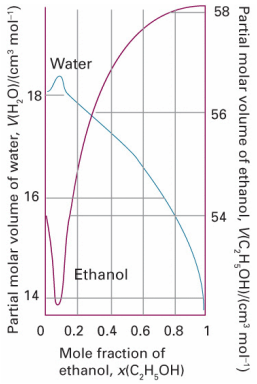
Svojstva otopina

Parcijalni molarni volumen

$$V_{\mathrm{J}} = \left(\frac{\partial V}{\partial n_{\mathrm{J}}}\right)_{p,T,n'}$$

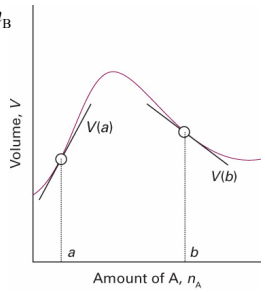


Parcijalni molarni volumen

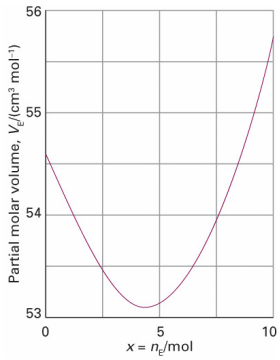
$$dV = \left(\frac{\partial V}{\partial n_{\mathrm{A}}}\right)_{p,T,n_{\mathrm{B}}} dn_{\mathrm{A}} + \left(\frac{\partial V}{\partial n_{\mathrm{B}}}\right)_{p,T,n_{\mathrm{A}}} dn_{\mathrm{B}}$$

$$dV = V_{\mathrm{A}} dn_{\mathrm{A}} + V_{\mathrm{B}} dn_{\mathrm{B}}$$

$$V = V_{\mathrm{A}} n_{\mathrm{A}} + V_{\mathrm{B}} n_{\mathrm{B}}$$



Parcijalni molarni volumen

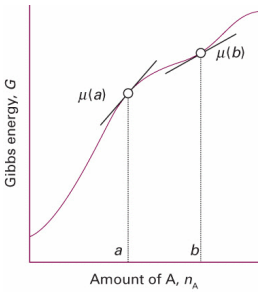


Kemijski potencijal

Parcijalna molarna Gibbsova energija.

$$\mu_{\mathrm{J}} = \left(\frac{\partial G}{\partial n_{\mathrm{J}}}\right)_{p,T,n'}$$

$$G = n_{\mathrm{A}}\mu_{\mathrm{A}} + n_{\mathrm{B}}\mu_{\mathrm{B}}$$



Kemijski potencijal

Fundamentalna jednadžba kemijske termodinamike:

$$dG = Vdp - SdT + \mu_{\mathrm{A}} dn_{\mathrm{A}} + \mu_{\mathrm{B}} dn_{\mathrm{B}} + \ldots$$

Pri konstantnom tlaku i volumenu:

$$dG = \mu_{\mathrm{A}} dn_{\mathrm{A}} + \mu_{\mathrm{B}} dn_{\mathrm{B}} + \ldots$$

$$dw_{\max.dodatni} = \mu_{\mathrm{A}} dn_{\mathrm{A}} + \mu_{\mathrm{B}} dn_{\mathrm{B}} + \ldots$$

Kemijski potencijal

$$dU = \mu_{\mathrm{A}} dn_{\mathrm{A}} + \mu_{\mathrm{B}} dn_{\mathrm{B}} + \ldots$$

$$\mu_{\mathrm{J}} = \left(\frac{\partial U}{\partial n_{\mathrm{J}}}\right)_{S,V,n'}$$

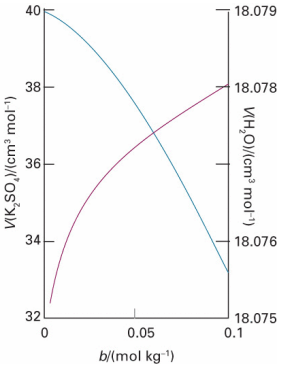
$$\mu_{\mathrm{J}} = \left(\frac{\partial G}{\partial n_{\mathrm{J}}}\right)_{p,T,n'} = \left(\frac{\partial U}{\partial n_{\mathrm{J}}}\right)_{S,V,n'} = \left(\frac{\partial H}{\partial n_{\mathrm{J}}}\right)_{S,p,n'} = \left(\frac{\partial A}{\partial n_{\mathrm{J}}}\right)_{T,V,n'}$$

