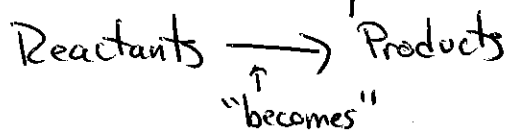


Chapter 9 Balancing Equations & Reaction Types

Chapter 11 Stoichiometry

Key

Any reaction can be written as an equation



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.

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

- ① Convert given information into moles.
- ② Use mole ratios 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.

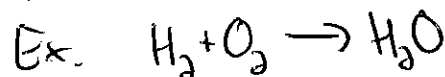
Excess Reactant - the extra reactant that is not used up in a reaction because there isn't enough limiting reactant to react with.

Actual yield - the amount of product formed in an experiment

Theoretical yield - the amount "calculated" from stoichiometry.

Balancing Equations

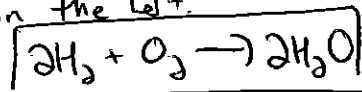
- the total # of atoms on either side of a reaction must be the same. Use coefficients to balance.



- 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 .



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



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

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 + O₂ \longrightarrow CO₂
- OK 2. H₂O + SO₃ \longrightarrow H₂SO₄
- F 3. K + F₂ \longrightarrow KF
- O 4. C₂H₂ + O₂ \longrightarrow 2 CO₂ + H₂O
- Fe 5. Fe₂O₃ + 3H₂ \longrightarrow Fe + 3 H₂O
- OK 6. 6 Li + N₂ \longrightarrow 2 Li₃N
- H 7. CH₄ + 2 Br₂ \longrightarrow CHBr₃ + HBr
- O 8. 4 NaOH + 2 F₂ \longrightarrow 2 O₂ + 4 NaF + 2 H₂O
- Cl 9. Al + 2 HCl \longrightarrow AlCl₃ + H₂
- OK 10. K₂O + CaCl₂ \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 + bCl₂ \longrightarrow cNaCl
- a 2 b 3 c 2 2. aFe + bI₂ \longrightarrow cFeI₃
- a 1 b 1 c 1 3. aH₂CO₃ \longrightarrow bH₂O + cCO₂
- a 2 b 1 c 2 d 1 4. aLi + bBaF₂ \longrightarrow cLiF + dBa
- a 1 b 2 c 2 5. aO₂ + bCl₂ \longrightarrow cCl₂O
- a 2 b 1 c 1 6. aK + bO₂ \longrightarrow cK₂O₂
- a 4 b 1 c 2 7. aNa + bO₂ \longrightarrow cNa₂O
- a 1 b 1 c 1 d 2 8. aHgCl₂ + bH₂S \longrightarrow cHgS + dHCl
- a 2 b 2 c 1 9. aBaO₂ \longrightarrow bBaO + cO₂
- a 2 b 5 c 1 d 4 10. aSO₂ + bC \longrightarrow cCS₂ + dCO

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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

SD = single displacement

D = decomposition

DD = double displacement

C = combustion

- 1.
- SD
- zinc(s) + silver nitrate(aq) → silver(s) + zinc nitrate(aq)

balanced equation: $\underline{Zn + 2AgNO_3 \rightarrow 2Ag + Zn(NO_3)_2}$

- 2.
- D
- iron (III) hydroxide(s) → iron (III) oxide(s) + water(g)

balanced equation: $\underline{2Fe(OH)_3 \rightarrow Fe_2O_3 + 3H_2O}$

- 3.
- S
- ammonia(g) + sulfuric acid(aq) → ammonium sulfate(aq)

balanced equation: $\underline{2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4}$

- 4.
- SD
- magnesium(s) + nitric acid(aq) → magnesium nitrate(aq) + hydrogen(g)

balanced equation: $\underline{Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2}$

- 5.
- DD
- calcium nitrate(s) + hydrochloric acid(aq) → nitric acid(aq) + calcium chloride(aq)

balanced equation: $\underline{Ca(NO_3)_2 + 2HCl \rightarrow 2HNO_3 + CaCl_2}$

- 6.
- SD
- Na(s) + H
- ₂
- O(l) → NaOH(aq) + H
- ₂
- (g)

