Cyclic and Noncyclic Organic Compounds

Cyclic and Noncyclic Organic Compounds:

A Textbook of Organic Chemistry

By

V. M. Abbasov, C. G. Rasulov,
A. M. Askerova and S. A. Ismailov

Cambridge
Scholars
Publishing

Cyclic and Noncyclic Organic Compounds:
A Textbook of Organic Chemistry

By V. M. Abbasov, C. G. Rasulov, A. M. Askerova and S. A. Ismailov

This book first published 2024

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN (10): 1-5275-5302-7
ISBN (13): 978-1-5275-5302-6

The book discusses the main classes of cyclic and non-cyclic organic compounds, their structure, properties and methods of preparation. In close connection with the material under discussion, information is presented on theoretical concepts, spectral characteristics, issues of stereochemistry, kinetics and thermodynamics, and the most important modern methods of synthesis and analysis. The textbook is intended for students of chemical faculties of universities and chemical universities.

CONTENTS

PREFACE

> You my dear friend
> I love chemistry
> Chemistry takes water from fire,
> Where is such a science?
> **Sokhrab Ismailov**

The selection and systematization of the material for this textbook intended for undergraduate students of chemistry faculties of higher schools is designed to lay the foundations of active knowledge in accordance with the main goal of the course, to guide modern research in chemistry and to work effectively in the chosen field.

In order not to deviate from the main goal and to ensure brevity, the textbook includes information acquired by students in high school, as well as advanced areas of organic chemistry that have become the subject of special research (dyes and heterocycles, steroids, terpenes, large alicycles, compounds of some organic elements, oils and waxes and etc.).

Information on theoretical concepts, spectral characteristics, issues of stereochemistry, kinetics and thermodynamics, the most important modern methods of synthesis and analysis is presented in close connection with the material under discussion and therefore is easier to digest. For example, the essence of IR spectroscopy and mass spectrometry, the use of the energy profile of a reaction to judge its mechanism has already been described in the section "Chemical Reactions"; in the "alkenes" section, students will get acquainted with some important provisions of stereochemical theory; in the "chemical bonds" section, the theory of molecular orbitals, UV spectroscopy, kinetic and thermodynamic control of reactions and the basics of reactions; in the "alkynes" section about CH-acidity, conjugated acids and bases; in the section of alkyl halides, with SN_1- and SN_2-substitution mechanisms, on the role of solvent and ion pairs, on the principle of soft and hard acids and bases in the section of alcohols, in the section of esters and α-oxides - the use of crown -ethers and interfacial catalysis in organic synthesis, etc., occurs.

The student begins the consideration of cyclic compounds, already knowing the properties of functions. In the case of alicycles, first discussed in Part II, this approach allows us to study how ring size and steric structure properties affect their reactivity. In the section on the simplest benzoid systems described after alicyclic compounds, the material is systematized by function, as in non-cyclic compounds. Particular attention is paid to the specific properties of the latter (different from the properties of non-aromatic compounds), as well as the effect of substituents on the aromatic nucleus.

In order not to increase the volume of the tutorial, the section “Heterocyclic Compounds” is not included. Relevant material is usually covered in special courses.

In almost all textbooks, a review of each class of organic compounds begins with a listing of methods for their synthesis. This breaks the logic of the presentation because it includes material that the student is not yet familiar with. For example, speaking of alkanes, the methods for their preparation at the initial stage are usually given as the action of water on organomagnesium compounds, the electrolysis of carbonic acid salts, the action of metallic sodium on alkyl halides. However, the relevant material is discussed in detail later when considering the properties of organomagnesium compounds, carboxylic acid salts and halogen derivatives. Therefore, in this case, the reader is directed not to understanding, but to remembering. However, if the class of compounds is considered in the middle or at the end of the course, it would still be inappropriate to single out methods of synthesis in a separate section. This is because the student is already familiar with most of the material when describing the properties of the previously considered classes of compounds. So, for example, when he begins to study amines, he already knows such methods for their preparation as the alkylation of ammonia with alkyl halides, alcohols and epoxides, the reductive amination of ketones, the rearrangement and reduction of ketone oximes, the Mannix reaction, and the addition of ammonia to the reaction.

INTRODUCTION

Organic chemistry is the study of carbon compounds, which is why organic chemistry is also called the chemistry of carbon compounds.

Organic chemistry can also be defined as the chemistry of hydrocarbons and their derivatives. Although such a definition more clearly reflects the content of organic chemistry, it also does not allow for a sharp distinction between organic and inorganic substances. Since all phenomena in nature are connected with each other, it is naturally impossible to roughly separate one field of science from another: there are natural dialectical transitions between related sciences. On the border between organic and inorganic compounds are soda, carbon disulfide, urea, carbon monoxide (II), etc., which can be considered equally as organic and inorganic compounds.

