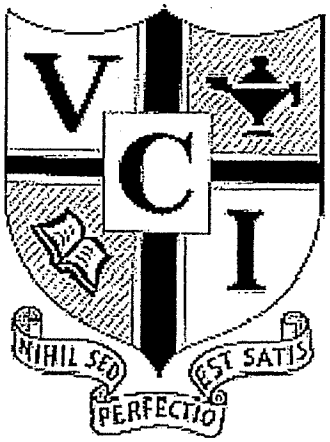
Science Notebook



30S Chemistry

Stoichiometry

Student Name: _____ Date: _____

Chemistry 30S

Stoichiometry
Introductory Questions

Answer the following questions in your Chemistry notebook. Show your work for any calculations.

1. a. $2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$
   2 molecules CO + 1 molecule $O_2 \longrightarrow$ 2 molecules CO_2
   2 mol CO + 1 mol $O_2 \longrightarrow$ 2 mol CO_2
   $(2 \times 28\text{ g}) + 32\text{ g} = 2 \times 44\text{ g}$
   88 g = 88 g (law of conservation of mass)
   44.8 L CO + 22.4 L $O_2 \longrightarrow$ 44.8 L CO_2

   b. $2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g)$
   2 atoms Na + 2 molecules $H_2O \longrightarrow$ 2 formula units NaOH + 1 molecule H_2
   2 mol Na + 2 mol $H_2O \longrightarrow$ 2 mol NaOH + 1 mol H_2
   $(2 \times 23\text{ g}) + (2 \times 18\text{ g}) = (2 \times 40\text{ g}) + 2\text{ g}$
   82 g = 82 g (law of conservation of mass)

   c. $2C_2H_2(g) + 5O_2(g) \longrightarrow 4CO_2(g) + 2H_2O(g)$
   2 molecules C_2H_2 + 5 molecules $O_2 \longrightarrow$ 4 molecules CO_2 + 2 molecules H_2O
   2 mol C_2H_2 + 5 mol $O_2 \longrightarrow$ 4 mol CO_2 + 2 mol H_2O
   $(2 \times 26\text{ g}) + (5 \times 32\text{ g}) = (4 \times 44\text{ g}) + (2 \times 18\text{ g})$
   212 g = 212 g (law of conservation of mass)
   44.8 L + 112 L $\longrightarrow$ 89.6 L + 44.8 L

2. a. $\frac{4\text{ mol Al}}{3\text{ mol }O_2}$ $\frac{3\text{ mol }O_2}{4\text{ mol Al}}$ $\frac{4\text{ mol Al}}{2\text{ mol }Al_2O_3}$ $\frac{2\text{ mol }Al_2O_3}{4\text{ mol Al}}$
   $\frac{3\text{ mol }O_2}{2\text{ mol }Al_2O_3}$ $\frac{2\text{ mol }Al_2O_3}{3\text{ mol }O_2}$

   b. $2.3\text{ mol }Al_2O_3 \times \frac{4\text{ mol Al}}{2\text{ mol }Al_2O_3} = 4.6\text{ mol Al}$

   c. $0.84\text{ mol Al} \times \frac{3\text{ mol }O_2}{4\text{ mol Al}} = 0.63\text{ mol }O_2$

   d. $17.2\text{ mol }O_2 \times \frac{2\text{ mol }Al_2O_3}{3\text{ mol }O_2} = 11.5\text{ mol }Al_2O_3$

3. a. $13.0\text{ g }C_2H_2 \times \frac{1\text{ mol }C_2H_2}{26.0\text{ g }C_2H_2} \times \frac{5\text{ mol }O_2}{2\text{ mol }C_2H_2} \times \frac{32.0\text{ g }O_2}{1\text{ mol }O_2} = 40.0\text{ g }O_2$

   b. $13.0\text{ g }C_2H_2 \times \frac{1\text{ mol }C_2H_2}{26.0\text{ g }C_2H_2} \times \frac{4\text{ mol }CO_2}{2\text{ mol }C_2H_2} \times \frac{44.0\text{ g }CO_2}{1\text{ mol }CO_2} = 44.0\text{ g }CO_2$

   $13.0\text{ g }C_2H_2 \times \frac{1\text{ mol }C_2H_2}{26.0\text{ g }C_2H_2} \times \frac{2\text{ mol }H_2O}{2\text{ mol }C_2H_2} \times \frac{18.0\text{ g }H_2O}{1\text{ mol }H_2O} = 9.0\text{ g }H_2O$

   c. Mass reactants = mass products
   13.0 g + 40.0 g = 44.0 g + 9.0 g
   53.0 g = 53.0 g

