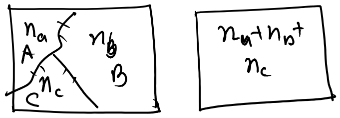
Super heated vapor at ambient temp. possible?
Yes if p_v is very low

$p = p_o$

$p_o = p_v + p_a$

$$\frac{n_v}{n_v + n_a} = \frac{p_v}{p_o}$$



$$\frac{p_A}{p} = \frac{n_a}{(n_a+n_b+n_c)}$$

$$\frac{p_B}{p} = \frac{n_b}{n_a+n_b+n_c}$$

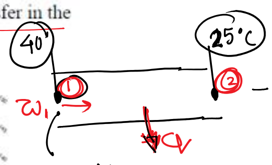
$$\frac{p_C}{p} = \frac{n_c}{n_a+n_b+n_c}$$

999 kmols of air
1 " " of H_2O

$$\frac{p_v}{p_o} = 10^{-3} \Rightarrow p_v = 10^{-3} \text{ bar}$$

A flow of moist air at 100 kPa, 40°C, and 40% relative humidity is cooled to ~~[illegible]~~ 25°C in a constant pressure device. Find the humidity ratio of the inlet and the exit flow and the heat transfer in the device per kilogram of dry air.

DP



$\phi = 40\%$

$$\omega_1 = \frac{0.622 \times 0.4 \times 0.07384}{(1 - 0.4 \times 0.07384)}$$

$= 0.0189 \ \frac{kg}{kg\ DA}$

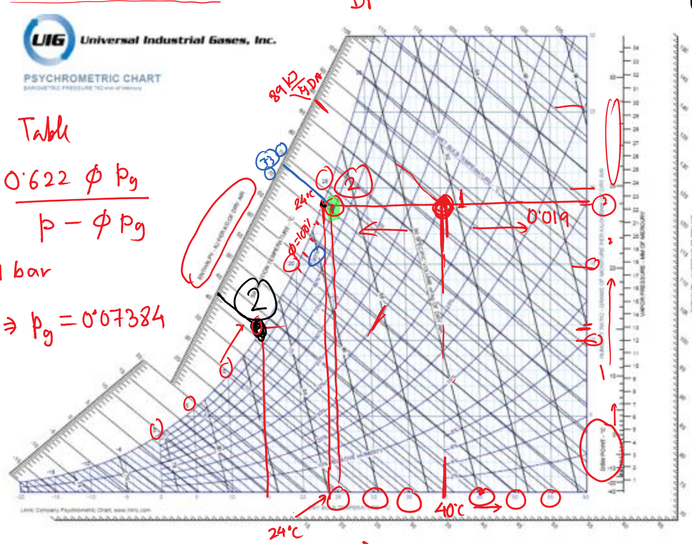
$\omega_{From\ PC} = 19 \times 10^{-3}$ "
$= 0.019$ "

Steam Table

$$\omega = \frac{0.622\ \phi\ p_g}{p - \phi\ p_g}$$

$p = 1$ bar

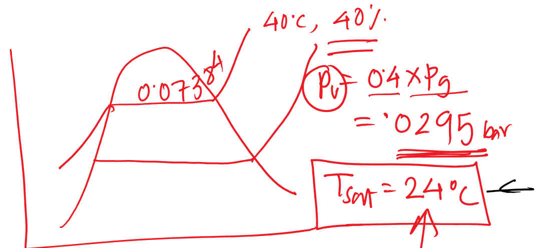
at 40°C ⇒ $p_g = 0.07384$



DBT

Dew point ⇒ Sole fn. of ω

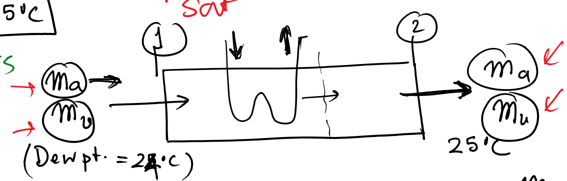
Dew point at 40° & 40% RH?



