بسم الله الرحمن الرحيم

الدرس الرابع

- × ※ Ideal Gas الغاز المثالي
- × ※ Some thermodynamical processes
- ※ Thermodynamical Potential.

① Ideal Gas الغاز المثالي

What is the meaning of Ideal Gas?

ما معنى الغاز المثالي؟

The Hamiltonian for Ideal Gas is

Total Energy ← $H = H_0 + \cancel{H_I}$ 0

For Intraction

We ignore this part

يعني بدون تفاعل

↓

Internal Energy

الطاقة الداخلية

Also we ignore its volume

$$\lim \frac{v}{V} = 0$$

v → The volume of Particle

تجاهل حجم جسيم

V → The Volume of Container

What is Internal Energy ? $U = ?$

To derive U, We have 4 approaches.

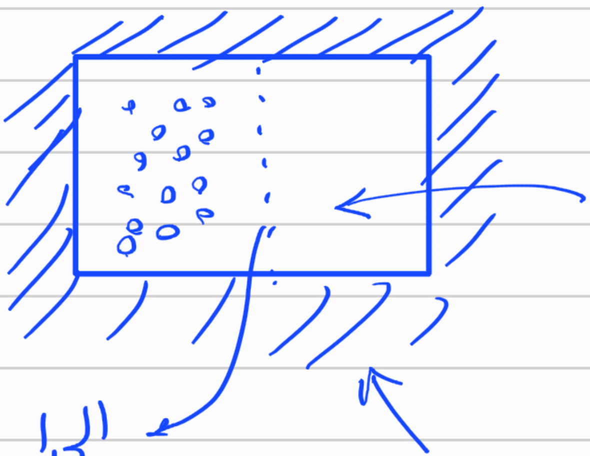
* First approach

النهج الاول

according to Joule Expansion

(Free Expansion)

التوسع الحر



خلاء (Empty part)

الجدار

Isolated from rest Part of Universe.

After Removing wall

After Removing wall	Befor removing wall
$V = V_2$	$V = V_1$
$T = T_2$	$T = T_1$
$P = P_2$	$P = P_1$

$V_2 \neq V_1$

$P_2 \neq P_1$

$T_2 = T_2$ ← Important

Also Work done by system is

Zero

$\Delta W = 0$, $W_1 = W_2$

there is no Heat Transfer so

$Q_1 = Q_2 \Rightarrow \Delta Q = 0$

$$\Delta U = \Delta Q + \Delta W = 0$$

So $\longrightarrow U_1 = U_2$

Now $U(T)$: Only depends on Temperature

$$\boxed{U = \frac{3}{2} N K_B T}$$ For Ideal Gas

* Second approach النهج الثاني

$$U = -\frac{\partial}{\partial \beta} \ln Z \quad , \beta \equiv \frac{1}{K_B T}$$

$\uparrow$ Partition Function

* Third approach النهج الثالث

Virial Theorem

* Forth approach　　　　النهج الرابع

State Function　　$PV = NK_BT$

First law of thermodynamics

$$dU = Tds - Pdv$$

Exercise: Using Forth approach

Show that $U = \frac{3}{2} NK_BT$

التمرين لكم

② Some Thermodynamical Processes

بعض العمليات الديناميكية

☆ Ⓐ Isobaric Process — المتساوي الضغط

$$P = cts. \quad \text{ثابت}$$

$$dU = T\,ds - P\,dv \quad , \quad dW = -P\,dv$$

$\boxed{\text{Variation in Work}}$ → تغيرات في الشغل $\Longrightarrow$ $\Delta W = -P(V_2 - V_1)$

