CHAPTER 8 REVIEW

Chemical Equations and Reactions

SECTION 1

SHORT ANSWER  Answer the following questions in the space provided.

1. Match the symbol on the left with its appropriate description on the right.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>( \Delta )</td>
</tr>
<tr>
<td>a</td>
<td>( \downarrow )</td>
</tr>
<tr>
<td>b</td>
<td>( \uparrow )</td>
</tr>
<tr>
<td>f</td>
<td>(l)</td>
</tr>
<tr>
<td>e</td>
<td>(aq)</td>
</tr>
<tr>
<td>c</td>
<td>⇄</td>
</tr>
</tbody>
</table>

(a) A precipitate forms.
(b) A gas forms.
(c) A reversible reaction occurs.
(d) Heat is applied to the reactants.
(e) A chemical is dissolved in water.
(f) A chemical is in the liquid state.

2. Finish balancing the following equation:

\[ 3 \text{Fe}_3\text{O}_4 + 8 \text{Al} \rightarrow 4 \text{Al}_2\text{O}_3 + 9 \text{Fe} \]

3. In each of the following formulas, write the total number of atoms present.

- 12 atoms
- 16 atoms
- 51 atoms
- \(3 \times 10^{24}\) atoms

(a) 4SO\(_2\)
(b) 8O\(_2\)
(c) 3Al\(_2\)(SO\(_4\))\(_3\)
(d) 6 \times 10^{23} \text{HNO}_3

4. Convert the following word equation into a balanced chemical equation:

aluminum metal + copper(II) fluoride \(\rightarrow\) aluminum fluoride + copper metal

\[ 2\text{Al}(s) + 3\text{CuF}_2(aq) \rightarrow 2\text{AlF}_3(aq) + 3\text{Cu}(s) \]

5. One way to test the salinity of a water sample is to add a few drops of silver nitrate solution with a known concentration. As the solutions of sodium chloride and silver nitrate mix, a precipitate of silver chloride forms, and sodium nitrate is left in solution. Translate these sentences into a balanced chemical equation.

\[ \text{NaCl}(aq) + \text{AgNO}_3(aq) \rightarrow \text{AgCl}(s) + \text{NaNO}_3(aq) \]

6. a. Balance the following equation:

\[ \text{NaHCO}_3(s) \xrightarrow{\Delta} \text{Na}_2\text{CO}_3(s) + \text{H}_2\text{O}(g) + \text{CO}_2(g) \]

\[ 2\text{NaHCO}_3(s) \xrightarrow{\Delta} \text{Na}_2\text{CO}_3(s) + \text{H}_2\text{O}(g) + \text{CO}_2(g) \]
b. Translate the chemical equation in part a into a sentence.

When solid sodium hydrogen carbonate (bicarbonate) is heated, it decomposes into solid sodium carbonate while releasing carbon dioxide gas and water vapor.

7. The poisonous gas hydrogen sulfide, H₂S, can be neutralized with a base such as sodium hydroxide, NaOH. The unbalanced equation for this reaction follows:

\[ \text{NaOH}(aq) + \text{H}_2\text{S}(g) \rightarrow \text{Na}_2\text{S}(aq) + \text{H}_2\text{O}(l) \]

A student who was asked to balance this equation wrote the following:

\[ \text{Na}_2\text{OH}(aq) + \text{H}_2\text{S}(g) \rightarrow \text{Na}_2\text{S}(aq) + \text{H}_3\text{O}(l) \]

Is this equation balanced? Is it correct? Explain why or why not, and supply the correct balanced equation if necessary.

It is balanced but incorrect. In two of the formulas the subscripts were changed, which changed the compounds involved. Water is not H₃O, and sodium hydroxide is not Na₂OH. The correct balanced equation is \(2\text{NaOH} + \text{H}_2\text{S} \rightarrow \text{Na}_2\text{S} + 2\text{H}_2\text{O}\).

PROBLEM  Write the answer on the line to the left. Show all your work in the space provided.

8. Recall that coefficients in a balanced chemical equation give relative amounts of moles as well as numbers of molecules.

