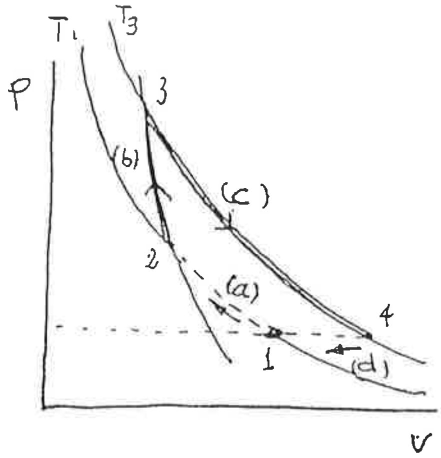

Equilibrio inicial $p_1 = \frac{Mg}{A} = \frac{\nu R T_1}{h_1 A}$

$$h_1 = \frac{\nu R T_1}{Mg}$$

Proceso (a) : $\Delta E_i = 0$, $Q + W = 0$

$$W = 2Mg(h_1 - h_2)$$

Al final del proceso $p_2 = \frac{2Mg}{A} = 2p_1$

y $\nu R T_1 = p_2 h_2 A = p_1 h_1 A$; $h_2 = \frac{h_1}{2}$

De donde $Q_{(a)} = -W = -Mgh_1$ (calor cedido al ext.)

Proceso (b) : Adiabático, reversible: $Q_{(b)} = 0$

$$T_3 V_3^{\gamma-1} = T_1 V_2^{\gamma-1} \quad ; \quad h_3 \equiv \frac{V_3}{A} = \frac{1}{\left(\frac{T_3}{T_1}\right)^{1/\gamma-1}} h_2 = \frac{1}{2^{1/\gamma-1}} h_2 = \frac{1}{2^{\gamma/\gamma-1}}$$

Proceso (c) Isotermo ; además $p_f = p_1$; $\Delta E_i = 0$, $Q + W =$

$$W = -\int p\,dV = -\nu R T_3 \ln \frac{V_4}{V_3}$$

y $V_4 = \frac{\nu R T_3}{p_4} = \frac{2\nu R T_1}{p_1} = 2V_1$, $h_4 = 2h_1$

Por tanto $Q_{(c)} = -W = 2\nu R T_1 \ln \frac{h_4}{h_1}\frac{h_1}{h_3} =$

$$= 2\nu R T_1 \ln\left(2 \times 2^{\gamma/\gamma-1}\right) = \frac{2(2\gamma-1)}{\gamma-1}\nu R T_1 \ln 2$$ (calor absorb

Proceso (d)

$$\Delta E_i = \frac{1}{\gamma-1}\nu R(T_1 - 2T_1)$$

$$W = Mg(h_4 - h_1) = Mgh_1$$

Por tanto $Q_{(d)} = \Delta E_i - W = -\frac{\gamma}{\gamma-1}\nu R T_1$ (calor cedido)

$$\eta = 1 - \frac{|Q_a| + |Q_d|}{Q_c} = 1 - \frac{\nu R T_1 + \frac{\gamma}{\gamma-1}\nu R T_1}{\frac{2(2\gamma-1)}{\gamma-1}\nu R T_1 \ln 2} = 1 - \frac{1}{2\ln 2} \simeq 0{,}3$$