* Air Conditioning *

Air conditioning :- it is the process of simuteneous contool of temp., humidity, Velocity and purity of Air.

Psychrometry :- it is the branch of Science which deals with the properties of moist air.

→ Moist air is considered as two component hence three variables are required for our study. We have fixed total pressure equal to 1 atm therefore we are able to draw psychrometry chart in 2-D.

		v	mas.
Dry air	O_2	21%	23%
	N_2	79%	77%

Moist air → Dry air, Water Vapour

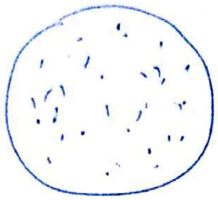
* $P + F = C + 2$

$1 + F = 2 + 2 \Rightarrow F = 3$

$P_t = P_{vap} + P_{air}$

$P_{total} = 1\ atm$ (const.)

Psychrometric Properties :-



P_t, V
T, P_a, P_v
m_v, m_a

$$P_v V = m_v R_v T \quad -(1)$$

$$P_a V = m_a R_a T \quad -(2)$$

(1) Specific humidity / humidity Ratio / Absolute humidity (ω)

$$\omega = \frac{m_v}{m_a}$$

~~mass of water vapour in moist air~~

From eqn (1) & (2)

$$\frac{P_v}{P_a} = \frac{m_v}{m_a} \times \frac{R_v}{R_a} \qquad R_v \rightarrow \bar{R}/18, \quad R_a \rightarrow \frac{\bar{R}}{29}$$

$$\frac{P_v}{P_a} = \frac{m_v}{m_a} \times \frac{29}{18}$$

* mass of water vapour present in moist air per kg of dry air

$$\therefore \frac{m_v}{m_a} = \frac{18}{29} \frac{P_v}{P_a}$$

*
$$\boxed{\omega = 0.622 \frac{P_v}{P_t - P_v}} \quad \text{kg v / kg dry air}$$

m_t = H/W

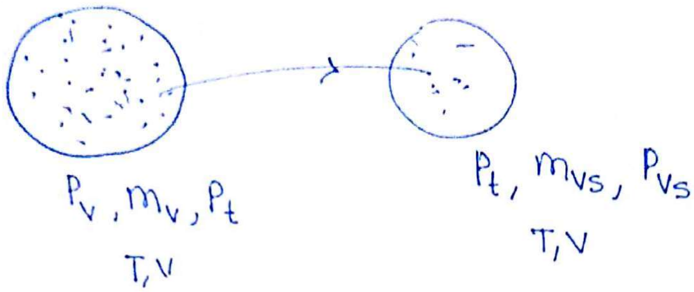
$$m_t = m_v + m_a$$

$$\frac{m_t}{m_a} = \frac{m_v}{m_a} + 1$$

$$\frac{m_t}{m_a} = \omega + 1$$

*
$$\boxed{m_a = \frac{m_t}{\omega + 1}}$$

② Relative humidity :- (ϕ)



$$P_v V = m_v R_v T \quad -①$$

$$P_{vs} V = m_{vs} R_v T \quad -②$$

①/②

$$\frac{P_v}{P_{vs}} = \frac{m_v}{m_{vs}}$$

*

$$\boxed{\phi = \frac{P_v}{P_{vs}} = \frac{m_v}{m_{vs}}}$$ → V saturated V.

* Relative humidity represent vapour absorption capacity whereas specific humidity represent the actual mass of vapour.
* If the relative humidity is 100% air is called as saturated air

③ Dry bulb temp. (DBT) :- It is the normal temp. measured by an ordinary thermometer.

③

④ Wet bulb temp :-(WBT) :-

it is the minimum temp. achieved by a wet cloth due to evaporation of water.

→ it is the temp. measured by a thermometer whose tip is covered with wet cloth.

→ it is the temp. upto which air can be cooled in desert cooler.

→ It is the temp. upto which water can be cooled in cooling towers

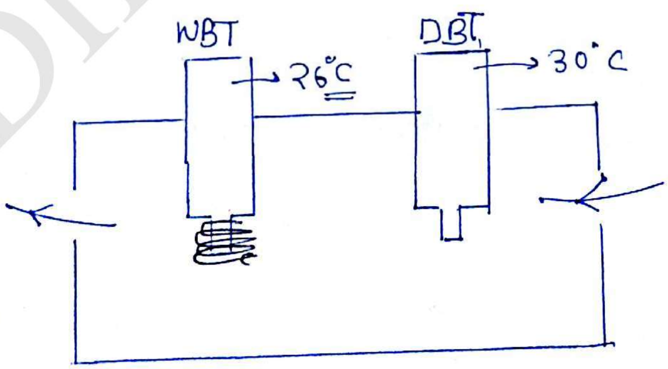
→ It is the minimum temp upto which water can be cooled earth & pot.

→ Wet bulb depression (WBD) = DBT − WBT

$$\boxed{WBD = DBT - WBT}$$

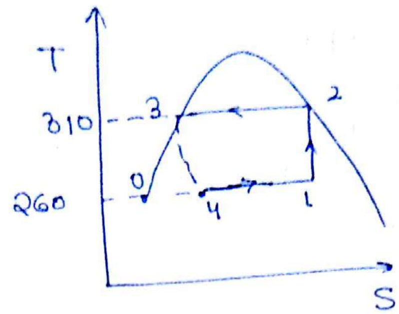
→ Use of desert coolar is benifecial if the WBD is high.

→ For saturated air $\boxed{DBT = WBT}$



Q 1.17 Gate book

P- 411



@ 310 LH = 1054

$C_{liq} = 4.8$

$h_1 - h_0 = ?$

$$\frac{h_1 - h_0}{260} = s_1 - s_0$$

$$s_2 - s_3 = \frac{h_2 - h_3}{310} = \frac{1054}{310} \quad -(1)$$

$$s_3 - s_0 = C_{p_l} \log \frac{T_f}{T_i} = 4.8 \ln \frac{310}{260}$$

$$s_3 - s_0 = 4.8 \ln \frac{310}{260} \quad -(2)$$

(1) + (2)

$$s_2 - s_0 = 4.8 \ln \frac{310}{260} + \frac{1054}{310}$$

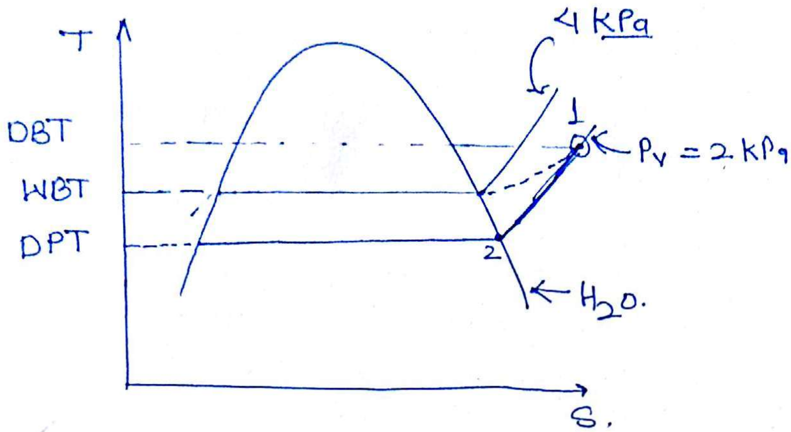
$s_1 = s_2$

$$s_1 - s_0 = 4.8 \ln \frac{310}{260} + \frac{1054}{310} = \frac{h_1 - h_0}{260}$$

$$h_1 - h_0 = 260 \left\{ 4.8 \ln \frac{310}{260} + \frac{1054}{310} \right\}$$

$$h_1 - h_0 = 1103.51 \text{ KJ/kg.}$$

(5) Dew point temprature :-



{ unsaturated :- DBT > WBT > DPT
{ saturated :- DBT = WBT = DPT

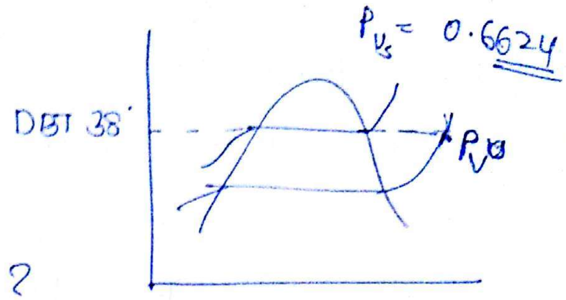
- Dew point temp. is the temp. of air at which water vapour present in the air starts condensing when cooled at constant pressure

→ Air is saturated means water vapour is present in air is saturated.

