Thermodynamics II	*Test no.2 Saturday 12 December 2009 Time 10:00-11:30*
เลขที่นั่งสอบ...Section.....ID....................Name.....Solution........................	

1. A 20x10x5 m^3 room contains air at 20°C and 98 kPa at a relative humidity of 85 percent. Calculate (a) the dew point of the air, (b) the mass of water and the mass of dry air, (c) the specific humidity of the air, and (d) the enthalpy per unit mass of dry air. (10 Marks)

System Air + water vapor

Assumption: Ideal gas.

20x10x5 m^3
$T = 20°C$
$\phi = 85\%$
$P = 98 kPa$

a) $T_{dp} = ?$
b) $m_a = ?$, $m_v = ?$
c) $\omega = ?$
d) $h = ?$

a) $T_{dp} = T_{sat} @ P_v$

$P_v = \phi P_g = 0.85(2.3390 \text{ kPa})$

$= 1.9882 \text{ kPa}$

Interporate: $T_{sat} = 13.03 + \frac{(1.9882-1.5)}{(2.0-1.5)} \times (17.5-13.03)$

$= 17.39°C$ Answer.

b) c) $m_a = \frac{P_a V}{R_a T} = \frac{(98-1.9882) \text{ kPa } (20\times10\times5) m^3}{(0.287 \text{ kJ/kgK})(293) K}$

$= 1,141.8$ kg Answer

$\omega = 0.622 \frac{P_v}{P-P_v} = \frac{0.622(1.9882) \text{ kPa}}{(98-1.9882) \text{ kPa}} = 0.01288 \frac{kg}{kgda}$ Ans

$m_v = \omega m_a = (0.01288 \frac{kg}{kgda})(1,141.8 \text{ kgda}) = 14.7$ kg Ans

d) $h = h_a + \omega h_v$

$h_a = C_{pa} T = (1.005 \frac{kJ}{kgK})(20) K = 20.10 \text{ kJ/kgda}$

$h_v = 2500.9 + C_{pw} T = 2500.9 + (1.82)(20) = 2537.3 \text{ kJ/kg}$

$h = (20.10 \frac{kJ}{kgda}) + (0.01288 \frac{kg}{kgda})(2537.3 \frac{kJ}{kg})$

$h = 52.78 \text{ kJ/kg da}$ Answer.

