بسم الله الرحمن الرحيم

الدرس الثالث

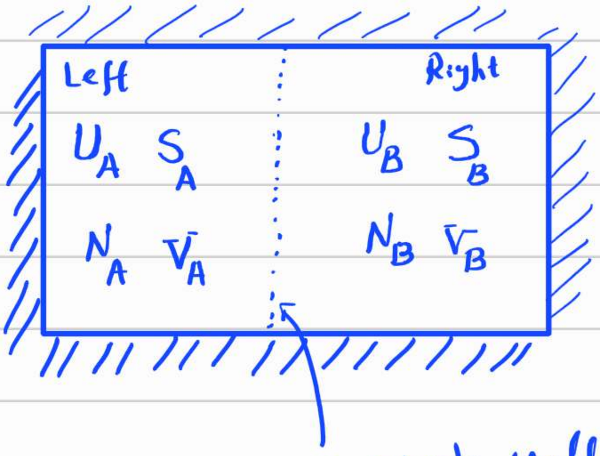
Lesson 3

٢/٢/١٤٠٤

Thermodynamical Equilibrium التوازن الديناميكي الحراري

Thermodynamical Laws القوانين الديناميكا الحراري

① What is the concept of thermodynamical Equilibrium?



a simple wall

$U \equiv$ Internal Energy

$S \equiv$ Entropy

$N =$ Number of Particles

$V =$ Volume

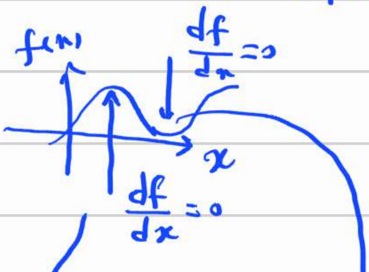
(1-1) ☆ Thermall Equilibrium

التوازن حراري $\Rightarrow \boxed{T_A = T_B}$

$$S_{total} = S_A + S_B$$

$$\underline{U_{total}} = U_A + U_B = \text{Constant} : \underline{cts.} \quad \text{ثابت}$$

For Equilibrium : $S_{total} \equiv$ Extremum ?



☆ $$\left.\frac{\partial S_{total}}{\partial U_A}\right|_{N_A = cts,\ V_A = cts} = 0$$

$\hookrightarrow \dfrac{d^2f}{dx^2} < 0$ $\qquad$ $\downarrow \dfrac{d^2f}{dx^2} > 0$

Principle of Statistical Mechanics

$$\underbrace{\left.\frac{\partial S_{total}}{\partial U_A}\right|_{\substack{N_A = cts \\ V_A = cts}} = 0 \quad \text{or} \quad \left.\frac{\partial S_{total}}{\partial U_B}\right|_{\substack{N_B = cts \\ V_B = cts}} = 0}$$

$$0 = \frac{\partial S_{total}}{\partial U_A} = \frac{\partial [S_A + S_B]}{\partial U_A} = \boxed{\frac{\partial S_A}{\partial U_A} + \frac{\partial S_B}{\partial U_A} = 0} \quad \text{I}$$

$$0 = dU_{total} = d(U_A + U_B) = dU_A + dU_B = 0$$

Isolated System

$$\boxed{dU_A = -dU_B} \quad \text{II}$$

$$\text{I}, \text{II} \Rightarrow \frac{\partial S_A}{\partial U_A} + \frac{\partial S_B}{-\partial U_B} = 0 \Rightarrow \boxed{\frac{\partial S_A}{\partial U_A} = \frac{\partial S_B}{\partial U_B}} \ \star\star\star$$

$N = cts$
$V = cts$

Energy Conservation (First law of thermodynamics)

$$dU = Tds - \underbrace{Pdv}_{=0} + \underbrace{\mu dN}_{=0} \Rightarrow \underbrace{du - \underset{0}{\mu dN} + \underset{0}{PdV}}_{\substack{N = cts \\ V = cts}} = TdS$$

$$\Rightarrow \quad dU = T\,dS \rightarrow \boxed{\frac{dS}{dU} = \frac{1}{T}}$$

For thermall Equilibrium with $N = cts$, $V = cts$

$$\frac{1}{T_A} = \frac{1}{T_B} \Rightarrow \boxed{T_A = T_B}$$

1-2 ★ Mechanical Equilibrium. / توازن مکانیکی

$$\boxed{P_A = P_B}$$

$$\left.\frac{\partial S_{total}}{\partial V_A}\right|_{\substack{N = cts \\ U = cts}} = 0 \Rightarrow \left.\frac{\partial S_A}{\partial V_A}\right|_{\substack{N_A = cts \\ U_A = cts}} = \left.\frac{\partial S_B}{\partial V_B}\right|_{\substack{N_B = cts \\ U_B = cts}}$$

$$dU = T\,dS - P\,dV \rightarrow \begin{cases} U_A = cts \\ U_B = cts \end{cases} \quad \begin{cases} dU_A = 0 \\ dU_B = 0 \end{cases}$$

$$T\,ds = P\,dv \Rightarrow \left.\frac{ds}{dv}\right|_{\substack{U=cts \\ N=cts}} = \frac{P}{T}$$