The place of organic chemistry among other sciences is determined not only by its proximity to inorganic chemistry. By studying the most complex organic substances that play an important role in the life of animal and plant organisms, organic chemistry enters into close contact with biology. In the border area between these two sciences, a new young science has arisen and is successfully developing - biological chemistry. Finally, the connection between organic chemistry and physical chemistry and physics is becoming ever closer as a result of the ever wider application of physical methods to the study of organic substances.

Among the reasons for the separation of organic chemistry into a separate science, the following can be distinguished:

1. The number of known organic compounds (about 16 million) far exceeds the number of compounds of all other elements of the periodic system of Mendeleev. Currently, about 700,000 inorganic compounds are known, while about 150,000 new organic compounds are obtained per year. This is explained not only by the fact that chemists are especially intensively engaged in the synthesis and study of organic compounds, but also by the special ability of the carbon element to give compounds with an almost unlimited number of carbon atoms linked in chains and cycles.

2. Organic substances are of exceptional importance in connection with their extremely diverse practical applications, and especially in connection with the fact that they play an important role in the life processes of organisms.

3. There are significant differences in the properties and reactivity of organic compounds from inorganic compounds, as a result of which many special methods for studying organic compounds had to be developed.

A special place among the elements of the periodic system of D. I. Mendeleev is occupied by carbon. This is due to the fact that its atoms, having the ability to form sufficiently strong bonds among themselves, form the so-called carbon skeletons - straight and branched chains, various rings, bulk structures of countless molecules. The valencies of free carbon in the carbon skeleton are saturated due to the formation of bonds with hydrogen (in this case, hydrocarbon molecules are obtained), as well as with other atoms and groups of atoms (the latter are called substituents). The ability to vary the number and arrangement of atoms in the carbon skeleton, as well as the number, types and arrangement of substituents means that an arbitrarily large number of carbon compounds can be "designed". This was one of the reasons that prompted the chemistry of the latter to be singled out as a separate science. This science is characterized by an approach to the systematization of the material and the development of new ways of development. Since the first carbon compounds were isolated from living organisms or their metabolic products, it was called organic chemistry.

Later it turned out that carbon compounds play a decisive role in almost all processes that determine the nature of the activity of a living cell, so the original name of the science of carbon compounds - organic chemistry - sounds relevant to the present time.

Organic chemistry, on the one hand, comes into contact with inorganic chemistry, since its objects of study are, for example, derivatives of carbonic acid or compounds of silicon and boron, which have a relatively small proportion of carbon in their molecules, on the other hand. with biology, since a number of its sections are devoted to the study of substances actively involved in vital processes (nucleic acids, proteins, polysaccharides, lipids, steroid hormones, etc.).

The great diversity and specificity of the properties of organic compounds led to the fact that the successes of organic chemistry began to significantly influence the development of already existing chemical disciplines (inorganic, analytical, physical chemistry, biochemistry) and contributed to the creation of new chemicals.

The practical significance of organic compounds determined the emergence and development of many special areas of organic chemistry (the chemistry of paints, medicines, explosives and aromatics, plant protection products, combustible and structural materials).

Organic chemistry penetrates deeper and more intensively into neighboring fields of knowledge. There is a natural process of the disappearance of clear boundaries separating the fields of science, the rapid growth of related disciplines, where discoveries are often made at the “crossroads of sciences”, which determines the direction of research for many years.

History of organic chemistry

Substances in nature are divided into two types: inorganic and organic. It is no coincidence that the substances are named so. Water, salt, ash, etc. are inorganic substances. They are mainly found in inanimate nature. Organic matter is found in living organisms. Organic substances formed in organisms could not previously be obtained in laboratories. Proteins (meat, egg white), starch, fats, sugars, etc., are formed in plant and animal organisms. Currently, people can artificially synthesize organic substances in laboratories. All organic substances contain the element carbon. In addition to the carbon element, they contain oxygen, hydrogen, nitrogen, and other elements. If we burn organic matter, they turn into inorganic matter. For example, if we heat a seed in a test tube, it will turn black, char, and then burn to ashes. As a result of its combustion, carbon dioxide and water are released. At this time, inorganic substances are obtained from organic substances. On the other hand, starch is produced from carbon dioxide and water, which are inorganic substances, during photosynthesis in green plants.

If the number of organic substances common in nature is approximately 700,000, then the number of organic substances formed by one element carbon is several million.

