

## 8.9: Exercises

### 8.3: Stoichiometry and the Molar Interpretation

1. What are all the conversion factors that can be constructed from the balanced chemical reaction:  $2 \text{S(s)} + 3 \text{O}_2\text{(g)} \rightarrow 2 \text{SO}_3\text{(g)}$ ?

**Answer**

$$\frac{2 \text{ mol S}}{3 \text{ mol O}_2}, \frac{3 \text{ mol O}_2}{2 \text{ mol S}}, \frac{1 \text{ mol S}}{1 \text{ mol SO}_3}, \frac{1 \text{ mol SO}_3}{1 \text{ mol S}}, \frac{3 \text{ mol O}_2}{2 \text{ mol SO}_3}, \frac{2 \text{ mol SO}_3}{3 \text{ mol O}_2}$$

2. Construct the three independent conversion factors possible for these two reactions:

- a.  $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$   
b.  $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}_2$

Why are the ratios between  $\text{H}_2$  and  $\text{O}_2$  different?

**Answer**

The conversion factors are different because the stoichiometries of the balanced chemical reactions are different.

### 8.4: Molar Ratios and Mole-to-Mole Conversions

3. Given the chemical equation:  $\text{Na(s)} + \text{H}_2\text{O(l)} \rightarrow \text{NaOH(aq)} + \text{H}_2\text{(g)}$
- a. Balance the equation.  
b. How many moles of  $\text{H}_2$  are produced when 332 moles of Na react?

**Answer**

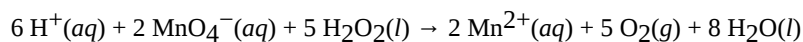
- a.  $2 \text{Na(s)} + 2 \text{H}_2\text{O(l)} \rightarrow 2 \text{NaOH(aq)} + \text{H}_2\text{(g)}$   
b. 166 mol  $\text{H}_2$

4. Given the chemical equation:  $\text{S(s)} + \text{O}_2\text{(g)} \rightarrow \text{SO}_3\text{(g)}$
- a. Balance the equation.  
b. How many moles of  $\text{O}_2$  are needed when 38 moles of S react?

**Answer**

- a.  $2 \text{S(s)} + 3 \text{O}_2\text{(g)} \rightarrow 2 \text{SO}_3\text{(g)}$   
b. 57 mol  $\text{O}_2$

5. For the balanced chemical equation:

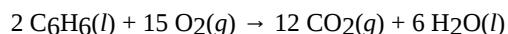


how many moles of  $\text{H}_2\text{O}$  are produced when 75 moles of  $\text{H}_2\text{O}_2$  react?

**Answer**

120 mol  $\text{H}_2\text{O}$

6. For the balanced chemical reaction:

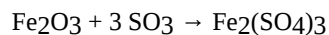


how many moles of  $\text{CO}_2$  are produced when 56 moles of  $\text{C}_6\text{H}_6$  react?

**Answer**

$$3.4 \times 10^2 \text{ mol CO}_2$$

7. For the balanced chemical equation:

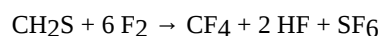


suppose we need to make 145 moles of  $\text{Fe}_2(\text{SO}_4)_3$ . How many moles of  $\text{SO}_3$  do we need?

**Answer**

$$435 \text{ mol SO}_3$$

8. One way to make sulfur hexafluoride is to react thioformaldehyde,  $\text{CH}_2\text{S}$ , with elemental fluorine:

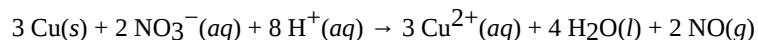


If 45.8 moles of  $\text{SF}_6$  are needed, how many moles of  $\text{F}_2$  are required?

**Answer**

$$275 \text{ mol F}_2$$

9. For the balanced chemical equation:

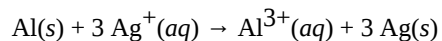


how many moles of  $\text{Cu}^{2+}$  are formed when 55.7 mol of  $\text{H}^+$  are reacted?

**Answer**

$$20.9 \text{ mol Cu}^{2+}$$

10. For the balanced chemical equation:

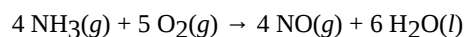


how many moles of Ag are produced when 0.661 mol of Al are reacted?

**Answer**

$$1.98 \text{ mol Ag}$$

11. For the balanced chemical reaction:

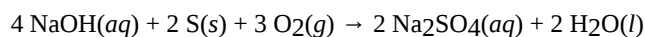


how many moles of  $\text{H}_2\text{O}$  are produced when 0.669 mol of  $\text{NH}_3$  react?

