Section 4.3 Conservation of Mass and Chemical Equations

(Student textbook pages 159 to 168)

Specific Expectations

- **C3.2** explain, using the law of conservation of mass and atomic theory, the rationale for balancing chemical equations
- **C3.4** write word equations and balanced chemical equations for simple chemical reactions

In this section, students study chemical reactions by developing balanced equations from word equations. Equations and investigation are used to confirm the law of conservation of mass.

Common Misconceptions

- Equal signs may be mistakenly used in place of the arrow in a chemical equation. Reinforce that the arrow signifies a process of chemical change that "produces" the products. Products and reactants (left and right sides of the equation) are completely different, not equal. Only the number of elements/ratio of atoms remains the same.
- The arrow in a balanced equation may lead students to think that chemical changes are simple. The arrow actually represents a very complex process.
- It may be erroneously said that equations are balanced in order to satisfy the law of conservation of mass. In fact, the law is satisfied regardless of whether anyone ever balances a chemical equation. The correct relation is the reverse of this statement: using the law of conservation of mass, we are able to write balanced equations in which the number of each type of atom is present in equal amounts in the reactants and products.
- Gases are often misjudged as massless and omitted from the law of conservation of mass. Use a scale to evaluate the mass of products and reactants in a closed system (e.g., Activity 4–1 Making a Reaction Happen).
- Formulas are sometimes changed to balance equations. Remind students that changing even a single subscript in the formula of a compound changes the identity of that compound completely. Coefficients are used to balance equations. You might share an example to illustrate, such as the difference in toxicity, odour, density, and colour between CO_2 and CO.

Background Knowledge

The idea of a balanced equation goes hand in hand with the law of conservation of mass. The starting substances in a chemical reaction (or equation) are called *reactants* and the new substance(s) formed are called *products*. The arrow in a balanced equation represents a range of complex processes, such as combustion, decomposition, displacement, and synthesis.

Literacy Support

Using the Text

- In this section, students apply the concept of conservation of mass to chemical equations. Chemical equations are processed mathematially to reinforce the concepts.
- To provide context, have students read the opener text and page 167. Then, read the rest and work through the Practice Problems in small groups.

Before Reading

- Key word concept maps: Use a key word concept map to help students broaden their understanding of key concepts. Before reading, pre-teach or clarify *chemical reaction, chemical equation, word equation, symbolic equation, coefficient, state of matter, skeleton equation,* and *balanced chemical equation.* You may wish to use **BLM G-42 Concept Map** for this activity.

During Reading

- Think-Pair-Share: This helps students confirm, expand, and refine their ideas by sharing responses with a partner. Have students read a section of text independently, record their thoughts, then pair with another student to discuss their thoughts on the text. For this section, you may wish to ask students to draw diagrams showing a reaction and then annotate their diagram with labels that help illustrate the ideas they have covered reading this section.
- Remind students to use the strategy the Identifying the Main Idea and Details as outlined on page 138 of the student textbook.

After Reading

- Reflect and Evaluate: Have students outline the interesting information they have learned and why they found it interesting. Then, identify concepts they wish to learn more about. You may wish to use **BLM G-48 K-W-L Chart** for this activity.

