Practice Quiz: Gas Laws

If this were an actual quiz, each problem would be worth 4 points for a total of 20 points.

1. Calculate the density in g/L of gaseous SF_6 at 50.0°C and 650. torr. (You should be able to calculate the density of any gas at any temperature and pressure assuming ideal gas behavior.)

SF_6, sulfur hexafluoride

146.07 g/mol

$$d = \frac{P}{RT} \cdot MM = \frac{\left(\frac{650}{760}\right)}{(0.0821)(50+273)} \cdot (32.07 + 6 \cdot 19.00)$$

$$d = \frac{(0.85526)(146.07)}{(0.0821)(323)} = 4.71\ g/L$$

This is a rather high density for a gas.

2. Aluminum metal shavings (10.0 g) are placed in 100. mL of 6.00 M hydrochloric acid. What is the maximum volume of hydrogen, measured at STP, which can be produced?
$2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$

$$10.0\ g\ Al \times \frac{1\ mol}{26.98\ g} \times \frac{3H_2}{2Al} = 0.556\ mol$$

limiting $* (100.0\ mL)\left(6.00\ \frac{mmoles}{mL}\right)\left(\frac{3H_2}{6HCl}\right) = 300.\ mmoles = 0.300\ mol$

$$0.300 \times 22.4\ L/mol = \underline{6.72\ L\ H_2(g)}$$

3. A 20.0-L container holds 15.3 mol of Cl_2 gas at 227°C.

   a. Calculate the pressure in atmospheres, assuming ideal behavior.

$$P = \frac{nRT}{V} = \frac{(15.3)(0.0821)(500.)}{20.0} = 31.4\ atm$$

   b. Calculate the pressure in atmospheres, assuming van der Waals behavior. The van der Waals constants for Cl_2 are a = 6.49 atm×L²/mol² and b = 0.0562 L/mol. The van der Waals gas equation is:

$$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$$

$$\left(P + \frac{(15.3)^2 \cdot 6.49}{20.0^2}\right)(20.0 - (15.3 \cdot 0.0562)) = (15.3)(0.0821)(500)$$

$$\left(P + \frac{1519.2441}{400}\right)(19.14014) = 628.065$$

$$(P + 3.7981)(19.14014) = 628.065$$

$$19.14014\ P = 555.3686 \qquad \underline{P = 29.0\ atm}$$

Lower than the pressure predicted by the ideal gas law.

4. A weather balloon was initially at a pressure of 0.950 atm, and its volume was 35.0 L. The pressure decreased to 0.750 atm, without loss of gas or change in temperature. What was the change in the volume?

$P_1V_1 = P_2V_2$

$(0.950)(35.0) = (0.750)(V_2)$ $\quad V_2 = 44.33\,L$

Change in volume: $44.33 - 35.0 = 9.3\,L$

The volume of the weather balloon increased by 9.3L to become 44.3L.

5. Small quantities of hydrogen can be prepared by the addition of hydrochloric acid to zinc. A sample of 195 mL of hydrogen was collected over water at 25°C and 753 torr. What mass of hydrogen was collected? (P_{water} = 24 torr at 25°C)

$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}\uparrow$

$T = 298K$

$P_{WET} = \frac{753}{760} = 0.9908\ atm = P_{H_2} + P_{H_2O}$

$P_{H_2} = \frac{753 - 24}{760} = 0.9592\ atm$

$n_{H_2} = \frac{PV}{RT} = \frac{(0.9592)(0.195L)}{(0.0821)(298)} = 0.0076451\ mol$

$\times\ 2.02\,g/mol = 0.0154\,g\ H_2$

$15.4\,mg\ H_2$