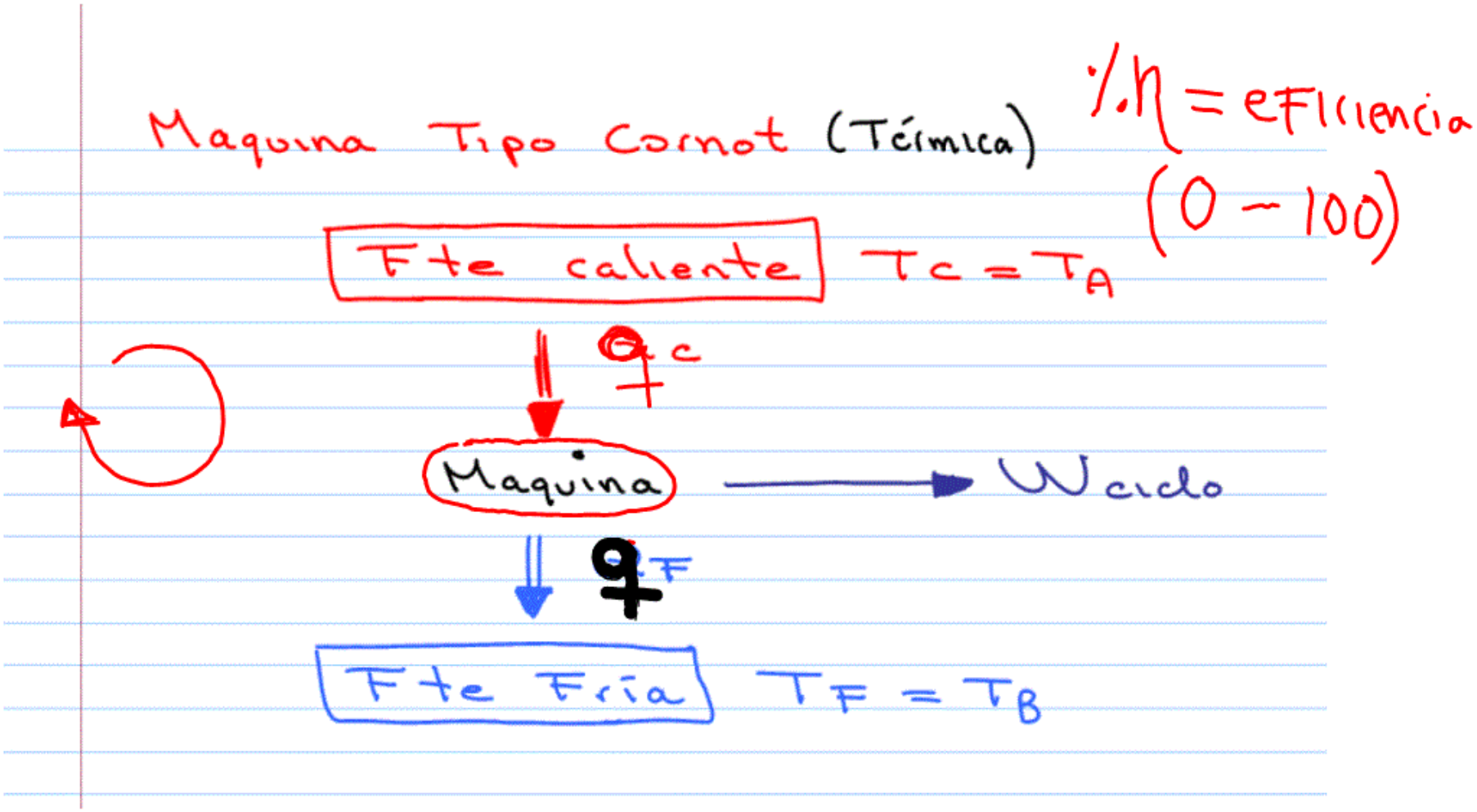
Clase 41 11 noviembre 2020

Título de la nota 11/11/2020



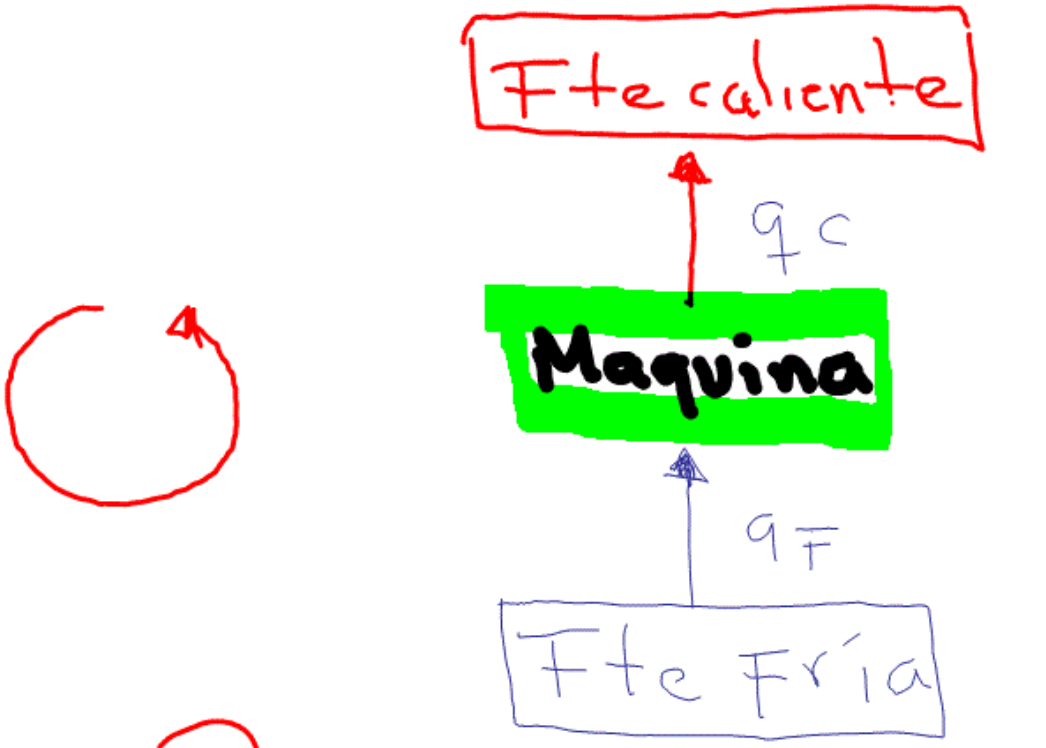
Bosquejo preliminar

I	II	III	IV
$n_1 \rightarrow n_2 = cte$	$n_2 \rightarrow n_2 = cte$	$n_3 \rightarrow n_4 = cte$	$n_4 \rightarrow n_1 = cte$
$T_1 \rightarrow T_2 = cte$	$T_2 \rightarrow T_3 \downarrow$	$T_3 \rightarrow T_4 = cte$	$T_4 \rightarrow T_1 \uparrow$
$V_1 \rightarrow V_2 \uparrow$	$V_2 \rightarrow V_3 \uparrow$	$V_3 \rightarrow V_4 \downarrow$	$V_4 \rightarrow V_1 \downarrow$
