# *RAC*

Book
P.L. Ballaney.

open system

① steady state

② $\Delta K.E. = 0$ & $\Delta P.E. = 0$

**S.F.E.E.**

$$h_1 + q = h_2 + W_{c.v.}$$

Adiabatic → Rev. / irrev. } $q = 0$

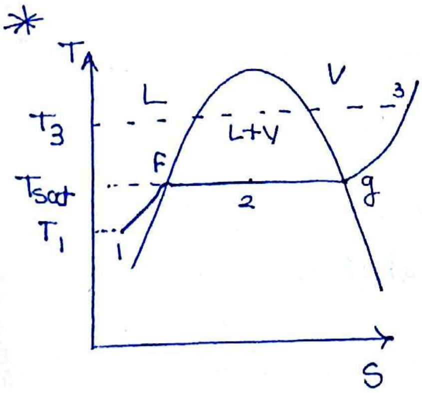
$$W_{c.v.} = h_1 - h_2$$

**Polytropic ($PV^n = c$)**

$$W_{cv} = -\int v\,dp$$

$$W_{c.v.} = \frac{n}{n-1}\left(P_1V_1 - P_2V_2\right)$$

*




① Sub cooled Region

$$h_f - h_1 = C_{p\,liq}\left(T_{sat} - T_1\right)$$

$$s_f - s_1 = C_{p\,liq.} \ln \frac{T_{sat}}{T_1}$$

② Wet Region.

$$h_2 = h_f + x_2 h_{fg} \qquad s_g - s_f = \frac{L.H.}{T_{sat}}$$

$$s_2 = s_f + x_2 s_{fg}. \qquad s_g - s_f = \frac{h_g - h_f}{T_{sat}}$$

L.H $Q_p = h_g - h_f$

$LH = h_g - h_f$

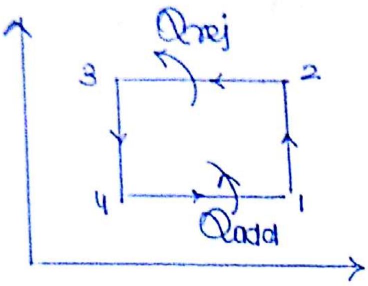
③ super heated (ideal gas)

$$h_3 - h_g = C_{p_v}\left(T_3 - T_{sat}\right).$$

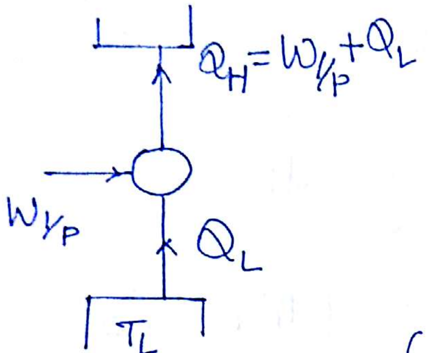
$$s_3 - s_g = C_{p_v} \ln \frac{T_3}{T_{sat}} - R \ln \frac{P}{P}$$

$$s_3 - s_g = C_{p_v} \ln\left(\frac{T_3}{T_{sat}}\right)$$

# Ideal Cycle for Refrigeration:-
## (Reversed Carnot Cycle)




1–2 isentropic comp.
2–3 isoth heat rej
3–4 isentropic exp.
4–1 isoth. heat add.




$$(COP)_{Ref} = \frac{Q_L}{W_{I/P}}$$

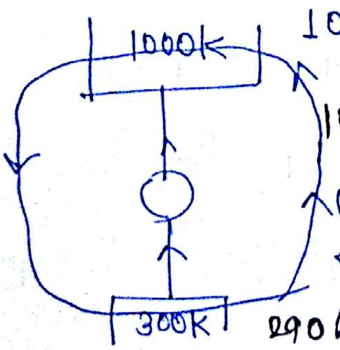
$$(COP)_{HP} = \frac{Q_H}{W_{I/P}}$$

$$(COP)_{ref} = (COP)_{HP} - 1$$

$$(COP)_{HP} - (COP)_{ref} = 1$$

* $(COP)_{ref} = \frac{T_L}{T_H - T_L}$ $(COP)_{H.P} = \frac{T_H}{T_H - T_L}$

eg if 10K diff b/w temp of working substance and sink
COP = ?