4. a. $5.00\text{ g }CaC_2 \times \frac{1\text{ mol }CaC_2}{64.1\text{ g }CaC_2} \times \frac{1\text{ mol }C_2H_2}{1\text{ mol }CaC_2} \times \frac{26.0\text{ g }C_2H_2}{1\text{ mol }C_2H_2} = 2.03\text{ g }C_2H_2$

   b. $98.0\text{ g }H_2O \times \frac{1\text{ mol }H_2O}{18.0\text{ g }H_2O} \times \frac{1\text{ mol }CaC_2}{2\text{ mol }H_2O} = 2.72\text{ mol }CaC_2$

   c. $5.34\text{ mol }C_2H_2 \times \frac{1\text{ mol Ca(OH)}_2}{1\text{ mol }C_2H_2} \times \frac{74.1\text{ g Ca(OH)}_2}{1\text{ mol Ca(OH)}_2} = 396\text{ g Ca(OH)}_2$

5. a. $\text{vol }G\text{ (L)} \times \frac{1\text{ mol }G}{22.4\text{ L }G} \times \frac{b\text{ mol }W}{a\text{ mol }G} \times \frac{\text{gfm }W}{1\text{ mol }W} \longrightarrow \text{mass of }W$

   b. $\text{representative particles }G \times \frac{1\text{ mol }G}{6.02 \times 10^{23}} \times \frac{b\text{ mol }W}{a\text{ mol }G} \longrightarrow \text{mol }W$

   c. $\text{mass of }G \times \frac{1\text{ mol }G}{\text{gfm }G} \times \frac{b\text{ mol }W}{a\text{ mol }G} \times \frac{6.02 \times 10^{23}\text{ particles }W}{1\text{ mol }W} \longrightarrow \text{particles }W$

6. a. $7.42 \times 10^{24}\text{ molecules HF} \times \frac{1\text{ mol HF}}{6.02 \times 10^{23}\text{ molecules HF}} \times \frac{1\text{ mol }SnF_2}{2\text{ mol HF}} \times \frac{156.7\text{ g }SnF_2}{1\text{ mol }SnF_2} = 9.66 \times 10^2\text{ g }SnF_2$

   b. $23.4\text{ g Sn} \times \frac{1\text{ mol Sn}}{118.7\text{ g Sn}} \times \frac{1\text{ mol }H_2}{1\text{ mol Sn}} \times \frac{22.4\text{ L }H_2}{1\text{ mol }H_2} = 4.42\text{ L }H_2$

   c. $14.2\text{ L }H_2 \times \frac{2\text{ L HF}}{1\text{ L }H_2} = 28.4\text{ L HF}$

   d. $80.0\text{ L HF} \times \frac{1\text{ mol HF}}{22.4\text{ L HF}} \times \frac{1\text{ mol }H_2}{2\text{ mol HF}} \times \frac{6.02 \times 10^{23}\text{ molecules }H_2}{1\text{ mol }H_2} = 1.08 \times 10^{24}\text{ molecules }H_2$

Practice
STOICHIOMETRY PROBLEMS - KEY

1. $\overset{0.880\ mol}{2\,NaClO_3} \rightarrow \overset{?\ mol}{2\,NaCl} + 3\,O_2$

$$0.880\ mol\ NaClO_3 \times \frac{3\ mol\ O_2}{2\ mol\ NaClO_3} = 1.32\ mol\ O_2$$

2. $\overset{?\ mol}{4\,Fe} + 3\,O_2 \rightarrow \overset{7.40\ mol}{2\,Fe_2O_3}$

$$7.40\ mol\ Fe_2O_3 \times \frac{3\ mol\ O_2}{2\ mol\ Fe_2O_3} = 11.1\ mol\ O_2$$

3. $\overset{7.60\ mol}{4\,P} + \overset{?\ mol}{5\,O_2} \rightarrow 2\,P_2O_5$

$$7.60\ mol\ O_2 \times \frac{2\ mol\ P_2O_5}{5\ mol\ O_2} = 3.04\ mol\ P_2O_5$$

4. $\overset{0.300\ mol}{2\,C_8H_{18}} + \overset{?\ mol}{25\,O_2} \rightarrow 16\,CO_2 + 18\,H_2O$

$$0.300\ mol\ C_8H_{18} \times \frac{25\ mol\ O_2}{2\ mol\ C_8H_{18}} = 3.75\ mol\ O_2$$

5. $\overset{0.660\ mol}{3\,KOH} + H_3PO_4 \rightarrow \overset{g\ ?}{K_3PO_4} + 3\,H_2O$

$$0.660\ mol\ KOH \times \frac{1\ mol\ K_3PO_4}{3\ mol\ KOH} \times \frac{3(39.10\ g) + 30.97\ g + 4(16.00\ g)}{1\ mol\ K_3PO_4} = 46.7\ g\ K_3PO_4$$

STOICHIOMETRY PROBLEMS - Key - Page 2

6.

