Clausius - Clapeyron Equation

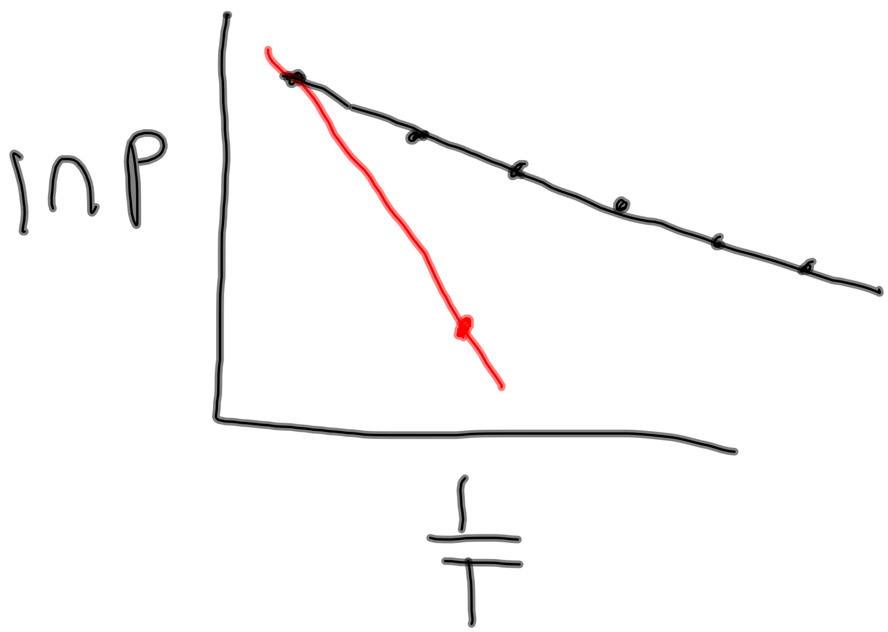
$$\ln P = \frac{-\Delta H_{vap}}{R}\left(\frac{1}{T}\right) + \ln B$$

$$y = m \cdot x + b$$

$$\text{Slope} = -\frac{\Delta H_{vap}}{R}$$

$$\downarrow$$

$$\Delta H_{vap} = -R \cdot \text{Slope}$$


ln P
1/T

$$(T_1, P_1) \quad (T_2, P_2)$$

$$\ln P = -\frac{\Delta H_{vap}}{R}\left(\frac{1}{T}\right) + \cancel{\ln B}$$

$$\ln P_2 = -\frac{\Delta H_{vap}}{R}\left(\frac{1}{T_2}\right) + \cancel{\ln B}$$

$$-\left[\ln P_1 = \frac{-\Delta H_{vap}}{R}\left(\frac{1}{T_1}\right) + \ln B\right]$$

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

$$\boxed{\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$$

2-point Clausius-Clapeyron Equation

The normal boiling point of H_2O is $100°C$, and its heat of vaporization is $40.7 \frac{kJ}{mol}$
Estimate the equilibrium vapor pressure of H_2O at $50°C$.

$R = 8.314 \frac{J}{K\,mol}$

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

$P_2 = ?$ $T_2 = 50°c = 323.15\,K$

$P_1 = 760$ torr $T_1 = 100°c = 373.15\,K$

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

$$e^{\ln\left(\frac{P_2}{P_1}\right)} = e^{\frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$$

$$\frac{P_2}{P_1} = e^{\frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$$

$$P_2 = P_1 \cdot e^{\frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$$

$$= 760\,\text{torr} \cdot e^{\frac{40700\,J/mol}{8.314\,J/mol\,K} \cdot \left(\frac{1}{373.15\,K} - \frac{1}{323.15\,K}\right)}$$

$$= 99.8\,\text{torr}$$

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

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

$$\left(\frac{R}{\Delta H_{vap}}\right)\cdot\ln\left(\frac{P_2}{P_1}\right) + \frac{1}{T_2} = \frac{1}{T_1}$$