1. Air at 20°C, 40% relative humidity is mixed adiabatically with air at 40°C, 40% RH in the ratio of 1Kg former with 2Kg of latter (on dry basis). Find the final condition (humidity and enthalpy) of air.

Given:

- Dry bulb temp \( t_{d1} \) = 20°C
- Relative humidity \( \phi_1 \) = 40%
- Dry bulb temp \( t_{d2} \) = 40°C
- Relative humidity \( \phi_2 \) = 40%
- Ratio of 1Kg of former with 2Kg of latter \( \frac{m_1}{m_2} = \frac{1}{2} \)

To find:

- The final condition of air
  - Enthalpy \( h_1, h_2, h_3 \)
  - Humidity \( \omega_1, \omega_2, \omega_3 \)

Solution:

Step :1

From Psychometric chart
Use \( t_{d1} = 20^\circ\text{C} \) Relative humidity \((\phi_1) = 40\%\)

Enthalpy \((h_1) = 35\text{KJ/Kg}\)

Humidity \((\omega_1) = 0.0058\text{KJ/Kg of dry air}\)

Step :2

From Psychometric chart

Use \( t_{d2} = 40^\circ\text{C} \) Relative humidity \((\phi_2) = 40\%\)

Enthalpy \((h_2) = 90\text{KJ/Kg}\)

Humidity \((\omega_2) = 0.019\text{KJ/Kg of dry air}\)

Step :3

\[
\frac{m_{a1}}{m_{a2}} = \frac{h_2 - h_3}{h_3 - h_1}
\]

\[
\frac{1}{2} = \frac{90 - h_3}{h_3 - 35}
\]

\(2(90 - h_3) = 1(h_3 - 35)\)

\(180 - 2h_3 = h_3 - 35\)

\(180 - 2h_3 + h_3 + 35 = 0\)

\(-3h_3 + 215 = 0\)

\(3h_3 = 215\)

\(h_3 = 215/3\)

\(h_3 = 71.6666\text{KJ/Kg}\)

Step :4

\[
\frac{m_{a1}}{m_{a2}} = \frac{\omega_2 - \omega_3}{\omega_3 - \omega_1}
\]
\[ \frac{1}{2} = \frac{0.019 - \omega_3}{\omega_3 - 0.0058} \]

\[ 2(0.019 - \omega_3) = 1(\omega_3 - 0.0058) \]

\[ 0.038 - 2 \omega_3 = \omega_3 - 0.0058 \]

\[ 0.038 - 2 \omega_3 = \omega_3 + 0.0058 = 0 \]

\[ -3 \omega_3 + 0.0438 = 0 \]

\[ 3 \omega_3 = 0.0438 \]

\[ \omega_3 = 0.0438/3 \]

\[ \omega_3 = 0.0146 \text{Kg of vap / Kg of dry air} \]
2. 30m³/min of moist air at 15°C DBT and 13°C WBT are mixed with 12m³/min of moist air at 25°C DBT and 18°C WBT. Determine DBT and WBT of the mixture. Assuming the barometric pressure is 1 atm

**[AU DEC 2008]**

**Given:**

Volume of air \( V_{a1} \) = 30m³/min

Volume of air \( V_{a2} \) = 12m³/min

Dry bulb temp \( t_{d1} \) = 15°C

Dry bulb temp \( t_{d2} \) = 25°C

Wet bulb temp \( t_{ω1} \) = 13°C

Wet bulb temp \( t_{ω2} \) = 18°C

**To find:**

1. Dry bulb temp of mixture \( t_{d} \)_{mixing}

2. Wet bulb temp of mixture \( ω_d \)_{mixing}

**Solution:**

Step :1

From Psychometric chart

Use \( t_{d1} = 15°C \ & \ ω_{d1} = 13°C \)

Enthalpy \( (h_1) = 37KJ/Kg \)

Step :2

From Psychometric chart

Use \( t_{d2} = 25°C \ & \ ω_{d2} = 18°C \)

