Chapter Ten

10.6 (a) number of moles and temperature
(b) number of moles and pressure
(c) number of moles and volume
(d) number of moles

10.7 An ideal gas obeys the gas laws over all pressures and temperatures. A real gas behaves most like an ideal gas at low pressures and high temperatures.

10.9 $P_{total} = P_a + P_b + P_c + \cdots$

10.10 Mole fraction is the ratio of the number of moles of one component of a mixture to the total number of moles of all components.

10.12 Diffusion is the spontaneous intermingling of one substance with another while effusion is the movement of a gas through a very tiny opening into a region of lower pressure.

$$\frac{\text{effusion rate (A)}}{\text{effusion rate (B)}} = \sqrt{\frac{d_B}{d_A}} = \sqrt{\frac{M_B}{M_A}}$$

10.20 It is not true that the gas particles occupy no volume themselves, apart from the volume between the gas particles. Also, it is not true that the gas particles exert no force on one another. In other words, real molecules occupy space and attract or repel one another. Because of short-range interactions, it is also not true that particles travel always in straight paths.

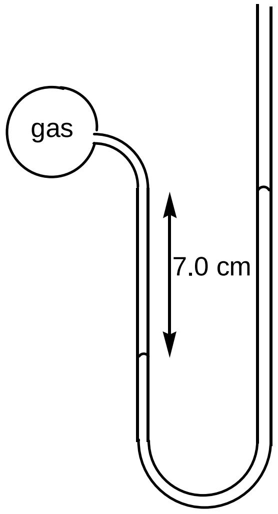
10.26 (a) $\text{torr} = (0.625 \text{ atm})\left(\frac{760 \text{ torr}}{1 \text{ atm}}\right) = 475 \text{ torr}$

(b) $\text{atm} = (825 \text{ torr})\left(\frac{1 \text{ atm}}{760 \text{ torr}}\right) = 1.09 \text{ atm}$

(c) $\text{torr} = 62 \text{ mm Hg}\left(\frac{760 \text{ torr}}{760 \text{ mm Hg}}\right) = 62 \text{ torr}$

10.30 $820 \text{ torr} - 750 \text{ torr} = 70 \text{ torr}$ $\quad 70 \text{ torr}\left(\frac{760 \text{ mm Hg}}{760 \text{ torr}}\right) = 70 \text{ mm Hg}$

$\text{cm Hg} = (70 \text{ mm Hg})\left(\frac{1 \text{ cm}}{10 \text{ mm}}\right) = 7.0 \text{ cm Hg}$



10.32 $82\text{ mm Hg}\left(\dfrac{760\text{ torr}}{760\text{ mm Hg}}\right) = 82\text{ torr}$ $\quad$ $752\text{ torr} - 82\text{ torr} = 670\text{ torr}$

10.35 Use Boyle's Law to solve for the second volume:

$$V_2 = \frac{P_1V_1}{P_2} = \frac{(255\text{ mL})(725\text{ torr})}{365\text{ torr}} = 507\text{ mL}$$

10.38 Use Charles's Law to solve for the second volume:

$$V_2 = \frac{V_1T_2}{T_1} = \frac{2.50\text{ L }(258\text{ K})}{295\text{ K}} = 2.19\text{ L}$$

10.39 Compare pressure change to temperature to solve for temperature change:

$$T_2 = \frac{P_2T_1}{P_1} = \frac{(1700\text{ torr})(558\text{ K})}{850\text{ torr}} = 1116\text{ K} = 1120\text{ K} \qquad 1116\text{ K} - 273\text{ K} = 843\text{ °C}$$

10.42 In general the combined gas law equation is: $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$, and in particular, for this problem, we have:

$$P_2 = \frac{P_1V_1T_2}{T_1V_2} = \frac{(0.985\text{ atm})(648\text{ mL})(336.2\text{ K})}{(289.2\text{ K})(689\text{ mL})} = 1.08\text{ atm}$$

10.44 In general the combined gas law equation is: $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$, and in particular, for this problem, we have:

$$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{(741\text{ torr})(280\text{ mL})(306.2\text{ K})}{(291.2\text{ K})(760\text{ torr})} = 287\text{ mL}$$

10.50 $$V = \frac{nRT}{P} = \frac{\left(1.67\text{ g}\left(\dfrac{1\text{ mol}}{28.0\text{ g}}\right)\right)\left(0.0821\ \dfrac{\text{L atm}}{\text{mol K}}\right)(295.2\text{ K})}{\left(756\text{ torr}\left(\dfrac{1\text{ atm}}{760\text{ torr}}\right)\right)} = 1.45\text{ L}$$

10.52 $$P = \frac{nRT}{V} = \frac{\left(12.0\text{ g}\left(\dfrac{1\text{ mol}}{18.0\text{ g}}\right)\right)\left(0.0821\ \dfrac{\text{L atm}}{\text{mol K}}\right)(381\text{ K})}{(3.60\text{ L})} = 5.80\text{ atm}$$