Heat rej from high temp. to low temp

$$(COP) = \frac{290}{1010 - 290} = 0.4027$$

$$\frac{1000}{1000 - 300} = 0.4285$$

* The expressions developed in terms of temp. can be used when
  - The cycle is internally rev. (may or may not be externally rev.)
  - Heat add. and heat rej. should be isothermal.
  - Temp. should be temp. of working fluid.

* The eff. ($\eta$) of an engine increases by increases $T_H$ and by decreasing $T_L$. but increment is more when the $T_L$ is decrease.

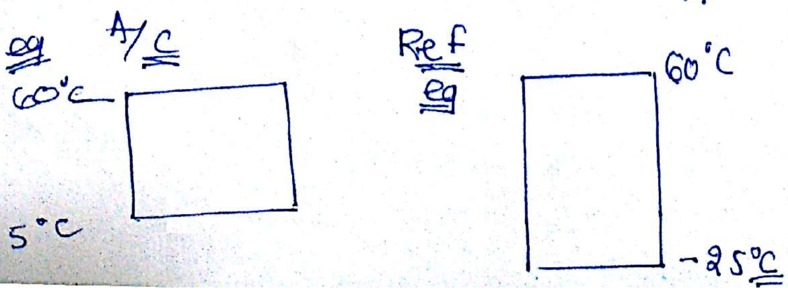
* COP of heat pump & ref. increases by decreasing $T_H$ and by increasing $T_L$. Here increasing $T_L$ is more benefesial.

* The COP of AC ~~and~~ is more than COP of ref. but the electrisity bill of AC is more because the total ~~to~~ heat removed i.e. Desired effect is more as compare to ref., since

Reasons
- total space to cooled is more
- Heat gen. ~~sorces~~ sources are present (fan, light people)
- ~~fan, li~~ Heat leakage from outside

Suppose $(COP)_{A/C} = 2 = \frac{D.E. \rightarrow 100}{W_{I/P}}$ $\quad W_{I/P} = 50$

$(COP)_{ref} = 1 = \frac{D.E. \rightarrow 10}{W_{I/P}}$ $\quad W_{I/P} = 10$



Heat Capacity

* $(COP)_{ref} = \frac{R.E.}{W_{I/P}} = \frac{R.C}{W_{I/P}}$ , $(COP)_{HP} = \frac{H.E.}{W_{I/P}} = \frac{H.C}{W_{I/P}}$

R.C = Ref. Capasity, H.C = Heat cap.

$Q_L$ from lower temp.

- The amount of heat absorbed to maintain a space at a lower temp. is called refrigeration effect. The rate of heat absorption is called refrigeration capasity.
- The amount of heat rejected is called heating effect and the rate of heat rejection is called heating capacity.

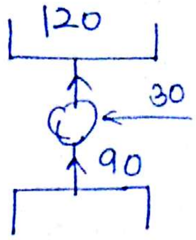
Imp
* 1 Ton of Refrigeration: (1TR)

$$1\,TR = 3.5167\ kW$$
$$= 211\ kJ/min$$
$$= 50.4\ kcal/min$$

It is the amount of heat which has to be removed to convert 1 ton of water at 0°c into 1 ton of ice at 0°c in 24 hrs. hence ton of refrigeration represents heat transfer rate.

