2° PRINCIPIO TERMODINAMICA

- Evidenza sperimentale di IRREVERSIBILITÀ

{ · GAS PERFETTO
· TRA. REV.

$$\delta Q = nC_V\,dT + \delta L = nC_V\,dT + p\,dV \qquad T_S = T$$

$$\frac{\delta Q}{T} = nC_V\frac{dT}{T} + nR\frac{dV}{V}$$

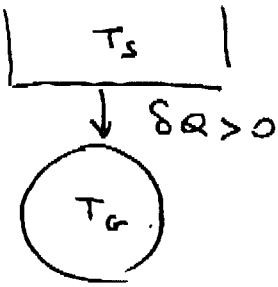
$$\boxed{\frac{\delta Q}{T} = nR\left\{d\,lg\left(VT^{\frac{1}{\gamma-1}}\right)\right\}}$$

↑ DIFFERENZIALE ESATTO

$$dS = \frac{\delta Q}{T} \qquad S = \text{ENTROPIA}$$

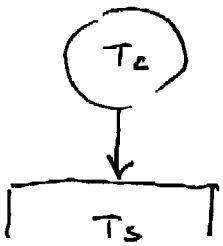
CICLO IRREVERSIBILE

$$\oint \frac{\delta Q}{T_S}$$



$$\boxed{T_S > T_C = T}$$

$$\frac{\delta Q}{T_S} < \frac{\delta Q}{T_C}$$



$$\boxed{T_S < T_C}$$

$$\left|\frac{\delta Q}{T_S}\right| > \left|\frac{\delta Q}{T_C}\right|$$

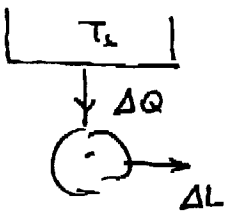
$$\oint_{IRR} \frac{\delta Q}{T_s} < \oint_{REV} \frac{\delta Q}{T} = 0$$

$$\boxed{\oint \frac{\delta Q}{T} \leq 0}$$

DISUGUAGLIANZA DI CLAUSIUS

FORMULAZIONE ANALITICA 2° PRINCIPIO

A)

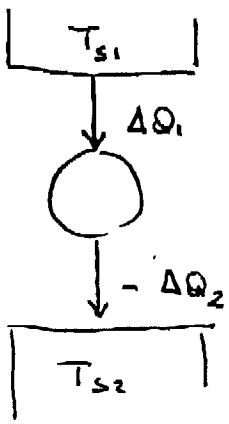


$$\oint \frac{\delta Q}{T_s} \leq 0 \qquad T_s > 0$$

$$\delta Q < 0 \Rightarrow \delta L < 0$$

|| Impossibile produrre lavoro $\delta L > 0$ operando con una sola sorgente (Enunciato di Kelvin)

B)



Supponiamo $\Delta Q_1 = |\Delta Q_2|$

$$\frac{\Delta Q_1}{T_1} - \frac{\Delta Q_2}{T_2} \leq 0$$

$$\frac{\Delta Q}{T_1} - \frac{\Delta Q}{T_2} \leq 0$$

$$\frac{1}{T_1} - \frac{1}{T_2} \leq 0 \Rightarrow \boxed{T_2 \leq T_1}$$

Impossibile realizzare il ciclo se $T_2 > T_1$

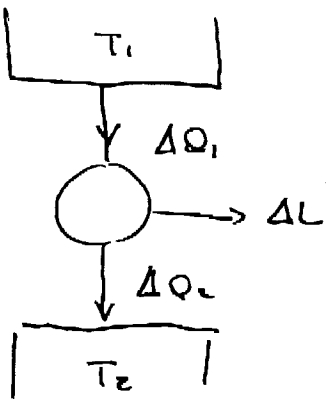
|| Impossibile senza fare lavoro far passare calore da una sorgente più fredda ad una più calda

Enunciato di Clausius

TEOREMA DI CARNOT

1) $\eta < \eta_c$

2) η indipende dalla sostanza termodinamica



Disuguaglianza di Clausius

$$\frac{\Delta Q_1}{T_1} - \frac{\Delta Q_2}{T_2} \leq 0 \rightarrow \frac{\Delta Q_1}{T_1} \leq \frac{\Delta Q_2}{T_2}$$

$$\eta = 1 - \frac{\Delta Q_2}{\Delta Q_1}$$

$$\frac{T_2}{T_1} \leq \frac{\Delta Q_2}{\Delta Q_1}$$

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

$$\eta \leq \eta_c$$

TEMPERATURA ASSOLUTA

Macchina di Carnot $T_2 = 100°$; $T_1 = 0°C$

$$\eta_c = \frac{T_1 - T_2}{T_1} \rightarrow T_1 = \frac{\Delta T}{\eta_c}$$

↑ VALORE ASSOLUTO DI T_1