Chapter 9
Balancing Equations & Reaction Types

Chapter 11
Stoichiometry

(Key)

Any reaction can be written as an equation

Reactants ⟶ Products
("⟶" = "becomes")

(5) Reaction types

1. Synthesis $A + B \rightarrow AB$ (marriage)
2. Decomposition $AB \rightarrow A + B$ (splitting up)
3. Single Replacement $A + BC \rightarrow AC + B$
4. Double Replacement $AB + CD \rightarrow AD + BC$
5. Combustion - any reaction w/ O_2 as a reactant.

Balancing Equations

- the total # of atoms on either side of a reaction must be the same. Use coefficients to balance.

Ex. $H_2 + O_2 \rightarrow H_2O$

(1) There are 2 H's on either side
(2) There are 2 oxygens on the left but only 1 on the right, so we put a "2" in front of H_2O

$H_2 + O_2 \rightarrow 2H_2O$

(3) Now, we need to balance H's by putting a "2" in front of H_2 on the left.

$$2H_2 + O_2 \rightarrow 2H_2O$$

Stoichiometry - A chemist's way of following a recipe. Everything must be compared in moles.

(1) Convert given information into moles.
(2) Use mole ratio from balanced equation to convert moles of given information into moles of needed information.
(3) Convert moles of needed information into what the question is asking for (grams, liters, molecules...)

Limiting Reactant - it is the reactant that will produce the least amount of product. It is "limiting" because it is holding up the reaction.

Excess Reactant - the extra reactant that is not used up in a reaction because there isn't enough limiting reactant to react with.

Actual Yield - the amount of product formed in an experiment

Theoretical Yield - the amount "calculated" from stoichiometry.

$$\%\text{Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100$$

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7 ATOMS AND MOLECULES

7-3 Chemical Equations

The Juggling Act

For each reaction below, underline the reactant(s) and circle the product(s). Then check the equation to see if it is balanced. If the equation is balanced, write *OK* on the numbered space to the left of the equation. If the equation is not balanced, write the symbol of the element that is not balanced.

O 1. $CO + O_2 \longrightarrow CO_2$

OK 2. $H_2O + SO_3 \longrightarrow H_2SO_4$

F 3. $K + F_2 \longrightarrow KF$

O 4. $C_2H_2 + O_2 \longrightarrow 2\ CO_2 + H_2O$

Fe 5. $Fe_2O_3 + 3H_2 \longrightarrow Fe + 3\ H_2O$

OK 6. $6\ Li + N_2 \longrightarrow 2\ Li_3N$

H 7. $CH_4 + 2\ Br_2 \longrightarrow CHBr_3 + HBr$

O 8. $4\ NaOH + 2\ F_2 \longrightarrow 2\ O_2 + 4\ NaF + 2\ H_2O$

Cl 9. $Al + 2\ HCl \longrightarrow AlCl_3 + H_2$

OK 10. $K_2O + CaCl_2 \longrightarrow CaO + 2\ KCl$

Find the Coefficient

In the following equations the missing coefficient for each formula is indicated with the letter *a*, *b*, *c* or *d*. Balance the equations by finding the correct coefficient for each formula. Then write the coefficient on the space next to the appropriate letter.

a 2 *b* 1 *c* 2 — 1. $aNa + bCl_2 \longrightarrow cNaCl$

a 2 *b* 3 *c* 2 — 2. $aFe + bI_2 \longrightarrow cFeI_3$

a 1 *b* 1 *c* 1 — 3. $aH_2CO_3 \longrightarrow bH_2O + cCO_2$

a 2 *b* 1 *c* 2 *d* 1 — 4. $aLi + bBaF_2 \longrightarrow cLiF + dBa$

a 1 *b* 2 *c* 2 — 5. $aO_2 + bCl_2 \longrightarrow cCl_2O$

a 2 *b* 1 *c* 1 — 6. $aK + bO_2 \longrightarrow cK_2O_2$

a 4 *b* 1 *c* 2 — 7. $aNa + bO_2 \longrightarrow cNa_2O$

a 1 *b* 1 *c* 1 *d* 2 — 8. $aHgCl_2 + bH_2S \longrightarrow cHgS + dHCl$

a 2 *b* 2 *c* 1 — 9. $aBaO_2 \longrightarrow bBaO + cO_2$

a 2 *b* 5 *c* 1 *d* 4 — 10. $aSO_2 + bC \longrightarrow cCS_2 + dCO$

Name

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STUDY GUIDE

6.2 Types of Reactions

CHAPTER 6

Use with text pages 202 – 209

Choose the correct symbol listed below to describe each of the chemical reactions listed in questions 1–15. Also write a balanced chemical equation for each reaction.