$P_1 \rightarrow P_2 \downarrow$	$P_2 \rightarrow P_3 \downarrow$	$P_3 \rightarrow P_4 \uparrow$	$P_4 \rightarrow P_1 \downarrow$
✓	✓		✓
$V_3 > V_2 > V_4 > V_1$	$P_1 > P_2 > P_4 > P_3$		$T_1 = T_2 > T_3 = T_4$

Diseñar un ciclo de Carnot que pueda operar a condiciones de Laboratorio donde

$T_C = 298.15\,K$ $T_F = 273.15\,K$ $p_1 = 0.771\ atm\ (586\ mm\,Hg)$

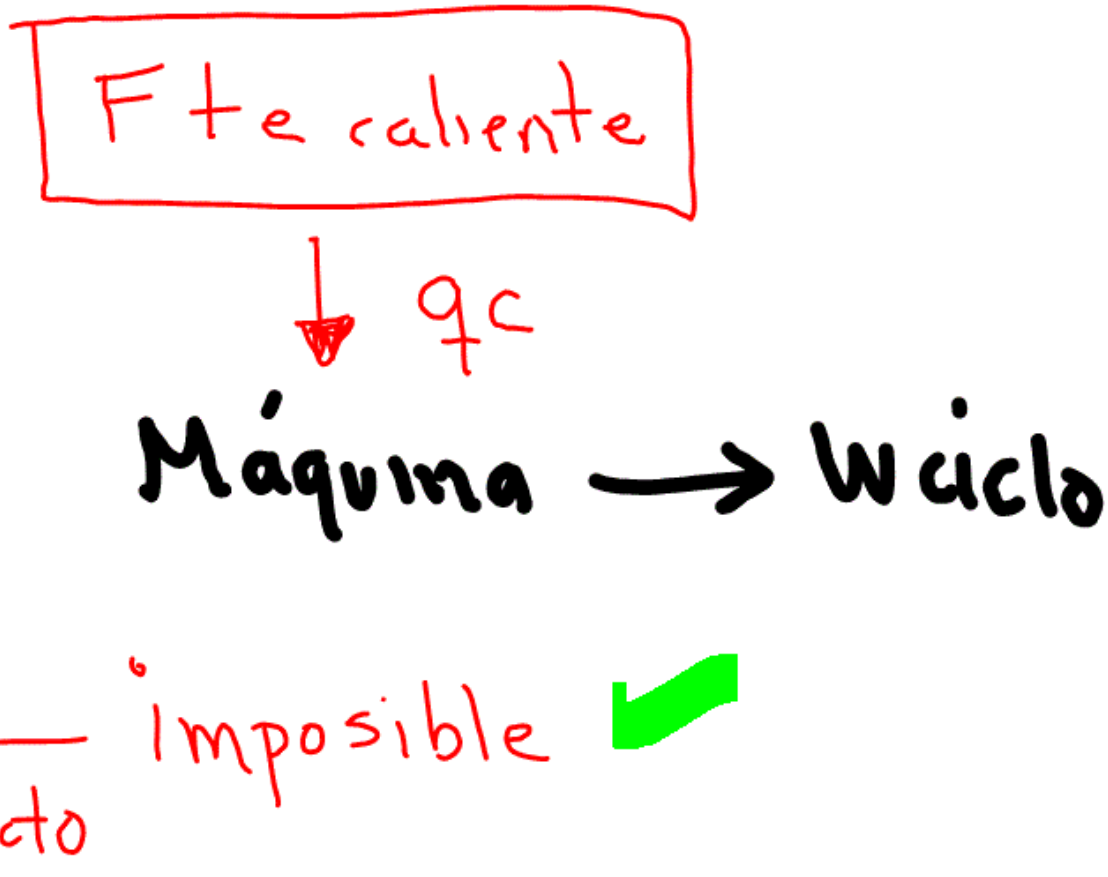
$n_1 = 1\ mol$ gas diatómico $\gamma = 1.4$



