Quiz 5.1 – Mixtures

Name: Key

The Gibbs-Duhem Equation

The reaction A ⟶ B is in a non-equilibrium state with 0.54 moles of A and 0.72 moles of B.

If $d\mu_B = 4.5\frac{J}{mol}$, find $d\mu_A$ $d\mu_B = -\frac{n_A}{n_B} d\mu_A$ $4.5\frac{J}{mol} = -\frac{0.54}{0.72} d\mu_A$ $d\mu_A = -6.0\frac{J}{mol}$

Which direction will the reaction shift in order to reach equilibrium?

Left, toward reactants

Thermodynamics of Mixing

4.2 moles of helium are mixed under constant temperature and pressure with 2.7 moles of argon at a temperature of 298 K 6.9 total moles $\chi_{He} = 0.609$ $\chi_{Ar} = 0.391$

Find ΔG_{mix} for this process

$\Delta G_{mix} = nRT(\chi_A \ln\chi_A + \chi_B \ln\chi_B) = 6.9\text{ moles} \cdot 8.314\frac{J}{mol\cdot K} \cdot 298K\,(0.609 \cdot \ln 0.609 + 0.391 \cdot \ln 0.391) = -11.4\,kJ$

Find ΔS_{mix} for this process

$\Delta S_{mix} = nR(\chi_A \ln\chi_A + \chi_B \ln\chi_B) = 6.9\text{ moles} \cdot 8.314\frac{J}{mol\cdot K} \cdot (0.609 \cdot \ln 0.609 + 0.391 \cdot \ln 0.391) = -38.4\frac{J}{K}$

Liquid Phase Mixtures

@298 K Find the change in chemical potential for both solvent and solute when 0.35 mol of acetone dissolve into 2.5 mol of chloroform 2.85 total moles $\chi_{CH_2O} = 0.123$ $\chi_{CHCl_3} = 0.877$

$\Delta\mu_{mix,A} = nRT\ln\chi_A$

$\Delta\mu_{CH_2O} = 0.35\,mol \cdot 8.314\frac{J}{mol\,K} \cdot 298K \cdot \ln 0.123 = -1.82\,kJ$ $\Delta\mu_{CHCl_3} = 2.5 \cdot 8.314\frac{J}{mol\cdot K} \cdot 298K \cdot \ln 0.877 = -813\,J$

Use the table below to estimate the partial pressures for each component and the total solution pressure

	CH_2O	$CHCl_3$
$p^*\,(kPa)$	46	35
$K_H\,(kPa)$	23	22

Raoult's Law: $p = \chi p^*$

$CHCl_3$: $p = 0.877 \cdot 35\,kPa = 30.7\,kPa$

Henry's Law: $p = \chi K_H$

CH_2O: $p = 0.123 \cdot 23\,kPa = 2.83\,kPa$

Total Pressure: 33.5 kPa