A. Completion

Use this completion exercise to check your knowledge of the terms and your understanding of the concepts introduced in this chapter. Each blank can be completed with a term, short phrase, or number.

A chemical reaction can be concisely represented by a chemical ______. The substances that undergo a chemical change are the ______. The new substances formed in a chemical reaction are the ______. In accordance with the law of conservation of ______, a chemical equation must be balanced. In balancing an equation, ______ are placed in front of the reactants and products so that the same number of atoms of each ______ are on each side of the equation. An equation must never be balanced by changing the ______ in the chemical formula of a substance.

Special symbols are used to show the physical state of a substance in a reaction. The symbol for a liquid is ______; for a solid, ______; and for a gas, ______. A substance dissolved in water is designated ______.

If a ______ is used to increase the speed of a chemical reaction, its formula is written above the arrow.

It is possible to ______ the products of some chemical reactions. In order to do this, you must be able to recognize at least five general types of reactions. For example, in a ______ reaction, the reactants are two or more ______ and/or compounds and there is always a ______ product.

In a ______ reaction, a single compound is broken down into two or more simpler substances.

In a ______ reaction, the reactants and products are an element and a compound. The ______ can be used to predict whether most single-replacement reactions will take place. A ______ reaction involves the exchange of cations (or anions) between two compounds. This reaction
generally takes place between two ionic compounds in \textit{21} solution.

One of the reactants in a combustion reaction is \textit{22}. The products of the complete combustion of a hydrocarbon are \textit{23} and \textit{24}.

\begin{itemize}
\item \textit{21} aqueous 7-6
\item \textit{22} oxygen 7-7
\item \textit{23} carbon dioxide/water 7-7
\item \textit{24} water/carbon dioxide 7-7
\end{itemize}

\section*{B. True–False}

Classify each of these statements as always true, AT; sometimes true, ST; and never true, NT.

\begin{itemize}
\item \textit{25}. In an equation, a substance is shown to be in the gaseous state by placing an upward-pointed arrow after its formula. 7-1
\item \textit{26}. The symbol \(\Delta\) placed over the arrow in an equation means that heat is supplied to the reaction. 7-1
\item \textit{27}. Atoms are destroyed in a chemical reaction. 7-1
\item \textit{28}. A skeleton equation is not a balanced equation. 7-2
\item \textit{29}. In a decomposition reaction there is a single reactant. 7-4
\item \textit{30}. The activity series of metals can be used to predict products in double-replacement reactions. 7-6
\item \textit{31}. Carbon dioxide and water are the products of the combustion of hexane, \(\text{C}_6\text{H}_{14}\). 7-7
\item \textit{32}. The product of a combination reaction is a compound. 7-3
\item \textit{33}. A nonmetal can replace another nonmetal from a compound in a single-replacement reaction. 7-5
\item \textit{34}. One of the products of a double-replacement reaction is a gas that bubbles out of the mixture. 7-6
\end{itemize}

\section*{C. Questions}

Answer the following questions in the space provided.

\begin{itemize}
\item \textit{35}. Balance the following equations. Tell what type of reaction each represents.
\begin{align*}
\text{a. } \text{Zn} & + \text{HCl} \rightarrow \text{H}_2 \uparrow + \text{ZnCl}_2 \\
\text{Zn} + 2\text{HCl} & \rightarrow \text{H}_2 \uparrow + \text{ZnCl}_2 \quad \text{single-replacement}
\end{align*}
\begin{align*}
\text{b. } \text{AgNO}_3 & + \text{Al}_2 \rightarrow \text{AgI} \downarrow + \text{Al(NO}_3)_3 \\
3\text{AgNO}_3 + \text{Al}_2 & \rightarrow 3\text{AgI} \downarrow + \text{Al(NO}_3)_3 \quad \text{double-replacement}
\end{align*}
\begin{align*}
\text{c. } \text{Al}_2\text{O}_3 & \rightarrow \text{Al} + \text{O}_2 \uparrow \\
2\text{Al}_2\text{O}_3 & \rightarrow 4\text{Al} + 3\text{O}_2 \uparrow \quad \text{decomposition}
\end{align*}
\begin{align*}
\text{d. } \text{C}_4\text{H}_{10} & \xrightarrow{\Delta} \text{CO}_2 \uparrow + \text{H}_2\text{O} \uparrow \\
2\text{C}_4\text{H}_{10} + 13\text{O}_2 & \xrightarrow{\Delta} 8\text{CO}_2 \uparrow + 10\text{H}_2\text{O} \uparrow \quad \text{combustion}
\end{align*}
\end{itemize}
36. Balance the following equation. Indicate the physical state of the reactants and products by using the proper symbols.

