SAMPLE PROBLEM C

For more help, go to the *Math Tutor* at the end of this chapter.

Three experiments were performed to measure the initial rate of the reaction

$$A + B \longrightarrow C$$

Conditions were identical in the three experiments, except that the concentrations of reactants varied. The results are as follows:

Experiment	[A] (M)	[B] (M)	Rate (M/s)
1	1.2	2.4	8.0×10^{-8}
2	1.2	1.2	4.0×10^{-8}
3	3.6	2.4	7.2×10^{-7}

Write the rate law for the reaction. Find the value and units of the specific rate constant.

SOLUTION

1 ANALYZE

The general rate law for this reaction has the form $R = k[A]^n[B]^m$. We need to calculate the values of the powers n and m.

2 PLAN

Find the ratio of the reactant concentrations between two experiments that have the same [A] but different [B]. Then, see how this ratio affects the ratio of rates, $\frac{R_2}{R_1}$; this ratio of rates lets us find the value of m. A similar approach of comparing two experiments that have the same [B] but a different [A] lets us find the value of n.

3 COMPUTE

First compare Experiments 1 and 2, which have the same [A], to find m:

$$\text{Concentration ratio: } \frac{[B]_1}{[B]_2} = \frac{2.4\text{ M}}{1.2\text{ M}} = 2.0; \quad \text{rate ratio: } \frac{R_1}{R_2} = \frac{8.0 \times 10^{-8}\text{ M/s}}{4.0 \times 10^{-8}\text{ M/s}} = 2.0$$

Thus, when the concentration of B changes by a factor of 2, the rate changes by a factor of 2, or 2^1. So, m is 1, and the reaction is first order in B.

Then, compare Experiments 1 and 3, which have the same [B], to find n:

$$\text{Concentration ratio: } \frac{[A]_3}{[A]_1} = \frac{3.6\text{ M}}{1.2\text{ M}} = 3.0; \quad \text{rate ratio: } \frac{R_3}{R_1} = \frac{7.2 \times 10^{-7}\text{ M/s}}{8.0 \times 10^{-8}\text{ M/s}} = 9.0$$

Thus, when the concentration of A changes by a factor of 3, the rate changes by a factor of 9, or 3^2. So, n is 2, and the reaction is second order in A.

The rate law is $R = k[A]^2[B]$.

To find the value of k, we can rearrange the rate law and substitute known values for any one experiment. Do the following for Experiment 1:

$$k = \frac{R}{[A]^2[B]} = \frac{8.0 \times 10^{-8}\text{M/s}}{(1.2\text{ M})^2(2.4\text{ M})} = 2.3 \times 10^{-8}\text{ M}^{-2}\text{s}^{-1}$$

4 EVALUATE

The same value of k can be calculated from the data for any other experiment. So, the rate law and the calculation of k are correct.