# Entropy Change in an Irreversible Process

## Principle of increase of entropy

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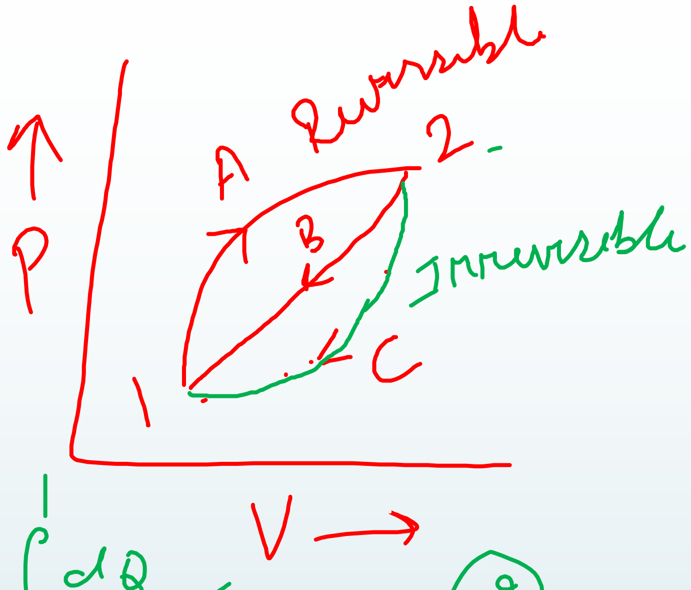
Reversible

$$\oint_r \frac{dQ}{T} = \int_{1A}^{2} \frac{dQ}{T} + \int_{2B}^{1} \frac{dQ}{T} = 0$$




$$\Rightarrow \int_{1A}^{2} \frac{dQ}{T} = -\int_{2B}^{1} \frac{dQ}{T} \quad — (1)$$

For irreversible cycle $\oint \frac{dQ}{T} = \int_{A1}^{2} \frac{dQ}{T} + \int_{C2}^{1} \frac{dQ}{T} < 0 \quad — (2)$

$$-\int_{2B}^{1} \frac{dQ}{T} + \int_{2C}^{1} \frac{dQ}{T} < 0$$

$$\Rightarrow \int_{2B}^{1} \frac{dQ}{T} > \int_{2C}^{1} \frac{dQ}{T} \quad — (3)$$

path B is reversible $\int_{B2}^{1} \frac{dQ}{T} = \int_{B2}^{1} dS \quad — (4)$

$$\int_{2_B}^{1} ds = \int_{2_C}^{1} ds \quad \text{--- (5)}$$

$$\Rightarrow \int_{2_C}^{1} ds > \int_{2_C}^{1} \frac{dQ}{T}$$

$$\boxed{ds > \frac{dQ_i}{T}}$$

$$ds = \frac{dQ_r}{T}$$

$$\Rightarrow ds \geq \frac{dQ}{T}$$

$$\text{or} \quad S_2 - S_1 \geq \int_1^2 \frac{dQ}{T}$$

$T_{surr}$ $T_{sys}$

$$dS \geq \frac{dQ}{T}$$

For an isolated system $dQ = 0$

$$dS \geq 0$$

Reversible $dS = 0 \Rightarrow S = \text{Const}$

Irr. $\underline{\underline{dS > 0}}$

$$dS[\underline{\text{universe}}] \geq 0$$

# Entropy and Second Law of Thermodynamics

$$\oint \frac{dQ}{T} = 0$$

$$\Rightarrow \int_{1A}^{2} \frac{dQ}{T} + \int_{2B}^{1} \frac{dQ}{T} = 0 \quad \text{— (1)}$$

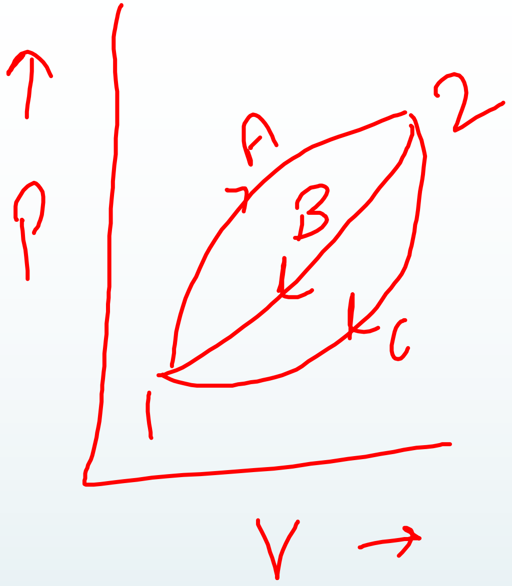
$$\int_{1A}^{2} \frac{dQ}{T} + \int_{2C}^{1} \frac{dQ}{T} = 0 \quad \text{— (2)}$$

