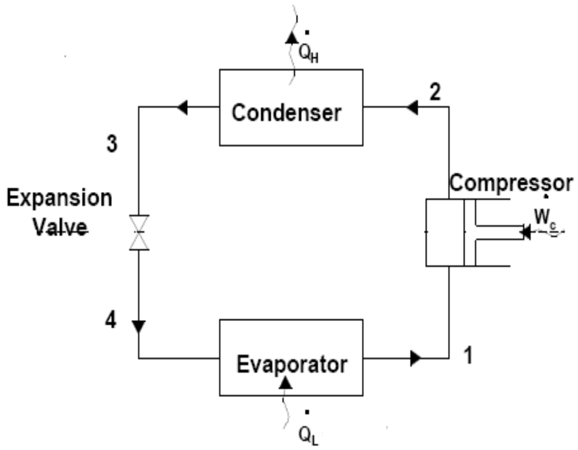
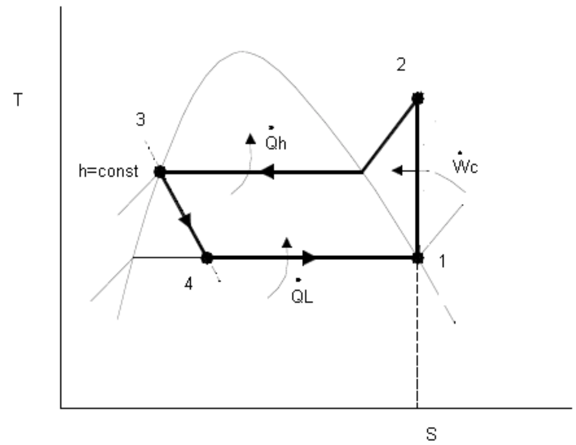
Summary

The ideal Refrigeration cycle schematic and T-s diagram:





Common Assumptions:

1) Evaporator and Condenser are constant pressure devices (P_4=P_1 & P_3=P_2)
2) Saturated vapour at the evaporator outlet (state 1)
3) Saturated liquid at the condenser outlet (state 3)
4) Steady operating conditions
5) $\Delta ke, \Delta pe = 0$
6) Adiabatic process in expansion valve (h_3=h_4)
7) For **Ideal Vapor Compression Refrigeration Cycle**: Isentropic compression (s_2=s_1)

Analysis:

Compressor → $w_{in} = h_2 - h_1$

Condenser → $q_{Ht} = h_2 - h_3$

Expansion Valve → $h_3 = h_4$

Evaporator → $q_L = h_1 - h_4$

Coefficient of Performance (COP_R):

$$COP_R = \frac{Benefit}{Cost} = \frac{q_L}{w_{in}} = \frac{h_1 - h_4}{h_2 - h_1}$$

Compressor Isentropic Efficiency:

$$\eta_c = \frac{w_s}{w_a} = \frac{h_{2s} - h_1}{h_{2a} - h_1}$$

Question

A large refrigeration plant is to be maintained at -15°C, and it requires refrigeration at a rate of 100 kW. The condenser of the plant is to be cooled by liquid water, which experiences a temperature rise of 8°C as it flows over the coils of the condenser. The plant uses refrigerant-134a between the pressure limits of 120 kPa and 700 kPa. Assuming the compressor has an isentropic efficiency of 75%, determine:

a) The mass flow rate of the refrigerant
b) The power input to the compressor
c) The mass flow rate of the cooling water
d) The rate of exergy destruction associated with the compression process (assume T_0=25°C)