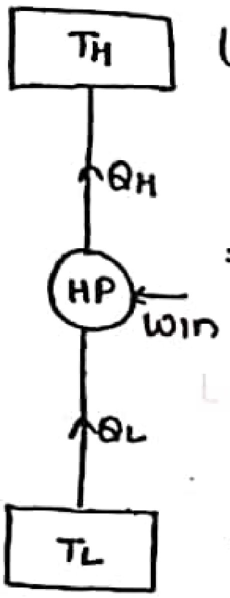
BASIC CONCEPT:-

Refrigeration effect:- It is the ammount of heat which is require to extract in order to provide and maintain lower temperature than that of sorrounding

Refrigerant:- It is a working fluid or working substance that is used to extract the heat from the storage space.

COP:- It is defined as the ratio of Desired effect to the work input

$$COP = \frac{DE}{W_{in}}$$



$$(COP)_{HP} = \frac{DE}{W_{in}}$$

$$= \frac{Q_H}{W_{in}}$$

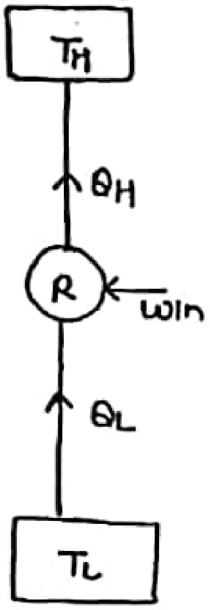
$$\Rightarrow Q_L + W_{in} = Q_H$$

$$\Rightarrow W_{in} = Q_H - Q_L$$

$$\therefore COP = \frac{Q_H}{Q_H - Q_L}$$

**

$$\boxed{COP = \frac{T_H}{T_H - T_L}}$$



$$(COP)_R = \frac{DE}{W_{in}}$$

$$= \frac{Q_L}{W_{in}} = \frac{Q_L}{Q_H - Q_L}$$

$$= \frac{T_L}{T_H - T_L}$$

**

$$\boxed{(COP)_R = \frac{T_L}{T_H - T_L}}$$

Relationship b/w COP of Heat engine and COP of Refrigeration:-

$$1 + (COP)_R = \frac{T_L}{T_H - T_L} + 1$$

$$= \frac{T_L + T_H - T_L}{T_H - T_L}$$

$$\Rightarrow 1 + (COP)_R = \frac{T_H}{T_H - T_L} = (COP)_{HP}$$

**

$$\Rightarrow \boxed{(COP)_{HP} = 1 + (COP)_R}$$

The above expression is applicable b/w same temp limit and Ratio also.

Question:- If efficiency of engine is 40% than COP of HP is.

A) 0.5 $\qquad \eta = 0.4 = 1 - \frac{T_L}{\;}$

Question:- If efficiency of engine is 40% than COP of HP is

A) 0.5

B) 1.5

c) 2.5

d) 3.5

$$\eta = 0.4 = 1 - \frac{T_L}{T_H}$$

$$\frac{T_L}{T_H} = 0.6$$

$$(COP)_{HP} = \frac{T_H}{T_H - T_L}$$

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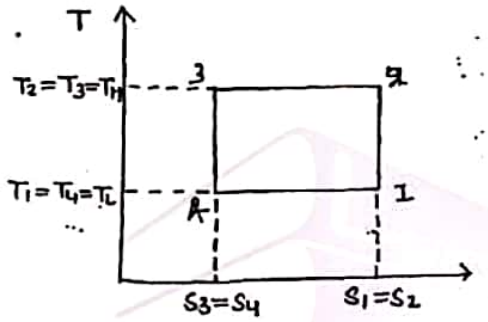
$$= \frac{1}{1 - \frac{T_L}{T_H}} = \frac{1}{1-0.6} = 2.5$$

