1. Consider the first-order decomposition of hydrogen peroxide in an open beaker as given by the reaction below. (20)

\[ 2\text{H}_2\text{O}_2 (\text{aq}) \rightarrow 2\text{H}_2\text{O} + \text{O}_2 (\text{g}) \]

The graph below tracks the various substances involved in the decomposition.

![Graph of Decomposition of Hydrogen Peroxide]

Label the lines on the graph to identify the \(\text{H}_2\text{O}_2\), \(\text{H}_2\text{O}\), and \(\text{O}_2\).

Does the reaction come to equilibrium? Explain why or why not.

If you massed the beaker before the decomposition started and after, would the beaker have the same mass? If no, does this violate the law of conservation of matter? Explain.

When is the decomposition fastest?
2. The equilibrium constant for the formation of ammonia is $4.3 \times 10^{-3}$ at 300°C as given by the reaction below:

$$\text{N}_2 (g) + 3\text{H}_2 (g) \rightarrow 2\text{NH}_3 (g)$$

What are the equilibrium constant expression and the value of $K$ for the reverse reaction?

3. The interconversion of two isomers of 2-butene has an equilibrium constant of 3.4 at room temperature.

$$\text{cis-2-butene (g)} \leftrightarrow \text{trans-2-butene (g)}$$

If a container has an initial concentration of cis-2-butene of 0.015M, what are the equilibrium concentrations of both isomers after a period of time?
4. Nitrosyl bromide decomposes at 10°C according to the reaction given below.

\[ 2\text{NOBr} (g) \rightarrow 2\text{NO} (g) + \text{Br}_2 (g) \]

Use the following kinetic data to determine the order of the reaction. Justify your choice of order.

\[
\begin{array}{|c|c|c|c|c|}
\hline
\text{Time (s)} & 0 & 10 & 20 & 30 & 40 \\
\text{(NOBr)} & 0.0400 & 0.0303 & 0.0244 & 0.0204 & 0.0175 \\
\hline
\end{array}
\]
5. In the vapor phase, acetic acid, \( \text{CH}_3\text{COOH} \), dimerizes according to the reaction given below.

\[
\text{H}_3\text{C} = \!
\begin{array}{c}
\text{O} \\
\text{H}
\end{array}
\text{O} + 
\text{H}_3\text{C} = \!
\begin{array}{c}
\text{O} \\
\text{H}
\end{array}
\text{O} \rightarrow 
\text{H}_3\text{C} = \!
\begin{array}{c}
\text{O} \\
\text{H} \\
\text{H} \\
\text{O} \\
\text{O} \\
\text{O} \\
\text{H}
\end{array}
\text{O} \text{---HO} \text{---CH}_3
\]

The equilibrium constant at 25\(^\circ\)C is 3.2 \times 10^4. Fill in the molecular view for the acetic acid vapor.