6-3 Show one mole = 22.414 L at STP

Given: STP = 273.16 K, 101.325 kPa
Solution:

a. Solve Eqn. 6-2 for V. Note that J = (N)(m) and that Pa = N/m^2 so that units are

$$V = \frac{(\text{mole})\left(\frac{(\text{N})(\text{m})}{\text{K-mole}}\right)(\text{K})}{\frac{\text{N}}{\text{m}^2}} = \text{m}^3$$

b. Using Eqn. 6-2 with n = 1

$$V = \frac{(1\ \text{mole})(8.3143\ \text{J/K-mole})(273.16\ \text{K})}{(101.325\ \text{kPa})(1{,}000\ \text{Pa/kPa})}(1{,}000\ \text{L/m}^3)$$

V = 22.414 L

6-4 Volume occupied by 1 mole

Given: T = 25.0 °C, 101.325 kPa
Solution:

a. Solve Eqn. 6-2 for V. Note that J = (N)(m) and that Pa = N/m^2 so that units are

$$V = \frac{(\text{mole})\left(\frac{(\text{N})(\text{m})}{\text{K-mole}}\right)(\text{K})}{\frac{\text{N}}{\text{m}^2}} = \text{m}^3$$

b. Using Eqn. 6-2 with n = 1

$$V = \frac{(1\ \text{mole})(8.3143\ \text{J/K-mole})(298.0\ \text{K})}{(101.325\ \text{kPa})(1{,}000\ \text{Pa/kPa})}(1{,}000\ \text{L/m}^3)$$

V = 24.453 L

6-5 Partial pressures of oxygen and nitrogen

Given: STP, oxygen = 8.583 moles/m^3, nitrogen = 15.93 moles/m^3, 1.0 m^3 of air
Solution:

a. Solve Eqn. 6-2 for P. Note that J = (N)(m) and that Pa = N/m^2 so that units are

$$P = \frac{(\text{mole})\left(\frac{(N)(m)}{\text{K-mole}}\right)(K)}{m^3} = \frac{N}{m^2} = Pa$$

b. Partial pressure of oxygen (Eqn. 6-3)

$$P_{O2} = \frac{(8.563\ \text{moles/m}^3)(8.314\ \text{J/K-mole})(273.16\ \text{K})(10^{-3}\ \text{g/kg})}{1.0\ \text{m}^3}$$

P_{O2} = 19.45 kPa

b. Partial pressure of nitrogen (Eqn. 6-3)

$$P_{N2} = \frac{(15.93\ \text{moles/m}^3)(8.314\ \text{J/K-mole})(273.16\ \text{K})(10^{-3}\ \text{g/kg})}{1.0\ \text{m}^3}$$

P_{N2} = 36.18 kPa

6-6 Partial pressures of oxygen, nitrogen, carbon dioxide

Given: T = 25.0 °C, oxygen = 18.32 moles, nitrogen = 16.40 moles, carbon dioxide = 6.15 moles, 1.0 m^3 tank
Solution:

a. Solve Eqn. 6-2 for P. Note that J = (N)(m) and that Pa = N/m^2 so that units are

$$P = \frac{(\text{mole})\left(\frac{(N)(m)}{\text{K-mole}}\right)(K)}{m^3} = \frac{N}{m^2} = Pa$$

b. Convert temperature to K

T = 25.0 + 273 = 298 K

c. Partial pressure of oxygen (Eqn. 6-2)

$$P_{O2} = \frac{(18.32\ \text{moles/m}^3)(8.314\ \text{J/K-mole})(298.0\ \text{K})(10^{-3}\ \text{g/kg})}{1.0\ \text{m}^3}$$

P_{O2} = 45.39 kPa

d. Partial pressure of nitrogen (Eqn. 6-2)

$$P_{N2} = \frac{(16.40\ \text{moles/m}^3)(8.314\ \text{J/K-mole})(298.0\ \text{K})(10^{-3}\ \text{g/kg})}{1.0\ \text{m}^3}$$

P_{N2} = 40.63 kPa

e. Partial pressure of carbon dioxide (Eqn. 6-2)

$$P_{CO2} = \frac{(6.15\ \text{moles/m}^3)(8.314\ \text{J/K-mole})(298.0\ \text{K})(10^{-3}\ \text{g/kg})}{1.0\ \text{m}^3}$$