COP_1

$COP_2 > 1$

Refrigerador ó bomba calorimétrica


Fte caliente
qc
Máquina → W ciclo
imposible
Isotérmico
Ideal ó perfecto

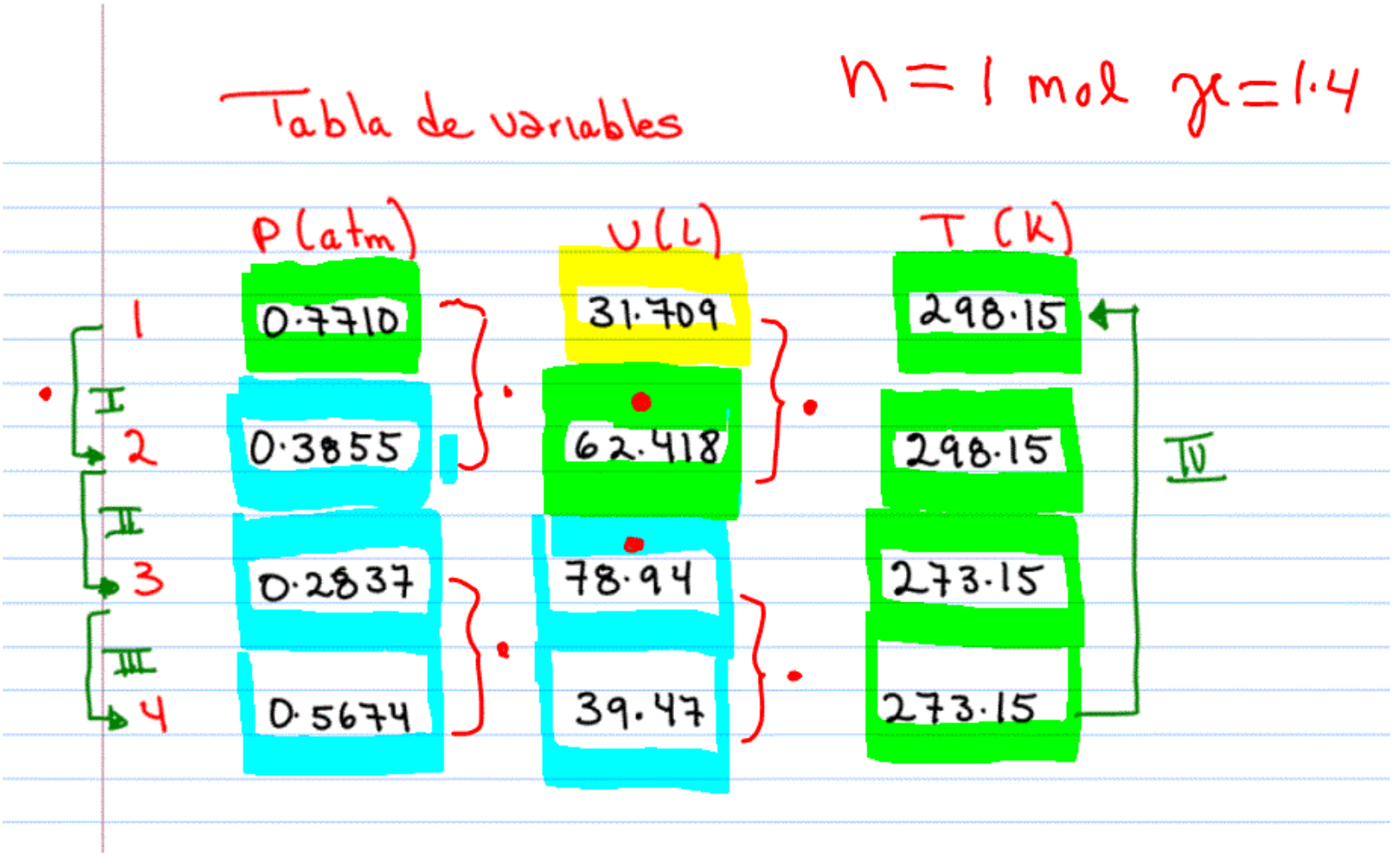


Tabla de variables
n = 1 mol γ = 1.4
P (atm)
V (L)
T (K)
1
2
3
4
I
II
III
IV
0.7710
0.3855
0.2837
0.5674
31.709
62.418
78.94
39.47
298.15
298.15
273.15
273.15

$$T_3 = T_2 \left(\frac{V_2}{V_3}\right)^{\gamma-1}$$

II Exp. Adiab. Rev.

