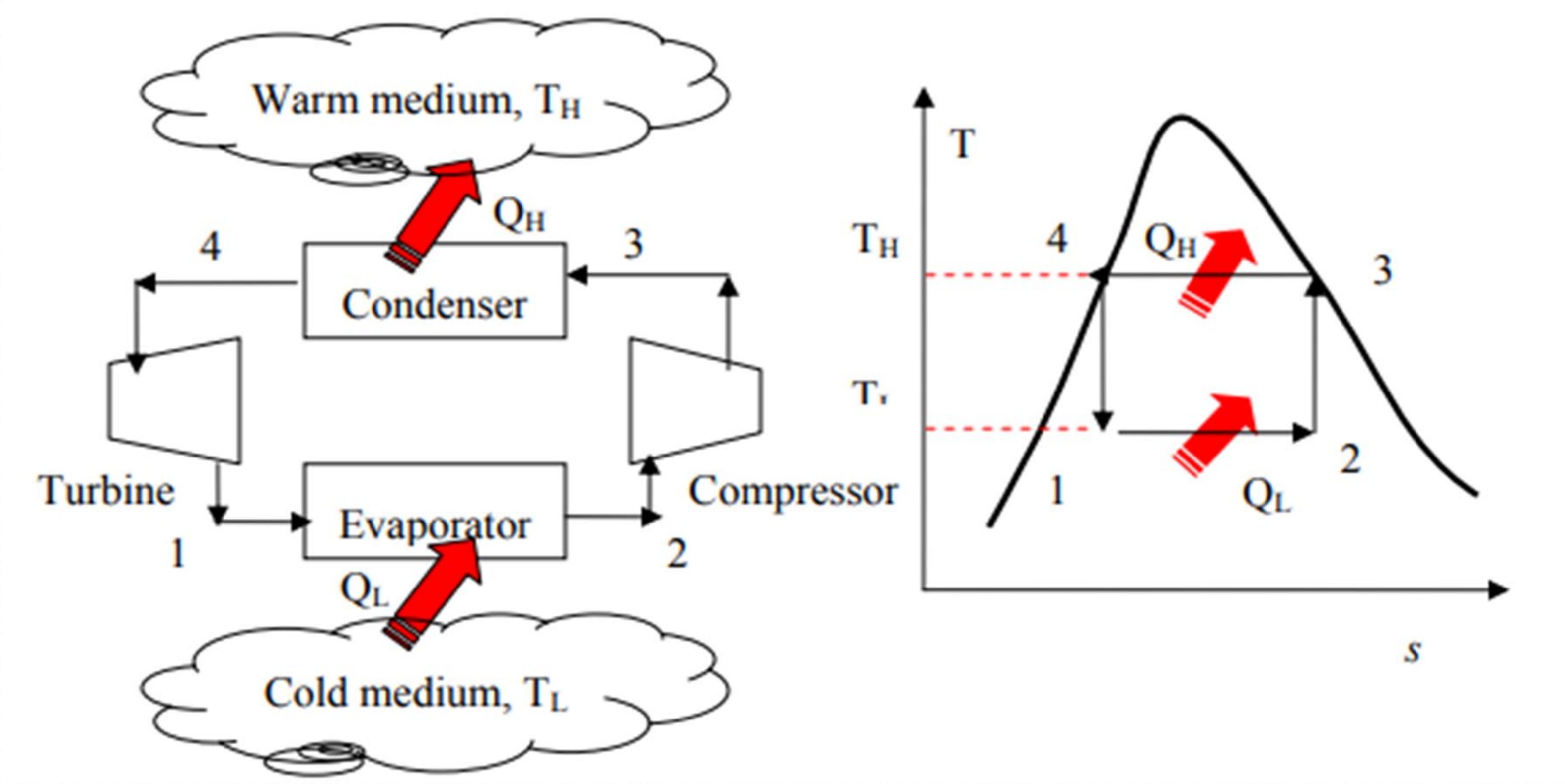
