

2.3 $\left(\frac{V}{n}\right)_{\text{lig}} = 1,88 \times 10^{-5} \text{ m}^3 \text{ mol}^{-1}$

$\left(\frac{V}{n}\right)_{\text{vapor}} = 3,06 \times 10^{-2} \text{ m}^3 \text{ mol}^{-1}$

$P_{\text{atm}} = 10^5 \text{ Pa}$

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$T = 373 \text{ K}$

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$L_{v,p} = 40,79 \text{ kJ/mol}$

- Calcular ΔH e ΔU para 1 mol H_2O , no processo:
 $\text{H}_2\text{O} (\text{lig.}, 373 \text{ K}, 10^5 \text{ Pa}) \longrightarrow \text{H}_2\text{O} (\text{gas}, 373 \text{ K}, 10^5 \text{ Pa})$

Resolução:

Lembrar que:

$H = U + PV \longrightarrow \Delta H = \Delta U + V \Delta P + P \Delta V$

e $\Delta U = Q_p - P_{\text{ex}} \Delta V \rightarrow U_2 - U_1 = Q_p - P_{\text{ex}} (V_2 - V_1) \rightarrow$
processo isobárico

$\rightarrow U_2 - U_1 = Q_p - P_{\text{ex}} V_2 + P_{\text{ex}} V_1 \rightarrow Q_p = \underbrace{(U_2 + P_{\text{ex}} V_2)}_{H_2} - \underbrace{(U_1 + P_{\text{ex}} V_1)}_{H_1}$

$\therefore Q_p = \Delta H$

Como $Q_p = \Delta H$ e $L_{v,p} = 40,79 \text{ kJ/mol} \rightarrow Q_p = \Delta H = 40,79 \frac{\text{kJ}}{\text{mol}}$

e $\Delta U = ?$

Como $\Delta H = \Delta U + P \Delta V \rightarrow \Delta U = \Delta H - P \Delta V$

ou seja $\Delta U = 40,79 \frac{\text{kJ}}{\text{mol}} - 10^5 \text{ Pa} \left(3,06 \times 10^{-2} \frac{\text{m}^3}{\text{mol}} - 1,88 \times 10^{-5} \frac{\text{m}^3}{\text{mol}} \right)$

ou $\Delta U = 40,79 \frac{\text{kJ}}{\text{mol}} - 3,06 \frac{\text{kJ}}{\text{mol}} = 37,73 \frac{\text{kJ}}{\text{mol}}$

2.4. Diferença entre ΔH e ΔU para

$$\begin{array}{ccc} 1 \text{ kg grafite} & \longrightarrow & 1 \text{ kg diamante} \\ \rho = 2250 \frac{\text{kg}}{\text{m}^3} & & \rho = 3520 \frac{\text{kg}}{\text{m}^3} \end{array}$$

$$P = 20000 \text{ atm} \quad (1 \text{ atm} \equiv 10^5 \text{ Pa})$$

$$\Delta H = \Delta U + V \Delta P + P \Delta V$$

isotérmica e isotérmica e sem mudança de fase, portanto $\Delta U = 0$

$$\text{Ou seja: } \Delta H = P \Delta V = 20000 \text{ atm} \times \frac{10^5 \text{ Pa}}{1 \text{ atm}} \times \left(\frac{1 \text{ kg}}{2250 \frac{\text{kg}}{\text{m}^3}} - \frac{1 \text{ kg}}{3520 \frac{\text{kg}}{\text{m}^3}} \right) = 320,7 \text{ kJ}$$

2.5. Ar atmosférico

$$\bar{c}_p = 29,0 \text{ J/Kmol}$$

Gás propano

$$\bar{c}_p = 67,3 \text{ J/Kmol}$$

1 mol ambos gases

$$P_1 = 3,2 \times 10^5 \text{ Pa}$$

$$V_1 = 8 \text{ l}$$

expansão

adiabática

$$V_2 = 20 \text{ l}$$

a) Calcular para o ar atmosférico (i) e gás propano (ii) o \bar{c}_v e o γ

i) ar atmosférico:

$$\bar{c}_p = \bar{c}_v + R \rightarrow \bar{c}_v = \bar{c}_p - R \rightarrow \bar{c}_v = 29,0 \frac{\text{J}}{\text{Kmol}} - 8,314 \frac{\text{J}}{\text{Kmol}} \rightarrow$$

$$T_2 = 300 \text{ K} \rightarrow T_2 = 215 \text{ K}$$

(Idem para o propano)

