Chap. 5 Application of Clausius-Clap Eqn



Feb. 21

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

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Given $P_1$, $T_1$, $T_2$, $\Delta_{vap}H$ $\rightarrow P_2$

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Given: $P_1, T_1, P_2, \Delta_{vap}H$ $\rightarrow T_2$

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Given: $P_1, P_2, T_1, T_2 \rightarrow \Delta_{vap}H$

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

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

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

**Chap. 5** **Application #2 of Clausius-Clapeyron Equation**
**Feb 26** **Slide #26**

**The enthalpy of vaporization of toluene is 33.8 kJ/mol. The normal boiling point is 111 °C. What is the vapor pressure of toluene, in torr, at 50 °C?**

$\Delta_{vap}H = 33.8\ kJ/mol = 3.38 \times 10^4\ J/mol$

$P_1 = 1\ bar = 100\ kPa$

$T_1 = 111^\circ C = 384\ K$

$T_2 = 50^\circ C = 323\ K$

$P_2 = ?$

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

$$\ln\frac{P_2}{1\ bar} = \frac{-3.38\times10^4\ J/mol}{8.315\ J/mol\text{-}K}\left[\frac{1}{323\ K} - \frac{1}{384\ K}\right]$$

$$= -2.00$$

$$e^{\ln(P_2/1\ bar)} = e^{-2.00}$$

$$\frac{P_2}{1\ bar} = 0.135$$

$$P_2 = 0.135\ bar \times \frac{750\ torr}{1\ bar}$$

$$= 101\ torr$$

**Chap. 5** **Application #1 of Clausius-Clapeyron Equation**
**Feb 26** **Slide #25**

**The enthalpy of vaporization of water is 40.7 kJ/mol.**

**The normal boiling point is 100 °C.**

**What is the boiling point of water under a pressure of 2 bar?**

$\Delta_{vap}H = 40.7\ kJ/mol$
$= 4.07 \times 10^4\ J/mol$

$T_1 = 100°C = 373K$

$P_1 = 1\ bar = 100\ kPa$

$P_2 = 2\ bar$

$T_2 = ?$

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

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

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

$$= \frac{1}{373K} - \frac{8.31\ J/mol\,K}{4.07\times10^4\ J/mol}\left[\ln\left(\frac{2}{1}\right)\right]$$

$$= 2.68\times10^{-3}\ K^{-1} - 0.14\times10^{-3}$$

$$\frac{1}{T_2} = 2.54\times10^{-3}\ K^{-1}$$

$$T_2 = \frac{1}{2.54\times10^{-3}\ K^{-1}}$$

$$T_2 = 394K - 273K$$

$$= 121°C$$