$$\overset{5.00\ mol}{N_2} + 3H_2 \rightarrow \overset{?\ g}{2NH_3}$$

$$5.00\ \text{mol}\ H_2 \times \frac{2\ \text{mol}\ NH_3}{3\ \text{mol}\ H_2} \times \frac{14.01\ g + 3(1.01\ g)\ NH_3}{1\ \text{mol}\ NH_3} = 56.8\ g\ NH_3$$

7.

$$\overset{1.32\ mol}{3H_2O} + P_2O_5 \rightarrow \overset{?\ g}{2H_3PO_4}$$

$$1.32\ g\ P_2O_5 \times \frac{1\ \text{mol}\ P_2O_5}{2(30.97\ g) + 5(16.00\ g)\ P_2O_5} \times \frac{2\ \text{mol}\ H_3PO_4}{1\ \text{mol}\ P_2O_5} \times \frac{3(1.01) + 30.97 + 4(16.00\ g)\ H_3PO_4}{1\ \text{mol}\ H_3PO_4}$$

$$= 1.82\ g\ H_3PO_4$$

8.

$$\overset{2.90\ mol}{3Cu} + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + \overset{?\ g}{2NO}$$

$$2.90\ \text{mol}\ HNO_3 \times \frac{2\ \text{mol}\ NO}{8\ \text{mol}\ HNO_3} \times \frac{14.01\ g + 16.00\ g\ NO}{1\ \text{mol}\ NO} = 21.8\ g\ NO$$

9.

$$\overset{63.8\ g}{C_3H_8} + 5O_2 \rightarrow 3CO_2 + \overset{?\ mol}{4H_2O}$$

$$63.8\ g\ C_3H_8 \times \frac{1\ \text{mol}\ C_3H_8}{3(12.01\ g) + 8(1.01\ g)\ C_3H_8} \times \frac{4\ \text{mol}\ H_2O}{1\ \text{mol}\ C_3H_8} = 5.79\ \text{mol}\ H_2O$$

STOICHIOMETRY REVIEW PROBLEMS - Key - Page 3

10. $\overset{47.6\,g}{4NH_3} + \overset{?\,mol}{5O_2} \rightarrow 4NO + 6H_2O$

$$47.6\,g\,NH_3 \times \frac{1\,mol\,NH_3}{14.01\,g + 3(1.01\,g)\,NH_3} \times \frac{5\,mol\,O_2}{4\,mol\,NH_3} = 13.96\,mol\,O_2 \approx 14.0\,mol\,O_2$$

3 sig figs

11. $\overset{3.84\,g}{CH_4} + \overset{?\,g}{2O_2} \rightarrow CO_2 + 2H_2O$

$$3.84\,g\,CH_4 \times \frac{1\,mol\,CH_4}{12.01\,g + 4(1.01\,g)\,CH_4} \times \frac{2\,mol\,O_2}{1\,mol\,CH_4} \times \frac{2(16.00\,g)\,O_2}{1\,mol\,O_2} = 15.3\,g\,O_2$$

12. $\overset{?\,g}{H_3PO_4} + \overset{54.0\,g}{3NaOH} \rightarrow Na_3PO_4 + 3H_2O$

$$54.0\,g\,NaOH \times \frac{1\,mol\,NaOH}{22.99\,g + 16.00\,g + 1.01\,g\,NaOH} \times \frac{1\,mol\,H_3PO_4}{3\,mol\,NaOH} \times \frac{3(1.01\,g) + 30.97\,g + 4(16.00\,g)\,H_3PO_4}{1\,mol\,H_3PO_4}$$

$$= 44.1\,g\,H_3PO_4$$

13. $\overset{154\,g}{S_8} + \overset{?\,g}{8O_2} \rightarrow 8SO_2$

$$154\,g\,S_8 \times \frac{1\,mol\,S_8}{8(32.06\,g)\,S_8} \times \frac{8\,mol\,SO_2}{1\,mol\,S_8} \times \frac{32.06\,g + 2(16.00\,g)\,SO_2}{1\,mol\,SO_2} = 308\,g\,SO_2$$

STOICHIOMETRY PROBLEMS – KEY – Page 4

14. $\overset{0.440\,g}{2\,C_4H_{10}} + 13O_2 \longrightarrow \overset{g?}{8\,CO_2} + 10\,H_2O$

$$0.440\,g\,C_4H_{10} \times \frac{1\,mol\,C_4H_{10}}{4(12.01\,g)+10(1.01\,g)\,C_4H_{10}} \times \frac{8\,mol\,CO_2}{2\,mol\,C_4H_{10}} \times \frac{12.01\,g+2(16.00\,g)\,CO_2}{1\,mol\,CO_2} =$$

