Model: Kinetics of a Unimolecular Reaction

Under certain conditions ozone in the atmosphere decomposes by dissociation ($O_3 \rightarrow O_2 + O$) with the kinetics given below. The data in the graph and table are described by the following equations. Note the curved line refers to the left scale, and the straight line refers to the right scale.

reaction rate = $-\Delta[O_3]/\Delta t$

rate law: Rate = $\Delta[O_3]/\Delta t = -k[O_3]$

integrated rate law: $\ln([O_3]/[O_3]_o) = -kt$

Ozone Decomposition
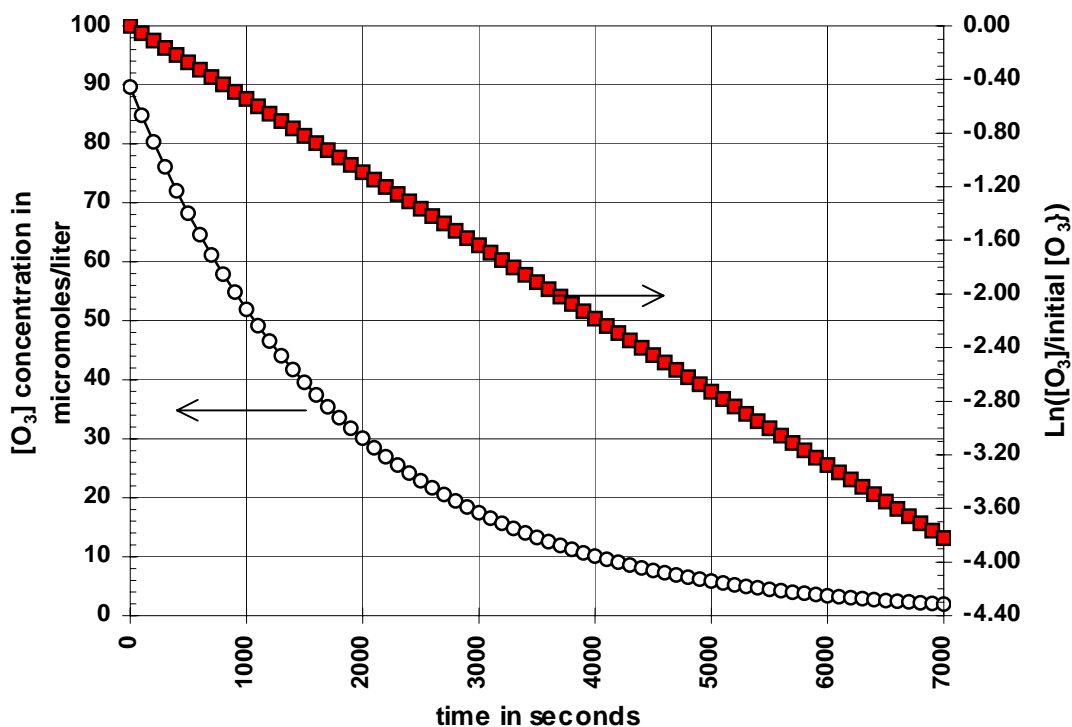
Data on Ozone Decomposition (half-life time = 1270 s)						
Time (s)	0	100	900	1000	6900	7000
concentration (10^{-6} M)	89.63	84.87	54.84	51.92	2.07	1.96
$\ln([O_3]/[O_3]_o)$	0.000	-0.0546	-0.4914	-0.5460	-3.767	-3.822

Key Questions

1. In the model, how long does it take for half the ozone to decompose, and what is the concentration of ozone after that time?

2. What is the initial reaction rate of the ozone decomposition reaction? Provide both the magnitude and the units.

3. What is the rate of the reaction after 1.92 hours have passed?

4. Why does the rate of the reaction change with time?

5. What is the order of the reaction with respect to ozone?

6. What is the overall order of the reaction?

7. If the concentration of ozone were doubled, what would happen to the rate?

8. What parameter in the integrated rate law determines the slope of the straight line in the graph?

9. Why does the concentration data, when plotted in the above graph with time on the x-axis, produce a curved line in one case and a straight line in the other?

9. What factors do you think affect the rate of a reaction?

Exercises

1. Draw lines on the graph in the model to mark the half-life time and the concentration at the half-life time and label this time with $t_{1/2}$ and concentration with $C_{1/2}$.

2. Write the rate law (aka the differential rate law) for the ozone decomposition reaction.

3. Write the integrated rate law for the ozone decomposition reaction.

4. Obtain the rate constant (magnitude and units) for the ozone decomposition reaction from the slope of the straight line in the graph.

5. Given the following rate law: Rate = k $[CHCl_3]$ $[Cl_2]^{1/2}$.
    (a) Write the reaction order with respect to chloroform.

    (b) Write the reaction order with respect to chlorine.

    (c) Write the overall reaction order.

    (d) If the concentration of chloroform is cut in half, identify what happens to the reaction rate.

    (e) If the concentration of chlorine is tripled, identify what happens to the reaction rate.