Topic 2.4
What are acids and bases, and how do they react?

Specific Expectations

- **C1.1** analyze, on the basis of research, the function of chemical reactions in the production of selected products and/or in the workplace, and communicate their findings
- **C1.2** identify practical applications of chemical reactions in a particular profession, and assess the associated hazards, including hazards associated with the handling and disposal of chemicals
- **C2.1** use appropriate terminology related to chemical reactions, including, but not limited to: *antacid, dilute, neutralization, product, reactant,* and *word equation*
- **C2.5** use an inquiry process to investigate acid-base neutralization reactions
- **C2.6** conduct an inquiry to classify some common substances as acidic, basic, or neutral
- **C2.7** investigate applications of acid-base reactions in common products and processes
- **C3.3** write word equations and balanced chemical equations for simple chemical reactions
- **C3.4** describe the process of neutralization for simple acid-base reactions
- **C3.5** describe how the pH scale is used to identify the concentration of acids and bases

Overview

In this topic, students will learn the properties of acids and bases, and how to identify them using chemical indicators. Students will also explore some common uses of acids and bases, and learn how to be safe while using them.

Common Misconceptions

- **Students may think that chemicals containing H are acidic and chemicals containing OH are basic.** It is not the presence of these atoms or groupings that make a substance acidic or basic. It is the ability of the ions to dissociate in solution to make free H and OH ions. A simple example is a glucose molecule which contains H and OH groups but is neither acidic nor basic because those atoms are strongly bonded to the rest of the molecule and do not detach in solution.
- **Students may think that *strength* and *concentration* are the same thing.** The strength of an acid or base depends on what percent of the H or OH detach in solution. HCl is a strong acid because all the molecules of HCl dissociate into ions in solution. Acetic acid is a weak acid because only one percent of the molecules dissociate into ions in solution. The concentration of an acid or base is based upon the ratio of the acid or base to water in the solution. The more water you add, the lower the concentration. Some acids actually become stronger as the concentration decreases.
- **Students may think that only acids are dangerous.** Both acids and bases are corrosive. Demonstrate this using a raw egg and a few drops of 1.0 M HCl. The transparent egg white will become opaque. Repeat the experiment using a raw egg and few drops of 1.0 M NaOH. Again, the egg white will become opaque. Connect this to safety and compare the egg to a student's eye. Students will want to wear safety goggles after seeing this.
- **Students may think acids and bases are only dangerous at school.** Many household cleaners contain very strong bases (for example, drain cleaners) or very strong acids (for example, oven cleaners). Point this out after students complete Activity 2.17, where they compare the pH of common household substances.

Background Knowledge

Acids are chemicals that release protons (H+ ions) into solution and bases are chemicals that release hydroxide (OH- ions) into solution. When acids and bases react, the protons join with the hydroxide and produce water and a salt in a neutralization reaction.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + HOH(l)$$

Acids will react with metals to produce hydrogen gas. This can be demonstrated by adding a small piece of zinc to hydrochloric acid in a test tube, collecting the gas produced while a stopper is on the test tube, and then introducing a burning splint to the gas in the tube. The gas will "pop." Students should recall this test from grade 9 and identify the gas as hydrogen.

pH is a logarithmic measure of the concentration of H ions in a solution; $pH = -\log [H+]$. The lower the pH, the more acidic the solution. The higher the pH, the more basic the solution. A pH of 7 refers to a neutral solution. pH can be determined using indicators that change colour at a specific pH value or by using an electronic pH meter.

Indicators are chemicals that react with either the proton or the hydroxide ion and change colour. This is a simple chemical change (a new chemical is produced each time). Red cabbage juice contains anthocyanin (just like hydrangeas), which demonstrates a different colour at each pH value. The hydrangea is a shrub with clusters of showy flowers. The colour of its flowers can change as the pH of the soil in which it grows changes. The flowers are red-pink under neutral to low soil acidity and blue under conditions of higher acidity. Hydrangeas contain a natural indicator, anthocyanin, which is responsive to the pH of its surroundings. Observations such as these about hydrangeas can constitute a central theme in understanding acids and bases.

Acids and bases have real-life significance. The human body functions properly only when delicate acid-base balances are maintained. Crops grow best in soil with the proper pH. Substances released into the atmosphere as pollutants often form acid rain. In addition, many substances used in the home are acids or bases.

Literacy Strategies

Before Reading

- Ask students to name acids and bases that they are familiar with. Discuss what they know about acids and bases already or have them complete **BLM 2-39 K-W-L Acids and Bases**. As students share, record so that English language learners can see and hear critical language and observe you recording ideas.

During Reading

- Have students complete **BLM 2-41 Properties of Acids and Bases**.
- Discuss the figures using think-aloud.
- Ask students how the text relates to their daily lives.
- Ask students to identify the WHMIS and HHPS that would apply to acids and bases.
- Have students add new words to their visual glossary. Use **BLM 2-8 Visual Glossary**, if necessary.

After Reading

- Haves students complete the Learning Check questions.
- Ask students to summarize what they have read in a paragraph or a visual format like a cartoon.

Skills

- apply and use safe practices while working with chemicals and in the lab
- locate information sources to research question
- organize and record relevant information on research topics
- identify and describe careers related to chemistry
- select appropriate instruments and materials
- conduct experiments, using equipment and materials safely and accurately
- gather data and display the data effectively
- analyze and interpret data to support a hypothesis, identifying bias or uncertainty
- make and justify conclusions
- identify Canadian scientists within the field of chemistry

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see pages TR-42 to TR-46 for a summary of the materials required in this topic.

