

# Clase 47 3 noviembre 2021

Título de la nota

03/11/2021

## I. Proceso de Expansión isotérmica reversible

$$n_1 \rightarrow n_2$$

*cte*

$$T_1 \rightarrow T_2$$

*cte.*

$$V_1 \rightarrow V_2$$

$$V_2 > V_1$$

$$p_1 \rightarrow p_2$$

$$p_1 > p_2$$

## II. Proceso de Expansión Adiabática Reversible

$n_1 \rightarrow n_2$	cte.
$T_2 \rightarrow T_3$	$T_2 > T_3$
$V_2 \rightarrow V_3$	$V_3 > V_2$
$p_2 \rightarrow p_3$	$p_2 > p_3$

III. Proceso de Compresión Isotérmica Reversible	
$n_3 \rightarrow n_4$	cte.
$T_3 \rightarrow T_4$	cte.
$V_3 \rightarrow V_4$	$V_3 > V_4$
$p_3 \rightarrow p_4$	$p_3 < p_4$

## IV. Proceso de Compresión Adiabática Reversible

$$n_4 \rightarrow n_1$$

cte.

$$T_4 \rightarrow T_1$$

$$T_4 < T_1$$

$$V_4 \rightarrow V_1$$

$$V_4 > V_1$$

$$p_4 \rightarrow p_1$$

$$p_1 > p_4$$

Temperatura (Kelvin)	presión (atm)	Volumen (L)
$T_1 = T_2 > T_3 = T_2$	$p_1 > p_2 > p_4 > p_3$	$V_3 > V_4 > V_2 > V_1$

$$T_1 = T_2 = T_C$$

$$T_3 = T_4 = T_F$$

$$T_1 = T_2 > T_3 = T_4$$

J/K

<i>Etapa</i>	$\Delta H (J)$	$q (J)$	$w (J)$	$\Delta U (J)$	<del><math>\Delta S (J/mol)</math></del>
1-2	0	+	+	0	+
2-3	-	0	+	-	0
3-4	0	-	-	0	-
4-1	+	0	-	+	0

## Cálculo de variables a mano:

I. Exp. Isot. R

$$T_1 = T_2$$

$$500\text{K} = 500\text{K}$$

$$pV = nRT$$

$$V_2 = \frac{nRT_2}{p_2} = \frac{(3)(0.082)(500)}{1.25} = 98.4\text{L}$$

$$V_1 = \frac{nRT_1}{p_1} = \frac{(3\text{ mol})(0.082\text{ atm}\cdot\text{L} / \text{mol}\cdot\text{K})(500\text{K})}{5\text{ atm}}$$

$$V_1 = \frac{123\text{ atm}\cdot\text{L}}{5\text{ atm}} = 24.6\text{L}$$

$$p_2 = \frac{nRT_2}{V_2} = \frac{(3\text{ mol})(0.082\text{ atm}\cdot\text{L} / \text{mol}\cdot\text{K})(500\text{K})}{98.4000\text{L}} = \frac{123\text{ atm}\cdot\text{L}}{98.4000\text{L}}$$

$$p_2 = 1.25\text{ atm}$$

$$p_1 = \frac{nRT_1}{V_1} = \frac{(3\text{ mol})(0.082\text{ atm}\cdot\text{L} / \text{mol}\cdot\text{K})(500\text{K})}{24.6\text{L}} = 5\text{ atm}$$

II Exp. odio b: Rev

$$P_3 = P_2 \left( \frac{V_2}{V_3} \right)^\gamma$$

$$\gamma = \frac{C_p}{C_v} = \frac{6.9794 \frac{\text{cal}}{\text{mol}\cdot\text{K}}}{4.9008 \frac{\text{cal}}{\text{mol}\cdot\text{K}}} = 1.3985$$

$$P_3 = 1.25 \text{ atm} \left( \frac{98.400 \text{ L}}{240.8540 \text{ L}} \right)^{1.3985}$$

$$P_3 = 1.25 \text{ atm} (0.408546)^{1.3985}$$

$$P_3 = 1.25 \text{ atm} (0.2859702581) = 0.3575 \text{ atm}$$

$$T_3 = T_2 \left( \frac{P_3}{P_2} \right)^{\frac{\gamma-1}{\gamma}}$$

$$T_3 = 500 \text{ K} \left( \frac{0.3575 \text{ atm}}{1.25 \text{ atm}} \right)^{\frac{1.3985-1}{1.3985}}$$

$$T_3 = 500 \text{ K} (0.286 \text{ atm})^{0.2849}$$

$$T_3 = 500 \text{ K} (0.7000332731) = 350.01 \text{ K}$$

$$V_3 = \left( \frac{P_2 V_2^\gamma}{P_3} \right)^{\frac{1}{\gamma}}$$

$$V_3 = \left( \frac{(1.25 \text{ atm})(98.4 \text{ L})^{1.3985}}{0.3575 \text{ atm}} \right)^{\frac{1}{1.3985}}$$

