HW 3.4:

14-14: Room contains air @ 20°C & 85 kPa @ relative humidity of 85%.

a.) Partial pressure of dry air: (P_a)

$T = 20°C$ $P = 85\,kPa$ $\phi = 85\%$

$P_{sat} @ T \Rightarrow 2.3392\,kPa = P_g$

$P_v = \phi(P_g) \Rightarrow .85(2.3392\,kPa)$

$P_v = 1.98832\,kPa$

$P_a = P - P_v$

$\boxed{P_a = 83.0117\,kPa}$

b.) Specific humidity of the air:

$$\omega = \frac{0.622 \times \phi \cdot P_g}{P - P_g \times \phi} \Rightarrow \boxed{\omega = .0176}$$

c.) The enthalpy per unit mass of dry air:

$h = h_a + \omega h_g$ $h_g @ T = 2537.4\,kJ/kg$

$h = c_p \times T + \omega h_g$

$h = c_{pa} \times T + \omega(h_g + c_{pv} \times T)$

$h = 1.005\,kJ/kg \cdot c \times 20°C + .0176(2537.4\,kJ/kg + 1.8723\,kJ/kg \cdot c \times 20°C)$

$$\boxed{h = 65.41\,kJ/kg}$$

14.16: An $8m^3$-tank contains saturated air @ 30°C & 105kPa.

a.) Mass of dry air: $P_aV = m_ART$

$P = 105kPa$

$P_{sat} @ T = 4.2469kPa = P_v$

$V = 8m^3$

$T = 30°C \Rightarrow 303K$

$R = 0.287 \, kJ/kg \cdot K$

$m_A = \dfrac{100.75kPa(8m^3)}{(0.287\frac{kJ}{kg \cdot K})(303K)}$ $\boxed{= 9.27kg = m_A}$

$P_a = P - P_v$

$\hookrightarrow P_a = 100.75kPa$

b.) The specific humidity: $\omega = \dfrac{0.622 \times P_v}{P - P_v}$

$\omega = \dfrac{0.622 \times 4.2469kPa}{105kPa - 4.2469kPa} \Rightarrow \boxed{\omega = 0.0262 \, kg_{\text{Wtr Vapor}}/kg_{\text{dry air}}}$

c.) Enthalpy of air per unit mass of dry air:

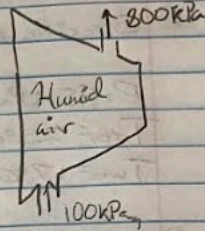
$h = h_a + \omega(h_g) \Rightarrow h = c_p \times T + \omega(h_g)$

$h = 1.005 \, kJ/kg \cdot C \times 30°C + 0.0262(2555.6) \Rightarrow \boxed{h = 97.107 \, kJ/kg}$

$h_g @ T \Rightarrow 2555.6 \, kJ/kg$

4-18: Humid air @ 100kPa, 20°C, & 90% relative humidity, compressed in steady-flow, isentropic compressor @ 800kPa.

a) Relative humidity of air @ compressor outlet: (ϕ)



$P_1 = 100kPa$ $\quad P_{sat} @ T_1 = 2.3392kPa = P_{g_1}$ $\quad$ Assume $\omega_1 = \omega_2$

$T_1 = 20°C \Rightarrow 293K$

$\phi_1 = 90\%$ $\quad\quad P_{v_1} = \phi_1 (P_{g_1})$

$P_{g_1} = 2.3392kPa$

$P_{v_1} = 2.10528kPa$ $\quad\quad \omega = \dfrac{0.622 (P_{v_1})}{P_1 - P_{v_1}} \Rightarrow 0.0134 \, kg_{water}/kg_{dry\,air}$ 20°C, 90%

$\omega = 0.0134 \, kg_{H_2O}/kg_{dry\,air}$

Isentropic process: $\dfrac{T_2}{T_1} = \left(\dfrac{P_2}{P_1}\right)^{\frac{k-1}{k}} \Rightarrow T_2 = 530.75K$ or $257.75°C$

$k = 1.4$

$P_2 = 800kPa \hookrightarrow P_{2sat} @ t_2 = 4526.07 \, kPa = P_{g_2}$ (Interp.)

$T_2 = 530.75K$ or $257.75°C$

$P_{g_2} = 4470.66kPa$

$P_{v_2} = 16.87kPa$ $\quad\quad \phi_2 = \dfrac{P_{v2}}{P_{g2}} \Rightarrow \dfrac{16.87kPa}{4526.07kPa} = .37\%$

$\omega = \dfrac{0.622 (P_{v_2})}{P_2 - P_{v_2}} \Rightarrow P_{v_2} = 16.87kPa$

$\boxed{\phi_2 = 0.37\%}$

14-28: Dry & Wet bulb temperatures of atmospheric air @ 95 kPa are 25°C & 17°C.

a) Specific humidity: (ω)

$$* \omega = \frac{c_p(T_{wb} - T_{db}) + \omega_{wb}(h_{fg,wb})}{h_{g,db} - h_{f,wb}}$$

