TEQB – Teste 2 Resolução

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Conteúdo

Questão 1

A temp afastadas do ponto crítico a curva de vap do but obedece à equação

$$\ln\left(P * 10^{-5}\right) = 13.440 - 3418.2/T$$
$$\ln P = 5 * \ln 10 + 13.440 - 3418.2/T$$

- $T_{(triplo,s-l-g)} = 134.86\,\mathrm{K}$
- $P_{sub,122.0\,\mathrm{K}} = 3.006 * 10^{-2}$
- $M_{butano} = 58.12\,\mathrm{g/mol}$
- $\rho_{(150.0\,\mathrm{K},P_{fus},s)} = 0.792\,\mathrm{g/cm^3}$
- $\rho_{(150.0\,\mathrm{K},P_{fus},l)} = 0.735\,\mathrm{g/cm^3}$
- $\alpha_{P,l} = 1.2 * 10^{-3}\,\mathrm{K^{-1}}$
- $\alpha_{P,s} = 4.3 * 10^{-3}\,\mathrm{K^{-1}}$
- $C_{p,s} = 84\,\mathrm{J\,K^{-1}\,mol^{-1}}$
- $C_{p,l} = 132\,\mathrm{J\,K^{-1}\,mol^{-1}}$
- $C_{p,g} = 95\,\mathrm{J\,K^{-1}\,mol^{-1}}$

Q1 a.

A pressão de fusão do butano a $150.0\,\mathrm{K}$

$$\left.\frac{\mathrm{d}P}{\mathrm{d}T}\right|_{fus} = \frac{\Delta H_{fus}}{T_{fus}\,\Delta V_{fus}} = \frac{\Delta H_{fus}}{T_{fus}\,(V_l - V_s)} = \frac{\Delta H_{sub} - \Delta H_{vap}}{T_{fus}\,(M/\rho_l - M/\rho_s)} =$$
$$= \frac{\Delta H_{sub} - \Delta H_{vap}}{T_{fus}\,M\,(\rho_l^{-1} - \rho_s^{-1})};$$

$$\left.\frac{\mathrm{d}P}{\mathrm{d}T}\right|_{vap} = \frac{\Delta H_{vap}}{T\,\Delta V_{vap}} = \frac{\Delta H_{vap}}{T\,(V_{vap,g} - V_{vap\,l})} \cong \frac{\Delta H_{vap}}{T\,V_{vap,g}} \cong \frac{\Delta H_{vap}}{T\,(RT/P)} = \frac{P\,\Delta H_{vap}}{RT^2} \implies$$
$$\implies \frac{\mathrm{d}P/P}{\mathrm{d}T} = \frac{\mathrm{d}\ln P}{\mathrm{d}T} = \frac{\Delta H_{vap}}{RT^2} = \frac{\mathrm{d}}{\mathrm{d}T}\left((13.440 - 3418.2/T) * 10^5\right) =$$
$$= -3418.2 * 10^5\,T^{-2} \implies \Delta H_{vap} \cong -3418.2 * 10^5\,R;$$

$$\left.\frac{\mathrm{d}P}{\mathrm{d}T}\right|_{sub} = \frac{\Delta H_{sub}}{T\,\Delta V_{sub}} = \frac{\Delta H_{sub}}{T\,(V_{sub,g} - V_{sub\,s})} \cong \frac{\Delta H_{sub}}{T\,V_{sub,g}} \cong \frac{\Delta H_{sub}}{T\,(RT/P)} \cdots;$$

$$\therefore P_{fus,150.0\,\mathrm{K}} \cong P_{sub,122.0\,\mathrm{K}} + \frac{\Delta H_{sub} - \Delta H_{vap}}{M(\rho_l^{-1} - \rho_s^{-1})} \ln \frac{T_l}{T_s}$$

Q1 b.