$$V_3 = \left( \frac{765.7969956 \text{ atm}\cdot\text{L}}{0.3575 \text{ atm}} \right)^{\frac{1}{1.3985}} = (2142.089498)^{\frac{1}{1.3985}}$$

$$V_3 = 240.8360 \text{ L}$$



## III. Com. Isot. Rev

$$T_3 = T_4$$

$$350\text{K} = 350\text{K}$$

$$V_4 = \left( \frac{V_1 \cdot V_3}{V_2} \right) \quad V_4 = \left( \frac{24.6\text{L} \times 240.8540}{98.4\text{L}} \right) = \frac{5925.0084\text{L}}{98.4\text{L}}$$

$$V_4 = 60.21\text{L}$$

$$P_4 = \left( \frac{P_1 \cdot P_3}{P_2} \right) = \left( \frac{5\text{atm} \times 0.3575\text{atm}}{1.25\text{atm}} \right) = 1.43\text{atm}$$

## IV. Comp. Adiab. Rev

$$T_1 = T_4 \left( \frac{P_1}{P_4} \right)^{\gamma-1} \quad T_1 = 350\text{K} \left( \frac{5\text{atm}}{1.4299\text{atm}} \right)^{0.2849}$$

$$T_1 = 350\text{K} (3.4967)^{0.2849} \quad T_1 = 350\text{K} (1.4285)$$

$$T_1 = 499.98\text{K}$$

$$P_2 = P_4 \left( \frac{V_4}{V_1} \right)^{\gamma} \quad P_2 = 1.4299 \left( \frac{60.21\text{L}}{24.6\text{L}} \right)^{1.3985}$$

$$P_2 = 1.4299 (2.447560976)^{1.3985} = 5\text{atm}$$

$$V_2 = \left( \frac{P_4 V_4^{\gamma}}{P_2} \right)^{1/\gamma} = \left( \frac{(1.4299\text{atm})(60.21\text{L})^{1.3985}}{5\text{atm}} \right)^{1/1.3985}$$

$$V_2 = \left( \frac{(1.4299\text{atm})(60.21\text{L})^{1.3985}}{5\text{atm}} \right)^{1/1.3985} = \left( \frac{440.7296\text{L}}{5} \right)^{1/1.3985}$$

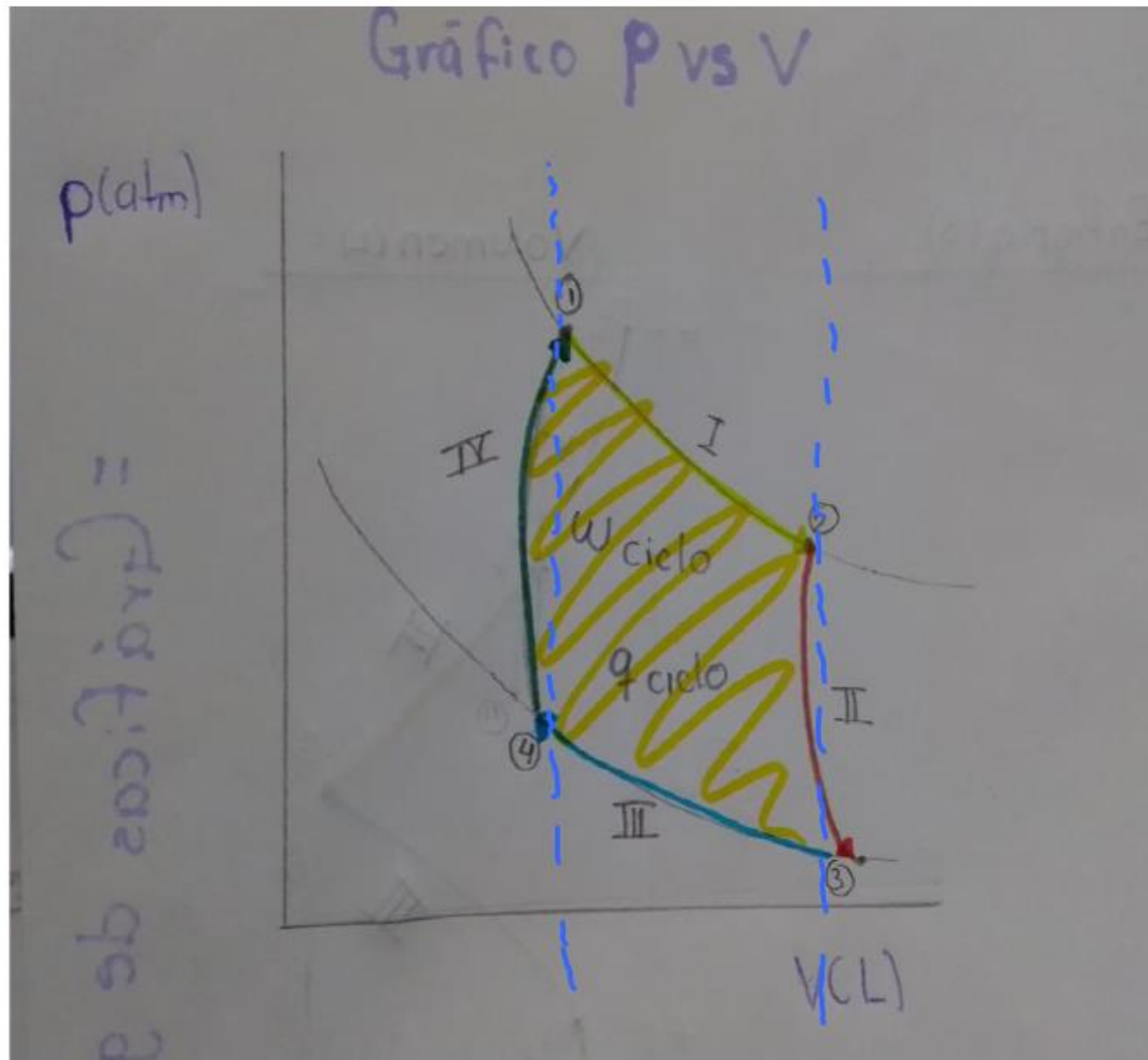
$$V_2 = (88.145924)^{1/1.3985} = 24.599\text{L}$$