Ⓑ Isochoric process — المتساوي الحجم

$$V = cts. \quad \text{ثابت}$$

$$\Delta W = 0 \quad \rightarrow \quad \Delta U = \Delta Q + \Delta W$$

$$V = cts$$

Ⓒ <u>Isothermal</u> Process — المتساوي الحرارة

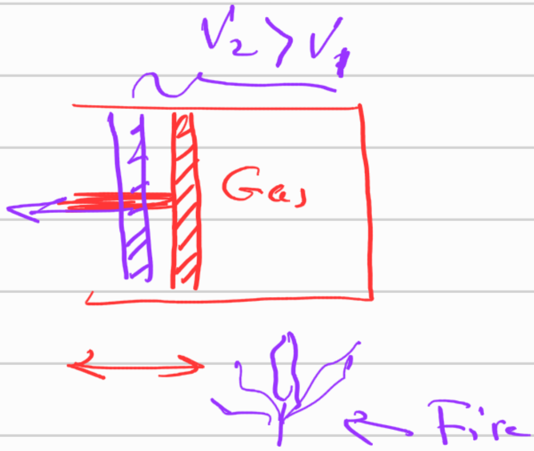
$$\underline{T = cts}$$

$$\Delta W = -\int_{V_1}^{V_2} P\,dV = -\int_{V_1}^{V_2} \frac{NK_BT}{V}\,dV$$

For Ideal Gas $PV = NK_BT \Rightarrow P = \frac{NK_BT}{V}$

$$\Delta W = -NK_BT\int_{V_1}^{V_2}\frac{dV}{V} = -NK_BT\ln\left(\frac{V_2}{V_1}\right)$$

$$\boxed{\Delta W = +NK_BT\ln\left(\frac{V_1}{V_2}\right)}$$



For Ideal Gas

$\Delta U = 0$

$U = \frac{3}{2}NK_BT$

$T = cts$

$$0 = \Delta U = \Delta Q + \Delta W \Rightarrow \boxed{\Delta Q = -\Delta W}$$

(D) Adiabatic Process المتساوي النتروبيا

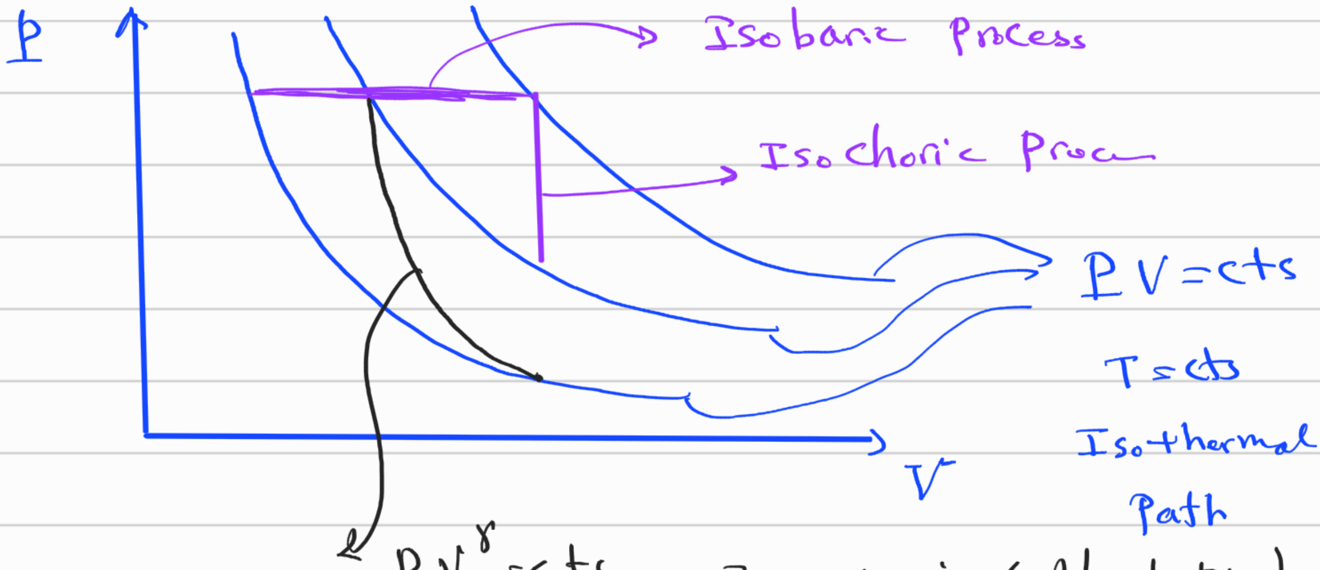
Same Entropy

Reversible path $dQ = Tds = 0$

$PV^{\gamma} = cts$ $\qquad \gamma \equiv \frac{C_p}{C_V}$

C_p → Heat Capasity In constant Pressure

C_V → Heat Capasity In Constant V



$PV^{\gamma} = cts$ = Iso entropic (Adiabatic)

البيع

$$\frac{3}{16} \times (16 \times 2)$$

$$\frac{3}{16} \times 32 = 3 \times 2 = 6$$