10.60 (a) $\text{formula mass} = \dfrac{dRT}{P} = \dfrac{(\text{mass})RT}{PV}$

$$\text{formula mass} = \frac{(6.3 \times 10^{-3}\text{ g})\left(0.0821\ \frac{\text{L atm}}{\text{mol K}}\right)(298.2\text{ K})}{(11\text{ torr})\left(\frac{1\text{ atm}}{760\text{ torr}}\right)(385\text{ mL})\left(\frac{1\text{ L}}{1000\text{ mL}}\right)}$$

formula mass = 28 g mol^{-1}

(b) The formula weights of the boron hydrides are:
BH_3, 13.8
B_2H_6, 27.7
B_4H_{10}, 53.3
And we conclude that the sample must have been B_2H_6.

10.64 The balanced equation is
$2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$

$$\text{mL O}_2 = (855\text{ mL CO}_2)\left(\frac{19\text{ mL O}_2}{12\text{ mL CO}_2}\right) = 1.35 \times 10^3\text{ mL O}_2$$

10.66 $\text{mol HNO}_3 = (12.0\text{ g HNO}_3)\left(\frac{1\text{ mole HNO}_3}{63.01\text{ g HNO}_3}\right) = 0.190\text{ mol HNO}_3$

$$\text{mol NO}_2 = (0.190\text{ mol HNO}_3)\left(\frac{3\text{ moles NO}_2}{2\text{ moles HNO}_3}\right) = 0.286\text{ mol NO}_2$$

$$V = \frac{nRT}{P} = \frac{(0.286\text{ moles NO}_2)\left(0.0821\frac{\text{L atm}}{\text{mol K}}\right)(298\text{ K})}{(752\text{ torr})\left(\frac{1\text{ atm}}{760\text{ torr}}\right)} = 7.07\text{ L or }7.07 \times 10^3\text{ mL}$$

10.68 $n_{NH_3} = \frac{PV}{RT} = \frac{(825\text{ torr})\left(\frac{1\text{ atm}}{760\text{ torr}}\right)(33.6 \times 10^{-3}\text{ L})}{\left(0.0821\ \frac{\text{L atm}}{\text{mol K}}\right)(400\text{ K})} = 1.11 \times 10^{-3}\text{ mol NH}_3$

$$\text{mol H}_2\text{O} = 1.11\text{ mol NH}_3\left(\frac{6\text{ mol H}_2\text{O}}{4\text{ mol NH}_3}\right) = 1.67 \times 10^{-3}\text{ mol H}_2\text{O}$$

$$V_{H_2O} = \frac{nRT}{P} = \frac{(1.67 \times 10^{-3}\text{ moles})\left(0.0821\ \frac{\text{L atm}}{\text{mol K}}\right)(591\text{ K})}{(735\text{ torr})\left(\frac{1\text{ atm}}{760\text{ torr}}\right)} = 8.36 \times 10^{-2}\text{ L} = 83.6\text{ mL}$$

10.72 $P_{Tot} = P_{N_2} + P_{O_2} + P_{CO_2}$
$P_{CO_2} = P_{Tot} - P_{N_2} - P_{O_2}$
P_{CO_2} = 740 torr – 120 torr – 400 torr = 220 torr

10.73 Assume all gases behave ideally and recall that 1 mole of an ideal gas at 0 °C and 1 atm occupies a volume of 22.4 L. So,

$$P_{N_2} = 0.30\text{ atm}\left(\frac{760\text{ torr}}{1\text{ atm}}\right) = 228\text{ torr}$$

$$P_{O_2} = 0.20\text{ atm}\left(\frac{760\text{ torr}}{1\text{ atm}}\right) = 152\text{ torr}$$

$$P_{He} = 0.40\text{ atm}\left(\frac{760\text{ torr}}{1\text{ atm}}\right) = 304\text{ torr}$$

$$P_{CO_2} = 0.10\text{ atm}\left(\frac{760\text{ torr}}{1\text{ atm}}\right) = 76\text{ torr}$$

10.76 $P_{total} = P_{H_2} + P_{H_2O}$
P_{H_2O} = 23.76 torr at 25 °C, from Table 10.2.
$P_{H_2} = P_{total} - P_{H_2O} = 742 - 23.76 = 718$ torr
The temperature stays constant so, $P_1V_1 = P_2V_2$, and

$$V_2 = \frac{P_1V_1}{P_2} = \frac{(718\text{ torr})(288\text{ mL})}{(760\text{ torr})} = 272\text{ mL}$$

10.80 Ethylene, C_2H_4, the lightest of these three, diffuses the most rapidly, and Cl_2, the heaviest, will diffuse the slowest.
$Cl_2 < SO_2 < C_2H_6$