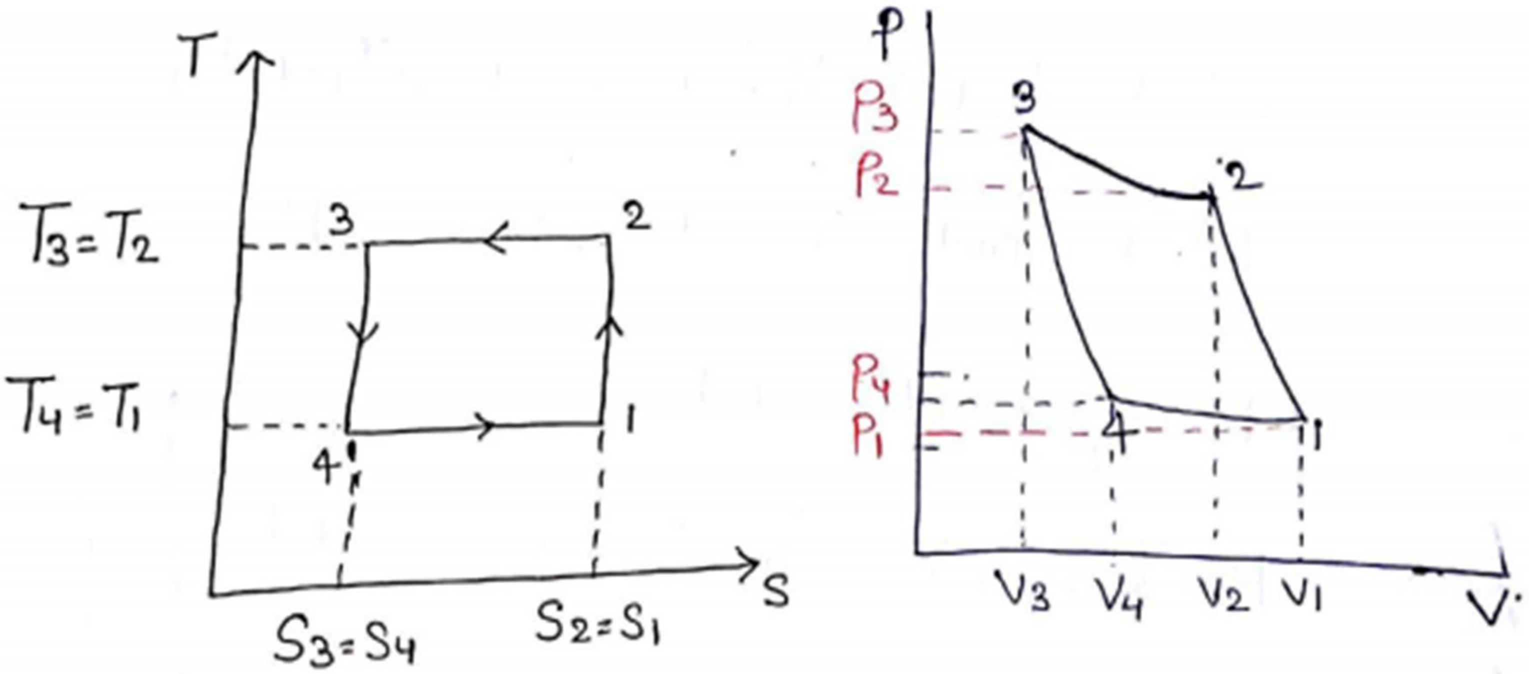
The Reversed Carnot Cycle

