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O VOLUME DO LÍQUIDO É:

$V_0 = h_0 \cdot S_0$ $\quad$ S_0: AREA DA BASE DO TUBO

E APÓS O AQUECIMENTO SERÁ:

$V = V_0 + \Delta V = V_0(1 + \beta \Delta T)$

O NÍVEL DO LÍQUIDO NO TUBO SERÁ:

$h = \frac{V}{S}$ $\quad$ $S = S_0(1 + \sigma \Delta T)$, $\sigma = 2\alpha_{VIDRO}$

E A DIFERENÇA DE NÍVEL ANTES E DEPOIS:

$$h - h_0 = \frac{V}{S} - \frac{V_0}{S_0} = \frac{V_0(1 + \beta\Delta T)}{S_0(1 + \sigma\Delta T)} - \frac{V_0}{S_0} =$$

$$= \frac{V_0(1 + \beta\Delta T) - V_0(1 + \sigma\Delta T)}{S_0(1 + \sigma\Delta T)} =$$

$$= \frac{h_0 \cdot S_0(\beta - \sigma)\Delta T}{S_0(1 + \sigma\Delta T)} = \frac{h_0 \cdot \Delta T(\beta - \sigma)}{1 + \sigma\Delta T} =$$

$$\boxed{h - h_0 = 1{,}28 \times 10^{-4}\ m}$$

19-63

P.1

$T_1 = 300K$ $\quad P_1 = 1\,atm$ $\quad V_1 = 0{,}0246\,m^3$

$T_2 = 600K$ $\quad P_2 = 2\,atm$ $\quad V_2 = V_1 =$

$T_3 = 455K$ $\quad P_3 = P_1 = 1\,atm$ $\quad V_3 = 0{,}0373\,m^3$

$n = 1$

$\gamma = \frac{C_P}{C_V} = \frac{5}{3}$

$C_V' = \frac{3}{2}R$

$C_P' = \frac{5}{2}R$

POR SER MONOATÔMICO

USANDOS AS RELAÇÕES DOS GASES IDEAIS COMPLETAMOS A TABELA ACIMA:

$$PV = nRT \Rightarrow \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} = \frac{P_3V_3}{T_3} = n.R$$

COM $V_1 = V_2$:

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \quad P_2 = \frac{T_2}{T_1}.P_1 = \underline{2\,atm}$$

OS VOLUMES SÃO CALCULADOS:

$$V = \frac{nRT}{P} \qquad V_1 = V_2 = \frac{nRT_1}{P_1} = 0{,}0246\,m^3$$

$\hookrightarrow 1{,}013 \times 10^5\,Pa$

$$V_3 = \frac{nRT_3}{P_3} = 0{,}0373\,m^3$$

OS CALORES TROCADOS SÃO

1-2: ISOCÓRICO $Q = C_V'\Delta T = \frac{3}{2}R\,\Delta T$

$$\underline{Q_{12} = 3{,}7395 \times 10^3\,J}$$

2-3: ~~ISOB~~ ADIABÁTICO $\underline{\Delta Q = 0}$

3-1: ISOBÁRICO $Q = C_P'\Delta T = \frac{5}{2}R.\Delta T =$

$$Q_{31} = -3{,}220 \times 10^3\,\underline{J}$$

19-63

P. 2

CICLO: $\Delta Q = \Delta Q_{12} + \Delta Q_{23} + \Delta Q_{31}$

$\Delta Q = 519\ J$

OS TRABALHOS SÃO

1-2: $W_{12} = 0$ $(\Delta V = 0)$

2-3: $\Delta U_{23} = -W_{23}$

3-1: $W_{31} = P\Delta V = P_1(V_1 - V_3) =$

$= -1{,}286 \times 10^3\ J = W_{31}$

CICLO: $W = W_{12} + W_{23} + W_{31}$

$= W_{23} - 1{,}286 \times 10^3$

MAS, EM UM PROCESSO CÍCLICO TEMOS:

$$\Delta U = 0 = Q - W = \underbrace{\Delta Q_{12} + \Delta Q_{23} + \Delta Q_{31}}_{519\ J} - \underbrace{W_{12}}_{0} - W_{23} - \underbrace{W_{31}}_{-W_{23} + 1{,}286 \times 10^3} = 0$$

QUE RESULTA: $W_{23} = 1{,}806 \times 10^3\ J$

OS ΔU SÃO CALCULÁVEIS ENTÃO:

$\Delta U = Q - W$: $\Delta U_{12} = Q_{12} - \underbrace{W_{12}}_{0} = +3{,}739 \times 10^3\ J$

$\Delta U_{23} = \underbrace{Q_{23}}_{0} - W_{23} = -1{,}806 \times 10^3\ J$

$\Delta U_{31} = Q_{31} - W_{31} = -1{,}934 \times 10^3\ J$

$\Delta U_{CICLO} = 0$!!!

