Section 5.2 Displacement Reactions

(Student textbook pages 190 to 198)

Specific Expectations

- **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
- **C3.4** 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 examine equations of single and double displacement reactions, predicting the products and exploring applications. They investigate patterns in the reactivity of metals using an activity series, and develop an activity series for a set of non-metals.

Common Misconceptions

- Some students think metals can only replace metals. Metals also can displace hydrogen because hydrogen behaves as a metal in that it loses an electron to form a positive charge.
- The first two elements and the second two elements are sometimes swapped by rote in a double displacement reaction. Direct students to first evaluate the valence charge of the elements to determine the proper combinations, reminding them that opposite charges attract to form ionic bonds.

Background Knowledge

Single and double displacement reactions are sometimes called replacement reactions. In both types of displacement reaction, an element with a positive valence will only displace another element with a positive valence. Similarly, a negative valence only displaces another negative valence. In double displacement reactions, the positive and negative portions of two compounds are interchanged. Double displacement reactions usually produce an insoluble precipitate.

The difference between elements' reactivity results from the differences among the attraction between electrons and protons, element to element. In each atom, this is affected by the distance between electrons and the nucleus as well as by the size of the charge in the nucleus. Thus, even though all group 17 elements have a charge of 1–, the elements can be ordered by reactivity. Some elements are so reactive they only exist in nature as compounds.

Literacy Support

Using the Text

- The photographs provide visual clues to double and single displacement reactions that match the balanced chemical equations.
- People frequently classify things—even our pets. For example, what kind of dogs are there? (Answer: hunting dogs, guard dogs, toy dogs, etc.) The same is true with chemical reactions. The main reason to classify chemical reactions is to allow us to predict outcomes or product in chemical reactions.

Before Reading

- On a piece of paper, have students draw three squares. Ask students to place the headings of single displacement reactions with a metal, single displacement with a non-metal, and double displacement reactions in each box.
- Have students create a glossary of Key Terms for the section, locating definitions in the text by their boldface and highlighting.
- Read the summary on page 198 of the student textbook to preview the major concepts and terms prior to reading the entire section. Have them create a K-W-L chart or four-corners placemat to summarize what they already know and what they want to know about the topic. You may wish to use **BLM G-48 K-W-L Chart** for this activity.

During Reading

- Ask students to add two example reactions from the text to each of their three pre-reading boxes.
- Students can use point form notation to reinforce the meaning of the Key Terms and identify their use and relevance in the chapter.
- Have students add to their pre-reading chart, adding new points as they learn them.

After Reading

- Have students compare the information in each of their three boxes and list the characteristics of each type of the three reactions. Students may find that using the photo images will be helpful.
- ELL English language learners students may benefit from listing synonyms for *displacement* and defining *trade,* and *switch* in their notes.
- Students should re-examine their glossary to consolidate understanding and identify areas, which require remediation. Encourage students to use a Key Term in a sentence that illustrates its meaning or use.
- Have students check their K-W-L charts, reviewing the textbook to fill in any outstanding points they have yet to learn.

Using the Images

- Have students view the images before reading the accompanying passages. Ask students if they have visited Sudbury or if students can identify, from the picture, what the major industry is located there. (Answer: mining)
- Ask students to write the formula for nickel(II) sulphide and predict what the products of its reaction with oxygen might be.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Practice Problems 1, page 193	Products are valid compounds.	Have students complete **BLM 4-15 Balancing Chemical Equations** for additional practice if they have not already done so.
Learning Check question 2, page 195	Reactions are correctly classified.	Allow students to use manipulatives such as the molecular model kits.
Section 5.2 Review question 6, page 198	Metal ions only replace metal ions.	Review valence charges of metals and non-metals to determine the correct charge on each of the elements in the displacement reaction

Instructional Strategies

- DI To aid bodily-kinesthetic and spatial learners, have three students illustrate the analogy of dance partners as a single displacement which occurs when one person (element) cuts in on a dancing couple (compound), producing a new couple and single dancer.
- Use brightly coloured manipulatives such as a molecular model kit to illustrate single displacement. Identify the positive and negative ions to reveal the pattern whereby positive displaces positive and negative displaces negative.
- Demonstrate a single displacement reaction between copper wire and aqueous silver nitrate. Have a volunteer record the class' observations before, during, and after the reaction. Link to prior learning by asking what clues to a chemical change are illustrated. Then, read Displacing Metals with Metals on page 191 of the student textbook, noting especially the balanced chemical equation and identifying the products.