S = synthesis
D = decomposition
C = combustion
SD = single displacement
DD = double displacement

1. SD zinc(s) + silver nitrate(aq) → silver(s) + zinc nitrate(aq)
balanced equation: $Zn + 2AgNO_3 \rightarrow 2Ag + Zn(NO_3)_2$

2. D iron (III) hydroxide(s) → iron (III) oxide(s) + water(g)
balanced equation: $2Fe(OH)_3 \rightarrow Fe_2O_3 + 3H_2O$

3. S ammonia(g) + sulfuric acid(aq) → ammonium sulfate(aq)
balanced equation: $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

4. SD magnesium(s) + nitric acid(aq) → magnesium nitrate(aq) + hydrogen(g)
balanced equation: $Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2$

5. DD calcium nitrate(s) + hydrochloric acid(aq) → nitric acid(aq) + calcium chloride(aq)
balanced equation: $Ca(NO_3)_2 + 2HCl \rightarrow 2HNO_3 + CaCl_2$

6. SD $Na(s) + H_2O(l) \rightarrow NaOH(aq) + H_2(g)$
balanced equation: $2Na + 2H_2O \rightarrow 2NaOH + H_2$

7. S $CO(g) + O_2(g) \rightarrow CO_2(g)$
balanced equation: $2CO + O_2 \rightarrow 2CO_2$

8. DD $FeS(s) + HCl(aq) \rightarrow FeCl_2(aq) + H_2S(g)$
balanced equation: $FeS + 2HCl \rightarrow FeCl_2 + H_2S$

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9. D $NaNO_3(s) \rightarrow NaNO_2(s) + O_2(g)$
balanced equation: $2NaNO_3 \rightarrow 2NaNO_2 + O_2$

10. C $CH_4(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$
balanced equation: $CH_4 + 2O_2 \rightarrow CO_2\ 2H_2O$

11. SD $Fe(s) + CuNO_3(aq) \rightarrow Cu(s) + Fe(NO_3)_2(aq)$
balanced equation: $Fe + 2CuNO_3 \rightarrow 2Cu + Fe(NO_3)_2$

12. SD $KI(aq) + Cl_2(g) \rightarrow KCl(aq) + I_2(aq)$
balanced equation: $2KI + Cl_2 \rightarrow 2KCl + I_2$

13. S $Al(s) + S(s) \rightarrow Al_2S_3(s)$
balanced equation: $2Al + 3S \rightarrow Al_2S_3$

14. D $KClO_3(s) \rightarrow KCl(s) + O_2(g)$
balanced equation: $2KClO_3 \rightarrow 2KCl + 3O_2$

15. C $C_4H_{10}(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$
balanced equation: ~~1~~ C_4H_{10} + ~~2~~ $O_2 \rightarrow$ ~~4~~ CO_2 + ~~5~~ H_2O
2 13 8 10

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Name ____________________ (A)

1. $C + O_2 \longrightarrow CO_2$ BALANCED

2. $2KClO_3 \longrightarrow 2KCl + 3O_2$

3. $NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl$ BALANCED!

4. $2S + 3O_2 \longrightarrow 2SO_3$

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

6. $FeS + 2HCl \longrightarrow FeCl_2 + H_2S$

7. $2Cu + O_2 \longrightarrow 2CuO$

8. $H_2SO_4 + BaO_2 \longrightarrow H_2O_2 + BaSO_4$ BALANCED!

9. $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

10. $Fe + S \longrightarrow FeS$ BALANCED!

11. $CaCO_3 \longrightarrow CaO + CO_2$ BALANCED!

12. $CaO + H_2O \longrightarrow Ca(OH)_2$ BALANCED!

13. $4P + 5O_2 \longrightarrow 2P_2O_5$

14. $3H_2SO_4 + 2Al \longrightarrow Al_2(SO_4)_3 + 3H_2$

15. ~~1~~ 2 C_4H_{10} + ~~13/2~~ 13 $O_2 \longrightarrow$ ~~4~~ 8 CO_2 + ~~5~~ 10 H_2O

16. ~~1~~ 2 C_2H_6 + ~~7/2~~ 7 $O_2 \longrightarrow$ ~~2~~ 4 CO_2 + ~~3~~ 6 H_2O

17. $H_2SO_4 + 2NaCl \longrightarrow Na_2SO_4 + 2HCl$

(B)

NAME ______________________________ PERIOD ________

BALANCE THE FOLLOWING:

