Chapter 5: 34, 36, 38, 52, 62, 67, 116, 125

34. Charles' Law: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$V_1 = 7.00 \times 10^2$ mL $T_1 = 20.0\ ^oC + 273.15 = 293.15$ K
$V_2 = ?$ $T_2 = 1.00 \times 10^2$ K

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{(7.00 \times 10^2 \text{ mL})(1.00 \times 10^2 \cancel{K})}{293.15 \cancel{K}} = \mathbf{239\ mL}$$

36. Avogadro's Law: $\frac{V_1}{n_1} = \frac{V_2}{n_2}$

$V_1 = 25.0$ mL $n_1 = 2$ mole (exact)
$V_2 = ?$ $n_2 = 1$ mole (exact)

$$V_2 = \frac{V_1 n_2}{n_1} = \frac{(25.0 \text{ mL})(1 \cancel{\text{mole}})}{2 \cancel{\text{mole}}} = \mathbf{12.5\ mL}$$

38. a.

P $7.74 \times 10^3 \cancel{Pa} \times \frac{1 \text{ atm}}{101{,}325 \cancel{Pa}} = \underline{0.0764 \text{ atm}}$

V $12.2 \text{ m}\cancel{L} \times \frac{1 \text{ L}}{1000 \text{ m}\cancel{L}} = \underline{0.0122 \text{ L}}$

n ?

R <u>0.0821 L-atm/mole-K</u>

T $25\ ^oC + 273 = \underline{298 \text{ K}}$

$$PV = nRT;\ n = \frac{PV}{RT} = \frac{(0.0.0764 \text{ at}\cancel{m})(0.0122 \cancel{L})}{\left(0.0821 \frac{\cancel{L} - \text{at}\cancel{m}}{\text{mole} - \cancel{K}}\right)(298 \cancel{K})} = \mathbf{3.81 \times 10^{-5}\ mole}$$

b.

P ?

V $43.0 \text{ m}\cancel{L} \times \frac{1 \text{ L}}{1000 \text{ m}\cancel{L}} = \underline{0.0430 \text{ L}}$

n <u>0.421 mole</u>

R <u>0.0821 L-atm/mole-K</u>

T <u>223 K</u>

$$PV = nRT;\ P = \frac{nRT}{V} = \frac{(0.421 \cancel{\text{mole}})\left(0.0821 \frac{\text{L} - \text{at}\cancel{m}}{\cancel{\text{mole}} - \cancel{K}}\right)(223 \cancel{K})}{0.0430 \cancel{L}} = \mathbf{1.80 \times 10^2\ atm}$$

c. P $455 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} = \underline{0.598 \text{ atm}}$

V ?

n $\underline{4.4 \times 10^{-2} \text{ mole}}$

R $\underline{0.0821 \text{ L-atm/mole-K}}$

T $331\ ^{o}C + 273 = \underline{604 \text{ K}}$

$$PV = nRT;\ V = \frac{nRT}{P} = \frac{(4.4 \times 10^{-2} \text{ mole})\left(0.0821 \frac{\text{L} - \text{atm}}{\text{mole} - \text{K}}\right)(604 \text{ K})}{0.598 \text{ atm}} = \mathbf{3.6\ L}$$

d. P $745 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} = \underline{0.980 \text{ atm}}$

V $\underline{11.2 \text{ L}}$

n $\underline{0.401 \text{ mole}}$

R $\underline{0.0821 \text{ L-atm/mole-K}}$

T ?

$$PV = nRT;\ T = \frac{PV}{nR} = \frac{(0.980 \text{ atm})(11.2 \text{ L})}{\left(0.0821 \frac{\text{L} - \text{atm}}{\text{mole} - \text{K}}\right)(0.401 \text{ mole})} = \mathbf{333\ K}$$

52. P $\underline{1 \text{ atm}}$

V ?

n $4.00 \text{ g } CO_2 \times \frac{1 \text{ mole } CO_2}{44.01 \text{ g } CO_2} = \underline{0.0909 \text{ mole } CO_2}$

R $\underline{0.0821 \text{ L-atm/mole-K}}$

T $0\ ^{o}C + 273 = \underline{273 \text{ K}}$

$$PV = nRT;\ V = \frac{nRT}{P} = \frac{(0.0909 \text{ mole})\left(0.0821 \frac{\text{L} - \text{atm}}{\text{mole} - \text{K}}\right)(273 \text{ K})}{1 \text{ atm}} = \mathbf{2\ L}$$

62. P $750 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} = \underline{0.987 \text{ atm}}$

V $256 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} = \underline{0.256 \text{ L}}$

g $\underline{0.800 \text{ g}}$

R $\underline{0.0821 \text{ L-atm/mole-K}}$

T $\underline{373 \text{ K}}$

FW ?

$$PV = \frac{gRT}{FW};\ FW = \frac{gRT}{PV} = \frac{(0.800 \text{ g})\left(0.0821 \frac{\text{L} - \text{atm}}{\text{mole} - \text{K}}\right)(373 \text{ K})}{(0.987 \text{ atm})(0.256 \text{ L})} = \mathbf{97.0\ g/mole}$$