**Answer**

$$1.00 \text{ mol H}_2\text{O}$$

12. For the balanced chemical reaction:

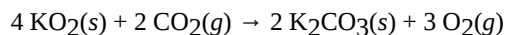


how many moles of  $\text{Na}_2\text{SO}_4$  are formed when 1.22 mol of  $\text{O}_2$  react?

**Answer**

0.813 mol  $\text{Na}_2\text{SO}_4$

13. For the balanced chemical reaction:

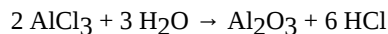


determine the number of moles of both products formed when 6.88 mol of  $\text{KO}_2$  react.

**Answer**

3.44 mol  $\text{K}_2\text{CO}_3$ ; 5.16 mol  $\text{O}_2$

14. For the balanced chemical reaction



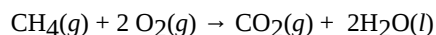
determine the number of moles of both products formed when 0.0552 mol of  $\text{AlCl}_3$  react.

**Answer**

0.0276 mol  $\text{Al}_2\text{O}_3$ ; 0.166 mol  $\text{HCl}$

### 8.5: Mass-to-Mass Conversions

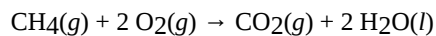
15. What mass of  $\text{CO}_2$  is produced by the combustion of 1.00 mol of  $\text{CH}_4$ ?



**Answer**

44.0 g  $\text{CO}_2$

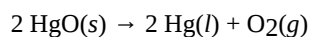
16. What mass of  $\text{H}_2\text{O}$  is produced by the combustion of 1.00 mol of  $\text{CH}_4$ ?



**Answer**

36.0 g  $\text{H}_2\text{O}$

17. What mass of  $\text{HgO}$  is required to produce 0.692 mol of  $\text{O}_2$ ?



**Answer**

$3.00 \times 10^2$  g  $\text{HgO}$

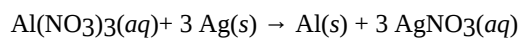
18. What mass of  $\text{NaHCO}_3$  is needed to produce 2.659 mol of  $\text{CO}_2$ ?



**Answer**

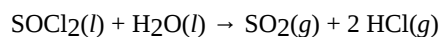
446.8 g  $\text{NaHCO}_3$

19. How many moles of Al can be produced from 10.87 g of Ag?

**Answer**

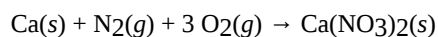
0.03359 mol Al

20. How many moles of HCl can be produced from 0.226 g of  $\text{SOCl}_2$ ?

**Answer**

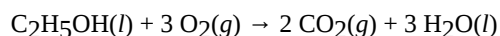
$3.80 \times 10^{-3}$  mol HCl

21. How many moles of  $\text{O}_2$  are needed to prepare 1.00 g of  $\text{Ca}(\text{NO}_3)_2$ ?

**Answer**

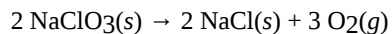
0.0183 mol  $\text{O}_2$

22. How many moles of  $\text{C}_2\text{H}_5\text{OH}$  are needed to generate 106.7 g of  $\text{H}_2\text{O}$ ?

**Answer**

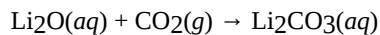
1.974 mol  $\text{C}_2\text{H}_5\text{OH}$

23. What mass of  $\text{O}_2$  can be generated by the decomposition of 100.0 g of  $\text{NaClO}_3$ ?

**Answer**

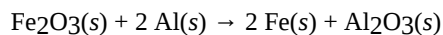
45.10 g  $\text{O}_2$

24. What mass of  $\text{Li}_2\text{O}$  is needed to react with 1,060 g of  $\text{CO}_2$ ?

**Answer**

$7.20 \times 10^2$  g  $\text{Li}_2\text{O}$

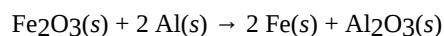
25. What mass of  $\text{Fe}_2\text{O}_3$  must be reacted to generate 324 g of  $\text{Al}_2\text{O}_3$ ?