Assessment FOR Learning		
Tool	**Evidence of Learning**	**Supporting Learners**
Learning Check, page 161	Students place at least 10 characteristics in the Venn diagram, comparing acids and bases.	• Refer to Table 2.10. Cut up the properties of acids and bases and have students sort them using a Venn diagram. Use **BLM 2-42 Table 2.10** and provide students with **BLM G-49 Venn Diagram.**
Learning Check, page 163 Activity 2.14, page 163 Activity 2.17, page 171	Students correctly identify a substance as acidic or basic by using the pH scale.	• Have students act out a pH scale. Assign students characteristics of acids or bases. Then ask them to line up from lowest pH to highest pH. • Provide **BLM 2-43 Using Indicators to Identify Acids and Bases** for students to record their answers.
Learning Check, page 164	Students state that the products of a neutralization reaction will be water and a salt. They also explain that the pH of the solution will become 7 (which is neutral).	• Have students colour **BLM 2-44 Double-Displacement Neutralization.** • Have students act out a neutralization reaction. Label student 1 with two pieces of paper (one with an H and the other with a Cl). Label student 2 with two pieces of paper (one with an OH and the other with an Na). Ask them to stand next to each other and then ask the class to rearrange their labels on students 3 and 4. Student 3 should be labelled with the Na and the Cl. Student 4 should get the H and the OH.
Learning Check, page 166 Activity 2.15, page 166	Students analyze chemical reactions, their products, and the workplace where they are used. They also indicate the hazards associated with the chemicals.	• Have students work in small groups. One student can research, one can record, and one can create a formal report. • As a class, combine the research for each profession and make a chemical careers book. • Provide **BLM 2-45 Acid and Base Careers** for student to record their work.
Activity 2.16, page 170 Investigation 2C, page 172	Students explain that *neutralization* means a pH of 7 is obtained and explain that neutralization occurs when acids and bases react.	• ELL Provide **BLM 2-46 Neutralization Reactions** to help students complete the activity. • DI Provide **BLM 2-48 Acid-Base Neutralization Reactions Instructions** for students who need additional help to prepare for the investigation. Visual learners may benefit from seeing diagrams of the steps. • Provide **BLM 2-47 Investigation 2C, Acid-Base Neutralization Reactions** to all students.
Investigation 2D, page 173	Students investigate acid-base neutralization reactions and use appropriate terminology to describe what occurs.	• Provide **BLM 2-50 The Effectiveness of Antacids Instructions Activity** for students who need additional help to prepare for the investigation. • Provide **BLM 2-49 Investigation 2D The Effectiveness of Antacids** to all students. • Provide students with **BLM 2-51 The Effectiveness of Antacids Instructions in Order** for self-assessment.

Topic 2.4 (Student textbook pages 158–175)

Using the Topic Opener

- Provide students with the following background information. Bacteria in the mouth change dental plaque caused by sugar. Bacteria also make acid. The acid causes tooth decay and can cause gum disease and bad breath. Tooth enamel is made of mostly calcium. Acid dissolves the calcium in the enamel. Eventually, the surface of the enamel breaks and a hole called a cavity forms.
- Student might be interested in knowing that cavities are found using X rays or a special laser, called a DIAGNOdent®, that detects early cavities. If the cavity is found early enough, it can be treated without extensive corrective procedures.
- Discuss the connection between an acidic drink like cola and the production of tooth decay (the same acid-calcium reaction will occur). Be sensitive to dental issues some students may have experienced due to poor nutrition related to the immigration experience.
- Use a **BLM 2-39 K-W-L Acids and Bases** to get students asking questions about acids and bases, and to direct your teaching.
- For enrichment of the Starting Point Activity, students could treat eggshells with different types of tooth hygiene products (for example, toothpaste, mouthwash, dental strips) to see if any of the products prevent the shells from corroding. Connect this activity to how these products would work on teeth. Students should be reminded that eggshell is also made of calcium. This activity will take at least two days before results can be seen.

Starting Point Activity (Student textbook page 159)

Pedagogical Purpose

This activity is designed to introduce students to acids and bases. Connecting the action of acid on bone to tooth decay will make students think about their own dental hygiene regimens.

Planning	
Materials	chicken bones white vinegar jars with lids **BLM 2-40 Topic 2.4 Starting Point Activity** (optional)
Time	5 min for several classes 10-30 min preparation
Safety	Remind students not to eat or drink anything in the science classroom. Vinegar is corrosive. If students get vinegar on their skin, have them rinse the area with water for a few minutes. Students should wear gloves and safety goggles while handling vinegar or making observations.

Activity Notes and Troubleshooting

- This activity can be done as a teacher demonstration or in small groups. Alternatively, it could be assigned as a challenge to be completed at home.
- Be careful to boil the chicken bones until all meat is removed. There is a danger of salmonella bacteria developing if bones are not completely disinfected.
- Make sure that the vinegar and bones are in a sealed container. Containers can be a jar with a lid, a beaker with plastic wrap, or a test tube or Erlenmeyer flask with a stopper.
- Use enough vinegar to submerge the bones.
- Instead of chicken bones, you could use eggshells or marble chips placed in a test tube of vinegar, sealed with a stopper.

Additional Support

- DI The television series, *Mythbusters*, demonstrates the effect of cola on several objects. Show students videos from this series that demonstrate the corrosive action of cola. Spatial learners will appreciate the video demonstrations. English language learners may benefit from the background information it provides.
- ELL Provide **BLM 2-40 Topic 2.4 Starting Point Activity** to help English language learners understand the instructions and to record their observations.
- DI Interpersonal learners and English language learners should complete their work with a partner. Allow time for discussion of the observations and results.

Starting Point Activity Answers

Students should observe that the bones become smaller as the calcium in the bones is leached out into the vinegar. The bones might become more flexible.

