CHAPTER 3 OPENER, pp. 70–71

USING THE PHOTO AND TEXT

Discuss with students that this chapter is about how elements combine to make compounds through chemical change. The opening photograph of a dissolving antacid tablet brings a good opportunity to notice the chemical reactions that happen all around us. Have students read and discuss the chapter opening text. Then demonstrate the reaction. Bigger is better in demonstrations, so use a litre-sized beaker and drop a handful of tablets in all at once. Ask students, "Is this a physical change or a chemical change?" (chemical change) "How can you be sure?" (Without further study of the materials, they cannot be sure—some physical changes appear to happen in exactly the same way.) "What is the difference between a physical change and a chemical change?" (In a chemical change, new substances are produced—the elements rearrange into new materials. In this case, carbon dioxide is being produced.) A demonstration involving dropping a candy into a carbonated beverage can be found at www.discoveringscience.ca.

USING THE WHAT YOU WILL LEARN/WHY IT IS IMPORTANT/SKILLS YOU WILL USE

Use the bolded descriptors under these headings to illustrate the variety of different opportunities for engagement that students will have in this chapter. Students will distinguish between covalent and ionic compounds and differentiate between chemical and physical change. In addition, they will write chemical names from the formulas of simple compounds. Have students read Why It Is Important, and then prompt them with the question "How many chemicals or compounds did you use before you left home this morning?" Students might start by listing basic items such as toothpaste, shampoo, conditioner, and soap. With prompting, though, they will add to the list to include deodorant, hair styling products, and cosmetics. They might even consider the foods and beverages they consumed.

USING THE FOLDABLES™ FEATURE

See the Foldables section of this resource.

3.1 COMPOUNDS

BACKGROUND INFORMATION

There are two basic types of chemical bonding in compounds—covalent bonds (atoms share pairs of electrons) and ionic bonds (oppositely charged ions attract each other). Covalent bonds lead to the formation of molecules (groups of atoms all connected together). A molecule is a discrete unit such that any atom in the molecule is part of only that specific molecule. For example, in a water molecule, the oxygen is connected to two (and only two) hydrogen atoms. By contrast, ionic bonds lead to the formation of crystal lattices in which all ions are attracted to all other ions in the crystal. Nearest ions have the greatest attraction, but all the ions are together in a repeating pattern of positive and negative charges.

Emphasizing the difference between molecules and ionic lattices is very helpful for setting the foundation for later studies. With the names and formulas of ionic compounds, it is very important not to refer to molecules, nor to imagine that, for example, one magnesium ion combines with two chloride ions. Instead, refer to a ratio of one magnesium ion for every two chloride ions.

COMMON MISCONCEPTIONS

- It is a misconception that an ionic compound is made of molecules. Teaching that ionic compounds are not molecules will help students in later courses.
- While it is a good rule of thumb that covalent bonding occurs between non-metals, there are exceptions. Polyatomic ions, which will be covered in later science courses, can contain metals covalently bonded to non-metals. To avoid fostering a misconception that will affect future learning, it is best to avoid saying that metals cannot be involved in covalent bonding. However, it is safe to say that metals are not found in covalent compounds, or molecules.

ADVANCE PREPARATION

- The following activities require chemical reagents that will need to be purchased in advance from a chemical supply house: Activity 3-1A, on page 73; Activity 3-1B, on page 76; Activity 3-3A, on page 87; and Activity 3-3C, on page 92.

Useful research materials for advance preparation can be found at www.discoveringscience.ca.

INTRODUCING THE SECTION, pp. 72–73

Using the Text

After students read page 72, ask, "Which do we know more about, stars or butterflies?" (Both are interesting, but a butterfly is more complex. Inside a star, no chemistry can happen because atoms are too hot to join together chemically. A butterfly has up to 1 million different kinds of compounds in it.) Even though there are so many different kinds of compounds, it does not mean we cannot understand chemistry. There are basically two different ways that different kinds of atoms can combine with each other:

- through sharing electrons, or
- by transferring electrons, forming ions, and then combining through opposite electric charges.

Have students examine the model of table sugar in Figure 3.1, on page 72. Have them count up all the different kinds of atoms and relate these numbers to the formula shown in the caption. ($C_{12}H_{22}O_{11}$—note that two hydrogen atoms are hidden from view.)

