

How Does Reactant Concentration Change as a Reaction Proceeds?

WARM-UP

Model 1: Integrated First- and Second-Order Rate Laws.

The concentration of a reactant decreases as a reaction proceeds. In some cases, the decrease in concentration of a reactant is a (relatively) simple function of time. We will examine two such cases.

For a reaction that is *first order* in a single reactant, R , the rate law is

$$\text{rate} = -\frac{d(R)}{dt} = k(R)^1 \quad (1)$$

This equation can be rearranged and integrated to provide the explicit relationship between (R) and time. The resulting equation is

$$\ln(R) = \ln(R)_0 - kt \quad (2)$$

where $(R)_0$ is the (R) at time 0 (the initial concentration) and t is the time. Equation 2 is called the **integrated form** of a first order rate law.

For a reaction that is *second order* in a single reactant, the rate law is

$$\text{rate} = -\frac{d(R)}{dt} = k(R)^2 \quad (3)$$

and the corresponding relationship between concentration and time is

$$\frac{1}{(R)} = \frac{1}{(R)_0} + kt \quad (4)$$

Equation 4 is the integrated form of a second-order rate law. Note that equations 2 and 4 each contain four potential variables: (R) , $(R)_0$, k , and t . Knowledge of any three of these variables permits the calculation of the fourth variable.

Critical Thinking Questions

1. Show that (R) decreases as t increases for each integrated rate law, equations 2 and 4.

END OF WARM-UP

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