Section 10.1 Reactions and Equations
In your textbook, read about evidence of chemical reactions.

For each statement, write yes if evidence of a chemical reaction is present. Write no if there is no evidence of a chemical reaction.

- yes 1. A tomato smells rotten.
- no 2. A drinking glass breaks into smaller pieces.
- no 3. A piece of ice melts.
- yes 4. Drain cleaner is mixed with water and the solution becomes warm.
- yes 5. Candle wax burns.
- no 6. Molten candle wax solidifies.
- yes 7. Green leaves turn yellow and red as the seasons change.
- yes 8. Baking powder produces a gas that makes a cake rise.

In your textbook, read about how to represent chemical reactions and how to balance chemical equations.

Use the terms below to complete the passage. Each term may be used once, more than once, or not at all.

<table>
<thead>
<tr>
<th>term</th>
<th>meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>arrow</td>
<td>represents the direction of the reaction</td>
</tr>
<tr>
<td>plus sign</td>
<td>indicates the addition of two reactants</td>
</tr>
<tr>
<td>reactant</td>
<td>the substance that is consumed in the reaction</td>
</tr>
<tr>
<td>product</td>
<td>the substance that is formed in the reaction</td>
</tr>
<tr>
<td>(s)</td>
<td>solid</td>
</tr>
<tr>
<td>(aq)</td>
<td>aqueous</td>
</tr>
</tbody>
</table>

The fuel for the space shuttle is hydrogen, which burns in oxygen to produce water vapor and energy. In this chemical reaction, hydrogen is \( \text{a(n)} \) reactant, oxygen is \( \text{a(n)} \) reactant, and water vapor is \( \text{a(n)} \) product. In a chemical equation for this reaction, \( \text{a(n)} \) arrow is used to separate hydrogen and oxygen from water vapor and energy. \( \text{a(n)} \) plus sign is used to separate the symbols for hydrogen and oxygen. \( \text{a(n)} \) symbol is used to tell the state of hydrogen in the reaction. \( \text{a(n)} \) symbol is used for the state of oxygen, and \( \text{a(n)} \) symbol is used for the state of water vapor.
Chemical Reactions

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arrow product plus sign (s) (aq) (l) (g)

The fuel for the space shuttle is hydrogen, which burns in oxygen to produce water vapor and energy. In this chemical reaction, hydrogen is an (9) reactant, oxygen is an (10) reactant, and water vapor is an (11) product. In a chemical equation for this reaction, an (12) arrow is used to separate hydrogen and oxygen from water vapor and energy. An (13) plus sign is used to separate the symbols for hydrogen and oxygen. An (14) symbol is used to tell the state of hydrogen in the reaction, an (15) symbol is used for the state of oxygen, and an (16) symbol is used for the state of water vapor.

For each of the following chemical reactions, write a word equation, a skeleton equation, and a balanced chemical equation. Be sure to show the state of each reactant and product. If you need more help writing formulas or determining the state of a substance, refer to Chapters 8 and 9 and the periodic table on pages 156-157.

17. Solid mercury(II) oxide breaks down when heated, forming the elements mercury and oxygen.
   mercury(II) oxide(s) → mercury(l) + oxygen(g); HgO(s) → Hg(l) + O₂(g);
   2HgO(s) → 2Hg(l) + O₂(g)

18. Sodium metal reacts with water vapor in air to form solid sodium hydroxide and hydrogen.
   sodium(s) + water(g) → sodium hydroxide(s) + hydrogen(g); Na(s) + H₂O(g) →
   NaOH(s) + H₂(g); 2Na(s) + 2H₂O(g) → 2NaOH(s) + H₂(g)

19. In the first step of refining zinc metal from its zinc sulfide ore, the ore is heated in the presence of oxygen. The products are solid zinc oxide and sulfur dioxide gas.
   zinc sulfide(s) + oxygen(g) → zinc oxide(s) + sulfur dioxide(g); ZnS(s) + O₂(g) →
   ZnO(s) + SO₂(g); 2ZnS(s) + 3O₂(g) → 2ZnO(s) + 2SO₂(g)

20. The next step of refining zinc involves heating the zinc oxide in the presence of carbon. This reaction produces zinc vapor and carbon monoxide gas.
   zinc oxide(s) + carbon(s) → zinc(g) + carbon monoxide(g); ZnO(s) + C(s) →
   Zn(g) + CO(g); ZnO(s) + C(s) → Zn(g) + CO(g)

21. Certain pollutants in the air react with water vapor to form acids. For example, sulfur trioxide reacts with water vapor to form sulfuric acid.
   sulfur trioxide(g) + water(g) → sulfuric acid(aq); SO₃(g) + H₂O(g) →
   H₂SO₄(aq); SO₃(g) + H₂O(g) → H₂SO₄(aq)

22. Solid calcium carbonate is commonly used in antacids because it reacts with the hydrochloric acid found in the stomach. The products of this reaction are aqueous calcium chloride, carbon dioxide, and water.
   calcium carbonate(s) + hydrochloric acid(aq) → calcium chloride(aq) + carbon
   dioxide(g) + water(l); CaCO₃(s) + HCl(aq) → CaCl₂(aq) + CO₂(g) + H₂O(l);
   CaCO₃(s) + 2HCl(aq) → CaCl₂(aq) + CO₂(g) + H₂O(l)
**Section 10.2 Classifying Chemical Reactions**

In your textbook, read about synthesis, combustion, decomposition, and replacement reactions.