- Introduce activity series by writing the potential single displacement Cu(s) + Fe $(NO_3)_3$ reaction on the board, then demonstrating that it does not occur. Ask, "Why didn't anything happen?" Have students read the section for the answer.
- Examine Figure 5.12, reading the accompanying text to identify what reaction is shown. (Relate this to the demonstration, if you carried it out.) Then refer students to the activity series and explanation on page 192 and ask if they expect the opposite reaction would happen. (Answer: No, because copper is more reactive than silver.)
- Have students carry out Activity 5-3 How Active Are the Non-Metals? See page TR-2-44 of this Teacher's Resource for teaching notes on this lab.
- Perform a POE (predict, observe, explain) demonstration or mini-lab using copper in zinc nitrate and zinc in copper nitrate. Have students first use the activity series to predict if a reaction will occur, then observe the reaction. Finally, have them explain the outcome using a balanced chemical equation.
- Show students a 35 mm camera, film, negative, and photo print to provide a context for the non-digital photography discussed on page 196 of the student textbook. Explain that the film acetate was coated with the light sensitive silver nitrate. A series of chemical baths turned the exposed film (i.e., after pictures were shot) into negatives, which were then used to filter light onto a light sensitive paper. A different set of chemical baths turned the exposed paper into prints.
- Have students use Table 5.1 to add to the graphic organizer they started in the last section.
- Clarify that the sulfites (discussed in food preservation) are a class of chemicals that includes sulfur dioxide.
- Have students carry out Inquiry Investigation 5-C Displacement Reactions. See page TR-2-55 of this Teacher's Resource for teaching notes on this lab.

Activity 5-3 How Active Are the Non-Metals? (Student textbook page 194)

Pedagogical Purpose

This activity provides the raw data necessary for students to develop an activity list for five non-metals. Students develop a useful activity series, and also experience how it might be possible to use experimental data to infer such as list.

Planning		
Materials	Molecular model kit **BLM 5-7 How Active Are the Non-Metals?**	Coloured pencils (optional)
Time	40 min	

Background

The elements in this activity (except oxygen) are halogens. Fluorine is so reactive that it reacts with both water and glass, making it hard to isolate in the laboratory. Fluorine is highest on the halogen activity series because it will take electrons from each element in the list below it. The larger the atom (more electron shells), the less reactive it is (because valence electrons are farther from the nucleus, the attraction to new electrons is less strong).

Activity Notes and Troubleshooting

- Reactivate understanding of how to use the molecular model kits.
- Reactivate learning of how to write chemical names.
- Each reaction involves a magnesium compound. It may help students to recognize that the reactivity of magnesium is not being evaluated.

- Wrap up by creating a master activity series. Compare the list to the periodic table. Can students recognize the pattern in the group 17 halogens?
- You may wish to use **BLM A-15 Venn Diagram Checklist** to assess students' work in question 5.

Additional Support

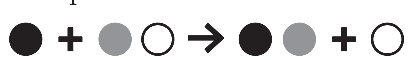
- DI This is an excellent activity for English language learners, spatial learners, and bodily-kinesthetic learners.
- DI Logical-mathematical learners may wish to evaluate the balanced equations alone to determine which elements did or did not replace each other.
- ELL Demonstrate or show videos of each reaction rather than using the model kits.
- Distribute copies of **BLM 5-7 How Active Are the Non-Metals?**, which scaffolds this activity.
- Challenge students to explain why precious metals are used for jewellery and coins rather than reactive metals. (Answer: Since they are less reactive, they resist rust, dissolving, etc.)
- Encourage students to use colour in their diagrams of the equations as a model.
- To help students get started, you may wish to point out that the element on its own in the products is the less reactive element of the pair.
- Provide a list of the chemicals in this activity for students to use when completing word equations.

