaving soap as a well-foam maker ?

(8) Write definition of following terms :

(i)	Chemotherapy	(ii)	Enzyme inhibitor
(iii)	Competitive inhibitors	(iv)	Allosteric site
(v)	Chemical messenger	(vi)	Antagonists
(vii)	Agonists	(viii)	Antacids
(ix)	Non-narcotic analgesic drug	(x)	Narcotic analgesic drug
(xi)	Antipyretics	(xii)	Antimicrobial drugs
(xiii)	Antibiotics	(xiv)	Microbicidal
(xv)	Microbiostatic	(xvi)	Antiseptics
(xvii)	Disinfectants	(xviii)	Antifertility drugs
(xix)	Food preservatives	(xx)	Antioxidants
(xxi)	Food colours	(xxii)	Cleansing agents
(xxiii)	Soaps	(xxiv)	Synthetic detergents
(xxv)	Anionic detergents	(xxvi)	Cationic detergents
(xxvii)	Nonionic detergents	(xxviii)	Biosoft detergents
(xxix)	Biohard detergents	(xxx)	Antivirus agents

3. Write the answers of the following questions :

(1) Mention two points of difference :

(i) Narcotic – Non narcotic analgesic drugs

(ii) Antiseptic drugs – Disinfectants

(iii) Soap – Synthetic detergents

(iv) Anionic – Cationic detergents

(v) Biosoft – Biohard detergents

(2) Write two examples of each of the following compounds :

(i) Antacids	(ii) Antiallergenic drugs
(iii) Tranquilizers	(iv) Antibiotics
(v) Artificial sweetening agents	(vi) Food preservatives
(vii) Antioxidants	(viii) Food colours

4. Write answers of the following questions in detail :

(1) Which four points are taken into consideration in classifying the drugs ? Explain.

(2) Explain drug- enzyme interaction.

(3) Describe drug- receptor interaction.

(4) Discuss about food preservatives and antioxidants added in food.

(5) What is saponification ? Write its chemical equation. Mention the names of compounds which are added during the preparation of bath soap, washing soap and medicated soap.

(6) Explain classification of detergents with examples.

APPENDIX

Atomic Number and Molar Mass of Elements

Element	Symbol	Atomic Number	Molar mass(g mol^{-1})
Actinium	Ac	89	227.03
Aluminium	Al	13	26.98
Americium	Am	95	(243)
Antimony	Sb	51	121.75
Argon	Ar	18	39.95
Arsenic	As	33	74.92
Astatine	At	85	210
Barium	Ba	56	137.34
Berkelium	Bk	97	(247)
Beryllium	Be	4	9.01
Bismuth	Bi	83	208.98
Bohrium	Bh	107	(264)
Boron	B	5	10.81
Bromine	Br	35	79.91
Cadmium	Cd	48	112.40
Cesium	Cs	55	132.91
Calcium	Ca	20	40.08
Californium	Cf	98	251.08
Carbon	C	6	12.01
Cerium	Ce	58	140.12
Chlorine	Cl	17	35.45
Chromium	Cr	24	52.00
Cobalt	Co	27	58.93
Copernicium	Cn	112	(277)
Copper	Cu	29	63.54
Curium	Cm	96	247.07
Darmstadtium	Ds	110	(271)
Dubnium	Db	105	(263)
Dysprosium	Dy	66	162.50

Element	Symbol	Atomic Number	Molar mass(g mol^{-1})
Einsteinium	Es	99	(252)
Erbium	Er	68	167.26
Europium	Eu	63	151.96
Fermium	Fm	100	(257.10)
Fluorine	F	9	19.00
Francium	Fr	87	(223)
Gadolinium	Gd	64	157.25
Gallium	Ga	31	69.72
Germanium	Ge	32	72.61
Gold	Au	79	196.97
Hafnium	Hf	72	178.49
Hassium	Hs	108	(269)
Helium	He	2	4.00
Holmium	Ho	67	164.93
Hydrogen	H	1	1.0079
Indium	In	49	114.82
Iodine	I	53	126.90
Iridium	Ir	77	192.2
Iron	Fe	26	55.85
Krypton	Kr	36	83.80
Lanthanum	La	57	138.91
Lawrencium	Lr	103	(262.1)
Lead	Pb	82	207.19
Lithium	Li	3	6.94
Lutetium	Lu	71	174.96
Magnesium	Mg	12	24.31
Manganese	Mn	25	54.94
Meitnerium	Mt	109	(268)
Mendelevium	Md	101	258.10

Element	Symbol	Atomic Number	Molar mass(g mol^{-1})
Mercury	Hg	80	200.59
Molybdenum	Mo	42	95.94
Neodymium	Nd	60	144.24
Neon	Ne	10	20.18
Neptunium	Np	93	(237.05)
Nickel	Ni	28	58.71
Niobium	Nb	41	92.91
Nitrogen	N	7	14.0067
Nobelium	No	102	(259)
Osmium	Os	76	190.2
Oxygen	O	8	16.00
Palladium	Pd	46	106.4
Phosphorus	P	15	30.97
Platinum	Pt	78	195.09
Plutonium	Pu	94	(244)
Polonium	Po	84	210
Potassium	K	19	39.10
Praseodymium	Pr	59	140.91
Promethium	Pm	61	(145)
Proactinium	Pa	91	231.04
Radium	Ra	88	(226)
Radon	Rn	86	(222)
Rhenium	Re	75	186.2
Rhodium	Rh	45	102.91
Roentgenium	Rg	111	(272)
Rubidium	Rb	37	85.47
Ruthenium	Ru	44	101.07
Rutherfordium	Rf	104	(261)
Samarium	Sm	62	150.35
Scandium	Sc	21	44.96

