CHEM 1110 ANSWERS TO GASES PROBLEM SET

1. $P_1V_1 = P_2V_2 \quad V_2 = \frac{P_1V_1}{P_2} = \frac{150 \text{ atm x } 10.0 \text{ L}}{1.00 \text{ atm}} = 1500 \text{ L}$

volume of helium at 1.00 atm = 1500 L; 10 L in the tank and 1490 L for the balloons.

No. of balloons = $1490 \text{ L x } \frac{1 \text{ balloon}}{1.50 \text{ L}}$ = **993 balloons**

2. $\frac{V_2}{T_2} = \frac{V_1}{T_1} \quad V_2 = \frac{V_1T_2}{T_1}$ $\quad V_1 = 250.00$ mL $\quad T_1 = 273$ K $\quad T_2 = 274$ K

$V_2 = \frac{250.00 \text{ mL x } 274 \text{ K}}{273 \text{ K}} = 251 \text{ mL}$ Increase = (251-250) mL = **1 mL**

3. (a) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $\quad T_1 = 273 + 25 = 298$ K $\quad T_2 = 273 + 75 = 348$ K

$P_1 = 2.00$ atm

$P_2 = \frac{P_1T_2}{T_1} = \frac{2.00 \text{ atm x } 348 \text{ K}}{298 \text{ K}}$ = **2.34 atm**

(b) $P_1 = 2.00$ atm $\quad P_2 = 10.0$ atm $\quad T_1 = 298$ K

$T_2 = \frac{P_2T_1}{P_1} = \frac{10.0 \text{ atm x } 298 \text{ K}}{2.00 \text{ atm}}$ = 1490 K = (1490-273)°C = **1217°C**

4. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\quad T_1 = 273 + 25 = 298$ K $\quad T_2 = 273 + 200 = 473$ K

$V_1 = 1.00$ L $\quad V_2 = 4.00$ L $\quad P_1 = 1.25$ atm

$P_2 = \frac{P_1V_1T_2}{T_1V_2} = \frac{1.25 \text{ atm x } 1.00 \text{ L x } 473 \text{ K}}{298 \text{ K x } 4.00 \text{ L}} = 0.496 \text{ atm}$

$= 0.496 \text{ atm x } \frac{760 \text{ mm Hg}}{1 \text{ atm}}$ = **377 mm Hg**

5. $PV = nRT = \frac{g}{MM} RT$ (g = mass in grams) $V = \frac{gRT}{MM \times P}$

$$V = \frac{3.00 \times 10^3 \text{ g} \times 0.0821 \text{ L·atm/K·mol} \times 373 \text{ K}}{44.0 \text{ g/mol} \times 266 \text{ torr}} \times \frac{760 \text{ torr}}{1 \text{ atm}} = \mathbf{5.97 \times 10^3 \text{ L}}$$

6. $PV = \frac{g}{MM} RT$ density $= \frac{g}{V} = \frac{P \times MM}{RT} = \frac{0.750 \text{ atm} \times 44.0 \text{ g/mol}}{0.0821 \text{ L·atm/K·mol} \times 298 \text{ K}}$

= **1.35 g/L**

7. $P = \frac{g}{V} \times \frac{RT}{MM} = \frac{dRT}{MM} = \frac{0.500 \text{ g/L} \times 0.0821 \text{ L·atm/K·mol} \times 323 \text{ K}}{28.0 \text{ g/mol}}$ = **0.474 atm**

8. $MM = \frac{g}{V} \times \frac{RT}{P} = \frac{dRT}{P} = \frac{0.572 \text{ g/L} \times 0.0821 \text{ L·atm/K·mol} \times 363 \text{ K}}{380/760 \text{ atm}}$ = **34.1 g/mol**

9. $MM = \frac{gRT}{PV} = \frac{0.300 \text{ g} \times 0.0821 \text{ L·atm/K·mol} \times 423 \text{ K}}{0.998 \text{ atm} \times 0.1800 \text{ L}}$ = **58.0 g/mol**

10. (a) moles CH_4 = 1.50 g Al_4C_3 x $\frac{1 \text{ mol } Al_4C_3}{144 \text{ g } Al_4C_3} \times \frac{3 \text{ mol } CH_4}{1 \text{ mol } Al_4C_3}$ = 0.03125 mol CH_4

$PV = nRT$ $V = \frac{nRT}{P}$

$$V = \frac{0.03125 \text{ mol gas} \times 0.0821 \text{ L·atm/K·mol} \times 293 \text{ K}}{0.750 \text{ atm}} = \mathbf{1.00 \text{ L}}$$

(b) $n = \frac{PV}{RT} = \frac{743}{760} \text{ atm} \times \frac{0.487 \text{ L}}{0.0821 \text{ L·atm/K·mol} \times 318 \text{ K}}$ = 0.018236 mol CH_4

moles Al_4C_3 = 0.018236 mol CH_4 x $\frac{1 \text{ mol } Al_4C_3}{3 \text{ mol } CH_4}$ = 0.0060787 mol Al_4C_3

mass Al_4C_3 = 0.0060787 mol Al_4C_3 x $\frac{144 \text{ g } Al_4C_3}{1 \text{ mol } Al_4C_3}$ = **0.875 g Al_4C_3**

11. (a) Total pressure = (0.200 + 0.600) atm = **0.800 atm**

(b) X_A (mole fraction of A) = $\frac{p_A}{P_{TOTAL}}$

$X_{CO} = \frac{0.200\text{ atm}}{0.800\text{ atm}}$ = **0.250** X_{CO_2} = 1 - 0.250 = **0.750 atm**