Enthalpy \( (h_2) = 51KJ/Kg \)
Step :3

\[ \frac{V_{m1}}{V_{m2}} = \frac{h_3 - h_2}{h_1 - h_3} \]

\[ \frac{30}{12} = \frac{h_3 - 51}{37 - h_3} \]

\[ 2.5 = \frac{h_3 - 51}{37 - h_3} \]

\[ 2.5(37 - h_3) = 1(h_3 - 51) \]

\[ 92.5 - 2.5 h_3 = h_3 - 51 \]

\[ 92.5 - 2.5 h_3 - h_3 + 51 = 0 \]

\[ -3.5 h_3 + 143.5 = 0 \]

\[ 3.5 h_3 = 143.5 \]

\[ h_3 = 143.5/3.5 \]

\[ h_3 = 41KJ/Kg \]

Step :4

From Psychometric chart Corresponding to, \( h_3 = 41KJ/Kg \)

The Dry bulb temp \([t_{d3}] = 17.5°C \)

The Wet bulb temp \([t_{\omega1}] = 14.6°C \)
3. Air conditioning plant is required to supply 60m\(^3\) of air per minute at a DBT of 21°C and 55% R.H. The outside air is at DBT of 35°C and 60% R.H. Determine the mass of water drained and capacity of the cooling coil. Assume the air conditioning plant is first to dehumidity and then to cool the air.

**Given:** Problem based on Dehumidification and the cooling.

- Volume \(V\) = 60/60 \(m^3\)/min = 1\(m^3\)/sec
- Dry bulb temp \((t_{d1})\) = 21°C
- Relative humidity \((\phi_1)\) = 55%
- Dry bulb temp \((t_{d2})\) = 35°C
- Relative humidity \((\phi_2)\) = 60%

**To find:**
1. Mass of water drained \((m_w)\)
2. Capacity if cooling coil \((Q)\)

**Solution:**

Step :1

Mass of water drained in Kg/sec \((m_w)\)

\[m_w = M_a [\omega_1 - \omega_2]\]

Where,

\[M_a = \frac{V}{V_2} = \frac{1}{0.84} = 1.1904 \text{ Kg/sec}\]

Where,

- \(V_2\) = Use \(\rightarrow t_{d1} = 21°C\) & \(\phi = 55%\)
- From Psychometric chart
  \[V_2 = 0.84 \text{ m}^3/\text{Kg}\]

humidity \((\omega_1)\) = From Psychometric chart
Use → $t_{d2} = 35^\circ C \& \phi = 60$

($\omega_1$) = 0.022 Kg/Kg of dry air

humidity ($\omega_2$) = From Psychometric chart

Use → $t_{d1} = 21^\circ C \& \phi = 55$

($\omega_2$) = 0.0086 Kg/Kg of dry air

Enthalpy ($h_1$) = From Psychometric chart

Use → $t_{d2} = 35^\circ C \& \phi = 60$

($h_1$) = 89.5 KJ/Kg

Enthalpy ($h_2$) = From Psychometric chart

Use → $t_{d2} = 25^\circ C \& \phi = 55$

($h_2$) = 43.5 KJ/Kg

$m_w = m_a [\omega_1 - \omega_2]$

$m_w = 1.1904 [0.022 - 0.0086]$

$m_w = 0.01595$ Kg of water/sec

$m_w = 0.01595 \times 3600$

$m_w = 57.4285$ Kg of water/hr

Step :2

Capacity of cooling coil (Q)

$Q = m_a [h_1 - h_2]$

$Q = 1.1904 [89.5 - 43.5]$

$Q = 54.7584$ KJ/sec
4. Air is initially at a temp of 23°C and a Relative humidity of 50%. It’s moisture content is increased from 0.0086 KJ/Kg of air to 0.0124 KJ/Kg of air.

1. Find the increase in wet bulb temp, dry bulb temp and specific humidity.

2. Determine Change in Relative Humidity.

3. If 200m³ of air is passed through the system every minute and the density of air is 1.3Kg/m³, calculate amount of moisture added per min.  

