$\therefore \quad \frac{T_2}{T_1} = \frac{T_3}{T_4} = \frac{T_2 - T_3}{T_1 - T_4} = r_p^{\frac{\gamma-1}{\gamma}}$

$$\therefore \boxed{C.O.P = \frac{1}{r_p^{\left(\frac{\gamma-1}{\gamma}\right)} - 1}}$$

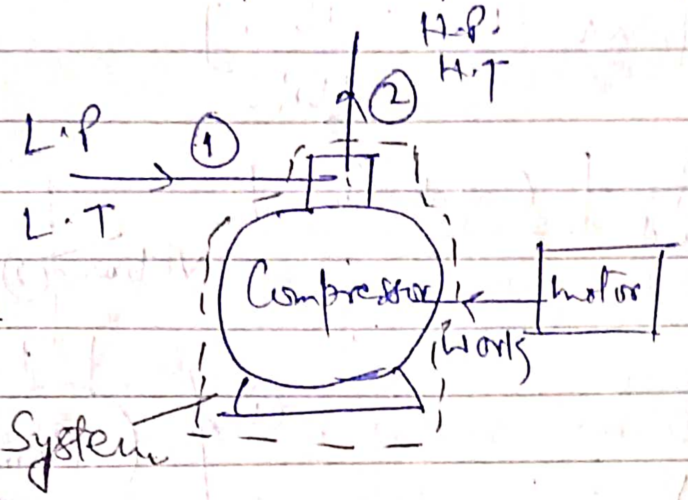
Bell coleman cycle

Vapour Compression refrigeration System

In this System, vapour refrigerant are compressed to such a level that heat is rejected to the atmosphere, hence it is called as ~~such~~ vapour Compression refrigeration System.

L.P means lower than the System

L.T means lower than the atm.



Process 1-2 Isentropic Compression in a Compressor.

Energy entering = energy outgoing

$$h_1 + W_c = h_2$$

$$\boxed{W_c = h_2 - h_1}$$

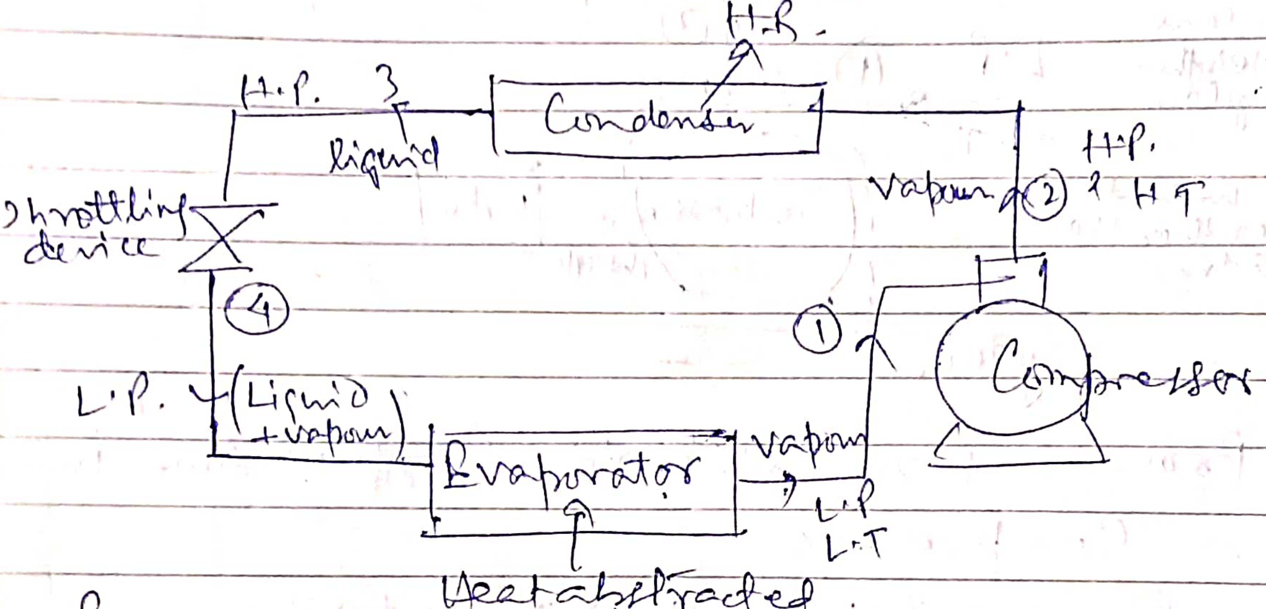
Compressor + Motor sealed in glove and surrounded by electrical winding. Then it is Known as