Instructional Strategies for Topic 2.4

Student textbook pages 160–161

- Before starting this lesson, have students complete **BLM 2-39 K-W-L Acids and Bases**.
- Have students add new words to their visual glossary. Use **BLM 2-8 Visual Glossary**, if necessary.
- You can use a lemon to demonstrate the properties of acids and bases.
  - Ask students to describe the taste of lemon juice (sour) and lemon peel (bitter).
  - Use a conductivity tester to demonstrate that the lemon is conductive. (This is review from grade 9.)
  - Add a variety of indicators to the juice and the peel, such as litmus, pH paper, bromothymol blue, or phenolphthalein. Repeat the indicator tests on a "mystery" chemical (for example, vinegar). Ensure that English language learners understand what is meant by "mystery". Ask students to compare the results of this test to the results of the lemon tests. Repeat again with a second mystery chemical (for example, baking soda dissolved in water) and compare.
  - Tell students that the juice is an acid and the peel is a base. Ask students to label the mystery chemicals as acids or bases.
- Ask students to name the items in Figure 2.22 and Figure 2.23. Ask them if they are surprised that those items are acids or bases.
- Have students complete the Learning Check questions. Explain what is meant by convert.
- DI Ask spatial learners to draw a cartoon that shows the properties of either acids or bases in a humorous way.
- DI Ask linguistic learners to write a joke that includes one of the characteristics of acids and bases.
- DI Bodily-kinesthetic, interpersonal, linguistic and English language learners can use this section as an opportunity to teach each other. Divide the class in half. Number one group 1 and the other group 2. Have the students numbered 1 learn five things about acids and those numbered 2 learn five things about bases. Allow them to work with a partner. Then have the class stand in "Inside-Outside Circle" formation with the students numbered 1 on the inside and students numbered 2 on the outside. Once they are in the circle, students tell the person opposite them one fact they learned. Have the inside circle move one step to the right and repeat the process of sharing until they have moved five times. Have the outside circle move one step to the left and have students summarize to their partner what they learned about the other topic (for example, student 1 will explain what bases are to student 2).

Student textbook pages 162–163

- DI Tell students about a problem you have with one of your plants (a hydrangea). When you bought it you thought it would have blue flowers but when it flowered, it had pink flowers. When you took it back to the greenhouse, the sales clerk told you that the pH of the soil made the flowers either pink or blue, and that you had to change the pH of your soil by adding a base. Ask students what they think pH is. Ask if they have heard the term *pH* before (perhaps in a shampoo commercial?). This is a good exercise for interpersonal learners.
- Decode the caption for Figure 2.24. Ask students why some of the letters are in red and some are in blue. This is a mnemonic to help students remember that litmus turns blue in a base. (both start with the letter b) and red in an acid (both end with the letter d).
- DI Gather some of the materials shown in Figure 2.25 and place them randomly on your desk. Challenge students to place them in order from the strongest acid to the strongest base. Bodily-kinesthetic learners will appreciate being able to manipulate the items before writing down their answers. Then, use Figure 2.25 to place the items on your desk in the correct order. Ask students to reflect on the correct order and to share comments on any items that were a surprise.

Student textbook pages 164–165

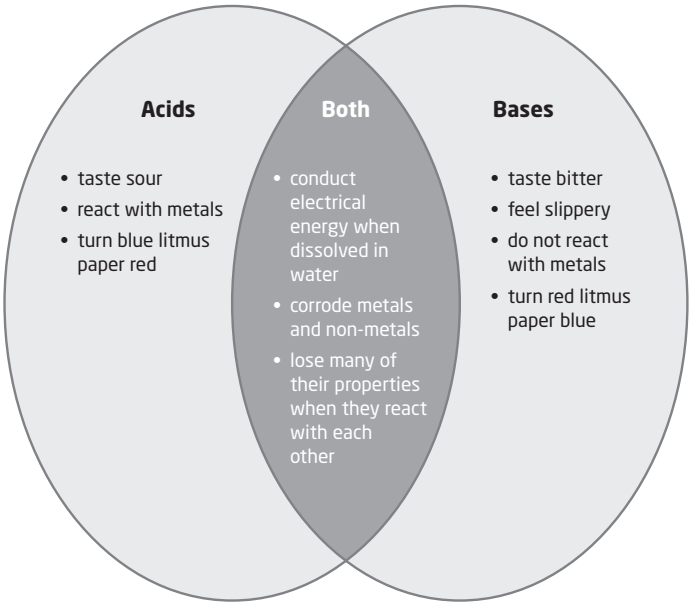
- Before starting the class, demonstrate the magic behind a neutralization reaction. Add 2 to 3 drops of bromothymol blue to a solution of pH 6 to 7 (a weak acid); it will make the solution yellow. Slowly add sodium hydroxide to the solution until its colour changes to green. Tell students that you are changing the pH of the acid by adding a base to it. When the solution turns green, it is neutral (pH of 7). Add a bit more NaOH and the solution will turn blue.
- Ask students to define the word *neutral*. Their definitions do not have to be in relation to chemistry. Use a think-pair-share strategy. Allow students to discuss the definition with a partner and then ask for volunteers to share their definition.
- Pause after Figure 2.26 and have students complete **BLM 2-44 Double-Displacement Neutralization.**
- Have students add definitions to their visual glossaries. Use **BLM 2-8 Visual Glossary**, if necessary.
- After reading, you could have several follow-up activities. Ask students to pair up with someone with a similar learning style and create a memory tool to help them remember the meaning of *neutralization*. This is a good exercise for interpersonal learners. Visual learners could draw a funny cartoon. Linguistic learners could make a rhyme or poem while musical learners could write a song. Bodily-kinesthetic learners could act out the reaction.
- ELL Provide English language learners with **BLM 2-44 Double-Displacement Neutralization** to help them consolidate the information.

Student textbook pages 166–167

- Before reading, ask students to brainstorm careers that might use acids and bases. Discuss any potential hazards that might be associated with the jobs (for example, corrosive and reactive chemicals, production of dangerous gases). To support English language learners, print key vocabulary on the board as students share hazards. Provide **BLM 2-45 Acid and Base Careers** for students to organize their work.
- Assign groups of students one career in Figure 2.29 and have students complete Activity 2.15. Invite English language learners to select the career that is most familiar to them.
- Have students compare the careers in the photos to the brainstormed list and add information to their table for Activity 2.15.