→ Air is unsaturated means water vapour is present in the air is superheated.

⇒ Saturation pressure corresponding to dew point temp. is the partial pressure of vapour in air at DBT conditions.

Q.23
P.g.58



$P_s = 0.6624$ bar

$P_{atm} = 1$ bar.

$\omega = ?$

$\phi = 72\%$

$0.72 \rightarrow \phi = \frac{m_v}{m_t} = \frac{P_v}{P_{vs}} \leftarrow 0.6624$ $\quad P_v = 0.47692$

$\omega = 0.622 \frac{P_v}{P_t - P_v}$

$\omega = 0.622 \frac{0.47692}{1 - 0.4762}$

$\omega = 0.56712$ kg/kg da $= 567.12$ gv/kg da

Q.24

$\omega = 0.01$

$m_i = 10.1$ kg/s. $\quad m_2 = 0.1$ kg/s.

$0.01 = 0.622 \frac{P_v}{P_t - P_v}$

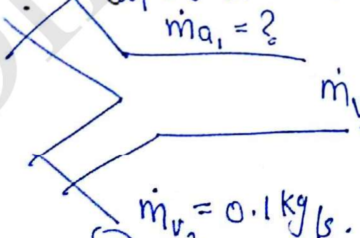
$0.0160(P_t - P_v) = P_v$

$0.0160 = (1+0.016) P_v$

$P_v = 0.01582$

~~$\omega = \frac{\dot{m}_1\omega_1 + \dot{m}_2\omega_2}{\dot{m}_1 + \dot{m}_2}$~~

① $m_{t_1} = 10.1$
$\omega_1 = 0.01$ $\quad \dot{m}v_1 = ?$
$\dot{m}a_1 = ?$



$\dot{m}_{v_3} = \dot{m}v_1 + \dot{m}v_2$

② $\dot{m}_{v_2} = 0.1$ kg/s.

$\frac{\dot{m}_t}{1+\omega} = \dot{m}_{a_1}$

$\dot{m}_{a_1} = \frac{10.1}{1.01} = 10$ kg d.a/se.

$\dot{m}v_1 = 0.1$

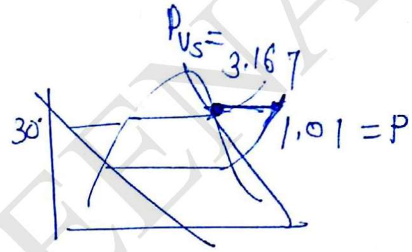
$\dot{m}_{v_3} = 0.1 + 0.1$

$\dot{m}_{a_3} = 10 = \dot{m}_{a_1}$ $\quad \omega_3 = \frac{\dot{m}_{v_3}}{\dot{m}_{v_1}} = \frac{0.2}{10} = 0.02$

Ques Moist air at 1.013 bar & 30°c Contains 10 g of water vapour per kg of dry air. Saturation pressure of water vapour at 30° is 3.167 KPa find relative humidity of moist air

⇒ $\omega = ?$

$\omega = 0.1$ $\qquad \dot{m}_v = 10\,g\,v / kg\,dr.$



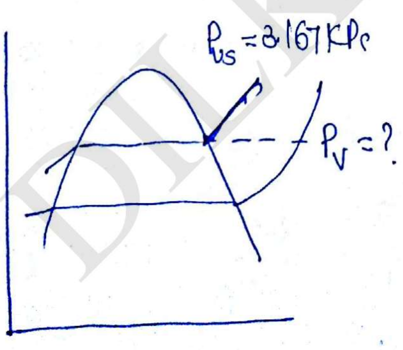
$P_{st} = 3.16$

$$\omega = 0.622 \frac{P_v}{P_t - P_v}$$

$$\omega = 0.622 \frac{P_v}{P_t - P_v} = 0.01$$

$$0.622 \times \frac{P_v}{1.013 - P_v} = 0.01 \Rightarrow P_v = 1.6028$$

$$\omega = 10 \times 10^{-3} = 0.01 = 0.622 \frac{P_v}{P_t - P_v}$$



$P_t = 1.013$

$$0.01 = 0.622 \frac{P_v}{1.013 - P_v}$$

$P_v = 1.6028$

$$\phi = \frac{P_v}{P_{vs}} = \frac{1.6028}{3.167} \times 100 = 50.61\%$$

Q. Atmospheric air at 100 kPa & 30°C has a relative humidity of 70 %. the saturation pressure of vapour at 30°C is 4.25 kPa then find the partial pressure of dry air

S/n

$$\phi = \frac{P_v}{P_{vs}} = 0.70$$

$$P_v = 0.70 \times 4.25 = 2.975$$

$$P_t = P_v + P_a$$

$$P_a = 100 - 2.975$$

$$= 97.025$$

Enthalpy of Moist Air:—

Moist air

$$H = H_a + H_v$$

$$H = m_a h_a + m_v h_v \quad \text{— (A)}$$

dry air

$$dh_a = C_{Pa}\, dt$$

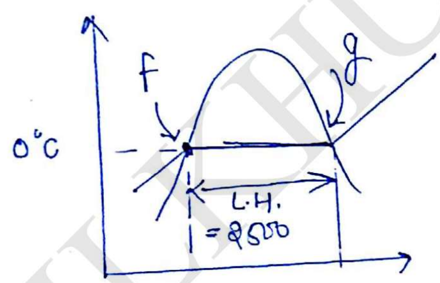
at $t = 0^\circ C$ let $h_a = 0$

$t = t^\circ C$ let $h_a = h_a$

$$(h_a - 0) = C_{Pa}(t - 0)$$

$$\boxed{h_a = C_{Pa}\, t}\ ,\ t \text{ is in } ^\circ C$$

water vapour



at $0^\circ C$, $h_f = 0$

$$h_v = 2500 + C_{Pv}(t - 0)$$

$$h_v = 2500 + 1.88t$$

from (A)

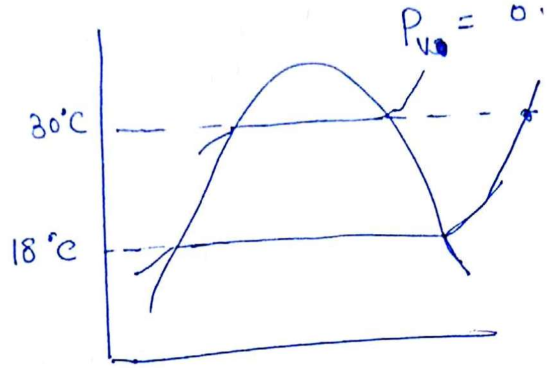
$$H = m_a \times C_{Pa} t + m_v(2500 + 1.88t)$$

$$h = \frac{H}{m_a} = 1.005t + \frac{m_v}{m_a}(2500 + 1.88t)$$

$$h = 1.005\,t + \omega(2500 + 1.88\,t) \ \ kJ/kg\ d.a.$$

$m_a = 1$
$m_v = \omega$

Q.2



$P_a = 1.013$ bar.
$P_v = 0.02062$

$$\omega = 0.622 \frac{\times 0.02062}{1.013 - 0.02062}$$

$$\omega = 0.01291$$

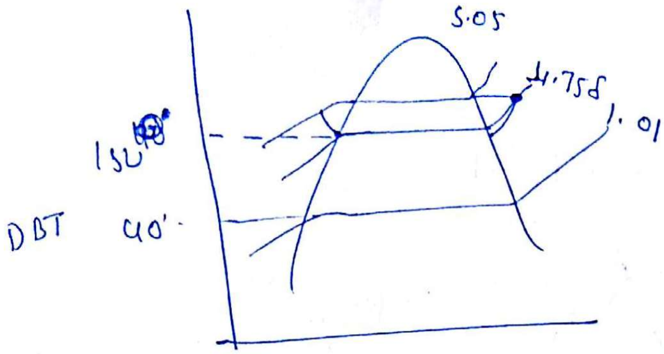
$$h = 1.005\,t + 0.0129(2500 + 1.88\,t)$$

