Chapter 6 HomeWork Key

6.1

3) Calculate the molar mass for each of the following:

Good warm-up & Review question.

a) P_4 $\quad 4 \times 30.97 = 123.88$ g/mole $= \boxed{123.9 \text{ g/mole}}$

b) H_2O

H $\quad 2 \times 1.008 = 2.016$

O $\quad 1 \times 16.00 \quad + 16.00$

18.016 g/mole $= \boxed{18.02 \text{ g/mole}}$

c) $Ca(NO_3)_2$

Ca $\quad 1 \times 40.08 = 40.08$

N $\quad 2 \times 14.01 = 28.02$

O $\quad 6 \times 16.00 = + 98.00$

166.10 $= \boxed{166.10 \text{ g/mole}}$

d) CH_3CO_2H

$2 \times 12.01 + 4 \times 1.008 + 2 \times 16.00 = 60.052 = \boxed{60.05 \text{ g/mole}}$

e) $C_{12}H_{22}O_{11}$ $\quad 12 \times 12.01 + 22 \times 1.008 + 11 \times 16.00 = 342.296$

$= \boxed{342.3 \text{ g/mole}}$

6.2

8) Calculate the following to four significant figures:

a) The percent composition of ammonia NH_3

$$\% = \frac{\text{Part}}{\text{Whole}} \times 100$$

$$\% N = \frac{N}{NH_3} \times 100 = \frac{14.01}{14.01 + 3 \times 1.008} \times 100 = 82.2472\,\%$$

$$= \boxed{82.25\%}$$

$$\% H = \frac{3H}{NH_3} \times 100 = \frac{3 \times 1.008}{14.01 + 3 \times 1.008} = 17.75272\,\%$$

$$= \boxed{17.75\%}$$

b) The percent composition of photographic fixer "hypo" $Na_2S_2O_3$

make it easy & calc molar mass 1st

$$2 \times 22.99 + 2 \times 32.07 + 3 \times 16.00 = \boxed{158.12\ g/mole}$$

$$\% Na = \frac{2\,Na}{Na_2S_2O_3} \times 100 = \frac{2 \times 22.99\ g/mol}{158.12\ g/mol} \times 100 = \boxed{29.08\%}$$

$$\% S = \frac{2S}{Na_2S_2O_3} \times 100 = \frac{2 \times 32.07\ g/mol}{158.12\ g/mol} \times 100 = \boxed{40.56\%}$$

$$\% O = \frac{3O}{Na_2S_2O_3} \times 100 = \frac{3 \times 16.00\ g/mol}{158.12\ g/mol} \times 100 = \boxed{30.36\%}$$

c) The percent of calcium ion in $Ca_3(PO_4)_2$

$$\% Ca^{2+} = \frac{3\,Ca^{2+}}{Ca_3(PO_4)_2} \times 100$$

$$= \frac{3 \times 40.08}{3 \times 40.08 + 2 \times 30.97 + 8 \times 16.00} \times 100 = \boxed{38.76\%\ Ca^{2+}}$$

10) Determine the percent ammonia, NH_3, in $Co(NH_3)_6Cl_3$ to 3 sig figs.

$NH_3 = 14.01 + 3 \times 1.008$
$= 17.034$ g/mole

$Co(NH_3)_6Cl_3$

Co	$1 \times 58.93 =$	58.93
N	$6 \times 14.01 =$	84.06
H	$18 \times 1.008 =$	18.144
Cl	$3 \times 35.45 =$	106.35
		267.484 g/mole

$$\% NH_3 = \frac{6\,NH_3}{Co(NH_3)_6Cl_3} \times 100$$

$$= \frac{6(17.034\ \text{g/mol})}{267.484\ \text{g/mole}} \times 100$$

$= 38.209388\%$

$= \boxed{38.2\%\ NH_3}$

11) Determine the percent water in $CuSO_4 \cdot 5H_2O$ to 3 Sig figs

$$\% = \frac{\text{Part}}{\text{whole}} \times 100$$

$H_2O = 2 \times 1.008 + 16.00$
$= 18.016$ g/mole

$CuSO_4 \cdot 5H_2O$

Cu	$1 \times 63.55 =$	63.55
S	$1 \times 32.07 =$	32.07
O	$9 \times 16.00 =$	144.00
H	$10 \times 1.008 =$	+ 10.08
		249.70 g/mole

$$\% H_2O = \frac{5\,H_2O}{CuSO_4 \cdot 5H_2O} \times 100$$

$$\% H_2O = \frac{5(18.016\ \text{g/mol})}{249.70\ \text{g/mol}} \times 100$$

$= 36.075290\%$

$\boxed{\% H_2O = 36.1\%}$

12) Determine the empirical formulas for compounds with the following percent compositions:

