Activity 14 – Mole Worksheet

Name Key

Section_____ Date_____

Questions and Problems

Solve the following problems, showing at least some of your work and making sure your answer is clearly boxed off. Your final answer will include the correct number of significant figures and the units. Use scientific notation if the answer is greater than 1000 or less than 1. Note: Make sure you have the correct chemical formula before doing any calculations. You will need a periodic table for this exercise.

1. A sample of mercury (II) bromide weighs 7.56 g.
    a. What is the molar mass of mercury (II) bromide?

    b. How many moles are in this sample?

2. What is the mass of 0.81 mol of ammonium carbonate?

3. How many ***molecules*** are contained in 8.25 mol of chlorine gas?

    a. How many ***atoms*** are contained in 8.25 mol of chlorine gas?

4. Calculate the percent by mass of barium in barium sulfate.

5. What is the mass of 4.2×10^{23} molecules of carbon dioxide?

6. Use the following equation to solve the following problems:

$$2\ KMnO_4 + 16\ HCl \longrightarrow 5\ Cl_2 + 2\ KCl + 2\ MnCl_2 + 8\ H_2O$$

a. How many moles of HCl are required to react completely with 1.00 mole of $KMnO_4$?

b. How many moles of chlorine will be produced by 25.0 moles of $KMnO_4$?

c. How many moles of water will be produced if 40. g of HCl are completely reacted with excess potassium permanganate?

d. What is the maximum mass of manganese(II) chloride that will be produced if 40. g of HCl are completely reacted with excess potassium permanganate?

7. A water solution of sulfuric acid (H_2SO_4) has a density of 1.67 g/mL and is 75 percent H_2SO_4 by mass. How many moles of H_2SO_4 are contained in 500. mL of this solution?

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1. A sample of Mercury(II) bromide weighs 7.56 g.

a. What is the molar mass of Mercury(II) bromide?

Hg^{2+} | Br^-, Br^- → $HgBr_2$

2+ | 2−

Hg 1×200.59 g/mole = 200.59

Br 2×79.904 g/mole = + 159.808

360.398

$HgBr_2$ = 360.40 g/mole

b. How many moles are in this sample?

Road Map: g → moles

$$7.56 \text{ g } HgBr_2 \times \frac{1 \text{ mole } HgBr_2}{360.40 \text{ g } HgBr_2} = 0.020976 \text{ mole}$$

(3 sig figs; 5 sig figs)

= ~~0.210~~ mole $HgBr_2$

0.0210

2. What is the ~~molar~~ mass of 0.81 mole of ammonium carbonate?

Road Map: mole → g

NH_4^+ | CO_3^{2-} → $(NH_4)_2CO_3$

NH_4^+

2+ | 2−

N 2×14.00674 = 28.01348

H 8×1.00794 = 8.06352

C 1×12.011 = 12.011

O 3×15.9994 = + 47.9982

96.0866 (4 sig figs; 5 sig figs)

$(NH_4)_2CO_3$ = 96.0866 g/mole

2. Cont.

$$0.81 \text{ mole } (NH_4)_2CO_3 \times \frac{96.0866 \text{ g } (NH_4)_2CO_3}{1 \text{ mole } (NH_4)_2CO_3} = 77.82966 \text{ g}$$

$$= \boxed{78 \text{ g } (NH_4)_2CO_3}$$

3. How many molecules are contained in 8.25 mole of Chlorine gas?

Chlorine gas is one of the diatomic elements (HOFBrINCl).

$\Longrightarrow Cl_2$

Road Map: mole $\longrightarrow$ molecule

$$8.25 \text{ mole } Cl_2 \times \frac{6.022 \times 10^{23} \text{ molecules } Cl_2}{1 \text{ mole } Cl_2} = 4.96815 \times 10^{24} \text{ molecule}$$

$$= \boxed{4.97 \times 10^{24} \text{ molecules } Cl_2}$$

a. How many atoms are contained in 8.25 mol of Chlorine gas?

Road Map: mole $Cl_2 \longrightarrow$ molecule $Cl_2 \longrightarrow$ atom Cl

$$8.25 \text{ mole } Cl_2 \times \frac{6.022 \times 10^{23} \text{ molecule } Cl_2}{1 \text{ mole } Cl_2} \times \frac{2 \text{ atoms Cl (count)}}{1 \text{ molecule } Cl_2} = 9.93263 \times 10^{24} \text{ atoms}$$

$$= \boxed{9.94 \times 10^{24} \text{ atoms Cl}}$$

4. Calculate the percent by mass of barium in barium Sulfate.

Ba^{2+}	SO_4^{2-}
2+	2-

$BaSO_4$

$$\% \text{ by mass} = \frac{\text{Mass part}}{\text{Mass whole}} \times 100\%$$

Part = Ba^{2+}
Whole = $BaSO_4$
} Choose an easy quantity such as 1 mole = Mass 1 mole

$$\frac{Ba^{2+}}{BaSO_4} \times 100 = \frac{137.327\ g\ Ba^{2+}}{265.457\ g\ BaSO_4} \times 100 = 51.7322\%$$

need molar mass

$$= \boxed{51.7323\% \text{ by mass}}$$

$1\ Ba \times 137.327\ g/mole = 137.327$
$1\ S \times 32.066\ g/mole = 64.132$
$4\ O \times 15.9994\ g/mole = 63.9976$
$265.4566 = 265.457\ g/mole$

