1,2 1,2
0,8

1) $n = 3$ mols

$\gamma = 1,67$

$V_1 = 20\,L \quad T_1 = 373\,K$

$p_1 V_1 = nRT_1 \rightarrow 20\times10^{-3} \times p_1 = 3 \times 8,314 \times 373$

$p_1 = 465,17\ kPa.$

$V_2 = 30\,L \quad T_2 = 373\,K$

$p_2 V_2 = nRT_2 \rightarrow 30\times10^{-3} \times p_2 = 3 \times 8,314 \times 373$

$p_2 = 310,11\ kPa.$

$V_3 = 35\,L \qquad T_3 = ? \qquad p_3 = ?$

$p_2 V_2^{\gamma} = p_3 V_3^{\gamma} \rightarrow (310,11\times10^{3}).(30\times10^{-3})^{1,67} =$

$p_3 \times (35\times10^{-3})^{1,67} \longrightarrow p_3 = 239,73\ kPa$

$p_3 V_3 = nRT_3 \rightarrow 239,73\times10^{3} \times (35\times10^{-3}) = 3 \times 8,314 \times T_3$

$T_3 = 336,40\,K$

$p_1 V_1^{\gamma} = p_4 V_4^{\gamma}$

$(465,17\times\cancel{10^{3}})(20\times\cancel{10^{-3}})^{1,67} = \dfrac{nRT_4}{V_4} \times (V_4)^{\gamma}$

$675,60 = 3\times 8,314 \times 336,4 \times V_4^{0,67}$

1

$0{,}081 = V_4^{0{,}67} \longrightarrow \boxed{V_4 = 23{,}3\ L}$

$P_4 V_4 = nRT_4 \therefore P_4 \cdot (23{,}3 \times 10^{-3}) = 3 \times 8{,}314 \times 336{,}4 \therefore \boxed{P_4 = 360{,}11\ kPa}$

ETAPA 1: Isotérmica

$\Delta U = Q + W$ $\quad$ $\Delta U = 0$ $\quad$ $W = -Q$

$W = -nRT \ln\left(\frac{V_f}{V_i}\right)$ $\quad$ $W = 3 \times 8{,}314 \times 373 \ln\left(\frac{3{,}0}{2{,}0}\right)$

$W \cong -3772\ J$ $\quad$ $Q = -(-3772) \longrightarrow$

$Q = +3772\ J$

ETAPA 2: adiabática reversível

$Q = 0$ $\quad$ $\Delta U = W$

$\Delta U = \int_{T_i}^{T_f} n\, C_{v,m}\, dT$ $\quad$ $\gamma = \frac{C_{p,m}}{C_{v,m}}$

$1{,}67 = \frac{R + C_{v,m}}{C_{v,m}} \therefore 1{,}67\, C_{v,m} = 8{,}314 + C_{v,m}$

$0{,}67\, C_{v,m} = 8{,}314 \longrightarrow C_{v,m} = 12{,}41\ J/molK$

$\Delta U = \int_{373}^{336{,}4} 3 \times 12{,}41\, dT \therefore \Delta U \cong -1330\ J$

$W = -1330\ J$

ETAPA 3

Isotérmica $\rightarrow$ $\Delta U = 0$ $\quad Q = -W$

$$W = -nRT \ln\left(\frac{V_f}{V_i}\right) = -3 \times 8{,}314 \times \overset{336{,}40}{} \ln\left(\frac{23{,}3}{35}\right)$$

$W \simeq +3414\ J$ $\rightarrow$ $Q = -3414\ J$

ETAPA 4

adiabática reversível $\rightarrow$ $Q = 0$

$\Delta U = W$

$$\sum_{i=1}^{4} \Delta U_i = 0$$

$$\cancel{\Delta U_1}^{0} + \Delta U_2 + \cancel{\Delta U_3}^{0} + \Delta U_4 = 0$$