**
$$(COP)_{HP} = 1 + (COP)_R = \frac{1}{\eta_E}$$

The above expression is applicable b/w same templimit

Ideal Refrigeration cycle(Reversed carnot cycle)



$$ds = (dS)_{IR} + (dS)_{EI}$$

$$ds = \dot{s}_{gen} + \frac{dQ}{T}$$

$$\Rightarrow \dot{s}_{gen} = 0$$

$$\Rightarrow ds = \frac{dQ}{T}$$

$$\Rightarrow dQ = T\,ds$$

$1-2 \rightarrow dQ = Tds = T\times 0 = 0$

$2-3 \rightarrow dQ = Tds = T(S_2 - S_1) = -ve$

1–2 → isentropic or Reversible adiabatic compression

2–3 → constant temp heat Rejection

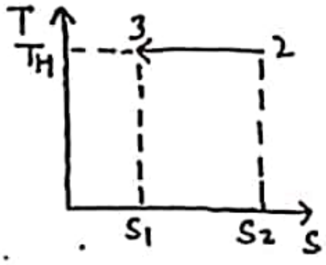
3–4 → isentropic expansion

4–1 → iso thermal heat addition

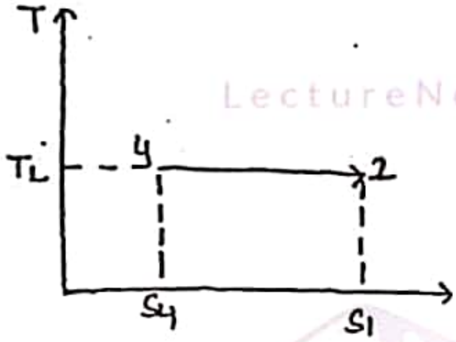
$$(COP) = \frac{DE}{W_{NET}}$$

$$\Rightarrow W_{NET} = Q_{NET} = \cancel{Q_{1-2}}^{0} + Q_{2-3} + \cancel{Q_{3-4}}^{0} + Q_{4-1}$$

$$\Rightarrow W_{NET} = Q_{NET} = Q_{2-3} + Q_{4-1} \quad \text{——} (1)$$



$$Q_{2-3} = T(S_F - S_I)$$
$$= T_H(S_3 - S_2)$$
$$= -T_H(S_2 - S_3)$$
$$\Rightarrow Q_{2-3} = -T_H(S_1 - S_4) \quad \text{--- (2)}$$



$$Q_{4-1} = T(S_F - S_I)$$
$$= T_L(S_1 - S_4) \quad \text{--- (3)}$$

use (I) and (3)

$$W_{NET} = Q_{NET} = -T_H(S_1 - S_4) + T_L(S_1 - S_4)$$
$$= \underset{-ve}{(T_L - T_H)}\ \underset{+ve}{(S_1 - S_4)} \quad \text{--- (4)}$$
$$\Rightarrow (-ve)$$

By the equation (4) we can say that our assumed system is a work absorbing device

$$COP = \frac{DE}{(T_H - T_L)(S_1 - S_4)} \xrightarrow{\text{using eq}^n (3)} \frac{T_L(S_1 - S_4)}{(T_H - T_L)(S_1 - S_4)}$$
$$= \frac{T_L}{T_H - T_L}$$

**

$$(COP)_{RRC/IRC} = \frac{T_L}{T_H - T_L}$$

Heat loose by one gained by other but may be it's ~~temp~~ increase or not.

NOTE:- 1) Reverse carnot COP is the func of temp only

2) If there are n no. of Refrigerants operating b/w same

temp limit with different working fluid then the value of maximum possible COP or Reversed carnot COP or ideal COP, is having same value.

3) Reversed carnot COP is independent of working fluid.

