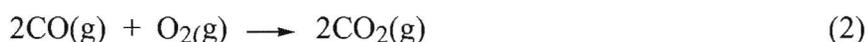


ChemActivity 29**Chemical Equations**

(What Happens When a Chemical Reaction Occurs?)

Model 1: Two Balanced Chemical Reactions.

Two balanced chemical reactions (or chemical equations) are given below:

**Critical Thinking Questions**

1. Indicate the reactants and products for each reaction in the table below:

Reaction	Reactant(s)	Product(s)
(1)		
(2)		

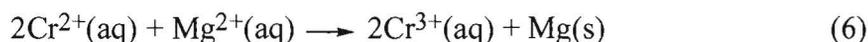
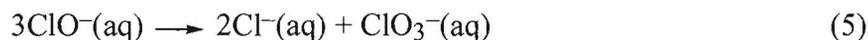
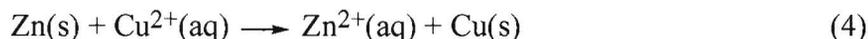
2. What does the arrow represent in a chemical reaction?
3. For reaction (1), how many H atoms, Cu atoms, and O atoms are represented on:
- the reactant side?
 - the product side?
4. For reaction (2), how many C atoms and O atoms are represented on:
- the reactant side?
 - the product side?
5. Based on your answers to CTQs 3 and 4, what general statement can be made about the number of atoms of each type on the two sides of a chemical equation?

Information

Atoms are neither created nor destroyed when chemical reactions take place. Therefore, the number of atoms of each element must be identical on the reactant (left) and product (right) sides of a balanced chemical reaction. Such a chemical equation is said to be **atom balanced**.

Model 2: Four Balanced Chemical Reactions.

In each of the balanced chemical reactions given below, the symbol "(aq)" indicates that the molecule or ion is surrounded by water molecules.



Critical Thinking Questions

6. Confirm that each of the chemical equations in Model 2 are *atom balanced*.
7.
 - a) For each of the chemical equations in Model 2, determine the sum of the charges on the left-hand side and the sum of the charges on the right-hand side.
 - b) Based on the reactions in Model 2, which, if any, of the following statements are correct?
 - i) The sum of the charges on both sides of a chemical equation must equal zero.
 - ii) The sum of the charges on both sides of a chemical equation must be a positive number.
 - iii) The sum of the charges on both sides of a chemical equation must be a negative number.
8. What general statement can be made about the sum of the charges on both sides of a balanced chemical reaction?

Information

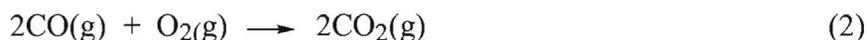
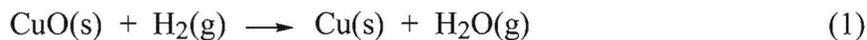
Protons and electrons are neither created nor destroyed when chemical reactions take place. Therefore, the total charge must be identical on the reactant and product sides of a balanced chemical reaction. Such a chemical equation is said to be **charge balanced**.

