Problem X3
Consider the bimolecular reaction: \( A + B \rightarrow C + D \). The hard sphere equivalent diameters of A and B are 0.2 and 0.3 nm (nanometers). The molecular weights are \( M_A = 20 \text{ kg/kgmol} \) and \( M_B = 30 \text{ kg/kgmol} \). The steric factor is 0.001 and the activation energy is 30 kcal/gmol. Compute the number of collisions per unit time, \( Z_{AB} \), and the rate of reaction \( \frac{d[A]}{dt} \) in gmol/m\(^3\)-s for the following conditions: (1) 100 kPa, 300K; (2) 100 kPa, 2000K; and (c) 100 MPa, 2000K. **Express the rate in terms of mole fractions, \( x_A \) and \( x_B \).** What can you conclude about the effects of temperature and pressure on the rate of reaction?

Problem X4
At low pressures \( \text{H}_2 \) and \( \text{O}_2 \) react as:

\[
\begin{align*}
\text{H}_2 + \text{O}_2 & \rightarrow 2\text{OH} & K_1 \\
\text{OH} + \text{H}_2 & \rightarrow \text{H}_2\text{O} + \text{H} & K_2 \\
\text{H} + \text{O}_2 & \rightarrow \text{HO} + \text{O} & K_3 \\
\text{O} + \text{H}_2 & \rightarrow \text{OH} + \text{H} & K_4 \\
\text{H} + \text{OH} + \text{M} & \rightarrow \text{H}_2\text{O} + \text{M} & K_5
\end{align*}
\]

Applying steady state approximations for all radial species (\text{OH}, \text{O} and \text{H}), find an expression for the rate of \( \text{H}_2\text{O} \) (i.e., \( \frac{d[\text{H}_2\text{O}]}{dt} \)) in terms of \([\text{H}_2]\) and \([\text{O}_2]\).

*(Contributed by Professor P. DesJardin, University at Buffalo)*