T. K. Veselovskaya, I. V. Machinskaya,
N. M. Przhiyalgovskaya

PROBLEMS AND EXERCISES IN ORGANIC CHEMISTRY

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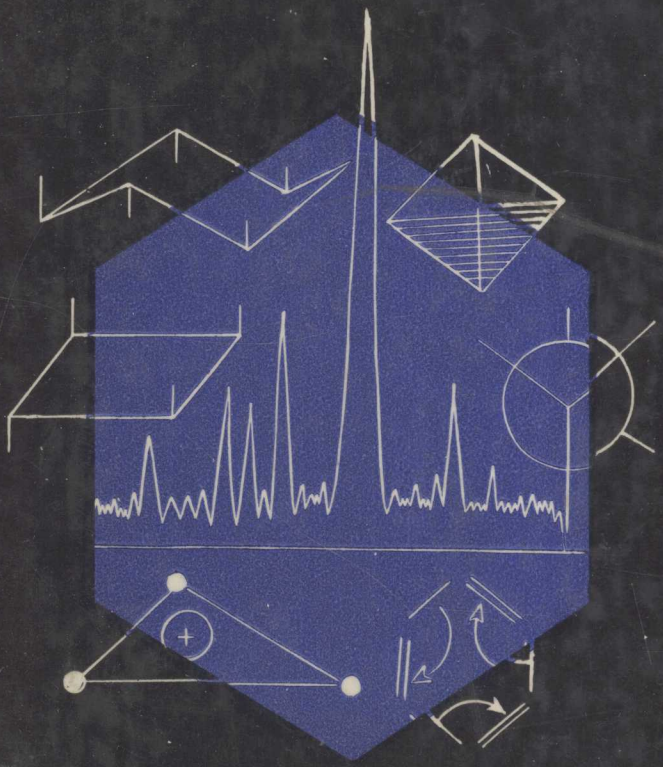

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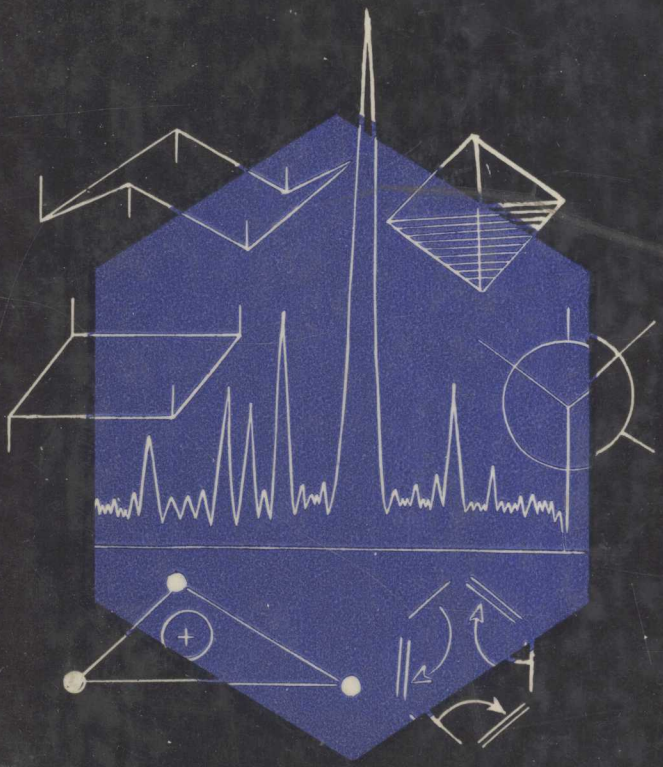

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T. K. VESELOVSKAYA, I. V. MACHINSKAYA,
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PROBLEMS AND EXERCISES IN ORGANIC CHEMISTRY

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by
Alexander Rosinkin

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На английском языке

PREFACE

New developments in the subject and in the scope of the course in organic chemistry now given to students, depend largely upon the remarkable advances which have occurred in the theory of organic chemistry. A series of comprehensive textbooks and manuals were published in which the structure and properties of organic compounds are presented in new theoretical contexts. Among these are such works as: *Fundamentals of Organic Chemistry** by A. N. Nesmeyanov and N. A. Nesmeyanov, vols. I-IV, *Basic Principles of Organic Chemistry* by J. Roberts and M. Caserio, *Chimie Organică* by C. D. Nenițescu.

As regards textbooks concerning problems and exercises in organic chemistry, most of them unfortunately do not devote sufficient attention to modern theory, except the book *Problems and Exercises in Organic Chemistry* by A. E. Agronomov**. But it is mainly intended for university students, while many other Soviet institutes that educate future chemical engineers, rather than researchers, still need a special textbook for their students.