Element	Symbol	Atomic Number	Molar mass(g mol^{-1})
Seaborgium	Sg	106	(266)
Selenium	Se	34	78.96
Silicon	Si	14	28.08
Silver	Ag	47	107.87
Sodium	Na	11	22.99
Strontium	Sr	38	87.62
Sulphur	S	16	32.06
Tantalum	Ta	73	180.95
Technetium	Tc	43	(98.91)
Tellurium	Te	52	127.60
Terbium	Tb	65	158.92
Thallium	Tl	81	204.37
Thorium	Th	90	232.04
Thulium	Tm	69	168.93
Tin	Sn	50	118.69
Titanium	Ti	22	47.88
Tungsten	W	74	183.85
Ununtrium	Uut	113	(284)
Ununquadium	Uuq	114	(289)
Ununpentium	Uup	115	(288)
Ununhexium	Uuh	116	(289)
Ununseptium	Uus	117	(290)
Ununoctium	Uuo	118	(293)
Uranium	U	92	238.03
Vanadium	V	23	50.94
Xenon	Xe	54	131.30
Ytterbium	Yb	70	173.04
Yttrium	Y	39	88.91
Zinc	Zn	30	65.37
Zirconium	Zr	40	91.22

(The Value given in parenthesis is the molar mass of the isotope of largest known half-life)

LOGARITHMS

	0	1	2	3	4	5	6	7	8	9	Mean Difference								
											1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21	25	29	33	37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19	23	26	30	34
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17	21	24	28	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	11	13	16	18	21	24
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	16	19	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	13	16	18	20
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5566	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6238	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6345	6454	6464	6474	6484	6494	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9

LOGARITHMS

	0	1	2	3	4	5	6	7	8	9	Mean Difference								
											1	2	3	4	5	6	7	8	9
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6	7
60	7782	7789	7769	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9843	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	3	4
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9

ANTILOGARITHMS

	0	1	2	3	4	5	6	7	8	9	Mean Difference								
											1	2	3	4	5	6	7	8	9
.00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
.01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
.02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
.03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	1	2	2	2
.04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
.05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
.06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	2	2	2	2
.07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	2
.08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
.09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
.10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
.11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	3	3
.12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
.13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
.14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
.15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
.16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
.17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
.18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
.19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
.20	1585	1289	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
.21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2	2	3	3	3
.22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3
.23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
.24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
.25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4
.26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
.27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4
.28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2	3	3	4	4
.29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2	3	3	4	4
.30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2	3	3	4	4
.31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2	3	3	4	4
.32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2	3	3	4	4
.33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2	3	3	4	4
.34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3	3	4	4	5
.35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3	3	4	4	5
.36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3	3	4	4	5
.37	2344	2350	2355	2360	2366	2371	2377	2380	2388	2393	1	1	2	2	3	3	4	4	5
.38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3	3	4	4	5
.39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3	3	4	5	5
.40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3	4	4	5	5
.41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3	4	4	5	5
.42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3	4	4	5	6
.43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3	4	4	5	6
.44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3	4	4	5	6
.45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3	4	5	5	6
.46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3	4	5	5	6
.47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	3	3	4	5	5	6
.48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	4	4	5	6	6
.49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	4	4	5	6	6
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9

ANTILOGARITHMS

	0	1	2	3	4	5	6	7	8	9	Mean Difference								
											1	2	3	4	5	6	7	8	9
.50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7
.51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4	5	5	6	7
.52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
.53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	6	6	7
.54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	6	6	7
.55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	6	7	7
.56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4	5	6	7	8
.57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4	5	6	7	8
.58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4	5	6	7	8
.59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5	5	6	7	8
.60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5	6	6	7	8
.61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5	6	7	8	9
.62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5	6	7	8	9
.63	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5	6	7	8	9
.64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5	6	7	8	9
.65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5	6	7	8	9
.66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5	6	7	9	10
.67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5	7	8	9	10
.68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6	7	8	9	10
.69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6	7	8	9	10
.70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6	7	8	9	11
.71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6	7	8	10	11
.72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6	7	9	10	11
.73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6	8	9	10	11
.74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6	8	9	10	12
.75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7	8	9	10	12
.76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7	8	9	11	12
.77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7	8	10	11	12
.78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7	8	10	11	13
.79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7	9	10	11	13
.80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7	9	10	12	13
.81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8	9	11	12	14
.82	6607	6622	6637	6653	6668	6683	6699	6715	6730	6745	2	3	5	6	8	9	11	12	14
.83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8	9	11	13	14
.84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8	10	11	13	15
.85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8	10	12	13	15
.86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8	10	12	13	15
.87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9	10	12	14	16
.88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9	11	112	14	16
.89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9	11	12	14	16
.90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	5	7	9	11	13	15	17
.91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9	11	13	15	17
.92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10	12	14	15	17
.93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10	12	14	16	18
.94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10	12	14	16	18
.95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10	12	15	17	19
.96	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	8	11	13	15	17	19
.97	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11	13	15	17	20
.98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11	13	16	18	20
.99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11	14	16	18	20
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9