Exercise 2

The volume of a binary mixture has a molar volume, V, that depends on its composition:

$$V_m = 75x_1 + 95x_2 + 3.7x_1x_2 \quad (\frac{cm^3}{mol})$$

For a mixture with $x_1 = 0.60$, determine

a) the molar volume of the mixture
b) the partial molar volume of component 1.

Solution 2

a. $(x_1 = 0.60 \rightarrow x_2 = 0.4 \; then, V = 83.9cm^3/mol)$

b. $\overline{V_1} = V_m + x_2 \left(\frac{\partial V_m}{\partial x_1}\right)_{P,T,n_1}$

$$V_m = 75x_1 + 95(1 - x_1) + 3.7x_1(1 - x_1) = 95 - 16.3x_1 - 3.7x_1^2$$

$$\left(\frac{\partial V_m}{\partial x_1}\right)_{P,T,n_1} = -16.3x_1 - 7.4x_1 = -16.3x_1 - 7.4(0.6) = -20.7$$

$$\overline{V_1} = 83.9 + 0.4(-20.7) = 75.6 \; cm^3/mol$$

Exercise 3

The molar enthalpy of a binary liquid system of species 1 and 2 at fixed T and P is represented by the following equation:

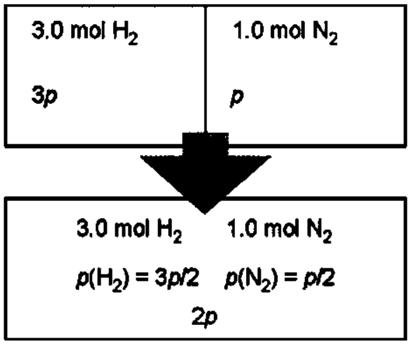
$$H = 400x_1 + 600x_2 + x_1x_2(40x_1 + 20x_2)$$

where H is in J/mol

a. determine expressions for $\overline{H_1}$ and $\overline{H_2}$as functions of x_1
b. Numerical values for the pure species enthalpies $H_1^*$and H_2^*
c. Find the expression of (H^E)
d. Numerical values for the partial enthalpies at infinite dilution $\overline{H_1}$ and $\overline{H_2}$

Exercise 4

A container is divided into two equal compartments (figure below). One contains 3.0 mol H_2 at $25°C$; the other contains $1.0\ mol\ N_2\ at\ 25^0C$. Calculate the *Gibbs energy* ***of mixing*** when the partition is removed. Assume perfect gas behavior. $P^0 = 1bar$



Solution

The Gibbs energy <u>of mixing</u> : so we have to consider both states initial and final

Two perfect gases in two identical containers with amounts n_A and n_B, both at the same T and P

We first calculate the initial Gibbs energy from chemical potentials. We need the pressure of each gas.

$$G_{initial} = n_A\overline{G_A} + n_B\overline{G_B} = n_A\mu_A + n_B\mu_B = n_A\left(\mu_A^\circ + RTln\frac{f_A}{f_A^\circ}\right) + n_B\left(\mu_B^\circ + RTln\frac{f_B}{f_B^\circ}\right) = n_A\left(\mu_A^\circ + RTln\frac{P_A}{P_A^\circ}\right) + n_B\left(\mu_B^\circ + RTln\frac{P_B}{P_B^\circ}\right)$$

$$G_{initial} = n_A\overline{G_A} + n_B\overline{G_B} = n_A\mu_A + n_B\mu_B = n_A\left(\mu_A^\circ + RTln\frac{f_A}{f_A^\circ}\right) + n_B\left(\mu_B^\circ + RTln\frac{f_B}{f_B^\circ}\right) = n_A\left(\mu_A^\circ + RTln\frac{P_{Ai}}{P_A^\circ}\right) + n_B\left(\mu_B^\circ + RTln\frac{P_{Bi}}{P_B^\circ}\right)$$
$$= n_A(\mu_A^\circ + RTln3P) + n_B(\mu_B^\circ + RTlnP) =$$

$$P_1V_1 = P_2V_2 \rightarrow \frac{P_1}{P_2} = \frac{V_2}{V_1} = 2 \rightarrow P_{Af} = \frac{3P}{2} and\ P_B = \frac{P}{2}$$

$$G_{final} = n_A\overline{G_A} + n_B\overline{G_B} = n_A\mu_A + n_B\mu_B = n_A\left(\mu_A^\circ + RTln\frac{P_{Af}}{P_A^\circ}\right) + n_B\left(\mu_B^\circ + RTln\frac{P_{Bf}}{P_B^\circ}\right)$$
$$= n_A\left(\mu_A^\circ + RTln\frac{P_{Af}}{P_A^\circ}\right) + n_B\left(\mu_B^\circ + RTln\frac{P_{Bf}}{P_B^\circ}\right) = n_A\left(\mu_A^\circ + RTln\frac{3P}{2}\right) + n_B\left(\mu_B^\circ + RTln\frac{P}{2}\right)$$
$$\Delta G = G_f - G_i = n_ARTln\frac{1}{2} + n_BRTln\frac{1}{2} = 4(8.314JK^{-1}mol^{-1})(298K)\ln\frac{1}{2} = -6900j.mol^{-1}$$

Exercise 5

https://www.youtube.com/watch?v=bof3vwEBdc0&t=1s

For a mixture contains 75% H_2 and 25% N_2 (molar basis) estimate the pseudo critical Temperature and pressure ($P_{pc} and\ T_{pc}$) using Kay's rule.

We give:

For N_2: $T_C = 126.2K\ \ and\ P_C = 33.5atm$

For H_2 $T_C = 33 + 8 = 41K\ \ and\ P_C = 12.8 + 8 = 20.8\ atm$

Solution

$$T_{pc} = y_{H_2}T_{c_{H_2}} + y_{N_2}T_{c_{N_2}} = 62.3K\ P_{pc} = 24atm$$