Process
- % → mass
- mass → mole
- divide by small
- mult. til whole

a) 15.8% Carbon & 84.2% S

	C	S
%	15.8%	84.2%
mass	15.8g	84.2g
mole	$15.8g \times \frac{1 \text{ mole C}}{12.01g}$	$84.2g \times \frac{1 \text{ mole S}}{32.07g}$
	$= 1.315570358$	$= 2.625506704$
divide by small	$= \frac{1.315570358}{1.315570358}$	$= \frac{2.625506704}{1.315570358}$
	$= 1$	$= 2$

Assume 100g sample

whole #'s so no need to multiply

C_1S_2

$\boxed{\text{Emperical Formula} = CS_2}$

b) 40.0% C, 6.7% hydrogen, 53.3% Oxygen

A little faster this time

	C	H	O
%	40.0%	6.7%	53.3%
mass	40.0g	6.7g	53.3g
moles	$40.0g \times \frac{1 \text{ mole C}}{12.01g}$	$6.7 \times \frac{1 \text{ mole H}}{1.008g}$	$53.3g \times \frac{1 \text{ mole O}}{16.00g}$
	= 3.330557868 mol (small)	= 6.646825397 mol	= 3.33125000 mol
Divide by small	= 1	2	1

$C_1H_2O_1$

$$\boxed{\text{Emperical Formula} = CH_2O}$$

15) Dichloroethane, a compound that is often used for dry cleaning, contains carbon, hydrogen, and chlorine. It has a molar mass of 99 g/mole. Analysis of a sample shows it contains 24.3% carbon and 4.1% hydrogen. What is it's molecular formula?

	C	H	Cl
%	24.3%	4.1%	100 - 4.1 - 24.3 = 71.6%
mass	24.3 g	4.1 g	71.6 g
mole	$24.3\,g \times \frac{1\text{ mole C}}{12.01\,g}$	$4.1\,g \times \frac{1\text{ mole H}}{1.008\,g}$	$71.6\,g \times \frac{1\text{ mole Cl}}{35.45\,g}$
	= 2.0233139	= 4.067460317	small = 2.019746121
divide by small	1	2	1

$C_1H_2Cl_1$

Emperical Formula CH_2Cl

molar mass Emperical =

C $1 \times 12.01 = 12.01$

H $2 \times 1.008 = 2.016$

Cl $1 \times 35.45 = 35.45$

49.476 g/mole

molecular formula = x emperical formula

molecular molar mass = x emperical molar mass

$$x = \frac{\text{molecular molar mass}}{\text{emperical molar mass}} = \frac{99\text{ g/mol}}{49.476\text{ g/mole}} = 2$$

molecular formula = 2 × emperical = $2(CH_2Cl)$

$$= \boxed{C_2H_4Cl_2}$$

6.3

22) Determine the molarity for each of the following solutions:

a) 0.444 mol of $CoCl_2$ in 0.654 L of Solution

$$\text{molarity} = \frac{\text{mols Solute}}{\text{L Solution}}$$

$$= \frac{\overset{3}{0.444}\ \text{mol } CoCl_2}{\underset{3}{0.654}\ \text{L Sol}} = \overset{3}{0.678}899\ \text{mols/L}$$

$$= \boxed{0.679\ \text{mols/L } CoCl_2}$$

b) 0.515 g of H_2SO_4 in 1.00 L Solution

Road map

$$\frac{g\ H_2SO_4 \rightarrow \text{mole } H_2SO_4}{\text{L sol}}$$

* need molar mass H_2SO_4

H $2 \times 1.008 = 2.016$

S $1 \times 32.07 = 32.07$

O $4 \times 16.00 = 64.00$

98.086

$= 98.09$ g/mole

$$\frac{\overset{3}{0.515}\ g\ H_2SO_4}{1\ \text{L sol}} \times \frac{1\ \text{mole } H_2SO_4}{\underset{4}{98.09}\ g\ H_2SO_4} = 0.00525028\ \text{mol/L}$$

$$= \boxed{0.00525\ \text{mols/L } H_2SO_4}$$

c) 0.2074 g of Calcium hydroxide, $Ca(OH)_2$, in 40.00 mL of Solution.