While the science of inorganic chemistry has been known since ancient times, the concept of organic chemistry hardly existed until the early 19th century. However, people used natural dyes for dyeing fabrics, vegetable and animal oils as food, sugar obtained from beets, and in some areas of artisanal production, vinegar was obtained by fermenting alcohol. With the development of chemical analysis methods, it was found that the composition of plant and animal substances mainly consists of the element carbon. For the first time in 1807, the famous Swedish chemist J. Berzelius proposed to call substances obtained from living organisms organic substances, and the science that studies them, organic chemistry. Other chemists of the time believed that organic substances were fundamentally different from inorganic substances. In their opinion, organic substances cannot be obtained by the laboratory method, like inorganic substances. Organic substances can only be formed with the help of the “life force” of living organisms. At that time, this approach was called the vitalistic approach (from the Latin “vita” - life). In 1828, a student of J. Berzelius, the German chemist F. Wöhler for the first time synthesized organic matter from inorganic substances - urea ($CO(NH_2)_2$), and in 1824 - oxalic acid ($C_2H_2O_4$), a big blow to the views of vitalists.

$$AgNCO + NH_4Cl \rightarrow \underset{\text{(urea)}}{(NH_2)_2CO} + AgCl;$$

$$CNCN \xrightarrow{H_2O;\ OH^-} NH_2COCONH_2 \xrightarrow{H^+} \underset{\text{(Oxalic Acid)}}{C_2H_2O_4}$$

Föller’s dicyanide CNCN, like oxalic acid nitrile, reacts in an alkaline medium to form oxalic acid amide (oxamide) $NH_2COCONH_2$, from which oxalic acid is readily formed. Later, the German scientist A. Kolbe, the French chemist M. Berthelot, and the Russian scientist A. Butlerov proved in principle the possibility of mutual transformation of inorganic and organic substances and the absence of a sharp boundary between them by synthesizing organic substances from inorganic ones. Unlike inorganic substances, most organic substances are flammable and easily decompose when heated.

CHAPTER 1

THEORETICAL FOUNDATIONS

1. The subject of organic chemistry

In the body of plants and animals, a large number of carbon compounds are synthesized, many of which are necessary for humans. These are sugar, starch, vegetable oils and waxes, proteins, fats, dyes, fibers, etc. There are also simple carbon-containing substances (CO, CO_2, CS_2, cyanides, carbonates), which are classified and studied in the course of general and inorganic chemistry as inorganic compounds. In 1889, the German chemist K. Schorlemmer gave a definition of organic chemistry as a science, which is considered more successful: "Organic chemistry is the chemistry of hydrocarbons and their derivatives."

There are several reasons why organic chemistry was singled out as a separate science. Numerous and varied organic compounds now make up the majority of the 60 million compounds registered with the Chemical Abstracts Service (CAS) as of May 2012, and the number is steadily increasing.

2. The complexity and originality of organic compounds.

They differ significantly from inorganic compounds in their properties and reactivity: organic compounds are usually less stable, and have a lower phase transition temperature (ter., tg.). Almost all of them burn or are easily destroyed when heated with oxidizing agents, and CO_2 leaves. The molecules of most organic compounds do not decompose into ions. Reactions of organic compounds proceed very slowly and, in most cases, do not reach the end. The phenomenon of isomerism is widespread among organic compounds. Hence the need arises to develop special methods for the study of organic substances.

3. Variety of practical applications of organic compounds.

They play an important role in the life processes of animals and plants.

Organic chemistry is of exceptional scientific and practical importance. The object of this research is a large number of compounds of synthetic and natural origin. It is for this reason that organic chemistry has become the largest and most important branch of modern chemistry. In the process of obtaining new knowledge from organic chemistry, the chemistry of macromolecular compounds, bioorganic chemistry and biochemistry emerged as independent scientific disciplines. Organic chemistry forms the chemical basis of biochemistry and molecular biology, a science that studies the processes occurring in chemicals and at the molecular level at the level of organism cells. Research in this area allows a deeper understanding of the nature of natural phenomena.

Many synthetic organic compounds are produced on a large scale for use in various fields of human activity. These are petroleum products, fuel for various engines, solvents, explosives, polymeric materials (rubbers, plastics, fibers, films, varnishes, adhesives), surfactants, drugs, paints, plant protection products, perfumes and cosmetics, etc. Without knowledge of the basics of organic chemistry, it is impossible to organize the production and use of these products in an environmentally sound manner.