$$= 1.005 \times 30 + 0.0129(2500 + 1.88 \times 30)$$

$$h = 63.159$$

Q.20

$$\phi = 0.50 = \frac{P_v}{P_{vs}}$$



$P_{sat}|_{150} = 7.38$ kPa

$P_{sat}|_{40} = 4.758$

$$\phi = \frac{P_v}{P_{vs}} = 0.50$$

$P_v = ~~40~~ \; 0.50 \times ~~4.758~~ \; 7.38$

$P_v = ~~2.379~~ \; 3.69$ kPa

~~2.379~~

$\omega = 0.622$ ————

$$\omega = \left(0.622 \times \frac{3.69}{101 - 3.69}\right) \times 1000$$

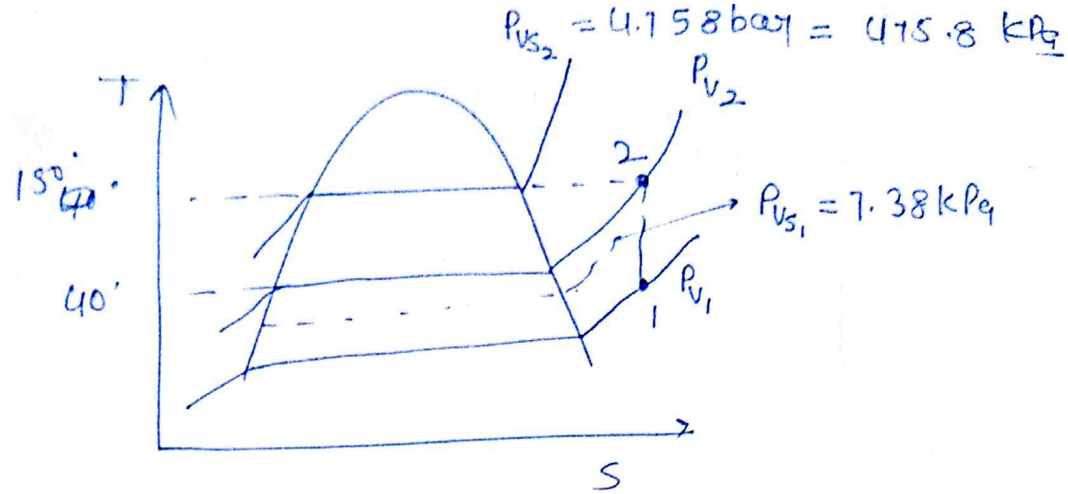
$\omega = \underline{23.58}$ g/kg da

$P_{vs} = 4.758$ bar.

~~$\omega = 0.622 \frac{P_v}{5.05 - P_v} = 0.236$~~

~~$P_v = 0.316$~~

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



$$0.5 = \phi_1 = \frac{P_{v_1}}{P_{vs_1}} = \frac{P_v}{7.38}$$

$$P_v = 3.69\ kPa$$

$$\omega_1 = 0.622\ \frac{P_{v_1}}{P_{t_1} - P_{v_1}} = 0.622\,\frac{\times 3.69}{101 - 3.69}$$

$$\omega_1 = 23.6 \times 10^{-3}\ kgv/kg\,da$$

$$\frac{P_{t_2}}{P_{t_1}} = \frac{P_{v_2}}{P_{v_1}} \Rightarrow \frac{505}{101} = \frac{P_{v_2}}{3.69}$$

$$P_{v_2} = 18.48\ kPa.$$

$$\phi_2 = \frac{P_{v_2}}{P_{vs_2}} = \frac{18.48}{475.8} = 0.0369$$

$$\phi_2 = 0.0388$$

$$\phi_2 = 3.9\%$$

Degree of saturation:- (μ)
Percent humidity

$$\mu = \frac{W}{W_s} = \frac{0.622 \frac{P_v}{P_t - P_v}}{0.622 \frac{P_{vs}}{P_t - P_{vs}}}$$

$$\therefore \quad \mu = \frac{P_v}{P_{vs}} \left(\frac{P_t - P_{vs}}{P_t - P_v} \right)$$

$$\mu = \phi \left(\frac{P_t - P_{vs}}{P_t - P_v} \right)$$

* Ap John Formula :-

$$P_v = P_{v'} - \frac{1.8\, P(t - t')}{2700}$$

- P_v = Partial pressure of vap.
- $P_{v'}$ = Sat. pressure corresponding to WBT
- P = total pressure
- t = DBT
- t' = WBT.

- Alignment circle is a pt on psychrometric chart
  DBT = 26°C
  ϕ = 50%

CP. 6 WB

Q.1 Pg. 57

$$\mu = \frac{P_v}{P_{vs}}\left(\frac{P_t - P_{vs}}{P_t - P_v}\right)$$

$$0.24 = \frac{P_v}{4}\left(\frac{100 - 4}{100 - P_v}\right)$$

$$0.24 \times 4\,(100 - P_v) = P_v \times 96$$

$P_v = 0.990$ ~~$\frac{120}{97.2} = P_v = 1.230\ kPa$~~

$$\phi = \frac{P_v}{P_{vs}} = \frac{0.990}{4} \times 100$$

$$\phi = 24.75$$

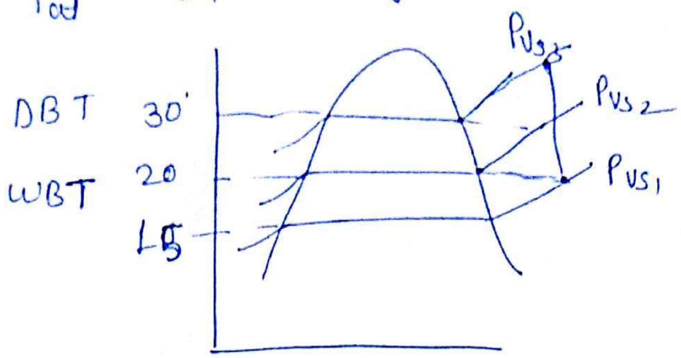
$$\omega = 0.622\,\frac{P_v}{P_t - P_v}$$

$$\omega = 0.622\,\frac{1}{99}$$

$$\omega = 0.0062$$

Q 26

$P_{at} = 740$ mm Hg. =



$P_{vs_3} = 0.04242$

$P_{vsg} = 0.02337$

$P_{vs_1} = 0.01679$

$P = 740$ mm of Hg

$760 \rightarrow 1.013$

$740 = \frac{1.013}{760} \times 740$

$P = 0.9869$ bc

(i) $P_v = P_v' - \frac{1.8\,P\,(t - t')}{2700}$

$P_v = 0.02337 - \frac{1.8 \times 0.9869\,(30-20)}{2700}$

$P_v = 0.01679$ $\quad$ DPT = 15 °C

(ii) $\omega = 0.622 \times \frac{0.01679}{0.9869 - 0.01679}$

$\omega = 0.01077$

(iii) $RH = \phi = \frac{P_v}{P_{vs}|_{at\ DBT}} = \frac{0.01679}{0.04242} = 39.5\%$

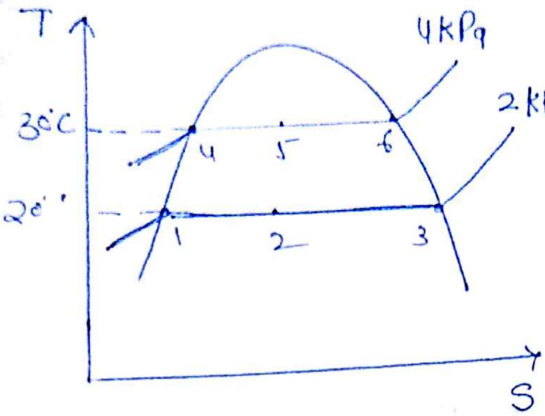
(iv) $P_v V = m_v R T$

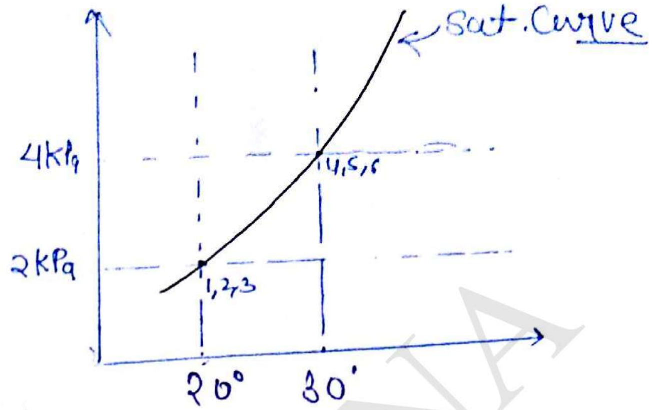
$P_v = \rho R T$

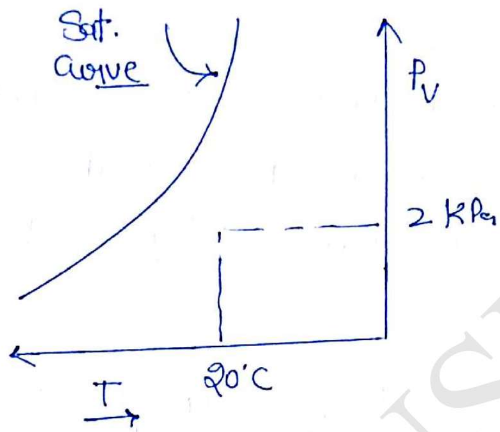
$\rho = \frac{P_v}{RT} = \frac{0.01679 \times 100 \text{ kPa}}{\frac{8.314}{18} \times 303}$

