efficiency Carnot cycle: $\eta = 1 - \frac{T_C}{T_H}$ = max efficiency of any cycle

Carnot refrigerator = Carnot cycle in reverse

$$C = \frac{Q_c}{W} = \frac{|Q_c|}{|W|} = \frac{|Q_c|}{|Q_H| - |Q_c|} = \frac{T_c}{T_H - T_c}$$

$T_H \to$ goes to ∞ $C \to 1$ ideal refrigerator

entropy $\frac{dQ_r}{T} = dS$ (reversible)

$$dU = TdS - PdV \qquad \text{(for a reversible process)}$$

all natural processes are irreversible
reverse process will not happen

Clausius' statement: it is impossible to construct a device that operates in a cycle and whose sole effect is to transfer heat from a cooler to a hotter body

Kelvin-Planck statement: it is impossible to construct a device that operates in a cycle and produces no other effect than the performance of work while exchange of heat with a single reservoir

Carnot's theorem: No engine operating between two reservoirs can be more efficient than a Carnot engine operating between the same two reservoirs

all reversible engines have the efficiency of a Carnot engine

$$\frac{Q_1'}{Q_2'} < \frac{Q_1}{Q_2} = -\frac{T_1}{T_2}$$

$$\int \frac{dQ'}{T} < 0$$

$$\downarrow$$

$$\int \frac{dQ}{T} \leq 0$$

$$dS \geq \frac{dQ_{irreversible}}{dT}$$

Entropy increases in irreversible process
and is unaltered in a reversible process

an isolated system is in equilibrium if its entropy has the maximum value

$$\Delta S_{universe} = \Delta S_{system} + \Delta S_{surroundings} \geq 0$$

one of the 2 can be negative

$$dU = TdS - PdV$$ always holds!