4. Theory of the structure of organic substances

In 1861 A. M. Butlerov formulated a scientific theory of the structure of organic substances, which stimulated the development of organic chemistry as an independent science.

The Scot A. Cooper and the German A. Kekule contributed to the formation of this theory.

They formed the idea of tetravalent carbon and expressed the idea of the ability of carbon atoms to combine into long chains.

The essence of Butlerov’s structural theory mainly consists of the following main provisions:

1. The chemical nature of each complex molecule is determined by the nature of the atoms that make up its composition, their number and chemical structure.

2. Chemical structure is a certain alternation of atoms in a molecule, their interaction with each other (both through neighboring and through other atoms).

3. The chemical structure of substances determines their physical and chemical properties.

4. The structure of a molecule can be expressed by a structural formula that is unique to a particular substance.

In the 1870s, the concept of the spatial arrangement of atoms in molecules was developed - this is called the stereochemical theory (J. Van't Hoff).

Since the beginning of the 20th century, the methods of quantum mechanics and computer technology began to penetrate into organic chemistry, with their help they tried to explain the reasons for the manifestation of the interaction of atoms in molecules and predict the ways of synthesizing new useful substances. Independent directions are formed: the chemistry of organic elements, macromolecular, heterocyclic, natural compounds. Physical and chemical research methods are actively used, which deepens the understanding of the structure and properties of substances. Many enzymes, hormones, vitamins, antibiotics, alkaloids, chlorophyll have been synthesized. The molecular structure of many proteins has been deciphered and their synthesis has been carried out in practice. The path has been opened for nucleic acids transcribed by the human genome.

5. Sources of organic compounds

The main raw materials for the production of organic compounds are natural gases, oil, hard and brown coal, shale, peat, agricultural and forestry products.

Natural gases usually accompany oil and have a different composition: as a rule, about 95% methane and 2% other hydrocarbons (ethane, propane, butane, etc.). They can be fractionated and separated into components by distillation at low temperature.

According to scientists, **oil** is the geochemically altered remains of ancient plants and animals. There are also theories about the inorganic origin of oil from metal carbides and water in the thickness of the earth's crust. Oil is a mixture of hydrocarbons with small amounts of oxygen, sulfur, nitrogen and other compounds.

Oil, purified from gases, water and mechanical impurities by distillation at normal pressure, is divided into three fractions: gasoline (30-180 ºC), kerosene (180-300 ºC) and fuel oil (distillation residue). Of these main fractions, those that boil at a lower temperature are distinguished: petroleum ether (30-100 ºC), naphtha (110-140 ºC), and white spirit (150-

210 ° C). A large number of substances, such as diesel fuel, lubricating oils, petrolatum and paraffin wax, are obtained from fuel oil by vacuum or steam distillation.

Coal is the most important raw material for the chemical industry, as its reserves far exceed oil.

In industry, several methods of coal processing are used: dry distillation (coking, semi-coking), hydrogenation, incomplete combustion, and the production of metal carbides.

About 3% of coal tar is obtained in the coking process, but large quantities are obtained in large coke production. During the processing of coal tar during the hydrogenation of coal, hydrocarbons, phenols, naphthalene, anthracenes, heterocyclic nitrogen-containing compounds, mixtures of hydrocarbons are obtained.

Incomplete combustion of coal leads to the formation of carbon monoxide (CO). The technology uses three types of gas mixtures containing CO - generator gas, water gas and synthesis gas (products of the conversion of methane and its homologues). Carbon monoxide is used to produce mixtures of hydrocarbons, alcohols, and also for the "oxosynthesis" process.

Oil shale is converted into high-calorific natural gas. At present, technologies for obtaining motor fuel from shale gas have been developed. Oxalic acid is obtained by the oxidation of peat mass. The products of agriculture and forestry are used as raw materials for the purchase of certain chemicals (ethyl alcohol from starch and cellulose, turpentine and rosin resin, soap oils, etc.).

6. Classification of organic compounds

The structure of organic compounds should be described by formulas. There are the following types of formulas:

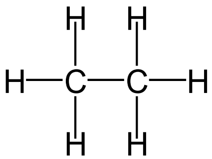
1) Empirical - indicates the smallest absolute ratio of various atoms in a molecule, for example, CH_3 (ethane C_2H_6); CH_2O (acetic acid $C_2H_4O_2$);

2) Molecular (gross) - shows the actual number of different atoms in the molecule: C_2H_6 (ethane); C_2H_4 (ethylene); $C_2H_4O_2$ (acetic acid);

3) Structure - not only reflects the type and number of atoms in a molecule, but also shows the location of bonds between atoms (structure).