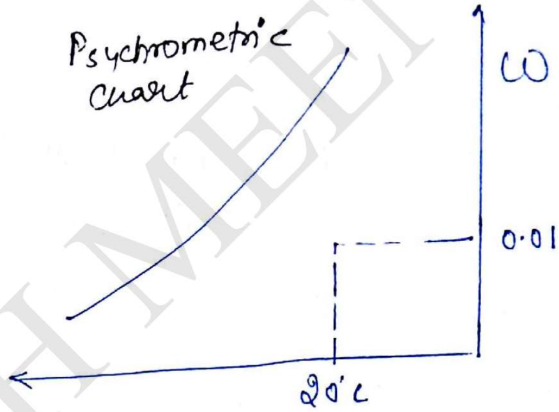
$\rho = 0.0119$ kg/m³

Development of Psychrometric chart :-









$$\omega = 0.622 \frac{P_v}{P_t - P_v} = \underline{\underline{f(P_v)}}$$

(P_t : let 1 atm)

ω @ $P_v = 2$ KPa let $\underline{\underline{0.01}}$

* humidity Ratio is the function of $\underline{\underline{P_v}}$

29 30/11

(25)

$\phi = 60\% = \dfrac{P_v}{P_{vs}}$

$P_{atm} = 0.1\ MPa = 0.1 \times 10^6\ Pa = 100\ kPa$

$P_v = 0.60 \times 5.63$

$\omega = 0.622 \times \left(\dfrac{0.60 \times 5.63}{100 - 0.60 \times 5.63}\right) \times 1000$

$\omega = 21.24$ gram/kg dry A

Ques if the volume of moist air with 50% relative humidity is isothermally reduced to half of the orgional val the relative humidity of moist air will become?

Sol^n

$\phi = 0.50 = \dfrac{P_{v_1}}{P_{vs}}$

$P_{v_1} V_1 = m R_{v_1} T$

$P_{v_1} = \dfrac{m R_{v_1} T}{V_1}$

$P_{vs} = \dfrac{P_{v_1}}{0.5}$

$V_2 = \dfrac{V_1}{2}$

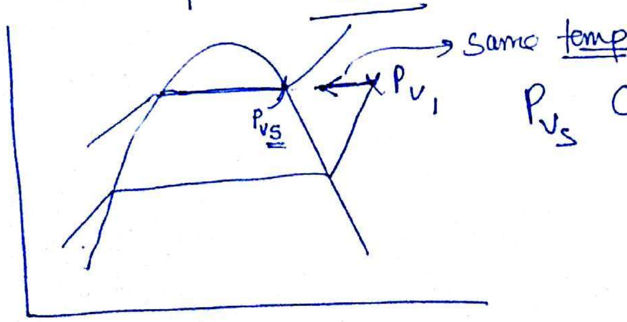
$P_{v_2} = 2\left(\dfrac{m R_v T}{V_1}\right)$

Now

$\phi = \dfrac{2 P_{v_1}}{P_{v_1}/0.5}$

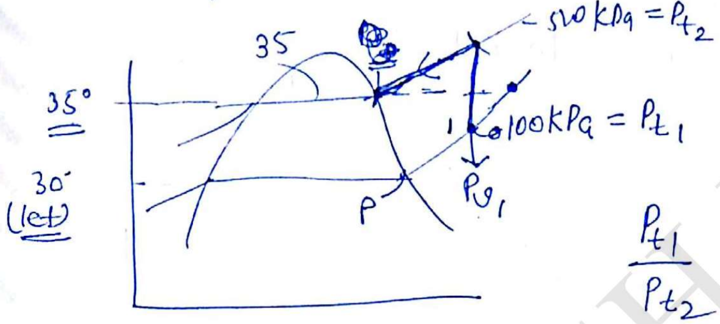
$P_{v_2} = 2 P_{v_1}$

$\phi = 100\%$



P_{vs} cost. (isothermaly)

Q Moist air at a pressure of 100 kPa is compressed to 500 kPa and then cooled to 35°C in a cooler at const. pressure (there is no condensation) the air at the entry to the cooler is unsaturated and becomes just saturate at the exit of cooler. The saturation pressure of vapour at 35°C is 5.628 kPa, find partial pressure of vapour in moist air entering the compressor