\\[30 \ \text{mol}\] a. Calculate the number of moles of CO₂ that form if 10 mol of C₃H₄ react according to the following balanced equation:

\[ \text{C}_3\text{H}_4 + 4\text{O}_2 \rightarrow 3\text{CO}_2 + 2\text{H}_2\text{O} \]

\\[40 \ \text{mol}\] b. Calculate the number of moles of O₂ that are consumed.
CHAPTER 8 REVIEW

Chemical Equations and Reactions

SECTION 2

SHORT ANSWER  Answer the following questions in the space provided.

1. Match the equation type on the left to its representation on the right.

   _c_ synthesis  
   _d_ decomposition  
   _b_ single-displacement  
   _a_ double-displacement

   (a) AX + BY → AY + BX  
   (b) A + BX → AX + B  
   (c) A + B → AX  
   (d) AX → A + X

2. In the reaction described by the equation 2Al(s) + 3Fe(NO₃)₂(aq) → 3Fe(s) + 2Al(NO₃)₃(aq), iron has been replaced by

   (a) nitrate.  
   (b) water.  
   (c) aluminum.  
   (d) nitrogen.

3. Of the following chemical equations, the only reaction that is both synthesis and combustion is

   (a) C(s) + O₂(g) → CO₂(g).  
   (b) 2C₄H₁₀(l) + 13O₂(g) → 8CO₂(g) + 10H₂O(l).  
   (c) 6CO₂(g) + 6H₂O(g) → C₆H₁₂O₆(aq) + 6O₂(g).  
   (d) C₆H₁₂O₆(aq) + 6O₂(g) → 6CO₂(aq) + 6H₂O(l).

4. Of the following chemical equations, the only reaction that is both combustion and decomposition is

   (a) S(s) + O₂(g) → SO₂(g).  
   (b) 2C₄H₁₀(l) + 13O₂(g) → 8CO₂(g) + 10H₂O(l).  
   (c) 2H₂O₂(l) → 2H₂O(l) + O₂(g).  
   (d) 2HgO(s) → 2Hg(l) + O₂(g).

5. Identify the products when the following substances decompose:

   _its separate elements_  
   _metal oxide + water_  
   _metal oxide + carbon dioxide_  
   _water + sulfur dioxide_

   a. a binary compound  
   b. most metal hydroxides  
   c. a metal carbonate  
   d. the acid H₂SO₃

6. The complete combustion of a hydrocarbon in excess oxygen yields the products CO₂ and H₂O.
7. For the following four reactions, identify the type, predict the products (make sure formulas are correct), and balance the equations:
   a. \( \text{Cl}_2(aq) + \text{NaI}(aq) \rightarrow \)
      \[ \text{Cl}_2(aq) + 2\text{NaI}(aq) \rightarrow \text{I}_2(aq) + 2\text{NaCl}(aq) \]

   b. \( \text{Mg}(s) + \text{N}_2(g) \rightarrow \)
      \[ 3\text{Mg}(s) + \text{N}_2(g) \rightarrow \text{Mg}_3\text{N}_2(s) \]

   c. \( \text{Co(NO}_3)_2(aq) + \text{H}_2\text{S}(aq) \rightarrow \)
      \[ \text{Co(NO}_3)_2(aq) + \text{H}_2\text{S}(aq) \rightarrow \text{CoS}(s) + 2\text{HNO}_3(aq) \]

   d. \( \text{C}_2\text{H}_5\text{OH}(aq) + \text{O}_2(g) \rightarrow \)
      \[ \text{C}_2\text{H}_5\text{OH}(aq) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 3\text{H}_2\text{O}(l) \]

8. Acetylene gas, \( \text{C}_2\text{H}_2 \), is burned to provide the high temperature needed in welding.
   a. Write the balanced chemical equation for the combustion of \( \text{C}_2\text{H}_2 \) in oxygen.
      \[ 2\text{C}_2\text{H}_2(g) + 5\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 2\text{H}_2\text{O}(l) \]

   b. If 1.0 mol of \( \text{C}_2\text{H}_2 \) is burned, how many moles of \( \text{CO}_2 \) are formed?
      2.5 mol

   c. If 1.0 mol of \( \text{C}_2\text{H}_2 \) is burned how many moles of oxygen gas are consumed?