Learning Check Answers (Student textbook pages 161)

1.



2. Answers may vary. For example:
Acids: lemons, oranges, and vinegar
Bases: batteries, soap, and bleach

3. Acids and bases are corrosive.

Learning Check Answers (Student textbook page 163)

1. It is a base.

2. a) basic
b) acidic
c) acidic
d) basic

3. bleach (pH 12.4), egg white (pH 7.8), urine (pH 6.0), coffee (pH 5.0)

Activity 2.14 Using Indicators to Identify Acids and Bases

(Student textbook page 163)

Pedagogical Purpose

The purpose of this activity is to introduce the use of indicators to identify acids and bases. Later in the topic, students will need to choose appropriate indicators and use them effectively. Students also practise their communication skills.

Planning	
Materials	Per group: spot plate with 10 wells paper towels solutions with pH values from 3 to 11 tweezers litmus paper (red and blue) cut into small squares coloured pencils or markers medicine dropper cabbage juice indicator **BLM 2-43 Using Indicators to Identify Acids and Bases** (optional)
Time	45 min in class 30 min preparation
Safety	Warn students that acids and bases are corrosive. Students should wear gloves, safety goggles, and aprons.

Skills Focus

- perform an experiment and record data
- interpret data

Activity Notes and Troubleshooting

- Prepare the cabbage juice indicator the day before the lab or purchase it from a grocery store, where available. The cabbage juice can be frozen and used for another lab.
- To prepare the cabbage juice indicator:
  - Use red cabbage. Chop the cabbage into small pieces until you have about two cups.
  - Place the cabbage into a large beaker.
  - Boil enough distilled water to cover cabbage.
  - Place the boiling water over the cabbage, making sure to cover the cabbage.
  - Allow at least ten minutes for the colour to leach out of the cabbage. Alternatively, you can place about two cups of cabbage in a blender, cover it with boiling water, and blend it.
  - Filter out the plant material to obtain a red-purple-blue liquid. Cool and pour the liquid into dropper bottles or small beakers for student use. This liquid is at about pH 7. The exact colour you get depends on the pH of the water.
- Pre-made solutions of pH 3 to pH 11 can ordered from chemical supply stores.
- To reduce the amount of preparation for this lab, set up nine stations each labelled with the pH of a solution (3 to 11). Have students rotate through the stations. At each station, place one spot plate, one set of coloured pencils, small pieces of litmus paper, a dropper bottle containing the buffer solution, a dropper bottle containing the cabbage indicator, and paper towel. Give students 3 to 4 minutes per station to mix, observe, test, and clean up. Then have students move to the next station.
- You could reduce the number of stations by half and give students two buffer solutions to analyze before having them move to the next station. Increase the amount of time at each station to 10 minutes.
- Clean up instructions should include rinsing the spot plates with water for a few minutes after each test. Quantities of acid and base used should be small enough that no special procedures need to be taken for clean up.
- Some students may have certain types of colour blindness. There is a greater portion of males who have this condition. Colour blindness types are red-green and blue-green. Those afflicted cannot distinguish between the two colours in the condition. You or another student will have to point out the different colours during the tests.

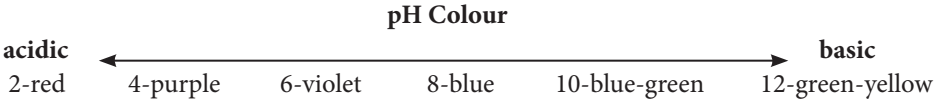
Additional Support

- DI Visual learners will enjoy the steps in the activity that involve colouring. Pair a bodily-kinesthetic learner with a visual learner. Have each person complete a different part of this activity.
- ELL Provide **BLM 2-43 Using Indicators to Identify Acids and Bases** to help English language learners follow the instructions and to record their observations as they participate with other students. Ensure that English language learners understand the steps and the instructional language required to complete the task, as well as comparative language, such as *most acidic*.
- DI Spatial and bodily-kinesthetic learners would benefit from colouring the cabbage results on small pieces of paper and labelling the pH on the back. Once all tests have been completed, student can then order their papers from most acidic to most basic and tape or glue them to their tables.

Activity 2.14 Answers

What To Do

Colours in students' tables should match the pH scale below.



What Did You Find Out?

1. pH 3, pH 4, pH 5, pH 6, pH, 7, pH 8, pH 9, pH 10, pH 11
2. If red and blue litmus are used, students should say that cabbage juice is better as it gives specific pH values. If universal litmus is used, students may say that the paper is easier because they can compare it to the picture on the side of the package.

Learning Check Answers (Student textbook page 164)

1. During a chemical reaction that involves an acid and a base, the H on the acid joins with the OH on the base to make water; the other atoms join to make a salt. The pH changes to neutral, pH 7.
2. Acids have a pH less than 7 because they have H ions. Bases have a pH greater than 7 because they have OH ions. Since H ions and OH ions are on opposite sides of the scale, acids and bases can be considered to be opposites. Also, when H ions and OH ions join together they make a "neutral" pair, which is sort of like the "middle". Compare this to integers like + 1 and –1. They are opposites and when they are added, they equal zero.
3. The equation is balanced because the number of atoms of each element on the left side of the equation equals the number of atoms of the same element on the right side of the equation.