$$P_{vs}\big)_{35} = 5.628$$

$$\frac{P_{t_1}}{P_{t_2}} = \frac{P_{v_1}}{P_{v_2}}$$

$$\frac{100}{510} = \frac{P_{v_1}}{5.625}$$

$$P_{v_1} = 1.1256 \text{ kPa}$$

$P_{t_1} = 100$ kPa

$P_{v_1} = ?$

$P_{t_2} = 510$ kPa

$P_{v_2} = 5.625$

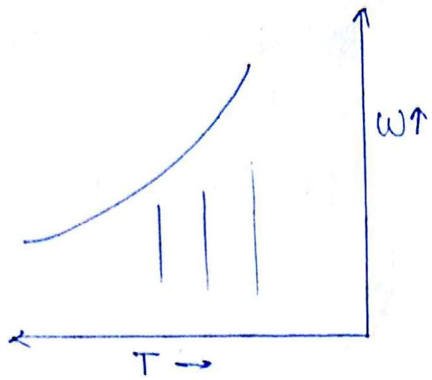
$P_{t_3} = 510$ kPa ; 35°C

$\phi_3 = 1$

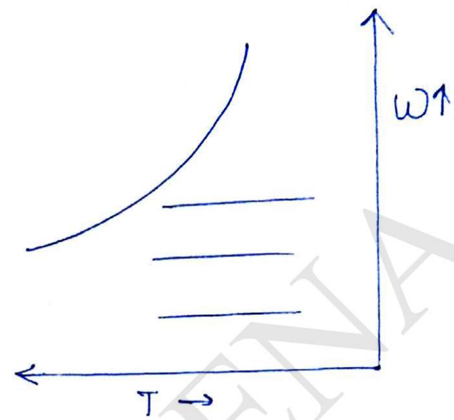
$P_{v_3} = P_{vs_3} = 5.628$ kPa

Various lines on Psychrometric chart:-

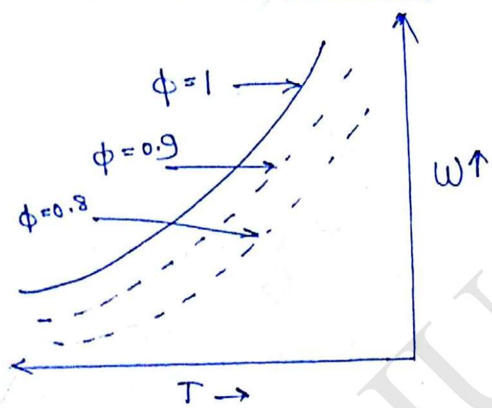
① Constant DBT lines



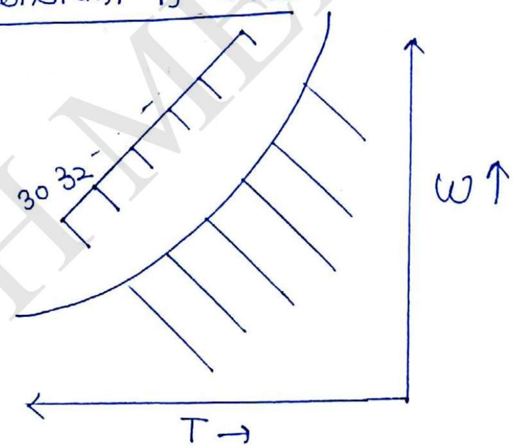
② Constant 'ω' lines



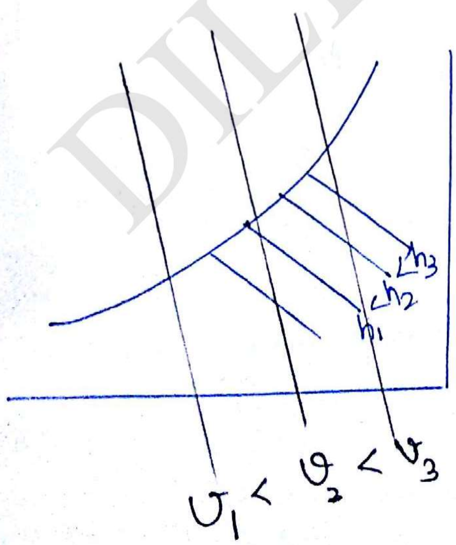
③ Constant R.H.(φ) lines



④ Constant 'h' lines



⑤ Const 'v' lines:



Specific Vol.

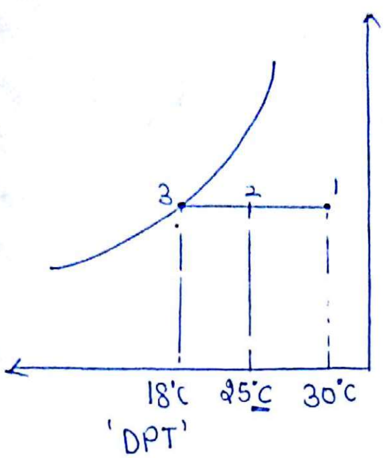
$$v = \frac{V}{m_a} \left(\frac{m^3}{kg\,d.a} \right)$$

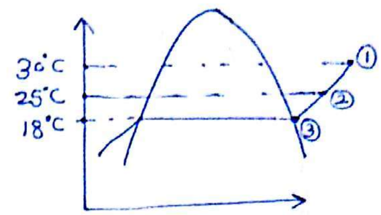
$$m_a = \frac{V}{v}$$

↓

dry air mass remain same

⑥ Constant 'DPT' lines





→ if 'P_v' is same, 'DPT' is same

→ $\omega = f(P_v \text{ only})$

if 'P_v' is same

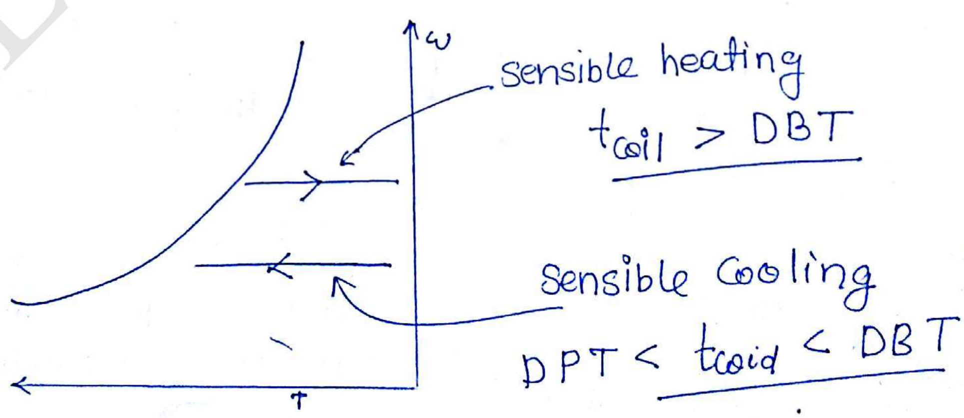
∴ ω is same

* Constant DPT lines follow constant 'ω' line and are Horizontal lines on psychrometric chart.

⑦ WBT line: Though there is slight deviation between Constant WBT lines and constant enthalpy lines but for all practicles purposes these lines are taken to be same.

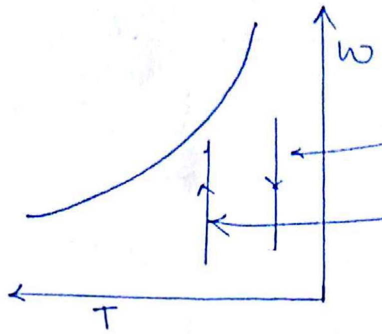
Various processes on psychrometric chart:-

① Sensible Cooling & sensible Heating:-

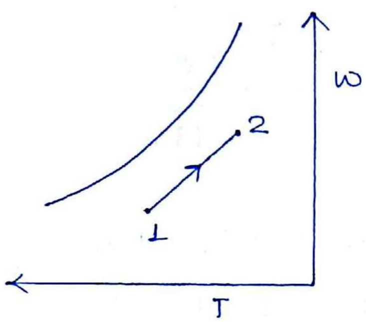


The process followed in the electrical room heater is sensible heating

② Humidification & Dehumidification :-

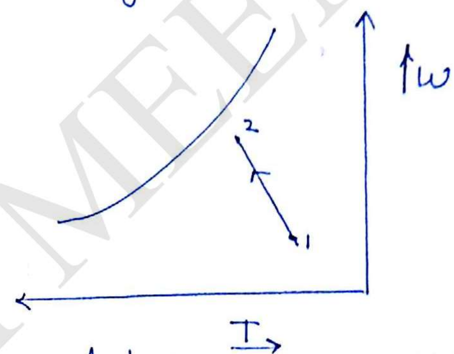


③ Heating and Humidification :-



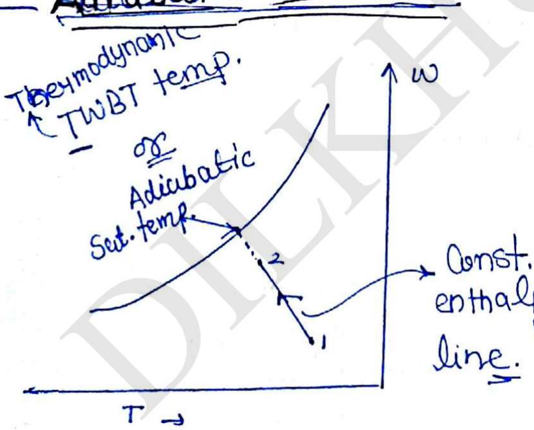
eg: steam spray in air

④ Cooling & humidification



eg:- Desert coolar follow adiabatic saturation process.

Imp Adiabatic saturation :-



⇒ if cooling and humidification occurs when air intract with water in the absence of a cooling coil then the process is called Adiabatic Saturation.

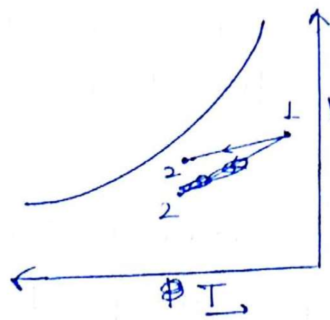
⇒ Adiabatic saturation lines are isenthalpic lines and also const. WBT lines.

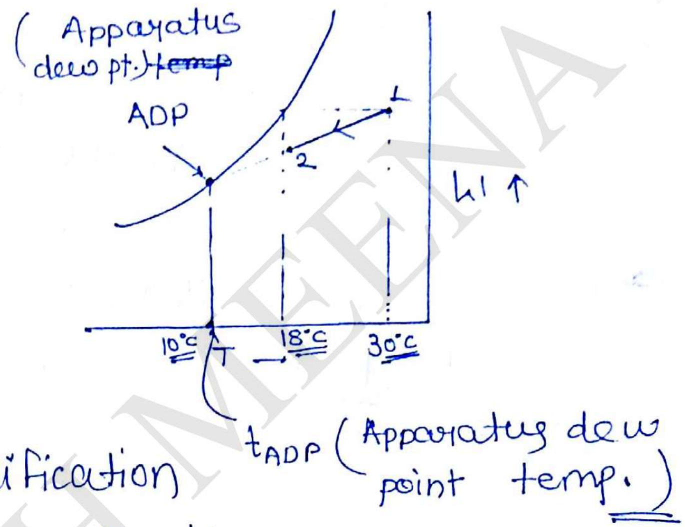
⇒ Temp. Corresponding to the point where adiabatic sat. line when produced intersects the saturation curve is called Thermodynamic wet bulb temp (TWBT) or adiabatic sat. temp.