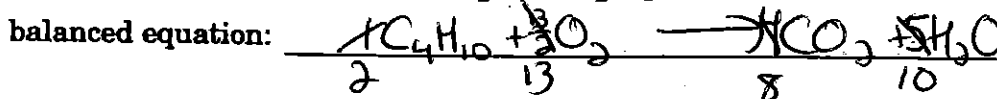
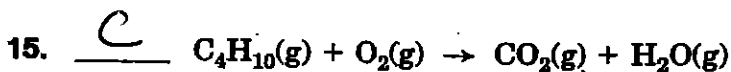
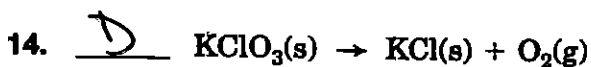
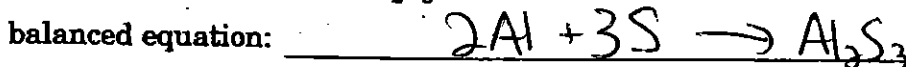
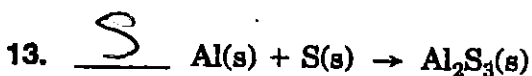
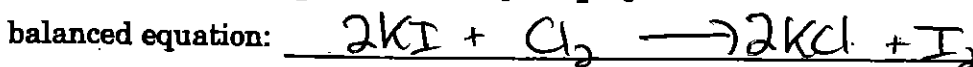
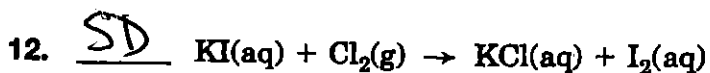
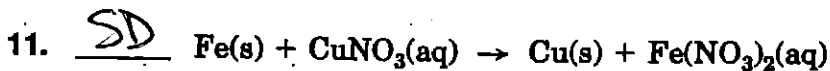
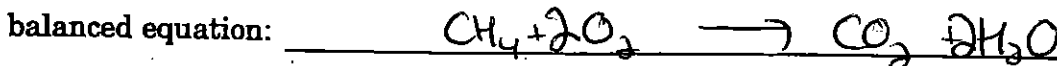
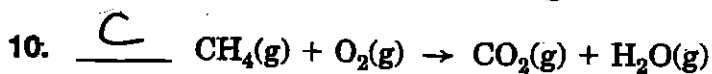
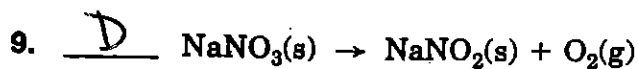
balanced equation: $\underline{2Na + 2H_2O \rightarrow 2NaOH + H_2}$

- 7.
- S
- CO(g) + O
- ₂
- (g) → CO
- ₂
- (g)

balanced equation: $\underline{2CO + O_2 \rightarrow 2CO_2}$

- 8.
- DD
- FeS(s) + HCl(aq) → FeCl
- ₂
- (aq) + H
- ₂
- S(g)

balanced equation: $\underline{FeS + 2HCl \rightarrow FeCl_2 + H_2S}$



Name _____

(A)

1. $C + O_2 \rightarrow CO_2$ BALANCED
2. $2KClO_3 \rightarrow 2KCl + 3O_2$
3. $NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$ BALANCED!
4. $2S + 3O_2 \rightarrow 2SO_3$
5. $Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$
6. $FeS + 2HCl \rightarrow FeCl_2 + H_2S$
7. $2Cu + O_2 \rightarrow 2CuO$
8. $H_2SO_4 + BaO_2 \rightarrow H_2O_2 + BaSO_4$ BALANCED!
9. $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
10. $Fe + S \rightarrow FeS$ BALANCED!
11. $CaCO_3 \rightarrow CaO + CO_2$ BALANCED!
12. $CaO + H_2O \rightarrow Ca(OH)_2$ BALANCED!
13. $4P + 5O_2 \rightarrow 2P_2O_5$
14. $3H_2SO_4 + 2Al \rightarrow Al_2(SO_4)_3 + 3H_2$
15. $C_4H_{10} + \frac{13}{2}O_2 \rightarrow 4CO_2 + 5H_2O$
16. $2C_2H_6 + 7\frac{1}{2}O_2 \rightarrow 4CO_2 + 6H_2O$
17. $H_2SO_4 + 2NaCl \rightarrow Na_2SO_4 + 2HCl$

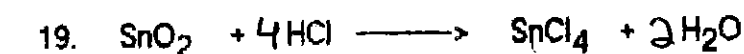
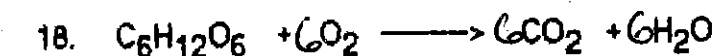
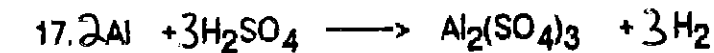
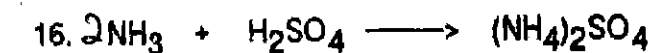
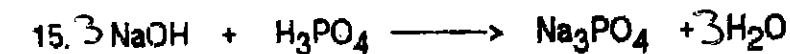
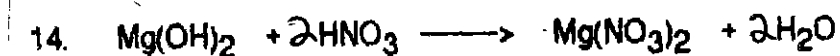
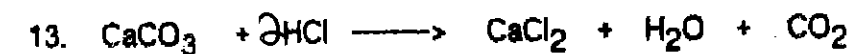
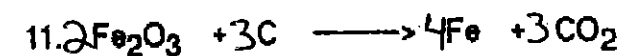
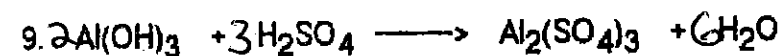
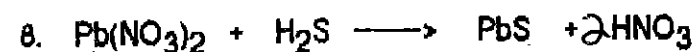
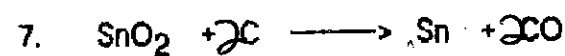
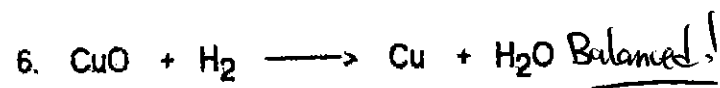
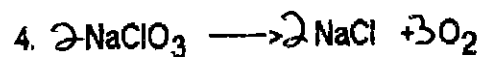
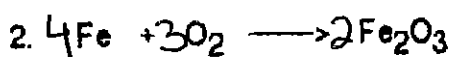
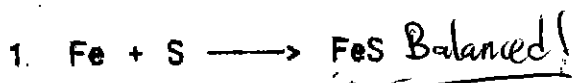
NAME _____