(i) ~~...~~ Sealed unit or Hermetically Sealed unit

(ii) Semi Sealed unit (Dome is surrounded by Cover plate & tightened by nut bolt)

(iii) Open unit.

[refrigerant vapour tempr is lower than atm. ~~pressure~~ tempr. If we compress it i.e, increase its pr. than corresponding tempr increases, therefore we compresses such a level that vapour tempr is higher than atmosphere. Hence heat flow from vapour to atm.]



<u>Process 2-3:</u> Constant pressure heat rejection in the condenser.

$$h_2 = H.R. + h_3$$

$$\boxed{H.R. = h_2 - h_3}$$

In refrigerator, this cooling is obtained with the help of air then it is called as <u>Air Cooled Condenser</u>.

Another type is water cooled condenser used in Ice plant, Building refrigeration

Process 3-4: Throttling process.

$$h_3 = h_4$$

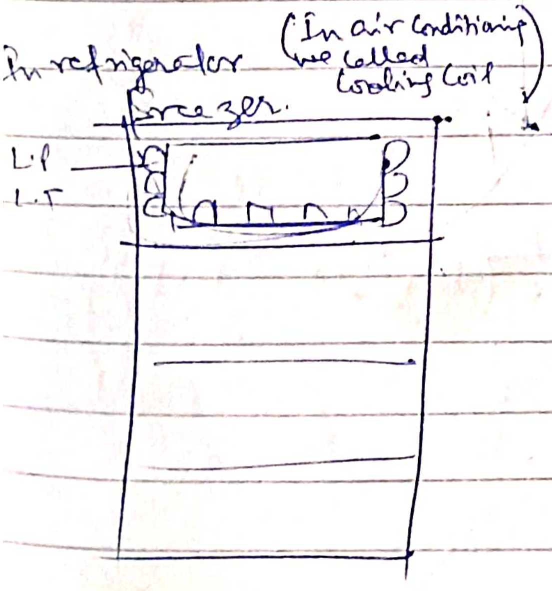
Due to friction, some liquid will be converted into vapour. Therefore after throttling we get mix of liquid and vapour.

Throttling device could be a

1. Capilliary tube
   ($\frac{1}{30th}$ to $\frac{1}{40th}$ of an inch)
   It is hold good for refrigerator and air conditioning.
2. Thermostatic exp. valve
3. Automatic exp. valve
4. Float valve → H.P. Side
   → L.P. Side.

Process 4-1:

Only liquid is evaporated into vapour. Technically called evaporator.



