Section 5.1 Synthesis and Decomposition Reactions

(Student textbook pages 179 to 189)

Specific Expectations

- **C2.1** use appropriate terminology related to atoms, elements, and compounds, including, but not limited to: *boiling point, mixtures, particle theory, pure substances,* and *viscosity*
- **C2.2** conduct an inquiry to identify the physical and chemical properties of common elements and compounds
- **C2.3** plan and conduct an inquiry into the properties of common substances found in the laboratory or used in everyday life, and distinguish the substances by their physical and chemical properties
- **C3.3** distinguish between elements and compounds
- **C3.4** describe the characteristic physical and chemical properties of common elements and compounds
- **C3.5** describe patterns in the arrangements of electrons in the first 20 elements of the periodic table, using the Bohr-Rutherford model

In this section, students explore the signs of chemical change, and examine and predict the products of synthesis and decomposition reactions.

Common Misconceptions

- Discourage the idea that a chemical change has occurred when a product cannot be changed back. While it does help distinguish dissolving as a physical change rather than a chemical one, many changes can be undone.
- Odour may be overlooked as a sign that a gas is released. Remind students to use all of their senses, and that gas may be smelled.
- Energy absorption may be overlooked as a sign of chemical change. Encourage students to recognize, for example, that a chemical cold pack absorbs thermal energy (becomes cold) during its chemical reaction.
- Heating is sometimes mistaken as a sign of chemical change. Temperature change from an external source such as a flame or fridge is a physical change.

Background Knowledge

Decomposition reactions are usually endothermic (they absorb thermal energy, causing cooling). Most synthesis reactions (also called combination or addition reactions) are exothermic (they release thermal energy).

Sometimes a catalyst is used to speed up a reaction. For example, electricity is used up in the electrolysis of water.

Fritz Haber (who developed the Haber process) was a German chemist who produced nitrates for explosives in World War 1. His contribution to the synthesis of ammonia (specifically, fixation of nitrogen from the air) won him a Nobel Prize, and his technology prolonged the war. It is thought that his wife, a chemist who opposed his work on poison gas, committed suicide after seeing the results of the chemical weapons.

Literacy Support

Using the Text

- ELL Have students highlight Key Terms in their notes and keep a list of the new terms with definitions and examples.
- DI ELL Have spatial and English language learners create a concept map linking all the types of chemical reactions and the signs of a chemical change.

Using the Images

- Before reading the captions for Figure 5.2, have the class describe the signs of change shown. Can they list all six signs? Can they name the reactants and the products?

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Learning Check question 2, page 185	Balanced equation includes diatomic iodine and a single compound product.	Reactivate understanding and implication of diatomic elements (HOFBrINCl). To reinforce that synthesis is “assembly,” have students use molecular models to build products from reactants.
Activity 5-2 Building Up and Breaking Down, page 188	Students identify b. as a decomposition reaction and a. and c. as synthesis reactions.	Have students work with a model of only the reactants, forming the products by either breaking them apart or combining them. Link the physical action of breaking and building to the difference between decomposition and synthesis respectively.

Instructional Strategies

- Have students carry out Activity 5-2 Building Up and Breaking Down. See page TR-2-40 of this Teacher's Resource for teaching notes on this lab.
- To capture students' attention, demonstrate the signs of chemical change: copper(II) sulfate and sodium hydroxide form a precipitate; light magnesium ribbon on fire to release heat and light; place a small piece of calcium metal in water to produce a gas; drip phenolphthalein into sodium hydroxide for a colour change. Discuss the observations as a class.
- Alternate materials—Use everyday objects for the same demonstration: glow stick, cold pack, fizzing antacid, rust, browning apple slice (colour and odour).
- Reinforce endothermic and exothermic chemical changes by having students measure the temperature change as calcium chloride and ammonium chloride each dissolve in water (separately).
- Have students carry out Plan Your Own Investigation 5-A Evidence of Chemical Change. See page TR-2-51 of this Teacher's Resource for teaching notes on this lab.
- Encourage students to begin the graphic organizer described on page 181. As they read the chapter, students should add details about the four reaction types and note examples. You may wish to refer students to Study Toolkit 4 on page 565 of the student textbook for examples of graphic organizers.
- Emphasize the pattern in each type of reaction. Use manipulatives to illustrate, for example, AB separating into separate A and B units, as shown on page 185 of the student textbook.
- Demonstrate a synthesis reaction by combining magnesium and oxygen to produce magnesium oxide. Then demonstrate a decomposition reaction using a can of soda (carbonic acid, H_2CO_3). After it sits for a while, the carbon dioxide gas escapes the solution and the soda goes flat: $H_2CO_3 \rightarrow CO_2 + H_2O$. Place the reaction into a useful context by asking students why they might be advised to drink flat ginger ale for an upset stomach (Answer: because the acid in "fresh" ginger ale upsets stomachs.)
- Using a Hoffman apparatus, demonstrate the electrolysis (decomposition) of water into hydrogen and oxygen. Link to previous learning by having the class develop a balanced equation for this reaction, then compare the relative volume of each gas to the ratio in the equation. You may wish to further reinforce prior learning by placing the whole apparatus on a balance, to confirm the law of conservation of mass.
- Have students carry out Inquiry Investigation 5-B Synthesis and Decomposition Reactions. See page TR-2-53 of this Teacher's Resource for notes on this lab.
- As a class, read the Case Study: Hydrogen: Fuel of the Future? See page TR-2-5 of this Teacher's Resource for notes on using this feature.

