

Chapter 6: Chemical Kinetics – Fundamentals

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Abstract

This chapter presents the basics of chemical kinetics, namely the rate of chemical reactions, rate laws, the order of reaction and also the molecularity. It gives an explanation of the rate of a reaction being dependent upon concentration, temperature and the nature of the reactants. Chapter gives a detailed discussion on the integrated rate equations of zero-, first-, and second-order reaction so that one can determine the concentration of the reactants as time progresses and can predict when the reaction will be completed. Molecularity and reaction mechanisms are brought to the fore so as to get to know the stepwise series of chemical transformations. An example Industrial relevance is emphasized with regards to manufacture of chemicals, polymerization, pharmaceutical synthesis, and catalytic processes, industrial reaction kinetics are important in design of processes, optimization of reactors, and increased yield. Combining theory and practice, the chapter provides the students with skills to study the behavior of reactions, make predictions and optimize the conditions of a reaction at both industrial and laboratory scales. Learning chemical kinetics can enable one to use process engineering, optimization of reactions, and sustainable chemical production, which is why it is an essential field of study among undergraduate and postgraduate chemistry students.

Keywords: Chemical kinetics, Reaction rate, Rate law, Reaction order, Molecularity, Industrial applications, Reaction mechanism

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6.1. Introduction

The study of the rate at which chemical reactions take place and how they occur is called chemical kinetics which is a branch of physical chemistry. In comparison to thermodynamics, which reveals whether a reaction is possible, kinetics gives an account of the rate at which a reaction occurs and the order in which it occurs. It discusses the most important variables, temperature, concentration, pressure, catalysts, surface area, all which determine the speed of the reaction. Chemical kinetics allows chemists to predict the behavior of reactions and to optimize such reactions to achieve the desired results by studying the rate laws and the activation energy. Kinetics in industry is instrumental in the construction of efficient reactors, maximization of the yield of the product, and safety in large scale production. Since pharmaceuticals, petrochemicals, and environmental processes all rely on kinetics, the knowledge of these reactions pathways allows the control of reaction direction and allows better optimization of the process. Therefore, the field of chemical kinetics is an essential instrument that connects laboratory science with the chemical manufacturing and technology in the real world.

6.1.1. Definition

Chemical kinetics is the branch of chemistry that deals with the study of reaction rates and the factors that influence the speed and mechanism of chemical reactions. It explains how fast a reaction occurs and the step-by-step pathway by which reactants are converted into products.

6.1.2. History

Chemical kinetics The history of chemical kinetics dates back to the middle of the 19th century, when chemists began to attempt to measure the rate of reaction. One of the first kinetic studies was conducted in 1850 by Ludwig Ferdinand Wilhelmy who measured the rate of inverting sucrose in the presence of acid. His work showed that the rate of reaction was mathematically expressible and was the first experimental rate law in