$$= 1.33\,g\,CO_2$$

15. $\overset{49.0\,g}{2\,KClO_3} \longrightarrow 2\,KCl + \overset{g?}{3O_2}$

$$49.0\,g\,KClO_3 \times \frac{1\,mol\,KClO_3}{39.10\,g+35.45\,g+3(16.00\,g)\,KClO_3} \times \frac{3\,mol\,O_2}{2\,mol\,KClO_3} \times \frac{2(16.00\,g)\,O_2}{1\,mol\,O_2} =$$

$$= 19.2\,g\,O_2$$

16. $\overset{g?}{2\,KMnO_4} + 16\,HCl \longrightarrow 2\,KCl + 2\,MnCl_2 + 8H_2O + \overset{17.8\,g}{5\,Cl_2}$

$$17.8\,g\,Cl_2 \times \frac{1\,mol\,Cl_2}{2(35.45\,g)\,Cl_2} \times \frac{2\,mol\,KMnO_4}{5\,mol\,Cl_2} \times \frac{39.10\,g+54.94\,g+4(16.00\,g)\,KMnO_4}{1\,mol\,KMnO_4} =$$

$$= 15.9\,g\,KMnO_4$$

Empirical and Molecular Formula Practice.

1. 1.0 g S 1.5 g O

$1.0\,g\,S \times \frac{1\,mol\,S}{32.06\,g\,S} = \frac{0.03119\,mol\,S}{0.03119} = 1\,mol\,S$

$1.5\,g\,O \times \frac{1\,mol\,O}{16.00\,g\,O} = \frac{0.09375\,mol\,O}{0.03119} = 3\,mol\,O$

The empirical formula is SO_3.

2. 75.0% C 25.0% H

Assume 100 g ∴ 75.0 g C, 25.0 g H

$75.0\,g\,C \times \frac{1\,mol\,C}{12.01\,g\,C} = \frac{6.2447\,mol\,C}{6.2447} = 1\,mol\,C$

$25.0\,g\,H \times \frac{1\,mol\,H}{1.01\,g\,H} = \frac{24.752\,mol\,O}{6.2447} = 3.96\,mol\,O = 4\,mol\,C$

The empirical formula is CH_4.

3. 81.8% C, 18.2% H

Assume 100 g ∴ 81.8 g C, 18.2 g H

$81.8\,g\,C \times \frac{1\,mol\,C}{12.01\,g\,C} = \frac{6.81099\,mol\,C}{6.81099} = 1\,mol\,C \times 3 = 3\,mol\,C$

$18.2\,g\,H \times \frac{1\,mol\,H}{1.01\,g\,H} = \frac{18.0198\,mol\,H}{6.81099} = 2.6\,mol\,H \times 3 = 8\,mol\,H$

The empirical formula is C_3H_8.

4. 37.5% C, 12.5% H, 50.0% O

Assume 100 g ∴ 37.5 g C, 12.5 g H, 50.0 g O

$37.5\,\text{g C} \times \frac{1\,\text{mol C}}{12.01\,\text{g C}} = \frac{3.1223\,\text{mol C}}{3.1223} = 1\,\text{mol C}$

$12.5\,\text{g H} \times \frac{1\,\text{mol H}}{1.01\,\text{g H}} = \frac{12.376\,\text{mol H}}{3.1223} = 3.96 = 4\,\text{mol H}$

$50.0\,\text{g O} \times \frac{1\,\text{mol O}}{16.00\,\text{g O}} = \frac{3.125\,\text{mol O}}{3.1223} = 1\,\text{mol O}$

The empirical formula is CH_4O.

5. 26.1% C, 4.3% H, 69.6% O

Assume 100 g ∴ 26.1 g C, 4.3 g H, 69.6 g O

$26.1\,\text{g C} \times \frac{1\,\text{mol C}}{12.01\,\text{g C}} = \frac{2.1731\,\text{mol C}}{2.1731} = 1\,\text{mol C}$

$4.3\,\text{g H} \times \frac{1\,\text{mol H}}{1.01\,\text{g H}} = \frac{4.2574\,\text{mol H}}{2.1731} = 1.96\,\text{mol H} = 2\,\text{mol H}$

$69.6\,\text{g O} \times \frac{1\,\text{mol O}}{16.00\,\text{g O}} = \frac{4.35\,\text{mol O}}{2.1731} = 2\,\text{mol O}$

The empirical formula is CH_2O_2.

6. 38.7% C, 16.1% H, 45.2% N

Assume 100g ∴ 38.7g C, 16.1g H, 45.2g N

$38.7\text{g C} \times \frac{1\text{mol C}}{12.01\text{g C}} = \frac{3.222\text{ mol C}}{3.222} = 1\text{mol C}$

$16.1\text{g H} \times \frac{1\text{mol H}}{1.01\text{g H}} = \frac{15.9406\text{ mol H}}{3.222} = 4.78\text{mol H} \approx 5\text{mol H}$

$45.2\text{g N} \times \frac{1\text{mol N}}{14.01\text{g N}} = \frac{3.226\text{ mol N}}{3.222} = 1\text{mol N}$

The empirical formula is CH_5N.