The present book differs substantially from previously published ones in that its practical problems are closely connected with modern theory. Properties of compounds from each class are considered with respect to chemical bonds, and spatial and electronic structure of molecules. Special attention is given to conditions under which organic

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* Translated into English by Mir Publishers in 1976-1978.

** Translated into English by Mir Publishers in 1974 (reprinted in 1977).

reactions take place, their mechanisms, and the ways by which structural factors affect the reactivity of organic compounds. Special importance is attached to physical methods of investigating organic compounds. Hence the textbook contains problems dealing with I-R, U-V, and NMR spectra of compounds from different classes.

This textbook differs in that, in addition to usual problems and exercises, it also contains questions which, in the authors' opinion, will call the student's attention to the main aspects of theoretical organic chemistry and will hence facilitate his learning.

Considering the practical character of this book, the authors compiled their problems and exercises so that they can be given as control tasks to different students. Hence there are series of similar problems on certain subjects that are variations of a typical model and differ only in the object or in the approach to a problem.

More difficult problems and exercises, as well as those extending beyond the limits of the program, are marked with an asterisk and their solution is given at the end of the book.

Along with trivial and rational names, the textbook gives also modern nomenclature according to the IUPAC system. The absorption spectra of substances are given mainly according to Sadtler Standard Spectra. The Appendix contains also spectral tables.

The authors will be grateful for any constructive criticism concerning this textbook.

CONTENTS

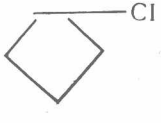
INTRODUCTION

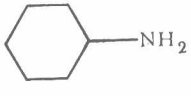
1. What is organic chemistry? For what reasons has organic chemistry been isolated into a separate subject?
2. Formulate the basic principles of the theory of chemical structure developed by A. M. Butlerov. Describe its importance for the development of organic chemistry.
3. What principles underlie the classification of organic compounds? By what characteristics can an organic compound be attributed to a series or a class?
4. To what series or class should the following compounds be attributed:

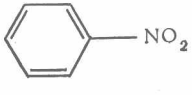
(a) divinyl, $CH_2=CH-CH=CH_2$

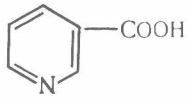
(b) isobutyl alcohol, $(CH_3)_2CH-CH_2OH$

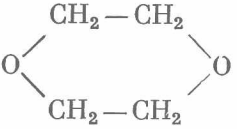
(c) acetone, $CH_3-CO-CH_3$ |

(d) chlorocyclopentane 

(e) cyclohexylamine 

(f) nitrobenzene 

(g) nicotinic acid 

(h) dioxane 

5. Characterize the role of quantum mechanical concepts in the development of our knowledge of the nature of a chemical bond.

6. Define the main types of chemical bonds: ionic and covalent. Indicate the physical causes that are responsible for the formation of bonds between atoms. Give examples of diatomic molecules:

(a) with an ionic bond, (b) with a covalent bond.

7. Characterize chemical bonds in molecules of the following compounds: (a) fluorine, (b) methane, (c) hydrogen bromide, (d) sodium fluoride, (e) sodium amide.

8. What is known as the donor-acceptor bond? Give examples of molecules with the donor-acceptor bonds.

9. Characterize chemical bonds in molecules of the following compounds: (a) carbon monoxide, (b) ammonium bromide, (c) nitric acid, (d) all oxides of nitrogen.

10. Give electronic structure of the following molecules and ions: (a) ammonia and NH_4^+ ion; (b) water, H_3O^+ ion, and OH^- ion; (c) bromine, Br^- anion, and Br^+ cation; (d) H_2, H^+, and H^-; (e) HNO_2, NO_2^-, NO_2^+, and NO^+.

11. Define the σ- and π-bonds. Give examples of organic and inorganic compounds whose molecules have: (a) only σ-bonds, (b) σ- and π-bonds.

12. Give electronic configurations of a carbon atom in the ground and excited state. How can the equivalence of all bonds in a molecule of methane be explained?

13. What kinds of hybridization are possible with the carbon atom? Characterize the form and spatial direction characteristics of the atomic orbitals.

14. Define chemical bonds in the following molecules: (a) ethane, (b) ethylene, (c) acetylene. Draw atomic-orbital diagrams of their structures.

15. What particles are known as free radicals? How do they differ from ions? Give examples of organic and inorganic free radicals.

16. Give electronic formulas for the following particles: (a) $CH_3\cdot$, (b) CH_3^+, (c) CH_3^-. In what state of hybridization is the carbon atom present in each of these particles?

17. Discuss the electronic and spatial structure of the following particles: (a) $CH_3—\dot{C}H—CH_3$, (b) $(CH_3)_3C^+$, (c) CN^-.