→ TWBT is a property of the air whereas WBT is not the property of the air.

⇒ * $\boxed{TWBT \leq WBT}$

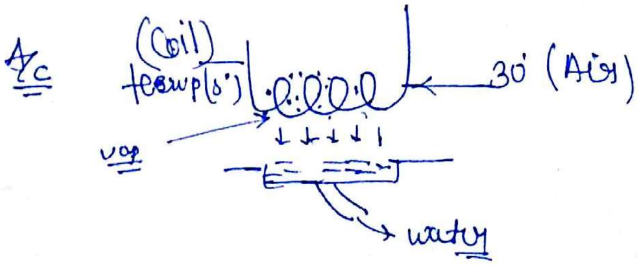
⑤ Cooling and dehumidification:-



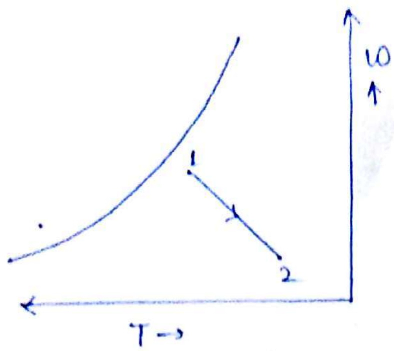


→ The cooling and dehumidification lines when produced intersects the saturation curve at the point called as apparatus due point. The temp. corresponding to this point is the temp of the cooling coil. called as apparatus dew point temp

→ The process followed in summer A/c is Cooling and dehumidification.



(6) Heating and dehumidification:-



This process is carried out with the help of chemicals like alumina (Al_2O_3). These chemicals absorbe water vapour from the air and ~~vap~~ water vapour while leaving the air, condenses and reject latent heat of condensation in the air, hence the temp of air increases.

→ This process is called as adiabatic chemical dehumidification and enthalpy of air remain const during the process.

Ques 5 gram of W. vapour per kg of dry air from atmospheric air is removed and temp of air after removing water vapour become 25 °C. Find

(i) Relative humidity & enthalpy of air after removal of moisture

(2) Cooling load on the cooling coil.

Sol Assume the atmospheric condition are 35 °C DBT and $\phi = 60\%$. Take the mass flow rate of air to 5 kg/per sec. (dry air basis) and condenset leaving the coil at 25 °C

Soln ~~ω = 5/100~~

t (°C)	P_{vs} (bar)
35	0.05733
25	0.03229

Solⁿ

$$\omega = \frac{5}{1000} = 0.005$$

$$\omega = 0.622 \frac{P_v}{P_t - P_v}$$

$$\omega = 0.622 \frac{P_v}{1.013 - P_v} = 0.005$$

$$P_v = 8.07 \times 10^{-3} \text{ bar.}$$

$$P_v = 8.07 \text{ KPa}$$

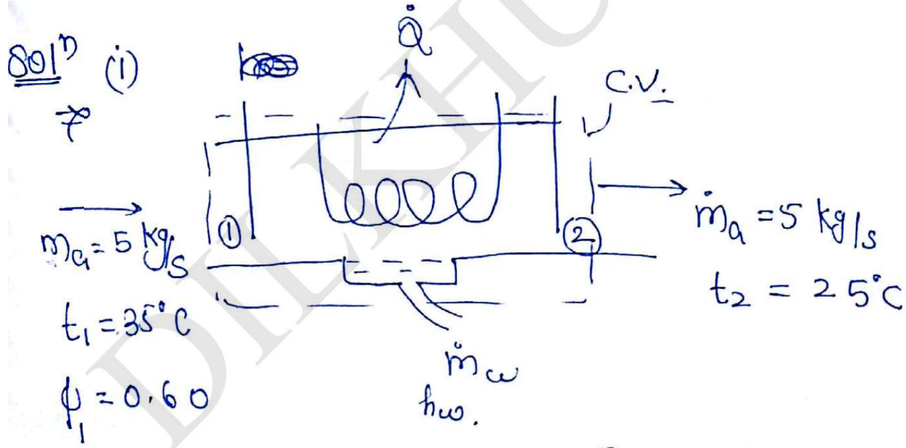
$$\phi = \frac{P_v}{P_{vs}} =$$

$$\phi = \frac{8.07 \times 10^{-3}}{~~0.05733~~ \; 0.03229} = 25.01$$

~~$\phi = 14.09$ %.~~ $\phi = 25.01$ %.

$$h = 1.005\, t + \omega(2500 + 1.88\, t)$$

Solⁿ (i)



$$\phi_1 = 0.60 = \frac{P_{v_1}}{P_{vs_1}} = \frac{P_{v_1}}{0.05733}$$

$$P_{v_1} = 0.03439.$$

$$w_1 = 0.622 \frac{P_{v_1}}{P'_{t_1} - P_{v_1}}$$

$$w_1 = 0.622 \frac{(0.03439)}{1.013 - 0.03439}$$

$$w_1 = 21.86 \times 10^{-3} \text{ kgv/kg da.}$$

$$h_1 = 1.005 \times t_1 + w_1 (2500 + 1.88 t_1)$$

$$= 1.005 \times 35° + 21.86 \times 10^{-2} (2500 + 1.88 \times 35)$$

$$h_1 = 91.36 \text{ kJ/kg d}$$

Now $w_2 = w_1 - w$ → removed

$$w_2 = 21.86 \times 10^{-3} - 5 \times 10^{-3}$$

$$w_2 = 16.86 \times 10^{-3} \text{ kgv/kg d.a.}$$

$$h_2 = 1.005 t_2 + w_2 (2500 + 1.88 t_2)$$

$$h_3 = 1.005 \times 25 + 16.86 \times 10^{-3} (2500 + 1.88 \times 25)$$

$$\boxed{h_3 = 68.07 \text{ kJ/kg d.a}}$$ Ans

$$w_2 = 0.622 \frac{P_{v_2}}{P_{t_2} - P_{v_2}} = 0.622 \frac{P_{v_2}}{1.013 - P_{v_2}} = 16.86 \times 10^{-3}$$

$$P_{v_2} = 0.0268 \text{ bar.}$$

$$\phi = \frac{0.0268}{0.03229} = 82.8\ \%$$

(ii) $\dot{E}_{in} = \dot{E}_{out}$

$$\dot{m}_a \times h_1 = \dot{m}_a h_2 + \dot{Q} + \dot{m}_w h_w$$

($\dot{Q}$ → ? ; ↑ Cooling Coil)

$$5 \times 91.36 = 5 \times 68.07 + \dot{Q} + \dot{m}_w h_w$$

$$\dot{m}_w = (\omega_1 - \omega_2) \frac{kg\,v}{kg\,d.a} \times 5 \frac{kg\,d.a}{s}$$

$$= 5 \times 10^{-3} \times 5 = 25 \times 10^{-3}\ kg/s$$

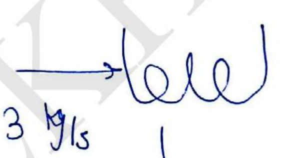
$$h_w = C_{pw} \times t_w \leftarrow \text{latent}$$

$$= 4.18 \times 25 \quad (\text{in ~~system~~ C.V.})$$

$$5 \times 91.36 = 5 \times 68.07 + \dot{Q} + 25 \times 10^{-3} \times 4.18 \times 28$$

$$\dot{Q} = 113.8\ kW$$

Ques 5
W.B. 5b



$m_a = 3\ kg/s$ $\quad E_{in} = E_{exit}$

$m_a = 3\ kg/s$

$h_1 = 85\ kJ/kg$

$\omega_1 = 19 \times 10^{-3}$

$h_2 = 43\ kJ/kg$

$\omega_2 = 8 \times 10^{-3}$

$h_w = 67\ kJ/kg.$ $\quad \dot{m}_w = (\omega_1 - \omega_2) \times \frac{kg\,v}{kg\,d.a} \times 3 \frac{kg\,d.a}{s}$

