Efficiency of Carnot engine (কার্নোইঞ্জিন)

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

* When $T_1 = T_2$ then $\eta = \frac{0}{T_1} = 0$. i.e. no work is done by Carnot engine.

* When $T_2 = 0\,K$ then $\eta = \frac{T_1 - 0}{T_1} = 1$ i.e. Carnot engine is 100% efficient

But it is not possible to reach absolute zero temp. i.e. 0K $(-273^\circ C)$.
So, we can not form 100 % efficient engine.

Q. A Carnot engine is working b/w temp. range 40°c to 80°c. Calculate η.

$T_1 = 80^\circ C = 353\,K$

$T_2 = 40^\circ C = 313\,K$

$$\eta = \frac{T_1 - T_2}{T_1} = \frac{(353 - 313)\,K}{353\,K} \times 100 = \frac{40 \times 100}{353} = 11.33\,\%$$

Entropy :-

Entropy is randomness of the system. Entropy $(S) = \frac{q}{T}$

$$\Rightarrow dS = \frac{dq}{T}$$

Unit = Joule/K (SI)

Cal/K or erg/K (CGS)

Entropy is a state function. (অবস্থা অপেক্ষক)

(*) Entropy change for 1-mole ideal gas, $\Delta S = C_v \ln\left(\frac{T_2}{T_1}\right) + R \ln\left(\frac{V_2}{V_1}\right)$ ------- (I)

$$\Delta S = C_p \ln\left(\frac{T_2}{T_1}\right) + R \ln\left(\frac{P_1}{P_2}\right) \text{ ------- (II)}$$

Q 2 moles of an ideal gas is expanded isothermally from 5 lit to 20 lit at 30°C. temp. Calculate change of entropy.

Ans :- we know $\Delta S = C_v \ln\left(\frac{T_2}{T_1}\right) + R \ln\left(\frac{V_2}{V_1}\right)$ {For isothermal proces $T_1 = T_2$ $\therefore C_v \ln\left(\frac{T_2}{T_1}\right) = 0$}

$\Rightarrow \Delta S = R \ln\left(\frac{V_2}{V_1}\right)$ for 1 mole ideal gas.

For 2 moles of an idal gas $\Delta S = 2R \ln\left(\frac{V_2}{V_1}\right) = 2 \times 8.314 \times \ln\left(\frac{20}{5}\right)$

$$\Rightarrow \Delta S = 23.051 \text{ Joule/K}.$$

Q. 1 gm-molecule of an ideal gas is heated from 25°C to 125°C at constant pressure. If the value of $C_p = \frac{5}{2}R$ then calculate entropy change.

$T_1 = 25°C = 298K$

$T_2 = 125°C = 398K$

Ans We know, $\Delta S = C_p \ln\left(\frac{T_2}{T_1}\right) + R \ln\left(\frac{P_1}{P_2}\right)$

At const. pressure $P_1 = P_2$; i.e. $R \ln\left(\frac{P_1}{P_2}\right) = 0$

∴ Entropy chang for 1 gm-molecules of ideal gas is

$$\Delta S = C_p \ln\left(\frac{T_2}{T_1}\right)$$

$$= \frac{5}{2} R \ln\left(\frac{398}{298}\right)$$

$$= \frac{5}{2} \times 1.98 \times \ln\left(\frac{398}{298}\right)$$

$$\Rightarrow \Delta S = 1.4323 \text{ Cal/K}$$