11.2 Vapor Pressure

Heat of Vaporization

→ The amount of heat required to convert a liquid to a gas: ΔH°_{VAP}

Which of the following molecules would you expect to have the smallest ΔH°_{vap}

a) CH_3OH b) C_2H6 ✓ c) C_4H_{10}

→ Why?

Non-polar with a smaller Molar Mass than C_4H_{10}, which is also non-polar.

CH_3OH is polar.

11.2 Vapor Pressure

Relationship Between P, T, and ΔH^o_{vap} – Clausius-Clapeyron Equation

$$\ln P = \frac{-\Delta H^\circ_{vap}}{RT} + C$$

ΔH°_{vap} = Heat of Vaporization

R : 8.314 J. mol⁻¹. K⁻¹ (Ideal Gas Constant)

a) GRAPHICALLY:

Plot $\ln P$ vs $1/T$: T must be in K

$$\text{Slope} = \frac{-\Delta H^\circ_{vap}}{R}$$

b) QUANTITATIVELY:

$$\ln P_1 = -\frac{\Delta H^\circ_{vap}}{RT_1} + C \quad ; \quad \ln P_2 = -\frac{\Delta H^\circ_{vap}}{RT_2} + C$$

$$\ln P_2 - \ln P_1 = -\frac{\Delta H^\circ_{vap}}{RT_2} + C + \frac{\Delta H^\circ_{vap}}{RT_1} - C$$

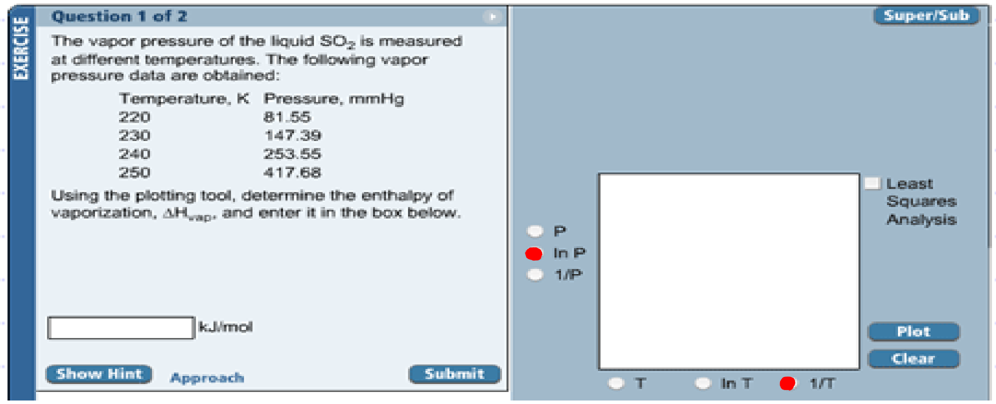
$$\ln P_2 - \ln P_1 = \frac{\Delta H^\circ_{vap}}{RT_1} - \frac{\Delta H^\circ_{vap}}{RT_2}$$

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

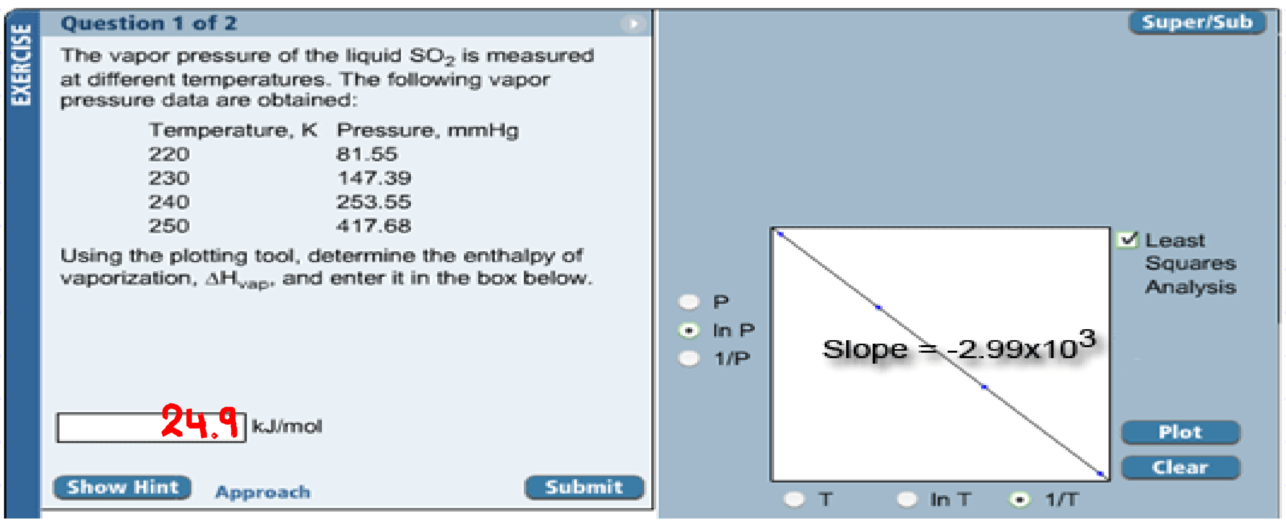
11.2 Vapor Pressure

Clausius-Clapeyron Equation – Graphical Method

Determine enthalpy of vaporization graphically



Determine enthalpy of vaporization graphically



$$-\frac{\Delta H^\circ_{vap}}{R} = \text{Slope}$$

$$= -2.99 \times 10^3$$

$$\Delta H^\circ_{vap} = -2.99\times10^3\,(8.314)$$

$$= -2.49 \times 10^4\ \text{J.mol}^{-1}$$

$$\Delta H^\circ_{vap} = 2.49 \times 10^4\ \text{J.mol}^{-1}$$

$$= 24.9\ \text{kJ.mol}^{-1}$$

11.2 Vapor Pressure

Clausius-Clapeyron Equation – Quantative

From the following vapor pressure data for heptane, an estimate of the molar heat of vaporization of C_7H_{16} is

P, mm Hg	T, Kelvins
100	315
400	351

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

$P_1 = 100$ $T_1 = 315$

$P_2 = 400$ $T_2 = 351$

$$\ln \frac{400}{100} = \frac{\Delta H^\circ_{vap}}{R}\left(\frac{1}{315} - \frac{1}{351}\right)$$

$$\ln 4\,(R) = \Delta H^\circ_{vap}\,(3.26 \times 10^{-4})$$

$$\Delta H^\circ_{vap} = \frac{1.39\,(8.314)}{3.26 \times 10^{-4}}$$

$$= 3.54 \times 10^{4}\ J.\ mol^{-1}$$

OR

$$35.4\ kJ.\ mol^{-1}$$

13.1 Quantitative Expressions of Concentration

Units of Concentration – Molarity, Molality, Mole Fraction, Weight %

Solution = Solute + Solvent

Solvent → that which is present in the greatest amount.

Molarity:

→ the only one you met in Chem 111

$$M = \frac{\text{Moles of solute}}{\text{Volume of the solution in L}}$$

DRAWBACK: We know nothing quantity wise about the solvent.

Mole Fraction:

$$X = \frac{\text{moles of solute}}{\text{moles of solute + moles of solvent}}$$

Molality:

$$m = \frac{\text{moles of solute}}{\text{mass of solvent (kg)}}$$

DRAWBACK: We know nothing quantity wise about the solution.

Weight %:

$$\text{Wt \% of A} = \left(\frac{\text{mass of A}}{\text{mass of A + mass B + ...}}\right)100$$