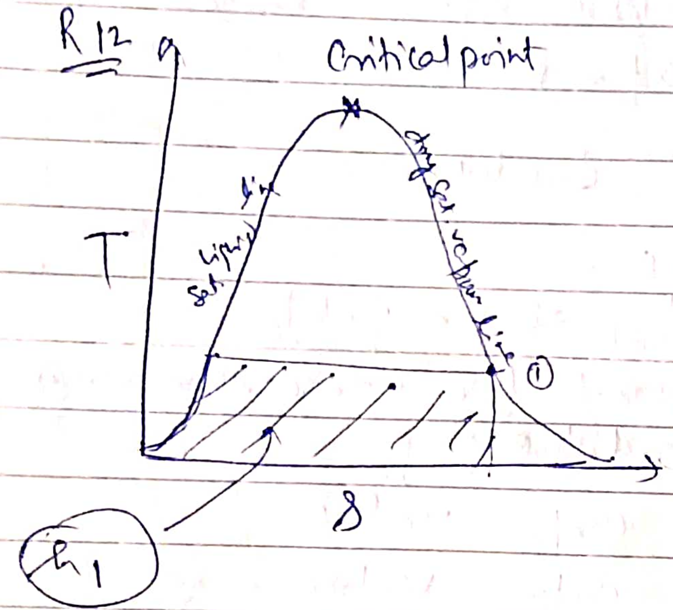
Constant pressure heat abstracted in the evaporator (Net refrigerating effect, N)

$$h_4 + N = h_1$$

$$N = h_1 - h_4$$

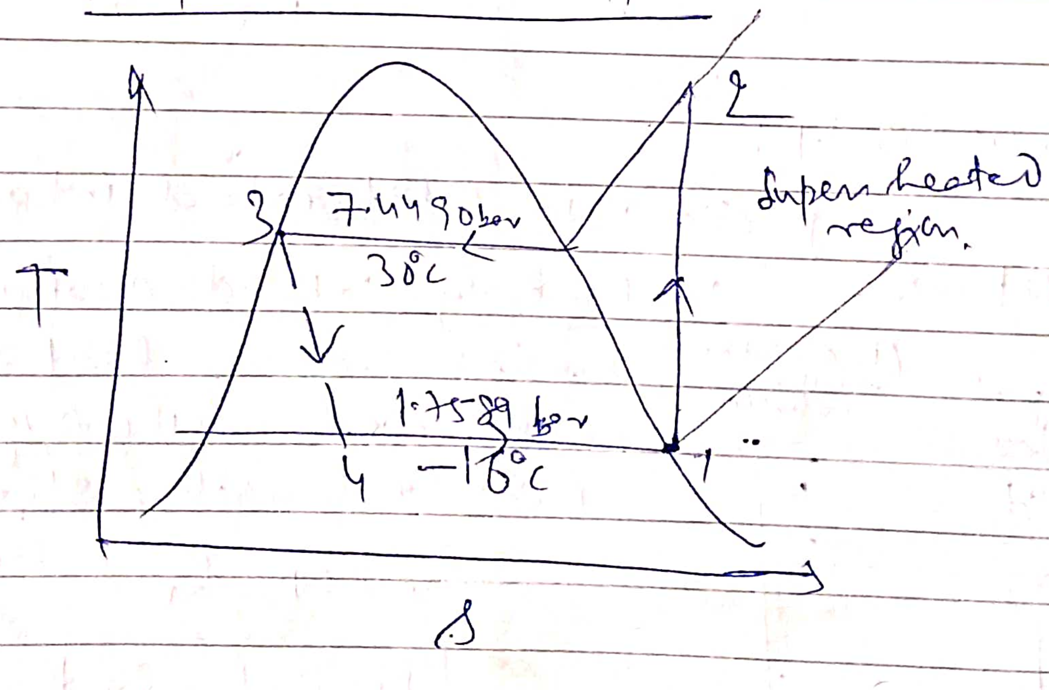
Evaporator
(1) Freezer (refrigerator)
(2) Cooling Coil (A/c)
(3) Chiller (Ice plant)

