Tutorial – 1

- Consider a mixture of N_2 and O_2 at 5 atm and temperature of 100 K.

- Calculate the distribution coefficients for N_2 and O_2. Also, calculate the vapor and liquid compositions using the obtained **K** values.

- Use the data from the tables given in the earlier slides.

Tutorial – 1

Given
Working Pressure : 5 atm
Temperature : 100 K
Mixture : N_2 + O_2

For above mixture, Calculate	
K_{N2}	Distribution coefficient of N_2
K_{O2}	Distribution coefficient of O_2
x_{N2}	Mole fraction of N_2 in liquid phase
x_{O2}	Mole fraction of O_2 in liquid phase
y_{N2}	Mole fraction of N_2 in vapor phase
y_{O2}	Mole fraction of O_2 in vapor phase

Tutorial – 1

- K_{N2}

$$\ln\left(\frac{Kp_{mix}}{p_0}\right)\Bigg|_{N2} = 2.004$$

$$K_{N2} = \frac{p_0}{p_{mix}} e^{2.004}$$

Data
p_{mix} = 5 atm
T = 100 K
p_0 = 1 atm

$$K_{N2} = \left(\frac{1}{5}\right) e^{2.004} = 1.483$$

	N_2
T	5 atm
94	1.550
96	1.702
98	1.853
100	2.004
102	2.156
104	2.307
106	2.459
108	2.610

Tutorial – 1

- K_{O2}

$$\ln\left(\frac{Kp_{mix}}{p_0}\right)\Bigg|_{O2} = 1.042$$

$$K_{O2} = \frac{p_0}{p_{mix}} e^{1.042}$$

Data
p_{mix} = 5 atm
T = 100 K
p_0 = 1 atm

$$K_{O2} = \left(\frac{1}{5}\right) e^{1.042} = 0.567$$

	O_2
T	5 atm
94	0.661
96	0.788
98	0.915
100	1.042
102	1.169
104	1.296
106	1.423
108	1.551

Tutorial – 1

- x_{N2}

$$x_{N2} = \frac{1 - K_{O2}}{K_{N2} - K_{O2}}$$

$$K_{N2} = 1.483 \qquad K_{O2} = 0.567$$

$$x_{N2} = \frac{1 - 0.567}{1.483 - 0.567} = 0.472$$

Tutorial – 1

- x_{O2}

$$x_{N2} + x_{O2} = 1$$

$$x_{O2} = 1 - x_{N2}$$

$$x_{N2} = 0.472$$

$$x_{O2} = 1 - 0.472 = 0.528$$

Tutorial – 1

- y_{N2}

$$y_{N2} = K_{N2} x_{N2}$$

$$K_{N2} = 1.483 \qquad x_{N2} = 0.472$$

$$y_{N2} = (1.483)(0.472) = 0.699$$

Tutorial – 1

- y_{O2}

$$y_{N2} + y_{O2} = 1$$

$$y_{O2} = 1 - y_{N2}$$

$$y_{N2} = 0.699$$

$$y_{O2} = 1 - 0.699 = 0.301$$

Tutorial – 2

- Consider a two phase mixture of N_2 and O_2 at a pressure of 2 atm. Use the T – s diagrams for the vapor pressures of N_2 and O_2 at 86 K.

- Determine the liquid and vapor composition of the mixture if the temperature of the mixture is 86 K.