Using the Key Terms and Section Summary

At the beginning of each section in the student textbook are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the Key Terms by scanning the text and using the Glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are important for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 1-2, Unit 1 Key Terms, which lists all the terms in the unit, can be used to assist students.

Using the Did You Know, p. 72

The Did You Know? feature provides an example of an ionic compound. In fact, when burned in air, a majority of the product is actually magnesium nitride. If you wish to demonstrate the burning of magnesium, instructions are provided in Using a Demonstration, which follows Using the Activity below.

Using the Activity

Find Out Activity 3-1A

The Synthesis of Oxygen, p. 73

Purpose

- Students decompose hydrogen peroxide by adding a catalyst and then test for the presence of oxygen using the "glowing splint" test.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Prepare chemicals and collect equipment.	For each group: – liquid dish soap – medium test tube in a test tube rack – 3% or 6% hydrogen peroxide (H_2O_2) solution – candle and lighter – scoopula – potassium iodide (KI) crystals – 2 wooden splints

Time Required

- 30 min

Safety Precautions

- The 6 percent hydrogen peroxide solution is corrosive. Remind students to be careful.
- Ensure students are careful around open flames.
- Have students tie back long hair.
- Remind students to wear protective safety eyewear and to take care that hydrogen peroxide does not get in their eyes.
- Gloves and a lab coat should be worn as the hydrogen peroxide will bleach skin or clothes.
- Make sure students understand that the use of hydrogen peroxide requires following the safe procedures that they have learned and have been using so far in this course. Emphasize that hydrogen peroxide must be used carefully.

Science Background

This is a decomposition reaction that occurs spontaneously for hydrogen peroxide (H_2O_2) in solution. The equation is:

$$H_2O_2(aq) \rightarrow O_2(g) + 2\ H_2O(\ell)$$

The 3 percent hydrogen peroxide is a common household product used as an antiseptic, as a treatment for some skin disorders, and for bleaching. If a bottle of 3 percent hydrogen peroxide is opened and then left on the shelf for a year, all the of hydrogen peroxide will be gone. In this reaction, a catalyst (KI crystals) is added to speed things up so that the same decomposition will happen in a few minutes. The 6 percent hydrogen peroxide gives a more satisfying effect, though a 3 percent solution can also be used. Be careful not to get 6 percent solution on the skin. It will bleach the skin white. If this happens, wash the skin right away. Caution students that the solution must not get in their eyes. Use standard safe lab techniques to prevent a mishap.

Activity Notes

- Do not overfill the test tube.
- The KI is a catalyst, meaning that not very much is needed, because it does not get used up.

If the reaction stops, it will not be necessary to add more catalyst. Add more hydrogen peroxide.

- The soap is not a necessary part of the reaction, but it helps to capture the oxygen gas so that it does not get away easily. If soap is omitted, the effect is not nearly as good.
- This is not the "pop" test for hydrogen, and putting a flaming splint into the test tube will not produce much of an effect.
- Make sure the splint has glowing embers and no flame. The glowing splint will burst back into flame with a very bright light, indicating a high concentration of oxygen.

Preparation/Disposal of Reagents

- Provided proper storage and handling facilities are present, it may be convenient to have a supply of 30 percent hydrogen peroxide on hand. Before use, dilute it 1:5 to make a 6 percent solution. A solution of 30 percent hydrogen peroxide is very corrosive, so use a fume hood, gloves, face protection, and good laboratory technique when handling it. Avoid spills and splashes. The 6 percent hydrogen peroxide is available for purchase at chemical supply houses.
- Reagents may be disposed of down the sink with plenty of water.

Supporting Diverse Student Needs

- This is a very good hands-on activity for body-kinesthetic and visual-spatial learners. Try to ensure a learner with these skills is in every group.
- For enrichment, use 3 M HCl(aq) and mossy zinc so students can compare the "pop" test with the "glowing splint" tests. Although they are likely to have already done this procedure, they will probably enjoy getting to do it again.

