PART I- TRANSPORT PROCESSES: MOMENTUM, HEAT, AND MASS

(1.2-1)

Eq.(1.3-4) $K = 353.2 = °C + 273.15$ $°C = 80.05 =$ **80°C**

Eq.(1.3-2) $°C = 80.0 = (1/1.8)(°F - 32)$ $°F =$ **176°F**

Eq.(1.3-3) $°R = °F + 460 = 176 + 460$ $°R =$ **636°R**

(1.2-2)

Eq.(1.3-2) $°C = (1/1.8)(°F - 32) = (1/1.8)(155 - 32) =$ **68.33°C**

Eq.(1.3-4) $K = °C + 273.15 = 68.33 + 273.15 =$ **341.5 K**

Eq.(1.3-3) $°R = °F + 460 = 155 + 460 =$ **615 °R**

(1.3-1)

$MW(O_2) = 32.00, \quad MW(N_2) = 28.02$

$MW(air) = 0.21(32.00) + 0.79(28.02) =$ **28.9 kg/kg mol**

(1.3-2)

$2CO + O_2 \rightarrow 2CO_2$

MW 28.01   32.00   44.01

$$\text{Moles } CO = \frac{56.0\ kg}{28.01\ kg/kg\ mol} = 2.00\ kg\ mol$$

Moles $O_2 = 1.00$, $1.00(32.00) =$ **32.0 kg O_2** $2.00(44.0) =$ **88.0 kg CO_2**

(1.3-3)

Gas	g	MW	g mol	Mol frac
N_2	20	28.02	0.7138	0.1648 mol frac
O_2	83	32.00	2.5938	0.5990
CO_2	45	44.01	1.0225	0.2362
Total	148 g		4.3301 g mol	1.0000

$$\text{average mol wt} = \frac{148\ g}{4.3301\ g\ mol} = \begin{array}{l}34.2\ g/g\ mol\\ 34.2\ kg/kg\ mol\end{array}$$

(1.4-1)

$P = 2.4$ mm Hg

From Appendix A.1

$1\ atm = 760\ mm\ Hg$

$$P = \frac{2.4\ mm\ Hg}{760\ mm\ Hg/atm} = \boxed{3.16 \times 10^{-3}\ atm}$$

$1\ atm = 33.90 \times 12\ in.\ H_2O\ (at\ 4°C)$

$$P = \frac{2.4}{760}\ atm\ \left(33.90 \times 12\ \frac{in.\ H_2O}{atm}\right) = \boxed{1.285\ in.\ H_2O}$$

$1\ \mu m = 10^{-3}\ mm$

$$P = \frac{2.4\ mm}{10^{-3}\ mm/\mu m} = \boxed{2{,}400\ \mu m\ Hg}$$

$1\ atm = 1.01325 \times 10^5\ Pa$

$$P = \frac{2.4}{760}\ atm\ \left(1.01325 \times 10^5\ \frac{Pa}{atm}\right) = \boxed{320\ Pa}$$

(1.4-2)

$V_1 = 65.0\ ft^3$, $T_1 = 460 + 90 = 550\ °R$, $T_2 = 460 + 65 = 525\ °R$

From Appendix A.1, $1\ atm = 14.696$ psia

$p_1 = 29.0 + 14.696 = 43.696$ psia, $p_2 = 75.0 + 14.696 = 89.696$ psia

$p_1 = 43.696/14.696 = 2.975\ atm$, $p_2 = 89.696/14.696 = 6.104\ atm$

Eq. (1.4-2)

$$V_2 = V_1 \frac{p_1}{p_2} = 65.0 \frac{(2.975)}{(6.104)} = \boxed{30.24\ ft^3}$$

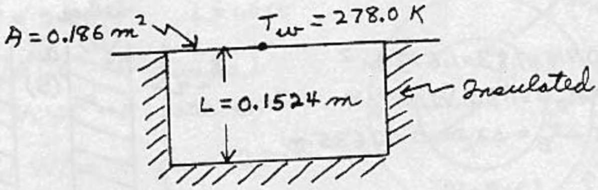
$R = 0.7302\ ft^3 \cdot atm/lb\ mol \cdot °R$, MW of $N_2 = 28.01$

Eq. (1.4-1)

$$n = pV/RT = (2.975)(65.0)/(0.7302)(550) = \boxed{0.4815\ lb\ mol}$$

$$\text{Density, } \rho = (0.4815)(28.01)/30.24 = \boxed{0.446\ lb_m/ft^3}$$

(4.3-12)



$\rho = 641 \ kg/m^3$

$k = 0.346 \ W/m\cdot K = 0.346 \ J/s\cdot m\cdot K$

$$\dot{q} = 0.070 \frac{kJ}{kg\cdot h}\left(641 \frac{kg}{m^3}\right) = 44.87 \frac{kJ}{h\cdot m^3}$$

Eq. (4.3-27)

$$T_0 = \frac{\dot{q} L^2}{2k} + T_w = \frac{(44.87\times 1000)(0.1524)^2}{(2)(0.346)(3600)} + 278.0$$

$$T_0 = 0.418 + 278.0$$

$$\boxed{T_0 = 278.42 \ K}$$

Eq. (4.3-28)

