

## Chapter 9 – Stoichiometry

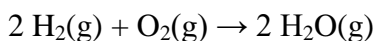
Chapter 9: 1, 3, 4, 6, 8 – 19, 22 – 32, 38, 43 – 46, 53, 55, 56

### Practice Problems

1. How many tricycle seats, wheels, and pedals are needed to make 288 tricycles?

Seats                                  wheels                                  pedals

3. Interpret the equation for the formation of water from its elements in terms of (a) numbers of molecules, (b) numbers of moles, and (3) volumes of gases at STP.



a. # of molecules:

b. # of moles:

c. Volumes of gases at STP:

4. Balance the equation for the combustion of acetylene:  $\text{C}_2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$

Then, interpret the equation in terms of (a) relative numbers of moles, (b) volumes of gases at STP, and (c) masses of reactants and products.

a.

b.

c.

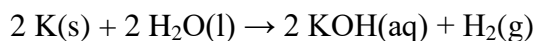
### Section Review 9.1

6. Balance this equation:  $\text{C}_2\text{H}_5\text{OH}(\text{l}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$ .

a. Interpret the equation in terms of numbers of molecules and moles.

b. Show that the balanced equation obeys the law of conservation of mass.

8. Interpret the following equation in terms of (a) relative numbers of representative particles, (b) numbers of moles, and (c) masses of reactants and products.



a.

b.

c.

### Practice Problems – Mole-Mole Calculations

9. This equation shows the formation of aluminum oxide:  $4 \text{Al(s)} + 3 \text{O}_2\text{(g)} \rightarrow 2 \text{Al}_2\text{O}_3\text{(s)}$

a. write out the six mole ratios that can be derived from this equation.

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b. How many moles of aluminum are needed to form 3.7 mol  $\text{Al}_2\text{O}_3$ ?

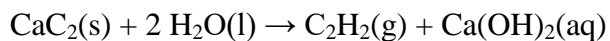
10. According to the equation in Problem 9:

a. How many moles of oxygen are required to react completely with 14.8 mol Al?

b. How many moles of  $\text{Al}_2\text{O}_3$  are formed when 0.78 mol  $\text{O}_2$  reacts with aluminum?

### Practice Problems – Mass-Mass Calculations

11. Acetylene gas ( $\text{C}_2\text{H}_2$ ) is produced by adding water to calcium carbide ( $\text{CaC}_2$ ).



How many grams of acetylene are produced by adding water to 5.00 g of  $\text{CaC}_2$ ?

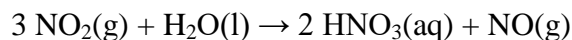
12. Using the same equation from Problem #11, determine how many moles of  $\text{CaC}_2$  are needed to react completely with 49.0 g  $\text{H}_2\text{O}$ .

### Practice Problems – Other Stoichiometric Calculations

13. How many molecules of oxygen are produced by the decomposition of 6.54 g of potassium chlorate (KClO<sub>3</sub>)?

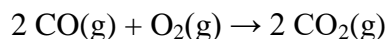


14. The last step in the production of nitric acid is the reaction of nitrogen dioxide with water:



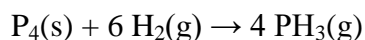
How many grams of nitrogen dioxide must react with water to produce  $5.00 \times 10^{22}$  molecules of nitrogen monoxide?

15. The equation for the combustion of carbon monoxide is:



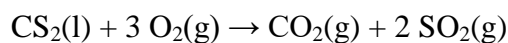
How many liters of oxygen are required to burn 3.86 L of carbon monoxide?

16. Phosphorus and hydrogen can be combined to form phosphine (PH<sub>3</sub>):



How many liters of phosphine are formed when 0.42 L of hydrogen reacts with phosphorus?

17. Consider this equation:

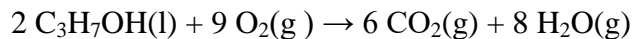


Calculate the volume of sulfur dioxide produced when 27.9 mL O<sub>2</sub> reacts with carbon disulfide.

18. From the equation in Problem 17, calculate the number of deciliters of carbon dioxide produced when 0.38 L SO<sub>2</sub> is formed.

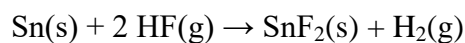
## Section Review 9.2

19. Isopropyl alcohol ( $\text{C}_3\text{H}_7\text{OH}$ ) burns in air according to this equation:



- Calculate the moles of oxygen needed to react with 3.40 mol  $\text{C}_3\text{H}_7\text{OH}$ .
- Find the moles of each product formed when 3.40 mol  $\text{C}_3\text{H}_7\text{OH}$  reacts with oxygen.

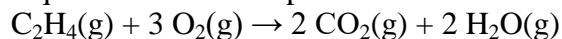
22. Tin(II) fluoride, formerly found in many kinds of toothpaste, is formed in this reaction:



- How many liters of HF are needed to produce 9.40 L of  $\text{H}_2$  at STP?
- How many molecules of  $\text{H}_2$  are produced by reaction of tin with 20.0 L HF at STP?
- How many grams of  $\text{SnF}_2$  can be made by reacting  $7.42 \times 10^{24}$  molecules of HF with tin?

## Practice Problems – Limiting Reagent

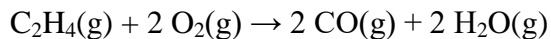
23. The equation for the complete combustion of ethene ( $\text{C}_2\text{H}_4$ ) is:



If 2.70 mol  $\text{C}_2\text{H}_4$  is reacted with 6.30 mol  $\text{O}_2$ ,

- identify the limiting reagent.
- calculate the moles of water produced.

