Answer on Question #66749-Physics-Molecular Physics-Thermodynamics

a. Draw the carnot cycle on P-V diagram. Show that the amount of heat absorbed (rejected) in a reversible cycle is proportional to the temperature of source (sink).

Solution

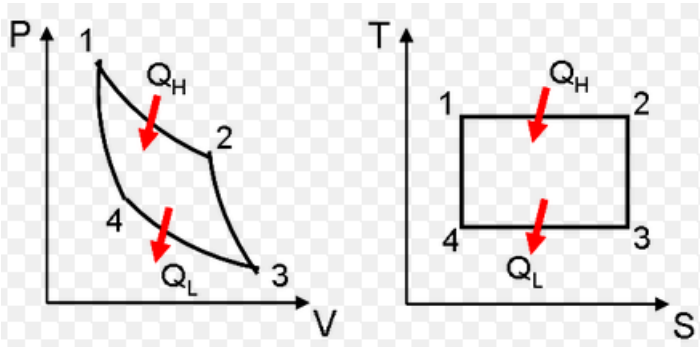
Carnot cycle is composed of four processes:

1-2. Isothermal heat addition (T=const)

2-3. Isentropic expansion (S=const)

3-4. Isothermal heat rejection (T=const)

4-1. Isentropic compression (S=const)



P-V and T-S diagrams of Carnot Cycle

The amount of heat absorbed from the T-S diagram is

$$Q_H = T_{source}(S_2 - S_1) \sim T_{source}.$$

The amount of heat rejected from the T-S diagram is

$$Q_L = T_{sink}(S_2 - S_1) \sim T_{sink}.$$

b. The efficiency of a Carnot engine is 30%. Its efficiency is to be raised to 60% by how much the temperature of the source be increased if the sink is at 27°?

Solution

$$\eta = 1 - \frac{T_{sink}}{T_{source}} = 0.3 \to T_{source} = \frac{T_{sink}}{0.7}.$$

$$\eta' = 1 - \frac{T_{sink}}{T'_{source}} = 0.6$$

$$T'_{source} = \frac{T_{sink}}{0.4}$$

The change in temperature of the source is

$$T'_{source} - T_{source} = \frac{T_{sink}}{0.4} - \frac{T_{sink}}{0.7} = T_{sink}\left(\frac{1}{0.4} - \frac{1}{0.7}\right) = (273 + 27)\left(\frac{1}{0.4} - \frac{1}{0.7}\right) = 321\ K.$$