King Saud University

Petroleum and Natural Gas Engineering

PGE 362: Properties of Reservoir Fluids

Thursday, February 23, 2017

Tutorial Two

Ideal gas (perfect gas) vs. non-ideal gas (real gas)

Q1)

Calculate the pressure exerted by the gas CO_2 which has the following properties;

V = 22.4 liter; n = 1.0 mole; T = 0 °C

a = 3.592 L^2 atm/mol^2

b = 0.04267 L/mol

1. Assume ideal gas behavior
2. Assume non-ideal gas behavior (use Van der Waals equation)

Solution

Part one: (ideal gas behavior)

PV = nRT : R = 0.08206 L atm/mol K

P = nRT/V = (1.0 mol)(0.08206 L atm/mol K) (0+273)/(22.4 L)

P = 1.0 atm

Part two: (non-ideal gas behavior)

$[P + an^2/V^2] (V – nb) = nRT$

$[P + (3.592\ L^2\ atm/mol^2)\ (1.0\ mol)^2 /(22.4\ L)^2]\ [22.4\ L – (1.0\ mol)(0.04267\ L/mol)] = (1.0\ mol)(0.08206\ L\ atm/mol\ K)(0+273\ K)$

P_{ideal} = 1 atm : P_{real} = 0.995 atm

V_{ideal} = 22.4 L : V_{real} = 22.4 – 1x0.04267 = 22.35733 L

V_{real} / V_{ideal} = 22.35733/22.4 = 0.9981 = 1.0

Q2)

Calculate the pressure exerted by the gas CO_2 which has the following properties;

V = 0.2 liter; n = 1.0 mole; T = 0 °C

a = 3.592 L^2 atm/mol^2

b = 0.04267 L/mol

1. Assume ideal gas behavior
2. Assume non-ideal gas behavior (use Van der Waals equation)

Solution

Part one: (ideal gas behavior)

PV = nRT

P = nRT/V = (1.0 mol)(0.08206 L atm/mol K) (0+273)/(0.2 L)

P = 112 atm

Part two: (non-ideal gas behavior)

$[P + an^2/V^2] (V – nb) = nRT$

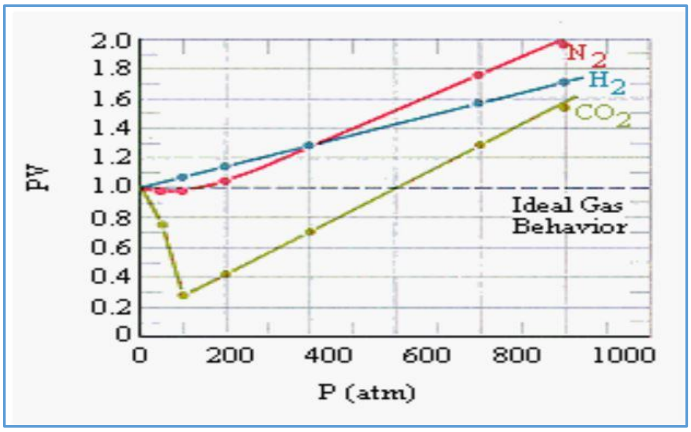
$[P + (3.592\ L^2\ atm/mol^2)\ (1.0\ mol)^2 / (0.2\ L)^2]\ [0.2\ L – (1.0\ mol)(0.04267\ L/mol)] = (1.0\ mol)(0.08206\ L\ atm/mol\ K)(0+273\ K)$

P_{ideal} = 112 atm : P_{real} = 52.6 atm

V_{ideal} = 0.2 L : V_{real} = 0.2 – 1x0.04267 = 0.15733 L

V_{real} / V_{ideal} = 0.15733/0.2 = 0.787

As the pressure of CO_2 increases the van der Waals equation initially gives pressures that are *smaller* than the ideal gas equation, as shown in the figure below, because of the strong force of attraction between CO_2 molecules.



Q3)

Calculate the pressure exerted by the gas CO_2 which has the following properties;

V = 0.05 liter; n = 1.0 mole; T = 0 °C

a = 3.592 L^2 atm/mol^2

b = 0.04267 L/mol

1. Assume ideal gas behavior
2. Assume non-ideal gas behavior (use Van der Waals equation)

Solution

Part one: (ideal gas behavior)

PV = nRT

P = nRT/V = (1.0 mol)(0.08206 L atm/mol K) (0+273)/(0.05 L)

P = 448 atm

Part two: (non-ideal gas behavior)

$[P + an^2/V^2] (V – nb) = nRT$

$[P + (3.592\ L^2\ atm/mol^2)\ (1.0\ mol)^2 / (0.05\ L)^2]\ [0.05\ L – (1.0\ mol)(0.04267\ L/mol)] = (1.0\ mol)(0.08206\ L\ atm/mol\ K)(0+273\ K)$

P = 1620 atm

P_{ideal} = 448 atm : P_{real} = 1620 atm

V_{ideal} = 0.05 L : V_{real} = 0.05 – 1x0.04267 = 0.00733 L

V_{real} / V_{ideal} = 0.00733/0.05 = 0.1466

The van der Waals equation gives results that are *larger* than the ideal gas equation at very high pressures, as shown in the figure above, because of the volume occupied by the CO_2 molecules.