$-1330 + \Delta U_4 = 0 \rightarrow$ $\Delta U_4 = +1330\ J$

$W = +1330\ J$

Ciclo

$$\sum_{i=1}^{n} \Delta U_i = 0 \rightarrow \sum_{i=1}^{n} W_i = -358\ J.$$

$$\sum_{i=1}^{n} Q_i = +358\ J.$$

2) $C_{p,m} = \left(\frac{\partial H}{\partial T}\right)_p$ $C_{v,m} = \left(\frac{\partial U}{\partial T}\right)_V$

p-const $\longrightarrow$ $\partial H_p = \delta q_p$.

se $\delta q_p > 0 \longrightarrow \partial H_p > 0$ e necessari-

amente, $\partial T > 0$. Então:

$$\left(\frac{\partial H}{\partial T}\right)_p > 0 \longrightarrow \underline{\underline{C_{p,m} > 0}}$$

V-const $\longrightarrow$ $\partial U_V = \delta q_V$

se $\delta q_V > 0 \longrightarrow \partial U_V > 0$ e necessaria-

mente, $\partial T > 0$. Então,

$$\left(\frac{\partial U}{\partial T}\right)_V > 0 \longrightarrow \underline{\underline{C_{V,m} > 0}}$$

3) $\Delta_f H^\circ_{298K, H_2(g)} = 0$.

A $p = 1\,atm$, $T = 298K$; o estado mais estável do hidrogênio é na forma $H_{2(g)}$. Assim, $\Delta_f H^\circ_{H_2(g)} = 0$. Logo,

$\Delta_f H^o_{298K,\, H(g)} \neq 0$. Assim, o valor não é zero.

1) material: Fe puro

$T_i = 25°C$, $p_i = 1\,atm$

$T_f = 1600°C$, $p_f = 1\,atm$ $\quad p = const.$

$$n_{Fe} = \frac{1000\,g}{55{,}85\,g/mol} = 17{,}905\ mols$$

$$\Delta H^\circ = \int_{298}^{1185} C_p^{\alpha}\,dT + 1013 + \int_{1185}^{1667} C_p^{\gamma}\,dT + 853 + \int_{1667}^{1811} C_p^{\delta}\,dT +$$

$$+ 13806 + \int_{1811}^{1873} C_p^{l}\,dT \qquad 0{,}5$$

$$\Delta H^\circ = 12698 + 1013 + 17001 + 853 + 7529{,}7 +$$

$$+ 13806 + 2852 = 55753 \qquad 0{,}5$$

$$Q_{total} = n_{Fe} \cdot \Delta H^\circ = 17{,}905 \times 55753$$

$$Q_{total}^{parcial} = 9{,}9825 \times 10^5\ J$$

100% rendimento.

