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# Refrigeration and Air conditioning

- Basic Concept
- VCRS
- Ref
- VARS
- RBC
- Ref Equipment

- Psychrometry
- Summer & winter AC

BOOKS : CP Arora
PL Ball

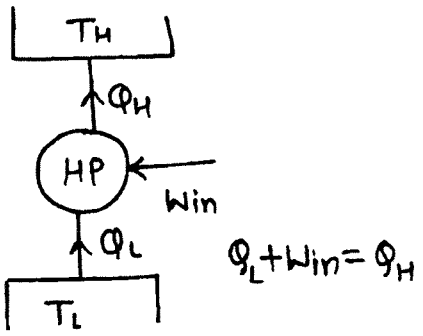
# BASIC CONCEPTS

- **Refrigeration Effect** :- It is the amount of heat which is required to extract from the Storage space in order to provide & maintain lower temperature than that of surroundings.

Refrigerant → It is the working fluid or working substance which is use to extract the heat from the storage space

**COP→ Coefficient of Performance or Energy Performance or EPR ratio :→**

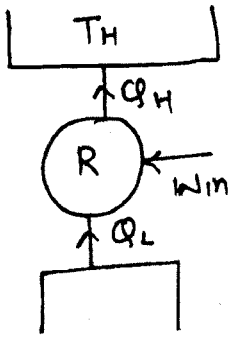
$$COP = \frac{DE}{W_{in}}$$




$Q_L + W_{in} = Q_H$

$$(COP)_{HP\ Actual} = \frac{Q_H}{Q_H - Q_L}$$

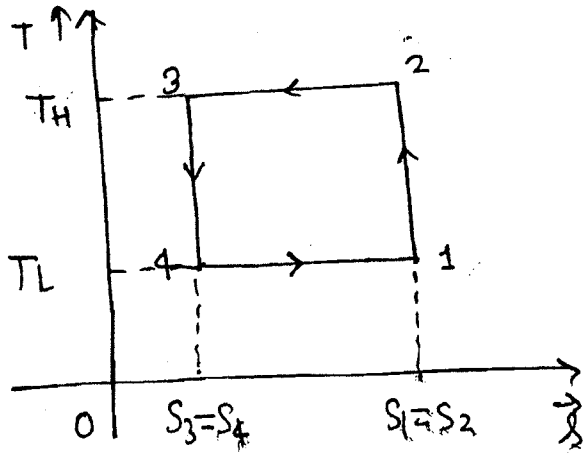
$$(COP_{HP})_{Ideal} = \frac{T_H}{T_H - T_L}$$




$$(COP)_{R\ Actual} = \frac{Q_L}{Q_H - Q_L}$$

$$(COP_R)_{Ideal} = \frac{T_L}{T_H - T_L}$$

- **Ideal Refrigeration Cycle or Reversed Carnot Cycle :→**



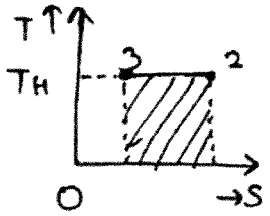
Process 1-2 Rev. adiabatic Compression

Process 2-3 Isothermal Heat rejection

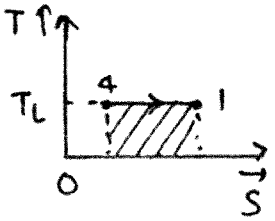
3-4 Isentropic Expansion

4-1 Isothermal heat addition

$$COP = \frac{DE}{W_{NET}} \qquad W_{Net} = Q_{Net} = \cancel{Q_{1-2}}^{\circ} + Q_{2-3} + \cancel{Q_{3-4}}^{\circ} + Q_{4-1}$$




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




$$dQ_{4-1} = T_L(S_1 - S_4) \quad \text{— (3)}$$

Use eqn (2) & (3) in eqn (1)

$$W_{Net} = Q_{Net} = -T_H(S_1 - S_4) + T_L(S_1 - S_4)$$

$$\boxed{W_{Net} = Q_{Net} = (T_L - T_H)(S_1 - S_4)} \quad \text{— (4)}$$

$$\boxed{W_{Net} = -ive}$$

From eqn (4) we can say that our System under consideration is a work absorbing device.