Road Map

g $Ca(OH)_2$ → moles $Ca(OH)_2$

mL sol → L sol

Can be done in one equation or in 2 seperate steps. I Like 1 step, but there is no right or wrong way through it.

molar mass $Ca(OH)_2$

$$
\begin{array}{llr}
Ca & 1 \times 40.08 = & 40.08 \\
O & 2 \times 16.00 = & 32.00 \\
H & 2 \times 1.008 = & 2.016 \\
\hline
 & & 74.096 = 74.10\ g/mole
\end{array}
$$

$$\frac{\overset{4}{0.2074}\ g\ \cancel{Ca(OH)_2}}{\underset{4}{40.00}\ \cancel{mL\ sol}} \times \frac{1\ mole\ Ca(OH)_2}{\underset{4}{74.10}\ g\ \cancel{Ca(OH)_2}} \times \frac{\overset{Exact}{1000}\ \cancel{mL\ sol}}{1\ L\ sol} = 0.06997\overset{4}{|}3009447$$

$$= \boxed{0.06997\ mols/L\ Ca(OH)_2}$$

24) Consider this question: What is the mass of the Solute in 0.500 L of 0.300 M glucose, $C_6H_{12}O_6$, used for intravenous injection?

a) outline the steps to solve the problem

Road Map

$$L\ sol \xrightarrow{molarity} moles\ glucose \xrightarrow{molar\ mass} g\ glucose$$

molar mass $C_6H_{12}O_6$

$6 \times 12.01 + 12 \times 1.008 + 6 \times 16.00 = 180.16\ g/mole$

b) Answer the question

$$\overset{3}{0.500}\ L\ sol \times \frac{\overset{3}{0.300}\ moles\ C_6H_{12}O_6}{1\ L\ sol} \times \frac{\overset{5}{180.16}\ g\ C_6H_{12}O_6}{1\ mole\ C_6H_{12}O_6} = 27.0\overset{3}{|}24\ g\ C_6H_{12}O_6$$

$$= \boxed{27.0\ g\ C_6H_{12}O_6}$$

28) Consider this question: What is the molarity of $KMnO_4$ in a solution of 0.0908 g $KMnO_4$ in 0.500 L solution?

a) Outline the steps

Road Map

$$\frac{g\ KMnO_4 \longrightarrow \text{mole}\ KMnO_4}{L\ \text{sol}}$$

molar mass

$KMnO_4$

K 1 × 39.10 = 39.10

Mn 1 × 54.94 = 54.94

O 4 × 16.00 = + 64.00

158.04 g/mol

b) Solve the problem

$$\frac{0.0908\,\cancel{g\ KMnO_4}}{0.500\,L\ \text{sol}} \times \frac{1\ \text{mole}\ KMnO_4}{158.04\,\cancel{g\ KMnO_4}} = 0.00114907662\ \text{mols/L}$$

3 3 5

$$= \boxed{0.00115\ \text{mols/L}\ KMnO_4}$$

33) What volume of a 1.00 M $Fe(NO_3)_3$ solution can be diluted to prepare 1.00 L of a solution with a concentration of 0.250 M?

C_1 = 1.00 M $Fe(NO_3)_3$

V_1 = ?

C_2 = 0.250 M

V_2 = 1.00 L

$C_1V_1 = C_2V_2$

$$V_1 = \frac{C_2V_2}{C_1}$$

$$V_1 = \frac{(0.250\,\cancel{M})(1.00\,L)}{1.00\,\cancel{M}} = \boxed{0.250\ L\ Fe(NO_3)_3}$$

34) If 0.1718 L of 0.3556 M C_3H_7OH solution is diluted to a concentration of 0.1222 M, what is the volume of the resulting solution?

$C_1 = 0.3556\ \underline{M}$

$V_1 = 0.1718\ L$

$C_2 = 0.1222\ \underline{M}$

$V_2 = ?$

$$C_1V_1 = C_2V_2$$

$$V_2 = \frac{C_1V_1}{C_2}$$

$$V_2 = \frac{(\overset{4}{0.3556}\ \cancel{\underline{M}})(\overset{4}{0.1718}\ L)}{\underset{4}{0.1222}\ \cancel{\underline{M}}}$$

$$V_2 = 0.4999|351882\ L$$

$$\boxed{V_2 = 0.4999\ L \text{ solution}}$$

35) If 4.12 L of a 0.850 M H_3PO_4 solution is to be diluted to a volume of 10.00 L, what is the concentration of the resulting solution?

$C_1 = 0.850\ \underline{M}$

$V_1 = 4.12\ L$

$C_2 = ?$

$V_2 = 10.00\ L$

$$C_1V_1 = C_2V_2$$

$$C_2 = \frac{C_1V_1}{V_2}$$

$$C_2 = \frac{(\overset{3}{0.850}\ \underline{M})(\overset{3}{4.12}\ \cancel{L})}{\underset{4}{10.00}\ \cancel{L}}$$

$$C_2 = 0.350|2\ \underline{M}\ H_3PO_4$$

$$\boxed{C_2 = 0.350\ \underline{M}\ H_3PO_4}$$

42) What volume of a 0.20 M K_2SO_4 solution contains 57 g of K_2SO_4?