$$Q_{total} = \frac{9{,}9825 \times 10^5\ J}{0{,}7} = 1{,}4261 \times 10^6\ J.$$

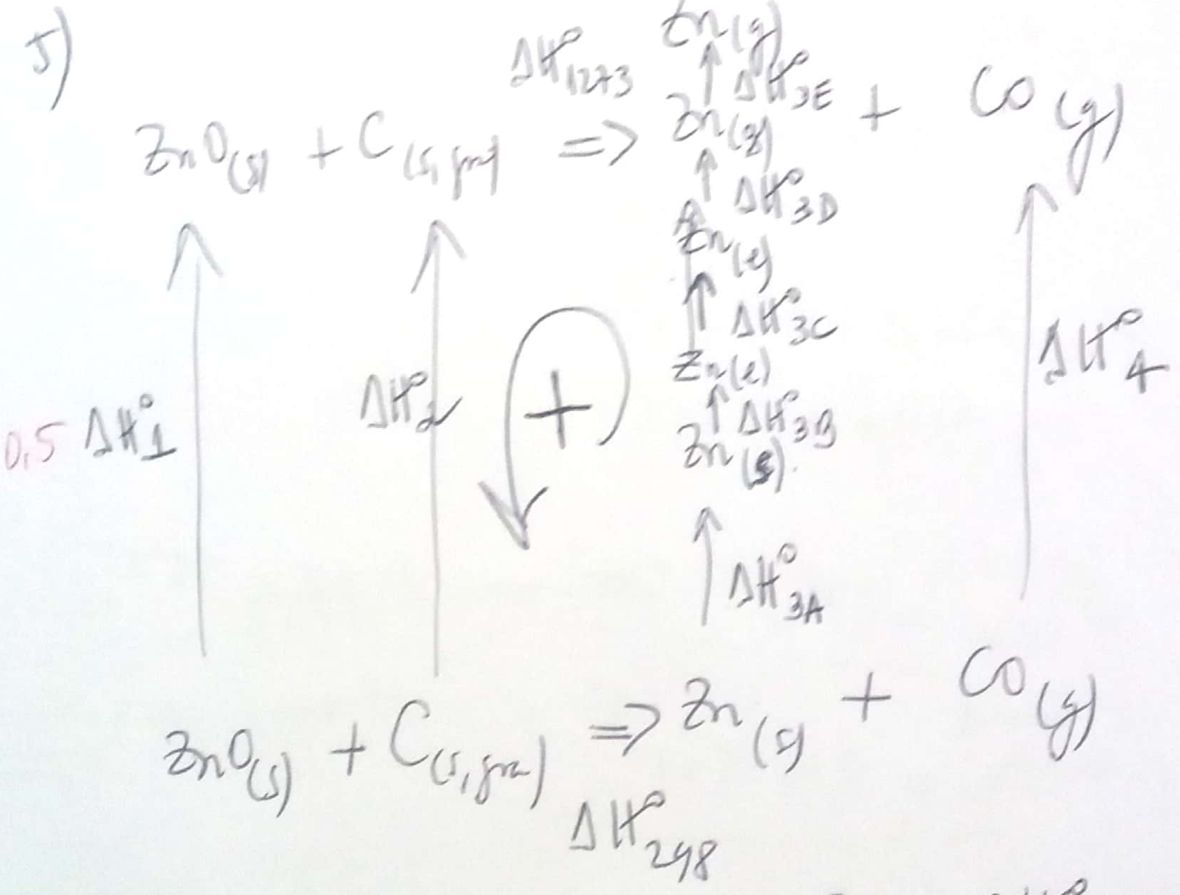
0,5 $\quad$ 70% rend.

$$1\ kWh = 10^3\ \frac{J}{\cancel{s}} \times 3600\,\cancel{s} = 3{,}6 \times 10^6\ J$$

$$Q_{min}^{kWh} = \frac{1,4261}{3,6} \times \frac{10^6}{10^6}$$

$$\boxed{Q_{min}^{kWh} \cong 0,4 \text{ kWh}}$$ 0,5

5)



$$-\Delta H^\circ_1 - \Delta H^\circ_2 + \Delta H^\circ_3 + \Delta H^\circ_4 - \Delta H^\circ_{1273} +$$

$$+ \Delta H^\circ_{298} = 0$$

$$\Delta H^\circ_1 = \int_{298}^{1273} C_p^{ZnO}\, dT = 12\,352 \text{ cal/mol}$$

$$\Delta H^\circ_2 = \int_{298}^{1273} C_p^{C(s)}\, dT = 4778{,}7 \text{ cal/mol}$$

$$\Delta H^\circ_3 = \int_{298}^{692} C_p^{Zn(s)}\, dT + 1740 + \int_{692}^{1180} C_p^{Zn(l)}\, dT +$$

$$+ 27300 + \int_{1180}^{1273} C_p^{Zn(g)}\, dT .$$

0,5

$$\Delta H^\circ_3 = 2576 + 1740 + 3660 + 27300 +$$
$$+ 462{,}21$$

$$\Delta H^\circ_3 = 35738$$

$$\Delta H^\circ_4 = \int_{298}^{1273} C_p^{CO(g)}\, dT = 7370{,}8$$

$$-12352 - 4778{,}7 + 35738 + 7370{,}8$$

$$+ \Delta H^\circ_{298} - \Delta H^\circ_{1273} = 0$$

$$\Delta H^\circ_{298} = \left[(-26442{,}6) + 0\right] -$$

$$- \left[(-83200) + (0)\right]$$

$$\Delta H^\circ_{298} = 56757 \text{ cal/mol.}$$

$$\Delta H^\circ_{1273} = 82735 \text{ cal/mol.}$$

$$\boxed{\Delta H^\circ_{1273} \simeq 345 \text{ kJ/mol.}}$$

1,5