7. 50.0g = 9.1g Na, 20.6g Cr, 22.2g O

$9.1\text{g Na} \times \frac{1\text{mol Na}}{22.99\text{g Na}} = \frac{0.3958\text{ mol Na}}{0.3958} = 1\text{mol Na} \times 2 = 2\text{mol Na}$

$20.6\text{g Cr} \times \frac{1\text{mol Cr}}{52.00\text{g Cr}} = \frac{0.3961\text{ mol Cr}}{0.3958} = 1\text{mol Cr} \times 2 = 2\text{mol Cr}$

$22.2\text{g O} \times \frac{1\text{mol O}}{16.00\text{g O}} = \frac{1.3875\text{ mol O}}{0.3958} = 3.5\text{mol O} \times 2 = 7\text{mol O}$

The empirical formula is $Na_2Cr_2O_7$.

8. C_3H_7 molar mass 86g

efm = 3(12.01g) + 7(1.01g) = 43.10 g

$$efu = \frac{MM}{efm} = \frac{86g}{43.10g} = 1.995 = 2.$$

The molecular formula is C_6H_{14}.

9. S molar mass 256g

efm = 32.06g

$$efu = \frac{MM}{efm} = \frac{256g}{32.06g} = 7.98 = 8$$

The molecular formula is S_8.

10. CH molarmass 26g

efm_{CH} = 12.01g + 1.01g = 13.02g

$$efu = \frac{MM}{efm} = \frac{26g}{13.02g} = 2$$

The molecular formula is C_2H_2

11. NO_2 molecular mass 46g.

efm = 14.01g + 2(16.00g) = 46.01g

$$efu = \frac{MM}{efm} = \frac{46g}{46.01g} = 1$$

The molecular formula is NO_2.

% Actual & Theoretical Yield

1. a) mass LiOH → mol LiOH → mol LiCl → mass LiCl

$$20\,g\,LiOH \times \frac{1\,mol\,LiOH}{6.94g+16.00g+1.01g\,LiOH} \times \frac{1\,mol\,LiCl}{1\,mol\,LiOH} \times \frac{6.94g+35.45g\,LiOH}{1\,mol\,LiOH}$$

$$= 35.398\,g\,LiOH = 40\,g\,LiOH$$

b) $$\%\,yield = \frac{actual\,yield}{Theoretical\,yield} \times 100 = \frac{6g}{35.398g} \times 100 = 16.95\% = 20\%$$

2. a) $$5g\,C_3H_8 \times \frac{1\,mol\,C_3H_8}{3(12.01g)+8(1.01g)\,C_3H_8} \times \frac{4\,mol\,H_2O}{1\,mol\,C_3H_8} = \frac{2(1.01g)+16.00g\,H_2O}{1\,mol\,H_2O}$$

$$= 8.170\,g\,H_2O = 8\,g\,H_2O$$

b) % yield = 75 % ? actual yield

$$\%\,yield = \frac{actual\,yield}{theoretical\,yield} \times 100$$

$$actual\,yield = \frac{\%\,yield\,(Theoretical\,yield)}{100}$$

$$= \frac{75\,(8g)}{100}$$

$$= 6\,g\,H_2O$$

3. T.Y = 10.7 g AY = 4.5 g

$$\%\,yield = \frac{actual\,yield}{Theoretical\,yield} \times 100 = \frac{4.5g}{10.7g} \times 100 = 42.05\% = 42\%$$

4. 20 g CaO TY = ?

$$20\,g\,CaO \times \frac{1\,mol\,CaO}{40.08g + 16.00g\,CaO} \times \frac{1\,mol\,Na_2O}{1\,mol\,CaO} \times \frac{2(22.99g) + 16.00g\,Na_2O}{1\,mol\,Na_2O}$$

(56.08 ~~61.98~~)

$$= 1.105\,g\,Na_2O = 1\,g\,Na_2O$$

5. a) TY = ?

$$34\,g\,FeBr_2 \times \frac{1\,mol\,FeBr_2}{55.85g + 2(79.90g)\,FeBr_2} \times \frac{1\,mol\,FeCl_2}{1\,mol\,FeBr_2} \times \frac{55.85g + 2(35.45g)\,FeCl_2}{1\,mol\,FeCl_2}$$

$$= 19.668\,g\,FeCl_2 = 20.\,FeCl_2$$

b) % yield = $\frac{\text{actual yield}}{\text{Theoretical yield}} \times 100 = \frac{4g}{20.g} \times 100 = 20.337\% = 20\%$