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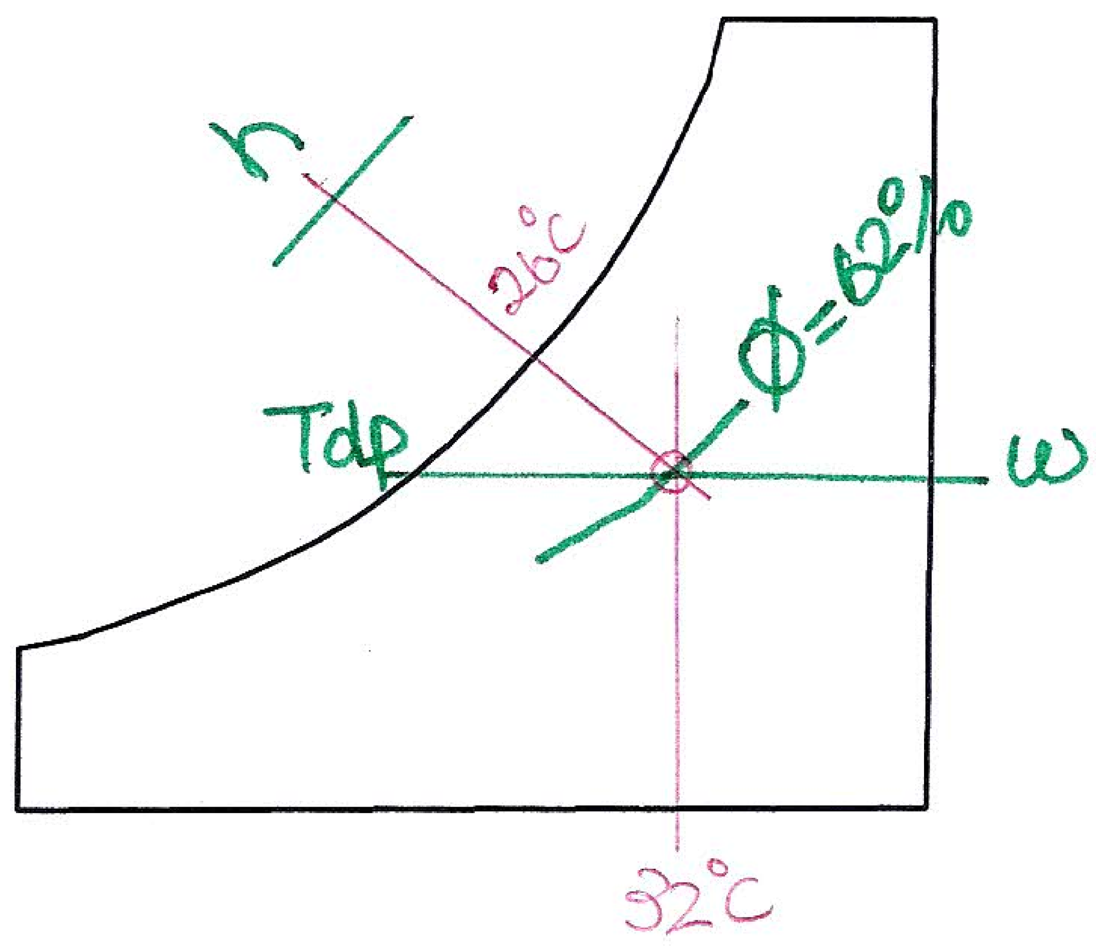
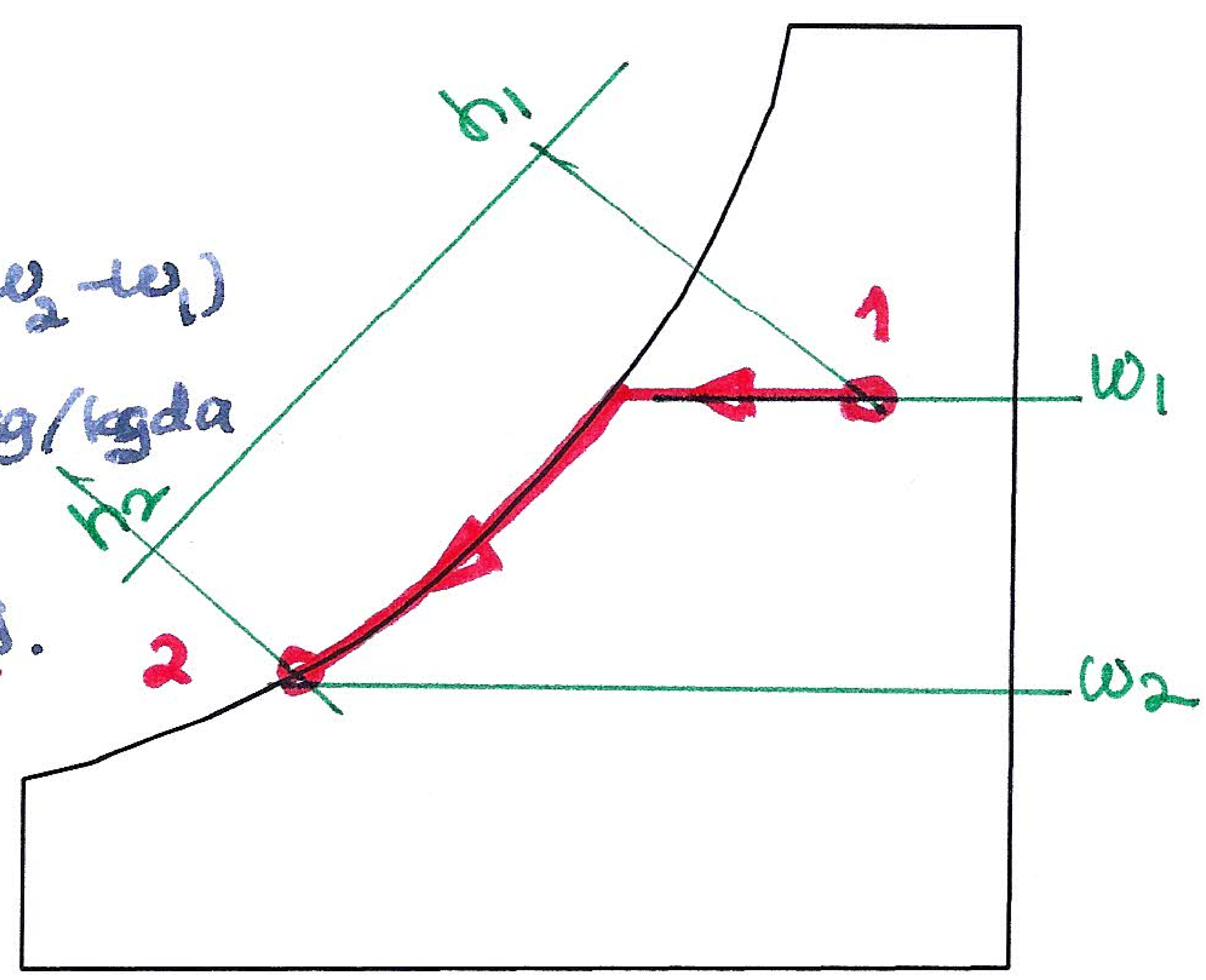
2) The air in a room has a pressure of 1 atm, a dry-bulb temperature of 32°C, and a wet-bulb temperature of 26°C. Using the psychrometric chart, determine (a) the specific humidity, (b) the enthalpy (in kJ/kg dry air), (c) the relative humidity, (d) the dew-point temperature. *(5 Marks)*