ΔH associado à passagem do butano no estado (161.0 K, 0.0002 bar) ao estado (161.0 K, 1300 bar)

$\Delta H_{161.0\,\mathrm{K},(0.0002 \rightarrow 1300)\,\mathrm{bar}};$

$$P_{vap,161.0\,\mathrm{K}} = P_l + \frac{\Delta H}{\Delta V}\,\ln\frac{T}{T_0}$$

Q1 c.

ΔS associado à passagem do butano no estado (170.0 K, 0.0004 bar) ao estado (150.0 K, 100 bar)

Q1 d.

ΔG associado à fusão do butano a 150.0 K e 920 bar.

body

Questão 2

- $V_{\mathrm{MeOH},m,*} = 40.45\,\mathrm{cm^3\,mol^{-1}}$
- $V_{\mathrm{H_2O},m,*} = 18.01\,\mathrm{cm^3\,mol^{-1}}$

Q2 a.

Calcule os volumes de metanol e água puros que são necessários para preparar $250\,\mathrm{cm}^3$ de uma solução com $X_{\mathrm{MeOH}} = 0.40$

$$V_{\mathrm{MeOH},*} = V_{\mathrm{MeOH},m,*} * n_{\mathrm{MeOH}} = V_{\mathrm{MeOH},m,*}\,(x_{\mathrm{MeOH}} * n_t) = V_{\mathrm{MeOH},m,*}\,x_{\mathrm{MeOH}}\left(\frac{V_{sol}}{V_{sol,m}}\right) =$$

$$= \frac{V_{\mathrm{MeOH},m,*}\,x_{\mathrm{MeOH}}\,V_{sol}}{x_{\mathrm{MeOH}}\,V_{\mathrm{MeOH},m} + (1 - x_{\mathrm{MeOH}})\,V_{agua,m}} \cong$$

$$\cong \frac{40.45 * 10^{-6} * 0.4 * 250 * 10^{-6}}{0.4 * (40.45 - 1.8) * 10^{-6} + 0.6 * (18.01 - 1.8) * 10^{-6}} \cong 160.61\,\mathrm{E{-}6};$$

$$V_{agua,*} \cong 160.61\,\mathrm{E{-}6}\frac{V_{agua,m,*}\,x_{agua}}{V_{\mathrm{MeOH},m,*}\,x_{\mathrm{MeOH}}} = 160.61\,\mathrm{E{-}6}\frac{18.01 * 0.6}{40.45 * 0.4} \cong 107.26\,\mathrm{E{-}6}$$

Q2 b.

Adicionou-se à solução da alínea anterior uma quantidade desconhecida de água, de modo a obter $V_{\mathrm{MeOH,m}} = 36.45\,\mathrm{cm^3\,mol^{-1}}$. Calcule o volume da nova solução.

$x_{MeOH,2}(36.45 - 40.45) = x_{MeOH,2}(-4) \cong 0.2;$

$$
\begin{aligned}
&V_{sol.2} = x_{agua,2}\,V_{agua,2} + x_{\mathrm{MeOH},2}\,V_{\mathrm{MeOH},2} = \\
&= (1 - x_{MeOH,2})\,(V_{agua,m,2}\,n_{agua}) + x_{MeOH,2}\,V_{\mathrm{MeOH},2} = \\
&= (1 - x_{MeOH,2})\,(V_{agua,m,2}\,(x_{agua}\,n_t)) + x_{MeOH,2}\,V_{\mathrm{MeOH},2} = \\
&= (1 - x_{MeOH,2})^2\,\left(V_{agua,m,2}\left(\frac{n_{\mathrm{MeOH}}}{x_{\mathrm{MeOH}}}\right)\right) + x_{MeOH,2}\,V_{\mathrm{MeOH},2} = \\
&= \frac{(1 - x_{MeOH,2})^2}{x_{\mathrm{MeOH}}}\,(V_{agua,m,2}\,(x_{\mathrm{MeOH},1} * n_{t,1})) + x_{MeOH,2}\,V_{\mathrm{MeOH},2} = \\
&= \frac{(1 - x_{MeOH,2})^2\,V_{agua,m,2}\,x_{\mathrm{MeOH},1}}{x_{\mathrm{MeOH},2}}\,\left(\frac{V_{sol.1}}{x_{\mathrm{MeOH},1}\,V_{\mathrm{MeOH},m,1} + (1 - x_{\mathrm{MeOH},1})\,V_{agua,m,1}}\right) + \\
&+ x_{MeOH,2}\,V_{\mathrm{MeOH},2} \cong \\
&\cong \frac{(0.8)^2(18.01 - 1) * 10^{-6} * 0.4}{0.2} * \\
&* \left(\frac{250 * 10^{-6}}{0.4 * (40.45 - 1.8) * 10^{-6} + 0.6 * (18.01 - 1.8) * 10^{-6}}\right) + \\
&+ 0.2\,(40.45 - 2) * 10^{-6} \cong \\
&\cong 223.81\,\mathrm{E{-}6}
\end{aligned}
$$

