

# Chapter 6 Homework Key

## 6.1

3) Calculate the molar mass for each of the following:  
*Good Warm-up & Review questions.*

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

b)  $H_2O$        $H \ 2 \times 1.008 = 2.016$   
                  $O \ 1 \times 16.00 + 16.00$   
    $\underline{18.016 \text{ g/mole}}$   
    $\downarrow$   
    $\boxed{18.02 \text{ g/mole}}$

c)  $Ca(NO_3)_2$        $Ca \ 1 \times 40.08 = 40.08$   
                          $N \ 2 \times 14.01 = 28.02$   
                          $O \ 6 \times 16.00 = 96.00$   
    $\underline{166.10}$   
    $\downarrow$   
    $\boxed{166.10 \text{ g/mole}}$

d)  $CH_3CO_2H$        $C \ 2 \times 12.01 = 24.02$   
                          $H \ 4 \times 1.008 = 4.032$   
                          $O \ 2 \times 16.00 = 32.00$   
    $\underline{60.052}$   
    $\downarrow$   
    $\boxed{60.05 \text{ g/mole}}$

e)  $C_{12}H_{22}O_{11}$        $12 \times 12.01 = 144.12$   
                          $22 \times 1.008 = 22.176$   
                          $11 \times 16.00 = 176.00$   
    $\underline{342.296}$   
    $\downarrow$   
    $\boxed{342.3 \text{ g/mole}}$

## 6.2

8) Calculate the following to four significant figures:

a) The percent composition of ammonia  $\text{NH}_3$

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

$$\% \text{ N} = \frac{\text{N}}{\text{NH}_3} \times 100 = \frac{14.01}{14.01 + 3 \times 1.008} \times 100 = 82.2472\% = \boxed{82.25\%}$$

$$\% \text{ H} = \frac{3\text{H}}{\text{NH}_3} \times 100 = \frac{3 \times 1.008}{14.01 + 3 \times 1.008} \times 100 = 17.75272\% = \boxed{17.75\%}$$

b) The percent composition of photographic fixer "hypo"  
 $\text{Na}_2\text{S}_2\text{O}_3$

make it easy & calc molar mass 1<sup>st</sup>

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

$$\% \text{ Na} = \frac{2 \text{ Na}}{\text{Na}_2\text{S}_2\text{O}_3} \times 100 = \frac{2 \times 22.99 \text{ g/mol}}{158.12 \text{ g/mol}} \times 100 = \boxed{29.08\%}$$

$$\% \text{ S} = \frac{2 \text{ S}}{\text{Na}_2\text{S}_2\text{O}_3} \times 100 = \frac{2 \times 32.07 \text{ g/mol}}{158.12 \text{ g/mol}} \times 100 = \boxed{40.56\%}$$

$$\% \text{ O} = \frac{3 \text{ O}}{\text{Na}_2\text{S}_2\text{O}_3} \times 100 = \frac{3 \times 16.00 \text{ g/mol}}{158.12 \text{ g/mol}} \times 100 = \boxed{30.36\%}$$

c) The percent of Calcium ion in  $\text{Ca}_3(\text{PO}_4)_2$

$$\begin{aligned} \% \text{Ca}^{2+} &= \frac{3 \text{Ca}^{2+}}{\text{Ca}_3(\text{PO}_4)_2} \times 100 \\ &= \frac{3 \times 40.08}{3 \times 40.08 + 2 \times 30.97 + 8 \times 16.00} \times 100 = \boxed{38.76\% \text{Ca}^{2+}} \end{aligned}$$

10) Determine the percent ammonia,  $\text{NH}_3$ , in  $\text{Co}(\text{NH}_3)_6\text{Cl}_3$  to 3 sig figs.

$$\begin{aligned} \% \text{NH}_3 &= \frac{6 \text{NH}_3}{\text{Co}(\text{NH}_3)_6\text{Cl}_3} \times 100 \\ &= \frac{6 (17.034 \text{ g/mol})}{267.484 \text{ g/mole}} \times 100 \\ &= 38.209388\% \\ &= \boxed{38.2\% \text{NH}_3} \end{aligned}$$

$$\begin{aligned} \text{NH}_3 &= 14.01 + 3 \times 1.008 \\ &= 17.034 \text{ g/mole} \end{aligned}$$

$$\begin{aligned} \text{Co}(\text{NH}_3)_6\text{Cl}_3 \\ \text{Co } 1 \times 58.93 &= 58.93 \\ \text{N } 6 \times 14.01 &= 84.06 \\ \text{H } 18 \times 1.008 &= 18.144 \\ \text{Cl } 3 \times 35.45 &= 106.35 \\ \hline &= 267.484 \text{ g/mole} \end{aligned}$$

