CHEM 3423 001 Spring 2024 **Name:** KEY

ID:

Worksheet #11 (Total number of points you can get is **3 pts**)

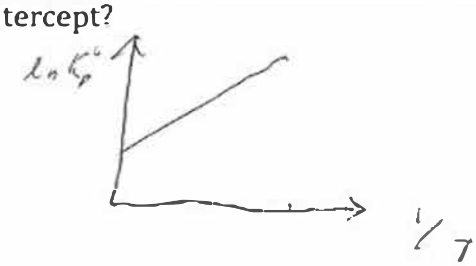
1. Assume an ideal solution of two components A and B. At T=300 K, $P^*(A) = 3$ kPa, and $P^*(B) = 9$ kPa. Compute the vapor pressure of a solution containing 0.6 mol fraction of A. What is the mole fraction of A in the vapor over the liquid?

$$P = x_A P_A^* + (1 - x_A) P_B^* = 0.6 \cdot 3 \times 10^3 Pa + 0.4 \cdot 9 \cdot 10^3 Pa$$

$$= 5.4 \times 10^3 Pa = 5.4 kPa$$

$$P_A = y_A^{vap} P \Rightarrow y_A^{vap} = \frac{P_A}{P} = \frac{x_A P_A^*}{P} = \frac{1.8 \ kPa}{5.4 \ kPa} = 0.33$$

2. Assume that in a chemical reaction ΔH^0 does not depend on temperature.
   a. Draw a van't Hoff plot, i.e $\ln K_p^0$ over $1/T$. What thermodynamic quantity can be obtained from the slope, and what quantity from the intercept?



Slope: $-\frac{\Delta H^0}{R}$

Intercept: $\Delta S^0 / R$

   b. If the temperature is increased from $T_1 = 30°C$ to $T_2 = 70°C$, what is the ratio between the equilibrium constants K_1^0 and K_2^0? ($\Delta H^0 = 150J$).

$$\ln K_1^0 = -\frac{\Delta H^0}{RT} + \frac{\Delta S^0}{R} \ ; \ \ln K_2^0 = -\frac{\Delta H^0}{RT} + \frac{\Delta S^0}{R}$$

$$\Rightarrow \ln K_2^0 - \ln K_1^0 = \ln \frac{K_2^0}{K_1^0} = -\frac{\Delta H^0}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) = \frac{\Delta H^0}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\Rightarrow \frac{K_2^0}{K_1^0} = \exp\left(\frac{\Delta H^0}{R}\left(\frac{T_2 - T_1}{T_1 T_2}\right)\right) = \exp\left(\frac{150}{8.3145} \cdot \frac{40}{303.15 \cdot 343.15}\right) = e^{0.0069} = \underline{1.007}$$

3. In an experiment, the vapor pressure of a liquid is measured as 5 kPa at 300K, and as 120 kPa at 400 K. Calculate from these data the enthalpy of vaporization $\Delta_{vap}H$ of the liquid.

$$\ln \frac{P_2}{P_1} = \frac{\Delta_{vap} H}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) = \frac{\Delta_{vap} H}{R} \frac{T_2 - T_1}{T_1 T_2}$$

$$\Rightarrow \Delta_{vap} H = R \ln \frac{P_2}{P_1} \frac{T_1 T_2}{T_2 - T_1} = 8.3145 \cdot \ln \frac{120}{5} \cdot \frac{300 \cdot 400}{100} \ J/mol$$

$$= 8.3145 \cdot 3.1781 \cdot 1200 \ J/mol$$

$$= 31.71 \ kJ/mol$$