Ejercicio 1

a) **Datos:**

$r = 1{,}2 \text{ m}$

$M = 2000 \text{ kg}$

$m = 10 \text{ kg}$

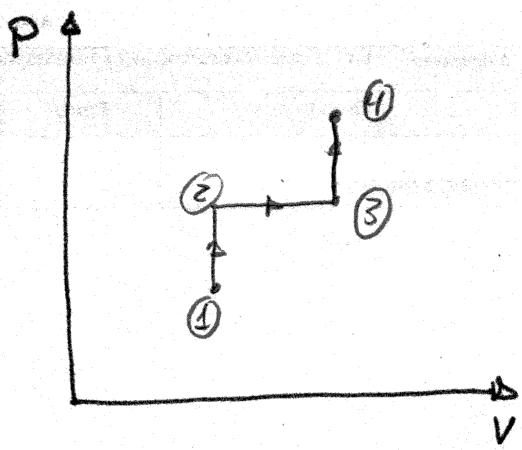
N_2 , $M_{N_2} = 28 \text{ g}$

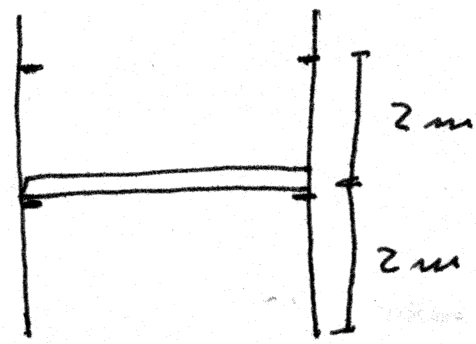
$P_0 = 104{,}3 \text{ kPa}$

$T_0 = 300 \text{ K}$

$c_p = \frac{7}{2} R$

$c_v = \frac{5}{2} R$





a) **Estado 1:**

$P_1 V_1 = n R T_1$ $\qquad n = \frac{m}{M_{N_2}} = 357$

$P_1 = \frac{n R T_1}{V_1}$, $\qquad V_1 = \pi (1{,}2)^2 \times 2 \Rightarrow \boxed{V_1 = 9{,}0 \text{ m}^3}$

$\boxed{P_1 = 98{,}4 \text{ kPa}}$

b) **Estado 2:** El pistón empieza a subir.

$1 \rightarrow 2$, proc. a V CTE $\qquad \frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow \boxed{T_2 = 331{,}0 \text{ K}}$

$P_{ext} = P_0 + \frac{Mg}{A} \Rightarrow P_{ext} = 108{,}6 \text{ kPa} \qquad P_2 = P_{ext}$

c) El proceso sigue a P CTE hasta el pistón tocar los topes.

Estado 3: El pistón toca los topes superiores

$\frac{V_2}{T_2} = \frac{V_3}{T_3} \qquad T_3 = 2 T_2 \qquad \boxed{T_3 = 662 \text{ K}}$

$V_3 = 2 V_2$

Como la $T_4 = 823$ K, el sistema sigue calentandose a V CTE

$$\frac{P_3}{T_3} = \frac{P_4}{T_4} \qquad T_4 = 823\,K \quad \Rightarrow \quad P_4 = P_2 \frac{T_4}{T_3} \Rightarrow \boxed{P_4 \simeq 133\,kPa}$$

e) $dQ_{1-2} = n\,C_v\,(T_2 - T_1) \simeq 229{,}9\,kJ$

$dQ_{2-3} = n\,C_p\,(T_3 - T_2) \simeq 3436{,}9\,kJ$

$dQ_{3-4} = n\,C_v\,(T_4 - T_3) \simeq 1194{,}1\,kJ$

$$\boxed{Q = 4860{,}9\ kJ}$$

$W = -P_2\,(V_3 - V_2) \Rightarrow \boxed{W = -977{,}4\,kJ}$

$\boxed{\Delta U = Q + W = 3883{,}5\,kJ}$

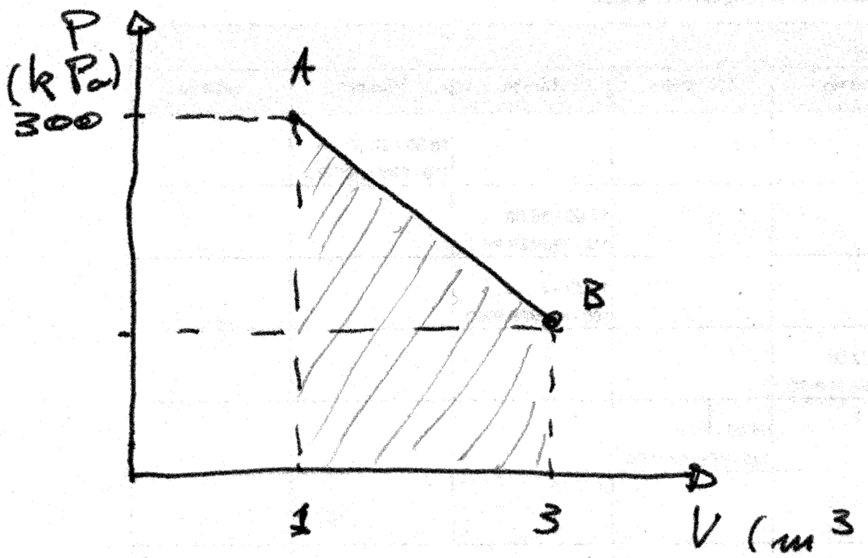
f) $\Delta S_U = \Delta S_{gas} + \Delta S_{fuente}$ $\quad \left\{ \begin{array}{l} \Delta S_{gas} = \int_1^4 \frac{dQ}{T} \\ \Delta S_f = -\frac{\int_1^4 dQ}{T_f} \end{array} \right.$

$$\Delta S_{gas} = n\,C_v \left[\ln\frac{T_2}{T_1} + \ln\frac{T_4}{T_3} \right] + n\,C_p \ln\frac{T_3}{T_2}$$

