Key : **WS 9.1** Stoichiometry! Name:_____________________________________ p.______

Steps for solving stoichiometry problems: If the problem asks you to convert between moles of one substance and moles of another substance, you can just do the problem in one step, using a mole ratio. You can also do the problem in one step if you only need to convert between molecules of one substance and molecules of another substance. If this is not the case, follow these steps:

Step 1. Convert from molecules, atoms, or grams of the given substance into moles of the given substance (unless it was already in moles).

use $\left(\frac{1\text{ mole}}{6.02\times10^{23}\text{ atoms or molecules}}\right)$ OR $\left(\frac{1\text{ mole}}{\text{molar mass (g)}}\right)$

Step 2. Use the mole ratio from the balanced equation to convert into moles of the sought substance.

Step 3. Convert the moles of sought substance back into molecules, atoms, or grams of the sought substance. (unless the answer is supposed to be in moles).

use $\left(\frac{6.02\times10^{23}\text{ atoms or molecules}}{1\text{ mole}}\right)$ OR $\left(\frac{\text{molar mass (g)}}{1\text{ mole}}\right)$

Formula masses	26.9815	36.4609		133.3405	2.0158
Reaction	$2\ Al_{(s)}$ +	$6\ HCl_{(aq)}$	------->	$2\ AlCl_{3\ (aq)}$	+ $3\ H_{2(g)}$

1. Fill the blanks, above, for the formula masses.

2. If 10.0 grams of aluminum react with excess hydrochloric acid, how many grams of hydrogen gas can form?

$$(10.0\text{ g Al})\left(\frac{1\text{ mole Al}}{26.9815\text{ g Al}}\right)\left(\frac{3\text{ moles }H_2}{2\text{ moles Al}}\right)\left(\frac{2.0158\text{ g}}{\text{mole}}\right) = 1.1207 \rightarrow \boxed{1.12\text{ g}}$$

3. If 6.02×10^{22} aluminum atoms react, how many grams of aluminum chloride can form?

$$(6.02\times10^{22}\text{ Al atoms})\left(\frac{1\text{ mole}}{6.02\times10^{23}\text{ atoms}}\right)\left(\frac{2\text{ moles }AlCl_3}{2\text{ moles Al}}\right)\left(\frac{133.3405\text{ g}}{1\text{ mole}}\right) = \boxed{13.3\text{ g}}$$

4. What mass of aluminum is needed to produce 4.00 grams of hydrogen gas?

$$(4.00\text{ g }H_2)\left(\frac{1\text{ mole}}{2.0158\text{ g}}\right)\left(\frac{2\text{ mole Al}}{3\text{ mole }H_2}\right)\left(\frac{26.9815\text{ g}}{1\text{ mole}}\right) = 5.693 \rightarrow \boxed{35.7\text{ g}}$$

5. If 3.21 moles of hydrochloric acid react, how many molecules of hydrogen gas can form?

$$(3.21\text{ moles HCl})\left(\frac{3\text{ moles }H_2}{6\text{ moles HCl}}\right)\left(\frac{6.02\times10^{23}\text{ molecules}}{1\text{ mole}}\right) = \boxed{9.66\times10^{23}\text{ molecules }H_2}$$

6. How many moles of acid are required in order to form 3.00 gram of aluminum chloride?

$$(3.00\text{ g }AlCl_3)\left(\frac{1\text{ mole}}{133.3405\text{ g}}\right)\left(\frac{6\text{ moles HCl}}{2\text{ moles }AlCl_3}\right) = \boxed{0.0675\text{ moles HCl}}$$

9.1 Key

7. $3\ BaCl_{2\,(aq)} + 2\ Na_3PO_{4\,(aq)} \longrightarrow Ba_3(PO_4)_{2(s)} + 6\ NaCl_{(aq)}$

a. If 56.3 grams of barium chloride react with excess sodium phosphate, how many grams of barium phosphate will form?