11) Determine the percent water in  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  to 3 sig figs

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

$$\begin{aligned} \text{H}_2\text{O} &= 2 \times 1.008 + 16.00 \\ &= 18.016 \text{ g/mole} \end{aligned}$$

$$\% \text{H}_2\text{O} = \frac{5 \text{H}_2\text{O}}{\text{CuSO}_4 \cdot 5\text{H}_2\text{O}} \times 100$$

$$\begin{aligned} \text{CuSO}_4 \cdot 5\text{H}_2\text{O} \\ \text{Cu } 1 \times 63.55 &= 63.55 \\ \text{S } 1 \times 32.07 &= 32.07 \\ \text{O } 9 \times 16.00 &= 144.00 \\ \text{H } 10 \times 1.008 &= 10.08 \\ \hline &= 249.70 \text{ g/mole} \end{aligned}$$

$$\begin{aligned} \% \text{H}_2\text{O} &= \frac{5 (18.016 \text{ g/mol})}{249.70 \text{ g/mol}} \times 100 \\ &= 36.075290\% \end{aligned}$$

$$\boxed{\% \text{H}_2\text{O} = 36.1\%}$$

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	$15.8g \times \frac{1 \text{ mole C}}{12.01g}$ $= 1.315570358$	$84.2g \times \frac{1 \text{ mole S}}{32.07g}$ $= 2.625506704$

Assume 100g sample

divide by small

$$= \frac{1.315570358}{1.315570358} = 1$$
$$= \frac{2.625506704}{1.315570358} = 2$$

whole #'s so no need to multiply



Empirical 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	$40.0\text{g} \times \frac{1\text{ mole C}}{12.01\text{g}}$	$6.7 \times \frac{1\text{ mole H}}{1.008\text{g}}$	$53.3\text{g} \times \frac{1\text{ mole O}}{16.00\text{g}}$
	$= \overset{\text{small}}{3.330557868}\text{ mol}$	$= 6.646825397\text{ mol}$	$= 3.3312500\text{ mol}$
Divide by small	= 1	2	1



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 its molecular formula?

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



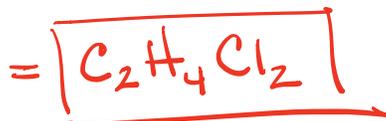
Empirical Formula  $\text{CH}_2\text{Cl}$

$$\begin{aligned} \text{molar mass Empirical} = & \text{C } 1 \times 12.01 = 12.01 \\ & \text{H } 2 \times 1.008 = 2.016 \\ & \text{Cl } 1 \times 35.45 = 35.45 \\ & \hline & 49.476 \text{ g/mole} \end{aligned}$$

molecular formula = x empirical formula  
molecular molar mass = x empirical molar mass

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

$$\text{molecular formula} = 2 \times \text{empirical} = 2(\text{CH}_2\text{Cl})$$



6.3

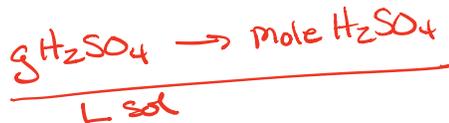
22) Determine the molarity for each of the following Solutions:

a) 0.444 mol of  $\text{CoCl}_2$  in 0.654 L of Solution

$$\begin{aligned} \text{molarity} &= \frac{\text{mols Solute}}{\text{L Solution}} \\ &= \frac{0.444 \text{ mol } \text{CoCl}_2}{0.654 \text{ L sol}} = 0.678899 \text{ mols/L} \\ &= \boxed{0.679 \text{ mols/L } \text{CoCl}_2} \end{aligned}$$

b) 0.515 g of  $\text{H}_2\text{SO}_4$  in 1.00 L Solution

Road map



\* need molar mass  $\text{H}_2\text{SO}_4$

$$\begin{aligned} \text{H } 2 \times 1.008 &= 2.016 \\ \text{S } 1 \times 32.07 &= 32.07 \\ \text{O } 4 \times 16.00 &= 64.00 \\ &= \underline{98.086} \\ &= 98.09 \text{ g/mole} \end{aligned}$$

$$\begin{aligned} \frac{0.515 \text{ g } \text{H}_2\text{SO}_4}{1 \text{ L sol}} \times \frac{1 \text{ mole } \text{H}_2\text{SO}_4}{98.09 \text{ g } \text{H}_2\text{SO}_4} &= 0.00525028 \text{ mol/L} \\ &= \boxed{0.00525 \text{ mols/L } \text{H}_2\text{SO}_4} \end{aligned}$$

