Balancing Equations Kit
Student Laboratory Kit

Introduction

Abstract concepts such as conservation of matter and chemical reactions can often be difficult to visualize. Matter is conserved during a chemical reaction; however, actually “seeing” this is not easy. In this activity, models of atoms will be used to build molecules, balance chemical equations, label reaction types, and visualize how matter is conserved in a chemical reaction.

Concepts

- Balancing equations
- Law of conservation of matter
- Coefficients/subscripts
- Chemical formulas

Background

Chemical reactions are occurring all the time in the world—for example, the rusting of metal, the burning of paper, the combustion of fuel, and the metabolism of food. What do all of these processes have in common? Each involves a form of chemical change in which matter combines or breaks apart to produce new kinds of matter with different properties. Evidence for a chemical change may involve the release of a gas, a color change, the formation of a precipitate, or changes in heat or light. Any chemical change involves the reorganization of the atoms in one or more substances. For example, when carbon (C) combines with oxygen gas (O₂) in the air and burns, carbon dioxide gas (CO₂) is formed. This process is represented by a chemical equation, a symbolic expression used in chemistry to represent a chemical reaction. The reactants (carbon and oxygen) are written on the left side of the equation and the products (carbon dioxide) are written on the right side of the equation. A plus sign is used between two substances to indicate reactants combined or products formed. An arrow represents the direction of the reaction and is read as “yields” or “produces”:

\[ \text{C(s)} + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) \]

Reactants Products

The chemical equation for a reaction provides two important types of information: the nature of the reactants and products (indicated by the correct chemical formula) and the relative numbers of each. The equation often also gives the physical states of the reactants and the products using state symbols, the symbols in parentheses written after the chemical formulas. Solids are represented with (s), liquids with (l), gases with (g), and aqueous solutions with (aq) to indicate that the substance is dissolved in water.

The basic types of chemical reactions can be broken down into five general categories: synthesis, decomposition, single replacement, double replacement, and combustion. In a synthesis reaction, two or more substances react to form a single product (Example: X + Y \rightarrow Z). In a decomposition reaction, a single reactant decomposes or breaks down into two or more products (Example: A \rightarrow B + C). In a single replacement reaction, one element replaces another in a compound such that an element combines with a compound to produce an element plus a compound (Example: X + Y \rightarrow XY + Z). In a double replacement reaction, two compounds react to produce two different compounds (Ex: AB + CD \rightarrow AD + CB). Finally, in a combustion reaction, one reactant (a fuel) combines with oxygen to produce an oxide and water (Ex: Fuel + O₂ \rightarrow CO₂ + H₂O).

Notice that atoms get reorganized in a chemical reaction from the reactant side to the product side. The chemical equation represents the reorganization—bonds are broken and new ones form. The Law of Conservation of Matter states that matter can neither be created nor destroyed in an ordinary chemical reaction. Thus it is important to recognize that in a chemical reaction, atoms are not created or destroyed; they are simply rearranged. All atoms present in the reactants must be accounted for among the products. In other words, there must be the same number of each type of atom on the reactant side and on the product side of the equation representing the reaction. The Law of Conservation of Matter, then, is followed when balancing a chemical equation.
The relative numbers of reactants and products in a chemical reaction are indicated by the coefficients in the balanced equation. A coefficient is a small whole number that is written in front of a chemical formula in an equation. When balancing an equation, the identities of the reactants and products must not be changed; thus the formulas of the compounds must never be changed. The only way, then, to balance an equation is to add coefficients. If no coefficient is written, it is assumed to be one.

The process of balancing equations involves the following steps and guidelines:

1. Determine the correct formula for each reactant and product.
2. Write the formula for each reactant on the left hand side of the equation and the formula for each product on the right side of the equation.
3. Count the number of atoms of each element on the reactants side and compare this to the number of atoms of each element on the products side.
4. Add coefficients in front of the formula until there are the same number of atoms of each element on each side of the equation.

Before learning to balance chemical equations, it is important to be able to accurately count the number of atoms of each element in the reaction and to understand how a chemical formula is written. A chemical formula provides two pieces of information about a compound—the elements that make up the compound and the number of atoms of each element in the compound. The number of atoms of each element are indicated with subscripts, numbers used in the chemical formula to represent the smallest whole-number ratio of each element. For example, the formula for water, \( \text{H}_2\text{O} \), indicates that there are two hydrogen atoms and one oxygen atom. Notice subscripts of one are assumed and not written.