1. $3Fe + 4H_2O$ -------> $Fe_3O_4 + 4H_2$

2. $H_2SO_4 + 2NaOH$ -------> $Na_2SO_4 + 2H_2O$

3. $2Na_2HPO_4$ ------> $Na_4P_2O_7 + H_2O$

4. $C_{12}H_{22}O_{11} + 12O_2$ ------> $12CO_2 + 11H_2O$

5. $4H_3PO_3$ ------> $3H_3PO_4 + PH_3$

6. $Ca_3(PO_4)_2 + 8C$ -------> $Ca_3P_2 + 8CO$

7. $PCl_5 + H_2O$ ------> $POCl_3 + 2HCl$

8. $2Pb + 2H_2O + O_2$ -------> $2Pb(OH)_2$

9. $Ca_3(PO_4)_2 + 3H_2SO_4$ -------> $2H_3PO_4 + 3CaSO_4$

10. $Al_2O_3 + 3C + 3Cl_2$ -------> $2AlCl_3 + 3CO$

11. $P_4 + 6Cl_2$ ------> $4PCl_3$

12. $2NH_3 + 2O_2$ -------> $NO + 3H_2O$

13. $Pb(NO_3)_2 + H_2S$ ---------> $PbS + 2HNO_3$

14. $2Al(OH)_3 + 3H_2SO_4$ --------> $Al_2(SO_4)_3 + 6H_2O$

15. $2Fe_2O_3 + 3C$ ---------> $4Fe + 3CO_2$

16. $2C_2H_6 + 7O_2$ -------> $4CO_2 + 6H_2O$

17. $CaCO_3 + 2HCl$ -------> $CaCl_2 + H_2O + CO_2$

18. $Mg(OH)_2 + 2HNO_3$ ---------> $Mg(NO_3)_2 + 2H_2O$

L IN THE NEEDED COEFFICIENTS IN ORDER TO BALANCE THE EQUATIONS.

1. $Fe + S \longrightarrow FeS$ Balanced!

2. $4Fe + 3O_2 \longrightarrow 2Fe_2O_3$

3. $2Sb + 3Cl_2 \longrightarrow 2SbCl_3$

4. $2NaClO_3 \longrightarrow 2NaCl + 3O_2$

5. $Fe + 2HCl \longrightarrow FeCl_2 + H_2$

6. $CuO + H_2 \longrightarrow Cu + H_2O$ Balanced!

7. $SnO_2 + 2C \longrightarrow Sn + 2CO$

8. $Pb(NO_3)_2 + H_2S \longrightarrow PbS + 2HNO_3$

9. $2Al(OH)_3 + 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 6H_2O$

10. $Na_2O + H_2O \longrightarrow 2NaOH$

11. $2Fe_2O_3 + 3C \longrightarrow 4Fe + 3CO_2$

12. $2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$

13. $CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

14. $Mg(OH)_2 + 2HNO_3 \longrightarrow Mg(NO_3)_2 + 2H_2O$

15. $3NaOH + H_3PO_4 \longrightarrow Na_3PO_4 + 3H_2O$

16. $2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$

17. $2Al + 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 3H_2$

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

19. $SnO_2 + 4HCl \longrightarrow SnCl_4 + 2H_2O$

20. $Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3$

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D

Equations

Write a balanced chemical equation to represent each of the following chemical reactions:

S 1. iron + sulfur → iron (II) sulfide $Fe + S \rightarrow FeS$ Balanced!

SD 2. zinc + cupric sulfate → zinc sulfate + copper $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$ Balanced!

DD 3. silver nitrate + sodium bromide → sodium nitrate + silver bromide
$AgNO_3 + NaBr \rightarrow NaNO_3 + AgBr$ Balanced!

D 4. potassium chlorate (heated) → potassium chloride + oxygen
$2KClO_3 \rightarrow 2KCl + 3O_2$

D 5. water (electricity) → hydrogen + oxygen
$2H_2O \rightarrow 2H_2 + O_2$

D 6. mercury (II) oxide (heated) → mercury + oxygen
$2HgO \rightarrow 2Hg + O_2$

DD 7. potassium iodide + lead (II) nitrate → lead (II) iodide + potassium nitrate
$2KI + Pb(NO_3)_2 \rightarrow PbI_2 + 2KNO_3$

S 8. aluminum + oxygen → aluminum oxide
$4Al + 3O_2 \rightarrow 2Al_2O_3$

DD 9. magnesium chloride + ammonium nitrate → magnesium nitrate + ammonium chloride
$MgCl_2 + 2NH_4NO_3 \rightarrow Mg(NO_3)_2 + 2NH_4Cl$

DD 10. iron (III) chloride + ammonium hydroxide → iron (III) hydroxide + ammonium chloride
$FeCl_3 + 3NH_4OH \rightarrow Fe(OH)_3 + 3NH_4Cl$

? 11. sodium peroxide + water → sodium hydroxide + oxygen
$2Na_2O_2 + 2H_2O \rightarrow 4NaOH + O_2$

SD 12. iron (III) oxide + carbon → iron + carbon monoxide
$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$

SD 13. iron + water → hydrogen + iron (III) oxide
$2Fe + 3H_2O \rightarrow 3H_2 + Fe_2O_3$

DD 14. iron (III) chloride + potassium hydroxide → potassium chloride + iron (III) hydroxide
$FeCl_3 + 3KOH \rightarrow 3KCl + Fe(OH)_3$

SD 15. aluminum + sulfuric acid → aluminum sulfate + hydrogen
$2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$

(continued)

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Worksheet #20 Predicting Products of Chemical reactions **Name** ______________________
Text Reference: pgs 256-264

A) For the following **synthesis reactions**, complete the chemical equation and balance the equation.

1. $4Na(s) + O_2(g) \rightarrow 2Na_2O$
2. $Mg(s) + F_2(g) \rightarrow MgF_2$ Balanced
3. $2Al(s) + 3S(s) \rightarrow Al_2S_3$
4. $3Ca(s) + 2P(s) \rightarrow Ca_3P_2$

B) For the following **decomposition reactions**, complete the chemical equation and balance the equation.