(c) $n_{TOTAL} = \frac{0.200\text{ atm}}{0.800\text{ atm}} = \frac{0.800\text{ atm x } 11.6\text{ L}}{0.0821\text{ L·atm/K·mol x } 323\text{ K}}$ = **0.350 mol gas**

(d) $n_A = X_A \times n_{TOTAL}$ n_{CO} = 0.250 x 0.350 mol = 0.0875 mol

No. of g CO = 0.0875 mol CO x $\frac{28.0\text{ g CO}}{1\text{ mol CO}}$ = **2.45 g CO**

n_{CO_2} = 0.350 - 0.0875 = 0.2625

No. of g CO_2 = 0.2625 mol CO_2 x $\frac{44.0\text{ g }CO_2}{1\text{ mol }CO_2}$ = **11.6 g CO_2**

12. moles NaOH = 0.475 L x 1.085 mol NaOH/L = 0.5154 mol NaOH

moles CO_2 = $\frac{PV}{RT} = \frac{815}{760}$ atm x $\frac{5.50\text{ L}}{0.0821\text{ L·atm/K·mol x } 298\text{ K}}$ = 0.2411 mol CO_2

moles NaOH needed by 0.2411 mole CO_2 =

0.2411 mole CO_2 x $\frac{2\text{ mol NaOH}}{1\text{ mol }CO_2}$ = 0.4822 mol NaOH

BUT, 0.5154 mol NaOH present; therefore, NaOH is in excess and CO_2 is the limiting reagent.

moles Na_2CO_3 = 0.2411 mol CO_2 x $\frac{1\text{ mol }Na_2CO_3}{1\text{ mol }CO_2}$ = 0.2411 mol Na_2CO_3

mass Na_2CO_3 = 0.2411 mol Na_2CO_3 x $\frac{106.0\text{ g }Na_2CO_3}{1\text{ mol }Na_2CO_3}$ = **25.6 g Na_2CO_3**

13. $\frac{r_{He}}{r_{hyd}} = \frac{\sqrt{M_{hyd}}}{\sqrt{M_{He}}} = 2.7$ (M = molar mass; hyd = hydrocarbon)

$M_{hyd} = 2.7^2 \times M_{He} = 7.29 \times 4 = 29$ g/mol

$$\text{C: } 3.30 \text{ mg CO}_2 \text{ x } \frac{12.01 \text{ mg C}}{44.01 \text{ mg CO}_2} \text{ x } \frac{1 \text{ mmol C}}{12.01 \text{ mg C}} = 0.0750 \text{ mmol C}$$

$$\text{H: } 2.05 \text{ mg H x } \frac{2.016 \text{ mg H}}{18.02 \text{ mg H}_2\text{O}} \text{ x } \frac{1 \text{ mmol H}}{1.008 \text{ mg H}} = 0.228 \text{ mmol H}$$

C : H mol ratio = 0.0750 : 0.228 = 1 : 3
therefore, empirical formula is CH_3 (formula weight = 15)

molecular formula is n(CH_3), where $n = \frac{29}{15} \approx 2$

therefore, molecular formula is 2(CH_3) = $\mathbf{C_2H_6}$

14. $$\text{He: } 6.00 \text{ g He x } \frac{1 \text{ mol He}}{4.00 \text{ g He}} = 1.50 \text{ mol He}$$

$$\text{CO}_2\text{: } 143.0 \text{ g CO}_2 \text{ x } \frac{1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} = 3.25 \text{ mol CO}_2$$

$$\text{H}_2\text{O: } 26.0 \text{ g H}_2\text{O x } \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} = 1.44 \text{ mol H}_2\text{O}$$

total moles of gas = 1.50 + 3.25 + 1.44 = 6.19 moles

(a) $X_{He} = \frac{1.50 \text{ mol}}{6.19 \text{ mol}} = \mathbf{0.242}$ $X_{CO_2} = \frac{3.25 \text{ mol}}{6.19 \text{ mol}} = \mathbf{0.525}$

$X_{H_2O} = \frac{1.44 \text{ mol}}{6.19 \text{ mol}} = \mathbf{0.233}$

(b) $p_{He} = P_{total}X_{He}$ = 720 torr x 0.242 = **174 torr**

p_{CO_2} = 720 torr x 0.525 = **378 torr**

p_{H_2O} = 720 torr x 0.233 = **168 torr**

15. (a) Total number of moles of gas produced in the reaction:

$$n_{total} = \frac{PV}{RT} = \frac{2.86 \text{ atm x } 1.00 \text{ L}}{0.0821 \text{ L·atm/K·mol x } 398.1 \text{ K}} = 8.75 \text{ x } 10^{-2} \text{ mol gas}$$

Initial mass of NH_4NO_3:

$$8.75 \text{ x } 10^{-2} \text{ mol gas x } \frac{2 \text{ mol NH}_4\text{NO}_3}{7 \text{ mol gas}} \text{ x } \frac{80.05 \text{ g NH}_4\text{NO}_3}{1 \text{ mol NH}_4\text{NO}_3} = \mathbf{2.00 \text{ g NH}_4\text{NO}_3}$$

(b) $X_{H_2O} = \frac{n_{H_2O}}{n_{total}} = \frac{4 \text{ mol } H_2O(g)}{7 \text{ mol gas}} = 0.571$

$p_{H_2O} = P_{total} X_{H_2O} = 2.86 \text{ atm} \times 0.571 =$ **1.63 atm**

(c) $P_1V_1 = P_2V_2$ $\quad P_2 = \frac{P_1V_1}{V_2} = \frac{2.86 \text{ atm} \times 1.00 \text{ L}}{4.00 \text{ L}} =$ **0.715 atm**