Extra Psychrometry Problems

Psychrometric charts are in the F&R textbook in section 8.4d-e. Additional problems that use these topics are 8.69-8.80 at the end of chapter 8.

1. (5 pts) You heard on the weather that the current conditions are 62°F and 40% RH. Using a psychrometric chart, find the following:

   a) Dry-bulb temperature
   b) Wet-bulb temperature
   c) Dew point
   d) Absolute humidity (humidity ratio)

2. (5 pts) F&R, Prob 8.69 The latest weather report states that the temperature is 24ºC and the relative humidity is 50%.

   (a) Use the psychrometric chart to estimate the absolute humidity, humid volume, specific enthalpy, wet-bulb temperature, and dew-point temperature of the air.
   (b) A thermometer is mounted on the back porch of your house. What temperature would it read?
   (c) A sample of outside air is cooled at constant pressure. At what temperature would condensation begin?
   (d) You step out of your neighborhood pool and feel quite cold until you dry off. Explain why. Estimate your skin temperature while you were still wet. Explain your answer. What would be different if the relative humidity were 98%?

3. (5 pts) F&R, Prob. 8.76 Air at 45ºC (dry bulb) and 10% relative humidity is to be humidified adiabatically to 60% relative humidity.

   (a) Use the psychrometric chart to estimate the adiabatic saturation temperature of the air.
   (b) Estimate the final temperature of the air and the rate at which water must be added to humidify 15 kg/min of the entering air.

4. (5 pts) Cold saturated air (10°C) at 10 m^3 dry air per minute is mixed with warm air (35° C dry-bulb and 25 °C wet-bulb) at 5 m^3 dry air per minute. After performing a mass and energy balance,

   a) What is the mass fraction of water vapor in the mixed air?
   b) What is the absolute humidity of the mixed air?
   c) What is the enthalpy of the mixed air?
   d) Using that information, what is the dry-bulb temperature and relative humidity of the mixed air?

5. (5 pts) Air enters a cooling tower at 40°C and 20% RH and exits at 26°C, using the psychrometric chart, find the following properties of the exit air:

   a) Wet-bulb temperature
   b) Relative humidity
   c) Dew point
   c) Absolute humidity (humidity ratio)

Solutions

1.

(These values may be +/- 0.5)

a) T(db) = 62 °F (16.7°C)

b) T(wb) = 49.6 °F (9.8°C)

c) T(dp) = 37.4 °F (3.0°C)

d) h_a = 0.00469 lbm water / lbm DA = 32.83 gr water / lbm DA

2.

8.69 **(a)** For 24°C and 50% relative humidity, from Figure 8.4-1,

Absolute humidity = 0.0093 kg water / kg DA, Humid volume ≈ 0.856 m^3 / kg DA

Specific enthalpy = (48 - 0.2) kJ / kg DA = 47.8 kJ / kg DA, Dew point = 13° C, T_{wb} = 17° C

(b) 24° C (T_{db})

(c) 13° C (Dew point)

(d) Water evaporates, causing your skin temperature to drop. $T_{skin} \approx 13°C$ (T_{wb}). At 98% R.H. the rate of evaporation would be lower, T_{skin} would be closer to $T_{ambient}$, and you would not feel as cold.

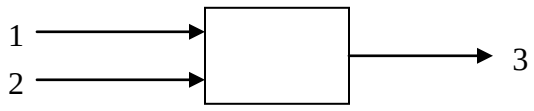
3.

8.76 **a.** $T_{db} = 45°C$, $h_r = 10\%$ $\xrightarrow[\text{Fig. 8.4-1}]{}$ $T_{as} = T_{wb} = 21.0°C$ $h_a = 0.0059$ kg H_2O/kg DA

b. $T_{wb} = 21.0°C$, $h_r = 60\%$ $\xrightarrow[\text{Fig. 8.4-1}]{}$ $T_{db} = 26.8°C$ $h_a = 0.0142$ kg H_2O/kg DA

H_2O added: $\dfrac{15 \text{ kg air}}{\text{min}} \left| \dfrac{1 \text{ kg D.A.}}{1.0059 \text{ kg air}} \right| \dfrac{(0.0142 - 0.0059) \text{ kg } H_2O}{1 \text{ kg D.A.}} = 0.12 \text{ kg } H_2O/\text{min}$

4.



Property	Stream 1	Stream 2
T_{db}	10 C (given)	35 C (given)
T_{wb}	10 C (given)	25 C (given)
T_{dp}	10 C (given)	21.2 C
h_a	0.00763 kg/kg DA	0.01582 kg/kg DA
H	29.223 kJ/kg DA	75.571 kJ/kg DA
V	0.812 m^3/kg DA	0.895 m^3/kg DA

a)

Mass Balance

Total: $m_1 + m_2 = m_3$

Water: $y_{1,w} * m_1 + y_{2,w} * m_2 = y_{3,w} * m_3$

$m_1 = 10\ m^3/min / (0.812 / (1 + 0.00763)) = 12.4$ kg/min
$m_2 = 5\ m^3/min / (0.895 / (1 + 0.015825)) = 5.7$
$m_3 = 18.1$ kg/min

$y_{1,w} = 0.00763 / 1.00763 = 0.00757$ kg/kg
$y_{2,w} = 0.015825 / 1.015825 = 0.01558$ kg/kg

substitute into water balance -> $y_{3,w}$ = **0.01008 kg/kg**

b) $h_a = y_{3,w} / (1 - y_{3,w}) = 0.01009 / (1 – 0.01009) =$ **0.01019 kg H20 / kg DA**

c)
Energy Balance (or use chart and draw line, find enthalpy where line crosses h_a)

$\Delta H + \Delta E_k + \Delta E_p = Q – W_s$
$\Delta E_k = \Delta E_p = Q = W_s = 0$, $\Delta H = 0$

$in – out = 0 = (H_1 * m_{1,da} + H_2 * m_{2,da}) – H_3 * m_{3,da}$

$m_{1,da} = 12.4\ m^3/min * (1 - y_{1,w}) = 12.31$ kg/min
$m_{2,da} = 5.7\ m^3/min * (1 - y_{2,w}) = 5.61$ kg/min
$m_{3,da} = 18.1 * (1- y_{3,w}) = 17.92$ kg/min = $(m_{1,da} + m_{2,da}) = (17.92$ kg/min)

substitute into energy balance -> H_3 = **43.69 kJ/kg DA**

d) T(db) = **17.9 °C**
RH = **79.6 %**
(if these values were determined using a chart, round to nearest whole number)

5. (These values may be +/- 0.5)
   a) T(wb) = 22 °C
   b) RH = 71 %
   c) T(dp) = 20.2 °C
   d) $h_a = 0.015$ kg water / kg DA