PERIOD _____

BALANCE THE FOLLOWING:

1. $3\text{Fe} + 4\text{H}_2\text{O} \longrightarrow \text{Fe}_3\text{O}_4 + 4\text{H}_2$
2. $\text{H}_2\text{SO}_4 + 2\text{NaOH} \longrightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$
3. $2\text{Na}_2\text{HPO}_4 \longrightarrow \text{Na}_4\text{P}_2\text{O}_7 + \text{H}_2\text{O}$
4. $\text{C}_{12}\text{H}_{22}\text{O}_{11} + 12\text{O}_2 \longrightarrow 12\text{CO}_2 + 11\text{H}_2\text{O}$
5. $4\text{H}_3\text{PO}_3 \longrightarrow 3\text{H}_3\text{PO}_4 + \text{PH}_3$
6. $\text{Ca}_3(\text{PO}_4)_2 + 8\text{C} \longrightarrow \text{Ca}_3\text{P}_2 + 8\text{CO}$
7. $\text{PCl}_5 + \text{H}_2\text{O} \longrightarrow \text{POCl}_3 + 2\text{HCl}$
8. $2\text{Pb} + 2\text{H}_2\text{O} + \text{O}_2 \longrightarrow 2\text{Pb}(\text{OH})_2$
9. $\text{Ca}_3(\text{PO}_4)_2 + 3\text{H}_2\text{SO}_4 \longrightarrow 2\text{H}_3\text{PO}_4 + 3\text{CaSO}_4$
10. $\text{Al}_2\text{O}_3 + 3\text{C} + 3\text{Cl}_2 \longrightarrow 2\text{AlCl}_3 + 3\text{CO}$
11. $\text{P}_4 + 6\text{Cl}_2 \longrightarrow 4\text{PCl}_3$
12. $2\text{NH}_3 + 2\text{O}_2 \longrightarrow \text{NO} + 3\text{H}_2\text{O}$
13. $\text{Pb}(\text{NO}_3)_2 + \text{H}_2\text{S} \longrightarrow \text{PbS} + 2\text{HNO}_3$
14. $2\text{Al}(\text{OH})_3 + 3\text{H}_2\text{SO}_4 \longrightarrow \text{Al}_2(\text{SO}_4)_3 + 6\text{H}_2\text{O}$
15. $2\text{Fe}_2\text{O}_3 + 3\text{C} \longrightarrow 4\text{Fe} + 3\text{CO}_2$
16. $2\text{C}_2\text{H}_6 + 7\text{O}_2 \longrightarrow 4\text{CO}_2 + 6\text{H}_2\text{O}$
17. $\text{CaCO}_3 + 2\text{HCl} \longrightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$
18. $\text{Mg}(\text{OH})_2 + 2\text{HNO}_3 \longrightarrow \text{Mg}(\text{NO}_3)_2 + 2\text{H}_2\text{O}$

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



Equations

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

- S 1. iron + sulfur → iron (II) sulfide $\text{Fe} + \text{S} \rightarrow \text{FeS}$ Balanced!
- SD 2. zinc + cupric sulfate → zinc sulfate + copper $\text{Zn} + \text{CuSO}_4 \rightarrow \text{ZnSO}_4 + \text{Cu}$ Balanced!
- DD 3. silver nitrate + sodium bromide → sodium nitrate + silver bromide
 $\text{AgNO}_3 + \text{NaBr} \rightarrow \text{NaNO}_3 + \text{AgBr}$ Balanced!
- D 4. potassium chlorate (heated) → potassium chloride + oxygen
 $2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$
- D 5. water (electricity) → hydrogen + oxygen
 $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$
- D 6. mercury (II) oxide (heated) → mercury + oxygen
 $2\text{HgO} \rightarrow 2\text{Hg} + \text{O}_2$
- DD 7. potassium iodide + lead (II) nitrate → lead (II) iodide + potassium nitrate
 $2\text{KI} + \text{Pb}(\text{NO}_3)_2 \rightarrow \text{PbI}_2 + 2\text{KNO}_3$
- S 8. aluminum + oxygen → aluminum oxide
 $4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3$
- DD 9. magnesium chloride + ammonium nitrate → magnesium nitrate + ammonium chloride
 $\text{MgCl}_2 + 2\text{NH}_4\text{NO}_3 \rightarrow \text{Mg}(\text{NO}_3)_2 + 2\text{NH}_4\text{Cl}$
- DD 10. iron (III) chloride + ammonium hydroxide → iron (III) hydroxide + ammonium chloride
 $\text{FeCl}_3 + 3\text{NH}_4\text{OH} \rightarrow \text{Fe}(\text{OH})_3 + 3\text{NH}_4\text{Cl}$
- ? 11. sodium peroxide + water → sodium hydroxide + oxygen
 $2\text{Na}_2\text{O}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{NaOH} + \text{O}_2$
- SD 12. iron (III) oxide + carbon → iron + carbon monoxide
 $\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 2\text{Fe} + 3\text{CO}$
- SD 13. iron + water → hydrogen + iron (III) oxide
 $2\text{Fe} + 3\text{H}_2\text{O} \rightarrow 3\text{H}_2 + \text{Fe}_2\text{O}_3$
- DD 14. iron (III) chloride + potassium hydroxide → potassium chloride + iron (III) hydroxide
 $\text{FeCl}_3 + 3\text{KOH} \rightarrow 3\text{KCl} + \text{Fe}(\text{OH})_3$
- SD 15. aluminum + sulfuric acid → aluminum sulfate + hydrogen
 $2\text{Al} + 3\text{H}_2\text{SO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + 3\text{H}_2$

