Review Questions:

1. An ethanol (e) and chloroform (c) liquid mixture contains a mole fraction of ethanol $x_e = 0.20$. At $25°C$, the vapor pressures of the pure liquids are 103 Torr for ethanol, and 295 Torr for chloroform. You may assume that gas phase mixtures of ethanol and chloroform vapors behave like ideal gases.
    a. If both components obey Raoult's law, what is the total vapor pressure p_T above the solution?
    b. Calculate ΔG for a solution that is formed at $25°C$ by combining two containers, one containing 0.2 moles of pure liquid ethanol, and the other containing 0.8 moles of pure liquid chloroform.
    c. The actual observed total pressure of the vapor above the solution of part (a) is 304 Torr. Is the Henry's law constant for ethanol K_e mixed with chloroform such that:
        i. $K_e > 103\, Torr$
        ii. $K_e = 103\, Torr$
        iii. $K_e < 103\, Torr$

2. An unknown non-volatile solid is dissolved in 100g of water. At $26°C$, the vapor pressure of the solution was observed to be 24.75 bar, whereas the vapor pressure of pure water at the same temperature is 25.20 bar. The molecular weight of the unknown compound is 120 g/mole. Calculate the mass of the unknown solid in the solution.

3. Consider the following data:

$$\Delta H_{vap}\left(H_2O\right) = 40 kJ/mol$$
$$\Delta H_{fus}\left(H_2O\right) = 6.0 kJ/mol$$

    a. One gram of pure crystalline substance A (ammonium acetate) known to have a molecular weight of $7.7\times10^{-2} kg$ is dissolved in 1.0 kg of pure water. What is the expected freezing point depression in degrees Celsius?

    b. Your answer to the previous question is based on several assumptions. What are those assumptions?

    c. If the observed freezing point depression is larger than your prediction in part A, what is the most likely reason for this departure from the standard model for colligative properties?

4. Consider the hypothetical reaction:

$$A(g) + 2B(g) \rightarrow C(g)$$

Using partial pressures, the rate of the reaction can be given in the form:

$$\frac{-d[A]}{dt} = k[A]^{\alpha}[B]^{\beta}$$

where [A] is given in units of pressure (i.e. it represents the partial pressure p_A)

A kinetic study of initial rates gave the following results:

$p_A\big\|_{t=0}$	$p_B\big\|_{t=0}$	$\frac{dp_T}{dt}\big\|_{t=0}$
100	100	-1.5
300	100	-4.5
300	300	-7.8

where $p_A\big|_{t=0}$ and $p_B\big|_{t=0}$ are the initial partial pressures in Torr and $\frac{dp_T}{dt}\big|_{t=0}$ is the initial rate of change in the *total* pressure of the reacting system in $Torr \cdot \sec^{-1}$.

a. Determine the reaction order with respect to A and with respect to B (i.e. find values for α and β).

b. Determine the numerical value of the rate constant k and specify its units.

5. Consider the reaction: $2A + B \rightarrow D$

Suppose that the mechanism of this reaction is found to consist of the elementary reactions:

$$\begin{aligned} &\mathrm{A + B} \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} \mathrm{C} \\ &\mathrm{A + C} \xrightarrow{k_2} \mathrm{D} \end{aligned}.$$

a. Write the equations for:

$$\frac{d[C]}{dt} =$$

$$\frac{d[D]}{dt} =$$

b. For which species in the mechanism is it appropriate to impose the steady-state approximation? For this species, find the steady-state concentration.

c. Use the steady-state approximation to derive the rate law for $\frac{d[D]}{dt}$ in terms of [A], [B], and the rate coefficients k_1, k_{-1}, and k_2.

d. If $k_2[A]_0 >> k_{-1}$, what are the apparent orders of the reaction with respect to [A] and [B]? Also, what is the effective rate coefficient (expressed in terms of k_1, k_{-1}, k_2 and $[A]_0$)?

e. Same as the previous question, except for $k_2[A]_0 << k_{-1}$

f. Suppose $[A]_0 = [B]_0 = 0$, but $[C]_0 \neq 0$. What would be the initial decay rate of [C]? What would be the final value of [D] (expressed in terms of $[C]_0$) assuming that C is completely consumed in the reaction?