**Q 6**
P.g. 41
WB

$$~~COP = \frac{30}{120-30} = \frac{1}{3}~~$$




$$COP = \frac{90}{30}$$

$$COP = 3$$

**Q. 10**

$$\frac{T_L}{T_H} = 0.8$$

10

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

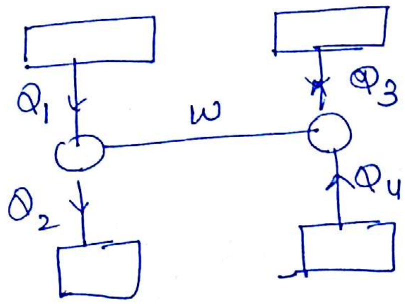
$$\left(\frac{1}{COP}\right)_{ref} = \frac{T_H}{T_L} - 1 = \frac{10}{0.8} - 1$$

$$\left(\frac{1}{COP}\right)_{ref} = 1.25 - 1$$

$$(COP)_{ref} = 4$$

$$(COP)_{HP} = 5$$

**Q. 17**




$$\eta_{HE} = \frac{Q_1 - Q_2}{Q_1} = 0.4$$

$$1 - \frac{Q_2}{Q_1} = 0.4$$

$$Q_2 = 0.6\,Q_1$$

$$Q_2 + Q_4 = 3Q_1$$

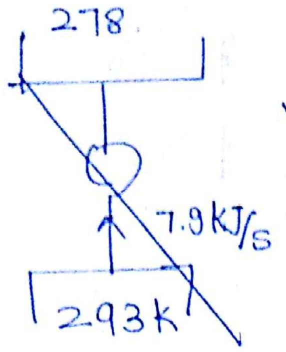
$$(COP) = \frac{Q_4}{Q_3 - Q_4} = \frac{3Q_1 - Q_2}{Q_1 - Q_2}$$

$$(COP) = \frac{3Q_1 - 0.6Q_1}{Q_1 - 0.6Q_1}$$

$$= \frac{2.4}{0.4}$$

$$COP = 6$$

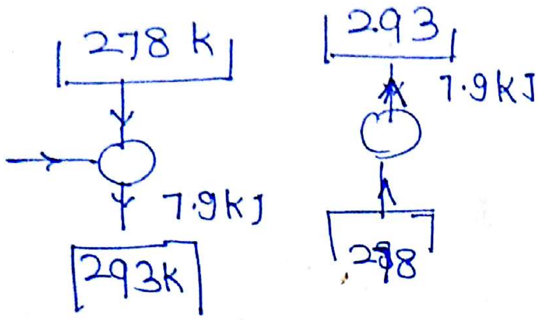
**Q.17**




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

$$\frac{7.9}{293} \times 5 = W$$

Heat pump

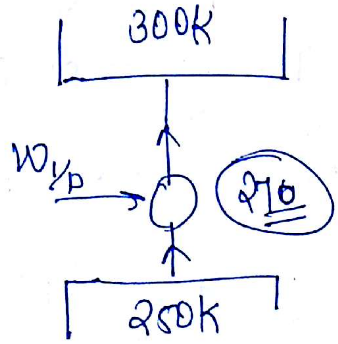



$$\frac{Q_H}{Q_H - Q_L} = \frac{T_H}{T_H - T_L} = \frac{293}{15}$$

$$Q_H - Q_L = W = \frac{7.9}{293} \times 15$$

$$W = 0.4045 \text{ kJ}$$

**Q.18**




$m = 3600$ kg

$t = 10$ hrs

$C_{P_F} = 2.0$ kJ/kg K above $-3°C$/270K

$C_{P_F} = 0.5$ kJ/kg K below 270 K

$LH = 230$ kJ/kg

$$(COP)_{idea} = 2\,(COP)_{act}$$

Heat removed = $m(c\,dT + LH + c\,dT)$

Heat absorbe $Q = 3600(2 \times 30 + 230 + 0.5 \times 20)$

$$\frac{5\,250}{50} = 2\,(COP)_{act}$$

$$(COP)_{act} = 2.5 = \frac{Q_L}{Q_H - Q_L} = \frac{3600 \times (0.5 \times 20 + 230 + 2 \times 30)}{W_{I/P}}$$

$$\dot{Q} = \frac{Q}{10 \times 3600} = \frac{1080000}{36000}$$

$$\dot{Q} = 30 \text{ KW}$$

$$2.5 = \frac{30}{W_{I/P}}$$

$$W_{I/P} = 12 \text{ KW Ans}$$