(continued)

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.

- $4\text{Na}(s) + \text{O}_2(g) \rightarrow 2\text{Na}_2\text{O}$
- $\text{Mg}(s) + \text{F}_2(g) \rightarrow \text{MgF}_2$ Balanced
- $2\text{Al}(s) + 3\text{S}(s) \rightarrow \text{Al}_2\text{S}_3$
- $3\text{Ca}(s) + 2\text{P}(s) \rightarrow \text{Ca}_3\text{P}_2$

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

- $2\text{HgO}(s) \rightarrow 2\text{Hg} + \text{O}_2$
- $\text{CuCl}_2(s) \rightarrow \text{Cu} + \text{Cl}_2$ Balanced
- $2\text{Al}_2\text{O}_3(s) \rightarrow 4\text{Al} + 3\text{O}_2$

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

- $\text{Zn}(s) + \text{Pb}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{Zn}(\text{NO}_3)_2 + \text{Pb}$ Balanced
- $2\text{Al}(s) + 3\text{NiSO}_4(\text{aq}) \rightarrow \text{Al}_2(\text{SO}_4)_3 + 3\text{Ni}$
- $2\text{Na}(s) + 2\text{H}_2\text{O}(l) \rightarrow 2\text{NaOH} + \text{H}_2$
- $\text{F}_2(g) + 2\text{NaCl}(aq) \rightarrow 2\text{NaF} + \text{Cl}_2$

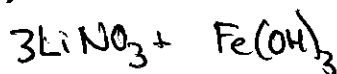
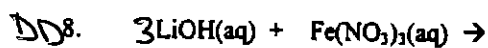
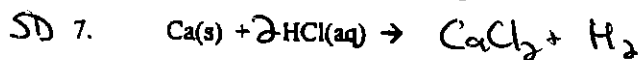
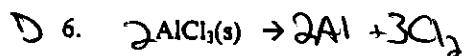
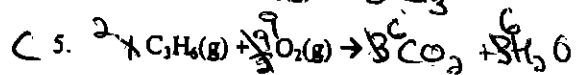
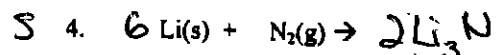
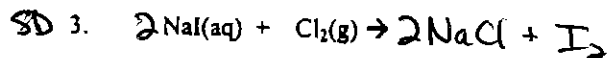
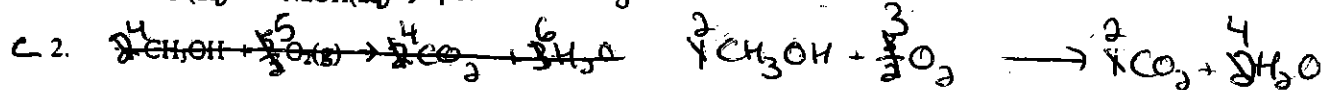
D) For the following double displacement reactions, complete the chemical equation and balance the equation.

- $2\text{AgNO}_3(\text{aq}) + \text{CaCl}_2(\text{aq}) \rightarrow \text{Ca}(\text{NO}_3)_2 + 2\text{AgCl}$
- $2\text{KOH}(\text{aq}) + \text{ZnCl}_2(\text{aq}) \rightarrow 2\text{KCl} + \text{Zn}(\text{OH})_2$
- $\text{FeS}(s) + 2\text{HCl}(\text{aq}) \rightarrow \text{FeCl}_2 + \text{H}_2\text{S}$
- $3\text{CoCl}_2(\text{aq}) + 2\text{Na}_3\text{PO}_4(\text{aq}) \rightarrow \text{Co}_3(\text{PO}_4)_2 + 6\text{NaCl}$

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

- $\text{C}_7\text{H}_{16}(g) + 11\text{O}_2(g) \rightarrow 7\text{CO}_2 + 8\text{H}_2\text{O}$
- $2\text{C}_2\text{H}_2(g) + 5\text{O}_2(g) \rightarrow 4\text{CO}_2 + 2\text{H}_2\text{O}$
- $2\text{C}_3\text{H}_8\text{O}(g) + 9\text{O}_2(g) \rightarrow 6\text{CO}_2 + 8\text{H}_2\text{O}$
- $\text{C}_{12}\text{H}_{22}\text{O}_{11} + 12\text{O}_2 \rightarrow 12\text{CO}_2 + 11\text{H}_2\text{O}$

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.