Assume that Q, T, X, and Z are symbols for elements. Match each equation in Column A with the reaction type it represents in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>c 1. Q + XZ → X + QZ</td>
<td>a. decomposition</td>
</tr>
<tr>
<td>d 2. Q + Z → QZ</td>
<td>b. double-replacement</td>
</tr>
<tr>
<td>a 3. QT → Q + T</td>
<td>c. single-replacement</td>
</tr>
<tr>
<td>b 4. QT + XZ → QZ + XT</td>
<td>d. synthesis</td>
</tr>
</tbody>
</table>

**Answer the following questions.**

5. Does the following equation represent a combustion reaction, a synthesis reaction, or both? Explain your answer.

\[ 2C(s) + O_2(g) \rightarrow 2CO_2(g) + \text{energy} \]

It is both types. It is a synthesis reaction because two reactants combine to form one product. It is combustion because it shows the rapid reaction of oxygen with another substance and energy is released.

6. Why is it sometimes incorrect to state that a compound is broken down into its component elements in a decomposition reaction?

In a decomposition reaction, a compound breaks down into simpler substances, not necessarily elements. These substances can be elements, or they might be simpler compounds.

7. When soap is added to hard water, solid soap scum forms. When water is added to baking powder, carbon dioxide bubbles form. When lemon juice is added to household ammonia solution, water is one of the products. Tell how you know a double-replacement reaction has occurred in each case.

A solid precipitate, a gas, and water, respectively, form in these reactions, indicating that double-replacement reactions have occurred.

8. Explain how you can use an activity series to determine whether a single-replacement reaction will occur.

If a listed metal or nonmetal is added to a compound, a reaction will occur if the free element is higher in the activity series than the corresponding element in the compound.

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**Table continued**

9. **calcium and water** \[ \text{Ca(s)} + \text{H}_2\text{O(l)} \rightarrow \text{CaO(s)} + \text{H}_2(g) \]

10. **magnesium and water** \[ \text{NR} \]

11. **rubidium and lithium chlorides** \[ \text{NR} \]

12. **potassium and aluminum oxide** \[ 6\text{K(s)} + \text{Al}_2\text{O}_3(s) \rightarrow 2\text{Al(s)} + 3\text{K}_2\text{O(s)} \]

13. **silver and calcium nitrate** \[ \text{NR} \]

14. **fluorine and potassium iodide** \[ \text{F}_2(g) + 2\text{Kl(s)} \rightarrow \text{I}_2(s) + 2\text{KF(s)} \]

15. **magnesium bromide and chlorine** \[ \text{MgBr}_2(\text{aq}) + \text{Cl}_2(g) \rightarrow \text{MgCl}_2(\text{aq}) + \text{Br}_2(\text{l}) \]

16. **copper and iron(III) sulfate** \[ \text{NR} \]

**Match each example of a chemical reaction in Column A to the type(s) listed in Column B. List all types from Column B that apply.**

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>e 17. Aluminum lawn furniture becomes coated with a layer of aluminum oxide when it sits out in the air.</td>
<td>a. combustion</td>
</tr>
<tr>
<td>d 18. Chlorine gas is bubbled through a calcium bromide solution. The solution turns brown, the color of bromine.</td>
<td>b. decomposition</td>
</tr>
<tr>
<td>c 19. Lime is added to acid water in a lake. Water and a salt form.</td>
<td>c. double-replacement</td>
</tr>
<tr>
<td>a 20. Propane is a common household fuel. When burned, water and carbon dioxide are produced.</td>
<td>d. single-replacement</td>
</tr>
<tr>
<td>b 21. Steel wool burns, forming an iron oxide.</td>
<td>e. synthesis</td>
</tr>
<tr>
<td>a 22. When an electric current is passed through molten potassium bromide, potassium and bromine form.</td>
<td></td>
</tr>
<tr>
<td>c 23. When solutions of sodium iodide and lead nitrate are combined, a yellow solid forms.</td>
<td></td>
</tr>
</tbody>
</table>
Section 10.3 Reactions in Aqueous Solutions

In your textbook, read about aqueous solutions, reactions that form precipitates, reactions that form water, and reactions that form gases.

Circle the letter of the choice that best completes the statement or answers the question.