Given:

Volume (V) = 200m³

Initial dry bulb temp (td1) = 23°C

humidity (ω1) = 0.0086 KJ/Kg of air

humidity (ω2) = 0.0124 KJ/Kg of air

Relative humidity (ϕ1) = 50%

Density of air (ρair) = 1.3Kg/m³

To find:

1. Increase in wet bulb temp.

2. Increase in dry bulb temp.

3. Change in Relative Humidity.

4. Amount of moisture added per min.

Solution:

Step :1

Increase in wet bulb temp = tω2 - tω1

Where,
From Psychometric chart
\[ t_{\omega_2} \rightarrow \omega_2 = 0.0124 \ & \ t_d = 23^\circ C \]
\[ (h_1) = 54.5 \text{ KJ/Kg} \]
\[ t_{\omega_2} = 19^\circ C \]

Where,
From Psychometric chart
\[ t_{\omega_1} \rightarrow \omega_1 = 0.0086 \ & \ t_d = 23^\circ C \]
\[ (h_2) = 45.5 \text{ KJ/Kg} \]
\[ t_{\omega_2} = 16.2^\circ C \]

Increase in wet bulb temp = \( t_{\omega_2} - t_{\omega_1} \)
\[ = t_{\omega_2} - t_{\omega_1} \]
\[ = 19 - 16.2 \]
\[ = 2.8^\circ C \]

Increase in dry bulb temp = \( t_{d_2} - t_{d_1} \)
\[ = 0 \]

Note,
\[ t_d = \text{Constant} \]

Step :2
Increase in Specific enthalpy = \( h_2 - h_1 \)
\[ = 54.5 - 45.5 \]
\[ = 9\text{ KJ/Kg} \]

Step :3
Increase in Relative Humidity = \( \phi_2 - \phi_1 \)
Where,
From Psychometric chart

\( \phi_2 \rightarrow h_2 = 54.5 \text{KJ/Kg} \) & \( \omega_2 = 0.0124 \)

\( (t_{\omega_2}) = 19^\circ\text{C} \) use

\( \phi_2 = 68\% \)

Increase in Relative Humidity = \( \phi_2 - \phi_1 \)

= 68 \(-\) 50

= 18\%

Step :4 Amount of moisture added per min

\[ m_w = m_a [\omega_2 - \omega_1] \]

\[ M_a = V/V_1 \]

Where,

\[ V_1 = 1/\rho_1 = 1/1.3 = 0.7692 \text{ m}^3/\text{Kg} \]

\[ M_a = V/V_1 = 200/0.7692 = 260 \text{ Kg of dry air/min} \]

So,

\[ m_w = m_a [\omega_2 - \omega_1] \]

\[ m_w = 260 [0.0124 - 0.0086] \]

\[ m_w = 0.988 \text{ Kg of moisture/min} \]
5. For the atmospheric air at room temp of 30°C and relative humidity of 60%. Determine partial pressure of air, humidity ratio, dew point temp, density and enthalpy of air. [AU MAY 2011]

**Given:**

Temp\(_{room}\) = 30°C + 273 = 303K

Relative humidity (\(\phi\)) = 60%/100 = 0.6

**To find:**

1. Partial pressure of air (\(P_{air}\))
2. Humidity ratio (\(\omega\))
3. Dew point temp (\(t_{dew}\))
4. Vapour density (\(\rho_v\))
5. Enthalpy of air (\(h_{air}\))

**Solution:**

Step :1

Partial pressure of air (\(P_{air}\)) = \(P_{atm} - P_{vapour}\)

Where,

Vapour pressure (\(P_{vapour}\)) = \(\phi \times P_{saturation}\)

Where,

From steam table at (\(T_{room}\))

\(P_{saturation} = 0.04242\) bar

\(P_{vapour} = \phi \times P_{sat}\)
\[ P_{\text{vapour}} = 0.6 \times 0.04242 \]
\[ P_{\text{vapour}} = 0.025452 \text{bar} \times 100 \]
\[ P_{\text{vapour}} = 2.5452 \text{ KN/m}^2 \]

Partial pressure of air \( (P_{\text{air}}) \)
\[ = P_{\text{atm}} - P_{\text{vapour}} \]
\[ P_{\text{air}} = 101.325 - 2.5452 \]
\[ P_{\text{air}} = 98.43798 \text{ KN/m}^2 \]

Step :2
Humidity ratio \( (\omega) \)
\[ = 0.622 \times \frac{P_{\text{v}}}{P_{\text{atm}} - P_{\text{v}}} \]
\[ = 0.622 \times \frac{2.5452}{101.325 - 2.5452} \]
\[ \omega = 0.01602 \text{ KJ/Kg of dry air} \]

Step :3 To find dew point temp \( (t_{dp}) \)

From steam table at \( P_{v} = 0.025452 \)
\[ (t_{dp}) = 21.10^\circ \text{C} \]