1. $2HgO(s) \rightarrow 2Hg + O_2$
2. $CuCl_2(s) \rightarrow Cu + Cl_2$ Balanced
3. $2Al_2O_3(s) \rightarrow 4Al + 3O_2$

C) For the following **single displacement reactions**, complete the chemical equation and balance the equation.

1. $Zn(s) + Pb(NO_3)_2(aq) \rightarrow Zn(NO_3)_2 + Pb$ Balanced
2. $2Al(s) + 3NiSO_4(aq) \rightarrow Al_2(SO_4)_3 + 3Ni$
3. $2Na(s) + 2H_2O(l) \rightarrow 2NaOH + H_2$
4. $F_2(g) + 2NaCl(aq) \rightarrow 2NaF + Cl_2$

D) For the following **double displacement reactions**, complete the chemical equation and balance the equation.

1. $2AgNO_3(aq) + CaCl_2(aq) \rightarrow Ca(NO_3)_2 + 2AgCl$
2. $2KOH(aq) + ZnCl_2(aq) \rightarrow 2KCl + Zn(OH)_2$
3. $FeS(s) + 2HCl(aq) \rightarrow FeCl_2 + H_2S$
4. $3CoCl_2(aq) + 2Na_3PO_4(aq) \rightarrow Co_3(PO_4)_2 + 6NaCl$

E) For the following **combustion reactions**, complete the chemical equation and balance the equation.

1. $C_7H_{16}(g) + 11O_2(g) \rightarrow 7CO_2 \; 8H_2O$
2. $2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2 + 2H_2O$
3. $2C_3H_8O(g) + 9O_2(g) \rightarrow 6CO_2 + 8H_2O$

4.) $C_{12}H_{22}O_{11} + 12O_2 \xrightarrow{(g)} 12CO_2 + 11H_2O$

F) For each of the following reactions, you will need to identify the reaction type from the reactants, predict the products and then balance the equation.

DD 1. $HCl(aq) + NaOH(aq) \rightarrow NaCl + H_2O$

C 2. ~~$CH_3OH + O_2(g) \rightarrow CO_2 + H_2O$~~ $2CH_3OH + 3O_2 \longrightarrow 2CO_2 + 4H_2O$

SD 3. $2NaI(aq) + Cl_2(g) \rightarrow 2NaCl + I_2$

S 4. $6Li(s) + N_2(g) \rightarrow 2Li_3N$

C 5. $2C_3H_6(g) + 9O_2(g) \rightarrow 6CO_2 + 6H_2O$

D 6. $2AlCl_3(s) \rightarrow 2Al + 3Cl_2$

SD 7. $Ca(s) + 2HCl(aq) \rightarrow CaCl_2 + H_2$

DD 8. $3LiOH(aq) + Fe(NO_3)_3(aq) \rightarrow$

$3LiNO_3 + Fe(OH)_3$

Stoichiometry: Mole-Mole Calculations

1. How many moles of CO_2 form when 3 moles of oxygen (O_2) burn with sufficient amount of propane? Unbalanced Equation: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

$$3 \text{ mol } O_2 \left(\frac{3 \text{ mol } CO_2}{5 \text{ mol } O_2}\right) = 1.8 \text{ mol } O_2 \text{ will form}$$

2. How many moles of chlorine, Cl_2, are required to form 0.90 moles of sodium chloride, NaCl? Unbalanced Equation: $2Na + Cl_2 \rightarrow 2NaCl$

$$.90 \text{ mol NaCl} \left(\frac{1 \text{ mol } Cl_2}{2 \text{ mol NaCl}}\right) = 0.45 \text{ mol } Cl_2 \text{ needed}$$

3. Carbon disulfide is an important industrial solvent. It is prepared by the reaction of coke (pure carbon) with sulfur dioxide.
Unbalanced Equation: $5C + 2SO_2 \rightarrow CS_2 + 4CO$

   a. How many moles of CS_2 form when 6.30 moles of C reacts?

$$6.30 \text{ mol C} \left(\frac{1 \text{ mol } CS_2}{5 \text{ mol C}}\right) = 1.26 \text{ mol } CS_2 \text{ form}$$

   b. How many moles of carbon are needed to react with 7.24 moles of SO_2?

$$7.24 \text{ mol } SO_2 \left(\frac{5 \text{ mol C}}{2 \text{ mol } SO_2}\right) = 18.1 \text{ mol C}$$

   c. How many moles of carbon monoxide form at the same time that 0.762 moles of CS_2 forms?

$$.762 \text{ mol } CS_2 \left(\frac{4 \text{ mol CO}}{1 \text{ mol } CS_2}\right) = 3.048 \text{ mol CO}$$

   d. How many moles of SO_2 are required to make 182 moles of CS_2?

$$182 \text{ mol } CS_2 \left(\frac{2 \text{ mol } SO_2}{1 \text{ mol } CS_2}\right) = 364 \text{ mol } SO_2$$