What Did You Find Out? Answers

1. A glowing splint placed into oxygen will glow brighter or burst into a bright flame.
2. (a) The tests for hydrogen and oxygen differ in that for hydrogen, the wooden splint must be in flame, while for oxygen it must have glowing embers. (Also acceptable as an answer: The test tube that may contain hydrogen must be inverted to prevent loss of gas, while in the test for oxygen, this step is not needed.)
   (b) In the hydrogen "pop" test, a small flash occurs, producing a popping sound, whereas in the oxygen "glowing splint" test, the glowing splint glows brighter or bursts into flame.

TEACHING THE SECTION, pp. 73–75

Using Reading

Pre-reading—K-W-L (Know-Want to Know-Learned)

As students read this section, have them record their questions. Later, students can share their questions as a class and together the class can discuss the answers to those questions.

During Reading—Note Taking

Encourage students to take notes as they read through the text. They can reword the topic titles as questions, and then take notes as a means of answering the questions.

After Reading—Reflect and Evaluate

When students have finished taking notes, they can quietly review their notes and select three facts that they find interesting. Students can then write a statement as to why they found the facts interesting. You may wish to use BLM 1-28, Anatomy of a Chemical Formula, as an overhead projection to discuss parts of a chemical formula. You may wish to have students complete some or all of BLM 1-29, Chemical Bonds Concept Map; BLM 1-30, Researching a Compound; BLM 1-31, Kitchen Chemistry; and BLM 1-32, Chemical Formulas.

Supporting Diverse Student Needs

Visual-spatial learners, interpersonal learners, and others may benefit from working in a small group to create a Venn diagram that compares and contrasts ionic and covalent compounds. Have students include characteristics, formation, and examples of each type of compound.

Reading Check Answers, p. 75

1. Elements can combine into ionic compounds by transferring electrons or covalent compounds by sharing electrons.
2. In covalent compounds, atoms are connected to each other by sharing a pair of electrons.
3. Sample answers: water, carbon dioxide, crude oil, table sugar
4. Sample answers: table salt, calcium carbonate
5. To form an ionic compound, a transfer of electrons between metals and non-metals must occur as a result of these atoms gaining or losing electrons.

USING THE ACTIVITIES

- Find Out Activity 3-1A, on page 73 of the student textbook, is best used as an introductory activity. Detailed information about this activity can be found in Introducing the Section.

- Activity 3-1B, on page 76 of the student textbook, may be used at any point in this section. Detailed notes on doing the activity follow.

Conduct an Investigation 3-1B

The Synthesis and Detection of Copper, p. 76

Purpose

- Students transform copper(II) chloride into pure copper metal and then test their product using a flame test.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Make the chemical solutions and ensure all equipment is ready.	For each group: – copper(II) chloride solution – two 400 mL beakers – aluminum foil – crucible tongs – waste container – dilute hydrochloric acid solution (HCl) – wooden splint – paper towel – Bunsen burner

Time Required

- 40 min

Safety Precautions

- This activity uses open flames. Ensure that students are careful.
- Remind students to handle chemicals safely. Hydrochloric acid is corrosive.
- Remind students to tie back long hair.
- Ensure students wash their hands thoroughly after this investigation.
- Ensure students wear safety eyewear and protective clothing.

Science Background

The reaction of copper(II) chloride with aluminum foil produces elemental copper in a single replacement reaction. The equation is as follows:

$$2Al(s) + 3CuCl_2(aq) \rightarrow 3Cu(s) + 2AlCl_3(aq)$$

The reaction is fairly exothermic, and the solution heats up a noticeable amount. The copper is not shiny because of the fine particle size. Washing the copper first with water and then with hydrochloric acid acts to purify the copper. The hydrochloric acid destroys excess aluminum pieces, while the water washes away aluminum chloride.

Students often react to the brown product as if it were something gross, such as feces. Remind them that there is nothing biological in the beaker. Ask them what it looks like that is not biological. Often the answer is rust. Explain that rust is corroded iron, so it cannot be that. Point out that no elements can be there other than those present in the reactants. This usually brings students around to seeing the product for what it is, copper. Students often make a connection when you point out to them that they made copper. They may feel as though they did some "real" science.