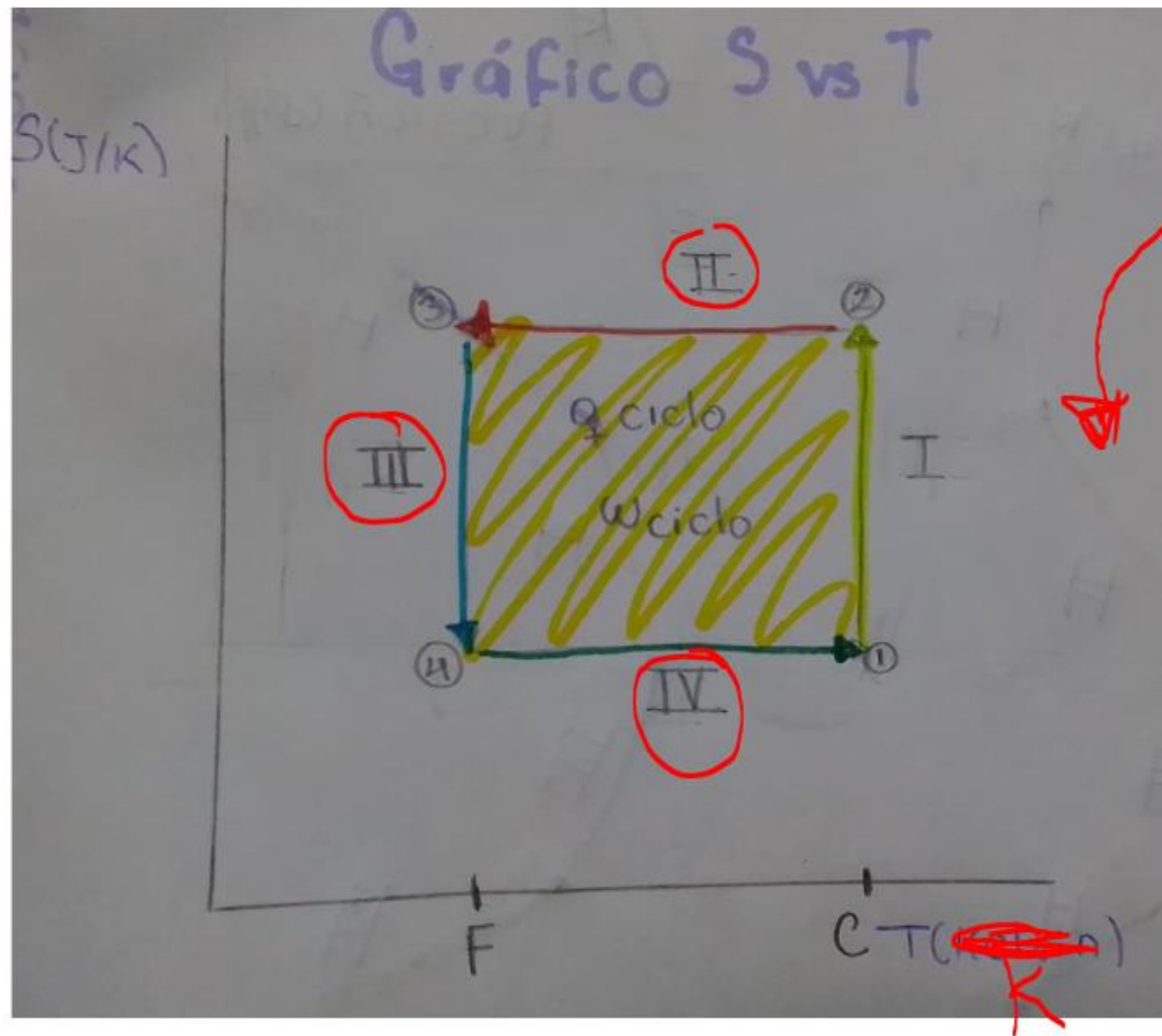
p (atm)	V(L)	T (K)	Variable
5.0000	24.6	500.00	1
1.25	98.4000	<del>500.00</del> 300	2
0.3575	240.8540	350.00	3
1.4299	60.21	<del>500.00</del> 350	4