**Answer**

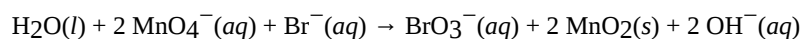
507 g Fe<sub>2</sub>O<sub>3</sub>

26. What mass of Fe is generated when 100.0 g of Al are reacted?

**Answer**

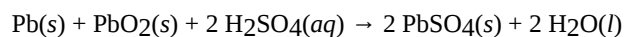
207.0 g Fe

27. What mass of MnO<sub>2</sub> is produced when 445 g of H<sub>2</sub>O are reacted?

**Answer**

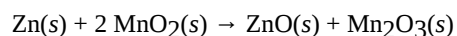
4290 g MnO<sub>2</sub>

28. What mass of PbSO<sub>4</sub> is produced when 29.6 g of H<sub>2</sub>SO<sub>4</sub> are reacted?

**Answer**

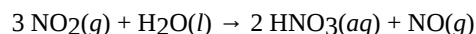
91.5 g PbSO<sub>4</sub>

29. If 83.9 g of ZnO are formed, what mass of Mn<sub>2</sub>O<sub>3</sub> is formed with it?

**Answer**

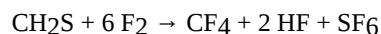
163 g Mn<sub>2</sub>O<sub>3</sub>

30. If 14.7 g of NO<sub>2</sub> are reacted, what mass of H<sub>2</sub>O is reacted with it?

**Answer**

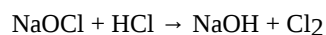
1.92 g H<sub>2</sub>O

31. If 88.4 g of CH<sub>2</sub>S are reacted, what mass of HF is produced?

**Answer**

76.7 g HF

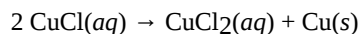
32. If 100.0 g of Cl<sub>2</sub> are needed, what mass of NaOCl must be reacted?



**Answer**

105.0 g NaOCl

33. Calculate the mass of each product when 100.0 g of CuCl react according to the reaction

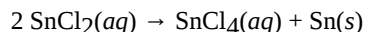


What do you notice about the sum of the masses of the products? What concept is being illustrated here?

**Answer**

67.90 g CuCl<sub>2</sub>; 32.10 g Cu; the sum is 100.0 g; this agrees with the Law of Conservation of Mass

34. Calculate the mass of each product when 500.0 g of SnCl<sub>2</sub> react according to the reaction

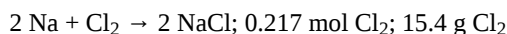


What do you notice about the sum of the masses of the products? What concept is being illustrated here?

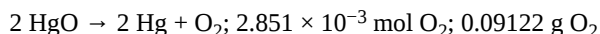
**Answer**

343.5 g SnCl<sub>4</sub>; 156.5 g Sn; the sum is 500.0 g; this agrees with the Law of Conservation of Mass

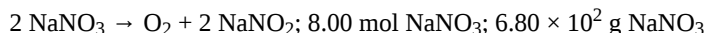
35. Write the balanced equation and then determine the number of moles and the mass of chlorine, Cl<sub>2</sub>, required to react with 10.0 g of sodium metal, Na, to produce sodium chloride, NaCl.

**Answer**

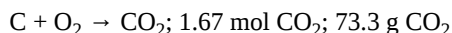
36. Write the balanced equation and then determine the number of moles and the mass of oxygen formed by the decomposition of 1.252 g of mercury(II) oxide.

**Answer**

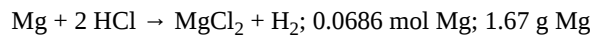
37. Write the balanced equation and then determine the number of moles and the mass of sodium nitrate, NaNO<sub>3</sub>, required to produce 128 g of oxygen. (NaNO<sub>2</sub> is the other product.)

**Answer**

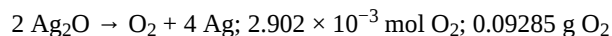
38. Write the balanced equation and then determine the number of moles and the mass of carbon dioxide formed by the combustion of 20.0 g of carbon in an excess of oxygen.

**Answer**

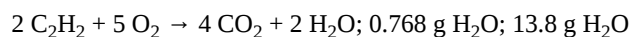
39. Write the balanced equation and then determine the number of moles and the mass of Mg required to react with 5.00 g of HCl and produce MgCl<sub>2</sub> and H<sub>2</sub>.

**Answer**

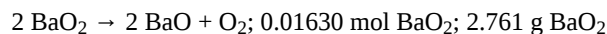
40. Write the balanced equation and then determine the number of moles and the mass of oxygen formed by the decomposition of 1.252 g of silver(I) oxide.

**Answer**

41. Write the balanced equation and then determine the number of moles and the mass of water formed by the combustion of 20.0 g of acetylene,  $\text{C}_2\text{H}_2$ , in an excess of oxygen.