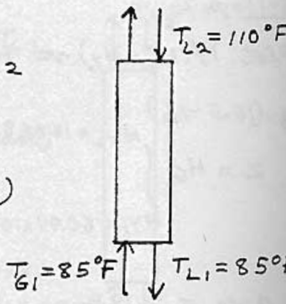
$\dot{q}_T = \dot{q}$ (volume)

$$\dot{q}_T = \frac{(44.87\times 1000)}{3600}(0.1524\times 0.186)$$

$$\boxed{\dot{q}_T = 0.353 W}$$

(1.22 btu/h)

(10.5-2)



$L = 2000\ lb_m/h\cdot ft^2$ $G = 1400\ lb_m\,air/h\cdot ft^2$

$K_G a = 6.90\ lb\,mol/h\cdot ft^3\cdot atm$

$T_{wet\,bulb}$ inlet air $= 75°F$

$H_1 = 0.0165$ lb water/lb dry air (Fig. 9.3-2)

Eq (9.3-8).

$H_y = (0.24 + 0.45H)(T - T_0\,°F) + H\lambda_0$

$H_{y1} = (0.24 + 0.45\times 0.0165)(85-32) + 1075.4(0.0165) = 30.8\ \frac{btu}{lb_m\ dry\ air}$

(a) Minimum air rate

Saturated enthalpies from Table 10.5-1 are plotted as H_y vs T_L. The point $H_{y1} = 30.8$ and $T_{L1} = 85°F$ is plotted.

The line for minimum G is plotted where the operating line becomes tangent as shown. At $T_{L2} = 110°F$, a value of $H_{y2} = 84.3$ is read off mins operating line.

Eq (10.5-2)

$G(H_{y2} - H_{y1}) = Lc_L(T_{L2} - T_{L1})$ $c_L = 1.00\ btu/lb_m\cdot°F$

$G(84.3 - 30.8) = 2000(1.0)(110-85)$

$G_{min} = 935\ lb_m\ air/h\cdot ft^2\ (4241\ kg/h\cdot m^2)$

(b) Use operating $G = 1400$

$1400(H_{y2} - 30.8) = 2000(1.0)(110-85)$ $H_{y2} = 66.7\ btu/lb_m$

Plot point H_{y2}, T_{L2}. Draw operating line. Read off values of H_y^* and H_y at given T_L values.

Make a plot of $\frac{1}{H^*-H_y}$ versus H_y.

Graphically integrate

T_L	H_y^*	H_y	H^*-H_y	$\frac{1}{H^*-H_y}$
85	41.8	30.8	11.0	0.0908
90	48	38	10.0	0.100
95	55.3	45.2	10.1	0.099
100	63.7	52.4	11.3	0.0885
105	73.6	59.5	14.1	0.0710
110	84.5	66.7	17.8	0.0562

Eq. (10.5-18)

$$\int_{H_{y1}=30.8}^{H_{y2}=66.7} \frac{dH_y}{H_y^* - H_y} = 3.12\ \text{(area)}$$

Eq. (10.5-18)

$$z = \frac{G}{M_B K_G a P}\int_{H_{y1}}^{H_{y2}} \frac{dH_y}{H_y^* - H_y} = \frac{1400}{29(6.90)(1.00)}(3.12)$$

$z = 21.8\ ft\ (6.64\ m)$

(13.9-1)

(a) Solution of 0.50 g mol NaCl/kg H_2O

Table A.2-3, $\rho = 997.0$ kg H_2O/m^3

$n = (2)(0.50 \times 10^{-3})$ kg mol (2 ions)

$$V_m = \frac{1.00 \text{ kg } H_2O}{997.0 \text{ kg } H_2O/m^3}$$

Eq. (13.9-1)

$$\pi = \frac{nRT}{V_m} = \frac{(2 \times 0.5 \times 10^{-3})(82.057 \times 10^{-3})(298.15)}{(1.0/997.0)}$$

π (Predicted) = 24.39 atm π (Exp.) = 22.55 atm

(b) Solution of 1.0 g sucrose/kg H_2O

$$n = \frac{1.0 \text{ g} \times 10^{-3} \text{ kg}}{342.3 \text{ kg/kg mol}} = 2.921 \times 10^{-6} \text{ kg mol sucrose}$$

Eq. (13.9-1)

$$\pi = \frac{(2.921 \times 10^{-6})(82.057 \times 10^{-3})(298.15)}{(1.0/997.0)} = \boxed{0.0713 \text{ atm} = \pi(\text{Pred})}$$

π (Exp) = 0.0714 atm

(c) Solution of 1.0 g $MgCl_2$/kg H_2O

$$n = \frac{1.0 \times 10^{-3} \text{ kg}}{95.23 \text{ kg/kg mol}}(3) = 3.150 \times 10^{-5} \text{ kg mol} \quad (3 \text{ ions})$$

Eq.(13.9-1)

$$\pi = \frac{(3.150 \times 10^{-5})(82.05 \times 10^{-3})(298.15)}{(1/997.0)}$$

π (Predicted) = 0.768 atm π (Exp) = 0.660 atm