Sometimes groups of atoms act as a single unit. Such a group of atoms is called a polyatomic ion. If a polyatomic ion is used in a formula more than once, it is put in parentheses and the subscript appears outside of the parentheses. When a subscript appears outside of the parentheses, it indicates that all of the elements inside the parentheses should be multiplied by that subscript. For example, the formula for the compound \( \text{Ca(NO}_3\text{)}_2 \) indicates that there is one calcium atom, two nitrogen atoms, and six oxygen atoms.

Part 1 of this activity will concentrate on counting atoms in chemical formulas. Once the task of counting atoms is mastered, then the equation can be balanced. Part II of this activity consists of balancing chemical equations. To do this, colored bingo chips will be used to represent the atoms in each molecule. The “atom” chips will be counted and rearranged until all of the atoms in the equation are conserved and the equation is balanced.

**Materials**

- Bingo Chips
- Data Tables
- Scissors
- Envelope

**Procedure**

**Part 1. Counting Atoms**

1. Locate Table 1 on the Balancing Equations Worksheet.
2. For each chemical formula in the table, list each element that is in the compound. Write both the element symbol and name—use a periodic table, if necessary.
3. Write the number of atoms of each element present. Follow the rules for counting atoms as outlined in the background section.
   The first example has already been completed.

**Part 2. Balancing Equations**

1. Locate Table 2 on the worksheet.
2. For each reaction in the table, follow steps 3–8 as outlined below.
3. Select a different colored chip to represent each different atom. (i.e., red for oxygen atoms and blue for hydrogen atoms)
4. Build one molecule of each reactant on the left side of a flat surface and one molecule of each product on the right side of a flat surface. Draw or imagine an arrow in between the reactants and the products.

5. Count all of the atoms of each element on the reactants side; count all of the atoms of each element on the products side.

6. If the number of each like atom is equal, the equation is balanced. If the number is not equal, add additional molecules to the appropriate side(s) until the total number of like atoms on the reactants side is equal to the total number on the products side. Once equal, the equation is balanced.

**Helpful Balancing Tips**

While some equations can be balanced by inspection (i.e., trial and error), the following tips can make the process a bit more systematic:

- Start with the most complicated molecule(s). If there does not seem to be one, start by balancing an element that occurs only once on each side of the arrow. Or simply start balancing systematically from left to right.

- Treat polyatomic ions, such as NO₃⁻ and SO₄²⁻, as units rather than balancing their atoms individually. (i.e., In this balancing exercise, use only one colored chip to represent the entire polyatomic ion.)

- If water is present in an equation, balance hydrogen and oxygen atoms last.

- Recount all atoms after the equation is balanced as an extra check.

7. Using circles to represent the atoms or polyatomic ions, draw a molecular representation of the balanced equation below each reaction in Table 2. Inside each circle, write the element or polyatomic ion symbol. **Note:** The chips provide a representation of the molecules and are not accurate in terms of atom size or of atom arrangement.

8. Count the total number of each molecule that you have constructed in the equation. Place coefficients in front of the appropriate molecule in the equation to depict the total number of each molecule in Table 2. Remember that coefficients are the only way to balance an equation and that coefficients of 1 are assumed but omitted in the equation.

9. List the reaction type below each reaction in Table 2 (synthesis, decomposition, single replacement, double replacement or combustion).
# Balancing Equations Worksheet

## Table 1. Counting Atoms

<table>
<thead>
<tr>
<th>Name and Use</th>
<th>Formula</th>
<th>Atoms in Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Silicon dioxide</td>
<td>SiO$_2$</td>
<td>Si = Silicon 1</td>
</tr>
<tr>
<td>Use: Sand</td>
<td></td>
<td>O = Oxygen 2</td>
</tr>
<tr>
<td>2. Butane</td>
<td>C$<em>4$H$</em>{10}$</td>
<td></td>
</tr>
<tr>
<td>Use: Lighter fluid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Iron(III) oxide</td>
<td>Fe$_2$O$_3$</td>
<td></td>
</tr>
<tr>
<td>Use: Rust</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Sulfuric acid</td>
<td>H$_2$SO$_4$</td>
<td></td>
</tr>
<tr>
<td>Use: Car batteries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Magnesium hydroxide</td>
<td>Mg(OH)$_2$</td>
<td></td>
</tr>
<tr>
<td>Use: Milk of magnesia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Sucrose</td>
<td>C$<em>{12}$H$</em>{22}$O$_{11}$</td>
<td></td>
</tr>
<tr>
<td>Use: Sugar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Trinitrotoluene (TNT)</td>
<td>C$_7$H$_5$(NO$_2$)$_3$</td>
<td></td>
</tr>
<tr>
<td>Use: Explosives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Calcium dihydrogen phosphate</td>
<td>Ca(H$_2$PO$_4$)$_2$</td>
<td></td>
</tr>
<tr>
<td>Use: Fertilizer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Table 2. Balancing Equations