Using the Images

- ELL Based on Figure 4.18, what do students think the narrative is about? This is a great entry into discussion of safety in the lab. Explain the importance of following instructions closely and telling the teacher of concerns. Have students discuss how this fire could have been prevented. What safety procedures were not followed? (e.g., contaminating samples or sealing containers of flammable vapour.) Review vocabulary such as *vapours* and *flammable*.
- ELL Examine Marie-Anne Lavoisier's illustration in Figure 4.19, evaluating which part is (and what is meant by) a "closed system." Note that the fire is open, but apparatus is closed. Extension to this would be to discuss the burning of wood in fire. Compare the mass of wood to the mass of ashes and account for the difference (i.e., gasses, heat, light, etc.).
- ELL Link the balloon exploding in a fireball (Figure 4.20) to the equations, reinforcing the reaction that occurred. Videos of this experiment are available at **www.scienceontario.ca**.
- ELL Discuss the purpose of the rebreather shown in Figure 4.21. Clarify that the diver has an underwater camera in her hands. The whole breathing apparatus is actually on her face and out of sight on her back. Note the absence of bubbles as the diver breathes out. A rebreather recycles rather than vents the exhaled breath. This is a closed loop wherein exhaled breath is pushed through a chemical absorbent (scrubber) to remove the carbon dioxide, and returns through the other side of the loop for the diver to breathe again (re-breathe), hence the name "closed circuit rebreather" or CCR.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Practice Problems 1–2, page 165	Chemical compound names are correctly translated into skeleton equations. Equations are balanced.	Reinforce understanding of nomenclature by having students complete **BLM 4-5 Binary Ionic Compounds, BLM 4-8 Multivalent Ionic Compounds,** and **BLM 4-9 Polyatomic Ionic Compounds** if they have not already done so. Perform one process together, as a class. Have students work together to resolve discrepancies in their answers. Provide model kits or other manipulatives for students to check their work.
Learning Check question 4, page 164 Inquiry Investigation 4-C Comparing the Masses of Reactants and Products	Formulas remain accurate in the balanced equation. Number of atoms are equal on both sides of the equation. Extend answer shows understanding that mass is added from somewhere, not created.	Reinforce that coefficients affect the whole formula, not a single element. Encourage students to check their work by multiplying subscripts by coefficients to calculate the number of atoms. Have students complete **BLM 4-15 Balancing Chemical Equations** for extra practice. Refer students to the scaffolded approach to developing balanced equations on page 165 of the student textbook.

Instructional Strategies

- **ELL** Model, or have students model, the law of conservation of mass using molecular model kits. Find the mass of the models of two hydrogen molecules (H_2) and one oxygen molecule (O_2). Then, rearrange the models into two water molecules (H_2O) and find the mass again. Students will see that atoms are simply rearranged and the mass stays the same.
- **ELL** Use the example in the student textbook (page 165) to guide students from a word equation, through the skeleton equation, to a balanced chemical equation. Bring out the H_2O molecular model used earlier to demonstrate the conservation of mass. Model the skeleton equation stage, to show that there is an oxygen atom left over. Recall from section 4.2 that oxygen is a diatomic molecule, so we know this equation cannot work. Run through the sequence again, adding a second H_2 molecule so that there are no lone atoms after the reaction. Alternatively, model this using simple cardboard cutouts or sticky notes on the board, and have students count the number of atoms on each side of the equation to illustrate that the number of atoms stays the same, just regrouped to form the different substance. Magnetic white boards and colourful magnets from a discount store can make this fun.
- **ELL** Read Reactions in a Rebreather to the class. Draw attention to the figure, noting the absence of bubbles as the diver breathes out. (Clarify that the diver has an underwater camera in her hands. The whole breathing apparatus is actually on her face and out of sight on her back.) Examine the equation, pointing out the state of each reactant and product. This is a good extension opportunity for students to investigate the concentration of oxygen required in the air we breathe, or to examine the mechanism that captures breath and remixes it students may get confused because oxygen is not a product of the reaction shown. You may wish to have them research the two different types of rebreathers.
- **DI** Provide bodily-kinesthetic learners with a set of cards representing balanced chemical equations. Write the word equation on the envelope, placing the cards inside along with extra coefficients. Have students arrange the pieces on their desks to create a balanced equation. You might structure this as a team relay, individual challenge, or enrichment activity.