$$\frac{T_3}{T_2} = \left(\frac{V_2}{V_3}\right)^{\gamma-1}$$

$$V_3 = \frac{V_2}{\left(\frac{T_3}{T_2}\right)^{1/\gamma-1}}$$

$$\left(\frac{T_3}{T_2}\right)^{\frac{1}{\gamma-1}} = \frac{V_2}{V_3}$$

$$V_3 = \frac{63.418\ L}{\left(\frac{273.15K}{298.15K}\right)^{\frac{1}{1.4-1}}} = 78.93\ L$$

Cálculo de variables

$$V_1 = \frac{(1\,mol)(0.082\,atm\,L/mol\,K)(298.15\,K)}{0.7710\,atm} = 31.709\,L$$

$$V_2 = 2V_1 = 2(31.709\,L) = 63.418\,L$$

I Exp. Isot. Rev.

$T_1 = 298.15\,K \qquad T_2 = T_1$

$T_3 = T_4 = 273.15\,K$

$$V_3 = \frac{T_3}{T_2} V_2^{\gamma-1} = \frac{273.15\,K}{298.15\,K} (63.418\,L)^{1.4-1}$$

$$V_3 = 78.940\,L$$

II Exp. Adiab. Rev.

$p_3 = ?$ II. Exp. Adiab. Rev.

$$p_3 V_3^{\gamma} = p_2 V_2^{\gamma}$$

$$p_3 = p_2 \left(\frac{V_2}{V_3}\right)^{\gamma}$$

$$p_3 =$$

$$P_2V_2 = P_1V_1 = P_2 = P_1\left(\frac{V_1}{V_2}\right) = 0.7710\,atm\left(\frac{31.709\,L}{63.418\,L}\right) = 0.3855\,atm$$

$$P_3V_3^{\gamma} = P_2V_2^{\gamma}$$

$$P_3 = P_2\left(\frac{V_2}{V_3}\right)^{\gamma} = 0 = 0.3855\,atm\left(\frac{63.418\,L}{78.94\,L}\right) = 0.2837\,atm$$

De la relación

$$\frac{V_2}{V_1} = \frac{V_3}{V_4} = V_4 = \frac{V_1V_3}{V_2} = \frac{(31.709\,L)(78.940\,L)}{(63.418\,L)} = 39.47\,L$$

$$P_4 = \frac{P_3V_3}{V_4} = 0.2837\,atm\left(\frac{78.94\,L}{39.47\,L}\right) = 0.5674\,atm$$

I Exp. Isot. Rev.

$\Delta H = 0 \quad \Delta U = 0$

$$q = w = nRT_1 \ln \frac{V_2}{V_1}$$

$$= (1\,mol)(8.314\,J/mol\,K)(298.15\,K)\ln 2$$

$$= 1718.2\,J$$

$$\Delta S = \frac{q}{T_1} = 5.76\,J/K = \frac{1718.2\,J}{298.15\,K}$$

$\Delta S = +$ expansion

$w = q = +$

Tabla de Funciones termodinámicas

	ΔU (J)	ΔH (J)	ΔS (J/K)	q (J)	w (J)
I	0	0	5.7628	1718.18	1718.18
II	-519.625	-727.475	0	0	519.625
III	0	0	-5.7628	-1574.115	-1574.115
IV	519.625	727.475	0	0	-519.625
total	0	0	0	144.06	144.06

Checar cálculos

II Exp. Adiab. Rev.

$q = 0$

$\Delta S = 0$

$T_3 = 273.15 K$

$T_2 = 298.15 K$

$\bar{C}_p = \frac{7}{2} R$

$\bar{C}_v = \frac{5}{2} R$

$\Delta H = n \bar{C}_p (T_3 - T_2)$

$\Delta U = n \bar{C}_v (T_3 - T_2)$

$R = \frac{8.314 J}{mol K}$

$\bar{C}_p = \frac{29.099 J}{mol K}$

$\bar{C}_v = \frac{20.785 J}{mol K}$

$\Delta H = -727.47 J$

$\Delta U = -519.62 J$

$W = -\Delta U = 519.62 J$

III Comp. Isot. Rev.