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

Road Map

$$\frac{\text{g Ca}(\text{OH})_2}{\text{mL Sol}} \rightarrow \frac{\text{moles Ca}(\text{OH})_2}{\text{L Sol}}$$

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

molar mass  $\text{Ca}(\text{OH})_2$

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

$$\frac{0.2074 \text{ g Ca}(\text{OH})_2}{40.00 \text{ mL Sol}} \times \frac{1 \text{ mole Ca}(\text{OH})_2}{74.10 \text{ g Ca}(\text{OH})_2} \times \frac{1000 \text{ mL Sol}}{1 \text{ L Sol}} = 0.069973009447$$

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

24) Consider this question: What is the mass of the solute in 0.500 L of 0.300 M glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$ , used for intravenous injection?

a) Outline the steps to solve the problem

Road Map

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

molar mass  $\text{C}_6\text{H}_{12}\text{O}_6$

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

b) Answer the question

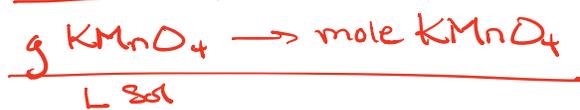
$$0.500 \text{ L Sol} \times \frac{0.300 \text{ moles C}_6\text{H}_{12}\text{O}_6}{1 \text{ L Sol}} \times \frac{180.16 \text{ g C}_6\text{H}_{12}\text{O}_6}{1 \text{ mole C}_6\text{H}_{12}\text{O}_6} = 27.024 \text{ g C}_6\text{H}_{12}\text{O}_6$$

$$= \boxed{27.0 \text{ g C}_6\text{H}_{12}\text{O}_6}$$

28) Consider this question: What is the molarity of  $\text{KMnO}_4$  in a solution of 0.0908 g  $\text{KMnO}_4$  in 0.500 L solution?

a) Outline the steps

Road Map



molar mass



$\text{K } 1 \times 39.10 = 39.10$

$\text{Mn } 1 \times 54.94 = 54.94$

$\text{O } 4 \times 16.00 = +64.00$

158.04 g/mol

b) Solve the problem

$$\frac{0.0908 \text{ g } \text{KMnO}_4}{0.500 \text{ L sol}} \times \frac{1 \text{ mole } \text{KMnO}_4}{158.04 \text{ g } \text{KMnO}_4} = 0.0011490762 \text{ moles/L}$$

↓

$$= \boxed{0.00115 \text{ moles/L } \text{KMnO}_4}$$

33) What volume of a 1.00 M  $\text{Fe}(\text{NO}_3)_3$  solution can be diluted to prepare 1.00 L of a solution with a concentration of 0.250 M?

$C_1 = 1.00 \text{ M } \text{Fe}(\text{NO}_3)_3$

$C_1 V_1 = C_2 V_2$

$V_1 = ?$

$V_1 = \frac{C_2 V_2}{C_1}$

$C_2 = 0.250 \text{ M}$

$V_2 = 1.00 \text{ L}$

$$V_1 = \frac{(0.250 \text{ M})(1.00 \text{ L})}{1.00 \text{ M}} = \boxed{0.250 \text{ L } \text{Fe}(\text{NO}_3)_3}$$

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?

$$C_1 = 0.3556 \text{ M}$$

$$V_1 = 0.1718 \text{ L}$$

$$C_2 = 0.1222 \text{ M}$$

$$V_2 = ?$$

$$C_1 V_1 = C_2 V_2$$

$$V_2 = \frac{C_1 V_1}{C_2}$$

$$V_2 = \frac{(0.3556 \text{ M})(0.1718 \text{ L})}{0.1222 \text{ M}}$$

$$V_2 = 0.4999351882 \text{ L}$$

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

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?