$P = 95\,kPa$

$T_{db} = 25°C$

$T_{wb} = 17°C$

$C_p = 1.005\,kJ/kg\cdot°C$

$P_{sat,db} @ 25°C = 3.1698\,kPa = P_{g,db}$

$P_{sat,wb} @ 17°C = 1.9591\,kPa = P_{g,wb}$

Interpo

$$\omega_{wb} = \frac{0.622(P_{gwb})}{P - P_{gwb}} \Rightarrow \underline{0.0131 \frac{kg\,wtr}{kg\,dry\,air}}$$

$h_{fg,wb} @ 17°C = 2460.64\,kJ/kg$

$h_{f,wb} @ 17°C = 71.3552\,kJ/kg$

$h_{g,db} @ 25°C = 2546.5\,kJ/kg =$

$$* \omega_1 = \frac{1.005\,kJ/kg\cdot°C\,(17°C - 25°C) + 0.0131\,kJ\,wtr/kg\,dry\,air\,(2460.64\,kJ/kg)}{2546.5\,kJ/kg - 71.3552\,kJ/kg}$$

$$\boxed{\omega_1 = 0.00977}$$

b.) Relative humidity (ϕ):

$$\phi = \frac{\omega_1 (P)}{(0.622+\omega_1) P_{g_{db}}} \Rightarrow \frac{0.00977\,(95kPa)}{(0.622+0.00977)\times 3.1698kPa}$$

$$\boxed{\phi = .4635 \text{ or } 46\%}$$

c.) Enthalpy of air in kJ/kg of dry air:

$$h = h_{a_{db}} + \omega (h_{g_{db}}) \Rightarrow h = c_p \times T_{db} + \omega (h_{g_{db}})$$

$$h = 1.005\,kJ/kg\cdot°C\,(25°C) + (0.00977)(2546.5\,kJ/kg)$$

$$\boxed{h = 50.004\,kJ/kg}$$

14-32

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given:

$\dot{m}_{a1} = \dot{m}_{a2}$ $P = 98\,kPa$ atm air $T_1 = 35°C$

$P_{a1} = P_{a2}$ $T_2 = 25°C$

Find both humidities:

sat. tables → $P_{g2@T_2} = 3.1698\,kPa$

$$\omega_2 = \frac{0.622 \cdot P_{g2}}{P - P_{g2}} = \frac{0.622 \cdot 3.1698\,kPa}{98\,kPa - 3.1698\,kPa} = \underline{0.0208}$$

$h_{f@T_2} = 104.83\,\frac{kJ}{kg}$ $h_{g@T_1} = 2564.6\,\frac{kJ}{kg}$ c_p @ dry air $= 1.005\,\frac{kJ}{kg \cdot K}$

$h_{fg} = 2441.7\,\frac{kJ}{kg}$ $\omega_1 = \frac{c_p(T_2 - T_1) + \omega_2 \cdot h_{fg2}}{h_{g1} - h_{f2}}$

$$\omega_1 = \frac{1.005\,\frac{kJ}{kg \cdot K}(25-35) + 0.0208 \cdot 2441.7\,\frac{kJ}{kg}}{2564.6\,\frac{kJ}{kg} - 104.83\,\frac{kJ}{kg}}$$

$\boxed{\omega_1 = 0.01655}$ $P_{g1@35°C} = 5.6291$

$$\phi = \frac{\omega_1 P}{(0.622 + \omega_1) P_{g1}} = \frac{0.01655 \cdot 98\,kPa}{(0.622 + 0.01655) 5.6291\,kPa} = \boxed{0.451 = \phi}$$

14.39

using Psychrometric chart @ 1 atm

Find ω, h_a, ϕ, dew point T, v_a

$T = 24°C$ wet bulb @ 17°C

ω = right $= 0.0095\,\frac{kg\,v}{kg\,a}$ ϕ = curve = 50%

$h \approx 47.8\,\frac{kJ}{kg\,a}$ $v = 0.855\,m^3/kg\,a$

$T_{dp} \approx 13.5°C$

14-41 use psychromatic chart @ 1atm

$T_{db} = 28°C$ $T_{wB} = 20°C$

Find ϕ, ω ratio, h, P_v, T_{dp}

ϕ = curve ≈ 48% $h \approx 57.6 \frac{kJ}{kga}$

ω ratio ≈ $0.015 \frac{kgv}{kga}$ $T_{dp} = 16°C$

1atm = 101.25 kpa

$$P_v = \frac{\omega \cdot P}{(0.622+\omega)} = \frac{0.015 \cdot 101.25 \text{kpa}}{0.622 + 0.015} = \boxed{2.384 \text{ Kpa}}$$

14-43 psychromatic chart @ 1atm

given: $90°F = T_{dB}$ $75°F = T_{dp}$ $°F = 1.8 \cdot °C + 32$

$90°F = 32.22°C$ $75°F = 23.889°C$

Find: ϕ, ω ratio, h, T_{wb}, P_v

$\phi = 60\%$ ω ratio $= 0.0185$

$h \approx 80 \frac{kJ}{kga}$ $T_{wB} \approx 25.9°C = 78.62°F$

$$P_v = \frac{\omega \cdot P}{0.622+\omega} = \frac{0.0185 \cdot 101.25 \text{kpa}}{0.622 + 0.0185} = \boxed{2.9245 \text{ Kpa}}$$