Stoichiometry: Mole-Mole Calculations

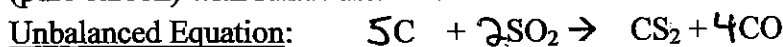
1. How many moles of CO_2 form when 3 moles of oxygen (O_2) burn with sufficient amount of propane? Unbalanced Equation: $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$

$$3 \cancel{\text{ mol O}_2} \left(\frac{3 \text{ mol CO}_2}{5 \cancel{\text{ mol O}_2}} \right) = \underline{1.8 \text{ mol O}_2 \text{ will form}}$$

2. How many moles of chlorine, Cl_2 , are required to form 0.90 moles of sodium chloride, NaCl ? Unbalanced Equation: $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$

$$0.90 \cancel{\text{ mol NaCl}} \left(\frac{1 \text{ mol Cl}_2}{2 \cancel{\text{ mol NaCl}}} \right) = \underline{0.45 \text{ mol Cl}_2 \text{ needed}}$$

3. Carbon disulfide is an important industrial solvent. It is prepared by the reaction of coke (pure carbon) with sulfur dioxide.



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

$$6.30 \cancel{\text{ mol C}} \left(\frac{1 \text{ mol CS}_2}{5 \cancel{\text{ mol C}}} \right) = \underline{1.26 \text{ mol CS}_2 \text{ form}}$$

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

$$7.24 \cancel{\text{ mol SO}_2} \left(\frac{5 \text{ mol C}}{2 \cancel{\text{ mol SO}_2}} \right) = \underline{18.1 \text{ mol C}}$$

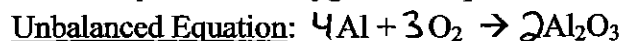
- c. How many moles of carbon monoxide form at the same time that 0.762 moles of CS_2 forms?

$$0.762 \cancel{\text{ mol CS}_2} \left(\frac{4 \text{ mol CO}}{1 \cancel{\text{ mol CS}_2}} \right) = \underline{3.048 \text{ mol CO}}$$

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

$$182 \cancel{\text{ mol CS}_2} \left(\frac{2 \text{ mol SO}_2}{1 \cancel{\text{ mol CS}_2}} \right) = \underline{364 \text{ mol SO}_2}$$

4. How many moles of oxygen are required to react completely with 0.84 moles of Al?



$$0.84 \cancel{\text{ mol Al}} \left(\frac{3 \text{ mol O}_2}{4 \cancel{\text{ mol Al}}} \right) = \underline{0.63 \text{ mol O}_2}$$

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: $2\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$

$$5.40 \text{ g H}_2 \left(\frac{1 \text{ mol H}_2}{2 \text{ g H}_2} \right) \left(\frac{2 \text{ mol NH}_3}{3 \text{ mol H}_2} \right) \left(\frac{17 \text{ g NH}_3}{1 \text{ mol NH}_3} \right) = \underline{30.6 \text{ g NH}_3}$$

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

$$30.6 \text{ g NH}_3 \left(\frac{1 \text{ mol NH}_3}{17 \text{ g NH}_3} \right) \left(\frac{2 \text{ mol N}_2}{2 \text{ mol NH}_3} \right) \left(\frac{28 \text{ g N}_2}{1 \text{ mol N}_2} \right) = \underline{50.4 \text{ g N}_2}$$

3. Acetylene gas, C_2H_2 , is produced by adding water to calcium carbide, CaC_2 .
Unbalanced Equation: $\text{CaC}_2 + 2\text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_2 + \text{Ca(OH)}_2$

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

$$49.0 \text{ g H}_2\text{O} \left(\frac{1 \text{ mol H}_2\text{O}}{18 \text{ g}} \right) \left(\frac{1 \text{ mol CaC}_2}{2 \text{ mol H}_2\text{O}} \right) = \underline{1.36 \text{ mol CaC}_2}$$

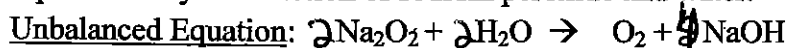
- b. How many grams of acetylene are produced by adding water to 5.00 grams of CaC_2 ?

$$5.00 \text{ g CaC}_2 \left(\frac{1 \text{ mol CaC}_2}{64 \text{ g CaC}_2} \right) \left(\frac{1 \text{ mol C}_2\text{H}_2}{1 \text{ mol CaC}_2} \right) \left(\frac{26 \text{ g}}{1 \text{ mol C}_2\text{H}_2} \right) = \underline{2.03 \text{ g C}_2\text{H}_2}$$

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

$$0.89 \text{ mol C}_2\text{H}_2 \left(\frac{1 \text{ mol Ca(OH)}_2}{1 \text{ mol C}_2\text{H}_2} \right) \left(\frac{74 \text{ g Ca(OH)}_2}{1 \text{ mol Ca(OH)}_2} \right) = \underline{65.86 \text{ g Ca(OH)}_2}$$

4. Oxygen is produced by the reaction of sodium peroxide and water.



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

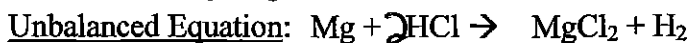
$$4.80 \text{ g O}_2 \left(\frac{1 \text{ mol O}_2}{32 \text{ g O}_2} \right) \left(\frac{2 \text{ mol Na}_2\text{O}_2}{1 \text{ mol O}_2} \right) \left(\frac{78 \text{ g Na}_2\text{O}_2}{1 \text{ mol Na}_2\text{O}_2} \right) = \underline{23.4 \text{ g Na}_2\text{O}_2}$$

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

$$4.80 \text{ g O}_2 \left(\frac{1 \text{ mol O}_2}{32 \text{ g O}_2} \right) \left(\frac{4 \text{ mol NaOH}}{1 \text{ mol O}_2} \right) \left(\frac{40 \text{ g NaOH}}{1 \text{ mol NaOH}} \right) = \underline{24.0 \text{ g NaOH}}$$

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?



