CH365 Chemical Engineering Thermodynamics

Lesson 29

Residual Properties II

Block 6 Look-Ahead (CDP)

Real Gas Properties

- Residual Properties
- M = V, U, H, S, or G

$$M^R \equiv M - M^{ig}$$ (Eq. 6.41) $$M \equiv M^{ig} + M^R$$

Ideal gas (ig) follows ideal gas law

Real Solution Properties (Liquids)

$$M^E \equiv M - M^{id}$$ (Eq. 6.41) $$M \equiv M^{id} + M^E$$

- Excess Properties
- $M^E = V^E, U^E, H^E, S^E$, or G^E

$$G^E \equiv G - G^{id} \qquad H^E \equiv H - H^{id} \qquad S^E \equiv S - S^{id}$$

Ideal solution (id) follows Raoult's law

GE is related to the activity coefficients

From Gibbs-Duhem:

$$\frac{G^E}{RT} = \sum_i x_i \ln \gamma_i$$ (Eq. 13.10)

Margules
(1-constant)

$$\log \gamma_1 = A x_2^2 \qquad \log \gamma_2 = A x_1^2$$

Constants are known from fitting experimental data
("binary interaction parameters" in CHEMCAD and capstone design problem)

Residual Properties from Cubic EOS

Generic cubic equation of state (in Z-Form) **(WPR3)**

$$q = q(x) = \frac{\Psi\alpha(x)}{\Omega T_r}$$ (Eq. 3.51)

$$\alpha = \alpha(x)$$

(α is found in Table 3.1)

Important: α is written as a function of x where x replaces T_r.

$$\beta = \Omega \frac{P_r}{T_r}$$ (3.50)

$$Z = 1 + \beta - q\beta \frac{Z - \beta}{(Z + \varepsilon\beta)(Z + \sigma\beta)}$$ (3.48)

$$\frac{H^R}{RT} = Z - 1 + T_r \left(\frac{dq}{dT_r} \right) \cdot I$$

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$$\frac{S^R}{R} = \ln(Z - \beta) + \left(q + T_r \frac{dq}{dT_r} \right) \cdot I$$

$$I = \frac{1}{\sigma - \varepsilon} \ln\left(\frac{Z + \sigma\beta}{Z + \varepsilon\beta} \right)$$

$\varepsilon \neq \sigma$

$$I = \frac{\beta}{Z}$$

$\varepsilon = \sigma$

Homework

Problem 6.141

change: 20 points

Calculate Z, H^R, and S^R by the Redlich-Kwong equation of state for parts (b) through (e).

(a) Ethylene at 300 K and 35 bar
(b) Hydrogen sulfide at 400 K and 70 bar
(c) Nitrogen at 150 K and 50 bar
(d) n-Octane at 575 K and 15 bar
(e) Propane at 375 K and 25 bar