5. What is the mass of 4.2×10^{23} molecules of Carbon dioxide?

Road Map molecules CO_2 → mole CO_2 → g CO_2

Info needed: Molar Mass CO_2

$1\,C \times 12.011 = 12.011$

$2\,O \times 15.9994 = +31.9988$

$44.0098 = 44.010$ g/mole CO_2

$$4.2 \times 10^{23}\ \text{molecule } CO_2 \times \frac{1\ \text{mole } CO_2}{6.022 \times 10^{23}\ \text{molecule } CO_2} \times \frac{44.010\ \text{g } CO_2}{1\ \text{mole } CO_2} =$$

$= 30.6944537$ g CO_2

$= \boxed{31\ \text{g } CO_2}$

6. Use the following equation to solve the following problems:

$$2KMnO_4 + 16HCl \longrightarrow 5Cl_2 + 2KCl + 2MnCl_2 + 8H_2O$$

a. How many moles of HCl are required to react completely with 1.00 mole $KMnO_4$?

Road Map: mole $KMnO_4$ → mole HCl

$$1.00 \text{ mole } KMnO_4 \times \frac{16 \text{ mole HCl}}{2 \text{ mole } KMnO_4} = \boxed{8.00 \text{ mole HCl}}$$

* watch sig figs here

b. How many moles of chlorine will be produced by 25.0 moles $KMnO_4$?

Road Map: mole $KMnO_4$ → Mole Cl_2

$$25.0 \text{ mole } KMnO_4 \times \frac{5 \text{ mole } Cl_2}{2 \text{ mole } KMnO_4} = \boxed{62.5 \text{ mole } Cl_2}$$

c. How many moles of water will be produced if 40. g of HCl are completely reacted with excess potassium permanganate?

Road map: g HCl → Mole HCl → Moles H_2O

Required Info: molar mass HCl

$$1H \times 1.00794 = 1.00794$$
$$1Cl \times 35.4527 = 35.4527$$
$$36.46064 \text{ g/mole} = 36.46064 \text{ g/mole HCl}$$

6c. Cont.

$$40.\ g\,HCl \times \frac{1\ mole\ HCl}{36.4606\ g\,HCl} \times \frac{8\ mole\ H_2O}{16\ mole\ HCl} = 0.5485373\ mole$$

(2 sig figs; count 6; count 2; calc error)

$$= \boxed{0.55\ mole\ H_2O}$$

d. What is the maximum mass of manganese(II) chloride that will be produced if 40. g of HCl are completely reacted with excess potassium permanganate?

Road Map: g HCl → mole HCl → mole $MnCl_2$ → g $MnCl_2$

Required Info: Molar Mass HCl from previous and Molar Mass of $MnCl_2$

$1\ Mn \times 54.93805 = 54.93805$

$2\ Cl \times 35.4527 = +\ 70.9054$

$125.843485 = 125.8434\ g/mole\ MnCl_2$

(2 sig figs; count 7; *Round even)

$$40.\ g\,HCl \times \frac{1\ mole\ HCl}{36.4606\ g\,HCl} \times \frac{2\ mole\ MnCl_2}{16\ mole\ HCl} \times \frac{125.8434\ g\ MnCl_2}{1\ mole\ MnCl_2} = 17.2574505\ g$$

(2 sig figs; count 6; count 7)

$$= \boxed{17\ g\ MnCl_2}$$

7. A water solution of Sulfuric acid (H_2SO_4) has a density of 1.67 g/mL and is 75% H_2SO_4 by mass. How many moles of H_2SO_4 are contained ~~in~~ in 500. mL of this solution.

- This one is complicated by the fact that we are dealing with a solution and not a pure material. The percent by mass is a conversion factor to convert the mass of the whole (solution) into the mass of the part (just the H_2SO_4).

Road Map: mL Solution → g Solution → g H_2SO_4 → moles H_2SO_4

Required Info: density solution ←

% by mass $\frac{75\text{ g } H_2SO_4}{100\text{ g Solution}}$ ←

molar mass H_2SO_4

$2H \times 1.00794 = 2.01588$

$1S \times 32.066 = 32.066$

$4O \times 15.9994 = +\,63.9976$

$98.079\,48 = 98.079\text{ g/mole } H_2SO_4$

$$500.\text{ mL Sol} \times \frac{1.67\text{ g Sol}}{1\text{ mL Sol}} \times \frac{75\text{ g } H_2SO_4}{100\text{ g Sol}} \times \frac{1\text{ mole } H_2SO_4}{98.079\text{ g } H_2SO_4} = 6.385159$$

(3 sig figs) (2 sig figs) (5 sig figs) (2 sig figs)

$$= \boxed{6.4\text{ mole } H_2SO_4}$$