T_{sat}

Case 1 **outlet at 25°C**

Conservation of mass



$\phi = 91\%$

$\phi = 40\%$

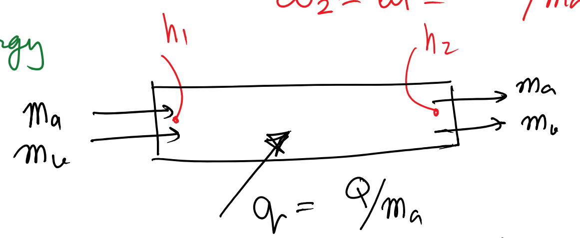
$m_{a1} = m_{a2} = m_a$

$m_{v1} = m_{v2} = m_v$

$\omega_2 = \omega_1 = m_v / m_a = 0.019$

$\frac{m_v}{m_a} = 0.019$ kg/kg DA

Conservation of Energy



$q = Q/m_a$

$\frac{dE}{dt} = \dot{Q} - \dot{W} + \dot{m}(h_1 - h_2)$

$\dot{Q} = \dot{m}(h_2 - h_1)$

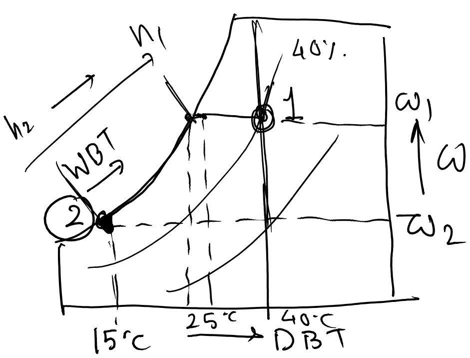
$h_1 = 89$ kJ/kg of DA

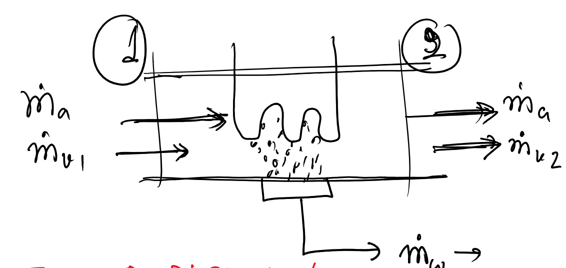
$h_2 = 73$ kJ/kg of DA

$\dot{Q} = \dot{m}_a (h_2 - h_1)$

$q = \dot{Q}/\dot{m}_a = (73 - 89) = -16$ kJ/kg DA

What if $T_2 = 15°C$?





$\omega_1 = 0.019$ kg/kg DA ✓

$\omega_2 = 0.0108$ kg/kg DA ✓

Mass Balance

D.A → $\dot{m}_{a1} = \dot{m}_{a2} = \dot{m}_a$

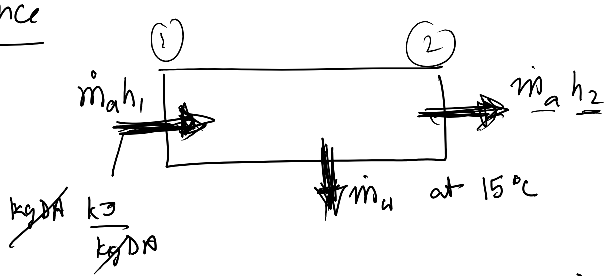
$\dot{m}_{v1} - \dot{m}_{v2} = \dot{m}_w$

$$\dot{m}_a(\omega_1 - \omega_2) = \dot{m}_w$$

$$\boxed{\omega_1 - \omega_2 = \dot{m}_w / \dot{m}_a}$$

$$(0.019 - 0.0108) = \boxed{0.0082 \text{ kg/kg DA}}$$

Energy Balance



$$\frac{dE}{dt} = \dot{Q} - \dot{W} + \dot{m}_a(h_1 - h_2) - \dot{m}_w h_w$$

$$\dot{Q} = \dot{m}_a(h_2 - h_1) - \dot{m}_a(\omega_1 - \omega_2) h_w$$

$$q = \dot{Q}/\dot{m}_a = \left[(h_2 - h_1) - (\omega_1 - \omega_2) h_w\right] = (42 - 89) - (0.0082)\, h_{f@15°C} = -47 - 0.5166 = -47.5166 \text{ kJ/kg DA}$$

$h_{f@15°C} \rightarrow 62.99$ kJ/kg

To improve RH from this condition :

Sensible Heating ⇒