Reversing the Carnot cycle does reverse the directions of heat and work interactions. A refrigerator or heat pump that operates on the reversed Carnot cycle is called a Carnot refrigerator or a Carnot heat pump.

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

Temp.in K

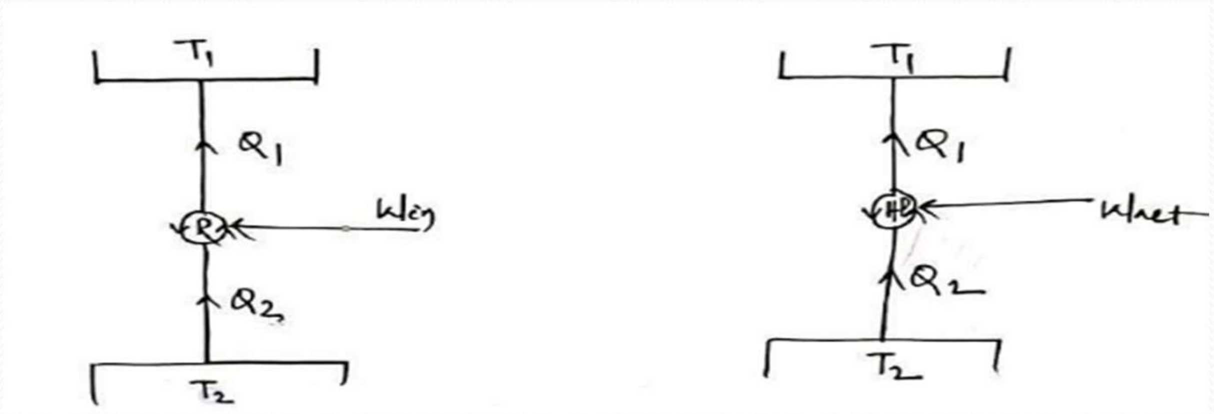

Warm medium, T_H
Q_H
4
3
Condenser
Turbine
Compressor
Evaporator
1
2
Q_L
Cold medium, T_L
T
T_H
4
Q_H
3
2
1
Q_L
s



l

Process 1-2: Isentropic Compression.
Process 2-3: Isothermal Compression.
Process 3-4: Isentropic Expansion.
Process 4-1: Isothermal Expansion.

Relation b/w COP of HP & Ref.



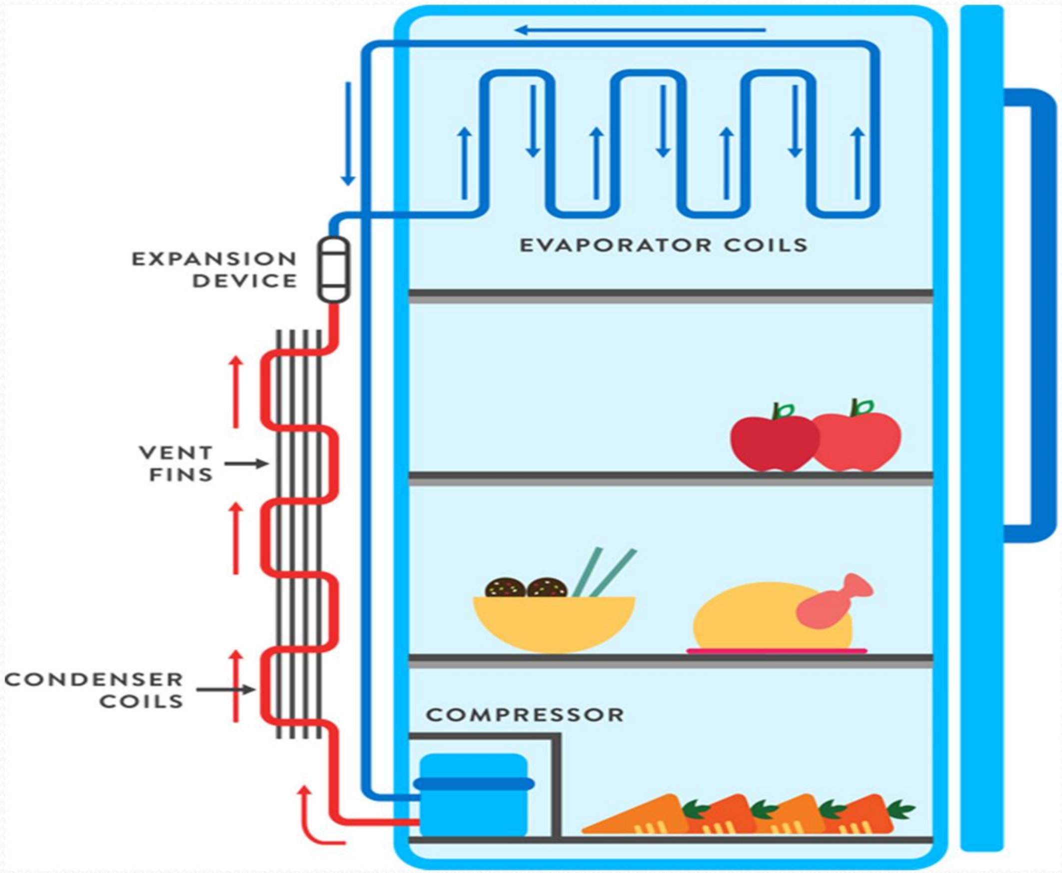
$$COP_{Ref} = \frac{Q_2}{Q_1 - Q_2} \qquad COP_{HP} = \frac{Q_1}{Q_1 - Q_2}$$