Step :4 To find vapour density \( (\rho_{v}) \)
\[ \rho_{v} = \frac{1}{V_{v}} \]

Where,
\[ P_{v}V_{v} = mRvT_{v} \]
\[ V_{v} = \frac{\frac{RvT_{v}}{P_{v}}}{\frac{mRv}{P_{v}}} = \frac{0.462 \times 303}{2.5452} \]
\[ V_{v} = 55m^3/\text{Kg} \]
\[ \rho_v = \frac{1}{V_v} = 1/55 \]

Vapour density \( (\rho_v) = 0.01818 \text{Kg/m}^3 \)

Step 5 To find enthalpy of air

\[ h = 1.005 \times T_{\text{room}} + \omega[2500 + 1.88 \times 30] \]

\[ = 1.005 \times 30 + 0.01602[2500 + 1.88 \times 30] \]

\[ = 30.15 + 40.9535 \]

\[ h = 71.1035 \text{KJ/Kg} \]
6. Atmospheric air at 1.0132 bar has a DBT of 32°C and a WBT of 26°C. Compute

1. The partial pressure of water vapour,
2. The specific humidity,
3. The dew point temp,
4. The relative humidity,
5. Degree of saturation,
6. The density of air in the mixture,
7. The density of vapour in the mixture,
8. The enthalpy of the mixture. Use thermodynamic table only. [AU DEC 2008].

Given:

\[ P_{\text{atm}} = 1.0132 \text{bar} \times 100 = 101.32 \text{KN/m}^2 \]

Dry bulb temp (DBT) = 32°C + 273 = 305K

Wet bulb temp (WBT) = 26°C + 273 = 299K

To find:

1. \( P_v \)
2. The specific humidity,
3. \( t_{dp} \)
4. \( \phi \)
5. \( \mu \)
6. \( \rho_a \)
7. \( \rho_v \)
8. \( h \)
Solution:

Step:1 To find partial pressure of water vapour ($P_v$)

\[ P_v = P_s - \frac{[Patm - P_s][tDBT - tWBT]}{1527.4 - 1.3 t\text{wbt}} \]

Where,

Saturation pressure ($P_s$) corresponding to $t_{WBT}$

From steam table corresponding to $t_w = 26^\circ C$

\[ P_s = 0.03360 \text{bar} \]

\[ P_v = 0.03360 - \frac{[1.0132 - 0.03360][32 - 26]}{1527.4 - 1.3 \times 26} \]

\[ P_v = 0.03360 - 0.00393519 \]

\[ P_v = 0.02966 \text{ bar} \times 100 \]

\[ P_v = 2.9664 \text{ KN/m}^2 \]

Step:2 To find specific humidity ($\omega$)

\[ \omega = 0.622 \frac{P_v}{P_{atm} - P_v} \]

\[ \omega = 0.622 \frac{0.02966}{1.0132 - 0.02966} \]

\[ \omega = 0.01875 \text{ Kg/Kg of dry air} \]

Step:3 To find dew point temp ($t_{dp}$)

From steam table, corresponding to

\[ P_v = 0.02966 \text{ bar} \]

\[ t_{dp} = 22.6^\circ C \]
Step :4 To find relative humidity ($\phi$)

$$\phi = \frac{P_v}{P_{vs}}$$

Where,

$P_{vs} =$ Corresponding to $t_{DBT} = 32^\circ C$

$P_{vs} = 0.04753$ bar

$$\phi = \frac{P_v}{P_{vs}}$$

$$\phi = \frac{0.02966}{0.04753}$$

$$\phi = 0.6240 \times 100$$

$$\phi = 62.40\%$$

Step :5 To find degree of saturation ($\mu$)

$$\mu = \frac{\text{specific humidity of air}}{\text{specific humidity of air when fully saturated}} = \frac{\phi}{\phi_{sat}}$$

$$\mu = \frac{P_v [P_{atm} - P_{vs}]}{P_{vs} [P_{atm} - P_v]}$$

$$\mu = \frac{0.02966 [1.0132 - 0.04753]}{0.04753 [1.0132 - 0.02966]}$$

$$\mu = 0.6126 \times 100$$

$$\mu = 61.26\%$$

Step :6 To density of air in mixture ($\rho_{air}$)

$$\rho_{air} = \frac{\rho_{air}}{R_{air} T_{air}}$$

$$= \frac{101.32 - 2.9664}{0.287 \times 305}$$
\[ \rho_{\text{air}} = 1.1235 \text{ Kg of air/m}^3 \]

