Chapter 5

Supplementary *Check for Understanding* Problems

Moles and Molar Mass

1. Indicate the appropriate quantity for each of the following.

   a) A mole of N atoms contains _____ atoms.
   b) A mole of N_2 molecules contains _____ molecules.
   c) A mole of N_2 molecules contains _____ atoms.
   d) A mole of N atoms has a mass of _____ grams.
   e) A mole of N_2 molecules has a mass of _____ grams.

2. a) What is the mass of 725 sodium atoms in atomic mass units?

   b) What is the mass of 725 sodium atoms in grams?

3. How many atoms of an element are present in a sample of that element if the sample has a mass in grams equal to the atomic mass of the element?

4. Blackboard chalk is mostly calcium sulfate. How would you determine how many moles of calcium sulfate it takes to write your name in chalk on a blackboard?

5. What mass of zinc metal contains the same number of atoms as 16.1 grams of silver?

6. One atom of an element is found to weigh 2.107×10^{-22} g. What is the atomic weight of this element?

7. Which has the larger mass, 1.0 mmol of calcium or 1.5 mmol of sulfur? Justify your choice.

8. Which has the larger number of atoms, 0.045 μg of nickel or 0.032 μg of potassium? Justify your choice.

9. Calculate the molar mass for each of the following compounds.

   a) potassium hydrogen phosphate
   b) $Pb(C_2H_3O_2)_2$

10. Calculate the number of moles of compound in each of the following samples.

    a) 2.239 g C_2H_5OH
    b) 63.1 ng sulfur trioxide
    c) 1.48×10^2 kg potassium permanganate

11. How many CO molecules are present in 18.4 metric tons of carbon monoxide? One metric tons equals 1000 kg.

12. Calculate the mass in grams of each of the following samples.

    a) 9.44 mol copper(II) sulfate
    b) 7.11 mmol Li_2CO_3

13. Calculate the moles of sulfur atoms in each of the following samples.

    a) 4.63 g sodium thiosulfate
    b) 5.81 μg Na_2S

14. Calculate the number of carbon atoms in a 3.92-g sample of $C_6H_4Cl_2$.

15. How many moles of oxygen atoms are present in 4.40 mmol calcium phosphate?

Mass Percent

1. Calculate the mass percent of each element in the following compounds.

    a) barium chloride
    b) sodium sulfate

2. Which of the following compounds contains the largest mass percent of nitrogen? Justify your choice.

    a) NH_4NO_3 b) HNO_3 c) N_2O_4 d) $Al(NO_3)_3$

3. In a particular molecular compound the mass percent sulfur is 50% and the mass percent oxygen is 50%. What is the ratio of oxygen atoms to sulfur atoms in a molecule of this compound?

4. If a type of stainless steel contains 18% chromium by mass, how many moles of chromium are present in a bar of this material weighing 1.5 kg?

Stoichiometric Calculations (mole-to-mole)

1. Balance the following equation and state the meaning of the equation in terms of individual units of reactants and products and in terms of moles of reactants and products.

$$Al(s) + MnO_2(s) \rightarrow Mn(s) + Al_2O_3(s)$$

2. How many moles of CO_2 are needed to react completely with 0.675 mol LiOH?

$$LiOH(aq) + CO_2(g) \rightarrow Li_2CO_3(aq) + H_2O(l) \quad \text{(unbalanced)}$$

3. Given the reaction

$$4FeS(s) + 7O_2(g) \rightarrow 2Fe_2O_3(s) + 4SO_2(g)$$

how many moles of O_2 are needed to:

a) produce 0.693 mol Fe_2O_3?

b) react completely with 9.14 mol FeS?

c) form 1.51 mol SO_2?

Stoichiometric Calculations (mole-to-mass & mass-to-mole)

1. How many moles of each product can be formed from the decomposition of 1.00 g of the rocket fuel hydrazine (N_2H_4)?

$$3N_2H_4(l) \rightarrow 4NH_3(g) + N_2(g)$$

2. How many moles of oxygen gas are needed for the complete combustion of 19.6 g C_2H_2?

3. How many kilograms of Li_2O are needed to react completely 4.17×10^3 mol H_2O?

$$Li_2O(s) + H_2O(g) \rightarrow 2LiOH(s)$$

4. Carbon dioxide is produced in the reaction

$$H_3PO_4(aq) + MgCO_3(s) \rightarrow Mg_3(PO_4)_2(s) + CO_2(g) + H_2O(l) \quad \text{(unbalanced)}$$

How many grams of $MgCO_3$ are needed to produce 14.8 moles of CO_2?

Stoichiometric Calculations (mass-to-mass)

1. How many grams of sulfur can react with 1.79 g of copper according to the following equation?

$$Cu(s) + S(s) \rightarrow CuS(s)$$

2. How many grams of chlorine are required to react completely with 0.455 g iron to form iron(III) chloride?

3. How many grams of each product can be formed from the decomposition of 14.0 g of sodium chlorate?

$$2NaClO_3(s) \rightarrow 2NaCl(s) + 3O_2(g)$$

4. How many grams of potassium are needed to produce 16.5 kg K_2O?

$$KNO_3(s) + K(s) \rightarrow K_2O(s) + N_2(g) \quad \text{(unbalanced)}$$

Theoretical Yield and Limiting Reactant

1. Which is the limiting reactant when 0.68 g magnesium reacts with 17 mmol nitrogen gas to form Mg_3N_2?

2. How many moles of AsF_5 can be produced when 14 moles of arsenic react with 29 mol fluorine gas?

3. When 26.5 g CO and 3.9 g H_2 are allowed to react as shown below,

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(l)$$

   a) which is the limiting reactant?

   b) what is the theoretical yield in grams of CH_3OH?

   c) how much of the reactant in excess remains?

4. How many grams of the excess reactant remain when a mixture of 2.50 kg of SiO2 and 2.5 kg of carbon react?

$$SiO_2(s) + 3C(s) \rightarrow SiC(s) + 2CO(g)$$