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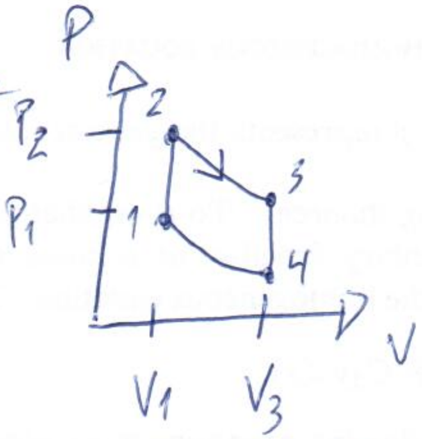

$V_3 = 4V_1$

$P_2 = 3P_1$

USAREMOS AQUI AS RELAÇÕES: $PV = mRT$ (EQ. GASES IDEAIS)

$P_1 V_1^\gamma = P_2 V_2^\gamma$ (PROCESSO ADIABÁTICO EM GÁS IDEAL)

$$\frac{T_2}{T_1} = \frac{\left(\frac{P_2 V_2}{mR}\right)}{\left(\frac{P_1 V_1}{mR}\right)} = \frac{P_2 V_2}{P_1 V_1} = \frac{3P_1 \cdot V_1}{P_1 \cdot V_1} = \boxed{\frac{T_2}{T_1} = 3}$$

$(V_2 = V_1)$

$$\frac{T_3}{T_1} = \frac{P_3 V_3}{P_1 V_1} \quad E \quad \underset{\downarrow\; 4V_1}{P_3 V_3^\gamma} = \underset{\downarrow\; 3P_1}{P_2}\underset{\searrow\; V_1}{V_2^\gamma} = 3P_1 V_1^\gamma = P_3 (4V_1)^\gamma$$

$$\Downarrow$$

$$\frac{P_3}{P_1} = \frac{3}{4^\gamma}$$

$$\frac{T_3}{T_1} = \frac{3}{4^\gamma} \cdot \frac{V_3}{V_1} = \frac{3}{4^\gamma} \cdot 4 = \boxed{1{,}979 = \frac{T_3}{T_1}}$$

$(\gamma = 1{,}3)$

$$\frac{T_4}{T_1} = \frac{P_4 V_4}{P_1 V_1} \quad E \quad P_4 V_4^\gamma = P_1 V_1^\gamma \Rightarrow \frac{P_4}{P_1} = \frac{V_1^\gamma}{V_4^\gamma}$$

$$\frac{T_4}{T_1} = \frac{V_1^\gamma \cdot V_4}{V_4^\gamma \cdot V_1} = \frac{V_1^{\gamma-1}}{V_4^{\gamma-1}} = \left(\frac{V_1}{4V_1}\right)^{\gamma-1} = \left(\frac{1}{4}\right)^{\gamma-1} = \boxed{\frac{T_4}{T_1} = 0{,}66}$$

20-35

PARA CALCULAR A EFICIÊNCIA, COMO TEMOS DOIS PROCESSOS ADIABÁTICOS:

$$e = \frac{|W|}{|Q_{12}|} = \frac{Q_{12} - |Q_{34}|}{Q_{12}} = 1 - \frac{|Q_{34}|}{Q_{12}} = 1 - \frac{C_V' |\Delta T_{34}|}{C_V' \Delta T_{12}} =$$

$$= 1 - \frac{|T_4 - T_3|}{T_2 - T_1} = 1 - \left(\frac{\left|\frac{T_4}{T_1} - \frac{T_3}{T_1}\right|}{\frac{T_2}{T_1} - \frac{T_1}{T_1}} \right) = 1 - \left(\frac{|0{,}66 - 1{,}979|}{3 - 1} \right) =$$

$$= 1 - 0{,}66 = 0{,}34 = \boxed{e = 34\%}$$

E AS PRESSÕES

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow \frac{P_1}{P_2} = \frac{T_1}{T_2} \cdot \frac{V_2}{V_1}$$

ASSIM: $$\frac{P_3}{P_1} = \frac{T_3}{T_1} \cdot \frac{V_1}{V_3} = 1{,}979 \cdot \left(\frac{1}{4}\right) = \boxed{\frac{P_3}{P_1} = 0{,}5}$$

$$\frac{P_4}{P_1} = \frac{T_4}{T_1} \frac{V_1}{V_4} = 0{,}66 \cdot 0{,}25 = \boxed{\frac{P_4}{P_1} = 0{,}165}$$