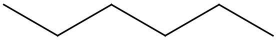
Structural formulas can be represented in the following form:

– Open structural formulas, for example, ethane;



– Abbreviated structural formulas: propane $CH_3–CH_2–CH_3$ or $CH_3CH_2CH_3$;

- Skeletal formulas of the structure, for example, hexane.



According to the structure of the carbon skeleton, organic compounds are classified according to the scheme (Fig. 1).

Acyclic (aliphatic) - compounds with an open chain of carbon atoms. Saturated - compounds that cannot combine hydrogen or other substances.

Unsaturated - compounds that can combine hydrogen or other substances.

Cyclic - compounds with a chain of atoms connected in a ring.

Carbocyclic - compounds in which a chain of only carbon atoms is connected to the ring.

Heterocyclic - compounds containing, in addition to carbon atoms in the cyclic skeleton, one or more heteroatoms - usually nitrogen, oxygen, sulfur atoms.

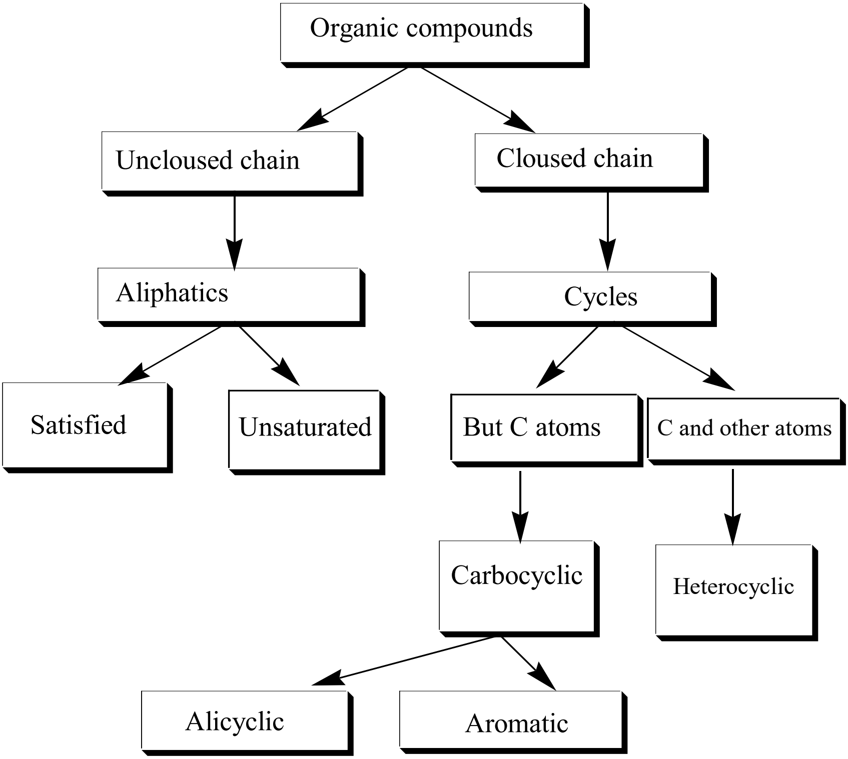
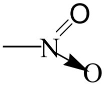
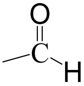
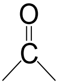
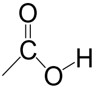
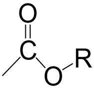


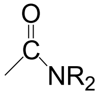
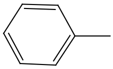
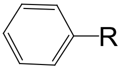
Figure 1. Classification of compounds according to the structure of the carbon skeleton

Carbon skeleton (carbon chain) - a sequence of connections of carbon atoms in a molecule. A functional group is an atom or a group of atoms that determines whether a compound belongs to a particular class and is responsible for its chemical properties. Depending on the nature of the functional group, hydrocarbon derivatives are divided into classes (Table 1).

Table 1

Main functional groups and their corresponding classes of organic compounds

Group	**The name of the group**	**The name of the class**	**General formula**
1	**2**	**3**	**4**
–F, –Cl, –Br, –İ (–Hal)	Halogen–	Halogenated	R–Hal
–OH	Hydroxy-	Alcohols, phenols	R–OH, Ar–OH
–SH	Mercapto-	Mercaptans	R–SH
–OR	Alkoxy-	Ethers	R–O–R^1
–N=O	Nitroso–	Nitrosocompounds	R–N=O
	Nitro–	Nitrocombination	$R–NO_2$
	Formyl-	Aldehydes	R–CH=O
	Oxo–(keto–)	Ketones	R–C(O)–R^1
	Carboxy-	Carbonic acids	R–C(O)OH
	Alkoxycarbonyl–	Esthers	R–C(O)OR^1

	Carbomoyl–	Amides	$R-C(O)NR_2$
$-C\equiv N$	Cyano–	Nitriles	$R-C\equiv N$
$-CH=CH_2$	Vinyl–	Alkenes	$R_1R_2C=CR_3R_4$
$-C\equiv CH$	Ethynyl–	Alkynes	$R_1C\equiv CR_2$
	Phenyl–	Aromatic hydrocarbons	

All classes of organic compounds are interconnected. The transition is mainly carried out by the transformation of functional groups without changing the carbon skeleton.