4. How many moles of oxygen are required to react completely with 0.84 moles of Al? Unbalanced Equation: $4Al + 3O_2 \rightarrow 2Al_2O_3$

$$.84 \text{ mol Al} \left(\frac{3 \text{ mol } O_2}{4 \text{ mol Al}}\right) = 0.63 \text{ mol } O_2$$

Stoichiometry: Gram-Gram Calculations

1. Calculate the number of grams of NH_3 produced by the reaction of 5.40 grams of hydrogen with an excess of nitrogen? Unbalanced Equation: $2N_2 + 3H_2 \rightarrow 2NH_3$

$$5.40\,g\,H_2 \left(\frac{1\,mol\,H_2}{2\,g\,H_2}\right)\left(\frac{2\,mol\,NH_3}{3\,mol\,H_2}\right)\left(\frac{17\,g\,NH_3}{1\,mol\,NH_3}\right) = 30.6\,g\,NH_3$$

2. How many grams of nitrogen are needed to produce the 30.6 grams of NH_3 in the previous problem?

$$30.6\,g\,NH_3 \left(\frac{1\,mol\,NH_3}{17\,g\,NH_3}\right)\left(\frac{2\,mol\,N_2}{2\,mol\,NH_3}\right)\left(\frac{28\,g\,N_2}{1\,mol\,N_2}\right) = 50.4\,g\,N_2$$

3. Acetylene gas, C_2H_2, is produced by adding water to calcium carbide, CaC_2.
Unbalanced Equation: $CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$

   a. How many **moles** of CaC_2 are needed to react completely with 49.0 grams of H_2O?

$$49.0\,g\,H_2O \left(\frac{1\,mol\,H_2O}{18\,g}\right)\left(\frac{1\,mol\,CaC_2}{2\,mol\,H_2O}\right) = 1.36\,mol\,CaC_2$$

   b. How many **grams** of acetylene are produced by adding water to 5.00 grams of CaC_2?

$$5.00\,g\,CaC_2 \left(\frac{1\,mol\,CaC_2}{64\,g\,CaC_2}\right)\left(\frac{1\,mol\,C_2H_2}{1\,mol\,CaC_2}\right)\left(\frac{26\,g}{1\,mol\,C_2H_2}\right) = 2.03\,g\,C_2H_2$$

   c. How many **grams** of $Ca(OH)_2$ are produced when 0.89 moles of C_2H_2 is reacted?

$$.89\,mol\,C_2H_2 \left(\frac{1\,mol\,Ca(OH)_2}{1\,mol\,C_2H_2}\right)\left(\frac{74\,g\,Ca(OH)_2}{1\,mol\,Ca(OH)_2}\right) = 65.86\,g\,Ca(OH)_2$$

4. Oxygen is produced by the reaction of sodium peroxide and water.
Unbalanced Equation: $2Na_2O_2 + 2H_2O \rightarrow O_2 + 4NaOH$

   a. Calculate the mass of Na_2O_2 in grams needed to form 4.80 g of oxygen.

$$4.80\,g\,O_2 \left(\frac{1\,mol\,O_2}{32\,g\,O_2}\right)\left(\frac{2\,mol\,Na_2O_2}{1\,mol\,O_2}\right)\left(\frac{78\,g\,Na_2O_2}{1\,mol\,Na_2O_2}\right) = 23.4\,g\,Na_2O_2$$

   b. How many grams of NaOH are produced when 4.80 g of O_2 is formed?

$$4.80\,g\,O_2 \left(\frac{1\,mol\,O_2}{32\,g\,O_2}\right)\left(\frac{4\,mol\,NaOH}{1\,mol\,O_2}\right)\left(\frac{40\,g\,NaOH}{1\,mol\,NaOH}\right) = 24.0\,g\,NaOH$$

Stoichiometry Calculations

1. A coil of magnesium ribbon with a mass of 0.6 grams is placed in hydrochloric acid. What mass of hydrogen is released?
   Unbalanced Equation: $Mg + 2HCl \rightarrow MgCl_2 + H_2$

   $$.6 g\ Mg \left(\frac{1 mol\ Mg}{24.3 g}\right)\left(\frac{1 mol\ H_2}{1 mol\ Mg}\right)\left(\frac{2 g}{1 mol\ H_2}\right) = \boxed{.0494 g\ H_2}$$

2. A piece of charcoal (carbon) with a mass of 12 grams is burned in an insufficient amount of air, forming carbon monoxide. What mass of oxygen is used?

   $$2C + O_2 \rightarrow 2CO$$

   $$12 g\ C \left(\frac{1 mol\ C}{12 g}\right)\left(\frac{1 mol\ O_2}{2 mol\ C}\right)\left(\frac{32 g}{1 mol\ O_2}\right) = \boxed{16 g\ O_2}$$

3. 2.16 grams of aluminum are burned in air. What mass of aluminum oxide, Al_2O_3, is formed? $4Al + 3O_2 \rightarrow 2Al_2O_3$

   $$2.16 g\ Al \left(\frac{1 mol\ Al}{27 g}\right)\left(\frac{2 mol\ Al_2O_3}{4 mol\ Al}\right)\left(\frac{102 g\ Al_2O_3}{1 mol\ Al_2O_3}\right) = \boxed{4.08 g\ Al_2O_3}$$

