Chemical Kinetics

1. In the following decomposition reaction,

$$2 N_2O_5 \rightarrow 4 NO_2 + O_2$$

oxygen gas is produced at the average rate of 9.1×10^{-4} mol · L^{-1} · s^{-1}. Over the same period, what is the average rate of the following:

   a) the production of nitrogen dioxide
   b) the loss of nitrogen pentoxide

2. Consider the following reaction:

$$N_2(g) + 3 H_2(g) \rightarrow 2 NH_3(g)$$

If the rate of loss of hydrogen gas is 0.03 mol · L^{-1}· s^{-1}, what is the rate of production of ammonia?

3. Nitrogen monoxide reacts with hydrogen gas to produce nitrogen gas and water vapor. The mechanism is believed to be:

   Step 1: $2 NO \rightarrow N_2O_2$

   Step 2: $N_2O_2 + H_2 \rightarrow N_2O + H_2O$

   Step 3: $N_2O + H_2 \rightarrow N_2 + H_2O$

For this reaction find the following:

   • the overall balanced equation
   • any reaction intermediates

4. Answer the following questions based on the potential energy diagram shown here:
   a) Does the graph represent an endothermic or exothermic reaction?
   b) Label the position of the reactants, products, and activated complex.
   c) Determine the heat of reaction, ΔH, (enthalpy change) for this reaction.
   d) Determine the activation energy, Ea for this reaction.
   e) How much energy is released or absorbed during the reaction?
   f) How much energy is required for this reaction to occur?
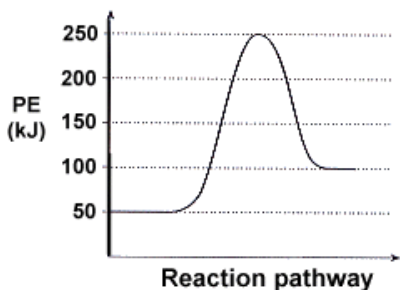
5. Using the kinetics data below, first determine the orders for A, B, and C. Once the orders are correct, determine the value of the rate constant.

	[A]	[B]	[C]	Rate(M/sec)
Trial 1	0.50	0.25	0.050	5.7×10^{-7}
Trial 2	1.00	0.75	0.050	5.1×10^{-6}
Trial 3	1.00	0.75	0.150	5.1×10^{-6}
Trial 4	1.00	0.25	0.050	5.7×10^{-7}

6. The decomposition of ethanol (C_2H_5OH) on an alumina (Al_2O_3) surface

$$C_2H_5OH(g) \rightarrow C_2H_4(g) + H_2O(g)$$

was studied at 600 K. Concentration versus time data were collected for this reaction, and a plot of [A] versus time resulted in a straight line with a slope of -4.00×10^{-5} mol/L· s.
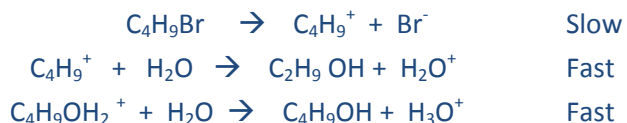
   a. Determine the rate law, the integrated rate law, and the value of the rate constant for the reaction
   b. If the initial concentration of C_2H_5OH was 1.25×10^{-2} M, calculate the half-life for this reaction.
   c. How much time is required for all the 1.25×10^{-2} M C_2H_5OH to decompose?

7. The rate law for the decomposition of phosphine (PH_3) is

$$Rate = -\frac{\Delta[PH_3]}{\Delta t} = k[PH_3]$$

It takes 120. s for 1.00 M PH_3 to decrease to 0.250 M. How much time is required for 2.00 M PH_3 to decrease to a concentration of 0.350 M?

8. Proposed mechanism for a reaction is

$$C_4H_9Br \rightarrow C_4H_9^+ + Br^- \qquad \text{Slow}$$
$$C_4H_9^+ + H_2O \rightarrow C_2H_9\ OH + H_2O^+ \qquad \text{Fast}$$
$$C_4H_9OH_2^+ + H_2O \rightarrow C_4H_9OH + H_3O^+ \qquad \text{Fast}$$

   a) What is the overall reaction?
   b) Derive the rate law and determine the reaction order.
   c) Determine the intermediate species.

9. The activation energy for the decomposition of HI(g) to $H_2(g)$ and $I_2(g)$ is 186 kJ/mol. The rate constant at 555 K is 3.52×10^{-7} L/mol · s. What is the rate constant at 645 K?