1. A spoonful of sodium chloride is dissolved in a liter of water. What is sodium chloride in this solution?
   a. molecule  b. precipitate  c. solute  d. solvent

2. In an aqueous solution, water is the
   a. homogeneous part  b. precipitate  c. solute  d. solvent

3. Compounds that produce hydrogen ions in aqueous solutions are
   a. acids  b. aqeous  c. bases  d. ionic compounds

4. What type of reaction occurs between ions present in aqueous solution?
   a. decomposition  b. double-replacement  c. single-replacement  d. synthesis

5. What type of ions are present in solution but are not actually involved in a chemical reaction?
   a. complete  b. net  c. precipitate  d. spectator

6. If hydrochloric acid and potassium hydroxide react, what is the product of the net ionic equation for the reaction?
   a. hydrochloric acid  b. hydrogen ions  c. potassium chloride  d. water

7. Which of the following gases is not commonly produced in a double-replacement reaction?
   a. carbon dioxide  b. hydrogen cyanide  c. hydrogen sulfide  d. sulfur dioxide

8. \( H^+ (aq) + Br^- (aq) + K^+ (aq) + OH^- (aq) \rightarrow H_2O(l) + Br^- (aq) + K^+ (aq) \) is an example of what type of chemical equation?
   a. complete ionic  b. net ionic  c. precipitation  d. spectator

For each of the following reactions, write chemical, complete ionic, and net ionic equations.

9. \( \text{KBr}(aq) + \text{KOH}(aq) \rightarrow \text{HBr}(aq) + \text{H}_2\text{O}(l) \)
   Column B
   a. gas  b. precipitate  c. water

10. \( \text{HNO}_3(aq) + \text{Na}_2\text{CO}_3(aq) \rightarrow \text{NaNO}_3(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g) \)
   b. \( \text{NaCl}(aq) + \text{PbCl}_2(aq) \rightarrow \text{NaCl}(aq) + \text{PbCl}_2(s) \)
   c. \( \text{CaO}(aq) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{CaSO}_4(aq) + \text{H}_2\text{O}(l) \)
   a. \( \text{K}_2\text{S}(aq) + \text{HCl}(aq) \rightarrow \text{KCl}(aq) + \text{H}_2\text{S}(g) \)

14. Phosphoric acid (\( \text{H}_3\text{PO}_4 \)) and lithium hydroxide react to form a salt and water.
   \( \text{H}_3\text{PO}_4(aq) + 3\text{LiOH}(aq) \rightarrow 3\text{Li}_2\text{O}(l) + \text{LiPO}_4(aq); 3\text{H}^+(aq) + \text{PO}_4^{3-}(aq) + 3\text{Li}^+(aq) + \text{OH}^- (aq) \rightarrow 3\text{H}_2\text{O}(l) \)

15. When solutions of magnesium sulfate and calcium chloride are mixed, calcium sulfate precipitates.
   \( \text{MgSO}_4(aq) + \text{CaCl}_2(aq) \rightarrow \text{CaSO}_4(s) + \text{MgCl}_2(aq); \text{Mg}^{2+}(aq) + \text{SO}_4^{2-}(aq) + \text{Ca}^{2+}(aq) + 2\text{Cl}^- (aq) \rightarrow \text{CaSO}_4(s) + \text{Mg}^{2+}(aq) + 2\text{Cl}^- (aq); \text{SO}_4^{2-}(aq) + \text{Ca}^{2+}(aq) \rightarrow \text{CaSO}_4(s) \)

16. Bubbles are released when nitric acid (\( \text{HNO}_3 \)) is added to a potassium carbonate solution.
   \( 2\text{HNO}_3(aq) + \text{K}_2\text{CO}_3(aq) \rightarrow 2\text{KNO}_3(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g); 2\text{H}^+(aq) + 2\text{NO}_3^-(aq) + 2\text{K}^+(aq) + \text{CO}_3^{2-} (aq) \rightarrow 2\text{KNO}_3(aq) + 2\text{H}_2\text{O}(l) + \text{CO}_2(g); 2\text{H}^+(aq) + \text{CO}_3^{2-} (aq) \rightarrow \text{H}_2\text{O}(l) + \text{CO}_2(g) \)

17. Bubbles are released when hydrobromic acid (\( \text{HBr} \)) is added to a solution of ammonium sulfide. Aqueous ammonium bromide also forms.
   \( 2\text{HBr}(aq) + (\text{NH}_4)_2\text{S}(aq) \rightarrow \text{H}_2\text{S}(g) + 2\text{NH}_4\text{Br}(aq); 2\text{H}^+(aq) + 2\text{Br}^- (aq) + 2\text{NH}_4^+(aq) + \text{S}^{2-} (aq) \rightarrow \text{H}_2\text{S}(g) + 2\text{NH}_4^-(aq) + 2\text{Br}^- (aq); 2\text{H}^+(aq) + \text{S}^{2-} (aq) \rightarrow \text{H}_2\text{S}(g) \)