**Answer**

42. Write the balanced equation and then determine the number of moles and the mass of barium peroxide,  $\text{BaO}_2$ , needed to produce 2.500 g of barium oxide,  $\text{BaO}$  ( $\text{O}_2$  is the other product.)

**Answer**

43.  $\text{I}_2$  is produced by the reaction of 0.4235 mol of  $\text{CuCl}_2$  according to the following equation:  $2 \text{CuCl}_2 + 4 \text{KI} \rightarrow 2 \text{CuI} + 4 \text{KCl} + \text{I}_2$
- How many moles of  $\text{I}_2$  are produced?
  - What mass of  $\text{I}_2$  is produced?

**Answer**

- 0.2118 mol  $\text{I}_2$
- 53.74 g  $\text{I}_2$

44. Silver is often extracted from ores as  $\text{K}[\text{Ag}(\text{CN})_2]$  and then recovered by the reaction:  $2 \text{K}[\text{Ag}(\text{CN})_2] + \text{Zn} \rightarrow 2 \text{Ag} + \text{Zn}(\text{CN})_2 + 2 \text{KCN}$
- How many moles of  $\text{Zn}(\text{CN})_2$  are produced by the reaction of 35.27 g of  $\text{K}[\text{Ag}(\text{CN})_2]$ ?
  - What mass of  $\text{Zn}(\text{CN})_2$  is produced?

**Answer**

- 0.08861 mol  $\text{Zn}(\text{CN})_2$
- 10.41 g  $\text{Zn}(\text{CN})_2$

## 8.6: Limiting Reactants and Excess Reactants

45. Given the statement “20.0 g of methane is burned in excess oxygen,” is it obvious which reactant is the limiting reactant?

**Answer**

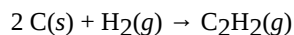
Yes. If oxygen is in excess, the methane must be the limiting reactant.

46. Given the statement “the metal is heated in the presence of excess hydrogen,” is it obvious which substance is the limiting reactant despite not specifying any quantity of reactant?

**Answer**

Yes. If the hydrogen is in excess, the metal must be the limiting reactant.

47. Acetylene ( $\text{C}_2\text{H}_2$ ) is formed by reacting 7.08 g of C and 4.92 g of  $\text{H}_2$ .

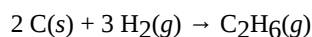


What is the limiting reactant? How many grams of  $\text{C}_2\text{H}_2$  are produced?

**Answer**

Limiting reactant = C; 7.67 g  $\text{C}_2\text{H}_2$

48. Ethane ( $\text{C}_2\text{H}_6$ ) is formed by reacting 7.08 g of C and 4.92 g of  $\text{H}_2$ .

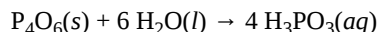


What is the limiting reactant? How many grams of  $\text{C}_2\text{H}_6$  are produced?

**Answer**

Limiting reactant = C; 8.86 g  $\text{C}_2\text{H}_6$

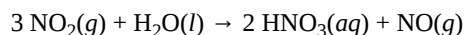
49. If 35.6 g of  $\text{P}_4\text{O}_6$  is reacted with 4.77 g of  $\text{H}_2\text{O}$ , what is the limiting reactant, and what mass of  $\text{H}_3\text{PO}_3$  is produced?



**Answer**

Limiting reactant =  $\text{H}_2\text{O}$ ; 14.5 g  $\text{H}_3\text{PO}_3$

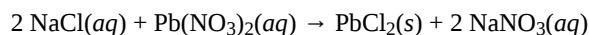
50. If 377 g of  $\text{NO}_2$  is reacted with 244 g of  $\text{H}_2\text{O}$ , what is the limiting reactant, and how many grams of  $\text{HNO}_3$  and  $\text{NO}$  are produced?



**Answer**

Limiting reactant =  $\text{NO}_2$ ; 344 g  $\text{HNO}_3$  and 82.0 g  $\text{NO}$

51. To form the precipitate  $\text{PbCl}_2$ , 2.88 g of  $\text{NaCl}$  and 7.21 g of  $\text{Pb}(\text{NO}_3)_2$  are mixed in solution. How much precipitate is formed? How much of which reactant is in excess?

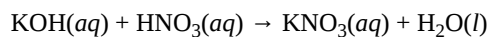


**Answer**

6.06 g  $\text{PbCl}_2$  formed; 0.34 g excess  $\text{NaCl}$



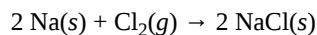
52. In a neutralization reaction, 18.06 g of KOH are reacted with 13.43 g of HNO<sub>3</sub>. What mass of H<sub>2</sub>O is produced, and what mass of which reactant is in excess?