$$W_{input} = (T_H - T_L)(S_1 - S_4)$$

$$COP = \frac{DE \longrightarrow Q_{4-1} = T_L(S_1 - S_4)}{(T_H - T_L)(S_1 - S_4)}$$

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

NOTE:-

1. Reversed carnot COP is a function of temp. limits only

2. If there are 'n' number of Rev. Refrigerator are operating between same temp. limits with different working fluids, then the value of max. possible COP or Ideal COP or Reversed carnot COP are having same value.

3. Reversed Carnot COP is independent of working fluid

4. Producing Ice at 0°C

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

~~(b)~~ $(COP)_S < (COP)_W$

(c) $(COP)_S = (COP)_W$

(d) Can't say

| Summer | Winter |
|---|---|
| $T_L = 0^\circ C$ | $T_L = 0^\circ C$ |
| $T_H = 30^\circ C$ | $T_H = 10^\circ C$ |

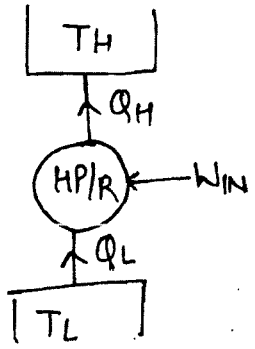
$T_L$ = constant — $(COP)_S < (COP)_W$

$(T_H)_S > (T_H)_W$

Relationship between Heat Pump COP & COP of Refrigerator: →

$$COP_{HP} = COP_R + 1$$

$$1 + COP_R = \frac{T_L}{T_H - T_L} + 1 = COP_{HP}$$




The above expression is applicable b/w same temp. limits

ESE

Q The efficiency of a reversible heat engine is 30% then the COP of reversible Heat Pump

Sol:

$$COP_{HP} = \frac{1}{\eta_{HE}} \Rightarrow (COP)_{HP} = \frac{1}{0.30} = 3.33$$

$$(COP)_{HP} = 1 + (COP)_R = \frac{1}{\eta_{HE}}$$

The above expression is applicable b/w same temp. limits/ratio.

- Unit of Refrigeration :→

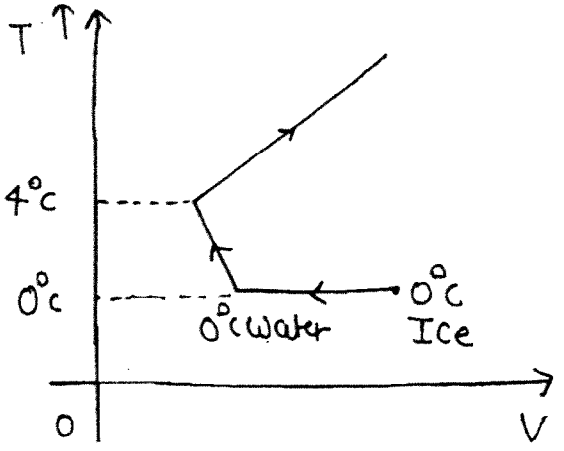
1 Ton of Refrigeration:

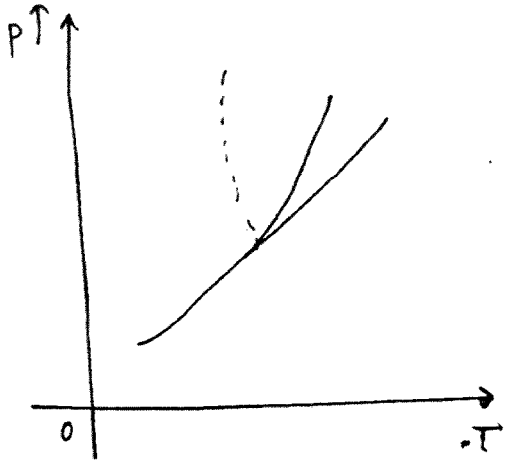
$$1TR = 3.5\,KW = 210\ \frac{KJ}{min} = 50\ \frac{kcal}{min}$$

It is the amount of heat which is required to extracts from one ton of water at 0°c in order to convert it into equivalent ICE at 0°c in a day (24 Hrs).