Every element glows a characteristic colour when heated sufficiently. When copper metal powder is heated in a Bunsen burner flame, a characteristic green colour reminiscent of the green patina on copper roofs is produced.

Activity Notes

- Darken the room as much as is practical when it is time to do the flame test.
- The copper solution is poisonous, but only if ingested. Remind students not to lick their fingers. The copper solution will taste bitter. Tasting the copper solution does not constitute an emergency, but students should wash their hands, and then wash them again at the end of the investigation.
- Students often decant very meticulously in order not to lose any copper powder, but this would take too long. Let students know that 99 percent of their product will settle within 1 min.
- Do not overheat the crucible tongs. It takes only a few moments to produce the green effect in the Bunsen burner.

Preparation/Disposal of Reagents

- Prepare a 0.5 M copper(II) chloride solution from copper(II) chloride dehydrate $CuCl_2•2H_2O$ 85.2 g/L. Do not substitute with copper(II) sulphate because the chloride acts as a catalyst to speed up the reaction to useful rates.
- For disposal, collect all waste solutions in a central container, add more aluminum, and leave overnight. This will remove poisonous copper(II) ions from the solution. This solution may be filtered and poured down the sink with lots of water.

Supporting Diverse Student Needs

- Keep in mind that people see colours differently, and that 8 percent of the male population is red-green colour-blind. If there are any students in the class who have difficulty detecting colour, pair them with other students who do not have a colour-vision deficiency, and have them compare their visual observations.
- Provide careful explanation of materials for struggling readers, and consider having them write definitions for the materials that are new to them.
- This is a good hands-on activity for body-kinesthetic and visual-spatial learners.
- For enrichment, have students find out how copper smelting is done commercially.

Analyze Answers

1. When aluminum was placed in the copper solution, the surface of the aluminum darkened. A brown substance (copper) began to appear, and the blue-green colour of the copper solution slowly turned colourless.
2. Placing copper metal powder in a Bunsen burner flame produces a green flame.

Conclude and Apply Answer

1. Copper has a distinctive colour different from the more common silver-grey colour of most metals. It is more malleable than iron, making it useful for jewellery. It also burns a distinctive green colour.

USING THE FEATURES

Science Watch: Petroleum—The Solution or the Problem?

Ask students if they can think of any examples of natural materials that are in limited supply. They might mention fossil fuels, water, food crops, or precious metals. Now ask if they can think of examples where chemical processes have offered alternatives to these natural materials. Responses might include ethanol-based fuels as an alternative to fossil fuels, water purification or desalination as a solution to a shortage of fresh water, the development of bioengineered food crops as an alternative to traditional ones, or the manufacture of synthetic materials as a substitute for precious metals. The key note here is that knowledge of chemistry is important for all of these processes. After students read the feature, you could have a class discussion or break into smaller groups for a mini-debate about the examples given in the feature. If you break the students into small groups, it will likely be practical to assign one example per group. For each example of a product or process that provides an alternative to a natural material, discuss the pros and cons of the substitutes that are available.

Science Watch Answers

1. Synthetic fibres such as polyester and nylon, pharmaceuticals such as aspirin, and printing inks made from carbon black are petroleum-derived products that substitute for natural materials.
2. Ethanol-based fuels and corn-based plastics are alternatives to petroleum-based materials.
3. Accept any logical answer. Sample answers: Petroleum is very versatile and can be used to produce a wide range of products. People used to think of petroleum as an abundant resource; however, this thinking has shifted as people have become more aware that there is a limited supply of fossil fuels and we are using them at a rapid rate.

Career Connect: Avalanche Technician, p. 78

Ask students why avalanche control is important in Newfoundland and Labrador. Recreation, such as skiing and snowmobiling, is popular in areas such as Gros Morne National Park, the Blow Me Down Mountains, and the Lewis Hills. There have been many close calls in these areas. Ask students how someone can learn to use explosives in a safe way. (The Canadian Avalanche Association offers courses in blasting and also in weather forecasting and first aid.)

Go to www.discoveringscience.ca for more information about avalanches in Newfoundland and Labrador.