$$\left(56.3\,g\ BaCl_2\right)\left(\frac{1\,mole}{208.236\,g}\right)\left(\frac{1\,mole\ Ba_3(PO_4)_2}{3\,mole\ BaCl_2}\right)\left(\frac{601.9327\,g}{1\,mole}\right) = 54.2474\,g \rightarrow \boxed{54.2\,g}$$

b. Learn the formula for % yield: % yield = $\frac{\text{actual (lab) value}}{\text{expected (stoichiometry) value}}$ x 100%

c. Suppose that when the reaction in (a) is done in lab, only 53.3 grams of barium phosphate precipitate are actually collected. What was the percent yield for the reaction?

$$\frac{53.3\,g}{54.2474\,g} \times 100 = \boxed{98.3\ \%}$$

d. What mass of sodium phosphate is needed to produce 100.0 grams of sodium chloride in the reaction?

$$\left(100.0\,g\ NaCl\right)\left(\frac{1\,mole}{58.4428\,g}\right)\left(\frac{2\,moles\ Na_3PO_4}{6\,mole\ NaCl}\right)\left(\frac{163.94076\,g}{1\,mole}\right) = \boxed{93.50\ g}$$

e. If 1.0 moles of sodium phosphate react, how many moles of barium phosphate will form?

$$\left(1.0\,moles\ Na_3PO_4\right)\left(\frac{1\,mole\ Ba_3(PO_4)_2}{2\,moles\ Na_3PO_4}\right) = \boxed{0.50\ moles\ Ba_3(PO_4)_2}$$

8. $4\ C_3H_5N_3O_{9\,(l)} \longrightarrow 12\ CO_{2\,(g)} + 10\ H_2O_{(g)} + 6\ N_{2\,(g)} + 1\ O_{2\,(g)}$ + heat

a. What mass of nitroglycerine are needed to produce 50.0 grams of oxygen gas?

$$\left(50.0\,g\ O_2\right)\left(\frac{1\,mole}{31.9988\,g}\right)\left(\frac{4\,moles\ C_3H_5N_3O_9}{1\,mole\ O_2}\right)\left(\frac{227.0872\,g}{1\,mole}\right) = 1419.3 \rightarrow \boxed{1420\,g}$$

b. If 450 grams of nitroglycerine decompose, how many moles of carbon dioxide gas will be produced?

$$\left(450\,g\ C_3H_5N_3O_9\right)\left(\frac{1\,mole}{227.0872\,g}\right)\left(\frac{12\,mole\ CO_2}{4\,moles\ C_3H_5N_3O_9}\right) = \boxed{5.9\ moles\ CO_2}$$

9. $3\ Cu_{(s)} + 8\ HNO_{3\,(aq)} \longrightarrow 3\ Cu(NO_3)_{2\,(aq)} + 4\ H_2O_{(l)} + 2\ NO_{(g)}$

a. If 1.0 x 10^{22} copper atoms react, what mass of NO gas can form?

$$\left(1.0\times10^{22}\,Cu\ atoms\right)\left(\frac{1\,mole}{6.02\times10^{23}\,atoms}\right)\left(\frac{2\,mole\ NO}{3\,mole\ Cu}\right)\left(\frac{30.0061\,g}{mole}\right) = 0.33229 \rightarrow \boxed{0.33\,g}$$

b. Suppose that the actual mass of NO collected in (a) is only 0.31 grams. Calculate the % yield.

$$\frac{0.31}{0.33229} \times 100 = \boxed{93\ \%}$$ (was 93.29 before rounding)

c. If 10.0 grams of copper react, what mass of water can form in the reaction?

$$\left(10.0\,g\ Cu\right)\left(\frac{1\,mole}{63.546\,g}\right)\left(\frac{4\,moles\ H_2O}{3\,moles\ Cu}\right)\left(\frac{18.0152\,g}{1\,mole}\right) = \boxed{3.78\,g\ H_2O}$$