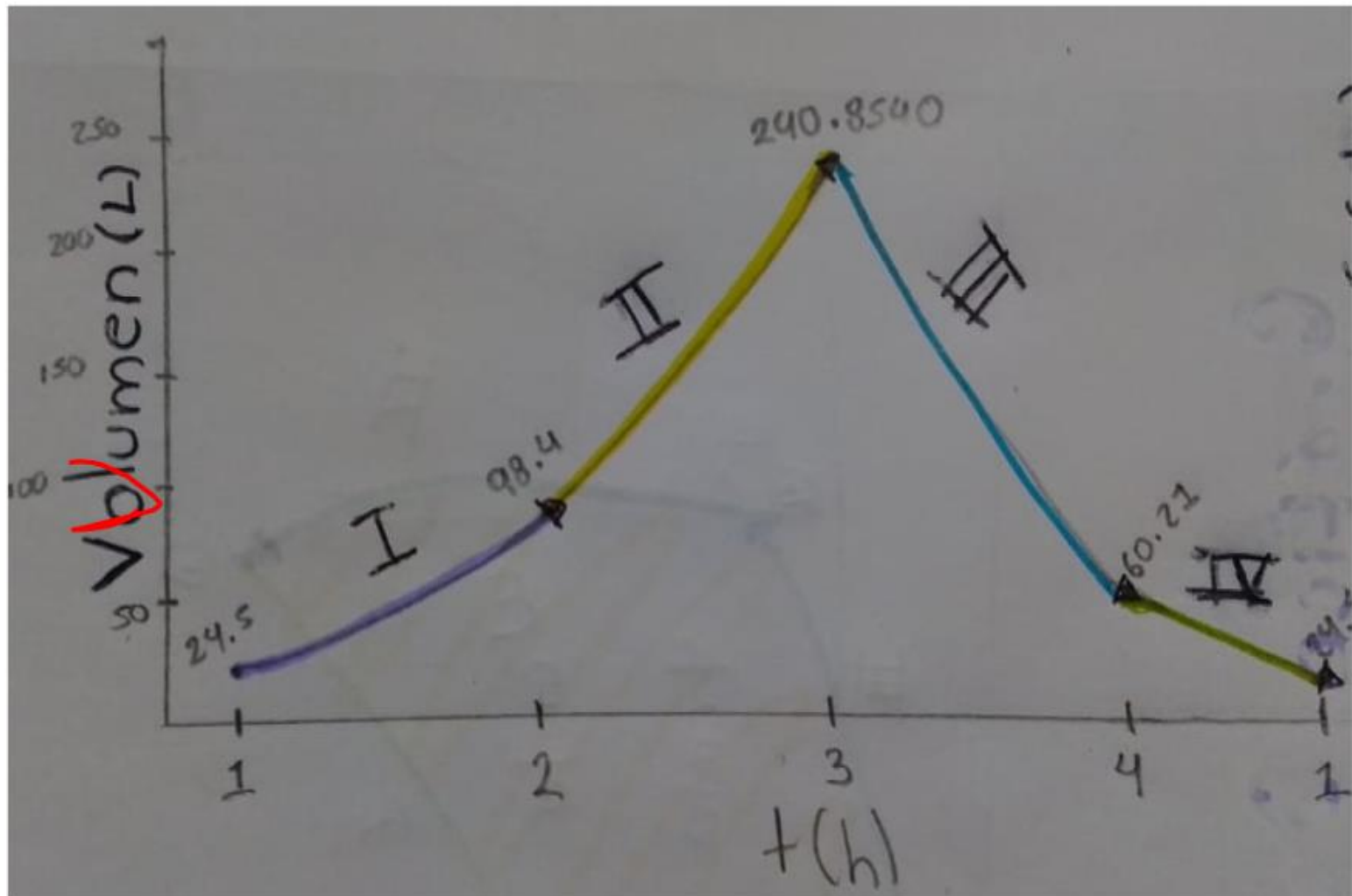
Tabla 0

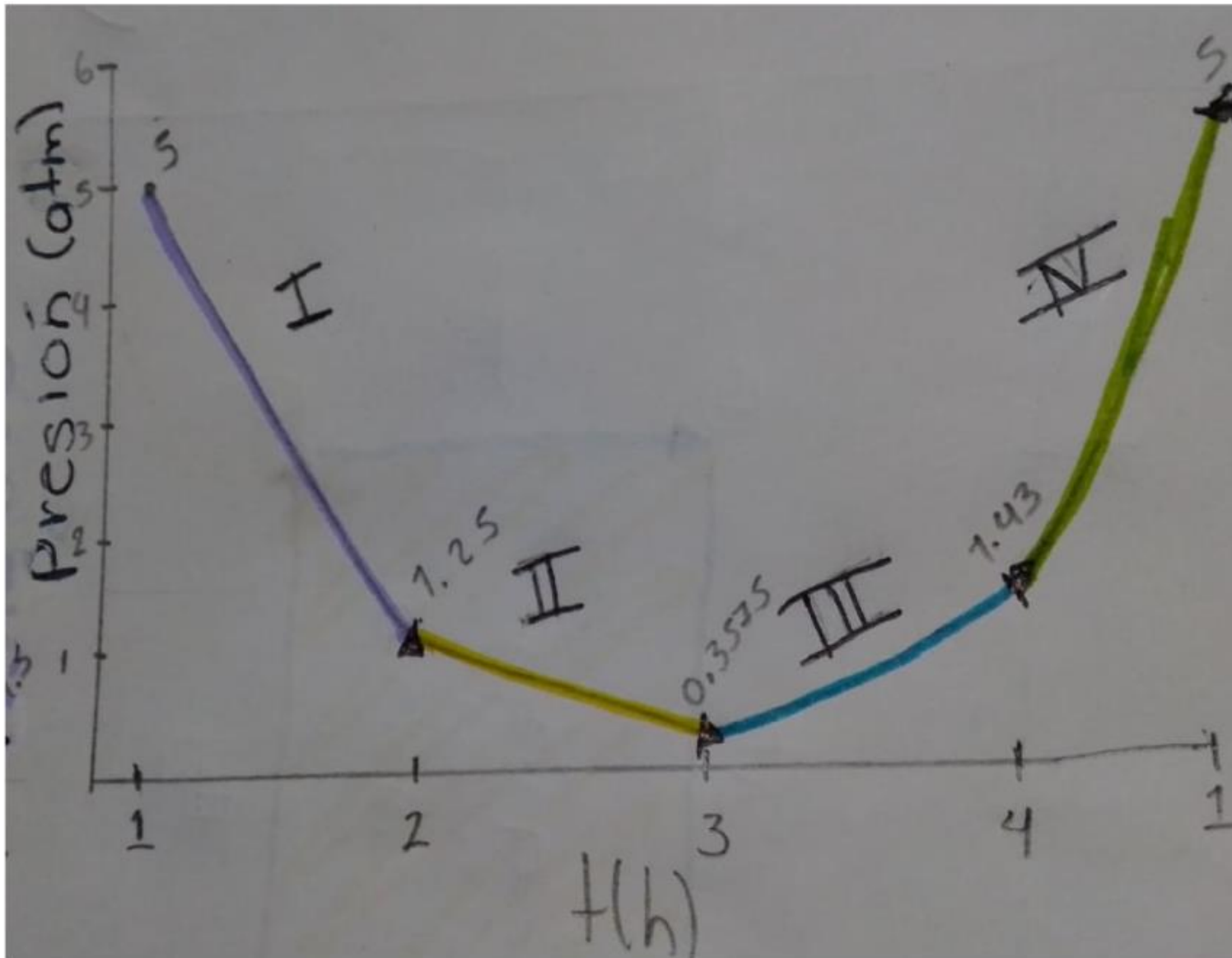
Puntos	T (K)	p (atm)	V (L)
1	500.0000	5.0000	24.6000
2	500.0000	1.2500	98.4000
3	350.0000	0.3575	240.8540
4	350.0000	1.4299	60.2136