1. \( \underline{2} \text{H}_2(\text{g}) + \underline{\text{O}_2(\text{g})} \rightarrow \underline{2}\text{H}_2\text{O(l)} \)
   
   Reaction type: Synthesis
   
   Molecular representation:

   ![Molecular Representation of H2O](image)

2. \( \underline{\text{PbCl}_2(\text{aq})} + \underline{\text{Na}_2\text{SO}_4(\text{aq})} \rightarrow \underline{\text{PbSO}_4(\text{s})} + \underline{\text{NaCl(\text{aq})}} \)
   
   Reaction type:
   
   Molecular representation:

3. \( \underline{\text{Si(s)}} + \underline{\text{Cl}_2(\text{g})} \rightarrow \underline{\text{SiCl}_4(\text{l})} \)
   
   Reaction type:
   
   Molecular representation:

4. \( \underline{\text{Cl}_2(\text{aq})} + \underline{\text{KBr(\text{aq})}} \rightarrow \underline{\text{KCl(\text{aq})}} + \underline{\text{Br}_2(\text{aq})} \)
   
   Reaction type:
   
   Molecular representation:

5. \( \underline{\text{Na(s)}} + \underline{\text{Cl}_2(\text{g})} \rightarrow \underline{\text{NaCl(\text{s})}} \)
   
   Reaction type:
   
   Molecular representation:
6. _____ N\textsubscript{2}(g) + _____ H\textsubscript{2}(g) → _____ NH\textsubscript{3}(g)

   Reaction type:
   Molecular representation:

7. _____ NaHCO\textsubscript{3}(s) → _____ Na\textsubscript{2}CO\textsubscript{3}(aq) + _____ CO\textsubscript{2}(g) + _____ H\textsubscript{2}O(l)

   Reaction type:
   Molecular representation:

8. _____ Al(s) + _____ O\textsubscript{2}(g) → _____ Al\textsubscript{2}O\textsubscript{3}(s)

   Reaction type:
   Molecular representation:

9. _____ CH\textsubscript{4}(g) + _____ O\textsubscript{2}(g) → _____ CO\textsubscript{2}(g) + _____ H\textsubscript{2}O(g)

   Reaction type:
   Molecular representation:

10. _____ Zn(s) + _____ HCl(aq) → _____ ZnCl\textsubscript{2}(aq) + _____ H\textsubscript{2}(g)

    Reaction type:
    Molecular representation:
11. _____ Li(s) + _____ O₂(g) → _____ Li₂O(s)
   Reaction type:
   Molecular representation:

12. _____ AgNO₃(aq) + _____ Cu(s) → _____ Cu(NO₃)₂(aq) + _____ Ag(s)
   Reaction type:
   Molecular representation:

13. _____ C₂H₄(g) + _____ O₂(g) → _____ CO₂(g) + _____ H₂O(g)
   Reaction type:
   Molecular representation:

14. _____ CaCO₃(s) → _____ CaO(s) + _____ CO₂(g)
   Reaction type:
   Molecular representation:

15. _____ NaOH(aq) + _____ HCl(aq) → _____ NaCl(aq) + _____ H₂O(aq)
   Reaction type:
   Molecular representation:
16. \[ \_\_\_\text{HgO(s)} \rightarrow \_\_\_\text{Hg(l)} + \_\_\_\text{O}_2(g) \]
   Reaction type:
   Molecular representation:

17. \[ \_\_\_\text{H}_2\text{O(l)} + \_\_\_\text{Fe(s)} \rightarrow \_\_\_\text{Fe}_2\text{O}_3(s) + \_\_\_\text{H}_2(g) \]
   Reaction type:
   Molecular representation:

18. \[ \_\_\_\text{Al(s)} + \_\_\_\text{HCl(aq)} \rightarrow \_\_\_\text{AlCl}_3(aq) + \_\_\_\text{H}_2(g) \]
   Reaction type:
   Molecular representation:

19. \[ \_\_\_\text{K(s)} + \_\_\_\text{H}_2\text{O(l)} \rightarrow \_\_\_\text{KOH(aq)} + \_\_\_\text{H}_2(g) \]
   Reaction type:
   Molecular representation:

20. \[ \_\_\_\text{NH}_3(g) + \_\_\_\text{O}_2(g) \rightarrow \_\_\_\text{NO(g)} + \_\_\_\text{H}_2\text{O(g)} \]
   Reaction type:
   Molecular representation:
Writing and Balancing Equations — Alternate Option

Procedure

For each chemical word equation below, first write the formula for each reactant and product. Then write the complete chemical equation; include the physical state for each substance. Balance each equation by following the procedure outlined on page 3 of the handout.

1. Hydrogen and oxygen gas react to form water.

2. Aqueous lead(II) chloride reacts with aqueous sodium sulfate to produce a lead(II) sulfate precipitate and aqueous sodium chloride.

3. Silicon reacts with chlorine gas to form liquid silicon tetrachloride.

4. Aqueous chlorine and aqueous potassium bromide react to make a solution of potassium chloride and bromine.

5. Sodium metal combines with chlorine gas to form crystalline sodium chloride.


7. Solid sodium bicarbonate decomposes to make aqueous sodium carbonate, carbon dioxide gas, and water.

8. Aluminum combines with oxygen gas to form solid aluminum oxide.

9. Methane gas undergoes combustion with oxygen to produce carbon dioxide and water.

10. Zinc reacts with aqueous hydrogen chloride to form aqueous zinc chloride and hydrogen gas.

11. Lithium metal combines with oxygen to form lithium oxide.

12. Aqueous silver nitrate reacts with solid copper to form a copper(II) nitrate solution and silver crystals.

13. Propane fuel burns in oxygen to form carbon dioxide and water.

14. Solid calcium carbonate decomposes to produce calcium oxide and carbon dioxide.

15. A sodium hydroxide solution neutralizes a hydrochloric acid solution to form a solution of sodium chloride and water.

16. Solid mercuric oxide decomposes to form liquid mercury metal and oxygen.

17. Iron metal reacts with water to form iron(III) oxide and hydrogen gas.

18. Aluminum reacts with a solution of hydrochloric acid to form aluminum chloride dissolved in water.

19. Potassium metal reacts violently with water to form a basic solution of potassium hydroxide, releasing hydrogen gas.

20. Ammonia gas and oxygen combine to form nitrous oxide and water vapor.
Teacher’s Notes
Balancing Equations Kit

Materials Included in Kit
Blue bingo chips, 250
Green bingo chips, 250
Red bingo chips, 250
Yellow bingo chips, 250
Magnetic wand
Reproducible student handout
Wire-rimmed counting chips, 100

Additional Materials Needed (for each group)
Colored pencils (optional)
Cup (to carry chips)
Envelope
Scissors

Additional Materials Needed (for overhead demonstration)
Overhead projector
Overhead transparency sheets, 4

Connecting to the National Standards
This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
- Systems, order, and organization
- Evidence, models, and explanation

Content Standards: Grades 5–8
- Content Standard B: Physical Science, properties and changes of properties in matter

Content Standards: Grades 9–12
- Content Standard B: Physical Science, structure of atoms, structure and properties of matter, chemical reactions

Tips
- To introduce and explain the activity, first perform a teacher overhead demonstration. Balance equations on the overhead using the colored wire-rimmed counting chips as the atoms. Use the magnetic wand to swipe up the chips.

- Distribute the colored bingo chips to the students to be used as atoms or polyatomic ions. Students can work individually or in small groups to balance equations. There are more than enough bingo chips to be used by a class of 30 working individually or in pairs.

- Students should choose a different color for each like atom in each equation to be balanced. However, because there are only four colors of chips, it is not possible to give a permanent assignment of a color to an atom. Also, simplify the activity by using a single chip to represent a polyatomic ion such as NO$_3^-$ or SO$_4^{2-}$.

