Additional Stoichiometry Review Problems

Name Key Period ___

Interpreting a Chemical Equation

1. Consider the general chemical equation:
$A + 3B \rightarrow 2C$
a. If 10.0g of A reacts with exactly 15.0g of B, what is the mass of C produced?

Conservation of mass
mass of C produced = $15.0_g + 10.0_g = \boxed{25.0_g C}$

b. If 50.0g of A reacts to produce 75.0g of C, what is the mass of B used?

Consv. of mass again
$50.0_g + x = 75.0_g \quad x = \boxed{25.0_g B}$

2. Verify the conservation of mass law using the molar masses of reactants and products for each substance in the following balanced equations.
a. $2KNO_{3(s)} \rightarrow 2KNO_{2(s)} + O_{2(g)}$
$2(101.10) \rightarrow 2(85.10) + 1(32.00)$
$\boxed{202.20_g = 170.20_g + 32.00_g}$
b. $2Al_{(s)} + 3Br_{2(s)} \rightarrow 2AlBr_{3(s)}$
$2(26.98) + 3(159.81) \rightarrow 2(266.69)$
$\boxed{53.96 + 479.43 = 533.39}$

Mole – Mole Relationships

3. Given the balanced equation, calculate the moles of oxygen gas that react with 0.500mol of hydrogen gas. How many moles of water are produced?
$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$
$0.500\,mol\,H_2 \left(\frac{1\,mol\,O_2}{2\,mol\,H_2}\right) = \boxed{0.250\,mol\,O_2}$
$0.500\,mol\,H_2 \left(\frac{2\,mol\,H_2O}{2\,mol\,H_2}\right) = \boxed{0.500\,mol\,H_2O}$

4. How many moles of chlorine gas react with 0.333mol of metallic iron? How many moles of iron(III)chloride are produced?
$2Fe_{(s)} + 3Cl_{2(g)} \rightarrow 2FeCl_{3(s)}$
$0.333\,mol\,Fe \left(\frac{3\,mol\,Cl_2}{2\,mol\,Fe}\right) = .4995 = \boxed{.500\,mol\,Cl_2}$
$0.333\,mol\,Fe \left(\frac{2\,mol\,FeCl_3}{2\,mol\,Fe}\right) = \boxed{.333\,mol\,FeCl_3}$

5. How many moles of propane gas, C3H8, react with 1.75mol of oxygen gas? How many moles of carbon dioxide are produced?
$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$
1.75 mol
$1.75\,mol\,O_2 \left(\frac{1\,mol\,C_3H_8}{5\,mol\,O_2}\right) = \boxed{0.35\,mol\,C_3H_8}$
$1.75\,mol\,O_2 \left(\frac{3\,mol\,CO_2}{5\,mol\,O_2}\right) = \boxed{1.05\,mol\,CO_2}$

Mass – Mass Problems

6. Given the balanced equation, calculate the mass of product that can be prepared from 2.36g of zinc metal.
$2Zn_{(s)} + O_{2(g)} \rightarrow 2ZnO_{(s)}$
① g → mol $2.36_g \left(\frac{1\,mol\,Zn}{65.39_g}\right) = .0361\,mol\,Zn$
② mole ratios $.0361\,mol\,Zn \left(\frac{2\,mol\,ZnO}{2\,mol\,Zn}\right) = .0361\,mol\,ZnO$
③ mol → g $.0361\,mol\,ZnO \left(\frac{81.39_g}{1\,mol\,ZnO}\right) = 2.9381_g = \boxed{2.94_g ZnO}$

7. Given the balanced equation, calculate the mass of product that can be prepared from 3.45g of bismuth metal.
$2Bi_{(s)} + 3Cl_{2(g)} \rightarrow 2BiCl_{3(s)}$
① $3.45_g Bi \left(\frac{1\,mol\,Bi}{208.98_g}\right) = .0165\,mol\,Bi$
② $.0165\,mol\,Bi \left(\frac{2\,mol\,BiCl_3}{2\,mol\,Bi}\right) = .0165\,mol\,BiCl_3$
③ $.0165\,mol\,BiCl_3 \left(\frac{315.34_g}{1\,mol\,BiCl_3}\right) = \boxed{5.20_g BiCl_3}$

8. What is the mass of silver that can be prepared from 0.615g of copper metal?
$Cu_{(s)} + 2AgNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + 2Ag_{(s)}$
① $0.615_g Cu \left(\frac{1\,mol\,Cu}{63.55_g}\right) = .00968\,mol\,Cu$
② $.00968\,mol\,Cu \left(\frac{2\,mol\,Ag}{1\,mol\,Cu}\right) = .0194\,mol\,Ag$
③ $.0194\,mol\,Ag \left(\frac{107.9_g}{1\,mol\,Ag}\right) = \boxed{2.09_g Ag}$