Learning Check Answers (Student textbook page 166)

1. Answers may vary. For example:
   - **a)** Car paint can cause damage to eyes, skin, and lungs.
   - **b)** Cleaning chemicals can damage skin and workers must be careful not to breathe in the fumes.
2. **a)** Hair stylists must wear gloves to protect their hands from chemicals used in processing hair. They must also wear aprons to protect their clothes.
   - **b)** Welders must wear welder's goggles to protect their eyes from UV radiation from the welding torch. They must also be careful when working with acetylene since it is very explosive. They should work in a well-ventilated area as fumes from melting metal and the acetylene can be noxious.

Activity 2.15 Minimizing the Risks (Student textbook page 166)

Pedagogical Purpose

This activity challenges students to put themselves in the place of a person performing a job that involves chemical reactions and to determine the dangers and preventative steps needed in that job.

Planning	
Materials	Internet access or research materials
Time	80 min in class

Skills Focus

- evaluate data sources
- make appropriate research notes

Activity Notes and Troubleshooting

- Assign groups of four to each career. Allow students to choose a career that interests them.
- Students will have to read a large amount of information to find the types of reactions involved in certain professions. Encourage them to write down some questions to narrow their search before starting their research. For example, for a career as a firefighter ask "What type of reaction is a fire? What type of reaction occurs when a fire extinguisher is used? What effect do fire extinguishers have on the environment? What safety gear do firefighters wear?"
- Once students have generated their research questions, they should divide the questions equally among the group members, do the research, and then share their findings.
- Ask the librarian to direct students to good sources of information.

Additional Support

- ELL Pair English language learners with students who have strong English skills. They may need to work with this partner to complete their research, and/or access information in their first language.
- DI Ask intrapersonal learners to reflect on whether they would like to work at their chosen career after doing this research.
- DI For bodily-kinesthetic learners, ask students to create a skit that demonstrates how chemical reactions are important in their chosen career. The safety issues involved should be included.
- DI Ask spatial learners to create a poster to display their work.
- DI Ask musical learners to write a song from the perspective of a worker in their chosen career.

Activity 2.15 Answers

Answers may vary. For example:

Profession	Benefits of Chemical Reactions	Ways to Minimize Risks to Personal Safety	Ways to Minimize Risks to the Environment
Food Preparation	• Cleaners kill bacteria. Ammonia is in cleaners and when it comes in contact with bacteria, it kills them.	• Wear rubber gloves, possibly an apron, safety goggles, and an air filtration mask.	• Use biodegradable cleaners. • Keep contaminated food separate from non-contaminated foods. For example, use a different cutting board for meat, chicken, and vegetables.

Using the Case Study Investigation (Student textbook pages 168–169)

Literacy Support

Before Reading

- Have students brainstorm what they know about acid rain. Students will have studied acid rain and its effect on ecosystems in grade 9.
- Students could provide examples within their own environment where there is evidence of acid rain effects. For example, the erosion of statues and carvings in local buildings or the reduction of certain fish stocks in locals water reservoirs.
- ELL Skim the text with English language learners, reviewing key concepts. Provide a simple outline of the text. Explain the key ideas in each section.

During Reading

- Have students make a list of items mentioned in the case study and their pH values.
- Visual learners will benefit from placing the items on a pH meter to consolidate their learning.
- ELL Partner English language learners with strong English language users. Have them go to the text to find support for the key ideas. Partners can explain unfamiliar vocabulary and unfamiliar structures, such as antecedents.

After Reading

- ELL Have students work in groups to research and answer the Over to You questions. Work can be presented as a poster, a brochure, or an oral presentation with visuals. This will be beneficial for English language learners.

Activity Notes

- ELL English language learners may find this activity intimidating initially. Students may research and write their findings in their first language and then translate their answers into English or work with a partner.
- Students who are comfortable using technology may wish to use computers and various applications to create a poster or other form of visual presentation of the group's work.
- To answer questions 2 to 4 in Over to You, refer students to **www.scienceontario.ca** and follow the links.

Case Study Investigation Answers

Answers may vary. For example:

1. This solution is only temporary because the cause of the problem has not been fixed nor is it isolated. Many factors could be responsible for the acidification of the lake, such as industrial pollution from remote and nearby industries (both land and airborne), fertilizer run off from nearby homes or cottages, and so on.
2. Eastern Canada has a large manufacturing industry, especially in Ontario. Lots of pollution is generated by the plants. Also, wind blows from west to east, moving pollution to eastern Canada. Most of the airborne pollution comes from mid-western United States. Seventy percent of the summer pollution in Windsor and ninety percent of the acid rain that reaches south Nova Scotia is from industries in the United States. The worst pollution occurs in the summer with airborne particles get trapped by hot air and stay as smog.
3. Because the United States is a major contributor to Canada's pollution levels, efforts by both countries to reduce pollution-causing emissions are necessary.
4. Killarney was heavily affected by acid rain due to the high levels of sulfur emissions from nearby smelter plants in Sudbury. With strict government regulations, sulfur emissions were greatly reduced. The surrounding lakes became less acidic. Current levels of sulfur emissions are suspected to be from long-range transportation.

Activity 2.16 Neutralization Reactions (Student textbook page 170)

Pedagogical Purpose

This activity gives student practice in performing a neutralization reaction. The skill of using an indicator and to know when an acid is neutralized will be important in a later investigation.

Planning	
Materials	Per group: graduated cylinder 20 mL dilute hydrochloric acid (1.0 M) small test tube test-tube rack medicine dropper and bottle (for each solution) bromothymol blue indicator 20 mL dilute sodium hydroxide (1.0M) **BLM 2-46 Neutralization Reactions** (optional)
Time	30-40 min in class 15 min preparation
Safety	Warn students that acids and bases are corrosive and that sodium hydroxide can cause blindness. Students should wear gloves, safety goggles, and aprons. Warn students that they must tell you immediately if any liquid gets on their skin. If any chemical is spilled on skin or clothing, run water on it. If the liquid is an acid, apply baking soda. If the liquid is a base, apply vinegar.