**Answer**

3.839 g H<sub>2</sub>O formed; 6.10 g excess KOH

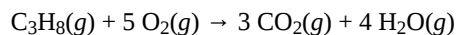
53. What is the limiting reactant in a reaction that produces sodium chloride from 8 g of sodium and 8 g of diatomic chlorine?



**Answer**

Cl<sub>2</sub>

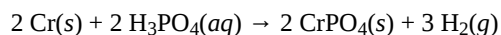
54. What is the limiting reactant when 30.0 g of propane, C<sub>3</sub>H<sub>8</sub>, is burned with 75.0 g of oxygen.



**Answer**

O<sub>2</sub>

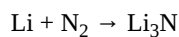
55. What is the limiting reactant when 0.50 g of Cr and 0.75 g of H<sub>3</sub>PO<sub>4</sub> react according to the following chemical equation?



**Answer**

H<sub>3</sub>PO<sub>4</sub>

56. What is the limiting reactant when 1.50 g of lithium and 1.50 g of nitrogen combine to form lithium nitride, a component of advanced batteries, according to the following *unbalanced* equation?



**Answer**

Li

### 8.7: Theoretical Yield and Percent Yield

57. What is the difference between the theoretical yield and the actual yield?

**Answer**

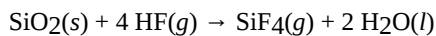
Theoretical yield is what you expect stoichiometrically from a chemical reaction; actual yield is what you actually get from a chemical reaction.

58. What is the difference between the actual yield and the percent yield?

**Answer**

Actual yield is the measured amount of product obtained from a chemical reaction; percent yield is the ratio of the actual yield to the amount predicted from stoichiometry.

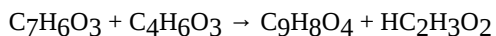
59. A worker isolates 2.675 g of  $\text{SiF}_4$  after reacting 2.339 g of  $\text{SiO}_2$  with HF. What are the theoretical yield and the actual yield?



**Answer**

Theoretical yield = 4.052 g; actual yield = 2.675 g

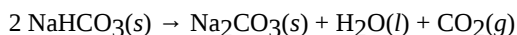
60. A worker synthesizes aspirin,  $\text{C}_9\text{H}_8\text{O}_4$ , according to this chemical equation. If 12.66 g of  $\text{C}_7\text{H}_6\text{O}_3$  are reacted and 12.03 g of aspirin are isolated, what are the theoretical yield and the actual yield?



**Answer**

Theoretical yield = 16.51 g; actual yield = 12.03 g

61. A chemist decomposes 1.006 g of  $\text{NaHCO}_3$  and obtains 0.0334 g of  $\text{Na}_2\text{CO}_3$ . What are the theoretical yield and the actual yield?



**Answer**

Theoretical yield = 0.6346 g; actual yield = 0.0334 g

62. A chemist combusts a 3.009 g sample of  $\text{C}_5\text{H}_{12}$  and obtains 3.774 g of  $\text{H}_2\text{O}$ . What are the theoretical yield and the actual yield?



**Answer**

Theoretical yield = 4.508 g; actual yield = 3.774 g

63. What is the percent yield in Exercise 59?

**Answer**

66.02%

64. What is the percent yield in Exercise 60?

**Answer**

72.86%

65. What is the percent yield in Exercise 61?

**Answer**

5.26%

66. What is the percent yield in Exercise 62?

**Answer**

83.72%

67. A student isolated 25 g of a compound following a procedure that would theoretically yield 81 g. What was his percent yield?

**Answer**

31%

68. A sample of 0.53 g of carbon dioxide was obtained by heating 1.31 g of calcium carbonate. What is the percent yield for this reaction?



**Answer**

91%

69. The phosphorus pentoxide used to produce phosphoric acid for cola soft drinks is prepared by burning phosphorus in oxygen.

- What is the limiting reactant when 0.200 mol of  $\text{P}_4$  and 0.200 mol of  $\text{O}_2$  react according to the reaction:  $\text{P}_4 + 5 \text{O}_2 \rightarrow \text{P}_4\text{O}_{10}$ ?
- Calculate the percent yield if 10.0 g of  $\text{P}_4\text{O}_{10}$  is isolated from the reaction.

**Answer**

- $\text{O}_2$
- 87.7%

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