- Show a video that illustrates the law of conservation of mass. Visit **www.scienceontario.ca** for videos.
- Have students carry out Inquiry Investigation 4-C Comparing the Masses of Reactants and Products. See page TR-2-32 of this Teacher's Resource for notes on this investigation. Alternatively, carry out Activity 4-1 from the Chapter Opener if you have not already done so (page TR-2-6 of this Teacher's Resource). Use a scale to verify that the mass remains the same.
- Introduce the section by reading the opener to the class. Ask students how the fires could have been prevented. Discuss the importance of lab safety and the dangers of not following instructions carefully. To really catch students' attention and emphasize safety, show a video of a water–sodium reaction, noting both the explosive reaction and the resulting fire. Visit at **www.scienceontario.ca** for videos.
- Alternatively, demonstrate the reaction of a pea-sized sample of sodium in a large beaker of water-phenolphthalein mixture which will produce a gas and turn pink. Wear safety goggles and put up plastic shield. Ensure all departmental safety precautions are followed. Ask students why cleaning with the wet paper towel might have injured the person in the anecdote in the student textbook. (Because their hand was directly exposed to the reaction of the sodium with the water on the paper towel.)
- Reactivate prior learning by summarizing as a class: "pure substance" (relate to classes of compounds: pure and mixture) and "signs of a chemical reaction" (physical properties change; temp change; precipitate, gas, or light forms). Post these on the word wall, along with supporting examples or illustrations.
- Introduce the Lavoisiers and John Dalton to illustrate how the law of conservation of mass was developed and the importance of their findings (page 160 in the student textbook). Review the figures and discuss the idea of a closed system as shown in Marie-Anne's sketch of the apparatus, noting that no matter can escape.
- As a class, use this new information to re-evaluate the water–sodium reaction. Were the anecdote and demonstration closed systems? How do we know? (No, gas escaped explosively.) Reactivate understanding that even gasses have mass (e.g., SCUBA or fire fighter's air tank weighs noticeably more when full). Get students thinking about the usefulness of the closed system in verifying the law.
- Introduce balanced equations by explaining that chemists have devised a clever and useful symbol to represent all the activity that occurs during a chemical reaction: an arrow. Everything that happens during a reaction is summarized by this one symbol. Modern chemistry would be impossible without this valuable tool as it would be an extraordinarily complex process to detail all the steps in every chemical reaction.
- ELL Go over the parts of the equation as a class, using an oversized sample equation on the board. Identify each part and its meaning, including coefficients and subscripts. Have students add the concepts to their notes and the classroom word wall.
  Example: reactant(state) + reactant(state) → reaction product(state) + product(state)
- Discuss the importance of including abbreviations in reactions to indicate if gases or solids are produced. This gives clues as to the energy (force, temperature change, etc.) that is produced and may pose a safety hazard, as well as indicating products that may be overlooked (such as a gas that quickly dissipates).
- Begin each subsequent lesson by having students balance a sample reaction. Repetition and drill is often the key to mastering balancing chemical equations. You may wish to use questions from **BLM 4-15 Balancing Chemical Equations,** the Learning Check, Practice Problems, or Section Review for this purpose.

- Have students answer any outstanding questions in the Learning Check and Practice Problems, swapping with a partner to identify and resolve any discrepancies.
- Enrichment—Have students analyze combustion reactions, identifying the "lost" mass (difference in mass between logs and ashes).
- To conclude the section, reflect on the anecdote in the section opener. Have students write the balanced chemical equation for the reaction of water and sodium. Ask students to explain whether this reaction obeyed the law of conservation of mass. (Answer: Yes)
- You may wish to revisit the Chapter Opener, developing a balanced equation for the reactions that inflate an air bag: decomposition reaction of sodium azide (Na_3N) and then a reaction with potassium nitrate.
- Have students read Making a Difference to themselves and answer the question, providing at least three examples and alternatives. See page TR-1-5 of this Teacher's Resource for related notes.
- Assign the Case Study: Green Chemistry for homework. See page TR-1-6 of this Teacher's Resource for notes on carrying out this activity.

Learning Check Answers (Student textbook page 164)

1. Example: word equation, skeleton equation, balanced equation
2. the law of conservation of mass
3. **a.** 2Na, 2I **b.** 3P, 15Cl **c.** 2Na, 2N, 6O **d.** 2N, 8H, 1S, 4O
4. **a.** $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$
   b. $2Li(s) + Br_2(g) \rightarrow 2LiBr(s)$
   c. $2Al(s) + 3CuO(s) \rightarrow Al_2O_3(s) + 3Cu(s)$
   d. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
   e. $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$
   f. $Ca(Cl)_2(aq) + 2AgNO_3(aq) \rightarrow 2AgCl(s) + Ca(NO_3)(aq)$
5. Example, cooking: meat + vegetable → meal + scraps

Section 4.3 Review Answers (Student textbook page 168)

Please see also **BLM 4-16 Section 4.3 Review (Alternative Format).**

1. The mass of the reactants will be greater than the mass of the products because the gas escapes from the container.
2. The gas should be hydrogen. To satisfy the law of conservation of mass, each atom used in the reactants must appear in the products. Hydrogen appears in the reactants, but is not a part of magnesium chloride. Therefore, hydrogen must be the missing element.
3. **a.** 2Fe, 6I **b.** 3Ca, 6O, 6H **c.** 3Ca, 6H, 18O **d.** 3N, 12H, 3Cl, 12O
4. Write the names of the reactants to the left and the names of the products to the right of an arrow.
5. A plus sign is used when more than one reactant or more than one product is involved in the reaction.
6. solid (s), liquid (ℓ), gas (g), and aqueous solution (aq)