CHCl FW = 48.47 g/mole

$$\frac{97.0}{48.47} = 2.00 \approx 2$$; Molecular formula = $\mathbf{C_2H_2Cl_2}$

67. Since the moles (of each gas) is constant and you should assume the temperature is constant (since an initial temperature is not given), this is a Boyle's Law problem, with the final **total** pressure the sum of the **partial** pressures of the two gases:

H_2: $P_1V_1 = P_2V_2$

P_1 = 475 torr V_1 = 2.00 L
P_2 = ? V_2 = 3.00 L

$$P_2 = \frac{P_1V_1}{V_2} = \frac{(475 \text{ torr})(2.00 \text{ L})}{3.00 \text{ L}} = \underline{317 \text{ torr}}$$

N_2: $P_1V_1 = P_2V_2$

P_1 = 152 torr V_1 = 1.00 L
P_2 = ? V_2 = 3.00 L

$$P_2 = \frac{P_1V_1}{V_2} = \frac{(152 \text{ torr})(1.00 \text{ L})}{3.00 \text{ L}} = \underline{50.7 \text{ torr}}$$

$$P_{total} = P_{H_2} + P_{N_2} = 317 \text{ torr} + 50.7 \text{ torr} = \mathbf{368\ torr}$$

116. Let x = mass of Zn
y = mass of Cr

$$Zn + 2\,HCl \longrightarrow ZnCl_2 + H_2$$

$$2\,Cr + 6\,HCl \longrightarrow 2\,CrCl_3 + 3\,H_2$$

P $750.\text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} = \underline{0.987 \text{ atm}}$

V $225 \text{ mL } H_2 \times \frac{1 \text{ L}}{1000 \text{ mL}} = \underline{0.225 \text{ L}}$

n ?
R <u>0.0821 L-atm/mole-K</u>
T $27\,^{o}C + 273 = \underline{300.\text{ K}}$

$$PV = nRT;\ n = \frac{PV}{RT} = \frac{(0.987\ \text{atm})(0.225\ \text{L})}{\left(0.0821\ \frac{\text{L}-\text{atm}}{\text{mole}-\text{K}}\right)(300.\ \text{K})} = \mathbf{9.015\ x\ 10^{-3}\ mole\ H_2}$$

$$x\ \text{g Zn x}\ \frac{1\ \text{mole Zn}}{65.38\ \text{g Zn}}\ \text{x}\ \frac{1\ \text{mole}\ H_2}{1\ \text{mole Zn}} + y\ \text{g Cr x}\ \frac{1\ \text{mole Cr}}{52.00\ \text{g Cr}}\ \text{x}\ \frac{3\ \text{mole}\ H_2}{2\ \text{mole Cr}} = 9.015\ \text{x}\ 10^{-3}\ \text{mole}\ H_2$$

Simplified, this is:

$0.0153x + 0.0288y = 9.015 \text{ x } 10^{-3}$ (1)

$x + y = 0.362$ g ; $y = 0.362 - x$ (2)

Plugging equation 2 into equation 1 gives:

$0.0153x + 0.0288(0.362 - x) = 9.015 \text{ x } 10^{-3}$

$x = 0.1053$ g Zn
$y = 0.362 - 0.1053 = 0.2567$ g Cr

$$\frac{0.105\ \text{g Zn}}{0.362\ \text{g sample}}\ \text{x}\ 100 = \mathbf{29.1\ \%Zn}$$

$$\frac{0.257\ \text{g Cr}}{0.362\ \text{g sample}}\ \text{x}\ 100 = \mathbf{70.9\ \%Cr}$$

125. a. If we have $1.0\text{x}10^6$ L of air, then there are $3.0 * 10^2$ L of CO

$$P_{CO} = \chi_{CO} * P_{Total}\ ;\quad \chi_{CO} = \frac{V_{CO}}{V_{total}}\ \text{since}\ V \propto n$$

$$P_{CO} = \frac{3.0*10^2\ \text{L}}{1.0*10^6\ \text{L}} * 628\ \text{torr} = 0.19\ \text{torr}$$

b. $n_{CO} = \frac{P_{CO} * V}{RT}$ 1.0 cm^3 of air = 1.0 mL = $1.0 * 10^{-3}$ L

$$n_{CO} = \frac{\frac{0.19}{760}\ \text{atm} * 1.0 * 10^{-3}\ \text{L}}{\frac{0.08206\ \text{L atm}}{\text{mol K}} * 273\ \text{K}} = 1.1 * 10^{-8}\ \text{mol CO}$$

$$1.1 * 10^{-8}\ \text{mol} * \frac{6.022 * 10^{23}\ \text{molecules}}{1\ \text{mole}} = 6.6 * 10^{15}\ \text{molecules CO in the 1.0 cm}^3\ \text{of air}$$