$\Delta S_{gas} = n \{ 0{,}79 + 2{,}42 \} \Rightarrow \boxed{\Delta S_{gas} = 9{,}5\ \frac{kJ}{K}}$

$\boxed{\Delta S_f = -5{,}9\ \frac{kJ}{K}} \quad \Rightarrow \quad \boxed{\Delta S_U \simeq 3{,}6\ J/K}$

Ejercicio 2



$T_A = T_B = 300 k$

$P_A = 300\ kPa$

$V_A = 1\ m^3$

$V_B = 3\ m^3$

$$\frac{P_A V_A}{T_A} = \frac{P_B V_B}{T_B} \Rightarrow \boxed{P_B = 100\ kPa}$$

a) Para el gas ideal $U(T) \Rightarrow \Delta U_{A-B} = 0$

$Q_{A-B} = -W_{A-B}$ $\quad W_{A-B} = $ Área bajo curva $= \frac{(P_A + P_B)}{2} \cdot (V_B - V_A)$

$$\begin{cases} W_{A-B} = -\int_{V_A}^{V_B} P(V)\, dV \\ P = \alpha V + \beta \Rightarrow \alpha = \frac{P_B - P_A}{V_B - V_A} \ ; \quad \beta = P_A - \alpha V_A \end{cases}$$

$\boxed{W_{A-B} = -400\ kJ} \Rightarrow \boxed{Q_{A-B} = +400\ kJ}$ Absorbido!

$\alpha = -100 \frac{kPa}{m^3}$ $\quad \beta = 400\ kPa$

b) $P = \alpha V + \beta$, $P = nR\frac{T}{V}$ $\Rightarrow nRT = \alpha V^2 + \beta V$

$$\boxed{T = \frac{1}{nR}\left[\alpha V^2 + \beta V\right]}$$

$$T_{max} \Rightarrow \left.\frac{dT}{dV}\right|_{V_x} = 0 \Rightarrow 0 = 2\alpha V_x + \beta \Rightarrow \boxed{V_x = \frac{-\beta}{2\alpha}}$$

$$\boxed{V_x = 2\ m^3} \Rightarrow T_{max} = \frac{1}{nR}\left[\alpha V_x^2 + \beta V_x\right]$$

$$n = \frac{P_A V_A}{R T_A} \Rightarrow T_{max} = \frac{T_A}{P_A V_A}\left[\alpha V_x^2 + \beta V_x\right]$$

$$= -100 \cdot 4 + 400 \times 2 \Rightarrow \boxed{T_{max} = 400 k}$$

c) $\Delta S_{gas} = \underbrace{n R}_{\frac{P_A V_A}{T_A}} \ln \frac{V_B}{V_A} \Rightarrow$ $\boxed{\Delta S_{gas} = 1,1 \text{ kJ/K}}$

Ejercicio 3:

a) $|Q_{agua}| = |m_a\, c_a\, (T' - T_i)| + |m\, L_f| + |m\, c_h\, (T_f - T')|$

$T_i = 20°C$ $\quad T_f = -5°C$ $\quad c_a = 4,2 \text{ kJ/°C}$ $\quad L_f = 330 \text{ kJ/°C}$

$T' = 0°C$ $\quad m = 1 \text{ kg}$ $\quad c_h = 2,1 \text{ kJ/°C}$

$Q_a = m\,[4,2 \times 20 + 330 + 2,1 \times 5] \Rightarrow$ $\boxed{Q_a = -424,5}$ Perdido! kJ

b) $dS = m\, c_a \int_{T_i}^{T'} \frac{dT}{T} + m\, c_h \int_{T'}^{T_f} \frac{dT}{T} - \frac{mL}{T'}$

T absoluta!

$\Delta S_{agua} = 4,2 \ln \frac{273}{293} + 2,1 \ln \frac{268}{273} - \frac{330}{273}$

$\boxed{\Delta S_{agua} = -1,54 \text{ kJ/K}}$

c) $\Delta S_U = \Delta S_{ag} + \Delta S_{Res}$; $\Delta S_{Res} = \frac{+Q_a}{T_f}$

$\Delta S_{Res} = +1,58 \text{ kJ/K} \Rightarrow$ $\boxed{\Delta S_U = 0,04 \text{ kJ/K}}$

Ejercicio 4

Para que el sistema sea posible, las eficiencias de la Maq. Term. y del Refrig. tienen, ambas, que ser menor que las eficiencias de un ciclo de Carnot equivalente.

M.T:

$$\eta = 1 - \frac{Q_L}{Q_H} = \frac{3}{8} \qquad \eta < \eta_c \Rightarrow \text{M.T. es posible}$$

$$\eta_c = 1 - \frac{2}{7} = \frac{5}{7}$$

Refrig.

$$\beta = \frac{Q_L}{W} = \frac{250}{1000} = 0,25$$

$\beta > \beta_c \Rightarrow$ NO SE PUEDE!

$$\beta_c = \frac{|Q_L|}{|Q_H| - |Q_L|} = \frac{1}{\frac{T_H}{T_L} - 1} \Rightarrow \beta_c = \frac{1}{6-1} = 0,2$$