4. Copper may be oxidized in the following unbalanced reaction:

   $$3\ Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$$

   If 1.82 grams of copper are used, what mass of water will be formed?

   $$1.82 g\ Cu \left(\frac{1 mol\ Cu}{63.55 g}\right)\left(\frac{4 mol\ H_2O}{3 mol\ Cu}\right)\left(\frac{18 g}{1 mol\ H_2O}\right) = \boxed{0.687 g\ H_2O}$$

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Limiting Reagent Worksheet

Using your knowledge of stoichiometry and limiting reagents, answer the following questions:

1) Write the balanced equation for the reaction of lead (II) nitrate with sodium iodide to form sodium nitrate and lead (II) iodide:

$$Pb(NO_3)_2 + 2NaI \longrightarrow 2NaNO_3 + PbI_2$$

2) If I start with 25.0 grams of lead (II) nitrate and 15.0 grams of sodium iodide, how many grams of sodium nitrate can be formed?

$$25.0g\ Pb(NO_3)_2 \left(\frac{1 mol\ Pb(NO_3)_2}{331.2g}\right)\left(\frac{2 mole\ NaNO_3}{1 mol\ Pb(NO_3)_2}\right)\left(\frac{85g}{1 mol\ NaNO_3}\right) = 12.83g\ NaNO_3$$

$$15.0g\ NaI \left(\frac{1 mol\ NaI}{150g}\right)\left(\frac{2 mol\ NaNO_3}{2 mol\ NaI}\right)\left(\frac{85g}{1 mol\ NaNO_3}\right) = \boxed{8.50g\ NaNO_3}$$

Lesser amount will be formed

3) What is the limiting reagent in the reaction described in problem 2?

NaI is the limiting reactant.

4) How much of the nonlimiting reagent will be left over from the reaction in problem #2?

$$15.0g\ NaI \left(\frac{1 mol\ NaI}{150g}\right)\left(\frac{1 mol\ Pb(NO_3)_2}{2 mol\ NaI}\right)\left(\frac{331.2g}{1 mol\ Pb(NO_3)_2}\right) = 16.56g\ Pb(NO_3)_2$$

needed in the reaction

$25 - 16.56 = 8.44g\ Pb(NO_3)_2$ will be left over.

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Limiting Reagent Worksheet

For the following reactions, find the following:

a) Which of the reagents is the limiting reagent?
b) What is the maximum amount of each product that can be formed?
c) How much of the other reagent is left over after the reaction is complete?

1) Consider the following reaction:

.375 mol   .304 mol

$$3\ NH_4NO_3 + Na_3PO_4 \rightarrow (NH_4)_3PO_4 + 3\ NaNO_3$$

Answer the questions above, assuming we started with 30 grams of ammonium nitrate and 50 grams of sodium phosphate.

a) $30g\ NH_4NO_3 \left(\frac{1 mol\ NH_4NO_3}{80g}\right)\left(\frac{1 mol\ (NH_4)_3PO_4}{3 mol\ NH_4NO_3}\right)\left(\frac{149g}{1 mol\ (NH_4)_3PO_4}\right)$ = **18.625g $(NH_4)_3PO_4$** ← Lesser amount Limiting reactant

$50g\ Na_3PO_4 \left(\frac{1 mol\ Na_3PO_4}{164g}\right)\left(\frac{1 mol\ (NH_4)_3PO_4}{1 mol\ Na_3PO_4}\right)\left(\frac{149g}{1 mol\ (NH_4)_3PO_4}\right) = 45.427g\ (NH_4)_3PO_4$

b) $30g\ NH_4NO_3 \left(\frac{1 mol\ NH_4NO_3}{80g}\right)\left(\frac{3 mol\ NaNO_3}{3 mol\ NH_4NO_3}\right)\left(\frac{85g}{1 mol\ NaNO_3}\right)$ = **31.875g $NaNO_3$**

c) $30g\ NH_4NO_3 \left(\frac{1 mol\ NH_4NO_3}{80g}\right)\left(\frac{1 mol\ Na_3PO_4}{3 mol\ NH_4NO_3}\right)\left(\frac{164g}{1 mol}\right)$

20.5g Na_3PO_4 needed

50-20.5 = **29.5g Na_3PO_4 left over**

2) Consider the following reaction:

1 mol   .298

$$3\ CaCO_3 + 2\ FePO_4 \rightarrow Ca_3(PO_4)_2 + Fe_2(CO_3)_3$$

Answer the questions at the top of this sheet, assuming we start with 100 grams of calcium carbonate and 45 grams of iron (III) phosphate.

a) $100g\ CaCO_3 \left(\frac{1 mol}{100g}\right) = 1 mol\ CaCO_3 \left(\frac{2 mol\ FePO_4}{3 mol\ CaCO_3}\right)$ = .667 mol $FePO_4$ needed to react all of the $CaCO_3$ - not enough

