Quiz 1.2 – Real Gases

Name: Key

Question 1

Using Table 1C.3 (van der Waals coefficients) at the end of your textbook, find the following (From those listed in the table):

- Smallest gas particle He
- Largest gas particle C_6H_6
- Gas with the strongest attractive forces C_6H_6
- Gas with the weakest attractive forces Kr

Question 2

0.344 L/mol

Ammonia has van der Waals constants of $a = 4.169 \frac{L^2 bar}{mol^2}$ and $b = 0.0371 \frac{L}{mol}$

8.00 mol of ammonia are placed in $2.75\ L$ at 348 K. Find the following:

- Pressure (bar) assuming ideal behavior

$$p = \frac{nRT}{V} = \frac{8.00\ mol \cdot 0.08314 \frac{L \cdot bar}{mol \cdot K}\ 348 K}{2.75 L} = 84.2\ bar$$

- Pressure (bar) using the van der Waals equation

$$p = \frac{nRT}{V-nb} - a\frac{n^2}{V^2} = \frac{8.00\ mol \cdot 0.08314 \frac{L \cdot bar}{mol \cdot K} \cdot 348\ K}{2.75 L - 8.00\ mol \cdot 0.0371 \frac{L}{mol}} - 4.169 \frac{L^2 bar}{mol^2} \cdot \frac{(8.00\ mol)^2}{(2.75\ L)^2} = 59.1\ bar$$

- Compression factor (Z) using this van der Waals pressure

$$Z = \frac{p}{p^{o}} = 0.702$$

(Note that this is a different form than given in the textbook)

- Reduced state variables, V_r, p_r, and T_r (You will need to refer to your textbook)

$$V_r = \frac{V}{V_c} = \frac{0.344\ L/mol}{0.0725\ L/mol} = 4.74 \qquad p_r = \frac{p}{p_c} = \frac{59.1\ bar}{113\ bar} = 0.523$$

$$T_r = \frac{T}{T_c} = \frac{348\ K}{405.5\ K} = 0.858$$

Question 3

Explain the significance of the Boyle temperature of a gas as it relates to:

- The virial equation –

The first virial coefficient transitions from negative to positive at the Boyle temperature.

- The ideal gas law –

At the Boyle temperature the gas behaves most like an ideal gas over the widest temperature range

Question 4

Ammonia has second virial coefficient of $B = -165\frac{cm^3}{mol}$ at 348 K

$\rightarrow 0.344\ L/mol$

8.00 mol of ammonia are placed in 2.75 L at 348 K

- Find the pressure (bar) ~~assuming ideal behavior~~ using the virial equation

$$pV_m = RT\left(1 + \frac{-.165\ L/mol}{0.344\ L/mol}\right) \rightarrow p \cdot 0.344\frac{L}{mol} = 0.08314\frac{L\cdot bar}{mol\cdot K}\cdot 348K\left(1+\frac{-0.165\ L/mol}{0.344\ L/mol}\right) 43.8\ bar$$

- Find the compression factor (Z) using this virial pressure

$$Z = \frac{p}{p^\circ} = \frac{43.8\ bar}{84.2\ bar} = 0.520$$

- Compare the van der Waals pressure calculated above to this virial pressure

The Virial pressure is a bit lower, by about 25%

- Explain how the results of the virial equation can rival those of the van der Waals equation, when it uses only one corrective term and the van der Waals equation uses two

The virial coefficients are temperature dependent, so they are not just 1 constant