Preface

Molecular mass transfer in rarefied and compressed gases is widely used in engineering. All main processes of chemical, petroleum, and gas industries are partly or completely diffusion processes: absorption, adsorption, chemisorption, drying, distillation, rectification, condensation, evaporation, mixing, chemical transformations in diffusion and intermediate regions, etc.

Equations to describe mass transport in a gas phase under isothermal conditions always include some coefficients, which characterize molecular mass transport in binary mixtures and evaluate the kinetics of diffusion process.

The properties are necessary for both justified calculations in developing new technological processes and apparatus and improvement of available technologies and equipment. They are also used in traditional design work and automated designing system.

Moreover, the properties of molecular mass transfer in the gas phase are used to determine the parameters of molecular interaction, in the theory and practice of gas chromatography, to solve the problems of environmental control, in aeronomy, and to teach students.

Therefore, diffusion mass transport in dilute and dense binary mixtures in the gas phase was studied in many works.

However, existing theoretical and empirical methods to calculate the properties of molecular mass transport in gases have some restrictions and often give inexact results. This problem cannot also be solved by a purely experimental way because there are a great deal of systems, which are important for engineering and science, and experimental methods are complex, labour-consuming, connected with the use of expensive equipment, and restricted by ranges of parameters and the number of substances that are within reach of experiment.

Therefore, currently, science has no way of determining the properties of molecular mass transport and no necessary experimental data in this field.

Nevertheless, modern scientific and technical progress requires wide and reliable data on the kinetic properties of rarefied and, especially, compressed binary systems in the gas phase.

Then, it is clear that, on the one hand, it is necessary to supplement available experimental results by new results.

On the other hand, it is useful to derive equations, which correctly reflect the dependence of the transport coefficients on the parameters of state. One of the possible solutions of this problem is direct approximation of many high-precision experimental results, using the statistical theory of treating measurement results.

Binary diffusion coefficients are the basic properties in the problem of molecular isothermal diffusion. They evaluate the rate of molecular mass conductivity, by determining the propagation rate of concentration or chemical potential fields; that is, these are coefficients of molecular potential conductivity under isothermal conditions. On the other hand, binary diffusion coefficients are defined as the root-mean-square distances, at which molecules move per unit time during molecular transport.

Then, it is clear that theoretical and experimental methods to determine binary diffusion coefficients in gaseous mixtures are the key problem of the problem of diffusion.

The kinetic theory of gases allows us, in principle, to calculate transport properties and to establish a numerical relationship between them.

Theoretical discussions and the formalism of derivation of the relationship between transport properties were repeatedly and comprehensively presented in fundamental monographs such as [5, 25, 26].

Theoretical methods to calculate the properties of molecular mass transport in gases are complex and inconvenient for practical implementation.

Methods to calculate binary diffusion coefficients of dilute mixtures in the gas phase can only partly satisfy the requirements of modern engineering and science in terms of the accuracy of results, the number of substances, and temperature range within reach of calculation [3, 5, 19, 20, 146]. The calculation errors far exceed the accuracy of experimental determination of binary diffusion coefficients.

Methods to calculate binary diffusion coefficients in dense gases lead to significant errors increasing with pressure [40, 99, 20]. Hence, the values of binary diffusion coefficients calculated under compression conditions cannot be recommended for use.

Empirical methods to calculate binary diffusion coefficients in the gas phase were developed for a limited number of mixtures and can only be used in narrow ranges of the parameters of state [3, 12].

Therefore, in the whole, available methods to calculate the properties of molecular mass transport in binary systems in gases cannot be accepted as satisfactory methods.

Experimental ways to determine the properties of molecular mass transport in binary mixtures in the gas phase are the most reliable origin of knowledge.

Experimental studies of diffusion in gases were first carried out by Graham [124] in 1829, and those of liquid vapor diffusion to gases, by Stefan [168, 169] in 1871.

The basic experimental methods of investigating diffusion in the gas phase were comprehensively reviewed in the works [1, 146]. The available handbooks [4, 27] give experimental data on binary diffusion coefficients obtained only till 1970. Liquid vapor diffusion to compressed gases, however, was not comprehensively studied till 1970.

In this book, we describe experimental methods of measuring binary diffusion coefficients of liquid vapors in gases. Experimental data on binary diffusion coefficients of liquid vapors in gases are given in wide temperature and pressure ranges (studies were performed by various investigators and by us).

When writing this book, we used many scientific works and, hence, we would like to thank the authors of all used papers.