Skills Focus

- gather and analyze data
- follow safety precautions when handling chemicals

Activity Notes and Troubleshooting

- This could activity could be done as a teacher demonstration. Use key vocabulary as you demonstrate. If carried out by students, have each student take turns adding drops of base to the solution and observe together.
- Students should work in groups. Assign a role to each group member: safety person, data collector, tester, and materials gatherer.
- A phenolphthalien indicator could be used instead of bromothymol blue but it changes colour when it is slightly acidic. The indicator is pink in a base and clear in an acid.
- Keep the molarity of the acid and base the same and then the expected results will be similar in ratio.
- Use 0.1 M acid and 0.1 M base instead to make the activity safer.

Additional Support

- DI Have spatial learners draw pictures of the procedure before performing the experiment.
- ELL Provide English language learners with **BLM 2-46 Neutralization Reactions** to help them complete the activity.
- Enrichment—Give students another molarity of acid to neutralize and ask them if the acid is stronger or weaker than the first one.
- DI Enrichment—Ask logical-mathematical learners to graph the volume of acid versus the number of drops of base needed to neutralize the acid. Ask students to extrapolate how many drops of base they think would be needed to neutralize 10 mL of acid.

Activity 2.16 Answers

What To Do

Answers may vary. Students' result should be similar to the table below.

Volume of Acid (mL)	Number of Drops Needed to Neutralize Acid
5.0	10
2.0	5
3.0	7

What Did You Find Out?

1. The pH of the neutral solution is 7. I know this because neutral pH is 7.
2. The more acid there is, the more base you need.
3. These acids and bases are very strong and dangerous to work with. It would take a large quantity of base or acid to neutralize them.

Activity 2.17 The pH of Common Substances in the Home

(Student textbook page 171)

Pedagogical Purpose

The purpose of this activity is to make the concept of pH more real to students and to give them practice using pH paper to find pH.

Planning	
Materials	Per group: variety of common substances (including household cleansers, fruit juices, and soft drinks) distilled water small beakers universal pH paper cut into small pieces spot plate dropper with dropper bottle (for each solution)
Time	75 min in class 30 min preparation
Safety	Many of the substances found in the home are very corrosive. Warn students to be very careful, to read each product's warning label, and to follow safety instructions.

Skills Focus

- make predictions
- make observations
- follow safety precautions when handling chemicals

Activity Notes and Troubleshooting

- This activity can be done in small groups. Assign a role to each group member: safety person, data collector, tester, and materials gatherer.
- If done in small groups, provide each group with a small sample of each chemical in small, disposable paper cups. To take less time setting up, you could make stations with one chemical tested per station. Have students move from one station to the next.
- As a substitute for pH paper, use filter paper. Students could use their pH scale that they prepared in Activity 2.14. Be sure to let the paper dry overnight.
- It would be helpful to make large colour photocopies of the pH scale found on the package for the pH paper. Give a copy to each group or place one copy at each station.

Additional Support

- DI Ask logical learners to make predictions and explain their reasons.
- DI Allow interpersonal learners to discuss their findings.
- DI Have spatial learners draw their conclusions by showing a "generic" cleaner and its pH as part of the cleaner's name.
- ELL Pair English language learners with other students. Have students with strong English skills act as mentors. This exercise will increase the mentors' leadership skills while reinforcing language and concepts for English language learners.

Activity 2.17 Answers

What Did You Find Out?

1. Answers may vary. Students should explain how their predictions compared to their results.
2. The cleaners have a pH greater than 7, so they are bases. The cleaners would have the same pH because they are used to clean similar things. Bases do not react with metals, so the cleaners are safe to use in the kitchen and bathroom.
3. Diagrams should be similar to Figure 2.25 on page 162.

Investigation 2C Acid-Base Neutralization Reactions

(Student textbook page 172)

Pedagogical Purpose

This investigation challenges students to use skills gained in previous activities to prove that salt is produced in a neutralization reaction.

Planning	
Materials	Per group: 10 mL 0.1 M HCl 10 mL 0.1 M NaOH graduated cylinder medicine dropper pH indicators as needed (cabbage juice, pH paper, bromothymol blue) hot plate 250 mL beaker **BLM 2-47 Investigation 2C, Acid-Base Neutralization Reactions** (optional) **BLM 2-48 Acid-Base Neutralization Reactions Instructions** (optional)
Time	90 min in class 10 min preparation
Safety	Warn students that acids and bases are corrosive and that sodium hydroxide can cause blindness. Students should wear gloves, safety goggles, and aprons. Warn students that they must tell you immediately if any liquid gets on their skin. If any chemical is spilled on skin or clothing, run water on it. If the liquid is an acid, apply baking soda. If the liquid is a base, apply vinegar.

Background

Acids and bases react to form water and a salt. The H from the acid joins with the OH from the base to form water and the metal from the base joins with the non-metal on the acid to form the salt. The salt formed in this reaction is sodium chloride.

$$HCl + NaOH \rightarrow NaCl + H_2O$$

Sodium chloride dissolves in water and is not visible in the solution. To show that salt is present, the water must be evaporated. This can be done quickly using a hot plate or slowly by leaving the beakers of solution uncovered to evaporate for several days.

A pH indicator like cabbage juice, universal indicator, or litmus paper can be used to determine the specific pH as the acid is neutralized. An indicator like bromothymol blue can also be used (as in Activity 2.16) to help students identify the moment the mixture is neutral.

Skills Focus

- plan a procedure
- choose appropriate materials and techniques
- work safely with chemicals and equipment
- make conclusions

Activity Notes and Troubleshooting

- Remind students that they have already performed a neutralization reaction with Activity 2.16 and that they have used a number of indicators to help them determine if a solution is neutral. Students should refer to their notes for Activity 2.16 to help them with this investigation.
- Provide students with **BLM 2-47 Investigation 2C, Acid-Base Neutralization Reactions.**
- Give students 30 minutes on the day prior to the lab to prepare their procedures and then complete the lab the next day.
- Circulate while students are designing their procedures and give feedback or make suggestions as needed.
- Collect the designs from each group at the end of the first period and gather the materials they have requested. (Place materials into baskets, bins, or trays.)
- List the available materials on the chalkboard to reduce the amount of preparation time needed. Supply a variety of each type of material to allow students to choose different options (for example, several indications, different strengths of acids and bases).