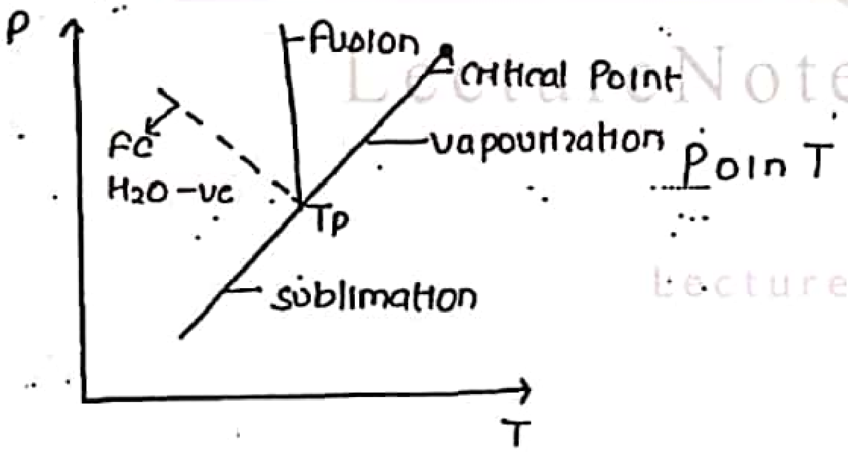
Unit of Refrigeration:-

TON of Ref:-

**
$$1\,TR = 3.5\,kW = 210\,\frac{kJ}{min} = \frac{50\,k\,cal}{min}$$

1 TON of Refrigeration is defined as the amount of heat, which is required to extract from 1 Ton of water at 0°c in order to convert it into equal ice (°c) in a day.

0°c → 0°c → 4°c
Ice H_2O H_2O



Note:-

1) Producing ice at 0°c

a) $(COP)_{summer} > (COP)_{winter}$

b) $(COP)_s < (COP)_w$

c) $(COP)_s = (COP)_w$

d) can't say

$$\downarrow (COP)_R = \frac{T_L}{(T_H - T_L)\uparrow}$$

$\Rightarrow T_L = const$
$\Rightarrow T_H \uparrow$
} $COP \downarrow$

Summer	Winter
$T_L = 0°C$	$T_L = 0°C$
$T_H = 30°$	$T_H = 10°C$

$T_L = Const$

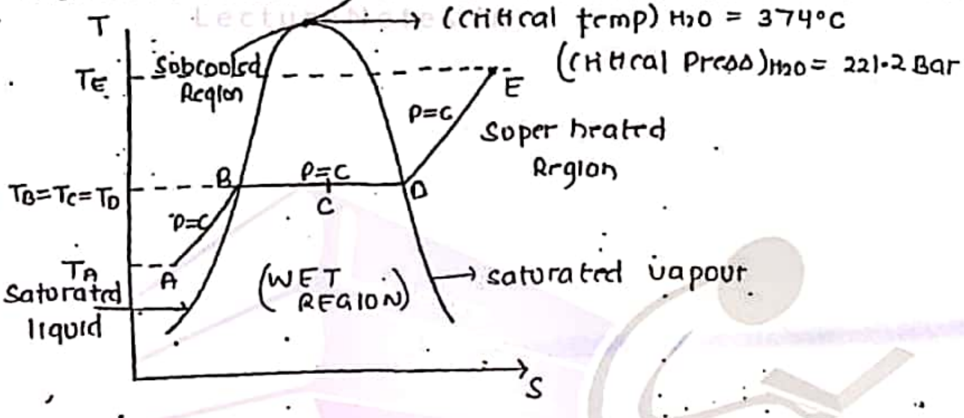
$(T_H)_s > (T_H)_w$

$(COP)_s < (COP)_w$

(b) ✓

CH :- PURE SUBSTANCE :-

Represantation of constant pressure lines on T-s Diagram:-



Degree of Superheating = $T_E - T_D$

Degree of Subcooling or undercooling = $T_B - T_A$

Superheating:-

It is a process of Increasing the temp at constant Press. above saturated vapour.

Subcooling:-

It is a process of decreasing the temp at constan press. below saturation liquid.

Wet Region:-

It is a mix^r of liquid and vapour.

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Critical point:-

It is the point above which liquid directly flash off into vapours.

