Lecture #4

Chemica Engineering Dept., KFUPM, CHE303, Handout_1, Specific volume of a gas using EOS's

Example

Calculate the specific volume of ethane gas at 50 °C and 15 bar using:

(a) The ideal gas E.O.S.
(b) The truncated virial E.O.S., with a value of the second virial coefficient obtained from generalized correlations.
(c) The Ridlich/Kwong E.O.S.

Solution

(a) $V = \frac{RT}{P}$ $\quad R = 83.14 \left(\frac{cm^3\ bar}{mol\ K}\right)$

$= \frac{(83.14)(50+273.15)}{15} = 1791.11 \left(\frac{cm^3}{mol}\right)$

(b) $Z = 1 + \frac{BP}{RT}$, $V = Z\frac{RT}{P}$

$\frac{BP_c}{RT_c} = B^0 + \omega B'$

From Appendix B.1 $\quad \omega = 0.1$, $T_c = 305.3\ K$

$P_c = 48.72\ bar$

$B^0 = 0.083 - \frac{0.422}{T_r^{1.6}} = 0.083 - \frac{0.422}{\left(\frac{50+273.15}{305.3}\right)^{1.6}}$

$= -0.3023$

$B' = 0.139 - \frac{0.172}{T_r^{4.2}} = 0.139 - \frac{0.172}{\left(\frac{50+273.15}{305.3}\right)^{4.2}}$

$= 3.5173 \times 10^{-3}$

$$\Rightarrow B = \left[-0.3023 + (0.1)\left(3.5173 * 10^{-3}\right)\right] \frac{(83.14)(305.2)}{48.72} \quad (2)$$

$$= -157.26 \quad \frac{cm^3}{mol}$$

$$\Rightarrow Z = 1 + \frac{(-157.26)(15)}{(83.14)(50+273.15)} = 0.9122$$

- $V = Z \frac{RT}{P} = 1633.85 \frac{cm^3}{mol}$

(c) $$Z = 1 + \beta - q\beta \frac{Z - \beta}{(Z + \epsilon\beta)(Z + \epsilon\beta)}$$

For RK E.O.S. from table 3.1

- $\alpha(T_r) = T_r^{-\frac{1}{2}}$, $\sigma = 1$, $\epsilon = 0$, $\Omega = 0.08664$

$\psi = 0.42748$

$$\beta = \Omega \frac{P_r}{T_r} = 0.08664 \frac{\left(\frac{15}{48.72}\right)}{\left(\frac{50+273.15}{305.3}\right)} = 0.0252$$

$$q = \psi \alpha(T_r) / (\Omega T_r)$$

$$= \frac{(0.42748)\left(\frac{50+273.15}{305.3}\right)^{-\frac{1}{2}}}{(0.08664)\left(\frac{50+273.15}{305.3}\right)} = 4.5309$$

$$\Rightarrow Z = 1 + 0.0252 - (4.5309)(0.0252)\,\frac{Z - 0.0252}{Z\,(Z + 0.052)}$$

$$Z - 1.0252 + 0.1142\,\frac{Z - 0.0252}{Z\,(Z + 0.052)} = 0$$

$\Rightarrow$ $F(Z) = 0$ solve by trail and error

Z	$F(Z)$
$Z_1 = 0.85$	-0.0523
$Z_2 = 0.95$	$+0.0357$
$\frac{Z_3 - 0.85}{0.95 - 0.85} = \frac{0 - (-0.0523)}{0.0357 - (-0.0523)}$	
$\Rightarrow Z_3 = 0.9094$	$0.000022 \approx 0$

$$\Rightarrow Z = 0.9094 \;,\; V = 1628.83\left(\frac{cm^3}{mol}\right)$$