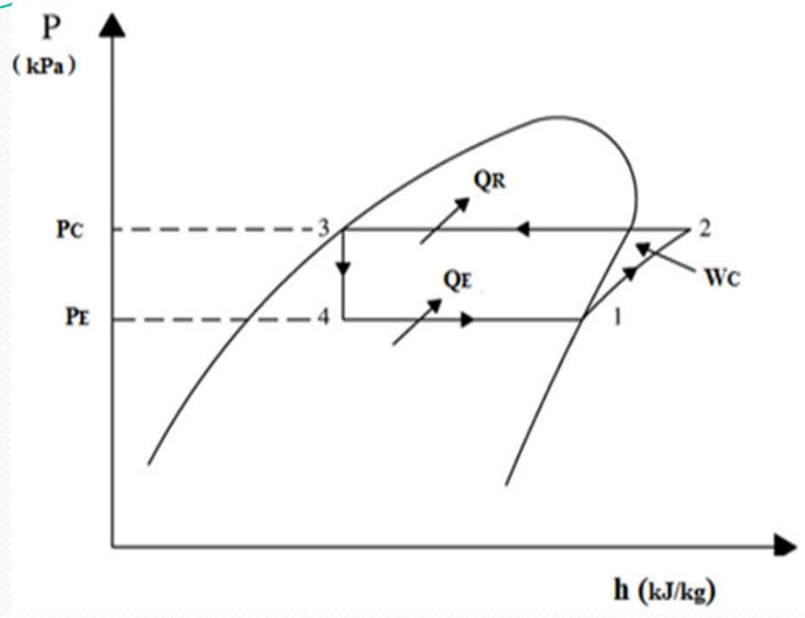
$$COP_{\ HP} = COP_{Ref} + \mathbf{1}$$

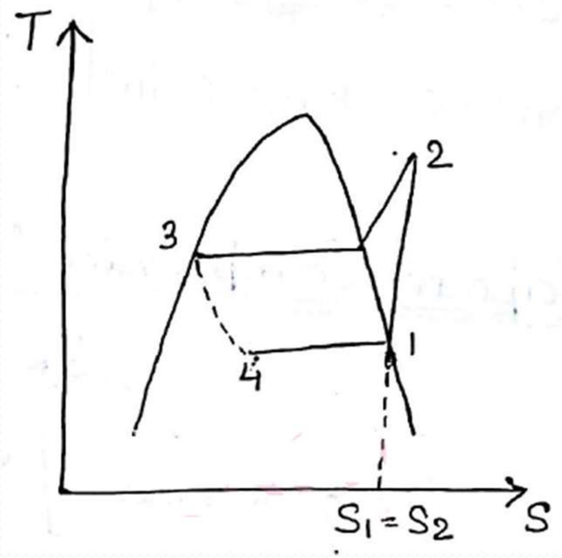
Same temp. limit

Vapor-Compression Refrigeration Cycle

Widely used cycle for refrigerators







- Process 1-2: Isentropic Compression.
- Process 2-3: const. pressure heat rejection
- Process 3-4: Isentropic Expansion (throttling).
- Process 4-1: constant pressure heat absorption

Compression :

$$W = h_2 - h_1$$

Condenser :

$$Q_r = h_2 - h_3$$

Expansion device:

$$h_3 = h_4$$

Evaporator

$$Q_E = h_1 - h_4$$

$$\mathbf{COP} = \frac{RE}{W}$$

$$\boldsymbol{COP_{max}} = \frac{h_1 - h_4}{h_2 - h_1}$$

$$h_3 = h_4$$

$$\boldsymbol{COP_{max}} = \frac{h_1 - h_3}{h_2 - h_1}$$

Volumetric Efficiency of a reciprocating compressor

It is the ratio of actual volume of refrigerant entering in compressor to the swept volume

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$$\eta_v = \frac{m^\circ v_1}{\frac{\pi}{4} D^2 L N K}$$

$$\eta_v = 1 + C - C\left[\frac{P_{higher}}{P_{lower}}\right]^{1/n} ; \eta_v = 1 + C - C\left[\frac{P_{cond.}}{P_{evop.}}\right]^{1/n}$$

n= polytropic index

C =clearance ratio

<u>Refrigeration Capacity RC</u>

$$RC = m^0 \ RE$$

$$RC = m^\circ (h_1 - h_4)$$

Power Input to the Compressor

$$P_{in} = m^\circ W_{in}$$

$$P_{in} = m^\circ (h_2 - h_1)$$