→ $\bar{c}_v = 20,686 \frac{J}{K \cdot mol}$

∴ $\gamma_{atm.} = \frac{\bar{c}_p}{\bar{c}_v} = \frac{29,0 \frac{J}{K \cdot mol}}{20,686 \frac{J}{K \cdot mol}} = 1,40$

ii) gás propano:

$\bar{c}_v = \bar{c}_p - R \rightarrow \bar{c}_v = \frac{67,3 J}{K \cdot mol} - \frac{8,314 J}{K \cdot mol} = \frac{58,986 J}{K \cdot mol}$

∴ $\gamma_{prop.} = \frac{\bar{c}_p}{\bar{c}_v} = \frac{67,3 \frac{J}{K \cdot mol}}{58,986 \frac{J}{K \cdot mol}} = 1,14$

b) $T_i = ?$ para ambos os gases
 $T_f = ?$

bi) an atmosférico:

Lembrar que

$$\begin{cases} T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1} & (eq. 2.48) \\ P_1 V_1^{\gamma} = P_2 V_2^{\gamma} & (" 2.49) \\ P_1^{\frac{1}{\gamma}-1} T_1 = P_2^{\frac{1}{\gamma}-1} T_2 & (" 2.50) \end{cases}$$

São dados: $V_1 = 8 l$, $V_2 = 20 l$ e $\gamma = 1,40$ (ai)

Para o estado inicial tem-se:

$P_1 V_1 = n R T_1 \rightarrow T_1 = \frac{P_1 V_1}{n R} = \frac{3,2 \times 10^5 Pa \times 8 l \times 10^{-3} m^3 l^{-1}}{1 mol \times 8,314 \frac{J}{K \cdot mol}} \approx 308 K$

Para o estado final do ar tem-se:

da eq. 248: $308 K \times (8 l)^{1,4-1} = T_2 \times (20 l)^{1,4-1} \Rightarrow$
 $T_2 = 308 K \times \left(\frac{8 l}{20 l}\right)^{1,4-1} = 213 K$

(Idem para o propano)

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2.6) $h_i = 550$ m acima nível mar

$$P_{atm} = 0,94 \times 10^5 \text{ Pa}$$

$$T_1 = 310 \text{ K}$$

exp.
adiabático

$h_f = 1550$ m acima nível mar

$$P_{atm} = 0,84 \times 10^5 \text{ Pa}$$

$$T_2 = ?$$

Processo adiabático:

$$P_1^{\frac{1}{\gamma} - 1} T_1 = P_2^{\frac{1}{\gamma} - 1} T_2$$

e p/lo ar, $\gamma = 1,40$ (assumimos à partir do ex. anterior)

$$(0,94 \times 10^5 \text{ Pa})^{\frac{1}{1,4} - 1} \times 310 \text{ K} = (0,84 \times 10^5 \text{ Pa})^{\frac{1}{1,4} - 1} \times T_2$$

$$T_2 = \left(\frac{0,94 \times 10^5 \text{ Pa}}{0,84 \times 10^5 \text{ Pa}} \right)^{\frac{1}{1,4} - 1} \times 310 = \underline{300 \text{ K}}$$

2. $Q_p = \Delta H$

Como $Q_p = \Delta H$ e $C_{p,m} = 40,79 \text{ kJ/mol} \rightarrow Q_p = \Delta H = 40,79 \text{ kJ/mol}$

e $\Delta U = ?$

Como $\Delta H = \Delta U + P \Delta V \rightarrow \Delta U = \Delta H - P \Delta V$

ou seja $\Delta U = 40,79 \frac{\text{kJ}}{\text{mol}} - 10^5 \text{ Pa} \left(3,06 \times 10^{-2} \frac{\text{m}^3}{\text{mol}} - 1,88 \times 10^{-2} \frac{\text{m}^3}{\text{mol}} \right)$

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