7. Nomenclature of organic compounds

Nomenclature is a set of rules by which the names of compounds are formed. With their help, you can build the name of any organic compound. In this case, it is necessary to observe an important principle: each name must correspond to a relationship. Several nomenclature systems are used in organic chemistry, the main ones being the trivial, rational, and IUPAC systems.

7.1. Trivial nomenclature. This is a historically established naming system that is still used today. They do not reflect the structure of molecules and often indicate what the organic compound consists of (formic acid, malic acid), its color (methyl orange, malachite green), method of preparation (acetone, phenolphthalein), etc.

Scientific nomenclature. To become familiar with rational and IUPAC nomenclature, you need to learn some basic concepts and terms used in naming.

Homologous series - a series of compounds similar in structure and chemical behavior, each subsequent (highest) member of the compound differs from the previous one by the CH2 group. Below is the homologous series of alkanes:

Formula	**Name**
CH_4	Methane
$CH_3CH_3(C_2H_6)$	Ethane

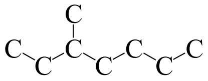
$CH_3CH_2CH_3(C_3H_8)$ Propane
$CH_3CH_2CH_2CH_3$ (C_4H_{10}) Butane
$CH_3(CH_2)_3CH_3$ (C_5H_{12}) Pentane
$CH_3(CH_2)_4CH_3$ (C_6H_{14}) Hexsane
$CH_3(CH_2)_5CH_3$ (C_7H_{16}) Heptane
$CH_3(CH_2)_6CH_3$ (C_8H_{18}) Octane
$CH_3(CH_2)_7CH_3(C_9H_{20})$ Nonane
$CH_3(CH_2)_8CH_3(C_{10}H_{22})$ Decan

Followed by: $C_{11}H_{24}$ - undecane, $C_{12}H_{26}$ - dodecane, $C_{13}H_{28}$ - tridecane, $C_{16}H_{34}$ - hexadecane (cetane), ..., C_{20} H_{42} - eicosane, etc.

The general formula of the homologous series is a formula that reflects the molecular formula of each member of the homologous series at a certain value of the number of carbon atoms, expressed by the index n (n = 1, 2, 3, etc.). $\mathbf{C_nH_{2n+2}}$ is the general formula for the homologous series of alkanes.

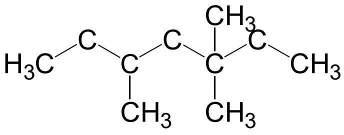
From the logical series of alkanes we get CH_4 - methane at n=1. The carbon skeleton (carbon chain) is a sequence of connections of carbon atoms in a molecule.

The normal carbon skeleton is a linear chain of carbon atoms linked to each other in the sequence: C-C-C-C-C. A branched carbon skeleton is a chain of carbon atoms connected to each other in series by branches:



Atoms connected to one carbon atom in the hydrocarbon chain are called single, to two - binary, to three - triple, and to four - quadruple.

The branched hydrocarbon shown below consists of five single (terminal), three double, one triple and one quadruple carbon atoms:

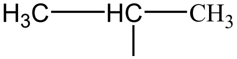
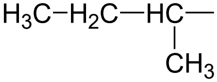
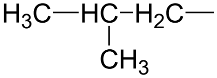
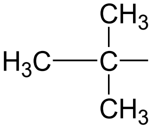
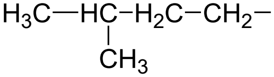


Alkyl group (hydrocarbon radical) - a fragment remaining after the removal of a hydrogen atom from an alkane molecule.

The Latin letter R is adopted as a general symbol for the designation of the alkyl group (Table 2).