Dryness fraction:-

x_B (sat. liquid) ⇒ $m_L = 1$

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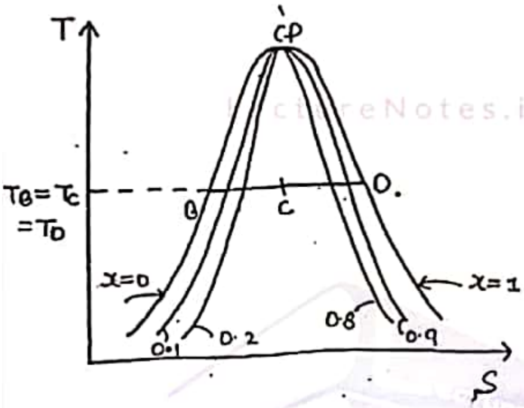


x_B (sat. liquid) ⇒ $m_L = 1$, $m_V = 0$

$x_B = 0$

x_D = (sat. vap) ⇒ $m_L = 0$

$x_D = 1$

$x = 0.20$ → 20 % vapour, 80 % liquid

$0 \le x \le 1$

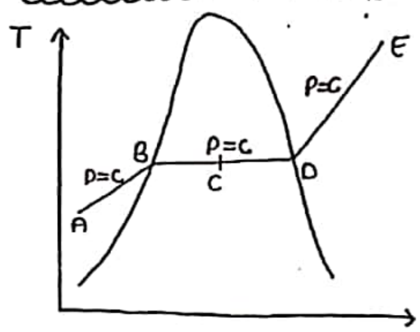
DO NOT APPLY
$PV = mRT$
in WET REGION

$h_f, h_g, u_f, u_g, s_f, s_g, v_f, v_g$

g → saturated vapour

f → sat. liquid

Entropy and Enthalpy at various point:-



① h_B (sat liquid) = h_f

② h_D (sat vap) = h_g

③ h_C (wet Region) = $h_B + x h_{fg}$

$= h_f + x(h_g - h_f)$

④ h_E = (superheated Region) = h_D or h_g + C_p (vapour) $(T_E - T_D)$

⑤ h_A (subcooled Region) = h_B or h_f − C_p (liquid) $(T_B - T_A)$

① $S_B = S_f$

④ h_E = (Superheated Region) = $h_D + C_p (T_E - T_D)$
or h_g ; C_p → vapour

⑤ h_A (Subcooled Region) = $h_B - C_p (T_B - T_A)$
or h_f ; C_p → Liquid

① $s_B = s_f$

② $s_D = s_g$

③ $s_C = s_B + x(s_{fg})$

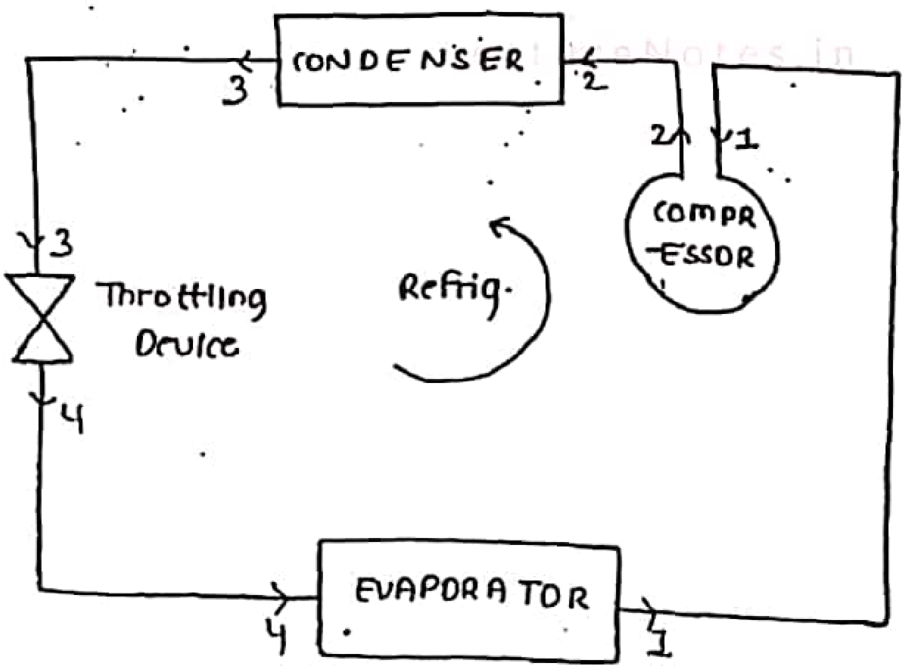
$= s_f + x(s_g - s_f)$

④ s_E (SHR) = $s_D + (C_p) \ln \left(\frac{T_E}{T_D}\right)$
or s_g ; C_p → Vapour

⑤ s_A (SCR) = $s_B - (C_p) \ln \left(\frac{T_B}{T_A}\right)$
or s_f ; C_p → Liquid

VCRS:-

Vapour compression Refrigeration system:-



Compressor:- * used to increase the pressure and temp. both

* It is a work absorving device.