Gibbs-Duhemova jednadžba

$$\sum_{\mathrm{J}} n_{\mathrm{J}} d\mu_{\mathrm{J}} = 0$$

Za binarne smjese:

$$d\mu_{\mathrm{B}} = -\frac{n_{\mathrm{A}}}{n_{\mathrm{B}}} d\mu_{\mathrm{A}}$$



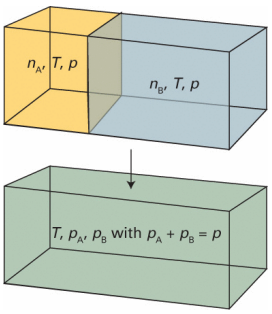
Termodinamika miješanja

Za miješanje dva idealna plina:

$$\mu = \mu^{\ominus} + RT \ln \frac{p}{p^{\ominus}}$$

$$\Delta_{\mathrm{mix}} G = n_{\mathrm{A}} RT \ln \frac{p_{\mathrm{A}}}{p} + n_{\mathrm{B}} RT \ln \frac{p_{\mathrm{B}}}{p}$$

$$\Delta_{\mathrm{mix}} G = nRT(x_{\mathrm{A}} \ln x_{\mathrm{A}} + x_{\mathrm{B}} \ln x_{\mathrm{B}})$$

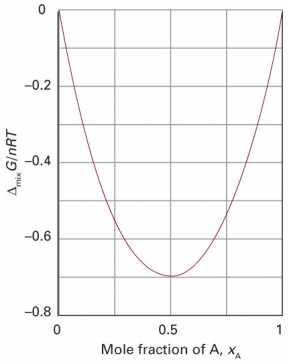


Termodinamika miješanja

Za miješanje dva idealna plina:

$$\Delta_{\mathrm{mix}} G = n_{\mathrm{A}} RT \ln \frac{p_{\mathrm{A}}}{p} + n_{\mathrm{B}} RT \ln \frac{p_{\mathrm{B}}}{p}$$

$$\Delta_{\mathrm{mix}} G = nRT(x_{\mathrm{A}} \ln x_{\mathrm{A}} + x_{\mathrm{B}} \ln x_{\mathrm{B}})$$

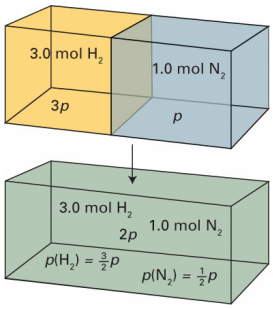


Termodinamika miješanja

Za miješanje dva idealna plina:

$$\Delta G_{\mathrm{mix}} = n_{\mathrm{A}} RT \ln \frac{p_{\mathrm{A}}}{p} + n_{\mathrm{B}} RT \ln \frac{p_{\mathrm{B}}}{p}$$

$$\Delta G_{\mathrm{mix}} = nRT(x_{\mathrm{A}} \ln x_{\mathrm{A}} + x_{\mathrm{B}} \ln x_{\mathrm{B}})$$



Termodinamika miješanja

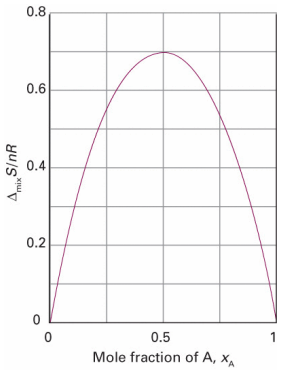
Entropija miješanja dva idealna plina:

$$\Delta_{\mathrm{mix}} S = \left(\frac{\partial \Delta_{mix} G}{\partial T} \right)_{p, n_A, n_B}$$

$$\Delta_{\mathrm{mix}} S = -nR(x_{\mathrm{A}} \ln x_{\mathrm{A}} + x_{\mathrm{B}} \ln x_{\mathrm{B}})$$

Entalpija miješanja dva idealna plina:

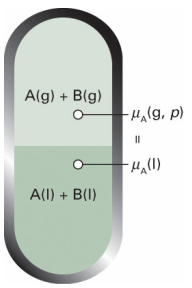
$$\Delta_{\mathrm{mix}} H = 0$$



Kemijski potencijal tekućina

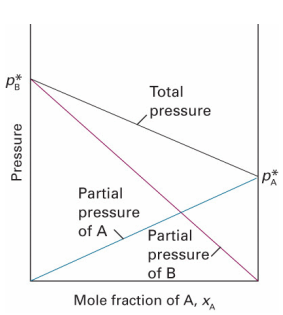
Kemijski potencijal idealne otopine:

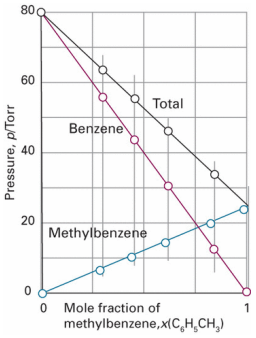
$$\mu_{\mathrm{A}} = \mu_{\mathrm{A}}^{*} + RT \ln x_{\mathrm{A}}$$



Kemijski potencijal tekućina

Parcijalni tlakovi para binarne smjese.