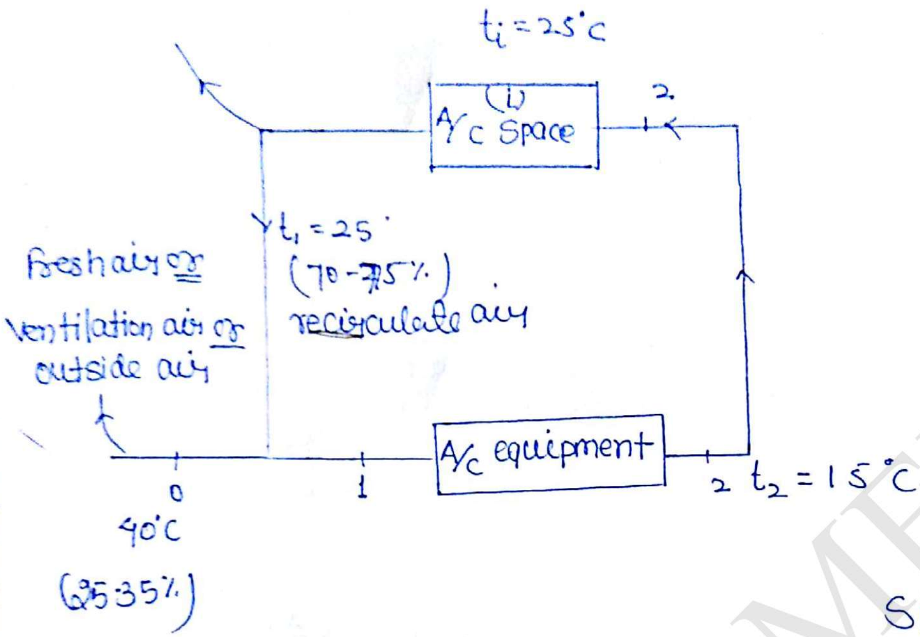
$$m_1 h_1 = m_2 h_2 + m_w h_w + \dot{Q}$$

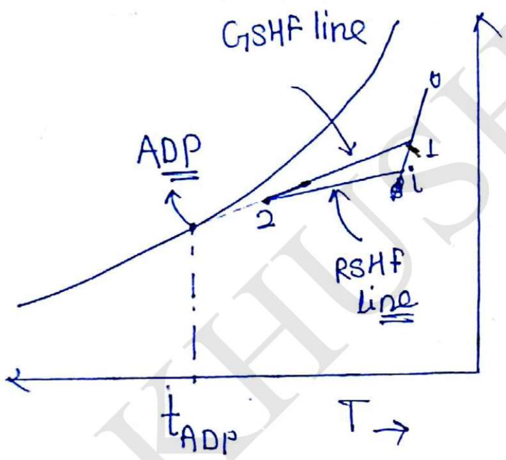
$$3 \times 85 = 3 \times 43 + \dot{Q} + 3(19-8) \times 10^{-3} \times 67$$

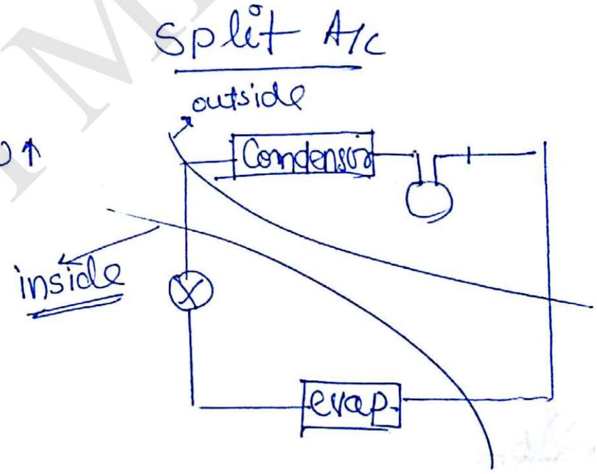
$$\dot{Q} = 123.78\ kW$$

★ $\dot{m}_w$ = Condenset rate

Summer Air conditioning with Ventilation Air







→ line joining the inlet and exit Conditions of A/c equipment is called Grand sensible heat factor line.

→ line joining the supply Condition to the room with the room inside Condition is Called Room sensible heat factor line RSHF.

→ The intersection of RSHF & GSHF gives the supply conditions to the room.

→ The outside air supplied in order to maintain purity of air is called ventilation air or fresh air.

→ In hospitals the recirculated air should be zero and ventilation air / fresh should be 100%.

Air changes:-

$$\text{Air changes per hour (ACH)} = \frac{V_o\,(m^3/hr)}{V\,(m^3)}$$

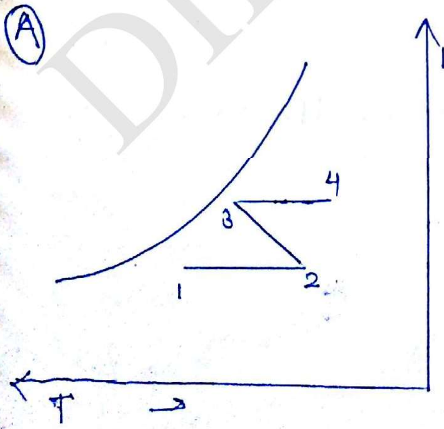
V_o - outside air
V → Vol. of A/c space.

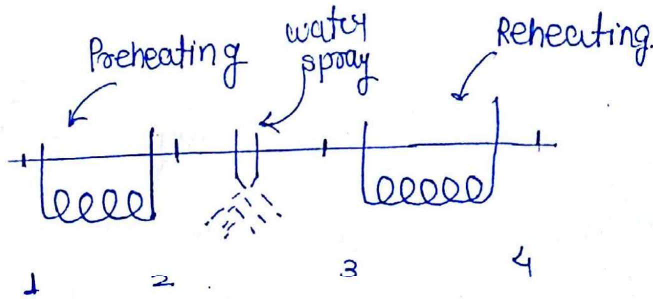
$$\text{Air changes per min} = \frac{V_o\,(m^3/min)}{V\,(m^3)}$$

(MM - Cubic meter per min (m^3/min))

Winter Air Conditioning:

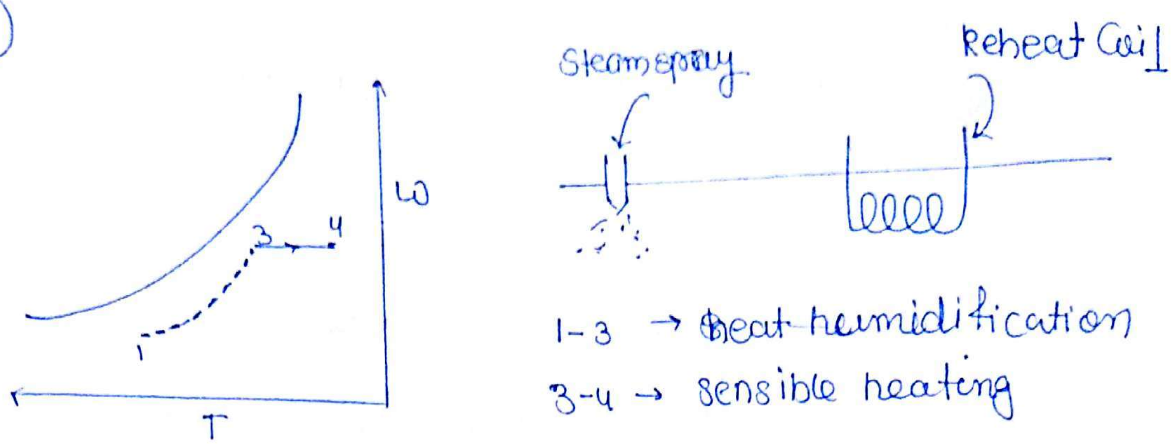
(A)





1 → 2 sensible heating
2 → 3 Adiabatic sat.
3 → 4 sensible heating.