$\Delta U = 0 \qquad \Delta H = 0$

$$T_3 = T_4 = T_F$$

$$q = -w = nRT_3 \ln \frac{V_4}{V_3} = nRT_F \ln \frac{V_4}{V_3}$$

$$= -1573.82\ J$$

$$= -1574.11\ J \quad \checkmark$$

$$\Delta S = \frac{q}{T_3} = \frac{-1574.11\ J}{273.15\ K} = -5.76\ J/K$$

IV Comp. Adiab. Rev.

$q = 0 \qquad \Delta S = 0 \qquad \Delta U = + \quad \Delta H = +$

$$\Delta U = n\bar{C}_v (T_1 - T_4) = 519.62\ J$$

$$\Delta H = n\bar{C}_p (T_1 - T_4) = 727.47\ J$$

$$w = -\Delta U = -519.62\ J$$

$q_{caliente} = q_{endotérmico}$

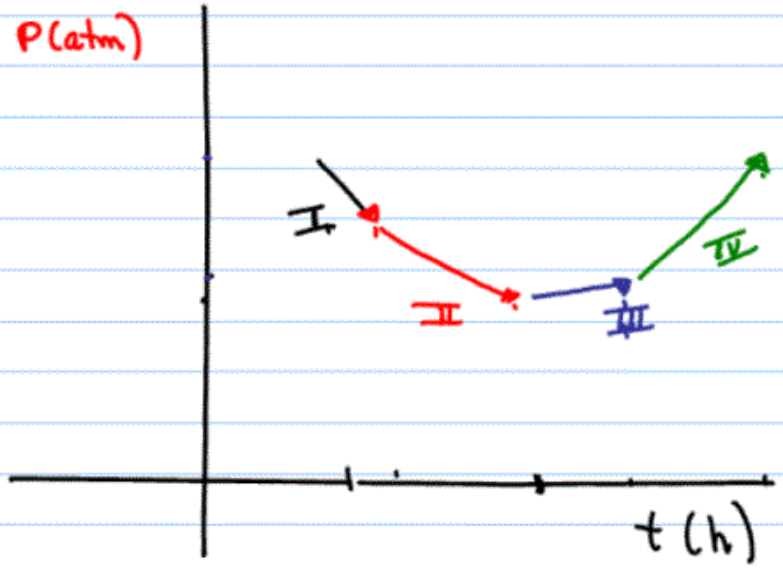
Exp. Isot. Rev.

Cálculo de eficiencia

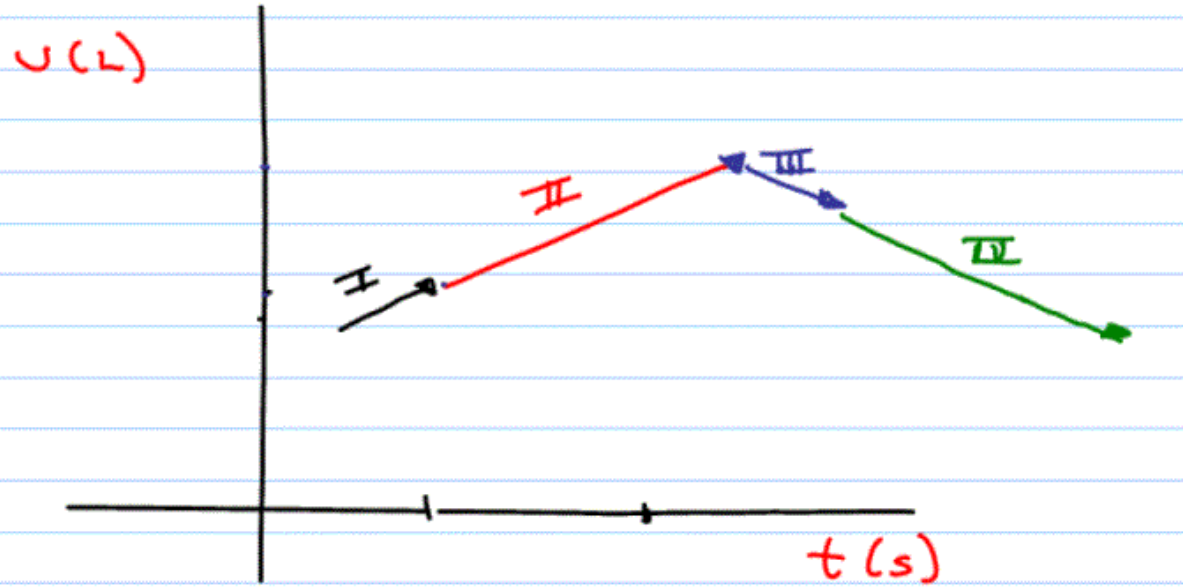
$$\%\eta = \frac{T_C - T_F}{T_C} \times 100 = \frac{298.15K - 273.15K}{298.15K} = 8.385\%$$

$$\%\eta = \frac{W_{ciclo}}{q_{caliente}} \times 100 = \frac{144.0642J}{1718.18J} \times 100 = 8.385\%$$

