MIXTURES

$$m = \sum_i m_i \qquad (13.1)$$

$$\text{mass fraction} = \frac{m_i}{m} = \frac{m_i}{\sum_i m_i}$$

$$\text{mass} = \text{moles} \times \text{MWT}$$

$$m = n \times \text{MWT} \qquad (12.3)$$

$$\text{mole fraction, } y = \frac{n_i}{n} = \frac{n_i}{\sum_i n_i} \qquad (13.2)$$

$$1 \text{ mole } CO_2 + 1 \text{ mole } N_2$$

	moles	molar analysis	MWT	weight	gravimetric analysis
CO_2	1	50%	44	44 lbs	61.1%
N_2	1	50%	28	28 lbs	38.9%
	2	100%		72lbs	

IDEAL MIXING ï IDEAL GASES

Ideal Gas $$p_i = \frac{m_i R_i T}{V} \qquad p_i = \frac{n_i \overline{R_i} T}{V}$$

Ideal Mixing - Daltons Law $$p_{mix} = \sum_i p_i \left(T_{mix}, V_{mix}\right) \quad (13-6)$$

$$\underset{(T,V)}{\boxed{p_1}} + \underset{(T,V)}{\boxed{p_2}} + é + \underset{(T,V)}{\boxed{p_n}} = \underset{(T,V)}{\boxed{p_{mix}}}$$

Ideal Gas $$V_i = \frac{m_i R_i T}{p} \qquad V_i = \frac{n_i \overline{R_i} T}{p}$$

Ideal Mixing - Agamats Law $$V_{mix} = \sum_i V_i \left(T_{mix}, p_{mix}\right) \quad (13-7)$$

$$\underset{(T,p)}{\boxed{V_1}} + \underset{(T,p)}{\boxed{V_2}} + é + \underset{(T,p)}{\boxed{V_n}} = \underset{(T,p)}{\boxed{V_{mix}}}$$

IDEAL MIXING

$$y_i = \frac{n_i}{n} = \frac{\dfrac{p_i T}{\overline{R}_i V}}{\dfrac{pT}{\overline{R} V}} = \frac{p_i}{p} \quad (13-8)$$