- When students draw the molecular representation of the atoms in their data tables, suggest that they write the element or polyatomic ion symbol inside of the circle or color the atoms in with colored pencils and include an atom key.

- Before performing this activity, students should have some background in element symbols and chemical formulas. The information provided in the background section is provided as brief supplementary information and is not meant to accomplish the encompassing job of the chemistry textbook.

- Remind students that the models they are making with the chips are flat models which are used primarily to get an atom count for balancing equations. Actual atoms and molecules differ in that they are much smaller, three-dimensional, and in constant motion. Also point out that although each chip has the same diameter, actual atoms vary in size.

- The chemical formulas are provided for the students in this activity. A great higher-level option for this activity is to have students write the formulas for each reactant and product in the equation, given the word equations. Then students can continue on with the activity as described. Because this kit is intended for a variety of levels, mastery of formula-writing is
Teacher’s Notes continued

not a requirement. However, if you would like your students to perform this option, an extension sheet is provided which includes each equation written in words rather than with formulas. This sheet may be photocopied for student use. All of the work for this option should be done on a separate sheet of paper.

- For an excellent kit on learning to write formulas, see the Ionic Formula Writing Kit, Catalog No AP4570, which may be found in the Flinn Chemical & Biological Catalog/Reference Manual.

### Sample Data Table 1. Counting Atoms

<table>
<thead>
<tr>
<th>Name and Use</th>
<th>Formula</th>
<th>Atoms in Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Silicon dioxide</td>
<td>SiO₂</td>
<td>Si = Silicon 1</td>
</tr>
<tr>
<td>Use: Sand</td>
<td></td>
<td>O = Oxygen 2</td>
</tr>
<tr>
<td>2. Butane</td>
<td>C₄H₁₀</td>
<td>C = Carbon 4</td>
</tr>
<tr>
<td>Use: Lighter fluid</td>
<td></td>
<td>H = Hydrogen 1</td>
</tr>
<tr>
<td>3. Iron(III) oxide</td>
<td>Fe₂O₃</td>
<td>Fe = Iron 2</td>
</tr>
<tr>
<td>Use: Rust</td>
<td></td>
<td>O = Oxygen 3</td>
</tr>
<tr>
<td>4. Sulfuric acid</td>
<td>H₂SO₄</td>
<td>H = Hydrogen 2</td>
</tr>
<tr>
<td>Use: Car batteries</td>
<td></td>
<td>S = Sulfur 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O = Oxygen 4</td>
</tr>
<tr>
<td>5. Magnesium hydroxide</td>
<td>Mg(OH)₂</td>
<td>Mg = Magnesium 1</td>
</tr>
<tr>
<td>Use: Milk of magnesia</td>
<td></td>
<td>O = Oxygen 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H = Hydrogen 2</td>
</tr>
<tr>
<td>6. Sucrose</td>
<td>C₁₂H₂₂O₁₁</td>
<td>C = Carbon 12</td>
</tr>
<tr>
<td>Use: Sugar</td>
<td></td>
<td>H = Hydrogen 22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O = Oxygen 11</td>
</tr>
<tr>
<td>7. Trinitrotoluene (TNT)</td>
<td>C₇H₅(NO₂)₃</td>
<td>C = Carbon 7</td>
</tr>
<tr>
<td>Use: Explosives</td>
<td></td>
<td>H = Hydrogen 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N = Nitrogen 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O = Oxygen 6</td>
</tr>
<tr>
<td>8. Calcium dihydrogen phosphate</td>
<td>Ca(H₂PO₄)₂</td>
<td>Ca = Calcium 1</td>
</tr>
<tr>
<td>Use: Fertilizer</td>
<td></td>
<td>H = Hydrogen 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P = Phosphorus 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O = Oxygen 8</td>
</tr>
</tbody>
</table>

### Sample Data Table 2. Balancing Equations

1. \[ \frac{2}{2} \text{H}_2(g) + \text{O}_2(g) \rightarrow \frac{2}{2} \text{H}_2\text{O}(l) \]
   Synthesis