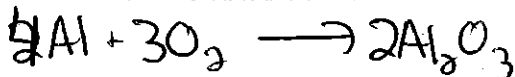
$$0.6 \text{ g Mg} \left(\frac{1 \text{ mol Mg}}{24.3 \text{ g}} \right) \left(\frac{1 \text{ mol H}_2}{1 \text{ mol Mg}} \right) \left(\frac{2 \text{ g}}{1 \text{ mol H}_2} \right) = \boxed{0.0494 \text{ g H}_2}$$

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?



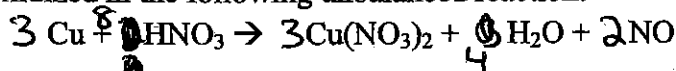
$$12 \text{ g C} \left(\frac{1 \text{ mol C}}{12 \text{ g}} \right) \left(\frac{1 \text{ mol O}_2}{2 \text{ mol C}} \right) \left(\frac{32 \text{ g}}{1 \text{ mol O}_2} \right) = \boxed{16 \text{ g O}_2}$$

3. 2.16 grams of aluminum are burned in air. What mass of aluminum oxide, Al_2O_3 , is formed?



$$2.16 \text{ g Al} \left(\frac{1 \text{ mol Al}}{27 \text{ g}} \right) \left(\frac{2 \text{ mol Al}_2\text{O}_3}{4 \text{ mol Al}} \right) \left(\frac{102 \text{ g Al}_2\text{O}_3}{1 \text{ mol Al}_2\text{O}_3} \right) = \boxed{4.08 \text{ g Al}_2\text{O}_3}$$

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



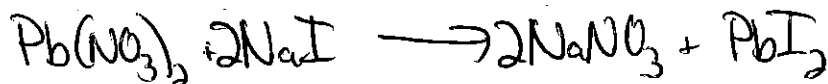
If 1.82 grams of copper are used, what mass of water will be formed?

$$1.82 \text{ g Cu} \left(\frac{1 \text{ mol Cu}}{63.55 \text{ g}} \right) \left(\frac{4 \text{ mol H}_2\text{O}}{3 \text{ mol Cu}} \right) \left(\frac{18 \text{ g}}{1 \text{ mol H}_2\text{O}} \right) = \boxed{0.687 \text{ g H}_2\text{O}}$$

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:



- 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?

$$25.0 \text{ g Pb}(\text{NO}_3)_2 \left(\frac{1 \text{ mol Pb}(\text{NO}_3)_2}{331.2 \text{ g}} \right) \left(\frac{2 \text{ mol NaNO}_3}{1 \text{ mol Pb}(\text{NO}_3)_2} \right) \left(\frac{85 \text{ g}}{1 \text{ mol NaNO}_3} \right) = 12.83 \text{ g NaNO}_3$$

$$15.0 \text{ g NaI} \left(\frac{1 \text{ mol NaI}}{150 \text{ g}} \right) \left(\frac{2 \text{ mol NaNO}_3}{2 \text{ mol NaI}} \right) \left(\frac{85 \text{ g}}{1 \text{ mol NaNO}_3} \right) = \boxed{8.50 \text{ g NaNO}_3}$$

Lesser amount will be formed

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

NaI is the limiting reagent.

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

$$15.0 \text{ g NaI} \left(\frac{1 \text{ mol NaI}}{150 \text{ g}} \right) \left(\frac{1 \text{ mol Pb}(\text{NO}_3)_2}{2 \text{ mol NaI}} \right) \left(\frac{331.2 \text{ g}}{1 \text{ mol Pb}(\text{NO}_3)_2} \right) = 16.56 \text{ g Pb}(\text{NO}_3)_2 \text{ needed in the reaction}$$

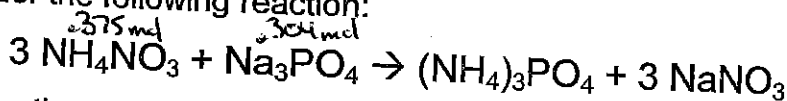
$25 - 16.56 = 8.44 \text{ g Pb}(\text{NO}_3)_2$ will be left over.