**Step :7  Density of vapour in the mixture (\(\rho_v\))**

\[ \rho_v = \frac{P_v}{R_v T_v} \]

Where,

\[ R_v = \frac{R_u}{M_w} = \frac{8.314}{18} = 0.4618 \text{ KJ/Kg. K} \]

\[ \rho_v = \frac{2.9664}{0.4618 \times 305} \]

\[ \rho_v = 0.02105 \text{ Kg of vapour/m}^3 \]

**Step :8  To find enthalpy of mixture (\(h_{\text{mix}}\))**

\[ h_{\text{mix}} = 1.005 t_d + \omega [h_g + 1.88 (t_d - t_{dp})] \]

Where,

\[ H_g = \text{corresponding to } t_{\text{DBT}} = 32^\circ \text{C} \]

\[ H_g = 2560 \text{ KJ/Kg.K} \]

\[ h_{\text{mix}} = 1.005 \times 32 + 0.01875[2560 + 1.88 (32 - 22.6)] \]

\[ h_{\text{mix}} = 32.16 - 48.3313 \]

\[ h_{\text{mix}} = 80.4913 \text{ KJ/Kg} \]
7. A sample of moist air at 1atm and 25°C has a moisture content of 0.01 by volume. Determine the humidity ratio, the partial pressure of water vapour, the degree of saturation, the relative humidity and dew point temp.  

**Given:**

\[ P_b = 1 \text{atm} \]

\[ T_d = 25^\circ C + 273 = 298K \]

Volume (V) = 0.01

**To find:**

1. \( \omega \)
2. \( P_v \)
3. \( \mu \)
4. \( \phi \)
5. \( t_d \)

**Solution:**

Step :1

Specific humidity \( (\omega) = \rho_{\text{water}} \times \frac{V\omega}{V_{\text{dry air}}} \)

\[ = \frac{1000 \times 0.01}{1000} \]

\[ \omega = 0.01 \text{ Kg/Kg of dry air} \]

Step :2
From Psychometric chart corresponding to specific humidity (ω) = 0.01 and dry bulb temp 25°C, mark point 1.

$P_v = 11.5 \text{ mm Hg}$

$\phi = 50\%$

$t_{dp} = 14^\circ C$

$P_v = \frac{11.5 \times 13.6 \times 9.81}{100000}$

$P_v = 0.015342 \text{ bar} \times 100 = 1.5342 \text{ KN/m}^2$

**Step :3** To find degree of saturation

$$\mu = \frac{P_v [\text{Patm} - P_v]}{P_v [\text{Patm} - P_v]}$$

Where,

$P_{vs} = \frac{P_v}{0.5} = 0.0306 \text{ bar}$

$$\mu = \frac{0.015342 [1.0132 - 0.0306]}{0.0306 [1.0132 - 0.015342]}$$

$$\mu = \frac{0.01507376}{0.028334454}$$

$\mu = 0.4936 \times 100$

$\mu = 49.36\%$
8. It is required to design an air conditioning plant for a small office room for following winter conditions.

Outdoor conditions = 14°C DBT and 10°C WBT

Required conditions = 20°C DBT and 60% R.H

Amount of air circulation 0.30 m³/min/person.

Seating capacity of office = 60

(1) Required condition is achieved first by heating and then by Adiabatic humidifying

Determine the following

(2) heating capacity of the coil in KW and the surface temperature required if the by pass factor of coil is 0.4.

