TUTORIAL 4 SOLUTION

PROBLEM 2

GIVEN

$V^{TOT} = 125\ cm^3$ but contents are 1 mole of methane so this is also the molar volume

$\Rightarrow V = 125\ cm^3/mol = 0.125\ L/mol$

$T_1 =$ room temperature $= 25°C = 298\ K$

$T_2 = 50°C = 323\ K$

Cylinder is rated for 200 atm

REQUIRED TO FIND: Will the cylinder explode?

i) Use I.G.L.

$$P = \frac{RT}{V} = \frac{\left(82.06\ \frac{cm^3\ atm}{mol\ K}\right)(323K)}{\left(125\ cm^3/mol\right)} = 212\ atm$$

$\therefore$ I.G.L. says cylinder will explode!

ii) Redlich-Kwong (Use Table 3.1)

$$P = \frac{RT}{V-b} - \frac{a(T)}{(V+\varepsilon b)(V+\sigma b)} \qquad (3.42)$$

$T_c = 190.4\ K \qquad P_c = 4.60\ MPa$

$$a(T) = \psi \frac{\alpha(T_r) R^2 T_c^2}{P_c} \qquad \text{(Eq'n 3.45)}$$

$$b = \Omega \frac{R T_c}{P_c} \qquad \text{(Eq'n 3.46)}$$

from Table 3.1

$\psi = 0.42748 \qquad \alpha(T_r) = T_r^{-1/2}$

$\Omega = 0.08664$

$\sigma = 1 \qquad \varepsilon = 0$

$$a(T) = 0.42748 \frac{\left(\frac{323}{190.4}\right)^{-1/2} \left(8.314 \frac{L \cdot kPa}{mol \cdot K}\right)^2 (190.4K)^2}{4600\ kPa}$$

~~= 178,820,400 kPa~~

$= 178.8 \ L^2 \cdot mol^{-2} \cdot kPa$

$$b = 0.08664 \left(8.314 \frac{L \cdot kPa}{mol \cdot K}\right)\left(\frac{190.4\ K}{4600\ kPa}\right)$$

$= 0.0298 \ L/mol$

Substituting

$$P_2 = \frac{R T_2}{(V - b)} - \frac{a}{V(V + b)}$$

$$P_2 = \frac{\left(8.314 \frac{L \cdot kPa}{mol\,K}\right)(323\,K)}{\left(0.125 \frac{L}{mol} - 0.0298 \frac{L}{mol}\right)} - \frac{178.8\ L^2\,mol^{-2}\,kPa}{\left(0.125\ L/mol\right)\left(0.125 - 0.298\ L/mol\right)}$$

$= 28{,}200\ kPa \quad + \quad 9{,}200\ kPa$

$= 19\,000\ kPa \cdot \frac{1\ atm}{101.3\ kPa}$

$= 187.6\ atm$

The tank will not eplode.

Note: Experimental result is 185 atm

Why not use Generalized Pitzer correlation with $Z = Z^0 + \omega Z^1$

$$B^0 = 0.083 - \frac{0.422}{T_r^{1.6}}$$

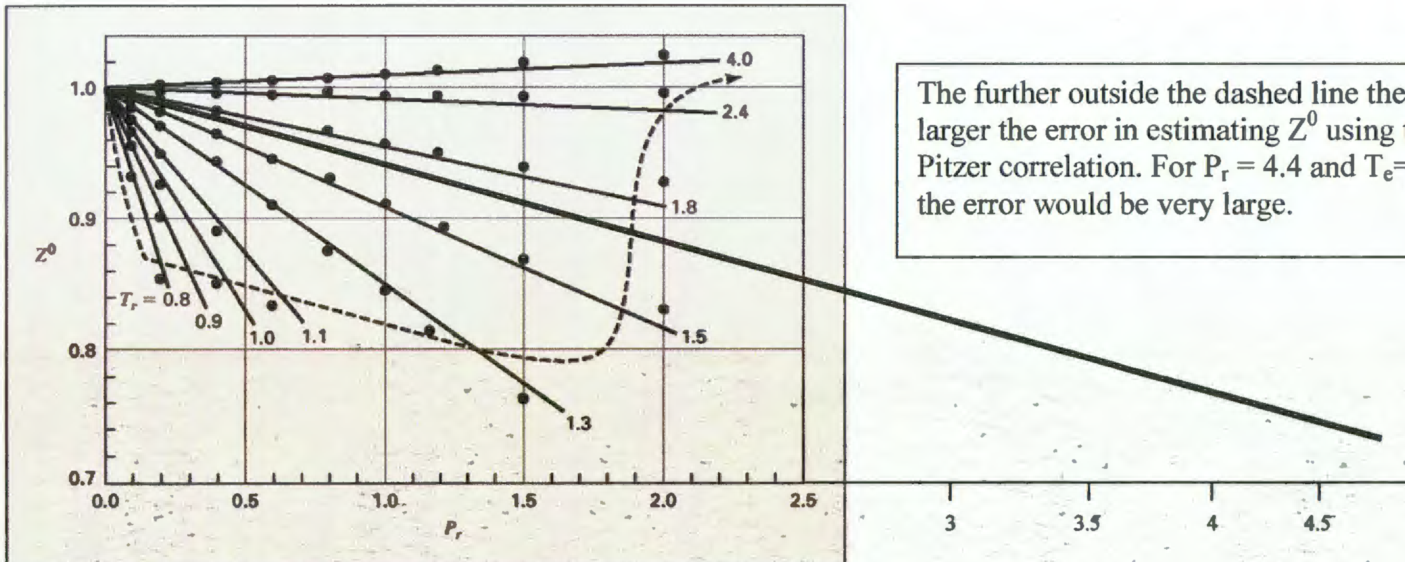
$$B^1 = 0.139 - \frac{0.172}{T_r^{4.2}}$$

$\omega = 0.012$ from Table B.1

$$P = \frac{ZRT}{V} \quad \text{(much easier but...!)}$$

$$T_r = \frac{323\ K}{190.4\ K} = 1.7 \qquad P_r = \frac{200 \times 101.4\ kPa}{4600\ kPa} = 4.41$$

1. A 125 cm3 cylinder is rated at 200 atm. It presently contains 1 mole of methane at room temperature. If the temperature is raised to 50 °C, will the cylinder rupture? Use the ideal gas equation, and the Redlich-Kwong correlation. Why not use the simple Generalized Pitzer Correlations?



The further outside the dashed line the larger the error in estimating Z^0 using the Pitzer correlation. For $P_r = 4.4$ and $T_e = 1.7$ the error would be very large.

Figure 3.14: Comparison of correlations for Z^0. The virial-coefficient correlation is represented by the straight lines; the Lee/Kesler correlation, by the points. In the region above the dashed line the two correlations differ by less than 2%.

$$B^0 = 0.083 - \frac{0.422}{(1.7)^{1.6}}$$

$$= -0.09755$$

$$Z^0 = 1 + (-0.09755)\frac{4.4}{1.7}$$

$$= 0.7475$$

$$B' = 0.139 - \frac{0.172}{(1.7)^{4.2}}$$

$$= 0.1205$$

$$Z' = 0.1205\,\frac{4.4}{1.7}$$

$$= 0.3118$$

$$Z = Z^0 + \omega Z'$$

$$= 0.7513$$

$$P_2 = 0.7513\frac{RT}{V}$$

$$= 0.7513 \times 212\text{atm}$$

$$= 160 \text{ atm}$$

(25atm low compared to expt'l.)