P_{CO2} = 45.39 kPa

6-7 **Volume of carbon dioxide**

Given: carbon dioxide = 5.2 kg, P = 152.0 kPa, T = 315.0 K
Solution:

a. Compute number of moles

GMW = 12.011 + 2(15.9994) = 44.0098

$$n = \frac{5{,}200\ \text{g}}{44.00\ \text{g/mole}} = 118.18\ \text{moles}$$

b. Compute volume as in 6-4 above

$$V = \frac{(118.18\ \text{mole})(8.3143\ \text{J/K-mole})(315.0\ \text{K})}{(152.0\ \text{kPa})(1{,}000\ \text{Pa/kPa})}(1{,}000\ \text{L/m}^3)$$

V = 2,036 L

6-8 Mass of oxygen

Given: volume = 5.0 m^3, pressure = 568.0 kPa, temp. = 263.0 K
Solution:

a. Solve Eqn. 6-2 for n

$$n = \frac{(P)(V)}{(R)(T)} = \frac{(568.0)(5.0)}{(8.314)(263.0)} = 1.2988$$

b. Compute mass

M_{O2} = (1.2988 moles)(31.9988 g/mole) = 41.56 g

6-9 Partial pressure of H_2S

Given: 250 mg/L of H_2S, temp. = 0 °C, pressure = 108.26 kPa
Solution:

a. Compute number of moles

GMW = 2(1.0079) + 32.06 = 34.07 g/mole

$$n = \frac{250 \text{ mg/L}}{34.07 \text{ g/mole}} = 7.3366 \text{ moles/L}$$

a. Solve Eqn. 6-2 for P (see 6-6 above)

$$P_{H2S} = \frac{(7.3366 \text{ moles})(8.314 \text{ J/K-mole})(273.0 \text{ K})(10^{-3} \text{ g/kg})}{1.0 \text{ L}}$$

P_{H2S} = 16.7 kPa

6-10 Partial pressures of CH_4, N_2, and CO_2

Given: 28 L volume, temp = 300 K, 11 g methane, 1.5 g nitrogen, 16 g of carbon dioxide
Solution:

a. Compute moles of each gas

GMW_{CH4} = 12.011 + 4(1.0079) = 16.04 g/mole

$$n = \frac{11 \text{ g}}{16.04 \text{ g/mole}} = 0.6856 \text{ moles}$$

$GMW_{N2} = 2(14.0067) = 28.013$ g/mole

$$n = \frac{1.5 \text{ g}}{28.013 \text{ g/mole}} = 0.05355 \text{ moles}$$

$GMW_{CO2} = 12.011 + 2(15.9994) = 44.01$

$$n = \frac{16 \text{ g}}{44.01 \text{ g/mole}} = 0.3633 \text{ moles}$$

b. Compute partial pressures (Eqn. 6-2)

$$P_{CH4} = \frac{(0.6857 \text{ moles})(8.314 \text{ J/K-mole})(300.0 \text{ K})(10^{-3} \text{ g/kg})}{(28.0 \text{ L})(10^{-3} \text{ m}^3/\text{L})}$$

$P_{CH4} = 61.08$ or 61 kPa

$$P_{N2} = \frac{(0.05355 \text{ moles})(8.314 \text{ J/K-mole})(300.0 \text{ K})(10^{-3} \text{ g/kg})}{(28.0 \text{ L})(10^{-3} \text{ m}^3/\text{L})}$$

$P_{N2} = 4.77$ or 4.8 kPa

$$P_{CO2} = \frac{(0.3633 \text{ moles})(8.314 \text{ J/K-mole})(300.0 \text{ K})(10^{-3} \text{ g/kg})}{(28.0 \text{ L})(10^{-3} \text{ m}^3/\text{L})}$$

$P_{CO2} = 32.36$ or 32 kPa

6-11 Moles of gas present in Problem 6-11

Given: See Problem 6-10
Solution:

a. Compute moles of each gas
(Note: this is essentially a repetition of part of Problem 6-9 computed here with significant figures equal to that given)

$GMW_{CH4} = 12.011 + 4(1.0079) = 16.04$ g/mole

$$n = \frac{11 \text{ g}}{16 \text{ g/mole}} = 0.688 \text{ or } 0.69 \text{ moles}$$