7. **a.** not balanced; Al; $2Al(s) + 3F_2(g) \rightarrow 2AlF_3(s)$

   b. not balanced; H and O; $Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O$

   c. balanced

   d. not balanced; C, O, H; $2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$

   e. not balanced; K, N, O; $K_2SO_4(aq) + 2AgNO_3(aq) \rightarrow Ag_2SO_4(s) + 2KNO_3(aq)$

8. Word equation: sodium + water → hydrogen + sodium hydroxide

   Skeleton equation: $Na + H_2O \rightarrow H_2 + NaOH$

   Balanced equation (including the states): $2Na(s) + 2H_2O \rightarrow H_2(g) + 2NaOH(aq)$

Inquiry Investigation 4-A Monitoring Paper Recycling

(Student textbook page 169)

Pedagogical Purpose

In this investigation, students test for the presence of several pollutants in the waste water of paper pulp. This reinforces the concept of environmental costs and benefits of chemical processes.

Planning	
Materials	50 mL paper-pulp waste water 6 test tubes Potassium iodide/starch(aq) in dropper bottle Barium hydroxide(aq) in dropper bottle Universal indicator(aq) in dropper bottle **BLM 4-4 Monitoring Paper Recycling** 25 mL graduated cylinder Test-tube rack Silver nitrate(aq) in dropper bottle 0.5 mol/L sulfuric acid(aq) in dropper bottle One or two days before, gather materials and prepare waste water samples and dropper bottles of testing solutions.
Time	Approximately 45 min in class
Safety	Wear safety goggles and an apron. Chlorine bleach in the waste water is caustic. Use the dropper bottles with care. Do not spill the testing solutions. Confirm school or board procedures for the disposal of each substance. Ensure proper disposal containers are available in class.

Background

Chlorine is used to whiten both new and recycled paper. Even the paper sludge for recycling contains residual chlorine. Besides burning skin, it was discovered in the 1980s that chlorine in industrial effluent is linked directly to the creation of the organochlorine dioxins, a man-made carcinogen that passes easily up the food chain.

Indicators solutions (such as iodine) indicate the presence of a substance (such as starch in a potato) by changing the colour of the mixture (it turns blue-black).

Activity Notes and Troubleshooting

- To prepare the paper-pulp waste water, half fill a 2 L container with shredded paper, then fill it with water and let it sit overnight. Then, puree the mix in a blender. Filter the mixture with either a fine sieve or a coffee filter, collecting the liquid.
- Either set up stations around the classroom, one for each indicator solution, or distribute all materials to students so that no liquids are moved around the classroom during the investigation.
- Communicate the correct procedure for cleaning spills and ensure safety apparatus is used.
- Read the procedure as a class, identifying each indicator solution in turn.
- Demonstrate how to use the dropper bottles without spilling solution.
- Briefly discuss the use of chemical indicators and explain that all senses must be used to observe for a change. Since students will not study signs of change until a later chapter, direct them to note colour change, a smell, or a new substance (precipitate) forming. Emphasize that chemicals should be used sparingly (i.e., five drops each). Using more indicator does not get better results!

- Demonstrate how to use universal indicator and interpret results for both an acid (e.g., lemon juice) and a base (e.g., ammonia). If colour charts are not provided, summarize the indicator results chart on the board: universal indicator turns a strong acid (i.e., pH of one or two) red, a substance with a pH of three to six turns orange/yellow, a pH of seven turns green, a pH of eight to 11 turns blue, and a strong base (i.e., pH of 11 to 14) turn purple. Note that pH is discussed in Chapter 5.
- Ensure students have a proper observation table prepared in their notes, or distribute **BLM 4-4 Monitoring Paper Recycling** for this purpose.
- Have students work in small groups of two or three.
- Some tests might show negative results (i.e., no change). Have students repeat the test as levels may be present in very small quantities.

Additional Support

- ELL Encourage students to draw their observations, as well as describing them verbally.
- To help students visualize the testing procedure, prepare an overhead that illustrates the process.
- Enrichment—Have students research the link between chlorine and dioxins and other carcinogens, or have students illustrate the concept of bioaccumulation.
- Enrichment—Have students research the environmental and health dangers of sulfide, sulfate, and sulfite ions. They might also evaluate the importance of pH values in the environment.