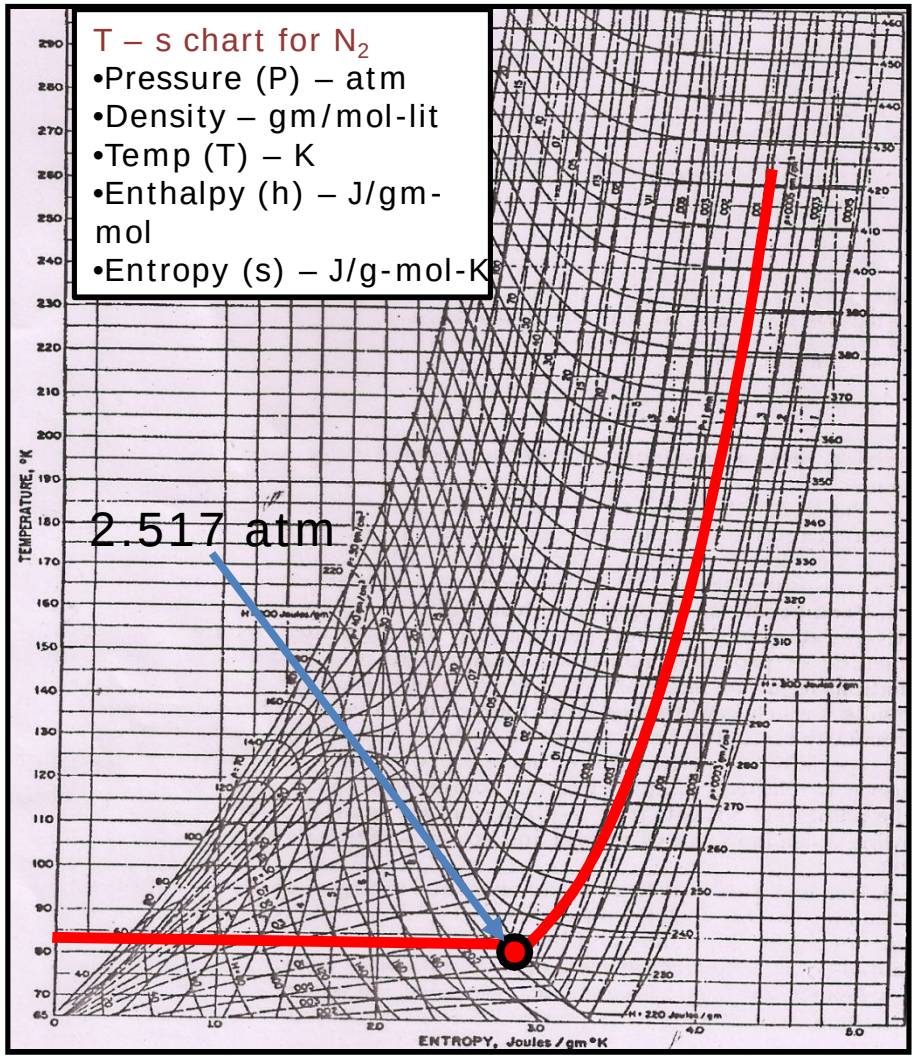
- Also, calculate K_{N2} and K_{O2} and compare them with the experimental data.

Tutorial – 2

Given
Working Pressure : 2 atm
Temperature : 86 K
Mixture : N_2 + O_2

For above mixture, Calculate	
x_{N2}	Mole fraction of N_2 in liquid phase
x_{O2}	Mole fraction of O_2 in liquid phase
y_{N2}	Mole fraction of N_2 in vapor phase
y_{O2}	Mole fraction of O_2 in vapor phase
K_{N2}	Distribution coefficient of N_2
K_{O2}	Distribution coefficient of O_2

Tutorial – 2



- Vapor pressures of **N_2** is taken from the T – s diagram.
- Following the similar procedure for **O_2**, we have the vapor pressures as

Vapor Pr.
Π_{N2} = 2.517 atm
Π_{O2} = 0.640 atm

Tutorial – 2

- x_{N2}

$$p_{tot} = \pi_{N2} x_{N2} + \pi_{O2}\left(1 - x_{N2}\right)$$

$$x_{N2} = \frac{p_{tot} - \pi_{O2}}{\pi_{N2} - \pi_{O2}}$$

Data
p_{tot} = 2 atm
Π_{N2} = 2.517 atm at 86 K
Π_{O2} = 0.640 atm at 86 K

$$x_{N2} = \frac{2 - 0.980}{3.550 - 0.980} = 0.724$$

Tutorial – 2

- x_{O2}

$$x_{N2} + x_{O2} = 1$$

$$x_{O2} = 1 - x_{N2}$$

$$x_{N2} = 0.724$$

$$x_{O2} = 1 - 0.724 = 0.276$$

Tutorial – 2

- y_{N2}

$$y_{N2} = \frac{\pi_{N2} x_{N2}}{p_{tot}}$$

Data
p_{tot} = 2 atm
Π_{N2} = 2.517 atm at 86 K
Π_{O2} = 0.640 atm at 86 K

$$x_{N2} = 0.724$$

$$y_{N2} = \frac{(2.517)(0.724)}{(2)} = 0.911$$

Tutorial – 2

- y_{O2}

$$y_{N2} + y_{O2} = 1$$

$$y_{O2} = 1 - y_{N2}$$

$$y_{N2} = 0.911$$

$$y_{O2} = 1 - 0.911 = 0.089$$

Tutorial – 2

- K_{N2}

$$K_{N2} = \frac{y_{N2}}{x_{N2}}$$

$$x_{N2} = 0.724 \qquad y_{N2} = 0.911$$

$$K_{N2} = \frac{0.911}{0.724} = 1.2583$$

Tutorial – 2

- K_{O2}

$$K_{O2} = \frac{y_{O2}}{x_{O2}}$$

$$x_{O2} = 0.276 \qquad y_{O2} = 0.089$$

$$K_{O2} = \frac{0.089}{0.276} = 0.3224$$

Tutorial – 2

- The calculated and experimental **K** values are as tabulated below.

Calculated		Experimental	
K_{N2}	1.2583	K_{N2}	1.2335
K_{O2}	0.3224	K_{O2}	0.3697

- The ideal (calculated) values differed from the experimental values by small amount.

- This is because, the effect of inter – molecular forces is neglected in the ideal mixtures.