Answer	Value	Unit
(a) the specific humidity	0.019	kg/kgda
(b) the enthalpy	80.9	kJ/kgda
(c) the relative humidity	62	%
(d) the dew-point temperature	24	°C



3) The air in problem 2) was cooled by a cooling coil to 15°C. Using Psychrometric chart, (a) show the process occurred. (b) determine the amount of moisture removed per kg dry air, and (c) determine the amount of heat removed per kg dry air.

(10 marks)



b) Water mass balance

$m_{v_1} + m_w = m_{v_2}$

$m_w = (m_{v_2} - m_{v_1}) = m_a(\omega_2 - \omega_1)$

$= 1\ \text{kgda}(0.0107 - 0.019)\ \text{kg/kgda}$

$m_w = -0.0083\ \text{kg}$ (removed) Ans.

c) 1^{st} law: SSSF,

$Q + m_a h_1 = m_a h_2$

$Q = m_a(h_2 - h_1) = 1\ \text{kg}\ (42 - 80.9)\ \text{kJ/kgda}$

$= -38.9\ \text{kJ}.$

heat removed = 38.9 kJ Ans.

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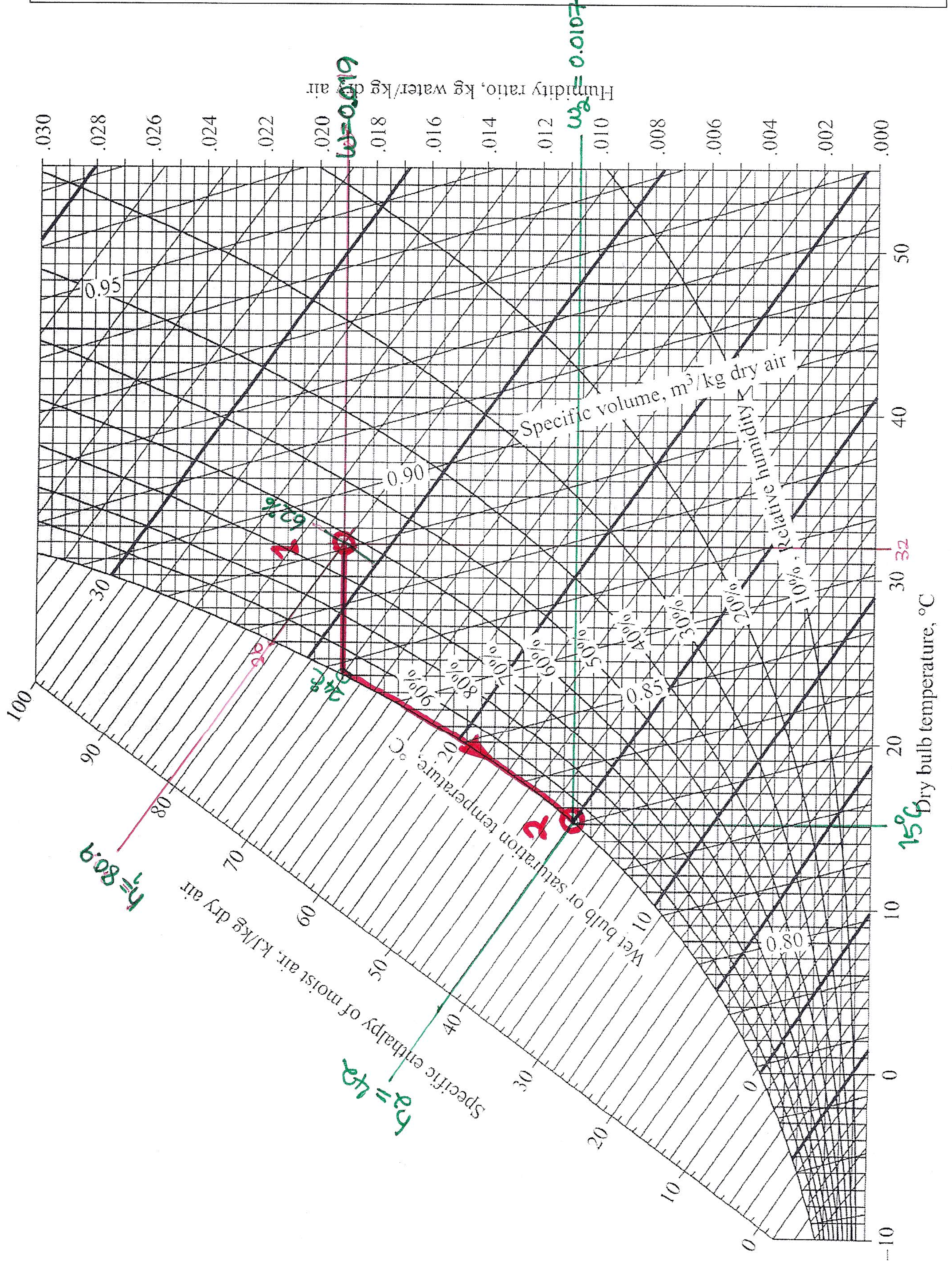

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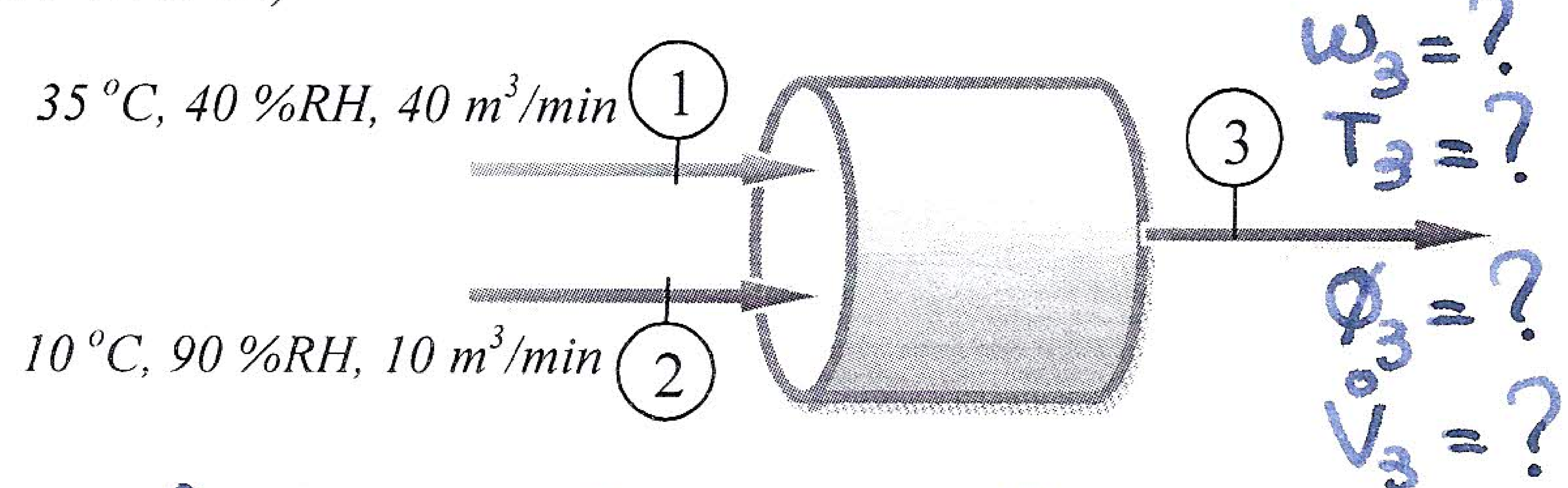
4) Two airstreams are mixed steadily and adiabatically. The first stream enters at 35°C and 40 percent relative humidity at a rate of 40 m^3/min, while the second stream enters at 10°C and 90 percent relative humidity at a rate of 10 m^3/min. Assuming that the mixing process occurs at a pressure of 100 kPa, determine (a) the specific humidity, (b)the dry-bulb temperature, (c) the relative humidity, and (d) *the* volume flow rate of the mixture. *(15 marks)*