Road Map

g K_2SO_4 → moles K_2SO_4 → L K_2SO_4

molar mass K_2SO_4 = $2 \times 39.10 + 32.07 + 4 \times 16.00 = 174.27$ g/mole

$$\underset{2}{57\text{g } K_2SO_4} \times \frac{1 \text{ mole } K_2SO_4}{\underset{5}{174.27\text{g } K_2SO_4}} \times \frac{1 \text{ L solution}}{\underset{2}{0.20 \text{ moles } K_2SO_4}} = 1.6|35393355 \text{ L solution}$$

$$= \boxed{1.6 \text{ L solution } K_2SO_4}$$

6.4

45) What mass of a 4.00% NaOH solution by mass contains 15.0g NaOH?

$$\% = \frac{\text{Part}}{\text{whole}} \times 100$$

When you use % always write the part/100

thus 4.00% by mass = $\frac{4.00\text{g Part}}{100 \text{ g whole}}$

Road Map

g NaOH → g solution

$$15.0\text{g NaOH} \times \frac{100 \text{ g solution}}{4.00\text{g NaOH}} = \boxed{375 \text{g Solution}}$$

49) The level of mercury in a stream was suspected to be above the minimum considered safe (1 part per billion by mass). An analysis indicated that the concentration was 0.68 parts per billion (Given). Assume a density of 1.0 g/mL (equality) and calculate the molarity of mercury (desired) in the stream.

$$\text{molarity} = \frac{\text{moles solute}}{\text{L sol}} \qquad \text{ppb} = \frac{\text{g part}}{\text{g whole}} \times 10^9$$

Road Map

$$\text{ppb: } \frac{\text{g Hg}}{10^9 \text{ g solution}} \xrightarrow{\text{molar mass}} \text{mole Hg} \qquad \xrightarrow{\text{density}} \text{mL solution} \longrightarrow \text{L solution} \qquad \text{molarity} = \frac{\text{mole Hg}}{\text{L solution}}$$

Difficult road map to build, but once you see it a few times it's not too hard.

$$\frac{\overset{2}{0.68} \text{ g } \cancel{\text{Hg}}}{10^9 \cancel{\text{ g solution}}} \times \frac{1 \text{ mole Hg}}{\underset{4}{200.6} \cancel{\text{ g Hg}}} \times \frac{\overset{2}{1.0} \cancel{\text{ g Sol}}}{1 \cancel{\text{ mL sol}}} \times \frac{\overset{\text{Exact}}{1000} \cancel{\text{ mL Sol}}}{1 \text{ L Sol}}$$

$$= 3.389830508 \times 10^{-9} \text{ mols/L Hg}$$

$$= \boxed{3.4 \times 10^{-9} \text{ mols/L Hg}}$$

52) Copper(I) iodide (CuI) is often added to table salt as a dietary source of iodine. How many moles of CuI are contained in 1.00 lb of table salt containing 0.0100 % CuI by mass?

Molar Mass CuI = 63.55 + 126.9
= 190.4 g/mole CuI

Road Map

(A) lbs salt → lbs CuI → g CuI → moles CuI

or

(B) lbs Salt → g Salt → g CuI → moles CuI

(A) $$1.00\text{ lbs Salt} \times \frac{0.0100\text{ lbs CuI}}{100\text{ lbs Salt}} \times \frac{453.6\text{ g CuI}}{1\text{ lbs CuI}} \times \frac{1\text{ mole CuI}}{190.4\text{ g CuI}}$$

$$= 2.382352941 \times 10^{-4}\text{ moles CuI}$$

$$= \boxed{2.38 \times 10^{-4}\text{ moles CuI}}$$

(B) $$1.00\text{ lbs Salt} \times \frac{453.6\text{ g Salt}}{1\text{ lbs salt}} \times \frac{0.0100\text{ g CuI}}{100\text{ g Salt}} \times \frac{1\text{ mole CuI}}{190.4\text{ g CuI}}$$

$$= \boxed{2.38 \times 10^{-4}\text{ moles CuI}}$$

works because % by mass can be any units of mass.

$$\frac{0.0100\text{ lbs CuI}}{100\text{ lbs CuI}} \quad \text{or} \quad \frac{0.0100\text{ g CuI}}{100\text{ g CuI}}$$

Ratio Holds regardless of units ⇒ as long as mass☺