Table 2

Names of some alkyl groups

The structural formula of the group	Name and abbreviation
CH_3-	Methyl (Me)
CH_3-CH_2-	Ethyl (Et)
$CH_3-CH_2-CH_2-$	Propyl (Pr)
 $H_3C-\underset{\vert}{HC}-CH_3$	Isopropyl (i-Pr)
$CH_3-CH_2-CH_2-CH_2-$	Butyl (Bu)
 $H_3C-H_2C-\underset{CH_3}{\underset{\vert}{HC}}-$	*Secondary butyl* (*s*-Bu)
 $H_3C-\underset{CH_3}{\underset{\vert}{HC}}-H_2C-$	Isobutyl (*i*-Bu)
 $H_3C-\overset{CH_3}{\overset{\vert}{\underset{CH_3}{\underset{\vert}{C}}}}-$	*Tertiary* butyl (*t*-Bu)
$CH_3(CH_2)_3CH_2-$	Pentyl (amil)
 $H_3C-\underset{CH_3}{\underset{\vert}{HC}}-H_2C-CH_2-$	Isopentyl (isoamyl)
$CH_2=CH-$	Vinyl, ethenyl
$CH_2=CH-CH_2-$	Allyl
C_6H_5-	Phenyl (Ph)
$CH_3-C_6H_4-$	Tolil (*o, m, p*)
$C_6H_5-CH_2-$	Benzyl (*Bn*)

A single hydrocarbon radical is a hydrocarbon radical (ethyl-, propyl-, butyl-, isobutyl-, etc.) with a free valence on one carbon atom.

Binary hydrocarbon radical - hydrocarbon radical with free valency at a binary carbon atom (isopropyl, dibutyl, etc.).

Tertiary hydrocarbon radical - hydrocarbon radical with free valency at the triplet carbon atom (tert-butyl-etc.).

7.2. Rational nomenclature. The nomenclature is based on the name of the simplest (often the first, less often the second) member of the homologous series. All other compounds are considered derivatives formed by replacing hydrogen atoms with alkyl groups, atoms, or functional groups.

To name a compound according to rational nomenclature, you must:

- determine the class of the called connection;
- choose the basis of the name (table 3);
- list the substituents surrounding the base, according to their degree, and the radicals of the same name are grouped by the prefixes di-, tri- and tetra-;
- form a name starting from simple pronouns to compound ones and ending with the name of the stem.

Plural prefixes - di-, tri-, tetra-, etc., are used to denote the number of identical substituents (or multiple bonds). The normal carbon skeleton is a linear chain of carbon atoms connected in series: C–C–C–C–C.

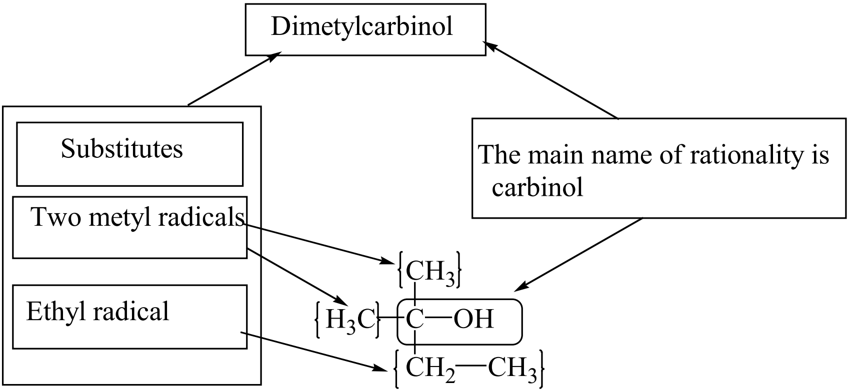
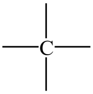
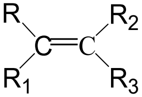
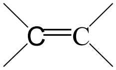
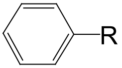
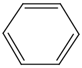
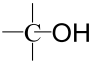
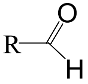
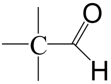
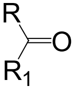
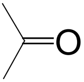
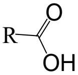
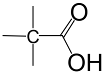
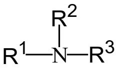
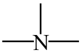


Table 3

Fundamentals of rational names and endings according to the systematic nomenclature of the main classes of organic compounds.

Classes of chemical bonds	General structural formulas	The basis of rational names	Rational nomenclature name	Suffixes according to IUPAC
1	2	3	4	5
Alkanes	$R{-}CH_2{-}CH_2{-}R_1$		Methane	-an
Alkenes			Ethylene	-en
Alkynes	$R\ C\equiv C{-}\ R_1$	$-C\equiv C-$	Acetylene	-in
Arenas			Benzene	Benzene
1	2	3	4	5
Alcohols	R–OH		Carbinol	+ol
Aldehydes			Acetic aldehyde	+al
Ketones			Keton	+on
Acides			Acetic acid	asid
Amines			Amine	Amine

7.3. The IUPAC systematic nomenclature is the most widely recognized and universal. Systematic names consist of words specially created or chosen to describe the structural features of a compound.