Activity 5-2 Building Up and Breaking Down (Student textbook page 188)

Pedagogical Purpose

Students manipulate molecular model kits to represent the products and reactants in synthesis and decomposition reactions.

Planning	
Materials	Molecular modelling kit One or two days before, gather molecular model kits, exploring them to ensure that all parts are present and that you know what each part represents.
Time	30 min

Background

Molecular model kits help bodily-kinesthetic learners because atom balls contain a representative number of points at which they can be joined. Each hole represents one ion charge. For example, elements from group 1 or 17 can be represented by an "atom" with one hole, which illustrates that there is one valence electron available for sharing. To mimic double bonds, some model kits use springs to join holes that do not align.

Activity Notes and Troubleshooting

- Show students how to assemble and disassemble the molecular model kits. Explain what the various parts represent, including a colour code, such as black has four holes. You may wish to use **BLM G-17 Using Models and Analogies in Science** for this activity.
- Reactivate understanding of valence charges and electron sharing.
- Reactivate understanding of the diatomic elements so that students will see that the oxygen in the first equation must start as a molecule of O_2.
- Provide **BLM 5-4 Building Up and Breaking Down,** which provides scaffolding for observations.

Additional Support

- DI ELL This is an excellent opportunity for English language learners and spatial learners.
- Provide students with nuts and bolts to model synthesis (assembly) and decomposition (disassembly or separation).
- To challenge students, provide models for one side of a chemical equation and have them work out the other side. For example, provide $2H_2 + O_2$ and let them work out that the product must be $2H_2O$.

Answers

1. Reaction b is a decomposition reaction because a larger molecule split into two smaller, simpler molecules.
2. Equations a and c are synthesis reactions since both combined two substances to form a single compound. Simple elements combine to make larger, more complex molecules.
3. Example: The models let me attach and separate atoms until it represents what is happening at the level of the elements and how many of each are involved in the synthesis or decomposition reaction.

Learning Check Answers (Student textbook page 185)

1. $A + B \rightarrow AB$
2. $2K(s) + I_2(g) \rightarrow 2KI(s)$
3. **a.** synthesis
   b. not synthesis
   c. synthesis
4. Example: In a synthesis reaction, a product is made by combining reactants. So, synthetic and synthesized must mean "made by combining parts."

Section 5.1 Review Answers (Student textbook page 189)

Please see also **BLM 5-6 Section 5.1 Review (Alternative Format).**

1. Two or more reactants combine to form a single product.
2. Example: Haber process produces ammonia for fertilizers
3. Rusting as iron decomposes into iron(II) oxide *or* iron(III) oxide.
4. A single reactant breaks down to form two or more products.
5. Because H_2O breaks down into hydrogen and oxygen. $2H_2O \rightarrow 2H_2 + O_2$.
6. Drawings should show how the processes are opposite with, for example, two arrows pointing opposite directions in the same equation.
7. **a.** $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$ Synthesis, since elements combine to form a compound.
   b. $8Ca(s) + S_8(s) \rightarrow 8CaS(s)$ Synthesis, since elements combine to form a compound.
   c. $2CsCl(s) \rightarrow 2Cs(s) + Cl_2(g)$ Decomposition, since a compounds breaks apart into elements.
8. **a.** $3Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)$ The reactants are two elements, so the reaction should be a synthesis.
   b. $2K_2O(s) \rightarrow 4K(s) + O_2(g)$ The reactant is a single compound, so the only reaction that could happen is the decomposition of the compound.
   c. $2Na(s) + Br_2(\ell) \rightarrow 2NaBr(s)$ The reactants are two elements, so the reaction should be a synthesis.