Exercises

- Balance these chemical reactions:
 - $\text{Cr(s)} + \text{S}_8\text{(s)} \longrightarrow \text{Cr}_2\text{S}_3\text{(s)}$
 - $\text{NaHCO}_3\text{(s)} \longrightarrow \text{Na}_2\text{CO}_3\text{(s)} + \text{CO}_2\text{(g)} + \text{H}_2\text{O(g)}$
 - $\text{Fe}_2\text{S}_3\text{(s)} + \text{HCl(g)} \longrightarrow \text{FeCl}_3\text{(s)} + \text{H}_2\text{S(g)}$
 - $\text{CS}_2\text{(l)} + \text{NH}_3\text{(g)} \longrightarrow \text{H}_2\text{S(g)} + \text{NH}_4\text{SCN(s)}$
- Write a chemical equation for the gaseous reaction of methane (CH_4) with oxygen (O_2) to form carbon dioxide (CO_2) and water (H_2O).
- Write a chemical equation that forms one mole of glycine, $\text{H}_2\text{NCH}_2\text{COOH(s)}$, from solid carbon, gaseous oxygen, gaseous nitrogen, and gaseous hydrogen.
- Write a chemical equation that has only ozone, O_3 , on the left-hand side and only molecular oxygen on the right-hand side.
- Which of the following chemical equations are not balanced?
 - $\text{NO}_2^-\text{(aq)} + \text{ClO}_2^-\text{(aq)} \longrightarrow \text{NO}_3^-\text{(aq)} + \text{Cl}^-\text{(aq)}$
 - $\text{NO}_2^-\text{(aq)} + \text{ClO}^-\text{(aq)} \longrightarrow \text{NO}_3^-\text{(aq)} + \text{Cl}^-\text{(aq)}$
 - $\text{Cr(s)} + \text{Pb}^{2+}\text{(aq)} \longrightarrow \text{Pb(s)} + \text{Cr}^{3+}\text{(aq)}$
 - $\text{H}^+\text{(aq)} + \text{SO}_3^{2-} \longrightarrow \text{HSO}_3^-\text{(aq)}$
 - $4\text{AgBr(s)} + 4\text{OH}^-\text{(aq)} \longrightarrow \text{O}_2\text{(g)} + 2\text{H}_2\text{O} + 4\text{Ag(s)} + 4\text{Br}^-\text{(aq)}$
- ~~J. N. Spencer, G. M. Bodner, and L. H. Rickard, *Chemistry: Structure & Dynamics*, Fourth Edition, John Wiley & Sons, 2009. Chapter 2: Problems: 13-17, 88.~~

Model 3: The Balanced Chemical Reaction.

A balanced chemical reaction can be interpreted in two ways. First, it can be thought of as describing how many molecules of reactants are consumed in order to produce a certain number of molecules of products. Analogously, it can be thought of as describing how many *moles* of reactants are consumed in order to produce the indicated number of *moles* of products.



Critical Thinking Questions

9. How many H₂O molecules are produced for every H₂ molecule that is consumed in reaction (1)?
10. For reaction (2):
 - a) How many CO₂ molecules are produced for every O₂ molecule consumed?
 - b) How many CO₂ molecules are produced for every CO molecule consumed?
 - c) How many molecules of CO₂ are produced when 2 molecules of O₂ are consumed?
 - d) How many moles of CO₂ are produced when 5 moles of O₂ are consumed?
11. How many moles of CuO react in order to produce 12 moles of Cu in reaction (1)?
12. Determine the number of reactant molecules and the number of product molecules for reaction (1) and reaction (2).

Exercises

- How many grams of Cr_2S_3 are produced when the reaction in Ex. 1a (above) occurs with 10.0 grams of chromium being consumed?
- How many grams of hydrogen sulfide are produced when 0.0365 grams of carbon disulfide are consumed in the reaction in Ex. 1d?
- How many grams of iron(III) chloride are produced when 26 grams of hydrogen sulfide gas are produced in the reaction in Ex. 1c?
- The thermite reaction has been used for welding railroad rails, in incendiary bombs, and to ignite solid-fuel rockets. The reaction is



What masses of iron(III) oxide and aluminum must be used to produce 15.0 g of iron? What is the mass of aluminum oxide that would be produced?

- Nitrogen (N_2) combines with hydrogen (H_2) to form ammonia (NH_3). How many grams of ammonia are formed when 145 grams of nitrogen are consumed by hydrogen?
- Indicate whether the following statement is true or false and explain your reasoning.
When carbon monoxide gas reacts with oxygen gas to form carbon dioxide gas, the number of gas molecules present decreases.
- J. N. Spencer, G. M. Bodner, and L. H. Rickard, *Chemistry: Structure & Dynamics*, Fourth Edition, John Wiley & Sons, 2009. Chapter 2: Problems: 21-23, 25, 27, 30, 32, 33.

Problems

- Nickel can react with gaseous carbon monoxide to form $\text{Ni}(\text{CO})_4$. Other metals present do not react. If 94.2 grams of a mixture of metals reacts with carbon monoxide to produce 98.4 grams of $\text{Ni}(\text{CO})_4$, what is the mass percent of nickel in the original sample?
- A 1.000 g sample of iron reacts with element "Q" to form 1.430 g of Fe_2Q_3 . a) Determine the identity of element "Q". b) Write a chemical equation for this reaction.