24. The equation for the incomplete combustion of ethene (C<sub>2</sub>H<sub>4</sub>) is:

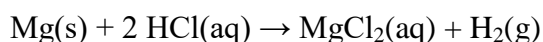


If 2.70 mol C<sub>2</sub>H<sub>4</sub> is reacted with 6.30 mol O<sub>2</sub>,

a. identify the limiting reagent.

b. calculate the moles of water produced.

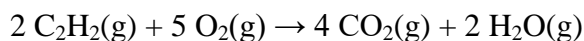
25. Hydrogen gas can be produced in the laboratory by the reaction of magnesium metal with hydrochloric acid.



a. identify the limiting reagent when 6.00 g HCl reacts with 5.00 g Mg.

b. How many grams of hydrogen can be produced when 6.00 g HCl is added to 5.00 g Mg?

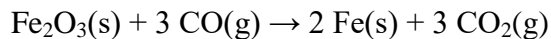
26. Acetylene (C<sub>2</sub>H<sub>2</sub>) will burn in the presence of oxygen:



How many grams of water can be produced by the reaction of 2.40 mol C<sub>2</sub>H<sub>2</sub> with 7.4 mol O<sub>2</sub>?

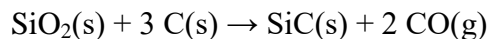
### Practice Problems – Percent Yield

27. When 84.8 g of iron(III) oxide reacts with an excess of carbon monoxide, 54.3 g of iron is produced according to the reaction:



What is the percent yield of this reaction?

28. If 50.0 g of silicon dioxide is heated with an excess of carbon, 27.9 g of silicon carbide is produced.

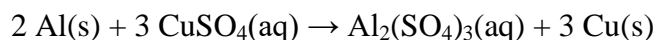


What is the percent yield of this reaction?

### Section Review 9.3

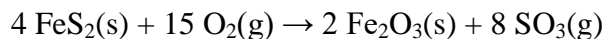
29. What is a limiting reagent? An excess reagent?

30. What is the percent yield if 4.65 g of copper is produced when 1.87 g of aluminum reacts with an excess of copper(II) sulfate?



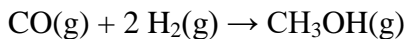
31. What is the difference between an actual yield and a theoretical yield? Which yield is larger for a given reaction? How are these values used to determine percent yield?

32. How many grams of  $\text{SO}_3$  are produced when 20.0 g  $\text{FeS}_2$  reacts with 16.0 g  $\text{O}_2$  according to:



Chapter 9 Review

38. Methanol (CH<sub>3</sub>OH) is used in the production of many chemicals. Methanol is made by reacting carbon monoxide and hydrogen at a high temperature and pressure. 9.2



a. How many moles of each reactant are needed to produce  $3.60 \times 10^2$  g CH<sub>3</sub>OH?

b. Calculate the number of grams of each reactant needed to produce 4.00 mol CH<sub>3</sub>OH.

c. How many grams of hydrogen are necessary to react with 2.85 mol CO?

43. Explain how you would identify a limiting reagent in a chemical reaction. 9.3

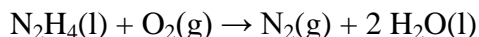
44. For each balanced equation, identify by *circling* the limiting reagent for the given combination of reactants. 9.3. *You may do your work on the back of this page.*

				# moles formed (#45)	excess (#46)		
a.	2 Al	+	3 Cl <sub>2</sub>	→	2 AlCl <sub>3</sub>	_____	_____
	3.6 mol		5.3 mol				
b.	2 H <sub>2</sub>	+	O <sub>2</sub>	→	2 H <sub>2</sub> O	_____	_____
	6.4 mol		3.4 mol				
c.	2 P <sub>2</sub> O <sub>5</sub>	+	6 H <sub>2</sub> O	→	4 H <sub>3</sub> PO <sub>4</sub>	_____	_____
	0.48 mol		1.52 mol				
d.	4 P	+	5 O <sub>2</sub>	→	2 P <sub>2</sub> O <sub>5</sub>	_____	_____
	14.5 mol		18.0 mol				

45. For each reaction in Problem 44, calculate the number of moles of product formed, and write next to the symbol for the products, as indicated above. 9.3

46. For each reaction in Problem 44, calculate the number of moles of excess reagent remaining after the reaction, and write as indicated above. 9.3

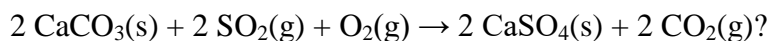
53. Hydrazine ( $\text{N}_2\text{H}_4$ ) is used as rocket fuel. It reacts with oxygen to form nitrogen and water.



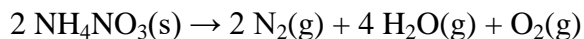
a. How many liters of  $\text{N}_2$  (at STP) form when 1.0 kg  $\text{N}_2\text{H}_4$  reacts with 1.0 kg  $\text{O}_2$ ?

b. How many grams of the excess reagent remain after the reaction?

55. If the reaction below proceeds with a 96.8 % yield, how many kilograms of  $\text{CaSO}_4$  are formed when 5.24 kg  $\text{SO}_2$  reacts with an excess of  $\text{CaCO}_3$  and  $\text{O}_2$ ?



56. Ammonium nitrate, marketed online as “Terrorists Choice,” will decompose explosively at high temperatures to form nitrogen, oxygen, and water vapor.



What is the total number of liters of gas formed when 228 g  $\text{NH}_4\text{NO}_3$  is decomposed? Assume STP.