* our system is working Fluid.
* In turbine expansion takes place, Temp ↓, In compressor both increase, In pump only pressure increase.

" It is a mechanical device In which energy is transfered from Rotor to working fluid. It is a work absorbing device and generally used to handle gaseous phase."

Evaporator:-

"It is a type of heat exchanger in which, heat is absorbed by the refrigerant at constant pressure.

Condensor:-

"It is a type of heat exchange heat is rejected by the Refrigerent at constant pressure.

throttling:-

" flow through a restricted passage, Partial open valve etc. is known as throttling.

Note:-

* Throttling is known as constant enthalphy Process or Isenthalpic process

*) Throttling always result a decrease in pressure (expansion)

* Throttling is a irreversible adiabatic process.

Process 1-2 → Isentropic or reversible adiabatic compression

Process 2-3 → constant pressure heat Rejection

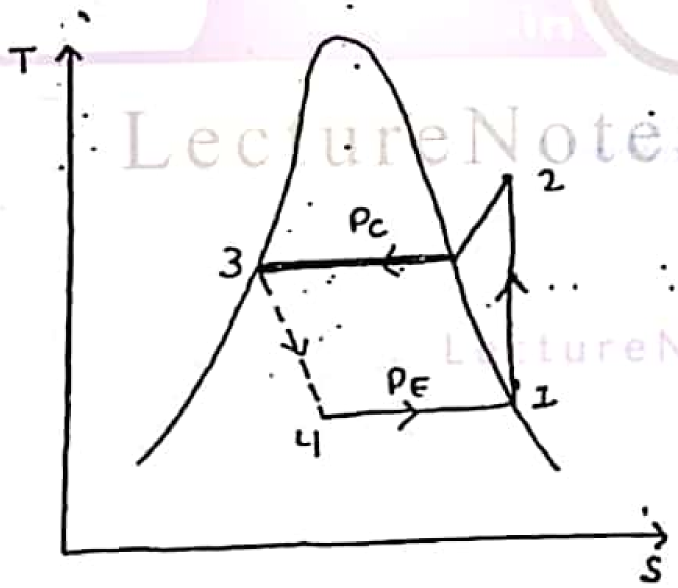
Process 3-4 → constant enthalpy expansion.

Process 4-1 → constant pressure heat addition.

Assumption:-

① Entry to the compressore or exit of evaporator is saturated ~~liquid~~ vapour (state 1).

② Exit of condensor or entry of throttling (state 3) is saturated liquid



In 3 to 4

$$ds = \dot{s}_{gen} + \frac{dQ^{\,0}}{T}$$

COP:-

$$COP = \frac{D \cdot E \cdot}{W_{in}} = \frac{h_1 - h_4}{h_2 - h_1}$$