Solution:

Step :1

Enthalpy (h₁) \(\rightarrow\) From Psychometric chart use WBT = 10°C

\[ h₁ = 29.5 \text{ KJ/Kg} \]

\[ V₁ = 0.825 \text{ m}³/\text{Kg} \]

Step :2

Enthalpy (h₂) \(\rightarrow\) From Psychometric chart use DBT = 20°C and 60% R.H

\[ H₂ = 42 \text{ KJ/Kg} \]

Step :3

Amount of dry air supplied (\(m_{a1}\))

\[ M_{a1} = \frac{\text{amount of air circulation (V)}}{V₁} \]

\[ M_{a1} = \frac{0.30 \times 60}{0.825 \times 60} \]

\[ M_{a1} = 0.363 \text{ Kg/sec} \]
Step :4

Capacity of heating coil = \( M_{a1} [h_2 - h_1] \)

\[
= 0.363 [42 - 29.5 ]
\]

\[
= 4.5375 \text{ KW}
\]

Step :5

By pass factor = \( \frac{t_s - t_{d2}}{t_s - t_{d1}} \)

\[
0.4 = \frac{ts - 20}{ts - 14}
\]

\[
0.4 [t_s - 14] = t_s - 20
\]

\[
0.4t_s - 5.6 = t_s - 20
\]

\[
0.4t_s - 14 - t_s + 20 = 0
\]

\[
-0.6t_s + 14.4 = 0
\]

\[
0.6t_s = 14.4
\]

\[
t_s = 14.4/0.6
\]

\[
t_s = 24^\circ C
\]

\[
t_s = 24^\circ C + 273
\]

\[
t_s = 297 K
\]

Step :6

Capacity of humidifier = \( M_{a1} [\omega_2 - \omega_1] \)

From Psychometric chart use \( t_{d2} = 20^\circ C \& 60\% \text{ RH} \rightarrow \omega_3 = 0.009 \)

WBT \( 10^\circ C \& 60\% \text{ RH} \rightarrow \omega_2 = 0.006 \)

Capacity of humidifier = \( M_{a1} [\omega_2 - \omega_1] \)

\[
= 0.363 [0.009 - 0.006 ]
\]
9. Saturated air at 20°C at a rate of 70 m³/min is mixed adiabatically with the outside air at 35°C and 50% relative humidity at a rate 30 m³/min. Assuming that the mixing process occurs at a pressure of 1 atm. Determine the specific humidity, the relative humidity, the dry bulb temp and the volume of flow rate of mixture.  

[AU DEC 2011]

**Given:**

Temp (T₁) = 20°C  
Volume (V₁) = 70 m³/min  
Temp (T₂) = 35°C  
Volume (V₂) = 30 m³/min  
Relative humidity (ϕ) = 50%  
Pressure (P₁) = 1 atm.

**To find:**

1. The specific humidity (ω),
2. The relative humidity (ϕ₃),
3. The dry bulb temp (t₁₃)
4. The volume of flow rate of mixture (Vₗ).

**Solution:**

Step : 1

\[ \text{Amount of dry air supplied (mₐ₁) = V/V₁} \]

Where,

From Psychometric chart use → T₁ = 20°C & ϕ = 50%
\[ V_1 = 0.85 \text{m}^3/\text{Kg} \]
\[ m_{a1} = V/V_1 \]
\[ m_{a1} = 70/0.85 \]
\[ m_{a1} = 82.35 \text{Kg/min} \]

Step :2

Amount of dry air supplied \( (m_{a2}) = V/V_2 \)

Where,

From Psychometric chart use \( \rightarrow T_2 = 35^\circ \text{C} \) & \( \phi = 50\% \)

\[ V_2 = 0.89 \text{m}^3/\text{Kg} \]
\[ m_{a2} = V/V_2 \]
\[ m_{a2} = 30/0.89 \]
\[ m_{a2} = 33.5 \text{Kg/min} \]

Step :3

From Psychometric chart use \( \rightarrow T_1 = 20^\circ \text{C} \) & \( \phi = 50\% \)

\[ h_1 = 57.5 \text{ KJ/Kg} \] & \( \omega_1 = 0.015 \text{ Kg/Kg of dry air} \)

From Psychometric chart use \( \rightarrow T_2 = 35^\circ \text{C} \) & \( \phi = 50\% \)

\[ h_2 = 81 \text{ KJ/Kg} \] & \( \omega_2 = \omega_3 = 0.018 \text{ Kg/Kg} \]

Step :4

\[ \frac{\omega_2 - \omega_3}{\omega_3 - \omega_1} = \frac{ma_1}{ma_2} \]
\[ \frac{\omega_2 - \omega_3}{\omega_3 - \omega_1} = \frac{82.5}{33.5} \]
\[
\frac{0.018 - \omega_3}{\omega_3 - 0.015} = 2.459
\]