6. 20 g TiS A.Y = 2.2 g

$$20\,g\,TiS \times \frac{1\,mol\,TiS}{47.90g + 32.06g\,TiS} \times \frac{1\,mol\,TiO}{1\,mol\,TiS} \times \frac{47.90g + 16.00g\,TiO}{1\,mol\,TiO}$$

$$= 15.9829\,g\,TiO = 20\,g\,TiO$$

% yield = $\frac{\text{actual yield}}{\text{Theoretical yield}} \times 100 = \frac{2.2g}{15.982g} \times 100 = 13.76\% = 10\%$

7. AY = ? 100g U → % Y = 83%

$$\%\text{ yield} = \frac{\text{actual yield}}{\text{Theoretical yield}} \times 100$$

$$\text{actual yield} = \frac{\%\text{ yield} \cdot \text{Theoretical yield}}{100}$$

$$= \frac{83\%\,(300\text{g})}{100}$$

$$= 249\text{ g } UBr_6 = 200\text{ g } UBr_6$$

$$100\text{g U} \times \frac{1\text{mol U}}{238.03\text{g U}} \times \frac{1\text{mol } UBr_6}{1\text{mol U}} \times \frac{238.03\text{g} + 6(79.90\text{g}) \text{ } UBr_6}{1\text{mol } UBr_6}$$

$$= 301.40\text{ g } UBr_6 = 300\text{ g } UBr_6$$

8. 89 g H_2SO_4 7.1 g H_2O % Y = ?

$$89\text{g } H_2SO_4 \times \frac{1\text{mol } H_2SO_4}{2(1.01\text{g}) + 32.07\text{g} + 4(16.00\text{g}) \text{ } H_2SO_4} \times \frac{1\text{mol } H_2O}{1\text{mol } H_2SO_4} \times \frac{2(1.01\text{g}) + 16.00\text{g } H_2O}{1\text{mol } H_2O}$$

$$= 14.3517\text{ g } H_2O = 16\text{ g } H_2O$$

$$\%\text{ yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100 = \frac{7.1\text{g}}{16.\text{g}} \times 100 = 44\%$$

Student Name: Key Date: _____

Chemistry 30S

Stoichiometry

Limiting Reagent Problems

Answer each of the following questions in your notebook. Show all work.

1. For the following balanced chemical reaction, if 9.35 grams of NH_3 are reacted with 22.23 grams of O_2, what is the limiting reagent?

$$4\,NH_3 + 5\,O_2 \rightarrow 4\,NO + 6\,H_2O$$

2. For the following balanced chemical reaction, if 13.2 grams of KO_2 are reacted with 2.89 grams of CO_2, what is the excess reagent?

$$4\,KO_2 + 2\,CO_2 \rightarrow 2\,K_2CO_3 + 3\,O_2$$

3. For the following balanced chemical reaction, if 66.6 grams of Na_2SO_4 are reacted with 12.6 grams of C, what is the limiting reagent?

$$Na_2SO_4 + 2\,C \rightarrow Na_2S + 2\,CO_2$$

4. For the following balanced chemical reaction, if 27.23 grams of Fe_3O_4 are reacted with 1.2 grams of H_2, what is the limiting reagent?

$$Fe_3O_4 + 4\,H_2 \rightarrow 3\,Fe + 4\,H_2O$$

5. For the following balanced chemical reaction, if 73.83 grams of C_6H_6 are reacted with 173.65 grams of O_2 , what is the limiting reagent? What mass of excess reagent remains?

$$2\,C_6H_6 + 15\,O_2 \rightarrow 12\,CO_2 + 6\,H_2O$$ 173.1 g C_6H_6

6. For the following balanced chemical reaction, if 23.8 grams of F_2 are reacted with 15.41 grams of H_2O, what is the limiting reagent?

$$2\,F_2 + 2\,H_2O \rightarrow 4\,HF + O_2$$

7. For the following balanced chemical reaction, if 71.11 grams of C_3H_6 are reacted with 218.17 grams of O_2, what is the excess reagent?

$$C_3H_6 + 3\,O_2 \rightarrow 3\,CO + 3\,H_2O$$

8. For the following balanced chemical reaction, if 72.78 grams of Al are reacted with 366.07 grams of MnO, what is the limiting reagent?

$$2\,Al + 3\,MnO \rightarrow Al_2O_3 + 3\,Mn$$

9. For the following balanced chemical reaction, if 73.96 grams of C_7H_{16} are reacted with 346.83 grams of O_2, how many grams of excess reagent are left over?

$$C_7H_{16} + 11\ O_2 \rightarrow 7\ CO_2 + 8\ H_2O$$ 87.09 g excess O_2.