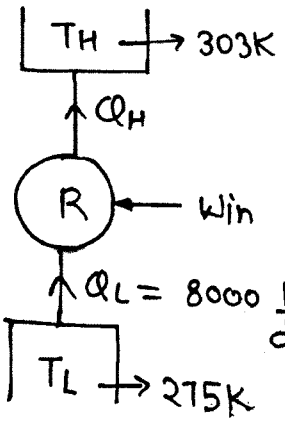
NOTE:→

1. density of water is max. at 4°c and during freezing it will expand



Que-4.




$$(COP)_A = 0.15\, COP_I = 0.15\left[\frac{T_L}{T_H - T_L}\right]$$

$$(COP)_A = 1.47$$

$$(COP)_A = \frac{DE}{Win} \Rightarrow Win = 0.062\ kw \times \frac{day}{24\ Hr}$$

$$\Rightarrow Win = 1.508\ \frac{Kw\,Hr}{day}$$

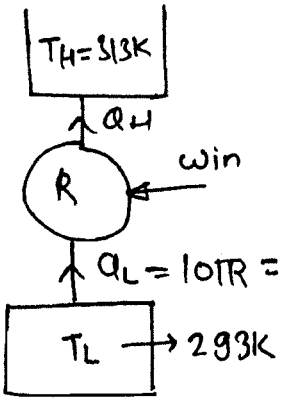
Que-3.

| Comfort | Ice |
|---|---|
| $T_H = 30°C$ | $T_H = 30°$ |
| $T_L = 16°C$ | $T_L = 0°C$ |

$T_H$ = Const.

$(COP)_{Comfort} > (COP)_{Ice}$

Que-5

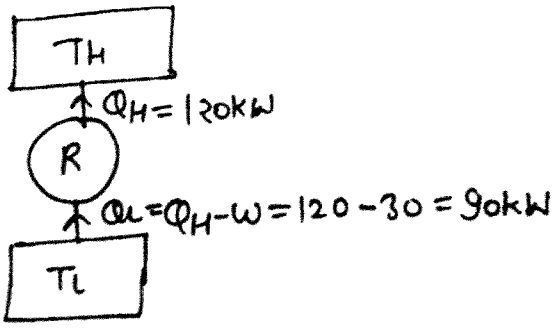



$Q_H = Q_L + W$

$Q_H = 35 + 2.37 = 37.37 KW$

$$(COP)_R = \frac{293}{313 - 293} = \frac{Q_L}{Win}$$

Que-6




$$(COP)_R = \frac{90}{30} = 3$$

Que-7.

$$COP_A = 0.75\left(\frac{T_L}{T_H - T_L}\right) = \frac{Q_L}{W_{in}}$$

$$W_{in} = 1.7kW$$

Que-8.

$$Q = \dot{m} C \Delta T$$

$$3.5 \times 1 = \dot{m} \times 4.187 \times (35-20)$$

$$\dot{m} = 0.055 \text{ kg/sec}$$

1 litre $= 10^{-3}\ m^3$

$$\rho = \frac{\dot{m}}{\dot{V}}$$

$$\dot{V} = \frac{\dot{m}}{\rho} = \frac{0.055}{1000} \text{ kg/sec}$$

$$\dot{V} = 200.9\ l/sec$$

Que-9.

1.5 kW/TR

↳ 1TR = 3.5kW

$$COP = \frac{3.5}{1.5} = \frac{7}{3}$$

$$(COP)_R = 2.33$$

Que 10

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

$$(COP)_{HP} = \frac{T_H}{T_H - T_L} = \frac{1}{1 - \frac{T_L}{T_H}} = \frac{1}{1-0.8} = 5$$

Que 11

$$Q_2 + Q_4 = 3Q_1$$

$$(COP)_R = 6$$