9. What is the mass of mercury that can be prepared from 1.25g of cobalt metal?

$2Co_{(s)} + 3HgCl_{2(aq)} \rightarrow 2CoCl_{3(aq)} + 3Hg_{(l)}$

$1.25\,g\,Co\left(\frac{1\,mol\,Co}{58.93\,g}\right)\left(\frac{3\,mol\,Hg}{2\,mol\,Co}\right)\left(\frac{200.6\,g\,Hg}{1\,mol\,Hg}\right)$

$= \boxed{6.38\,g\,Hg}$

10. What is the mass of calcium phosphate that can be prepared from 1.78g of Na_3PO_4?

$2\,Na_3PO_{4(aq)} + 3Ca(OH)_{2(aq)} \rightarrow Ca_3(PO_4)_{2(s)} + 6\,NaOH_{(aq)}$

$1.78\,g\,Na_3PO_4\left(\frac{1\,mol\,Na_3PO_4}{163.94\,g}\right)\left(\frac{1\,mol\,Ca_3(PO_4)_2}{2\,mol\,Na_3PO_4}\right)$

$\left(\frac{310.18\,g\,Ca_3(PO_4)_2}{1\,mol}\right) = \boxed{1.68\,g\,Ca_3(PO_4)_2}$

The Limiting Reactant Concept

11. If 1.00mol of nitrogen gas and 1.50mol of oxygen gas react, what is the limiting reactant and how many moles of NO are produced from the reaction?

$N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)}$

1.00 1.50

Since they are in a 1:1 ratio N_2 limits

$1.00\,mol\,N_2\left(\frac{2\,mol\,NO}{1\,mol\,N_2}\right) = \boxed{2.00\,mol\,NO}$

12. If 1.00mol of nitrogen monoxide gas and 1.00mol of oxygen gas react, what is the limiting reactant and how many moles of NO_2 are produced from the reaction?

$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$

1.00mol 1.00mol

Since NO reacts with O_2 in a 2:1 ratio, NO limits

$1.00\,mol\,NO\left(\frac{2\,mol\,NO_2}{2\,mol\,NO}\right) = \boxed{1.00\,mol\,NO_2}$

13. If 5.00mol of hydrogen gas and 5.00mol of oxygen gas react, what is the limiting reactant and how many moles of water are produced from the reaction?

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$

5.00mol 5.00mol

Since H_2 reacts with O_2 in a 2:1 ratio H_2 limits.

$5.00\,mol\,H_2\left(\frac{2\,mol\,H_2O}{2\,mol\,H_2}\right) = \boxed{5.00\,mol\,H_2O}$

14. If 1.00mol of ethane gas and 5.00mol of oxygen gas react, what is the limiting reactant and how many moles of water are produced from the reaction?

$2C_2H_{6(g)} + 7O_{2(g)} \rightarrow 4CO_{2(g)} + 6H_2O_{(g)}$

1.00mol 5.00mol

Since oxygen reacts with ethane in a 7:2 ratio you only need $1.00\left(\frac{7}{2}\right) = 3.50\,mol$ of O_2 to use up all of the ethane therefore ethane limits. The reaction produces

$1.00\,mol\,C_2H_6\left(\frac{6\,mol\,H_2O}{2\,mol\,C_2H_6}\right) = \boxed{3.00\,mol\,H_2O}$

15. Cobalt metal can react with sulfur to give cobalt(II)sulfide. Complete the following table by stating the moles of Co, S and CoS after the reaction is complete. The balanced equation for the chemical reaction is

$Co_{(s)} + S_{(s)} \rightarrow CoS_{(s)}$

Experiment	mol Co	mol S	mol CoS
1. Before reaction	1.50	2.00	0.00
2. After reaction	0.00	0.50	1.50
1. Before reaction	3.00	2.00	0.00
2. After reaction	1.00	0.00	2.00

Limiting Reactant Problems

16. If 40.0g of molten iron(II)oxide reacts with 10.0g of magnesium according to the following equation, what is the mass of iron produced?

$FeO_{(l)} + Mg_{(l)} \rightarrow Fe_{(l)} + MgO_{(s)}$

40.0g 10.0g

$mol\,FeO = \frac{40.0\,g}{71.84\,g/mol} = .557\,mol\,FeO$

$mol\,Mg = \frac{10.0\,g}{24.31\,g/mol} = .411\,mol\,Mg$

Since FeO & Mg react in a 1:1 ratio Mg limits (Fewer moles)

$.411\,mol\,Mg\left(\frac{1\,mol\,Fe}{1\,mol\,Mg}\right)\left(\frac{55.85\,g\,Fe}{1\,mol\,Fe}\right) = 22.954$

$\boxed{23.0\,g\,Fe}$

17. If 175g of molten iron(III)oxide reacts with 37.5g of aluminum according to the following equation, what is the mass of iron produced?

