Exam III (contd.)

2. \( O + N_2 \rightarrow NO + N \)

\[
\begin{align*}
  k &= \frac{Q^0}{Q_0^0} \exp\left(-\frac{E_a}{R T}\right) \\
  &\quad \text{pre-exponential factor}
\end{align*}
\]

Need to determine dependence of \( Q's \) on \( T \). Each \( Q \) is:

\[
Q = Q_{\text{max}} Q_{\text{m}} Q_{\text{vib}} Q_{\text{rot}}
\]

\[
Q_{\text{vib}} = \Sigma g_i \exp\left(-\frac{E_i}{R T}\right) \Rightarrow \text{no } T \text{ dependence because } E_i \text{ is usually zero, so exp term = 1}
\]

\[
Q_{\text{rot}} = \frac{1}{T} \exp\left(-\frac{I}{R T}\right) \Rightarrow T \text{ dependence since } \exp\left(-\frac{I}{R T}\right) \neq 0
\]

\[
Q_{\text{m}} = \frac{8\pi^2 m^3}{3 h^3} \Rightarrow \text{linear so } Q_{\text{m}} \propto T
\]

\[
Q_{\text{vib}} = \left(\frac{8\pi^2 m R}{h^3}\right)^{3/2} \Rightarrow \text{so } Q_{\text{vib}} \propto T^{3/2}
\]

\[
Q_{\text{rot}} \propto \frac{1}{T^{3/2}} \Rightarrow Q_{\text{m}} \propto T^{-3/2}
\]

So \( Q \propto \frac{1}{T} \times T^{3/2} \times (\text{either } T \text{ or } T^{3/2}) \)

Thus \( A \propto T^{3/2} \) contribution from \( Q's \)

\[
\text{for } O + N_2 \rightarrow \text{TS: linear, so } Q \propto T^{3/2} \quad \text{NO: linear, so } Q_{\text{m}} \propto T^{3/2}
\]

\[
\text{O: only constant, so } Q_{\text{vib}} \propto T^{-3/2}
\]
2. (continued)
so \( A \propto T^{-3/2} \)

\[ T_{0} = \text{nonlinear} \quad \Rightarrow \quad Q^{*} \propto T^{3/2} \]
\[ \text{OH: linear} \quad \Rightarrow \quad Q_{\text{OH}} \propto T \]
\[ \text{H}_2 \quad \text{linear} \quad \Rightarrow \quad Q_{\text{H}_2} \propto T^{-1} \]

so \( A \propto T^{-3/2} \)

3. a. \( \text{SO}_2^+ + 2 I^- \rightarrow \text{I}_2 + 2 \text{SO}_4^{2-} \)
   - The reaction rate will increase since the reacting ions are both negatively charged.

b. \( \text{H}_2\text{O}_2 + 2 \text{H}^+ + 2 \text{Br}^- \rightarrow 2 \text{H}_2\text{O} + 2 \text{Br}_2 \)
   - The reaction rate will decrease since the reacting ions have opposite charges.

4. a. The laser initiates the reaction by breaking \( \text{Cl}_2 \) into \( \text{Cl} \) atoms.
   b. To measure the vibrational state distribution of the products, it is necessary to know what frequencies of radiation are emitted by the chemiluminescence process. To do this, a monochromator would have to be added in place of the IR filter. The IR radiation will let all IR light reach the detector at the same time, while the monochromator separates the frequencies so that the intensity of chemiluminescence at a particular frequency can be measured.
The maximum rate could be diffusion limited because the reactants can't react before they have diffused through the solution to react with each other.

For model reactants:

\[ k_0 = 4\pi (D_A + D_B) R \]

\[ D_A = D_B = 3.0 \times 10^{-3} \text{ m}^2 \text{s}^{-1} \text{ in CCl}_4, T = 298 \text{ K} \]

radius of I = 2 \times 10^{-6} \text{ m}

\[ R = R_A + R_B = 4 \times 10^{-6} \text{ m} \]

\[ k_o = 4\pi (6.0 \times 10^{-9} \text{ m}^2\text{s}^{-1} \times 1.4 \times 10^{-6} \text{ m}) = 3.02 \times 10^{-16} \text{ m}^3\text{s}^{-1} \]

\[ k_o = \frac{3.02}{4 \times 10^{-16} \text{ m}^3} \times \frac{1}{(1 \text{ m}^{-1} \times 1 \text{ m}^{-1})} = 1.8 \times 10^{10} \text{ m}^3\text{s}^{-1} \approx 2 \times 10^{10} \text{ m}^3\text{s}^{-1} \]

b. \( k_o = 9.7 \times 10^{-15} \text{ m}^3\text{s}^{-1} \)

\[ k_0 = \frac{2k_T (r_A + r_B)^2}{3\pi r_A r_B} = \frac{2(1.3 \times 10^{-15} \text{ m}^3)(2.1 \times 10^{-12} \text{ m}^3)}{3\pi (1.1 \times 10^{-12} \text{ m})(2.1 \times 10^{-12} \text{ m})} \]

\[ k_0 = \frac{1.3 \times 10^{-15} \text{ m}^3}{1.1 \times 10^{-12} \text{ m}^3} = 1.17 \times 10^{-3} \text{ m}^3\text{s}^{-1} \text{ m}^3 / \text{kg} \times 1.17 \times 10^{-3} \text{ m}^3 / \text{kg} = 1.17 \times 10^{-3} \text{ m}^3 / \text{kg} 

\[ k_0 = 6.8 \times 10^{-9} \text{ m}^3 / \text{kg} \times \frac{7.10^{-11}}{3.0 \times 10^{-13}} \text{ m}^3 / \text{kg} = 7 \times 10^{-11} \text{ m}^3 / \text{kg} = 7 \times 10^{-11} \text{ m}^3 / \text{kg} \]