Additional Support

- ELL Direct English language learners to the last sentence in the opening paragraph. Review what is meant by design. Go back to Activity 2.16 and ask students to explain the design of the activity. Provide **BLM 2-48 Acid-Base Neutralization Reactions Instructions** to English language learners or to other students who need help writing their procedures and recording their observations.
- DI Allow spatial learners to present their procedures using diagrams.
- DI Allow logical-mathematical learners to create a flowchart for their procedures.

Investigation 2C Answers

What To Do

Procedures may vary. Students should get approval before conducting their investigations and should record their results in a table.

What Did You Find Out?

1. The pH is 7.

2. A white residue was left behind.

3. sodium chloride; salt; $HCl + NaOH \rightarrow NaCl + H_2O$

Investigation 2D The Effectiveness of Antacids

(Student textbook page 173)

Pedagogical Purpose

In this investigation students apply their knowledge of neutralization to a commercial product and then evaluate which works the best.

Planning	
Materials	Per group: antacids such as baking soda, Tums®, Rolaids®, Alka-Seltzer®, and generic antacids 0.1 M HCl medicine dropper three 250 mL beakers indicators such as bromothymol blue, pH paper, or cabbage juice **BLM 2-49 Investigation 2D, The Effectiveness of Antacids** (optional) **BLM 2-50 The Effectiveness of Antacids Instructions Activity** (optional) **BLM 2-51 The Effectiveness of Antacids Instructions in Order** (optional)
Time	75 min in class 30 min preparation
Safety	Warn students that acids and bases are corrosive. Students should wear gloves, safety goggles, and aprons. Warn students that they must tell you immediately if any liquid gets on their skin. If any chemical is spilled on skin or clothing, run water on it. If the liquid is an acid, apply baking soda. If the liquid is a base, apply vinegar.

Background

Antacids are weak bases in solid form. They are designed to neutralize most of the acid in the stomach and prevent it from splashing up into the esophagus, which causes heartburn. Some examples of antacids and the compounds they are made from are magnesium hydroxide (Milk of Magnesia®), calcium carbonate (Tums®, Rolaids®), and sodium bicarbonate (baking soda and Alka-Seltzer®).

Stomach acid has a pH of 2 to 3. The acid helps break down fibres in food and kills bacteria that have been ingested. The stomach lining replaces itself every 3 days and is also protected by mucus. The rest of the digestive system is not designed to withstand low pH. The secretions in the small intestine contain acid neutralizers that increase the pH of digested food to decrease damage to the lining of the small intestine. When acids splash up into the esophagus (called esophageal reflux or heartburn), they damage the lining of esophagus and cause a burning sensation. When acids travel into the small intestine, ulcers can form.

Side effects of using antacids include increased acid production (as a reaction to the neutralization), constipation and kidney stones (owing to high levels of calcium), renal failure (owing to high levels of magnesium and aluminum), and hypertension (owing to high levels of sodium).

Skills Focus

- plan a procedure, controlling for some variables
- work safely with chemicals and equipment
- think critically

Activity Notes and Troubleshooting

- Provide students with **BLM 2-49 Investigation 2D, The Effectiveness of Antacids.**
- The lower the molarity of the acid used, the greater the volume of base or antacids students will need to add. Use 0.1 M of HCl to be safe. Explain to students it will take a longer time for large volumes of acid to be neutralized.
- The following are three possible procedures:
  - Students could dissolve the antacids in equal amounts of water and add them to the acid. Then, they can determine how much of each antacid is needed to neutralize the acid.
  - Students could add acid to each antacid solution and determine how much acid each antacid can neutralize.
  - Students could add a dose of antacid (as per label instructions) to the acid and then determine the change in the pH.
- For students who need help writing their procedure, cut up **BLM 2-50 The Effectiveness of Antacids Instructions Activity** and give each group all the steps to sort into the correct order. If necessary, provide hints for each line of instruction as needed by each group.
- For an alternative experiment, have students control the volume of one reactant (antacid or acid) and vary the volume of the other reactant.
- Provide students with **BLM 2-51 The Effectiveness of Antacids Instructions in Order** for self-assessment.

Additional Support

- DI ELL For English language learners and bodily-kinesthetic learners, photocopy **BLM 2-50 The Effectiveness of Antacids Instructions Activity** and cut up the steps. Have students work in groups to put the steps in the correct order. Some English language learners may have a good sense of the design process, and may just need some support with language.
- DI To answer What Did You Find Out question 1 as a class, give each student two sticky notes and place students into groups of four. Ask each student to write one criterion they would like to use for the "best" antacid on each sticky note. For example, least expensive, works fastest, and so on. Have groups to sort the notes into similar piles by stacking similar statements on top of one another. Then each group combines their piles as a class. This activity will determine the most important characteristics of an antacid. It will appeal to interpersonal and logical-mathematical learners.
- DI Have visual learners draw pictures that show the steps of their procedure.

Investigation 2D Answers

What To Do

Procedures may vary. Students should get approval before conducting their investigations and should record their results in a table.

What Did You Find Out?

1. Answers may vary. For example, cost, speed of neutralization, neutralizes the most acid, or needs the least amount to work to prepare.
2. Answers may vary but should match the criteria listed in question 1. For example: baking soda cost the least and neutralizes the most acid but it tastes bad.
3. Yes. Taste needs to be considered because antacids are eaten. Side effects should also be examined.