$Fe_2O_{3(l)} + 2Al_{(l)} \rightarrow 2Fe_{(l)} + Al_2O_{3(s)}$

175g 37.5g

$175\,g\,Fe_2O_3 \left(\frac{1\,mol}{159.69\,g}\right) = 1.10\,mol$ needs to be 1:2 ratio Al limits

$37.5\,g\,Al \left(\frac{1\,mol\,Al}{26.98\,g}\right) = 1.39\,mol$

$1.39\,mol\,Al \left(\frac{2\,mol\,Fe}{2\,mol\,Al}\right)\left(\frac{55.85\,g\,Fe}{1\,mol}\right) = \boxed{77.6\,g\,Fe}$

18. If 1.00g of magnesium hydroxide reacts with 0.605g of sulfuric acid according to the following equation, what is the mass of magnesium sulfate produced?

$Mg(OH)_{2(s)} + H_2SO_{4(l)} \rightarrow MgSO_{4(aq)} + 2H_2O_{(l)}$

$1.00\,g\,Mg(OH)_2 \left(\frac{1\,mol\,Mg(OH)_2}{58.326\,g}\right) = .0171\,mol\,Mg(OH)_2$

$0.605\,g\,H_2SO_4 \left(\frac{1\,mol\,H_2SO_4}{98.086\,g}\right) = .00617\,mol\,H_2SO_4$

$.00617\,mol\,H_2SO_4 \left(\frac{1\,mol\,MgSO_4}{1\,mol\,H_2SO_4}\right) = .00617\,mol\,MgSO_4 \left(\frac{120.38\,g}{1\,mol\,MgSO_4}\right) = \boxed{.743\,g\,MgSO_4}$

19. If 1.00g of aluminum hydroxide reacts with 3.00g of sulfuric acid according to the following equation, what is the mass of water produced?

$2Al(OH)_{3(s)} + 3H_2SO_{4(l)} \rightarrow Al_2(SO_4)_{3(aq)} + 6H_2O_{(l)}$

$1.00\,g\,Al(OH)_3 \left(\frac{1\,mol\,Al(OH)_3}{78.004\,g}\right) = .0128\,mol\,Al(OH)_3$

$3.00\,g\,H_2SO_4 \left(\frac{1\,mol\,H_2SO_4}{98.086\,g}\right) = .0306\,mol\,H_2SO_4$

Since $Al(OH)_3$ & H_2SO_4 combine in a 2:3 ratio $Al(OH)_3$ limits

$.0128\,mol\,Al(OH)_3 \left(\frac{6\,mol\,H_2O}{2\,mol\,Al(OH)_3}\right)\left(\frac{18.016\,g\,H_2O}{1\,mol\,H_2O}\right) = .69288\ldots = \boxed{.693\,g\,H_2O}$

Percent Yield

20. A chemistry student prepares acetone by decomposing 31.6g of calcium acetate. If the student collected 10.4g of acetone and the theoretical yield is 11.6g, what is the percent yield?

$\%\,yield = \left(\frac{10.4\,g}{11.6\,g}\right) 100\%$

$= \boxed{89.7\%}$

21. A 1.50g sample of sodium nitrate is decomposed by heating. if the resulting sodium nitrite has a mass of 1.22g and the calculated yield is 1.29g, what is the percent yield?

$\%\,yield = \left(\frac{1.22\,g}{1.29\,g}\right) \times 100\%$

$= \boxed{94.6\%}$

General Exercises

22. What units are associated with molar mass?

grams per mole (g/mol)

23. The "volcano reaction" produces chromium(III)oxide, water, and nitrogen gas from the decomposition of ammonium dichromate. Calculate the mass of green chromium(III)oxide produced by the decomposition of 1.54g of orange ammonium dichromate.

$(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + 4H_2O + N_2$

$1.54\,g\,(NH_4)_2Cr_2O_7 \left(\frac{1\,mol}{252.084\,g}\right) = .006109\,mol$

$.006109\,mol \left(\frac{1\,mol\,Cr_2O_3}{1\,mol\,(NH_4)_2Cr_2O_7}\right)\left(\frac{152.0\,g}{mol}\right) = \boxed{0.929\,g\,Cr_2O_3}$

24. Manganese metal and aluminum oxide are produced by the reaction of manganese(IV)oxide and aluminum metal. Calculate the mass of aluminum necessary to yield 1.00kg of manganese metal.

$3MnO_2 + 4Al \rightarrow 3Mn + 2Al_2O_3$

$1.00\times10^3\,g\,Mn \left(\frac{1\,mol\,Mn}{54.94\,g}\right)\left(\frac{4\,mol\,Al}{3\,mol\,Mn}\right)\left(\frac{26.98\,g\,Al}{1\,mol\,Al}\right)$

$= 654.77 = \boxed{655\,g\,Al}$

25. A chemical reaction stops when one of the reactants is consumed. For example, the combustion reaction in an automobile stops when the gasoline "runs out." In this case, what is the limiting reactant? What is the excess reactant?

The gasoline is the limiting reactant.

Oxygen is the excess reactant.