R 12



Simple Saturation Cycle

R 12



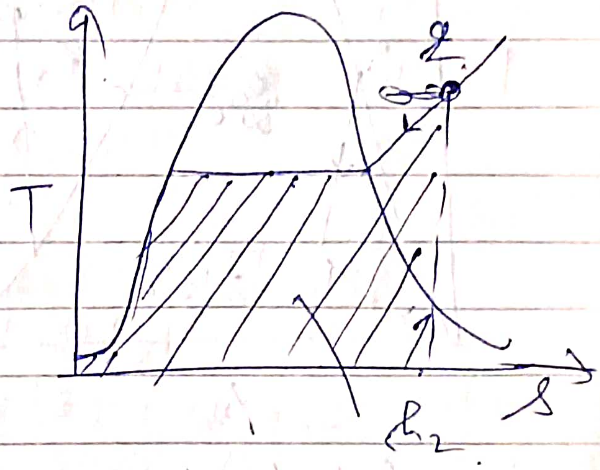
for finding enthalpy of any point,

(i) from the pt. under consideration draw a vertical line.

(ii) from the left hand side of the point move along the process line till we reach the liquid line.

(iii) Move along the liquid line till datum.

(iv) This entire area represents the enthalpy at the point under consideration.

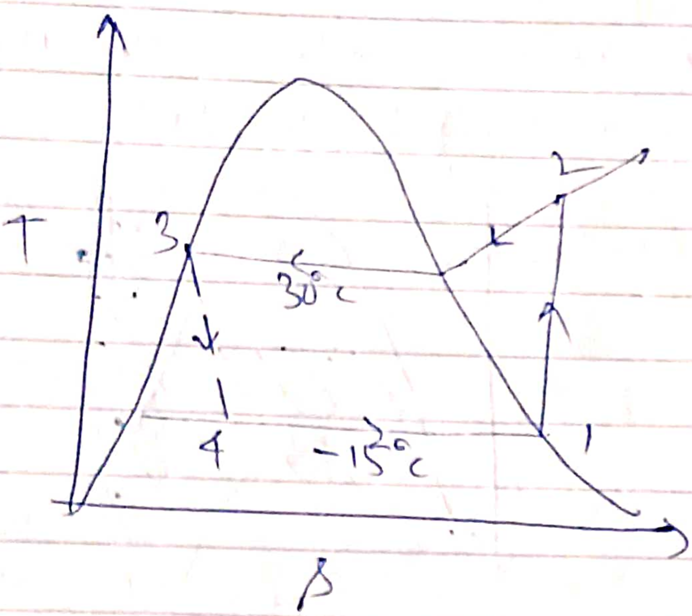


(1) A std. refrigerator working on vapour compression cycle. If the evaporator & condenser temp's are −15°C and 30°C then calculate h_2, work reqd, N, C.O.P, Heat rejected in the condenser, using R12.

Also calculate power and mass flow rate if capacity is 5TR.

Sol^n

R12



$h_1 = (h_g)_{-15°C} = 344.92 \frac{kJ}{kg}$

$s_1 = s_2 = 1.56317 \frac{kJ}{kgK}$

In superheated vapour,

At 30°C (or 7.4490 bar)

temp	entropy
35°C	1.555
?	1.56317
40°C	1.5673

$= 35 + \frac{5}{(1.5673 - 1.555)} \times (1.56317 - 1.555)$

$= 38.25°C$

temp	enthalpy
35°c →	367.274
38.25°c →	?
40°c →	370.944

$$h_2 = 367.274 + \frac{(370.944 - 367.274)}{5} \times 3.25$$

$$\boxed{h_2 = 369.659 \text{ kJ/kg}}$$

$h_3 - h_4 = (h_f)_{30°c} = 228.54$ kJ/kg

Work reqd $= h_2 - h_1$

$= ~~228.5~~\ 369.659 - 344.92$

$= 24.739$ kJ/kg

Net refrigerating effect

(N) $= h_1 - h_4$

$= 344.92 - 228.54$

$= 116.38$ kJ/kg

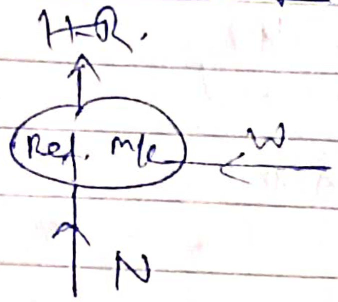
C.O.P $= \frac{N}{W} = \frac{116.38}{24.739} = 4.70$

Heat rejected in the Condenser

$= h_2 - h_3$

$= 369.659 - 228.54 = 141.119$ kJ/kg

For checkup



$N + W = H.R.$

$116.38 + 24.739 = 141.119$

given. Capacity $= 5\,TR$.