Activity 2.18 The Effect of pH on Corrosion (Student textbook page 174)

Pedagogical Purpose

This activity shows students the impact of acids on the environment. Acid rain causes the corrosion of metal in buildings and statues. Acids can degrade these structures and make them unsafe.

Planning	
Materials	Per group: paper towels steel wool four 250 mL beakers marker three acidic solutions (pH 4, 5, and 6) (10 mL each) 10 mL neutral solution (pH 7)
Time	20 min in class 15 min preparation
Safety	Warn students that acids and bases are corrosive. Students should wear gloves, safety goggles, and aprons. Warn students that they must tell you immediately if any liquid gets on their skin. If any chemical is spilled on skin or clothing, run water on it. If the liquid is an acid, apply baking soda. If the liquid is a base, apply vinegar.

Skills Focus

- make conclusions
- work safely with chemicals and equipment

Activity Notes and Troubleshooting

- Use just enough acid to cover a small piece of steel wool.
- Use commercially available buffer solutions of pH 4, 5, and 6. Otherwise you will have to use 0.1 M HCl, which has a pH of 1, and add NaOH until you get a pH of 4, 5, and 6.
- Students should work in groups of four. Allow each student to set up one beaker.
- Beakers can be labelled with tape and pens instead of markers.

Additional Support

- DI Have visual learners draw a picture of each beaker before and after the reaction.
- ELL Provide diagrams of the instructions for English language learners. Post the diagrams on the chalkboard.
- ELL Post descriptive words on the chalkboard for English language learners to use for their observations or remind students of the properties of lustre, colour, and texture before they make their observations.

Activity 2.18 Answers

What Did You Find Out?

1. The steel wool turned from grey to brown and disintegrated.

2. The lower the pH, the more the steel wool has disintegrated.

3. pH 4

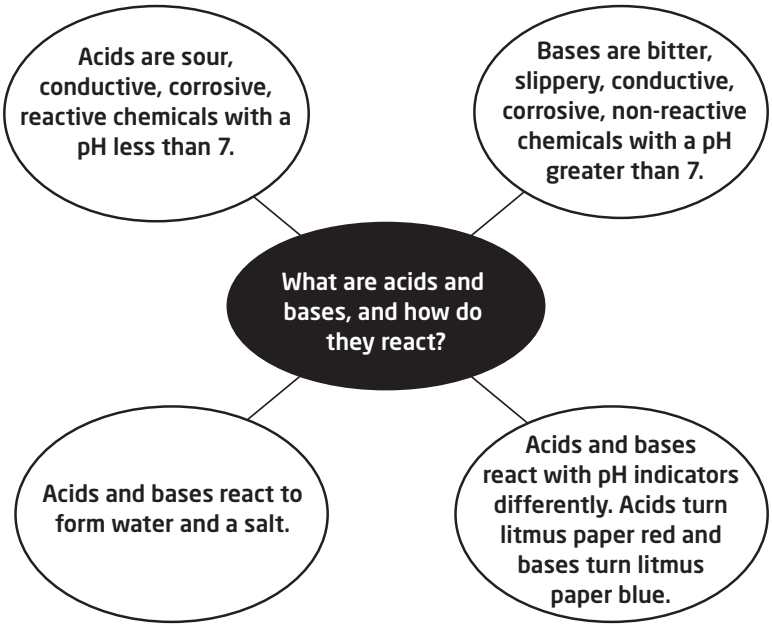
4. The evidence is a colour change.

Topic 2.4 Review (Student textbook page 175)

Please see also **BLM 2-52 Topic 2.4 Review (Alternative Format)**.

Answers

1. Answers may vary. For example:



2. blue

3. pH provides more information. Litmus paper just shows if the solution is an acid or a base. pH tells how strong the acid or base is by giving a number.

4. The substance could be an acid or a base. Need to use an indicator like litmus paper to check the pH to know if the substance is an acid or a base.

5. They would add base to neutralize the acid. They know it is safe when the pH is 7 or neutral.

6. These reactions make the pH of the resulting solution 7 or neutral.

7. A base. Add a base until the pH is 7 or neutral.

8. a) A is pH 1, B is pH 7, C is pH 9

b) A is acidic, B is neutral, C is basic

c) C

d) A and C

Using Science at Work (Student textbook pages 176–177)

Literacy Support

Before Reading

- Ask students to reflect on the careers that have been mentioned so far in this unit. List them and ask students to add any careers they feel should have been discussed because they involve chemistry.
- Have students scan the text for the names of careers and add them to the list. Direct English language learners to scan the text features.
- Ask students to use the headings "Workplace", "College", and "University" to classify the careers or have them develop and explain their own classification system.

During Reading

- Ask one student to act as Deeni de Medeiros and another to act as the interviewer and have them read the interview aloud. Other students can follow along in the text.
- Pause at the end of each interview question and have the class list additional questions they would like to ask Deeni.

After Reading

- Ask students to rate the listed careers from one to five with one being not very interesting and five being very interesting.
- Have students complete the Over to You questions.

Instructional Strategies

- Supply students with **BLM G-50 Science at Work Organizer.**
- DI Ask intrapersonal learners to write a personal reflection on being a glass artist. Or they can choose one of the other careers.
- DI Students could mark their career lists using three different colours of highlighters to represent the categories "Workplace", "College", and "University". Logical-mathematical learners will find this exercise useful.
- DI Have spatial learners prepare a poster that summarizes their research findings. Musical learners could write a jingle about the career.

Science at Work Answers

1. Answers may vary. Questions could include "How much money do you make?" or "Do you work at home?"
2. Acid can be used to etch glass to give it an aged look or to create designs on the surface of the glass. Different compounds in the glass will react differently to heat. Some minerals may change colour when heated or create different anomalies within the glass.
3. Answers may vary. Skills could include the following: computational, following directions, creativity, and self-discipline.