$45g\ FePO_4 \left(\frac{1 mol}{150.8}\right) = .298 mol\ FePO_4$

<u>$FePO_4$ is Limiting Reactant.</u>

b) $45g\ FePO_4 \left(\frac{1 mol\ FePO_4}{150.8g}\right)\left(\frac{1 mol\ Ca_3(PO_4)_2}{2 mol\ FePO_4}\right)\left(\frac{310g}{1 mol\ Ca_3(PO_4)_2}\right) = 46.25g\ Ca_3(PO_4)_2$ formed

$45g\ FePO_4 \left(\frac{1 mol\ FePO_4}{150.8g}\right)\left(\frac{1 mol\ Fe_2(CO_3)_3}{2 mol\ FePO_4}\right)\left(\frac{291.6}{1 mol\ Fe_2(CO_3)_3}\right) = 43.51g\ Fe_2(CO_3)_3$ formed

c) $45g\ FePO_4 \left(\frac{1 mol\ FePO_4}{150.8g}\right)\left(\frac{3 mol\ CaCO_3}{2 mol\ FePO_4}\right)\left(\frac{100g}{1 mol\ CaCO_3}\right) = 44.8g\ CaCO_3$ needed

100-44.8 = 55.2g extra

Name: Period: Date:

Stoichiometry- Limiting Reactants & Percent Yield

1. **Zinc and sulfur react to form zinc sulfide according to the equation:**

$$Zn + S \rightarrow ZnS$$

If 25.0 g of zinc and 30.0 g of sulfur are mixed,

a. **Which chemical is the limiting reactant (produced less ZnS)?**

$25.0\,g\,Zn \left(\frac{1\,mol\,Zn}{65.4\,g}\right)\left(\frac{1\,mol\,ZnS}{1\,mol\,Zn}\right)\left(\frac{97.4\,g}{1\,mol\,ZnS}\right) = 37.23\,g\,ZnS$ ← produces less ZnS, Zn is Limiting Reactant

$30.0\,g\,S \left(\frac{1\,mol\,S}{32.0\,g\,S}\right)\left(\frac{1\,mol\,ZnS}{1\,mol\,S}\right)\left(\frac{97.4\,g}{1\,mol\,ZnS}\right) = 91.31\,g\,ZnS$

b. **How many grams of ZnS will be formed?**

37.23 g ZnS (see work in part a)

c. **How many grams of excess reactant will remain after the reaction is complete?**

$25.0\,g\,Zn \left(\frac{1\,mol\,Zn}{65.4\,g}\right)\left(\frac{1\,mol\,S}{1\,mol\,Zn}\right)\left(\frac{32\,g\,S}{1\,mol\,S}\right) = 12.23\,g\,S$ needed

$30 - 12.23 =$ **17.76 g excess S**

2. **Consider the reaction:**

$$I_2O_5 + 5CO \rightarrow 5CO_2 + I_2$$

a. **If 80.0 grams of I_2O_5 reacts with 28.0 grams of CO, determine the mass of I_2 which could be produced.**

$80\,g\,I_2O_5 \left(\frac{1\,mol\,I_2O_5}{334\,g}\right)\left(\frac{1\,mol\,I_2}{1\,mol\,I_2O_5}\right)\left(\frac{254\,g}{1\,mol\,I_2}\right) = 60.84\,g\,I_2$

$28\,g\,CO \left(\frac{1\,mol\,CO}{28\,g}\right)\left(\frac{1\,mol\,I_2}{5\,mol\,CO}\right)\left(\frac{254\,g}{1\,mol\,I_2}\right) = 50.8\,g\,I_2$ ← Limiting Reactant

b. **If, in the above situation, the reaction produced only 40.64 g of I_2. What is the percent yield for the reaction?**

$\%\,Yield = \frac{Actual\ Yield}{Theoretical\ Yield} \times 100 = \frac{40.64\,g}{50.8\,g} \times 100 = 80\%\ Yield$

3. **Consider the reaction 2Al + 3S → Al_2S_3.**

   a. **How many grams of Al_2S_3 are formed when 5.00 g of Al is heated with 10.0 g of S?**

$$5\,g\,Al \left(\frac{1\,mol\,Al}{27\,g\,Al}\right)\left(\frac{1\,mol\,Al_2S_3}{2\,mol\,Al}\right)\left(\frac{150\,g\,Al_2S_3}{1\,mol\,Al_2S_3}\right) = \boxed{13.89\,g\,Al_2S_3}$$ - Smaller amount.

$$10\,g\,S \left(\frac{1\,mol\,S}{32\,g\,S}\right)\left(\frac{1\,mol\,Al_2S_3}{3\,mol\,S}\right)\left(\frac{150\,g\,Al_2S_3}{1\,mol\,Al_2S_3}\right) = 15.625\,g\,Al_2S_3$$

   b. **In actuality, the reaction only produced 12.0 grams of Al_2S_3. What is the percent yield for this reaction?**

$$\%\,Yield = \frac{Actual}{Theoretical} \times 100 = \frac{12\,g}{13.89} \times 100 = \boxed{86.4\%}$$