\[
\begin{align*}
\text{Fe}_2\text{O}_3 + \text{H}_2 & \xrightarrow{\Delta} \text{Fe} + \text{H}_2\text{O} \\
\text{Fe}_2\text{O}_3(s) + 3\text{H}_2(g) & \xrightarrow{\Delta} 2\text{Fe}(s) + 3\text{H}_2\text{O}(g)
\end{align*}
\]

37. Complete and balance the following equation. What must be true of one of the products?

\[
\begin{align*}
\text{Li}_3\text{PO}_4 + \text{Zn(NO}_3\text{)_2} & \rightarrow \\
2\text{Li}_3\text{PO}_4 + 3\text{Zn(NO}_3\text{)_2} & \rightarrow \text{Zn}_3(\text{PO}_4)_2 \downarrow + 6\text{LiNO}_3
\end{align*}
\]

For any double-replacement reaction to occur, one of the products must be a solid (precipitate), or water, or a gas.

38. Use the activity series of metals to determine which of the following reactions will occur. If a reaction will take place, complete and balance that equation.

a. \(\text{Al} + \text{H}_3\text{PO}_4 \rightarrow\)

\[
\begin{align*}
2\text{Al} + 2\text{H}_3\text{PO}_4 & \rightarrow 2\text{AlPO}_4 + 3\text{H}_2
\end{align*}
\]

b. \(\text{Fe} + \text{Cu(NO}_3\text{)_2} \rightarrow\)

\[
\begin{align*}
2\text{Fe} + 3\text{Cu(NO}_3\text{)_2} & \rightarrow 2\text{Fe(NO}_3\text{)_2} + 3\text{Cu}
\end{align*}
\]

c. \(\text{Cu} + \text{ZnSO}_4 \rightarrow\)

\[\text{no reaction}\]

Activity Series of Metals

- lithium
- potassium
- sodium
- magnesium
- aluminum
- zinc
- iron
- nickel
- lead
- hydrogen
- copper
- silver
- gold

39. Complete and balance the following equation. Tell what type of reaction it represents.

\[
\begin{align*}
\text{C}_2\text{H}_4 + \text{O}_2 & \rightarrow \\
\text{C}_2\text{H}_4 + 3\text{O}_2 & \rightarrow \text{2CO}_2 \uparrow + 2\text{H}_2\text{O} \uparrow
\end{align*}
\]

This equation represents the complete combustion of a hydrocarbon.
40. Complete the following table:

<table>
<thead>
<tr>
<th>General Equation</th>
<th>Reactants</th>
<th>Reaction type</th>
<th>Probable products</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R + S \rightarrow RS )</td>
<td>Two elements, Two compounds, at least one a molecular compound</td>
<td>Combination</td>
<td>A single compound</td>
</tr>
<tr>
<td>( RS \rightarrow R + S )</td>
<td>A single binary compound, A single ternary compound</td>
<td>Decomposition</td>
<td>Two elements</td>
</tr>
<tr>
<td>( T + RS \rightarrow TS + R )</td>
<td>An element and a compound</td>
<td>Single-replacement</td>
<td>A different element and a new compound</td>
</tr>
<tr>
<td>( RS + TU \rightarrow RU + TS )</td>
<td>Two ionic compounds</td>
<td>Double-replacement</td>
<td>Two new compounds</td>
</tr>
<tr>
<td>( CH + O \rightarrow CO + HO )</td>
<td>Oxygen and a compound of C, H, O</td>
<td>Combustion</td>
<td>CO(_2) and H(_2)O (C and/or CO may be formed in incomplete combustion)</td>
</tr>
</tbody>
</table>

41. Identify each of the following equations by type.

a. \( 3O_2 + 4Fe \rightarrow 2Fe_2O_3 \)  
   \( \text{Combination} \)

b. \( 3Mg + 2H_3PO_4 \rightarrow 3H_2 \uparrow + Mg_3(PO_4)_2 \downarrow \)  
   \( \text{Single-replacement} \)

c. \( CaCO_3 \rightarrow CaO + CO_2 \uparrow \)  
   \( \text{Decomposition} \)

d. \( 2AgNO_3 + CaCl_2 \rightarrow 2AgCl \downarrow + Ca(NO_3)_2 \)  
   \( \text{Double-replacement} \)

e. \( 2C_2H_2 + 3O_2 \xrightarrow{\Delta} 4CO \uparrow + 2H_2O \uparrow \)  
   \( \text{Incomplete combustion} \)