Problem Set #1 Solution
Problem 1.14

Calculate the volume of water using ideal gas model:

$$V = \frac{RT}{P}$$

a. P= 1.01 bar
   T = 373.15 K

   Ideal Gas model:

$$\hat{v} = \frac{0.08314\frac{L\,bar}{mol\,K} \times 373.15K}{1.01bar}$$

$$\hat{v} = 30.717\frac{L}{mol} * 1\frac{m^3}{10^3 L} * \frac{1mol}{18.015g} * \frac{10^3 g}{1kg}$$

$$\hat{v} = 1.705\frac{m^3}{kg} \qquad \boxed{+1}$$

   Using Steam Tables:

   At 100 C, 100 kPa=1bar

$$\hat{v} = 1.6958\frac{m^3}{kg} \qquad \boxed{+1}$$

   At 100 C, 101.35 kPa=1.0135 bar

$$\hat{v} = 1.6729\frac{m^3}{kg} \qquad \boxed{+1}$$

   Interpolating in 1/P since v is proportional to 1/P,

$$\hat{v}_{P=1.01bar} = \hat{v}_{P=1bar} + (\hat{v}_{P=1.0135bar} - \hat{v}_{P=1bar}) * \left(\frac{\frac{1}{P=1.01bar} - \frac{1}{P=1bar}}{\frac{1}{P=1.0135bar} - \frac{1}{P=1bar}} \right)$$

$$\hat{v}_{P=1.01bar} = 1.6958\frac{m^3}{kg} + (1.6729\frac{m^3}{kg} - 1.6958\frac{m^3}{kg}) * \frac{(1/1.01 - 1/1)}{(1/1.0135 - 1/1)}$$

$$\hat{v}_{P=1.01bar} = \boxed{1.6788\frac{m^3}{kg}} \qquad \boxed{+0.5}$$

   Linear interpolation is also acceptable since it results in approximately the same answer.

Percent error:

|Ideal gas model-Measured value| * 100%

Measured value

$$\frac{1.705\frac{m^3}{kg}-1.6788\frac{m^3}{kg}}{1.6788\frac{m^3}{kg}}*100\% = \boxed{1.561\%} \qquad \boxed{+0.5}$$

b. P = 1bar, T=500 C = 773.15 K

$$\hat{v} = \frac{0.08314\frac{L\,bar}{mol\,K}\times 773.15K}{1bar}$$

$$\hat{v} = 64.28\frac{L}{mol}*\frac{1m^3}{10^3 L}*\frac{1mol}{18.015g}*\frac{10^3 g}{1kg}$$

$$\boxed{\hat{v} = 3.568\frac{m^3}{kg}} \qquad \boxed{+1}$$

From steam tables:

Table B.4, P=1 bar=100 kPa, T=500 C

$$\boxed{\hat{v} = 3.5655\frac{m^3}{kg}} \qquad \boxed{+0.5}$$

Percent error:

|Ideal gas model-Measured value| * 100%

Measured value

$$\frac{3.568\frac{m^3}{kg}-3.5655\frac{m^3}{kg}}{3.5655\frac{m^3}{kg}}*100\% = \boxed{0.0701\%} \qquad \boxed{+0.5}$$

c. P = 100 bar, T= 500 C

$$\hat{v} = \frac{0.08314\frac{L\,bar}{mol\,K}\times 773.15K}{100bar}$$

$$\hat{v} = 0.6428\frac{L}{mol}*\frac{1m^3}{10^3 L}*\frac{1mol}{18.015g}*\frac{10^3 g}{1kg}$$

$$\boxed{\hat{v} = 0.03568\frac{m^3}{kg}} \qquad \boxed{+1}$$

From steam tables:

Table B.4, P=100 bar, 10 MPa, T=500 C

$$\boxed{\hat{v} = 0.03279 \frac{m^3}{kg}} \qquad \boxed{+0.5}$$

Percent error:

<u>|Ideal gas model-Measured value|</u> * 100%
Measured value

$$\frac{0.03568 \frac{m^3}{kg} - 0.03279 \frac{m^3}{kg}}{0.03279 \frac{m^3}{kg}} * 100\% = \boxed{8.814\%} \qquad \boxed{+0.5}$$

d. P= 100 bar, T = 1000 C

$$\hat{v} = \frac{0.08314 \frac{L\,bar}{mol\,K} \times 1273.15K}{100bar}$$

$$\hat{v} = 1.0585 \frac{L}{mol} * \frac{1m^3}{10^3 L} * \frac{1mol}{18.015g} * \frac{10^3 g}{1kg}$$

$$\boxed{\hat{v} = 0.05876 \frac{m^3}{kg}} \qquad \boxed{+1}$$

From steam tables:

Table B.4, P = 10 MPa, T = 1000 C

$$\boxed{\hat{v} = 0.05832 \frac{m^3}{kg}} \qquad \boxed{+0.5}$$

Percent error:

<u>|Ideal gas model-Measured value|</u> * 100%
Measured value

$$\frac{0.05876 \frac{m^3}{kg} - 0.05832 \frac{m^3}{kg}}{0.05832 \frac{m^3}{kg}} * 100\% = \boxed{0.754\%} \qquad \boxed{+0.5}$$