Incongruente: volume total não pode diminuir, algo está mal provavelmente nas relações iniciais de volume molar da água na solução 2 ao invés de $x_{i,2}\,V_{i,2}$ devia ser $x_{i,2}\,V_{i,m,2}$ e ao invés de $V_{sol,2}$ $V_{sol,m,2}$, falta multiplicar pelo numero total de mols

$x_{MeOH,2}(36.45 - 40.45) = x_{MeOH,2}(-4) \cong 0.2;$

$$
\begin{aligned}
&V_{sol.2} = (x_{agua,2}\,V_{agua,m,2} + x_{\mathrm{MeOH},2}\,V_{\mathrm{MeOH},m,2})\;n_{t,2} = \\
&= (x_{agua,2}\,V_{agua,m,2} + x_{\mathrm{MeOH},2}\,V_{\mathrm{MeOH},m,2})\;n_{t,2} = \\
&= (x_{agua,2}\,V_{agua,m,2} + x_{\mathrm{MeOH},2}\,V_{\mathrm{MeOH},m,2})\left(\frac{n_{\mathrm{MeOH},2}}{x_{\mathrm{MeOH},2}}\right) = \\
&= \frac{(x_{agua,2}\,V_{agua,m,2} + x_{\mathrm{MeOH},2}\,V_{\mathrm{MeOH},m,2})}{x_{\mathrm{MeOH},2}}\,(x_{\mathrm{MeOH},1} * n_{t,1}) = \\
&= \frac{(x_{agua,2}\,V_{agua,m,2} + x_{\mathrm{MeOH},2}\,V_{\mathrm{MeOH},m,2})\,x_{\mathrm{MeOH},1}}{x_{\mathrm{MeOH},2}} * \\
&* \left(\frac{V_{sol.1}}{x_{\mathrm{MeOH},1}\,V_{\mathrm{MeOH},m,1} + (1 - x_{\mathrm{MeOH},1})\,V_{agua,m,1}}\right) = \\
&= \frac{(x_{agua,2}\,V_{agua,m,2} + x_{\mathrm{MeOH},2}\,V_{\mathrm{MeOH},m,2})\,x_{\mathrm{MeOH},1}\,V_{sol.1}}{x_{\mathrm{MeOH},2}\,(x_{\mathrm{MeOH},1}\,V_{\mathrm{MeOH},m,1} + (1 - x_{\mathrm{MeOH},1})\,V_{agua,m,1})} \cong \\
&\cong \frac{(0.8 * (18.01 - 1) * 10^{-6} + 0.2 * (40.45 - 4) * 10^{-6})\,0.4 * 250 * 10^{-6}}{0.2\,(0.4 * (40.45 - 1.8) * 10^{-6} + 0.6 * (18.01 - 1.8) * 10^{-6})} \cong \\
&\cong 414.87\,\mathrm{E{-}6}
\end{aligned}
$$

Q2 c.

Defina o volume parcial mola de metanol numa mistura (metanol + água)

$$V_{\mathrm{MeOH},m} = \frac{V_{sol} - (1 - x_{\mathrm{MeOH}})\, V_{agua,m}}{x_{\mathrm{MeOH}}}$$