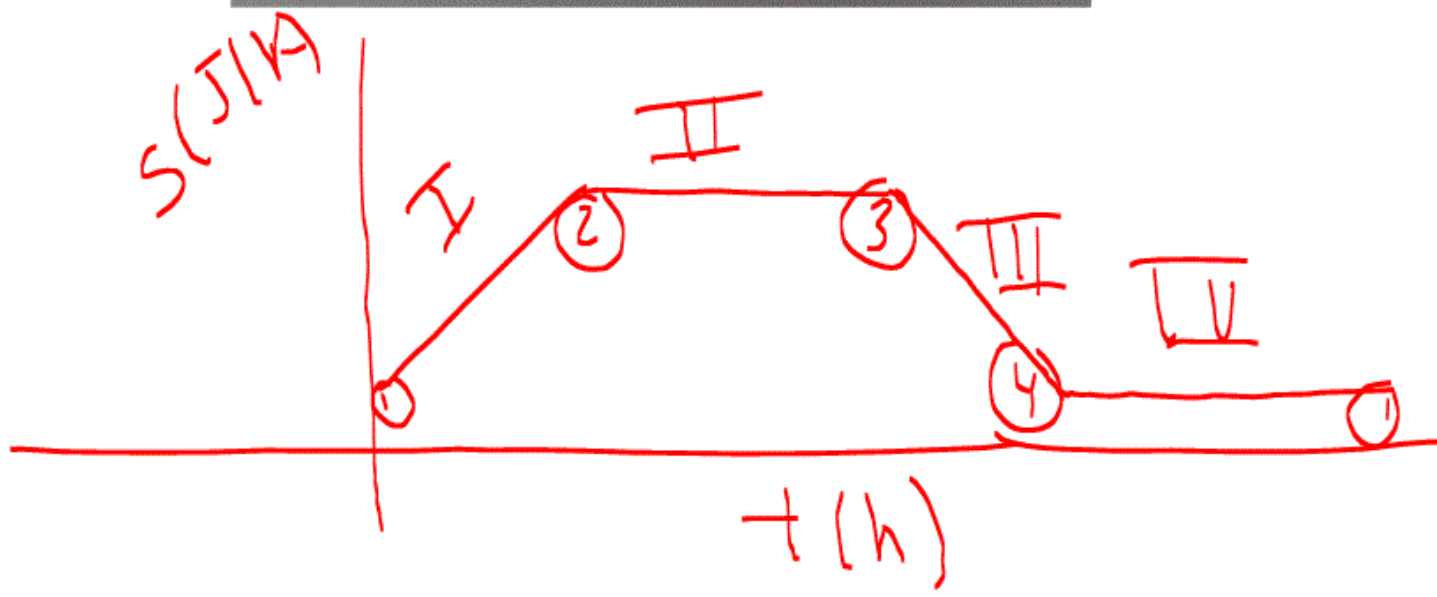
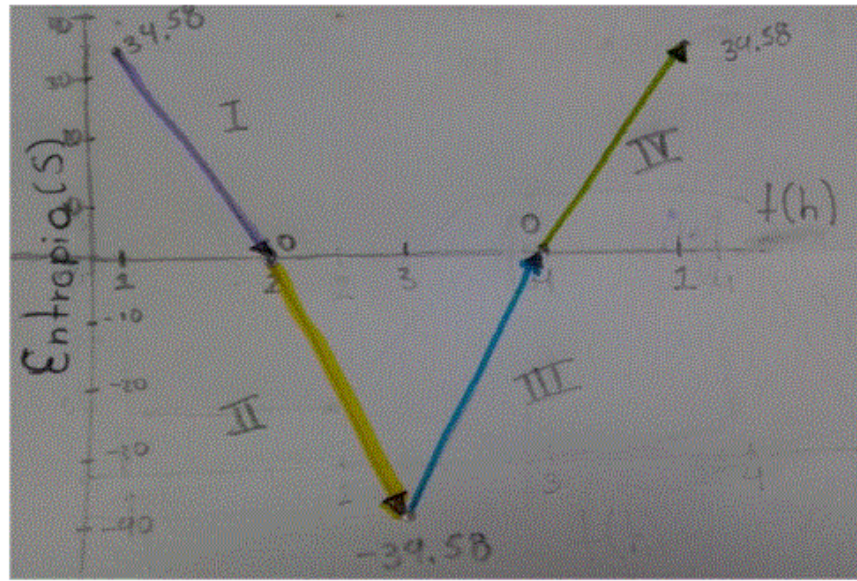
$V_2 / V_1$	4.000
$V_3 / V_4$	4.000
$V_3 / V_2$	2.448
$V_4 / V_1$	2.448