$$\int_{2B}^{1} \frac{dQ}{T} = \int_{2C}^{1} \frac{dQ}{T} \quad \text{— (3)}$$

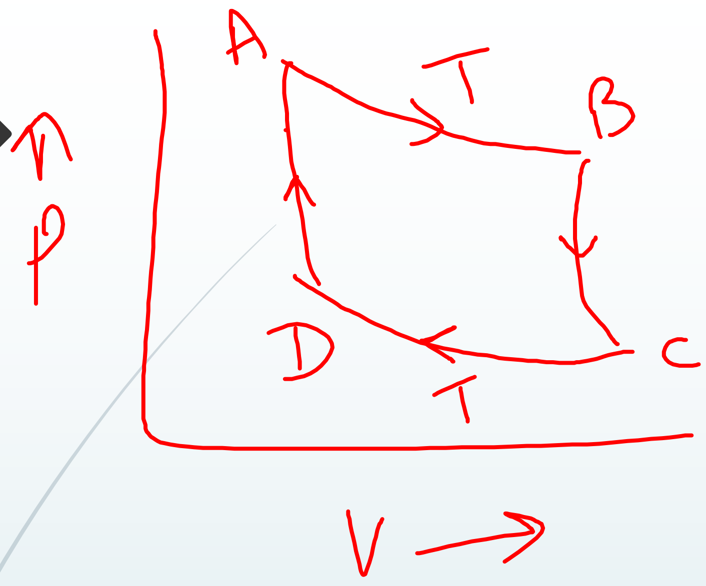
$$S_2 - S_1 = \int_{1}^{2} \frac{dQ}{T} \quad \text{— (4)}$$

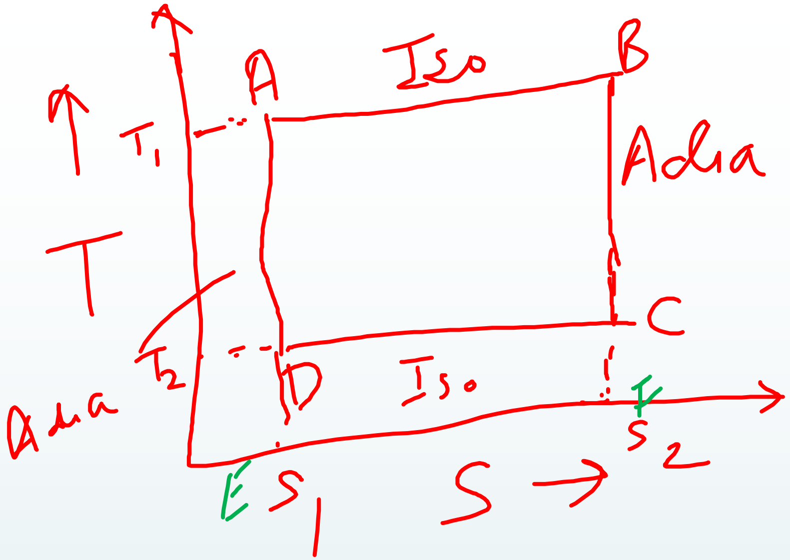
$$\Rightarrow dS = \frac{dQ}{T}$$

or $dQ = T\,dS$



# Temperature Entropy (T-S) Diagram




$Q_1 =$ Area ABFEA $= T_1(S_2 - S_1)$ — (1)

$Q_2 =$ Area CFEDC $= T_2(S_2 - S_1)$ — (2)

∴ Heat energy converted into work

$= Q_1 - Q_2 =$ Area ABCDA

$= (T_1 - T_2)(S_2 - S_1)$ — (3)

The efficiency of carnot engine

$$\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1}$$

$$= \frac{(T_1 - T_2)(S_2 - S_1)}{T_1 (S_2 - S_1)}$$

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

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

# Thank you