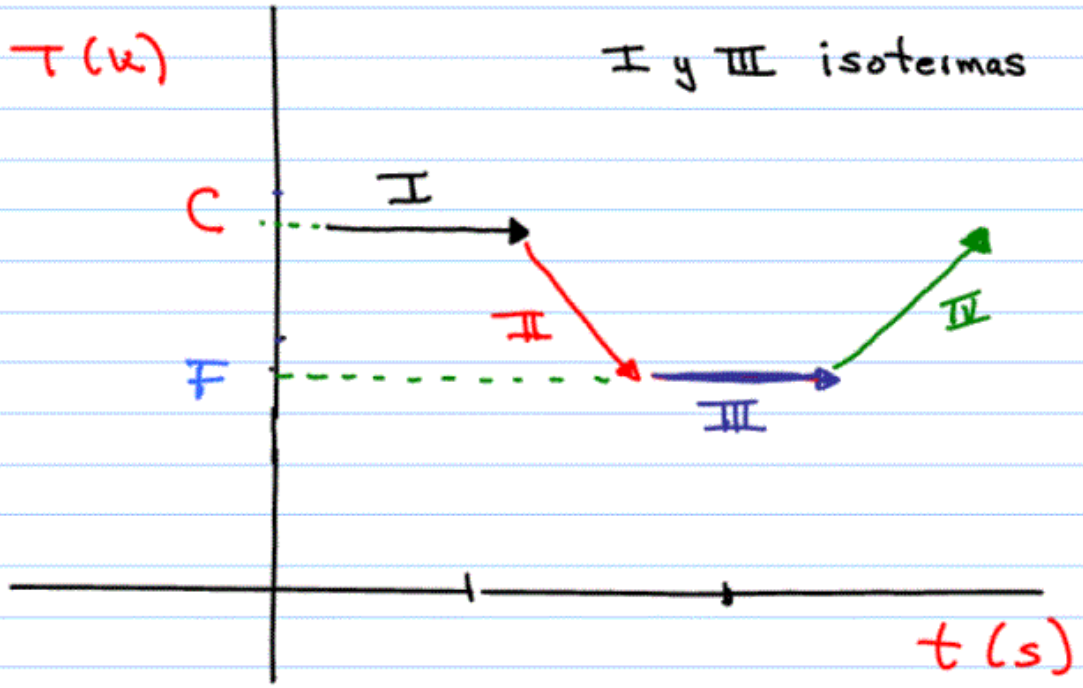
Diagramas Adicionales grado de avance

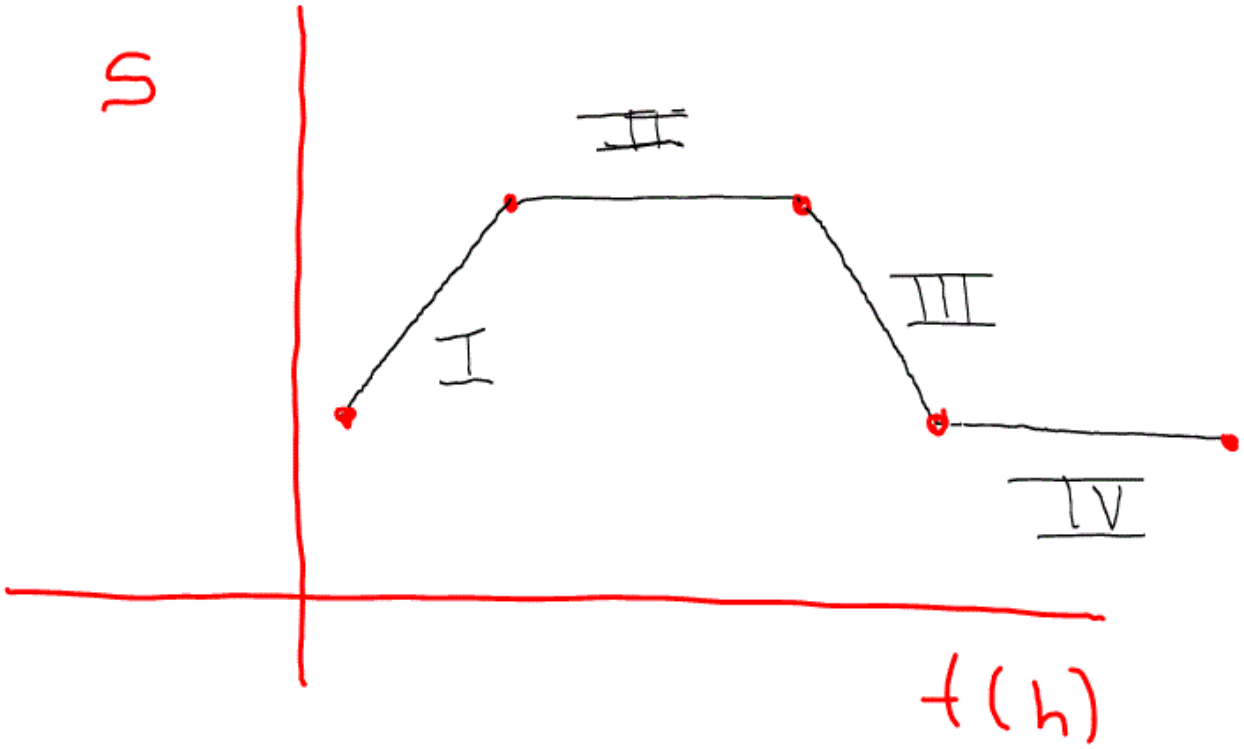


Gráficos de grado de avance



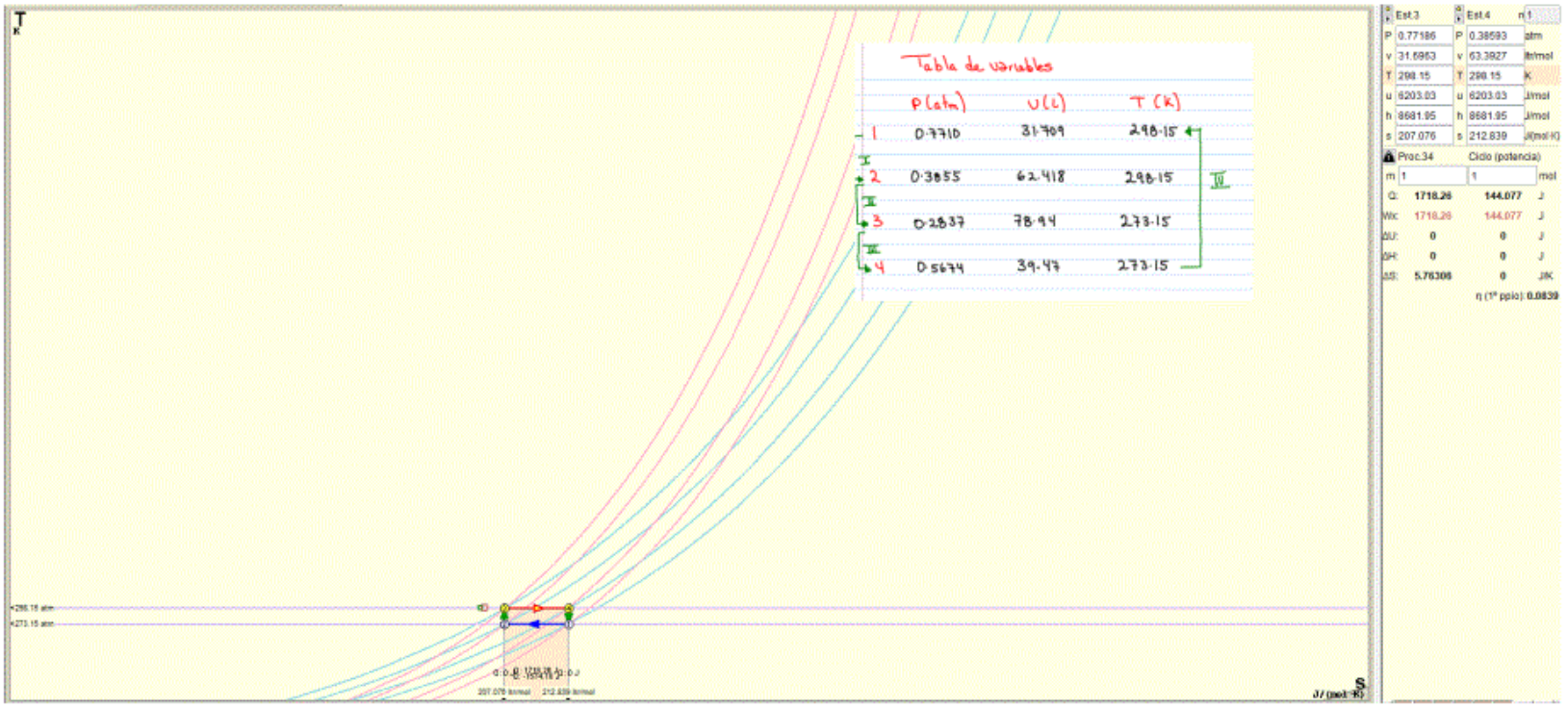
Gráficos de grado de avance

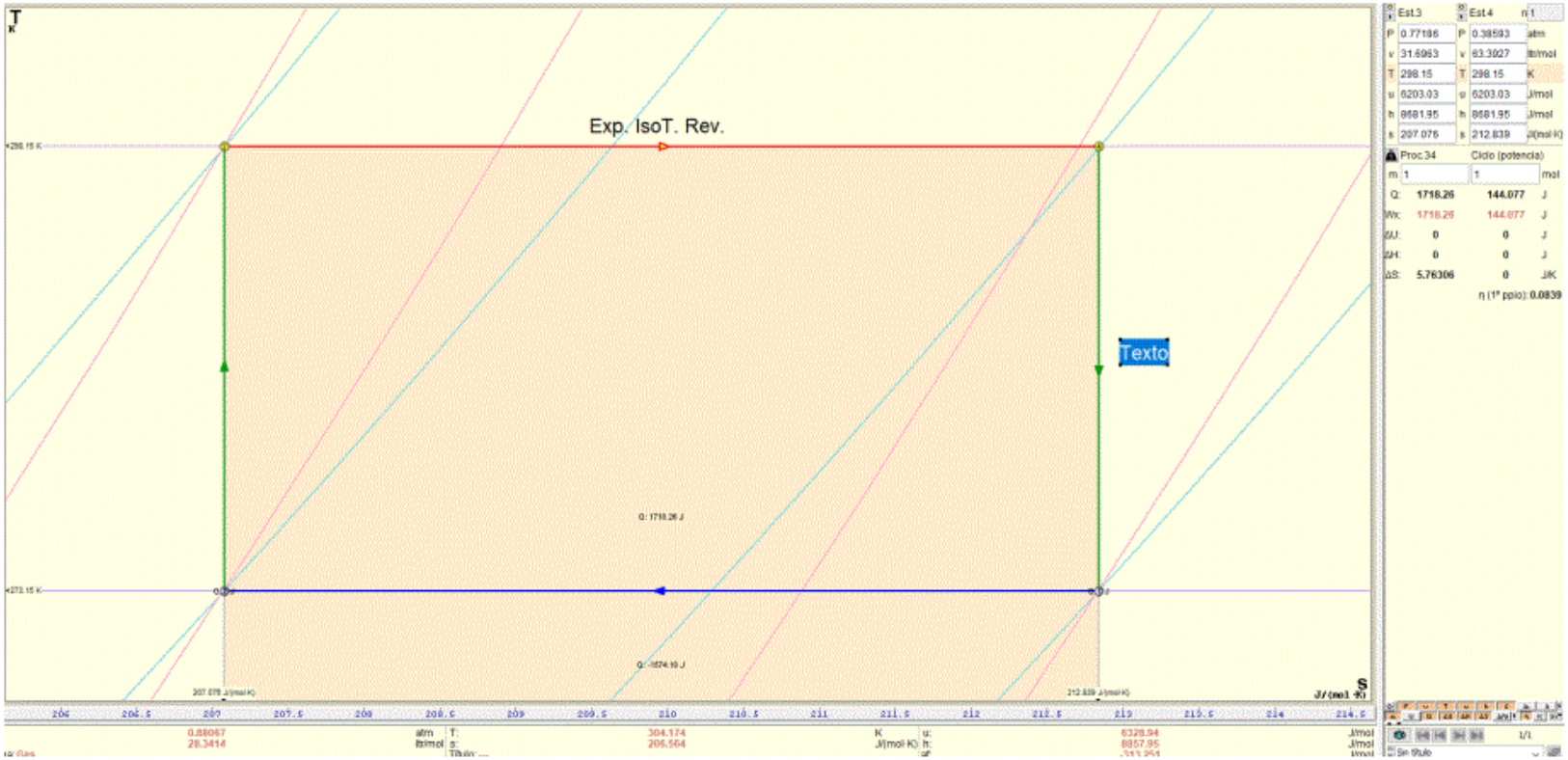



S
II
I
III
IV
t(h)


P
atm
Tabla de variables
P(atm) V(L) T (K)
1 0.7710 31.709 298.15
2 0.3855 62.418 298.15
3 0.2837 78.94 273.15
