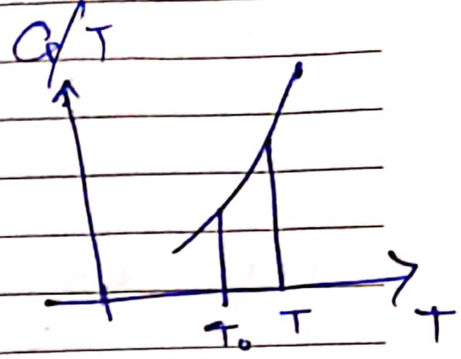
The third Law!



$$C_p = T\left(\frac{\partial S}{\partial T}\right)_p$$

$$\int_{T_0}^{T} dS = \int_{T_0}^{T} \frac{C_p}{T}\, dT$$

$$\Rightarrow S(T) = S(T_0) + \int_{T_0}^{T} \left(\frac{C_p}{T}\right) dT$$

Nernst:

$$G = H - TS$$

$$\Rightarrow \Delta G = \Delta H - T\Delta S \Rightarrow \Delta S = \frac{\Delta G - \Delta H}{T}$$

$$T \to 0 \Rightarrow \Delta G \to \Delta H$$

$$T \to 0 \Rightarrow \Delta S \to 0$$

Near absolute zero, all reactions in a system in internal equilibrium take place with no change of entropy.

$$\lim_{T \to 0} \Delta S \to 0$$

Plank: The entropy of all systems in internal equilibrium is the same at absolute zero, and may be taken to be zero

$$S = k_B \ln \Omega$$

Simon's statement:

The contribution to the entropy of a system by each aspect of the system which is in internal thermodynamic equilibrium tends to zero as $T \to 0$.

Consequences:

1.) $C_x = T\left(\frac{\partial S}{\partial T}\right)_x = \left(\frac{\partial S}{\partial \ln T}\right)_x \to 0$

$T \to 0 \Rightarrow \ln T \to -\infty \Rightarrow S \to 0 \Rightarrow C \to 0$

$C_V = \frac{3R}{2}$

2.) $S \to 0$ for $T \to 0$

$\Rightarrow \left(\frac{\partial S}{\partial p}\right)_T \to 0$

$\Rightarrow \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_p \to 0.$ $\alpha_p \to 0$

$\Rightarrow pV \neq RT$ $\Rightarrow$ Ideal gas will not remain ideal.

3. $C_p - C_V = R$

$$S_2 - S_1 = C_v \ln\left(T_2/T_1\right) + R \ln\left(V_2/V_1\right)$$

$$S = \text{Const} + C_v \ln T + R \ln V$$

$$T \to 0, \Rightarrow S \to -\infty$$

4.) $$\left(\frac{\partial S}{\partial B}\right)_T = \left(\frac{\partial M}{\partial T}\right)_B = \frac{VB}{\mu_0}\left(\frac{\partial \chi}{\partial T}\right)_B$$

~~$T \to \infty$, as~~ Curie's Law $\chi \sim \frac{1}{T}$

$\Rightarrow T \to 0, \Rightarrow \chi \to \infty$

$\Rightarrow \frac{\partial \chi}{\partial T}$

$$\left(\frac{\partial S}{\partial B}\right)_T \to 0$$

$\Rightarrow$ All ideal laws breaks.

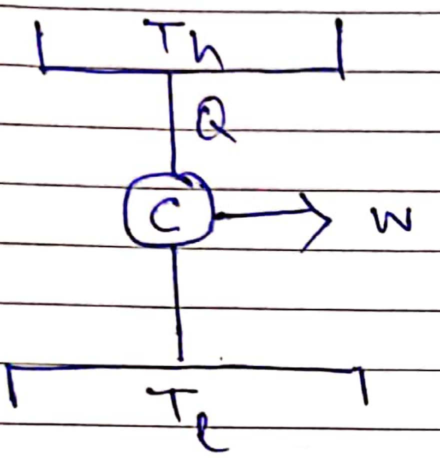
Interaction:

$\Rightarrow$ At high temp microscopic parts behave independently. $K_B T >$ int.

$\Rightarrow$ At low temp interactions are important

Final Statement:

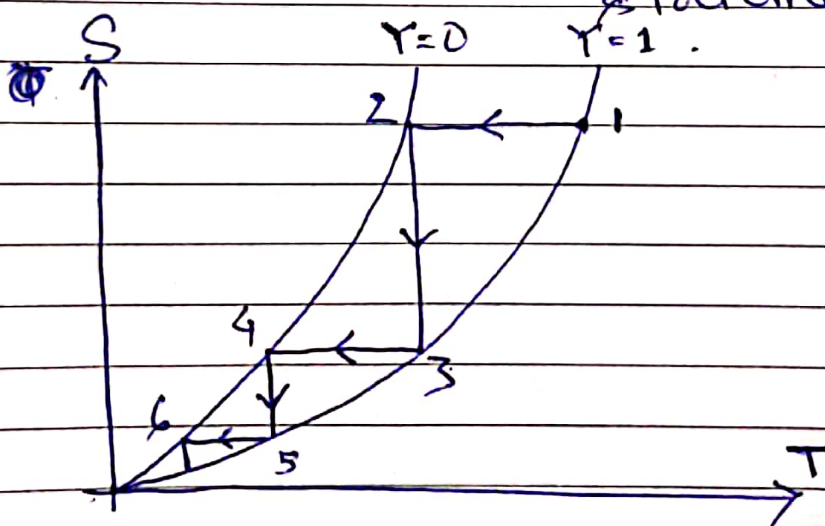
- It is impossible to cool to $T=0$ in a finite no of steps. (Reversible)



$$\eta = 1 - \frac{T_l}{T_h}$$

$T_l \to 0 \Rightarrow \eta \to 1$.

violation of Kelvin's statement.



$\boxed{Y = B}$

$$C_Y = \left(\frac{\partial S}{\partial T}\right)_Y T$$

$$\Rightarrow \frac{C_Y}{T} = \left(\frac{\partial S}{\partial T}\right)_Y \geq 0$$

$$\left(\frac{\partial T}{\partial Y}\right)_{S,N} = - \left(\frac{\partial T}{\partial S}\right)_{Y,N} \left(\frac{\partial S}{\partial Y}\right)_{T,N}$$

1) Isothermal expansion. $S\downarrow\ Y\uparrow$

2.) Adiabatic compressi $T\downarrow\ Y\downarrow$