Percent, Actual, and Theoretical Yield

1) $LiOH + KCl \rightarrow LiCl + KOH$

a) I began this reaction with 20 grams of lithium hydroxide. What is my theoretical yield of lithium chloride?

$$20\,g\ LiOH \left(\frac{1\ mol\ LiOH}{23.941\,g}\right)\left(\frac{1\ mol\ LiCl}{1\ mol\ LiOH}\right)\left(\frac{42.441\,g}{1\ mol\ LiCl}\right) = \boxed{35.45\,g\ LiCl}$$

b) I actually produced 6 grams of lithium chloride. What is my percent yield?

$$\%\,Yield = \frac{6\,g}{35.45} \times 100 = \boxed{16.9\%}$$

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

a) If I start with 5 grams of C_3H_8, what is my theoretical yield of water?

$$5\,g\ C_3H_8 \left(\frac{1\ mol\ C_3H_8}{44\,g}\right)\left(\frac{4\ mol\ H_2O}{1\ mol\ C_3H_8}\right)\left(\frac{18\,g}{1\ mol\ H_2O}\right) = \underline{8.18\,g\ H_2O}$$

b) I got a percent yield of 75% How many grams of water did I make?

$$Actual\ Yield = \left(\frac{\%\,Yield}{100}\right) \times Theoretical = \left(\frac{75}{100}\right) \times 8.18 = \underline{6.14\,g\ H_2O}$$

3) $Be + 2\,HCl \rightarrow BeCl_2 + H_2$

My theoretical yield of beryllium chloride was 10.7 grams. If my actual yield was 4.5 grams, what was my percent yield?

$$\%\,Yield = \frac{4.5\,g}{10.7\,g} \times 100 = \boxed{42.1\%}$$

4) $2\,NaCl + CaO \rightarrow CaCl_2 + Na_2O$

What is my theoretical yield of sodium oxide if I start with 20 grams of calcium oxide?

$$20\,g\ CaO \left(\frac{1\ mol\ CaO}{56\,g}\right)\left(\frac{1\ mol\ Na_2O}{1\ mol\ CaO}\right)\left(\frac{62\,g}{1\ mol\ Na_2O}\right) = \underline{22.1\,g\ Na_2O}$$

5) $FeBr_2 + 2\ KCl \rightarrow FeCl_2 + 2\ KBr$

a) What is my theoretical yield of iron (II) chloride if I start with 34 grams of iron (II) bromide?

$$34\text{ g } FeBr_2 \left(\frac{1\text{ mol } FeBr_2}{215.6\text{ g}}\right)\left(\frac{1\text{ mol } FeCl_2}{1\text{ mol } FeBr_2}\right)\left(\frac{126.8\text{ g}}{1\text{ mole } FeCl_2}\right) = \boxed{20.0\text{ g } FeCl_2}$$

b) What is my percent yield of iron (II) chloride if my actual yield is 4 grams?

$$\%\text{ Yield} = \frac{4\text{ g}}{20\text{ g}} \times 100 = \boxed{20\%}$$

6) $TiS + H_2O \rightarrow H_2S + TiO$

What is my percent yield of titanium (II) oxide if I start with 20 grams of titanium (II) sulfide and my actual yield of titanium (II) oxide is 22 grams?

$$20\text{ g } TiS \left(\frac{1\text{ mol } TiS}{79.867}\right)\left(\frac{1\text{ mol } TiO}{1\text{ mol } TiS}\right)\left(\frac{63.867}{1\text{ mol } TiO}\right) = 16.0\text{ g } TiO$$

$$\%\text{ Yield} = \frac{22\text{ g}}{16\text{ g}} \times 100 = 137.5\%$$

7) $U + 3\ Br_2 \rightarrow UBr_6$

What is my actual yield of uranium hexabromide if I start with 100 grams of uranium and get a percent yield of 83% ?

$$100\text{ g } U \left(\frac{1\text{ mol } U}{238\text{ g}}\right)\left(\frac{1\text{ mol } UBr_6}{1\text{ mol } U}\right)\left(\frac{717.4\text{ g}}{1\text{ mol } UBr_6}\right) = 301.4\text{ g } UBr_6$$

$$\text{Actual} = (301.4) \times .83 = \boxed{250\text{ g } UBr_6}$$

8) $H_2SO_4 \rightarrow H_2O + SO_3$

If I start with 89 grams of sulfuric acid and produce 7.1 grams of water, what is my percent yield?

$$89\text{ g } H_2SO_4 \left(\frac{1\text{ mol } H_2SO_4}{98\text{ g}}\right)\left(\frac{1\text{ mol } H_2O}{1\text{ mol } H_2SO_4}\right)\left(\frac{18\text{ g}}{1\text{ mol } H_2O}\right) = 16.34\text{ g } H_2O \text{ - theoretical}$$

$$\%\text{ Yield} = \frac{7.1\text{ g}}{16.34\text{ g}} \times 100 = \boxed{43.4\%}$$