0.018 - \omega_3 = 2.459(\omega_3 - 0.015)

0.018 - \omega_3 = 2.459\omega_3 - 0.036885

0.018 - 0.036885 = \omega_3 + 2.459\omega_3

0.054885 = 3.245\omega_3

0.054885/3.245 = \omega_3

\omega_3 = 0.0168 \text{ Kg/Kg of dry air}

**Step :5**

\[
\frac{h_2 - h_3}{h_3 - h_1} = \frac{V_1}{V_2}
\]

\[
\frac{h_2 - h_3}{h_3 - h_1} = \frac{70}{35}
\]

\[
\frac{81 - \omega_3}{\omega_3 - 57.5} = 2.3333
\]

81 - \omega_3 = 2.3333(\omega_3 - 57.5)

81 - \omega_3 = 2.3333\omega_3 - 134.16666

81 - 134.16666 = \omega_3 + 2.3333\omega_3

215.16666 = 3.3333\omega_3

215.16666/3.3333 = \omega_3

\omega_3 = 64.5506 \text{ Kg/Kg of dry air}

**Step :6**

From Psychometric chart use \( \rightarrow h_3 = 64.5506 \) & \( \omega_3 = 0.0168 \)

The relative humidity \( (\phi_3) = 80\% \)
The dry bulb temp \( t_{d3} \) = 24°C

\[ V_3 = 0.865 \text{m}^3/\text{Kg} \]

Step : 7

mass of air mixture \( (m_{a3}) = m_{a1} + m_{a2} \)

\[ = 82.5 + 33.5 \]

\[ m_{a3} = 115.85 \text{ Kg/min} \]

Step : 8

The volume of flow rate of mixture \( (V_m) = m_{a3} \times V_3 \)

\[ = 115.85 \times 0.865 \]

The volume of flow rate of mixture \( (V_m) = 100 \text{ m}^3/\text{min} \)
10. Two streams of moist air, one having flow rate of 3 Kg/sec at 30°C and 30% Relative humidity, other having flow rate of 2 Kg/sec at 35°C and 65% Relative humidity, get mixed adiabatically. Determine specific humidity and partial pressure of water vapour after mixing.

Given:

Mass \( m_1 \) = 3 Kg/sec

Mass \( m_2 \) = 2 Kg/sec

The relative humidity \( \phi_1 \) = 30%

The relative humidity \( \phi_2 \) = 65%

The dry bulb temp \( t_{d1} \) = 30°C

The dry bulb temp \( t_{d2} \) = 35°C

To find:

1. \( \omega_3 \)
2. \( P_w \)

Solution:

Step :1

From Psychometric chart use \( t_{d1} = 30°C \) & \( \phi_1 = 30% \)

\( \omega_1 = 0.008 \text{ Kg/Kg of dry air} \)

From Psychometric chart use \( t_{d2} = 35°C \) & \( \phi_2 = 65% \)

\( \omega_2 = 0.024 \text{ Kg/Kg of dry air} \)
Step :2

\[
\frac{m_1}{m_2} = \frac{\omega_3 - \omega_2}{\omega_1 - \omega_3}
\]

\[
\frac{3}{2} = \frac{\omega_3 - 0.024}{0.008 - \omega_3}
\]

\[
1.5 = \frac{\omega_3 - 0.024}{0.008 - \omega_3}
\]

\[
1.5[0.008 - \omega_3] = \omega_3 - 0.024
\]

\[
0.012 - 1.5\omega_3 = \omega_3 - 0.024
\]

\[
0.012 + 0.024 = \omega_3 + 1.5\omega_3
\]

\[
0.036 = 2.5\omega_3
\]

\[
\omega_3 = \frac{0.036}{2.5}
\]

\[
\omega_3 = 0.0144 \text{ Kg/Kg of dry air}
\]

Step :3

From Psychometric chart use \( \omega_3 = 0.0144 \text{ Kg/Kg of dry air} \)

Partial pressure of water vapour \( (P_w) = 16.5 \text{ mm of Hg} \)

Note,

\[
760 \text{ mm of Hg} = 1.013 \text{ bar}
\]

\[
16.5 \text{ mm of Hg} = (1.013/760) \times 16.5
\]

Partial pressure of water vapour \( (P_w) = 0.02199 \text{ bar} \)