$$C_1 = 0.850 \text{ M}$$

$$V_1 = 4.12 \text{ L}$$

$$C_2 = ?$$

$$V_2 = 10.00 \text{ L}$$

$$C_1 V_1 = C_2 V_2$$

$$C_2 = \frac{C_1 V_1}{V_2}$$

$$C_2 = \frac{(0.850 \text{ M})(4.12 \text{ L})}{10.00 \text{ L}}$$

$$C_2 = 0.3502 \text{ M } H_3PO_4$$

$$C_2 = 0.350 \text{ M } H_3PO_4$$

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

Road Map

g  $K_2SO_4$   $\rightarrow$  moles  $K_2SO_4$   $\rightarrow$  L  $K_2SO_4$

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

$$57 \text{ g } K_2SO_4 \times \frac{1 \text{ mole } K_2SO_4}{174.27 \text{ g } K_2SO_4} \times \frac{1 \text{ L solution}}{0.20 \text{ moles } K_2SO_4} = 1.635393355 \text{ L solution}$$

$\downarrow$

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

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 =  $\frac{4.00 \text{ g Part}}{100 \text{ g whole}}$

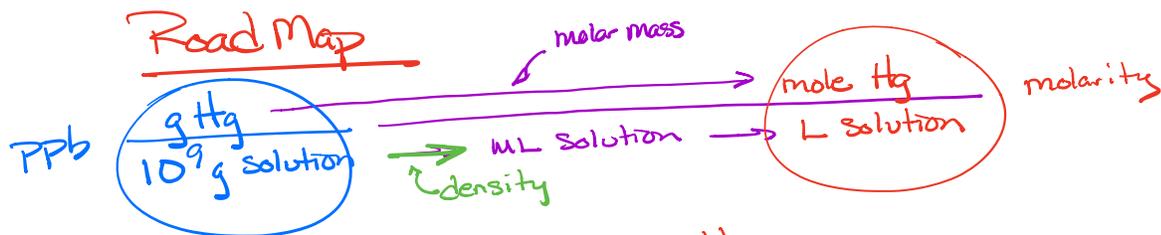
Road Map

g NaOH  $\rightarrow$  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 <sup>Given</sup> 0.68 parts per billion. Assume a density of <sup>equality</sup> 1.0 g/mL and calculate the <sup>desired</sup> molarity of Mercury in the stream.

$$\text{Molarity} = \frac{\text{moles Solute}}{\text{L Sol}} \quad \text{PPb} = \frac{\text{g part}}{\text{g whole}} \times 10^9$$



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

$$\begin{aligned} & \frac{0.68 \text{ g Hg}}{10^9 \text{ g solution}} \times \frac{1 \text{ mole Hg}}{200.6 \text{ g Hg}} \times \frac{1.0 \text{ g Sol}}{1 \text{ mL Sol}} \times \frac{1000 \text{ mL Sol}}{1 \text{ L Sol}} \\ & = 3.389830508 \times 10^{-9} \text{ mols/L Hg} \\ & = \boxed{3.4 \times 10^{-9} \text{ mols/L Hg}} \end{aligned}$$

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?

$$\begin{aligned} \text{molar mass CuI} &= 63.55 + 126.9 \\ &= 190.4 \text{ g/mole CuI} \end{aligned}$$

### Road Map

Ⓐ lbs salt  $\rightarrow$  lbs CuI  $\rightarrow$  g CuI  $\rightarrow$  moles CuI

or  
Ⓑ lbs salt  $\rightarrow$  g salt  $\rightarrow$  g CuI  $\rightarrow$  moles CuI

$$\begin{aligned} \text{Ⓐ } 1.00 \text{ lbs Salt} &\times \frac{0.0100 \text{ lbs CuI}}{100 \text{ lbs Salt}} \times \frac{453.6 \text{ g CuI}}{1 \text{ lbs CuI}} \times \frac{1 \text{ mole CuI}}{190.4 \text{ g CuI}} \\ &= 2.382352941 \times 10^{-4} \text{ moles CuI} \\ &= \boxed{2.38 \times 10^{-4} \text{ moles CuI}} \end{aligned}$$

$$\begin{aligned} \text{Ⓑ } 1.00 \text{ lbs Salt} &\times \frac{453.6 \text{ g Salt}}{1 \text{ lbs Salt}} \times \frac{0.0100 \text{ g CuI}}{100 \text{ g Salt}} \times \frac{1 \text{ mole CuI}}{190.4 \text{ g CuI}} \\ &= \boxed{2.38 \times 10^{-4} \text{ moles CuI}} \end{aligned}$$

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  $\Rightarrow$  as long as mass!