10. For the following balanced chemical reaction, if 49.2 grams of C_2H_5OH are reacted with 78.21 grams of O_2, what is the limiting reagent?

$$2\ C_2H_5OH + 6(O_2) \rightarrow 4\ CO_2 + 6\ H_2O$$

11. For the following balanced chemical reaction, if 90.69 grams of $C_6H_{12}O_2$ are reacted with 187.75 grams of O_2, what is the excess reagent?

$$(C_6H_{12}O_2) + 8\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$$

12. For the following balanced chemical reaction, if 52.85 grams of C_3H_8 are reacted with 267.71 grams of O_2 , what is the limiting reagent?

$$(C_3H_8) + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$$

13. For the following balanced chemical reaction, if 27.02 grams of CO are reacted with 247.52 grams of Fe_3O_4 , what is the limiting reagent?

$$(CO) + Fe_3O_4 \rightarrow 3\ FeO + CO_2$$

14. For the following balanced chemical reaction, if 13.05 grams of CaO are reacted with 17.12 grams of HCl , what is the mass of the excess reagent?

$$CaO + 2\ HCl \rightarrow CaCl_2 + H_2O$$

15. For the following balanced chemical reaction, if 55.95 grams of N_2H_4 are reacted with 105.82 grams of H_2O_2, what is the limiting reagent?

$$N_2H_4 + 2(H_2O_2) \rightarrow N_2 + 4\ H_2O$$

16. For the following balanced chemical reaction, if 39.97 grams of Fe_2O_3 are reacted with 3.5 grams of C, what is the excess reagent?

$$2(Fe_2O_3) + 3\ C \rightarrow 4\ Fe + 3\ CO_2$$

17. For the following balanced chemical reaction, if 10.92 grams of KO_2 are reacted with 2.84 grams of CO_2, what is the limiting reagent?

$$4\ KO_2 + 2(CO_2) \rightarrow 2\ K_2CO_3 + 3\ O_2$$

18. For the following balanced chemical reaction, if 43.92 grams of Na_2SO_4 are reacted with 5.92 grams of C, what is the limiting reagent?

$$Na_2SO_4 + 2(C) \rightarrow Na_2 + 2\ CO_2$$

Chemical Equations Involving Gases Measured At STP.

1. $0.360 \text{ mol } H_2 \times \frac{1 \text{ mol } O_2}{2 \text{ mol } H_2} \times \frac{22.4 \text{ L } O_2}{1 \text{ mol } O_2} = 4.03 \text{ L of } O_2$

2. $0.720 \text{ mol } H_2 \times \frac{2 \text{ mol } NH_3}{3 \text{ mol } H_2} \times \frac{22.4 \text{ L } NH_3}{1 \text{ mol } NH_3} = 10.8 \text{ L of } NH_3$

3. $C_2H_5OH = 2(12.01) + 6(1.01) + 16.00 = 46.08 \text{ g } C_2H_5OH$

$25.0 \text{ g } C_2H_5OH \times \frac{1 \text{ mol } C_2H_5OH}{46.08 \text{ g } C_2H_5OH} \times \frac{3 \text{ mol } O_2}{1 \text{ mol } C_2H_5OH} \times \frac{22.4 \text{ L } O_2}{1 \text{ mol } O_2} = 36.5 \text{ L}$

$H_2O = 2(1.01) + 16.00 = 18.02 \text{ g } H_2O$

$5.00 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} \times \frac{1 \text{ mol } O_2}{2 \text{ mol } H_2O} \times \frac{22.4 \text{ L } O_2}{1 \text{ mol } O_2} = 3.11 \text{ L } O_2$

5. $NaOH = 22.99 + 16.00 + 1.01 = 40.00 \text{ g } NaOH$

$12.0 \text{ g } NaOH \times \frac{1 \text{ mol } NaOH}{40.00 \text{ g } NaOH} \times \frac{1 \text{ mol } CO_2}{2 \text{ mol } NaOH} \times \frac{22.4 \text{ L } CO_2}{1 \text{ mol } CO_2} = 3.36 \text{ L of } CO_2$

$Al = 26.98\ g\ Al$

6. $O_2 = 2(16.00) = 32.00\ g\ O_2$

$$5.00\ L\ O_2 \times \frac{1\ mol\ O_2}{22.4\ L\ O_2} \times \frac{4\ mol\ Al}{3\ mol\ O_2} \times \frac{26.98\ g\ Al}{1\ mol\ Al} = 8.03\ g\ Al$$

7. $CaCO_3 = 40.08 + 12.01 + 3(16.00) = 100.09\ g\ CaCO_3$

$$9.97\ L\ CO_2 \times \frac{1\ mol\ CO_2}{22.4\ L\ CO_2} \times \frac{1\ mol\ CaCO_3}{1\ mol\ CO_2} \times \frac{100.09\ g\ CaCO_3}{1\ mol\ CaCO_3} = 44.5\ g\ CaCO_3$$

8. $ZnS = 65.38 + 32.06 = 97.44\ g\ ZnS$

$$112\ L\ O_2 \times \frac{1\ mol\ O_2}{22.4\ L\ O_2} \times \frac{2\ mol\ ZnS}{3\ mol\ O_2} \times \frac{97.44\ g\ ZnS}{1\ mol\ ZnS} = 325\ g\ ZnS$$