Answers

1. displacement
2. fluorine, oxygen, chlorine, bromine, iodine
3. Example: I started by writing pairs of elements, with the more reactive element on top. Then, I meshed the paired lists until all pairs were in a single list.

Learning Check Answers (Student textbook page 195)

1. $A + BC \rightarrow AC + B$
   $A + BC \rightarrow BA + C$
2. **a.** Decomposition, since the compound is broken down.
   b. Single displacement, since Ag replaces Au in the compound.
   c. Synthesis, since two separate elements form a single compound.
3. Example:



4. These elements are the least reactive, so they do not readily form compounds.

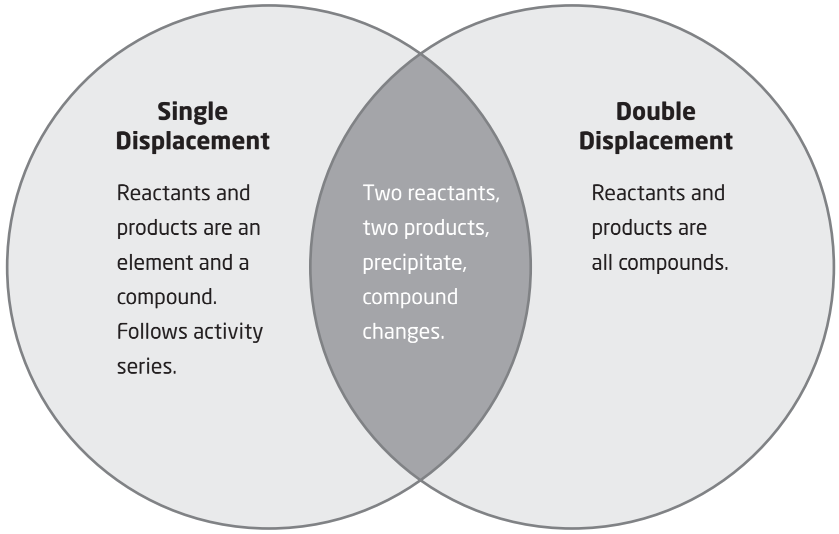
Section 5.2 Review Answers (Student textbook page 198)

Please see also **BLM 5-9 Section 5.2 Review (Alternative Format).**

1. A reactive element takes the place of a less reactive element in a compound.
2. **a.** $Ca(s) + 2AgNO_3(aq) \rightarrow 2Ag(s) + Ca(NO_3)_2(aq)$
   b. not reaction
   c. $Al(s) + HCl(aq) \rightarrow AlCl_3(aq) + H_2(g)$
3. Many metals are more reactive than silver is, so there are many elements that could be used to displace the silver. Lithium, however, is the most reactive of the metals in the activity series. There are no metals more reactive that could be used to displace it.

4. Two compounds exchange positive (or negative) ions, forming two new compounds.

5. Example:



6. **a.** single displacement $Cl_2(g) + 2CsBr(aq) \rightarrow Br_2 + 2CsCl$

b. double displacement $2AgNO_3(aq) + Na_2CrO_4(aq) \rightarrow Ag_2CrO_4 + 2NaNO_3$

c. double displacement $MgCl_2(aq) + 2AgNO_3(aq) \rightarrow 2AgCl + Mg(NO_3)_2$

d. single displacement $F_2(g) + 2NaI(aq) \rightarrow I_2 + 2NaF$

7. single displacement reaction; $3CuSO_4 + 2Al \rightarrow 3Cu + Al_2(SO_4)_3$; copper

8. A double displacement reaction because the arsenate would precipitate from the solution.