Answers

1. chlorine, colour changed to dark blue; chloride ion, a white precipitate formed; sulfide ion, a black precipitate formed; sulfate ion, a white precipitate formed; sulfite ion, a gas formed (there was a burnt-match odour), acid, colour changed to orange-red.
2. Example: Negative tests mean the substance was not detected, but it may be present in quantities too small for the indicator to show.
3. Example: No, because it contains dangerous chemicals.
4. Example: Yes, it does not eliminate all harmful chemicals.
5. Example: Oxygen, ozone, hydrogen peroxide, and other forms of oxygen are widely used in chlorine-free plants. Instead of elemental chlorine, some mills use chlorine dioxide whose by-products are much less harmful to the environment.

Inquiry Investigation 4-B Keep That Toothy Grin

(Student textbook pages 170 and 171)

Pedagogical Purpose

Students conduct an inquiry, controlling variables to test chemistry in action: the science and technology behind products that protect and whiten teeth. Data is gathered and organized from observations, and interpreted to determine whether the evidence supports or refutes the initial prediction, identifying possible sources of error.

Planning	
Materials	2 brands of toothpaste with fluoride 2 brands of teeth whitener Permanent marker 2 hard-boiled eggs Artist's paintbrush 300 mL lemon juice 2 cups or beakers Tea for stains **BLM 4-10 Keep That Toothy Grin** (optional) One or two days before: buy toothpaste, teeth whitener, eggs, and lemon juice. Day before: hard boil the eggs and stain one third of the eggs with strong black tea, divide the teeth whitener and toothpaste samples into four sets of Petri dishes, make copies of the BLM (optional).
Time	Approximately 45 min in class, plus 10 min to observe on two more days
Safety	Wear safety goggles and an apron.

Background

Toothpaste is slightly basic to neutralize the acids in food. A commonly used base is aluminum hydroxide. Fluoride is added to prevent tooth decay by maintaining the enamel. Fluoride is a very tiny particle that can fill in tiny gaps in your teeth so that bacteria can't lodge there. Teeth whiteners generally use hydrogen peroxide, which oxidizes stain-producing organic compounds in the enamel, leaving them colourless.

Activity Notes and Troubleshooting

- To stimulate interest and link chemistry to daily life, have students list the ingredients of toothpaste and tooth whiteners found in their home. Link this to prior learning by having them write as many chemical formulas of the ingredients as they can.
- Have investigation partners supply hard-boiled eggs and samples of toothpaste and teeth whitener from home. This increases the variety and may stimulate interest as students hope their product will prove most effective.
- Seashells may be substituted for eggs and teeth-whitening gel could be used instead of strips.
- To protect against spills while the test eggs sit for days, use cups with lids or place the cups in a drip tray to collect any spills or leaks.
- Remind students to prepare an observation chart, or hand out **BLM 4-10 Keep That Toothy Grin** for them to use.
- Read the procedure to students as they follow in their textbooks. Decide how many days observations will be made over (students may have ideas, two days should be enough). Direct students to include sufficient observation columns.
- Remind students not to eat anything in the lab.
- Since students study signs of change until a later chapter, have them now focus on the "disappearance" of the materials as a sign of corrosion. They may instinctively recognize bubbles and colour change as a sign that something is happening.

- Remind students to clean up their work area and wash their hands thoroughly at the end of the activity.
- Provide class time each day for students to record observations.
- You may wish to have students apply several treatments of teeth whitener, as per manufacturers' instructions.
- After final observations, have students answer and then discuss the questions that conclude the investigation. Survey their observations and conclusions. Did the results surprise them? To draw out the importance of experimental control, ask students why two halves of the same egg were used, rather than two different eggs. Since both toothpastes were immersed in the lemon juice, do they think any cross-contamination occurred? You might link their conclusions to consumer awareness and product marketing (e.g., Is Brand X really better than the cheaper toothpaste?).
- Ask students what other materials might they test with the toothpaste and whiteners. What other foods might they test (e.g., soda pop, vinegar, chocolate)?