4 0.5674 39.47 273.15
I
II
III
IV
V
Est.3
Est.4
Proc.34
Ciclo (potencia)

Proceso	m	Q	ΔU	ΔH	Wx	ΔS
roceso 4-1	1	0	-522.541	-730.4	522.541	0
roceso 3-4	1	1718.26	0	0	1718.26	5.76306
roceso 2-3	1	0	522.541	730.4	-522.541	0
roceso 1-2	1	-1574.18	0	0	-1574.18	-5.76306
Ciclo	m	Q	ΔU	ΔH	Wx	ΔS
iclo Θ1	1	144.077	0	0	144.077	0


T
K
Tabla de variables
P (atm)
V (L)
T (K)
1 0.7710 31.709 298.15
2 0.3855 62.418 298.15
3 0.2837 78.94 273.15
4 0.5674 39.47 273.15
I
II
III
IV
Est.3
Est.4
P 0.77186 P 0.38593 atm
v 31.6963 v 63.3927 lt/mol
T 298.15 T 298.15 K
u 6203.03 u 6203.03 J/mol
h 8681.95 h 8681.95 J/mol
s 207.076 s 212.839 J/(mol·K)
Proc.34
Ciclo (potencia)
m 1 1 mol
Q: 1718.26 144.077 J
Wc: 1718.26 144.077 J
ΔU: 0 0 J
ΔH: 0 0 J
ΔS: 5.76306 0 J/K
η (1ª ppio): 0.0839
S
J/(mol·K)


T
K
Exp. IsoT. Rev.
Texto
S
J/(mol·K)