Mechanical
↑ Equilibrium

ضغط

$$\boxed{\frac{P_A}{T_A} = \frac{P_B}{T_B}} \quad \Rightarrow \quad \boxed{P_A = P_B}$$

If $T_A = T_B$

(1-3) ☆ Chemical Equilibrium توازن الكيميائي

$$0 = \frac{\partial S_{total}}{\partial N_A} \Rightarrow \boxed{\frac{\partial S_A}{\partial N_A} = \frac{\partial S_B}{\partial N_B}}$$

$$dU = 0 \leftarrow \begin{cases} U_A = cts \\ U_B = cts \end{cases}$$

$$dV = 0 \leftarrow \begin{cases} V_A = cts \\ V_B = cts \end{cases}$$

$$d\cancel{U} + P\,d\cancel{V} - \mu\,dN = T\,ds$$

$$\boxed{\frac{\partial S}{\partial N} = -\frac{\mu}{T}} \quad \begin{matrix} U = cts \\ V = cts \end{matrix}$$

$$\boxed{\frac{\mu_A}{T_A} = \frac{\mu_B}{T_B}} \Rightarrow \boxed{\mu_A = \mu_B}$$

If $T_A = T_B$

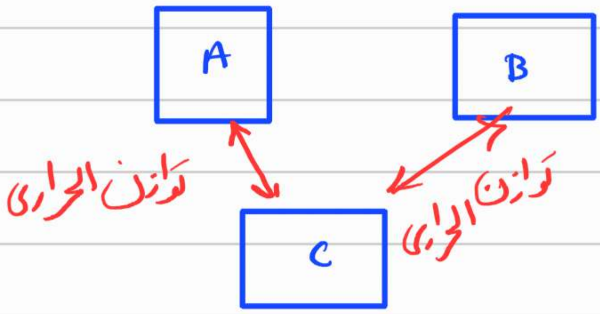
The lower value of μ, the higher desier to absorb particles

② A glance & brief about thermodynamical laws.

موجز عن القوانين الديناميكية الحراريه

2-1 Zeroth Law قانون صفري

Two systems which are in thermal Equilibrium with third system separately, are thermally Equilibrium togather



$T_A = T_C$

$T_B = T_C$

$\Rightarrow \boxed{T_A = T_B}$

2-2 First Law

انحفاظ الطاقة

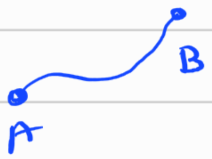
Conservation of Energy.

$$dU = \delta Q + \delta W$$

Change in Internal Energy is due to either change in $\underbrace{\text{heat}}_{Q}$ or/and $\underbrace{\text{Work}}_{W}$.

$$\boxed{dU = Tds - P dv + \mu dN}$$ General Form.

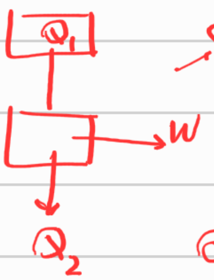
U: is state Parameter : this means that



$\Delta U = U_B - U_A$ and It is independent from selected path.

2-3 Second Law

$$\boxed{ds \geq \frac{\delta Q}{T}}$$



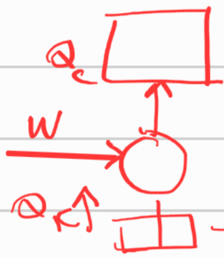
There is No Ideal car

$\cancel{Q_2 = 0}$

→ The efficiency of Machine is less Than 100%

For Reversible Process $ds = \frac{\delta Q}{T}$

For Irreversible Proce $ds > \frac{\delta Q}{T}$



$\cancel{w = 0}$

Hot Part

Cold part

There is No Ideal Rerigerator

2-4 Third Law:
القانون الثالث

- Nernst Statement
- Planck Statement
- Simon Statemen

If $T \rightarrow 0$ $\quad \Delta S \rightarrow 0$

$$\lim_{T \to 0} C_p - C_v \rightarrow 0$$

or at Zero Temperat (-273°)

No Ideal Gas

The Zero Kelvin is Not accesible.

لا يمكن الوصول الى صفر مطلق

الاحترام والتقدير