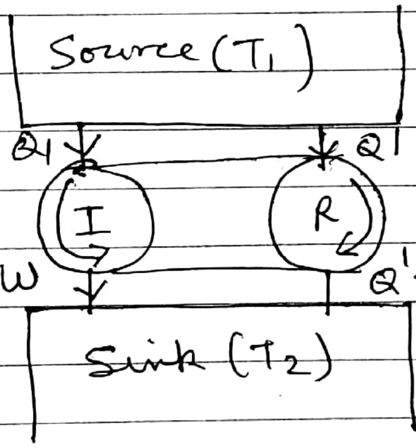
Second law of thermodynamics

Kelvin Planck statement :- It is impossible to construct a device which operates in a cycle has the sole effect of extracting heat from reservoir and performing the ~~same~~ equivalent amount of work.

Clausius statement :- It is impossible for self acting machine working in cycle process, unaided by any external agency to transfer heat from a body lower than the higher temp. i-e in other words the heat can not flow from colder to hotter body.

Carnot's Theorem: It states no engine working b/w two given temperature can be more sufficient than (carnot engine) working b/w the same limits of temperature (b/w source and sink)

Proof.



I & R are two engine I → Irreversible
R → Reversible

Efficiency of I → $\frac{W}{Q_1}$

R → $\frac{W}{Q_1'}$

Suppose $\eta_I > \eta_R$

$$\frac{W}{Q_1} > \frac{W}{Q'} \implies Q_1' - Q_1$$

$Q_1' - Q_1$ is a positive quantity

Now suppose two engine I & R couple together in a way that engine work directly forward and R backward. Now R work as refrigerator. Source Q_1 heat to I and gain from Q_1' from R

Heat gain by the source $= Q_1' - Q_1$

The sink gain heat $Q_1 - W$ from I and loses the $Q_1' - W$ to R.

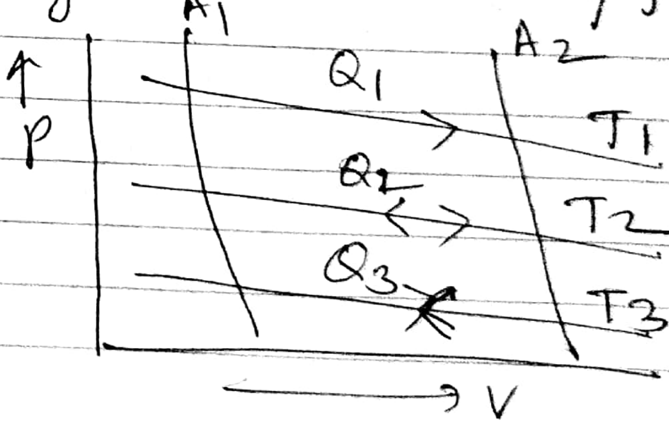
heat loss by sink $= (Q_1' - W) - (Q_1 - W)$

$= Q_1' - Q_1$

$= +ve$ quantity

Entropy :- Concept of entropy (Transformation) Clausius

Entropy of the system is a measure of the disorder of its molecular motion. Greater is the disorder of molecular motion of the system greater is the entropy.



Entropy from C → D

$$= \frac{Q_2}{T_2}$$ So loss in heat ③

So Net change in entropy

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

But in reversible carnot cycle $\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$

So $\frac{Q_1}{T_1} = \frac{Q_2}{T_2} = 0$

so $dS = \sum \frac{Q}{T} = 0$

(II) Change in irreversible process.

We know that $\eta = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$

or In terms of Temperature

$$\eta = 1 - \frac{T_2}{T_1}$$

According to the Carnot theorem this efficiency less that reversible engine

So $1 - \frac{Q_2}{Q_1} < 1 - \frac{T_2}{T_1}$

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

$$\frac{Q_2}{T_2} > \frac{Q_1}{T_1}$$

So $\frac{Q_2}{T_2} - \frac{Q_1}{T_1} > 0$ or positive there is increase in entropy of the system during irreversible process. Conduction of heat from higher to lower $T_1 > T_2$

Decrease in entropy of hotter body $= \frac{Q}{T_1}$

increase in entropy of colder body $\frac{Q}{T_2}$

Therefore net increase in entropy of the system $= \frac{Q}{T_2} - \frac{Q}{T_1}$ $T_1 > T$

$$= \frac{Q}{T_2} - \frac{Q}{T_1}$$

$$\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$$

$$\frac{Q_2}{T_2} = \frac{Q_3}{T_3} \Rightarrow \frac{Q_1}{T_1} = \frac{Q_2}{T_2} = \frac{Q_3}{T_3} = \text{const.}$$

$$\frac{Q}{T} = \text{const.}$$

- S_1 and S_2 are two arbitrary

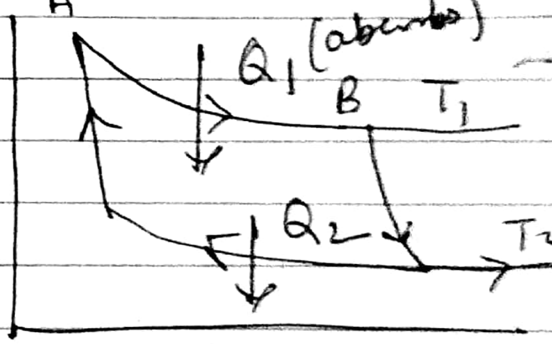
$$S_2 - S_1 = \frac{Q}{T}$$

in very small change $Q \rightarrow dQ$

$$dS = S_2 - S_1 = \int_{S_1}^{S_2} dS = \int \frac{dQ}{T}$$

change in entropy $= \dfrac{\text{Heat added or subtracted}}{\text{Absolute temp}}$.

- Change in entropy in reversible and irreversible process.



entropy of system from $A \rightarrow B$ +ve

$$\frac{Q_1}{T_1}$$

During adiabatic process $dQ = 0$ no change in entropy neither absorb or rejected.