System: Air mixing.

Assumption: Ideal Gas.



Solution.

a) Water mass balance: $\dot{m}_{a1}\omega_1 + \dot{m}_{a2}\omega_2 = (\dot{m}_{a1}+\dot{m}_{a2})\,\omega_3$ —(1)

State 1. 35°C, 40% RH, 40 m^3/min $\Rightarrow$ $P_g = 5.6280$ kPa

$$P_{v_1} = \phi P_g = 0.40 \times 5.6280 = 2.2512 \text{ kPa}$$

$$\omega_1 = 0.622\frac{P_{v1}}{(P-P_{v1})} = \frac{0.622\times 2.2512}{(100-2.2512)}$$

$$= 0.01432 \text{ kg/kgda.}$$

$$v_1 = \frac{R_a T_1}{P_{a1}} = \frac{(0.287\text{ kJ/kgK})(273+35)\text{K}}{(100-2.2512)\text{ kPa}}$$

$$= 0.9048 \text{ m}^3/\text{kg}$$

$$\dot{m}_{a1} = \frac{\dot{V}_1}{v_1} = \frac{40 \text{ m}^3/\text{min}}{0.9048 \text{ m}^3/\text{kg}} = 44.21 \text{ kg/min}$$

State 2 10°C, 90% RH, 10 m^3/min $\Rightarrow$ $P_g = 1.2276$ kPa.

(Calculate the same way as state 1)

$$\omega_2 = 0.00695 \text{ kg/kgda}$$

$$\dot{m}_{a2} = 12.17 \text{ kg/min.}$$

eqn(1) $\omega_3 = 0.01273$ Answer.

Prob. 4 cont.

b) 1^{st} law: SSSF, $\dot{Q}_{C.V.}=0$, $\dot{W}_{C.V.}=0$, neglect ΔKE, ΔPE

$$\dot{m}_{a1}h_1 + \dot{m}_{a2}h_2 = \dot{m}_{a3}h_3 \quad \text{—(2)}$$

$h_1 = h_{a1} + \omega_1 h_{v1} = C_{pa}T_1 + \omega_1 C_{pw}T_1$

$h_1 = 1.005(35) + (0.01432)(1.82\times35) = 71.91\ kJ/kgda$

$h_2 = \qquad\qquad = 27.55\ kJ/kgda$

eqn (3) $h_3 = 62.34\ kJ/kgda$

$h_3 = 1.005T_3 + \omega_3(1.82T_3)$

solve for T_3 yields $\quad T_3 = 29.66°C$ Answer

c) $\omega = 0.622\dfrac{P_v}{(P-P_a)}$ and $\phi = \dfrac{P_v}{P_g} = \dfrac{\omega(P-P_a)}{0.622P_g}$ —(3)

by interporation $P_{g_3} = 4.1726\ kPa$

$\phi_3 = 48.08\ \%$ Answer

$P_{v_3} = 2.006\ kPa$

d) $\dot{V}_3 = v_3\dot{m}_{a3}$

$$v_3 = \frac{R_aT_3}{P_{a3}} = \frac{(0.287)(273+29.66)}{(100-2.006)}$$

$$= 0.8869\ m^3/kgda$$

$$\dot{V}_3 = \left(0.8869\frac{m^3}{kgda}\right)\left(56.38\frac{kgda}{min}\right)$$

$$= 50.0\ \frac{m^3}{min}$$ Answer.

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