Limiting Reagent Worksheet

For the following reactions, find the following:

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

1) Consider the following reaction:



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

a) $30 \text{ g NH}_4\text{NO}_3 \left(\frac{1 \text{ mol NH}_4\text{NO}_3}{80 \text{ g}} \right) \left(\frac{1 \text{ mol } (\text{NH}_4)_3\text{PO}_4}{3 \text{ mol NH}_4\text{NO}_3} \right) \left(\frac{149 \text{ g}}{1 \text{ mol } (\text{NH}_4)_3\text{PO}_4} \right) = 18.625 \text{ g } (\text{NH}_4)_3\text{PO}_4$ ← Lesser amount Limiting reagent

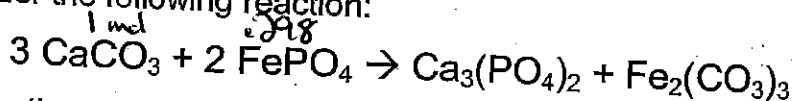
$50 \text{ g Na}_3\text{PO}_4 \left(\frac{1 \text{ mol Na}_3\text{PO}_4}{164 \text{ g}} \right) \left(\frac{1 \text{ mol } (\text{NH}_4)_3\text{PO}_4}{1 \text{ mol Na}_3\text{PO}_4} \right) \left(\frac{149 \text{ g}}{1 \text{ mol } (\text{NH}_4)_3\text{PO}_4} \right) = 45.427 \text{ g } (\text{NH}_4)_3\text{PO}_4$

b) $30 \text{ g NH}_4\text{NO}_3 \left(\frac{1 \text{ mol NH}_4\text{NO}_3}{80 \text{ g}} \right) \left(\frac{3 \text{ mol NaNO}_3}{3 \text{ mol NH}_4\text{NO}_3} \right) \left(\frac{85 \text{ g}}{1 \text{ mol NaNO}_3} \right) = 31.875 \text{ g NaNO}_3$

c) $30 \text{ g NH}_4\text{NO}_3 \left(\frac{1 \text{ mol NH}_4\text{NO}_3}{80 \text{ g}} \right) \left(\frac{1 \text{ mol Na}_3\text{PO}_4}{3 \text{ mol NH}_4\text{NO}_3} \right) \left(\frac{164 \text{ g}}{1 \text{ mol Na}_3\text{PO}_4} \right) = 20.5 \text{ g Na}_3\text{PO}_4 \text{ needed}$

$50 - 20.5 = 29.5 \text{ g Na}_3\text{PO}_4 \text{ is left over}$

2) Consider the following reaction:



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) $100 \text{ g CaCO}_3 \left(\frac{1 \text{ mol}}{100 \text{ g}} \right) = 1 \text{ mol CaCO}_3 \left(\frac{2 \text{ mol FePO}_4}{3 \text{ mol CaCO}_3} \right) = 0.667 \text{ mol FePO}_4 \text{ needed to react all of the CaCO}_3 - \text{not enough}$

$45 \text{ g FePO}_4 \left(\frac{1 \text{ mol}}{150.8} \right) = 2.98 \text{ mol FePO}_4$

FePO₄ is Limiting Reagent.

b) $45 \text{ g FePO}_4 \left(\frac{1 \text{ mol FePO}_4}{150.8 \text{ g}} \right) \left(\frac{1 \text{ mol Ca}_3(\text{PO}_4)_2}{2 \text{ mol FePO}_4} \right) \left(\frac{310 \text{ g}}{1 \text{ mol Ca}_3(\text{PO}_4)_2} \right) = 46.25 \text{ g Ca}_3(\text{PO}_4)_2 \text{ formed}$

$45 \text{ g FePO}_4 \left(\frac{1 \text{ mol FePO}_4}{150.8 \text{ g}} \right) \left(\frac{1 \text{ mol Fe}_2(\text{CO}_3)_3}{2 \text{ mol FePO}_4} \right) \left(\frac{291.6 \text{ g}}{1 \text{ mol Fe}_2(\text{CO}_3)_3} \right) = 43.51 \text{ g Fe}_2(\text{CO}_3)_3 \text{ formed}$

c) $45 \text{ g FePO}_4 \left(\frac{1 \text{ mol FePO}_4}{150.8 \text{ g}} \right) \left(\frac{3 \text{ mol CaCO}_3}{2 \text{ mol FePO}_4} \right) \left(\frac{100 \text{ g}}{1 \text{ mol CaCO}_3} \right) = 44.8 \text{ g CaCO}_3 \text{ needed}$

$100 - 44.8 = 145.2 \text{ g CaCO}_3 \text{ extra}$

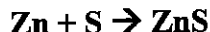
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Stoichiometry- Limiting Reactants & Percent Yield

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



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

- a. Which chemical is the limiting reactant (produces less ZnS)?

$$25.0 \text{ g Zn} \left(\frac{1 \text{ mol Zn}}{65.4 \text{ g}} \right) \left(\frac{1 \text{ mol ZnS}}{1 \text{ mol Zn}} \right) \left(\frac{97.4 \text{ g}}{1 \text{ mol ZnS}} \right) = 37.23 \text{ g ZnS}$$

← produces less ZnS,
Zn is Limiting
Reactant

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

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

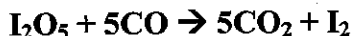
$$37.23 \text{ g ZnS} \quad (\text{see work in part a})$$

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

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

$$30 - 12.23 = \boxed{17.76 \text{ g excess S}}$$

2. Consider the reaction:



- 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.