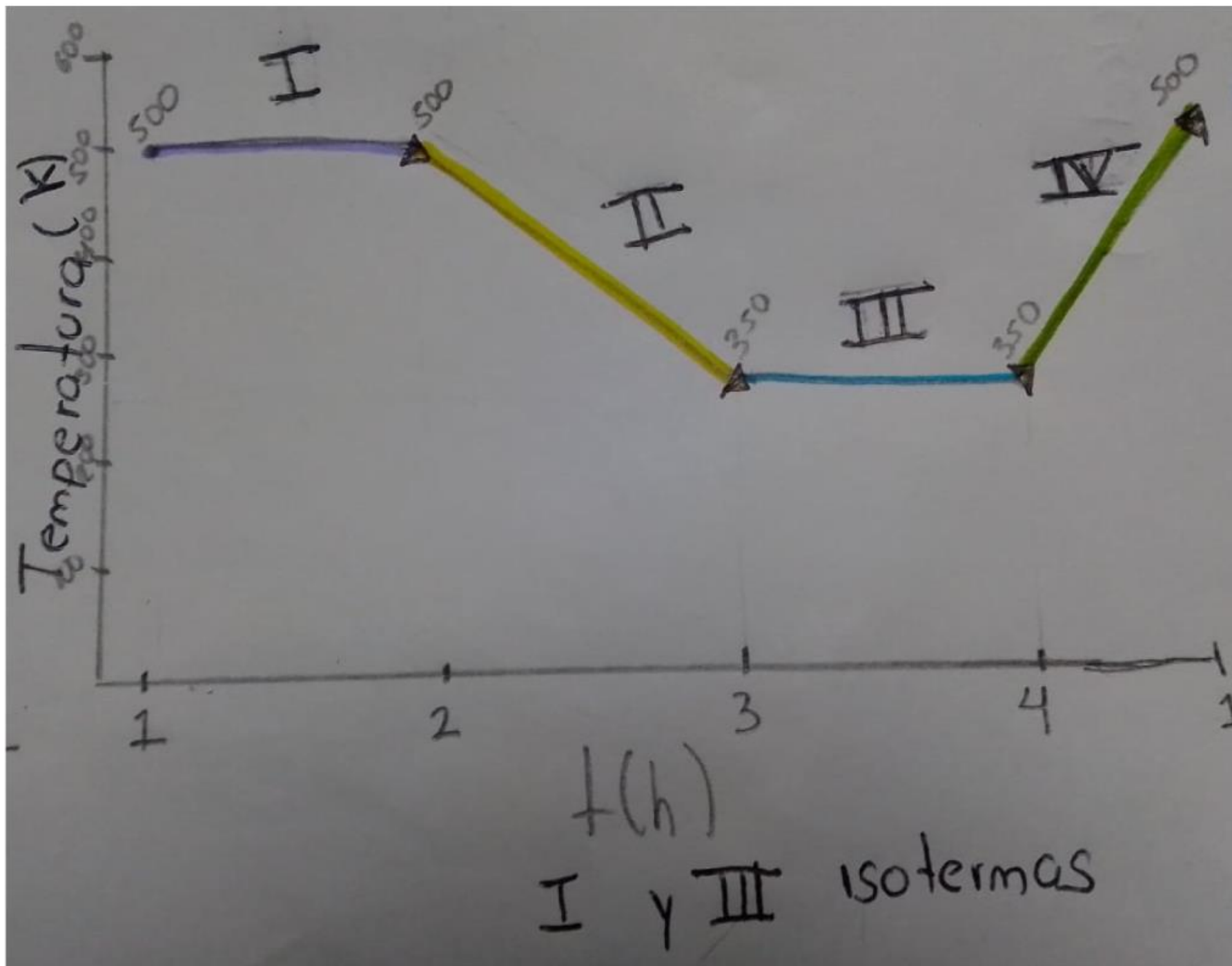




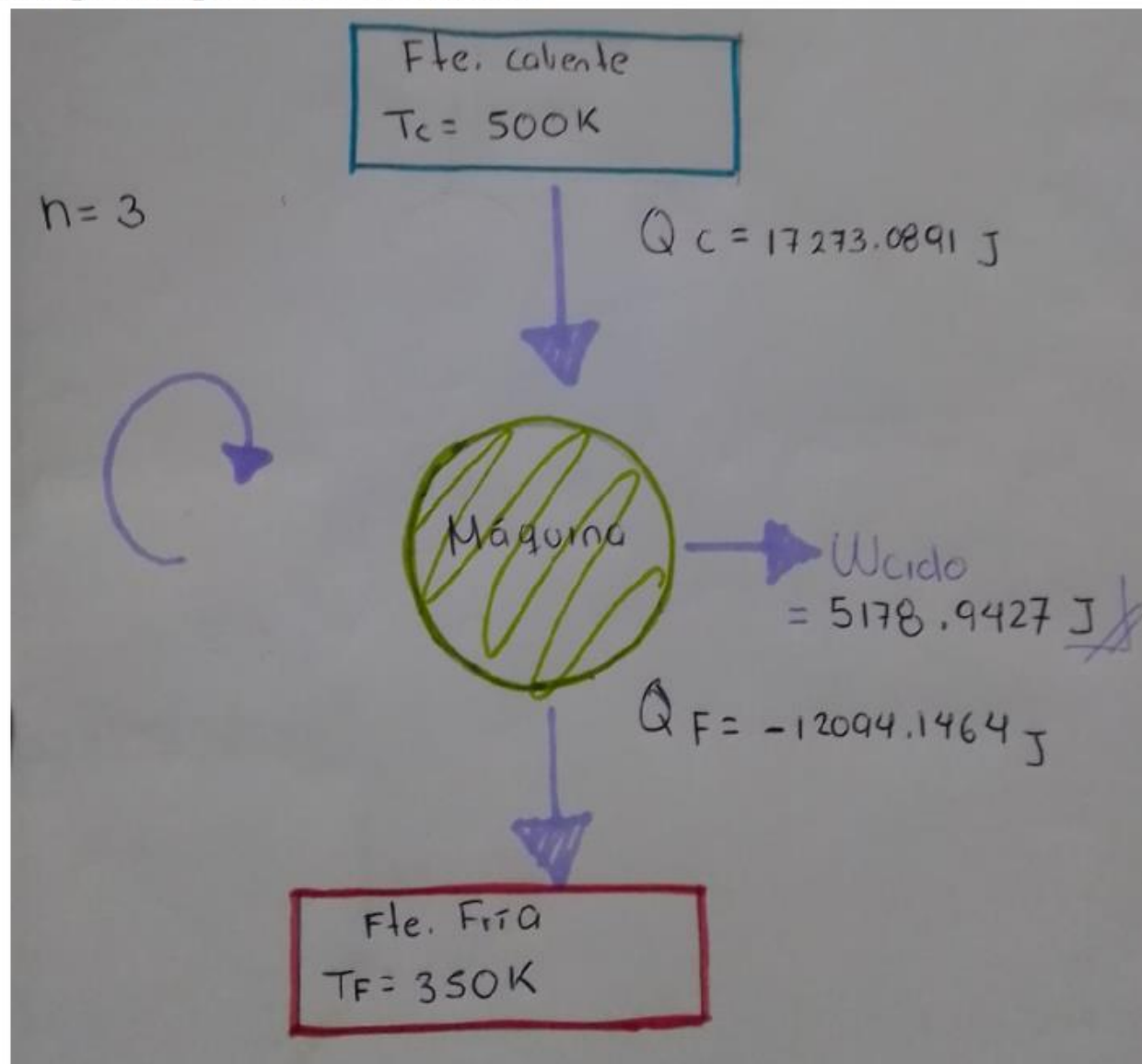








### Máquina tipo Carnot (térmica)



$$\eta = \frac{T_c - T_f}{T_c} \times 100$$

EFICIENCIA  
MÁXIMA

$$\eta = \frac{\text{Wciclo}}{\text{qendo}} \times 100$$

✓  
Real

$$= 30\%$$

## *Balance de energía en el simulador:*

Balance de energía								
Etapa	Proceso	$\Delta T$	$\Delta P$	$\Delta V$	$\Delta H$ (J)	q (J)	w (J)	$\Delta U$ (J)
de 1 a 2	ISOTÉRMICO	0.0000	-3.7500	73.8000	0.0000	17273.0891	17273.0891	0.0000
de 2 a 3	ADIABÁTICO	-150.0000	-0.8925	142.4540	-13147.0958	0.0000	9401.1700	-9401.1700
de 3 a 4	ISOTÉRMICO	0.0000	1.0724	-180.6405	0.0000	-12094.1464	-12094.1464	0.0000
de 4 a 1	ADIABÁTICO	150.0000	3.5701	-35.6135	13147.0958	0.0000	-9401.1700	9401.1700
Ciclo:	CARNOT	0.0000	0.0000	0.0000	0.0000	5178.9427	5178.9427	0.0000

MÁQUINA TÉRMICA		
Eficiencia	=	0.3000

Proceso	$\Delta S$ (J/molK)
I	34.58
II	0
III	-34.58
IV	0

$\Delta S_c = 0$  equilibrio ✓

# Ecuaciones Fundamentales

$$\Delta U = q - w \quad ds = \frac{q}{T}$$

$$du = Tds - pdv$$