Additional Support

- DI This is a good hands-on activity for bodily-kinesthetic learners.
- ELL Encourage students to record observations with diagrams as well as in writing.
- Set up a completed procedure on your desk as a model for students.
- Support students with a take-home, pre-lab quiz on the purpose of the investigation, procedures, and safety considerations. Encourage them to discuss the investigation with family and friends.
- Enrichment—Vinegar is commonly used as an "environmentally friendly" household cleaner. Ask student whether they think vinegar would harm (e.g., etch or dull) a stone countertop or tiles.

Answers

1. Example: The untreated eggshell was damaged and pitted, but the shell treated with toothpaste showed very little damage.
2. Examples: More damage appeared where the shells had cracks in them. It was difficult to tell whether the shell was completely treated.
3. Accept all reasonable responses based on the data.
4. Accept all reasonable responses based on the data.
5. Example: Because the sodium fluoride in the toothpaste protected the eggshell from the lemon juice.
6. Accept all reasonable responses based on the data.
7. Example: No, teeth would get stained again as the person ate and drank.
8. Example: Brush one half of an eggshell repeatedly with toothpaste, using a colour chart to evaluate whether or not it was whitened.
9. Example: Factors that should be considered when choosing in-home or professional whitening include cost, time required, ease of use, safety, and degrees of whitening possible.

Inquiry Investigation 4-C Comparing the Masses of Reactants and Products (Student textbook page 172)

Pedagogical Purpose

Students evaluate data from observations of a dramatic chemical reaction to confirm or refute the law of conservation of mass, identifying possible sources of error.

Planning	
Materials	20 mL 0.1 mol/L sodium hydroxide solution 15 mL 0.1 mol/L iron(III) nitrate solution 200 mL Erlenmyer flask Tongs 50 mL graduated cylinder (optional) **BLM G-13 Data Table** (optional) Stopper Small test tube (to fit inside flask) Balance Day before: prepare solutions and separate into four sets.
Time	Approximately 30 min in class
Safety	Wear safety goggles and an apron. Sodium hydroxide is caustic. Students should wash their hands at the end of the activity. Collected and dispose of waste according to school policy. Have spill and broken glass kits on hand.

Background

There should be no change in mass as the system is closed; no atoms can enter or leave during the experiment.

Activity Notes and Troubleshooting

- Alternative: Use the test tube in Erlenmeyer flask technique to mix baking soda and vinegar with a balloon stretched over the mouth of the flask to collect the gas. Use a balance to verify the mass does not change. Because the gas visibly inflates the balloon, this reinforces the concept that gases have mass.
- Alternative: Demonstrate the reaction of copper(II) sulphate and sodium hydroxide, forming a dark blue gelatinous copper(II) hydroxide precipitate. Or, combine potassium thiocyanate and iron(III) nitrate which turn a blood red colour.
- Have students prepare a lab report template before class, including an observation table. You may wish to provide **BLM G-13 Data Table.**
- To minimize congestion, divide materials equally into stations at the four corners of the class.
- State the safety procedures for cleaning up broken glass and spilled solutions.
- Survey the class for guidelines on making good observations and have partners verify that observation tables are correctly designed.
- Demonstrate how to use the balance and read it correctly. Reading errors are common. This provides and excellent opportunity to talk about the necessity of good technique to get meaningful data.
- Demonstrate how to lower the test tube into the Erlenmeyer flask.

- Direct students to wipe the outside of the test tube and Erlenmeyer flask after adding chemicals to them.
- Compile students' results on the board or an overhead for comparison. Reinforce that the purpose of this investigation is to test the law of conservation of mass. They are not attempting to "prove" or "disprove" the law. Only reproducible results are definitive, any discrepancies should be retested.
- This is a good opportunity to discuss the nature of error in experiments and why experiments need to be done many times before any kind of law can be validated. In practice, some students will not completely seal their apparatus so some gas will escape. You may encourage some groups to repeat their experiment to address any errors they identify.
- Have students review each others' Analyze and Interpret responses before they complete their reports for submission.

Additional Support

- DI This is a good hands-on activity for bodily-kinesthetic learners.
- ELL Review the procedure and check for understanding.
- Present an assembled set of equipment as a model or, illustrate the set-up on an overhead.
- Encourage students to illustrate their observations as well as making notes.
- Enrichment—Have students list evidence of a chemical change.

Answers

1. identical
2. Yes, because the mass was the same.
3. $3NaOH + Fe(NO_3)_3 \rightarrow 3NaNO_3 + Fe(OH)_3$
4. The increased mass could be the result of the copper powder combining with a gas in the air (adding mass).