9. a. Write the balanced chemical equation for the reaction that occurs when solutions of barium chloride and sodium carbonate are mixed. Refer to Table 1 on page 437 in Chapter 13 for solubility.
      \[ \text{BaCl}_2(aq) + \text{Na}_2\text{CO}_3(aq) \rightarrow \text{BaCO}_3(s) + 2\text{NaCl}(aq) \]

   b. To which of the five basic types of reactions does this reaction belong?
      double-displacement

10. For the commercial preparation of aluminum metal, the metal is extracted by electrolysis from alumina, \( \text{Al}_2\text{O}_3 \). Write the balanced chemical equation for the electrolysis of molten \( \text{Al}_2\text{O}_3 \).
    \[ 2\text{Al}_2\text{O}_3(l) \rightarrow 4\text{Al}(s) + 3\text{O}_2(g) \]

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CHAPTER 8 REVIEW

Chemical Equations and Reactions

SECTION 3

SHORT ANSWER  Answer the following questions in the space provided.

1. List four metals that will not replace hydrogen in an acid.
   Choose from Cu, Ag, Au, Pt, Sb, Bi, and Hg.

2. Consider the metals iron and silver, both listed in Table 3 on page 286 of the text. Which one readily forms an oxide in nature, and which one does not?
   Fe forms an oxide in nature, and Ag does not, because it is much less active.

3. In each of the following pairs, identify the more active element.
   a. F₂ and I₂
   F₂
   b. Mn and K
   K
   c. Cu and H
   H

4. Use the information in Table 3 on page 286 of the text to predict whether each of the following reactions will occur. For each reaction that will occur, complete the chemical equation by writing in the products formed and balancing the final equation.
   a. Al(s) + CH₃COOH(aq) 50°C →
      2Al(s) + 6CH₃COOH(aq) 50°C → 2Al(CH₃COO)₃(aq) + 3H₂(g)

   b. Al(s) + H₂O(l) 50°C →
      no reaction

   c. Cr(s) + CdCl₂(aq) →
      2Cr(s) + 3CdCl₂(aq) → 2CrCl₃(aq) + 3Cd(s)

   d. Br₂(l) + KCl(aq) →
      no reaction
SECTION 3 continued

5. Very active metals will react with water to release hydrogen gas and form hydroxides.
   a. Complete, and then balance, the equation for the reaction of Ca(s) with water.

   \[ \text{Ca}(s) + 2\text{H}_2\text{O}(l) \rightarrow \text{Ca(OH)}_2(aq) + \text{H}_2(g) \]

   b. The reaction of rubidium, Rb, with water is faster and more violent than the reaction of Na with water. Use the atomic structure and radius of each metal to account for this difference.

   Both are alkali metals and readily form a stable 1+ ion by ejecting an s\(^1\) electron.

   Rb has a larger radius than Na and holds its electron less tightly, making it more reactive.

6. Gold, Au, is often used in jewelry. How does the relative activity of Au relate to its use in jewelry?

   Gold has a low reactivity and therefore does not corrode over time.

7. Explain how to use an activity series to predict the outcome of a single-displacement reaction.

   In single-displacement reactions, if the activity of the free element is greater than that of the element in the compound, the reaction will take place.

8. Aluminum is above copper in the activity series. Will aluminum metal react with copper(II) nitrate, Cu(NO\(_3\))\(_2\), to form aluminum nitrate, Al(NO\(_3\))\(_3\)? If so, write the balanced chemical equation for the reaction.

   Yes; because aluminum is above copper in the activity series, aluminum metal will replace copper in copper(II) nitrate.

   \[ 2\text{Al}(s) + 3\text{Cu(NO}_3\text{)}_2(aq) \rightarrow 2\text{Al(NO}_3\text{)}_3(aq) + 3\text{Cu}(s) \]
MIXED REVIEW

SHORT ANSWER  Answer the following questions in the space provided.

1. b  A balanced chemical equation represents all the following except
   (a) experimentally established facts.
   (b) the mechanism by which reactants combine to form products.
   (c) identities of reactants and products in a chemical reaction.
   (d) relative quantities of reactants and products in a chemical reaction.