9.

$$4.93\ L\ H_2 \times \frac{1\ mol\ H_2}{22.4\ L\ H_2} \times \frac{2\ mol\ NH_3}{3\ mol\ H_2} \times \frac{6.02 \times 10^{23}\ molecules\ NH_3}{1\ mol\ NH_3} = 8.83 \times 10^{22}\ molecules\ NH_3$$

10. $C_4H_{10} = 4(12.01) + 10(1.01) = 58.14\ g\ C_4H_{10}$

$$33.65\ g\ C_4H_{10} \times \frac{1\ mol\ C_4H_{10}}{58.14\ g\ C_4H_{10}} \times \frac{8\ mol\ CO_2}{2\ mol\ C_4H_{10}} \times \frac{22.4\ L\ CO_2}{1\ mol\ CO_2} = 51.9\ L\ CO_2$$

Key

Student Name: _____ Date: _____

Chemistry 30S

Chemical Reactions

Stoichiometry ~~Review~~ Problems

Answer each of the following questions in your notebook. Show all work.

1. Silver sulfide (Ag_2S) is the common tarnish on silver objects. What weight of silver sulfide can be made from 1.23 mg of hydrogen sulfide (H_2S) obtained from a rotten egg? The reaction of formation of silver sulfide is given below:

3.61×10^{-5} mol 0.00894 g 0.008945 g

$2Ag(s) + H_2S(g) + O_2(g) \rightarrow Ag_2S(s) + H_2O(l)$ (Balance first)

2. A somewhat antiquated method for preparing chlorine gas involves heating hydrochloric acid with pyrolusite (manganese dioxide), a common manganese ore. (Reaction given below.) How many kg of HCl react with 5.69 kg of manganese dioxide?

9.538 kg 9.54 kg

$HCl(aq) + MnO_2(s) \rightarrow H_2O(l) + MnCl_2(aq) + Cl_2(g)$ (Balance first)

3. Given the following equation:

$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$

Show what the following molar ratios should be:

a. C_4H_{10} / O_2 2/13 b. O_2 / CO_2 13/8 c. O_2 / H_2O 13/10 C_4H_{10} / CO_2 2/8 e. C_4H_{10} / H_2O 2/10

4. Given the following equation: $2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$

How many moles of O_2 can be produced by letting 12.00 moles of $KClO_3$ react? 18.00 mol

5. Given the following equation: $2\ K + Cl_2 \rightarrow 2\ KCl$

How many grams of KCl is produced from 2.50 g of K and excess Cl_2. From 1.00 g of Cl_2 and excess K? 4.77 g KCl 2.10 g KCl

6. Given the following equation: $Na_2O + H_2O \rightarrow 2\ NaOH$

How many grams of NaOH is produced from 1.20×10^2 grams of Na_2O? How many grams of Na_2O are required to produce 1.60×10^2 grams of NaOH?

155 g NaOH 124 g Na_2O

7. Given the following equation:

$$8\ Fe + S8 \longrightarrow 8\ FeS$$

What mass of iron is needed to react with 16.0 grams of sulfur? How many grams of FeS are produced? 27.9g Fe 43.9g FeS

8. Given the following equation:

$$2\ NaClO_3 \longrightarrow 2\ NaCl + 3\ O_2$$

12.00 moles of $NaClO_3$ will produce how many grams of O_2? How many grams of NaCl are produced when 80.0 grams of O_2 are produced? 576.0g O_2 97.4g NaCl

9. Given the following equation:

$$Cu + 2\ AgNO_3 \longrightarrow Cu(NO_3)_2 + 2\ Ag$$

How many moles of Cu are needed to react with 3.50 moles of $AgNO_3$? If 89.5 grams of Ag were produced, how many grams of Cu reacted? 1.175 mol | 26.4g

10. Molten iron and carbon monoxide are produced in a blast furnace by the reaction of iron(III) oxide and coke (pure carbon). If 25.0 kilograms of pure Fe_2O3 is used, how many kilograms of iron can be produced? The reaction is:

$$Fe_2O_3 + 3\ C \longrightarrow 2\ Fe + 3\ CO$$

17.5kg

11. The average human requires 120.0 grams of glucose ($C_6H_{12}O_6$) per day. How many grams of CO_2 (in the photosynthesis reaction) are required for this amount of glucose? The photosynthetic reaction is:

$$6\ CO_2 + 6\ H_2O \longrightarrow C_6H_{12}O_6 + 6\ O_2$$

175.9g

12. Given the reaction:

$$4\ NH_3\ (g) + 5\ O_2\ (g) \longrightarrow 4\ NO\ (g) + 6\ H_2O\ (l)$$

When 1.20 mole of ammonia reacts, find the number of moles of H_2O formed. 1.80 mol H_2O