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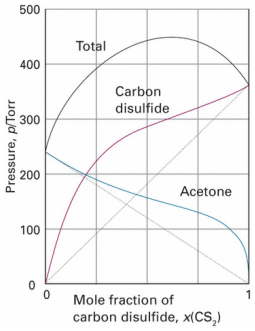
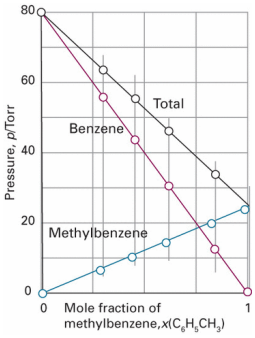
Kemijski potencijal tekućina





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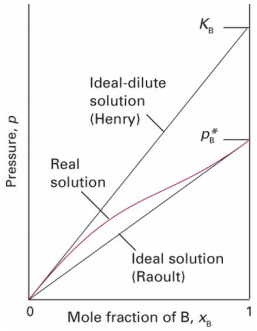
Idealno razrijeđene otopine

Raoultov zakon: $p_B = x_B p_B^*$

Henryjev zakon: $p_B = x_B K_B$

	K/(kPa kg mol^{-1})
CO_2	3.01×10^3
H_2	1.28×10^5
N_2	1.56×10^5
O_2	7.92×10^4

* More values are given in the *Data section*.



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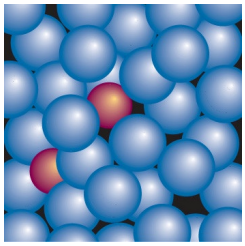
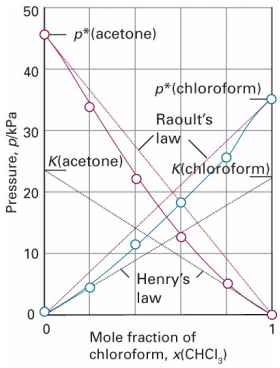
Svojstva otopina





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Miješanje tekućina

Termodinamičke fukcije miješanja idealnih tekućina:

$$\Delta G_{mix} = nRT(x_A \ln x_A + x_B \ln x_B)$$

$$\Delta_{mix} S = -nR(x_A \ln x_A + x_B \ln x_B)$$

$$\Delta_{mix} H = 0$$

Termodinamičke fukcije suviška miješanja realnih tekućina:

$$G^E = \Delta_{mix} G - \Delta_{mix} G^{ideal}$$

$$S^E = \Delta_{mix} S - \Delta_{mix} S^{ideal}$$

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Miješanje tekućina

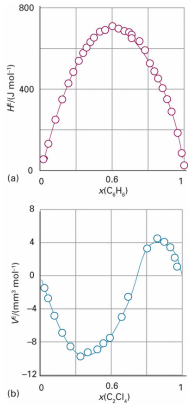
Termodinamičke fukcije suviška miješanja realnih tekućina:

$$G^E = \Delta_{mix} G - \Delta_{mix} G^{ideal}$$

$$S^E = \Delta_{mix} S - \Delta_{mix} S^{ideal}$$

$$H^E = \Delta_{mix} H$$

$$V^E = \Delta_{mix} V - \Delta_{mix} V^{ideal}$$



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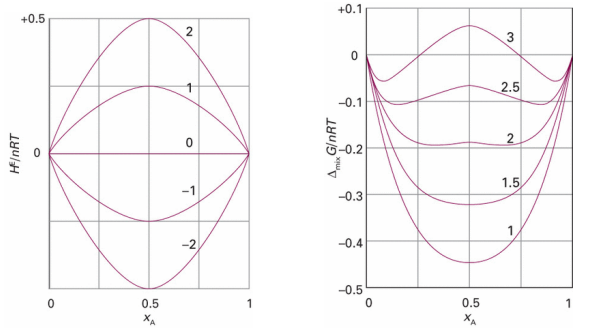
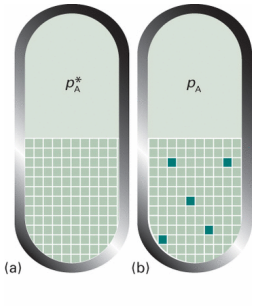
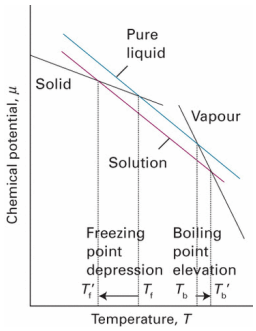
Regularne otopine

$H^{\mathrm{E}} = n\xi RTx_A x_B \qquad \Delta G_{\mathrm{mix}} = nRT(x_{\mathrm{A}} \ln x_{\mathrm{A}} + x_{\mathrm{B}} \ln x_{\mathrm{B}} + \xi x_{\mathrm{A}} x_{\mathrm{B}})$



Koligativna svojstva otapala





Povišenje vrelišta

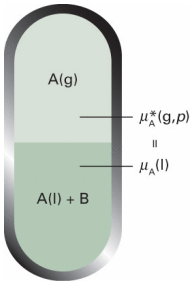
$\mu_{\mathrm{A}}^*(g) = \mu_{\mathrm{A}}^*(l) + RT \ln x_{\mathrm{A}}$

$\Delta T = Kx_{\mathrm{B}} \qquad K = \dfrac{RT^{*2}}{\Delta_{vap}H}$

$\Delta T = K_b b$

	K_f/(K kg mol^{-1})	K_b/(K kg mol^{-1})
Benzene	5.12	2.53
Camphor	40	
Phenol	7.27	3.04
Water	1.86	0.51

* More values are given in the *Data section*.



Sniženje tališta

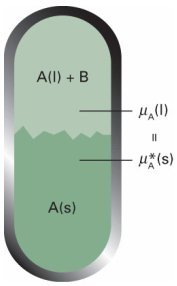
$\mu_{\mathrm{A}}^*(s) = \mu_{\mathrm{A}}^*(l) + RT \ln x_{\mathrm{A}}$

$\Delta T = K' x_{\mathrm{B}} \qquad K' = \dfrac{RT^{*2}}{\Delta_{fus}H}$

$\Delta T = K_f b$

	K_f/(K kg mol^{-1})	K_b/(K kg mol^{-1})
Benzene	5.12	2.53
Camphor	40	
Phenol	7.27	3.04
Water	1.86	0.51

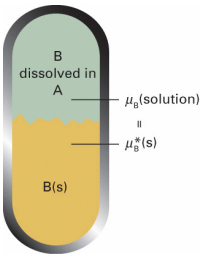
* More values are given in the *Data section*.

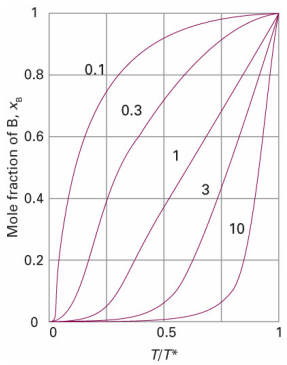


Topljivost

$\mu_{\mathrm{B}}^*(s) = \mu_{\mathrm{B}}^*(l) + RT \ln x_{\mathrm{B}}$

$\ln x_{\mathrm{B}} = \dfrac{\Delta_{fus}H}{R}\left(\dfrac{1}{T_f} - \dfrac{1}{T}\right)$

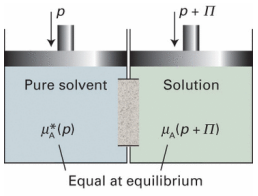




Osmotski tlak

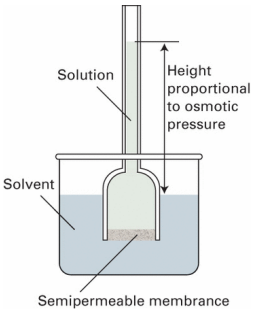
Van't Hoffova jednadžba

$\Pi = \dfrac{n_{\mathrm{B}}}{V} RT$



$\mu_{\mathrm{A}}^*(p) = \mu_{\mathrm{A}}(x_{\mathrm{A}}, p + \Pi)$

Osmometrija



$$\frac{h}{c} = \frac{RT}{\rho g M}$$