2. d  According to the law of conservation of mass, the total mass of the
      reacting substances is
      (a) always more than the total mass of the products.
      (b) always less than the total mass of the products.
      (c) sometimes more and sometimes less than the total mass of the products.
      (d) always equal to the total mass of the products.

3. Predict whether each of the following chemical reactions will occur. For each reaction that will
   occur, identify the reaction type and complete the chemical equation by writing in the products
   formed and balancing the final equation. General solubility rules are in Table 1 on page 437 of the
   text.
   a.  \( \text{Ba(NO}_3\text{)}_2(aq) + \text{Na}_3\text{PO}_4(aq) \rightarrow \)
      \( \text{double-displacement; } 3\text{Ba(NO}_3\text{)}_2(aq) + 2\text{Na}_3\text{PO}_4(aq) \rightarrow \)
      \( \text{Ba}_3(\text{PO}_4)_2(s) + 6\text{NaNO}_3(aq) \)
   b.  \( \text{Al}(s) + \text{O}_2(g) \rightarrow \)
      \( \text{synthesis; } 4\text{Al}(s) + 3\text{O}_2(g) \rightarrow 2\text{Al}_2\text{O}_3(s) \)
   c.  \( \text{I}_2(s) + \text{NaBr}(aq) \rightarrow \)
      \( \text{no reaction} \)
   d.  \( \text{C}_3\text{H}_4(g) + \text{O}_2(g) \rightarrow \)
      \( \text{combustion; } \text{C}_3\text{H}_4(g) + 4\text{O}_2(g) \rightarrow 3\text{CO}_2(g) + 2\text{H}_2\text{O}(g) \)
MIXED REVIEW continued

e. electrolysis of molten potassium chloride

\[ 2\text{KCl} (l) \rightarrow 2\text{K}(s) + \text{Cl}_2(g) \]

4. Some small rockets are powered by the reaction represented by the following unbalanced equation:

\[(\text{CH}_3)_2\text{N}_2\text{H}_2(l) + \text{N}_2\text{O}_4(g) \rightarrow \text{N}_2(g) + \text{H}_2\text{O}(g) + \text{CO}_2(g) + \text{heat} \]

a. Translate this chemical equation into a sentence. (Hint: The name for \((\text{CH}_3)_2\text{N}_2\text{H}_2\) is dimethylhydrazine.)

When liquid dimethylhydrazine is mixed with dinitrogen tetroxide gas, the products are nitrogen gas, water vapor, and gaseous carbon dioxide, along with energy in the form of heat.

b. Balance the formula equation.

\[(\text{CH}_3)_2\text{N}_2\text{H}_2(l) + 2\text{N}_2\text{O}_4(g) \rightarrow 3\text{N}_2(g) + 4\text{H}_2\text{O}(g) + 2\text{CO}_2(g) \]

5. In the laboratory, you are given two small chips of each of the unknown metals X, Y, and Z, along with dropper bottles containing solutions of \(\text{XCl}_2(aq)\) and \(\text{ZCl}_2(aq)\). Describe an experimental strategy you could use to determine the relative activities of X, Y, and Z.

Wording and strategies will vary. First, place one chip of Y into \(\text{XCl}_2(aq)\) and another into \(\text{ZCl}_2(aq)\). If Y reacts with one solution but not the other, the activity series can be established. If Y replaces X but not Z, the series is \(Z > Y > X\). If Y replaces Z but not X, the series is \(X > Y > Z\). If Y reacts with neither solution, Y is at the bottom of the series. Next, put one chip of X into \(\text{ZCl}_2(aq)\). If it reacts, the series is \(X > Z > Y\). If it does not react, the series is \(Z > X > Y\). If Y reacts with both solutions, Y is the most reactive. Last, put a chip of X into \(\text{ZCl}_2(aq)\). If it reacts, the series is \(Y > X > Z\). If it does not react, the series is \(Y > Z > X\).

6. List the observations that would indicate that a reaction had occurred.

Signs of a reaction include generation of energy as heat or light, formation of a precipitate, formation of a gas, and change in color.