$$80 \text{ g I}_2\text{O}_5 \left(\frac{1 \text{ mol I}_2\text{O}_5}{334 \text{ g}} \right) \left(\frac{1 \text{ mol I}_2}{1 \text{ mol I}_2\text{O}_5} \right) \left(\frac{254 \text{ g}}{1 \text{ mol I}_2} \right) = 60.84 \text{ g I}_2$$

$$28 \text{ g CO} \left(\frac{1 \text{ mol CO}}{28 \text{ g}} \right) \left(\frac{1 \text{ mol I}_2}{5 \text{ mol CO}} \right) \left(\frac{254 \text{ g}}{1 \text{ mol I}_2} \right) = 50.8 \text{ g I}_2 \leftarrow \text{Limiting Reactant}$$

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

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

3. Consider the reaction $2\text{Al} + 3\text{S} \rightarrow \text{Al}_2\text{S}_3$.

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

$$5 \text{ g Al} \left(\frac{1 \text{ mol Al}}{27 \text{ g Al}} \right) \left(\frac{1 \text{ mol Al}_2\text{S}_3}{2 \text{ mol Al}} \right) \left(\frac{150 \text{ g Al}_2\text{S}_3}{1 \text{ mol Al}_2\text{S}_3} \right) = \boxed{13.89 \text{ g Al}_2\text{S}_3} \text{ - Smaller amount.}$$

$$10 \text{ g S} \left(\frac{1 \text{ mol S}}{32 \text{ g S}} \right) \left(\frac{1 \text{ mol Al}_2\text{S}_3}{3 \text{ mol S}} \right) \left(\frac{150 \text{ g Al}_2\text{S}_3}{1 \text{ mol Al}_2\text{S}_3} \right) = 15.625 \text{ g Al}_2\text{S}_3$$

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

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

Percent, Actual, and Theoretical Yield

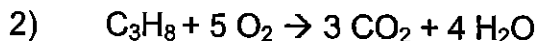


a) I began this reaction with 20 grams of lithium hydroxide. What is my theoretical yield of lithium chloride?

$$20 \text{ g LiOH} \left(\frac{1 \text{ mol LiOH}}{23.94 \text{ g}} \right) \left(\frac{1 \text{ mol LiCl}}{1 \text{ mol LiOH}} \right) \left(\frac{42.44 \text{ g}}{1 \text{ mol LiCl}} \right) = \boxed{35.45 \text{ g LiCl}}$$

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

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



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

$$5 \text{ g C}_3\text{H}_8 \left(\frac{1 \text{ mol C}_3\text{H}_8}{44 \text{ g}} \right) \left(\frac{4 \text{ mol H}_2\text{O}}{1 \text{ mol C}_3\text{H}_8} \right) \left(\frac{18 \text{ g}}{1 \text{ mol H}_2\text{O}} \right) = \underline{8.18 \text{ g H}_2\text{O}}$$

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

$$\text{Actual Yield} = \left(\frac{\% \text{ Yield}}{100} \right) \times \text{Theoretical} = \left(\frac{75}{100} \right) \times 8.18 = \underline{6.14 \text{ g H}_2\text{O}}$$



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

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



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

$$20 \text{ g CaO} \left(\frac{1 \text{ mol CaO}}{56 \text{ g}} \right) \left(\frac{1 \text{ mol Na}_2\text{O}}{1 \text{ mol CaO}} \right) \left(\frac{62 \text{ g}}{1 \text{ mol Na}_2\text{O}} \right) = \underline{22.1 \text{ g Na}_2\text{O}}$$

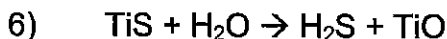


a) What is my theoretical yield of iron (II) chloride if I start with 34 grams of iron (II) bromide?

$$34 \text{ g FeBr}_2 \left(\frac{1 \text{ mol FeBr}_2}{215.6 \text{ g}} \right) \left(\frac{1 \text{ mol FeCl}_2}{1 \text{ mol FeBr}_2} \right) \left(\frac{126.8 \text{ g}}{1 \text{ mol FeCl}_2} \right) = \boxed{20.0 \text{ g FeCl}_2}$$

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

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



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?

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

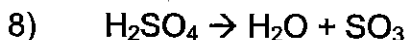
$$\% \text{ Yield} = \frac{22 \text{ g}}{16 \text{ g}} \times 100 = 137.5\%$$



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

$$100 \text{ g U} \left(\frac{1 \text{ mol U}}{238 \text{ g}} \right) \left(\frac{1 \text{ mol UBr}_6}{1 \text{ mol U}} \right) \left(\frac{717.4 \text{ g}}{1 \text{ mol UBr}_6} \right) = 301.4 \text{ g UBr}_6$$

$$\text{Actual} = (301.4) \times .83 = \boxed{250 \text{ g UBr}_6}$$



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

$$89 \text{ g H}_2\text{SO}_4 \left(\frac{1 \text{ mol H}_2\text{SO}_4}{98 \text{ g}} \right) \left(\frac{1 \text{ mol H}_2\text{O}}{1 \text{ mol H}_2\text{SO}_4} \right) \left(\frac{18 \text{ g}}{1 \text{ mol H}_2\text{O}} \right) = 16.34 \text{ g H}_2\text{O} - \text{theoretical}$$

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