To name a compound according to IUPAC nomenclature, do the following:

1) Choose the initial structure, which can be a carbon chain or a closed ring, including a large group;

2) Identify all functional groups present in the compound, and among them the old name is reflected by a suffix at the end of the compound name; all other groups are called prefixes in the form (see Table 1);

3) Unsaturation is indicated by the appropriate suffix (-en or -in), as well as the prefix (dehydro-, tetrahydro-, etc.);

4) Number the main chain with the smallest possible number, giving a large group;

5) List the prefixes in alphabetical order (di-, tri-, etc. multiplying prefixes are currently not taken into account);

6) Draw the full name of the connection according to the diagram (Fig. 2).

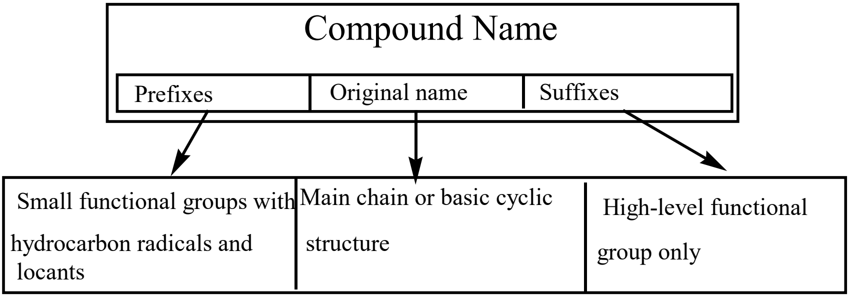
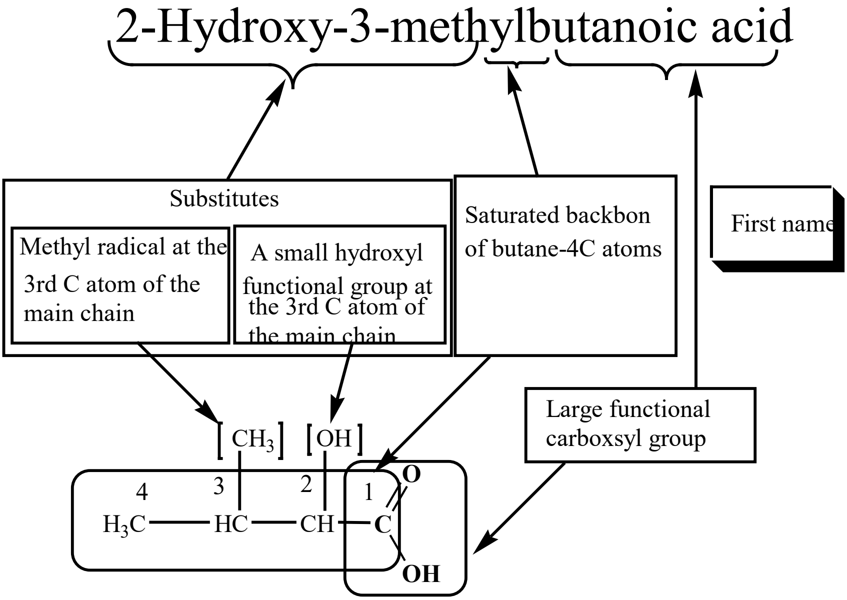


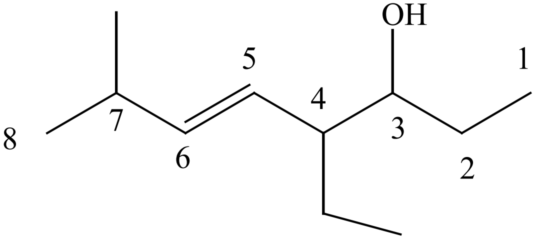
Figure 2. IUPAC name order of the compound.



Group size (desc): **–COOH > –HSO_3 > –CHO > >C=O > –OH > –NH_2 > –C=C– > –C≡C– > R, Br, I, Cl, F, N=O, NO_2, –N=N–**.

The seniority among the last groups is determined alphabetically. The roots of the initial names depending on the length of the chain of carbon atoms are presented in Table 4.

When writing the name of a substance, digits are separated from letters by a hyphen (–), and digits are separated from digits by a comma (,). Substituents in the prefix are listed in alphabetical order of the language from which the name is derived, regardless of their precedence.



7-methyl-4-ethyloct-5-en-3-ol