Chapter 9 Chemical Quantities

9.1 Using Chemical Equations

Key Term

mole ratio

Summary

The equation for a chemical reaction shows the relative numbers of reactant and product molecules needed for the reaction to take place. Using the equation makes it possible to determine the amounts of reactants needed to give a certain amount of product or to predict how much product we can make from a certain amount of reactants.

A balanced equation uses coefficients (numbers) to show the relative numbers of molecules or moles of molecules. We can use a balanced equation to predict the moles of products that a given number of moles of reactants will yield using conversion factors or mole ratios. The *mole ratio* is the ratio of moles of one substance to moles of another substance in a balanced equation. The mole ratios then can be used in calculations.

9.2 Using Chemical Equations to Calculate Mass

Key Term

stoichiometry

Summary

Converting between moles and masses is often used in dealing with chemical reactions. If we know the balanced equation for a reaction and the mass of one of the substances involved, we can perform calculations to determine various unknown quantities.

To calculate the amount, in grams, of one reactant that is needed to react exactly with a known amount of another reactant, we follow three steps: (1) Convert the known mass of the substance from grams to moles by using the substance's molar mass. (2) Use the coefficients in the balanced equation to determine how many moles of the other reactant are required. (3) Use the molar mass of the reactant in step 2 to convert that measurement from moles to grams.

The steps for calculating the masses of reactants and products in chemical reactions are as follows: (1) Balance the equation for the reaction. (2) Convert the masses of reactants or products to moles. (3) Use the balanced equation to set up the appropriate mole ratio or ratios. (4) Use the mole ratio or ratios to calculate the number of moles of the desired reactant or product. (5) Convert from moles back to mass.

The process of using a chemical equation to calculate the relative masses of reactants and products involved in a reaction is called *stoichiometry.* Chemists say that the balanced equation for a chemical reaction describes the stoichiometry of the reaction.

Comparing the stoichiometry of two reactions means comparing the moles of reactants and products involved in the chemical reactions. This process can be useful in determining the amounts of different reactants needed to react with a certain amount of another reactant. For example, both baking soda, $NaHCO_3$, and milk of magnesia, $Mg(OH)_2(s)$, can neutralize hydrochloric acid, HCl. Stoichiometric calculations can determine which substance can neutralize more hydrochloric acid per gram.

9.3 Limiting Reactants and Percent Yield

Key Terms

limiting reactant (limiting reagent) theoretical yield percent yield

Summary

Often reactants are not mixed in stoichiometric quantities. They do not "run out" at the same time, and the reaction stops when one of the reactants runs out. In this case, we must use the *limiting reactant (limiting reagent),* the reactant that runs out first, to calculate the amounts of products formed. Chemists solve stoichiometry problems involving limiting reactants using the following steps: (1) Write and balance the equation for the reaction. (2) Convert the known masses of reactants to moles. (3) Using the numbers of moles of reactants and the appropriate mole ratios, determine which reactant is limiting. (4) Using the amount of the limiting reactant and the appropriate mole ratios, compute the number of moles of the desired product. (5) Convert from moles of product to grams of product using the molar mass (if this is required by the problem).

In a chemical reaction, products stop forming when the limiting reactant runs out. The amount of product that is predicted to be formed as a result of calculations using the limiting reactant is known as the reaction's *theoretical yield.* The actual yield of a reaction, which is the amount of product actually obtained, is usually less than its theoretical yield. The actual yield of product often is compared with the theoretical yield. This comparison, usually expressed as a percentage, is called the *percent yield.* The actual yield divided by the theoretical yield all times 100% equals the percent yield.

Additional Active Reading Questions

1. Describe the basic information given by a chemical equation.
2. What is the term for the ratio of moles of one substance to moles of another substance in a balanced chemical equation?
3. The molar mass of manganese is 54.94 g/mol. How many moles does a 219.76-g sample of manganese contain?
4. What is the process of using a chemical equation to calculate the relative amounts of reactants and products involved in a reaction?
5. When does a chemical reaction stop?
6. If the actual yield of a reaction is 22.5 g of titanium(II) oxide and the theoretical yield is 25.0 g, what is the percent yield?