2. \[ \frac{}{\text{PbCl}_2(aq)} + \frac{}{\text{Na}_2\text{SO}_4(aq)} \rightarrow \frac{}{\text{PbSO}_4(s)} + \frac{2}{2} \text{NaCl(aq)} \]
   Double replacement
3. \( \underline{\text{Si(s)}} + \underline{\text{Cl}_2(g)} \rightarrow \underline{\text{SiCl}_4(l)} \)
   Synthesis
4. \( \underline{\text{Cl}_2(aq)} + \underline{\text{KBr(aq)}} \rightarrow \text{KCl(aq)} + \underline{\text{Br}_2(aq)} \)
   Single replacement
5. \( \underline{\text{Na(s)}} + \underline{\text{Cl}_2(g)} \rightarrow \underline{\text{NaCl(s)}} \)
   Synthesis
6. \( \underline{\text{N}_2(g)} + \underline{\text{H}_2(g)} \rightarrow \underline{\text{NH}_3(g)} \)
   Synthesis
7. \( \underline{\text{NaHCO}_3(s)} \rightarrow \underline{\text{Na}_2\text{CO}_3(aq)} + \underline{\text{CO}_2(g)} + \underline{\text{H}_2\text{O(l)}} \)
   Decomposition
8. \( \underline{\text{Al(s)}} + \underline{\text{O}_2(g)} \rightarrow \underline{\text{Al}_2\text{O}_3(s)} \)
   Synthesis
9. \( \underline{\text{CH}_4(g)} + \underline{\text{O}_2(g)} \rightarrow \underline{\text{CO}_2(g)} + \underline{\text{H}_2\text{O(g)}} \)
   Combustion
10. \( \underline{\text{Zn(s)}} + \underline{\text{HCl(aq)}} \rightarrow \underline{\text{ZnCl}_2(aq)} + \underline{\text{H}_2(g)} \)
    Single replacement
11. \( \underline{\text{Li(s)}} + \underline{\text{O}_2(g)} \rightarrow \underline{\text{Li}_2\text{O(s)}} \)
    Synthesis
12. \( \underline{\text{AgNO}_3(aq)} + \underline{\text{Cu(s)}} \rightarrow \underline{\text{Cu(NO}_3)_2(aq)} + \underline{\text{Ag(s)}} \)
    Single replacement
13. \( \underline{\text{C}_2\text{H}_2(g)} + \underline{\text{O}_2(g)} \rightarrow \underline{\text{CO}_2(g)} + \underline{\text{H}_2\text{O(g)}} \)
    Combustion
14. \( \underline{\text{CaCO}_3(s)} \rightarrow \underline{\text{CaO(s)}} + \underline{\text{CO}_2(g)} \) Balanced
    Decomposition
15. \( \underline{\text{NaOH(aq)}} + \underline{\text{HCl(aq)}} \rightarrow \underline{\text{NaCl(aq)}} + \underline{\text{H}_2\text{O(aq)}} \) Balanced
    Double replacement
16. \( \underline{\text{HgO(s)}} \rightarrow \underline{\text{Hg(l)}} + \underline{\text{O}_2(g)} \)
    Decomposition
17. \( \underline{\text{H}_2\text{O(l)}} + \underline{\text{Fe(s)}} \rightarrow \underline{\text{Fe}_2\text{O}_3(s)} + \underline{\text{H}_2(g)} \)
    Single replacement
18. \( \underline{\text{Al(s)}} + \underline{\text{HCl(aq)}} \rightarrow \underline{\text{AlCl}_3(aq)} + \underline{\text{H}_2(g)} \)
    Single replacement
19. \( \underline{\text{K(s)}} + \underline{\text{H}_2\text{O(l)}} \rightarrow \underline{\text{KOH(aq)}} + \underline{\text{H}_2(g)} \)
    Single replacement
20. \( \underline{\text{NH}_3(g)} + \underline{\text{O}_2(g)} \rightarrow \underline{\text{NO(g)}} + \underline{\text{H}_2\text{O(g)}} \)
    Combustion

Materials for the Balancing Equations Kit—Student Laboratory Kit are available from Flinn Scientific, Inc.

<table>
<thead>
<tr>
<th>Catalog No.</th>
<th>Description</th>
</tr>
</thead>
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<td>AP4577</td>
<td>Balancing Equations Kit—Student Laboratory Kit</td>
</tr>
<tr>
<td>AP4396</td>
<td>Scissors, Office-type</td>
</tr>
<tr>
<td>AP1196</td>
<td>Cup, Styrofoam® 16-oz</td>
</tr>
</tbody>
</table>