$m(h_1 - h_4) = 5 \times 3.5$

$\dot{m} = \dfrac{5 \times 3.5}{116.38} = 0.1504\ kg/s$

$\boxed{\dot{m} = 0.1504\ kg/s}$

Power reqd. $= m(h_2 - h_1)$

$= 0.1504 \times 24.739$

$= 3.7207\ kW$

(2)

Q→ It is proposed to replaced R12 by ozone friendly R134a in a refrigeration plant of 10 TR Capacity with evaporator and Condenser tempr of 0°c and 40°c respectively. Considering standard saturation cycle (evaporater exit) and Condense exit as saturated stage, Compare the mass flow rate, Compressor work (kW), Condenser heat rejection (kW) & COP for the two refrigerants. The

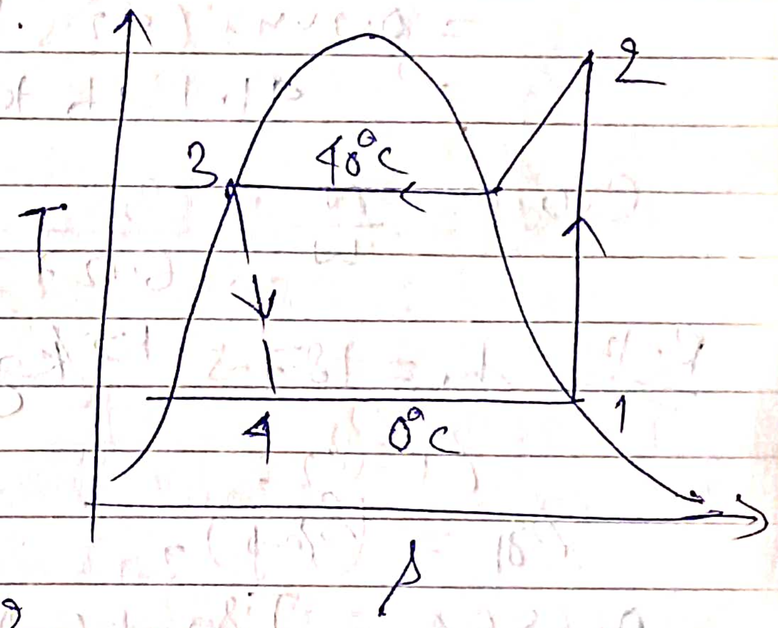
Saturation properties and vapour specific heat are as follows

	$t\,^\circ C$	h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kgK)	s_g (kJ/kgK)	C_p (kJ/kgK)
R134a	0	200.81	398.78	1.0025	1.7261	—
	40	255.73	418.63	1.1884	1.7128	1.068
R12	0	36.1	187.5	0.0142	0.6966	—
	40	74.6	203.2	0.2718	0.6845	0.776

Soln.

R134a

$h_1 = (h_g)_{0^\circ C} = 398.78$ kJ/kg



$s_1 = s_2$

$(s_g)_1 = (s_{sup})_2$

$1.7261 = \left[s_g + C_p \ln \frac{T_2}{T_s}\right]_2$

$= 1.7128 + 1.068 \ln \frac{T_2}{313}$

$\therefore T_2 = 316.92$ K $(43.92^\circ C)$

$h_2 = h_g + C_p(T_2 - T_s)$

$= 418.63 + 1.068(43.92 - 40)$

$\boxed{h_2 = 423.82}$ kJ/kg