(B)

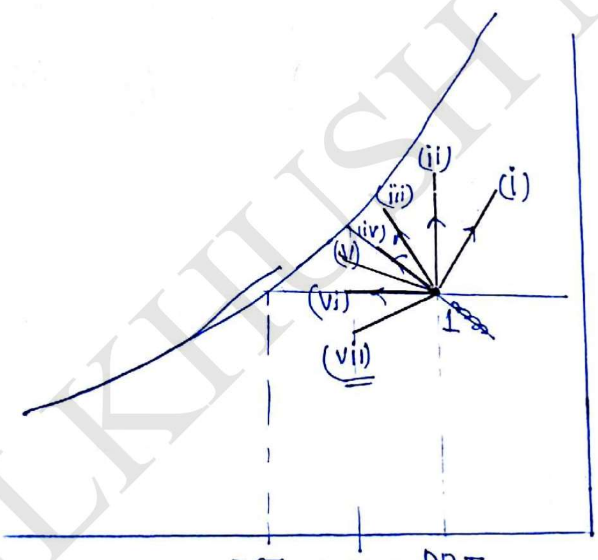


1-3 → heat humidification

3-4 → sensible heating

→ In winters the outside air is at low ω and low temp. hence heating and humidification of air is required. This can be acheived by one of the above method.

Air washer :-



(I) $t_w > DBT$ → heating & humidification
→ heating Coil
→ $h_a \uparrow$

(II) $t_w = DBT$ → humidification
→ heating Coil
→ $h_a \uparrow$

(iii) WBT < t_w < DBT

→ Cooling and humidification
→ heating Coil
→ $h_a \uparrow$

(iv) t_w = WBT

→ Cooling & humidification
→ No Coil
→ h_a = Const.

(v) DPT < t_w < WBT

→ Cooling & humidification
→ Cooling Coil
→ $h_a \downarrow$

(vi) t_w = DPT

→ sensible Cooling
→ Cooling Coil
→ $h_a \downarrow$

(vii) t_w < DPT

→ Cooling & dehumidification
→ Cooling Coil
→ $h_a \downarrow$

Human Comfort and Effective temprature :-

→ The physical comfort of a human being which can be ~~aj~~ adjected by adjecting the temp., humidity, air velocity & purity of air.

→ Effective temp is the temp. of a saturated envt. where the person feel same level of confort as in the normal environment.

→ According to the study conducted by american society for heating refrigeration and air condition engineers (ASHRAE), 99% of the adults wearing light cloths involved in ligth activity (eg. office work) will experiance comfort at

DBT → 24–25°C & RH → 50–60 %

Effective temp 21.6°C (summer)
20°C (winter)

Factors affecting human Comfort:-

1. Gender:- man experiance comfort at a lower temp. compare to woman.

2. Age:- Adult experiance comfort at a lower temp. comfare to children & old age people.

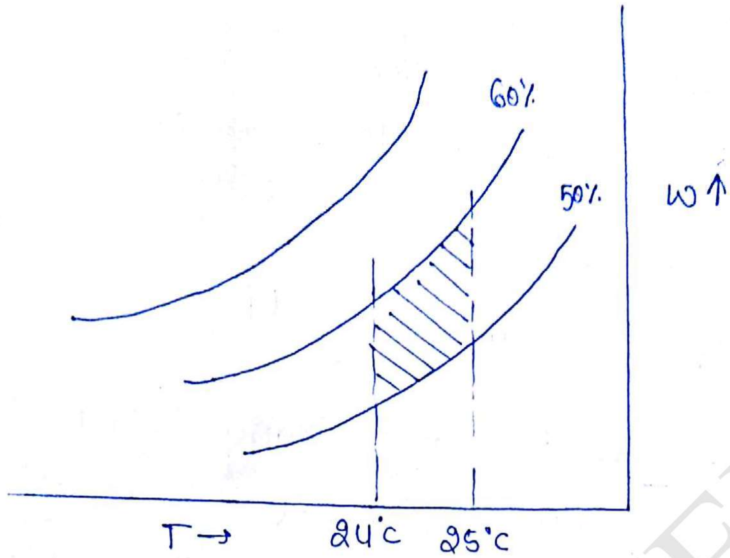
3. kind of Clothing:- Person wearing light Cloths will experiance comfort at a relatively higher temp. compare to people wearing heavy cloths.

4. kind of activity:- Person involved in heavy physical activity (for ex. gym) will experiance comfort at a lower temp. Compared to person involved in light activities (offic work)

5. climatic Condition: people habitual to cold climate experiance comfort at lower temp a compare to people living in hot climatic condition

6. Seasons:- People experiance comfort at a lower temp. in winters compare to summer.

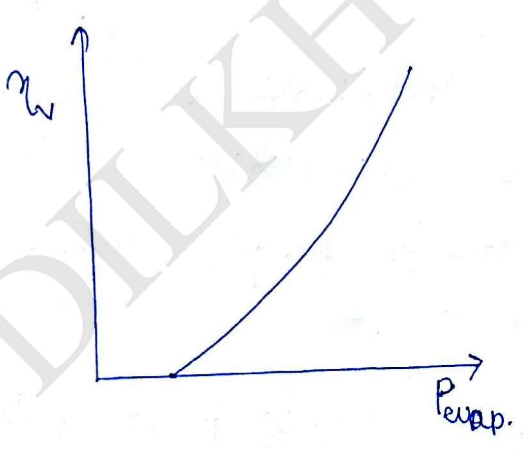
Comfort chart :-



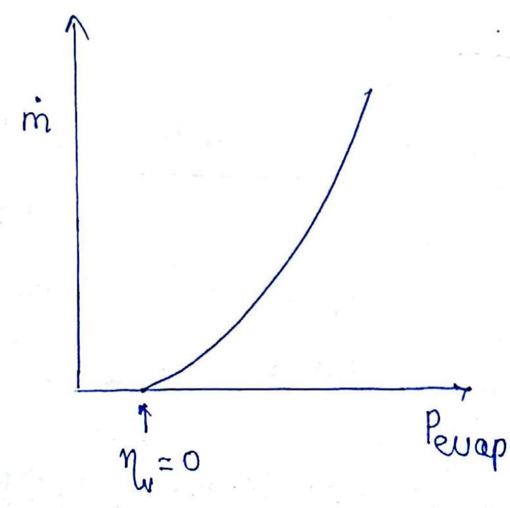
* The chart representing the year round comfort condition is called as comfort chart.

* Performance curve :-

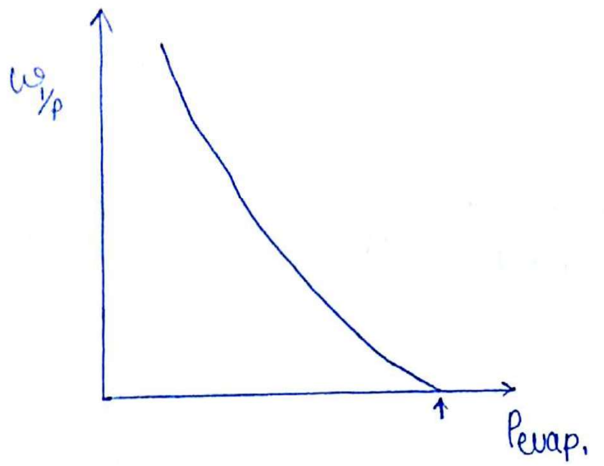
(i) η_v Vs $P_{evp.}$



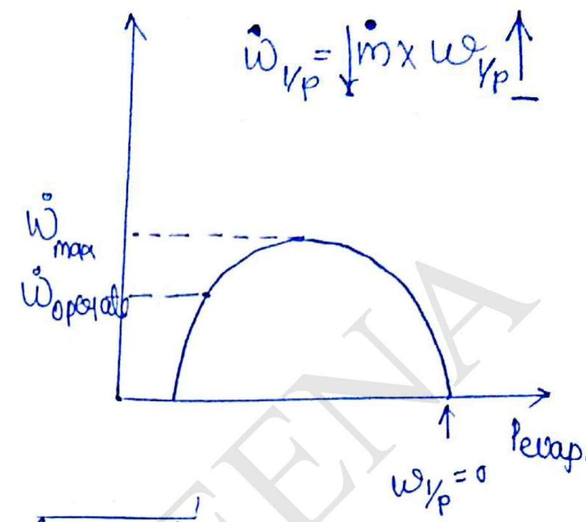
(ii) $\dot{m}$ Vs $P_{evap.}$



(iii) $w_{i/p}$ Vs P_{evap}.



(iv) $\dot{W}_{i/p}$ Vs P_{evap}.



~~$\dot{W}_{i/p}$ Vs P_{evap}.~~

* The operating is less than the maximum ~~ba~~ power but the compressor motors are designed for maximum power conditions because ~~for~~ reaching the operating power we have to cross the max. power condition.