↓  
1ra ecuación

$$du = T ds - p dv$$

Si es isocórico

$$du = T ds$$

$$du = \delta q$$

$$d(u - Ts) = \cancel{Tds} - pdv - \cancel{Tds} - s dT$$

$$dA = -pdv - s dT$$

Helmholtz

$dA = 0$  equilibrio

$dA > 0$  no espontáneo

$dA < 0$  espontáneo



$$d\bar{A} = -p d\bar{V} - \bar{S} dT$$

$$a \quad T \text{ y } V = \text{cte}$$

$$dA = 0$$

Equilibrio

$$du = Tds - p dv$$

$$dh = du + dpv$$

$$dh = Tds - \cancel{p} dv + \cancel{p} dv + v dp$$

$$dh = Tds + v dp$$

$$dH = T ds + v dp$$

si es isobárico

$$dH = T ds$$

$$dH = \delta q$$

$$d(H - TS) = \cancel{Tds} + v dp - \cancel{Tds} - SdT$$

$$dG = v dp - SdT$$

Gibbs

$dG = 0$  equilibrio

$dG < 0$  espontáneo

$dG > 0$  no espontáneo

$$dG = v dp - S dT$$

Si  $p$  y  $T = \text{cte}$

$dG = 0$  equilibrio

Cambio de estado

$$dG = dH - Tds$$

$$\Delta G = \Delta H - T \Delta S$$

Isotérmico ideal.

$$\Delta H = 0$$

$$\Delta G = -T \Delta S$$

si es isotérmico

$$\Delta G = -T\Delta S \quad \text{expansión}$$

$$\Delta S = +$$

$$\Delta G = - \quad \text{espontánea}$$