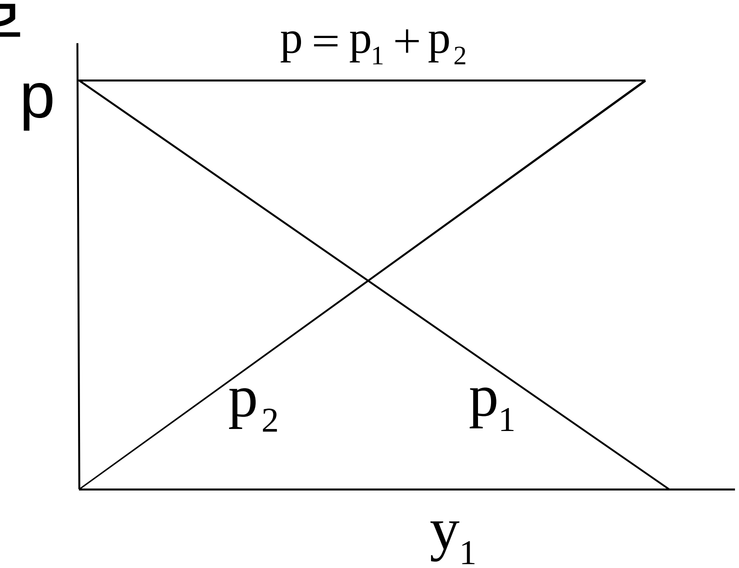
$$p \times y_i = p_i$$

$$p = \sum_i p_i = \sum_i p \times y_i$$

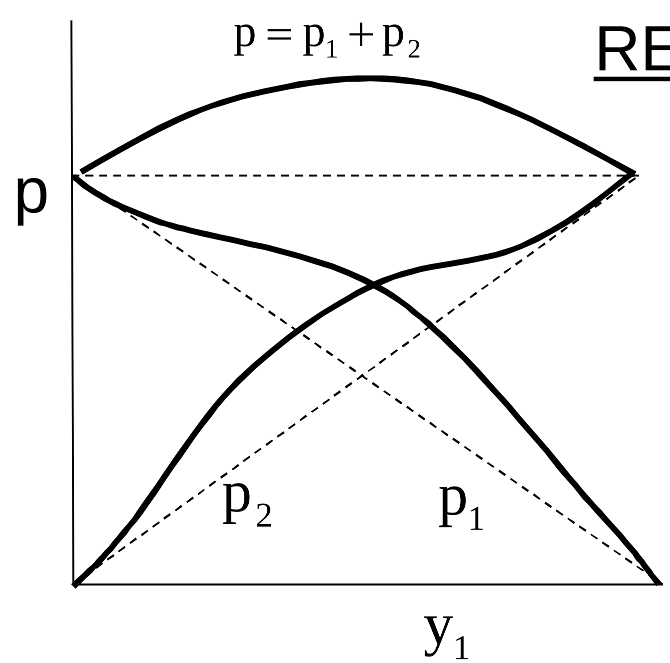
for a binary mixture

$$p = y_1 \times p_1 + y_2 \times p_2$$

$$p = y_1 \times p_1 + (1 - y_1) \times p_2$$



REAL MIXING



MIXTURE PROPERTIES

$$p = \sum_i p_i = \sum_i \frac{m_i R_i T}{V}$$

$$\frac{mRT}{V} = \sum_i \frac{m_i R_i T}{V}$$

$$R = \sum_i \frac{m_i}{m} R_i$$

$$H = \sum_i H_i \qquad (12.18)$$

$$mh_i = \sum_i m_i h_i$$

$$h = \sum_i \frac{m_i}{m} h_i$$

$$c_p \int dT = \sum_i \frac{m_i}{m} c_{pi} \int dT$$

$$c_p = \sum_i \frac{m_i}{m} c_{pi}$$

$$U = \sum_i U_i \qquad (13\text{-}14)$$

$$c_v = \sum_i \frac{m_i}{m} c_{vi}$$

$$S = \sum_i S_i$$

molar basis

Mass Basis of Calculation – 1 lb dry air, 1 kg dry air

$$H = \sum H_i$$

$$h = h_a + \frac{m_{vapor}}{m_{dryair}} h_{vapor} \qquad \text{kJ/kg dry air, Btu/lb dry air}$$

$$S = \sum S_i$$

$$s = s_a + \frac{m_{vapor}}{m_{dryair}} s_{vapor} \qquad \text{kJ/kg dry air K, Btu/lb dry air R}$$

Ideal Gas, Isentropic process

$$\varphi s = \left(c_{p\,air} \ln\left(\frac{T_{2\,air\,iss}}{T1}\right) - R_{air} \ln\left(\frac{p_2}{p_1}\right)\right) + \frac{m_{vapor}}{m_{air}} \left(c_{p\,vapor} \ln\left(\frac{T_{2iss}}{T1}\right) - R_{vapor} \ln\left(\frac{p_2}{p_1}\right)\right) = 0$$

$$T_{2\,air\,iss} = T_{2\,vapor\,iss}$$

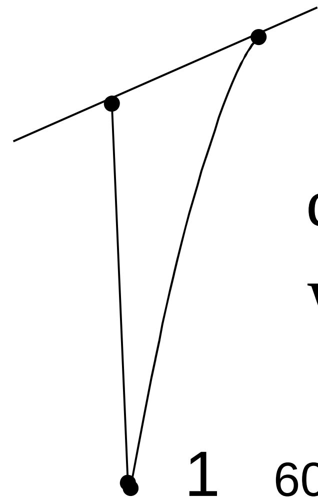
$$\frac{p_{2\,air}}{p_{1air}} = \frac{p_{2\,vapor}}{p_{1\,vapor}}, \qquad \gamma = \frac{m_{vapor}}{m_{air}} \qquad \text{(specific humidity)}$$

$$\ln\left(\frac{T_{2\,iss}}{T_1}\right)(c_{p\,air} + \gamma \times c_{p\,vapor}) - \ln\left(\frac{p_2}{p_1}\right)(R_{air} + \gamma \times R_{vapor}) = 0$$

$$\ln\left(\frac{T_{2\,iss}}{T1}\right) = \frac{(R_{air} + \gamma \times R_{vapor})}{(c_{p\,air} + \gamma \times c_{p\,vapor})} \ln\left(\frac{p_2}{p_1}\right)$$

$$T_{2iss} = T_1 \times e^{\left(\frac{(R_{air} + \gamma \times R_{vapor})}{(c_{p\,air} + \gamma \times c_{p\,vapor})} \ln\left(\frac{p_2}{p_1}\right)\right)}$$

Compressing Humid Air



2 100 psia

$\eta = 80\%$

$\text{Work} = ?$

1 60 F, 14.7 psia

75% specific humidity

$$R_{air} = 1545.15/28.96/778 = .0686$$

$$R_{vapor} = 1545.15/18/778 = .11$$

$$c_{pair} = .24$$

$$c_{pvapor} = .45$$

$$\omega = .00823 \text{ lb vapor/lb dry air (60 F, 14.7 psia, 75\% relatrive humidity)}$$

$$T_{2iss} = T_1 \times e^{\left(\frac{(R_{air} + \omega \times R_{vapor})}{(c_{p\,air} + \omega \times c_{p\,vapor})} \ln\left(\frac{p_2}{p_1}\right)\right)}$$

$$\frac{(R_{air} + \omega \times R_{vapor})}{(c_{p\,air} + \omega \times c_{p\,vapor})} \ln\left(\frac{p_2}{p_1}\right) = \frac{.0686 + .00823 \times .11}{.25 + .00823 \times .45} \ln\frac{100}{14.7} = .544$$

$$T_{2iss} = 520 \times e^{.544} = 520 \times 1.7235 = 896.26$$

$$T_2 = T_1 + \left(T_{2iss} - T_1\right)/\eta_c = 520 + (896.26 - 520)/.8 = 990.33\,\text{R},\ \ 530.64\,\text{F}$$

$$h_1 = h_a + \omega \times h_v@60\text{F} = .24 \times 60 + .00823 \times 1087.4 = 10.38$$

$$h_2 = .24 \times 530.64 + .00823 \times 1197. = 137.20$$

$$W = (h_2 - h_1) = 137.20 - 10.38 = 126.82 \text{ Btu/lb dry air}$$