Career Connect Answers

1. Avalanche technicians provide safety from avalanches by forecasting avalanche activity, implementing closures, and doing control work to make slopes safe. They are also trained in giving first aid.
2. Avalanches are controlled by causing the snow to avalanche by dropping explosives from a helicopter, launching explosives from the road-side, or detonating charges at the side of the road that send a concussion wave through the air.
3. Avalanche technicians are responsible for assembling and delivering charges made from chemical explosives. Their knowledge of these chemicals and their reactions allows them to work efficiently and safely.

SECTION 3.1 ASSESSMENT, p. 79

Check Your Understanding Answers

Checking Concepts

1. A chemical bond is a link between two or more atoms that holds the atoms together.
2. Covalent and ionic
3. In a covalent bond, atoms are connected by sharing a pair of electrons.
4. In an ionic compound, positive ions and negative ions are attracted to each other through their opposite electric charges.
5. Magnesium chloride forms when one magnesium atom combines with two chlorine atoms.
6. NaCl
7. (a) Two
   (b) One
8. (a) Two

(b) Calcium bromide would be a solid at room temperature, since it is an ionic compound. All ionic compounds are solids at room temperature.

Understanding Key Ideas

9. The compound is ionic, since ionic compounds form between metals and non-metals. (Covalent bonds can form between metals and non-metals, but the result would be an ion, not a compound. **Note:** This additional explanation is not required from students.)
10. Ionic
11. Covalent
12. You could melt the solid compound or attempt to dissolve it in water, and then perform an electrical conductivity test on the compound. If it conducts electricity, it is an ionic compound. If it does not, it is a covalent compound.

Pause and Reflect Answer

Any compound containing a metal is ionic. Since lead is also a metal, lead and chlorine will form an ionic compound.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

3.2 NAMES AND FORMULAS OF SIMPLE COMPOUNDS

BACKGROUND INFORMATION

The teaching of names and formulas is a vehicle to help students understand ways in which elements can combine to form new substances. For ionic compounds, it is helpful to remind students that there are always two parts to a chemical name and also to a chemical formula because there are always two kinds of ions present—one negative and the other positive. This reminder points out that ionic compounds never contain more than two kinds of ions. If students are presented with this concept now, they will be better prepared for later science courses, in which they will encounter ionic compounds containing polyatomic ions.

In this course, students learn how to name simple ionic and covalent compounds. It is not necessary at this point for students to be able to write the formula from the name of a compound. However, learning naming conventions now will get students familiar with chemical symbols and formulas, which will set the stage for future science courses in which they will be required to write chemical formulas.

COMMON MISCONCEPTIONS

- Keep reminding students that ionic compounds are composed of vast numbers of two kinds of ions in which all positive ions are attracted to all negative ions (most strongly to the closest ones). There is no molecule in ionic compounds (except that polyatomic ions are molecular ions). The formula represents the ratio of each kind of ion in the compound. Failure to keep this in mind misrepresents the topic and builds misconceptions that cause problems in later chemistry courses.

ADVANCE PREPARATION

- Complete the practice problems in this section yourself before teaching the section to students. This will ensure that you are completely familiar with the material and can answer any questions that arise.

Useful research materials for advance preparation can be found at www.discoveringscience.ca.

INTRODUCING THE SECTION, p. 80

Using the Text

Ask students whether it matters if a compound has more than one name. (Possibly not, because each particular compound is still uniquely identified.
In practice, many compounds have more than one name, even among chemists. Iron sulphide is more likely to be called pyrite by a geologist or simply fool's gold by others.) Ask, "Does it matter whether more than one compound has the same name?" (Yes, think of the problems if this kind of confusion occurred with medicines. Another example is that calcium carbonate is known as chalk. The famous white cliffs of Dover are made of this material. But do not use this kind of chalk to try to write on the chalkboard. Chalkboard chalk is calcium phosphate.)

Using the Key Terms and Section Summary

At the beginning of each section in the student textbook are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the Key Terms by scanning the text and using the Glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are important for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 1-2, Unit 1 Key Terms, which lists all the terms in the unit, can be used to assist students.

Using the Activity

Find Out Activity 3-2A

What's in a Name?, p. 80

Purpose

- Students investigate what information is included in the names of ionic compounds.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	No advance preparation necessary	For each student/ group: – periodic table, such as BLM 1-19, The Modern Periodic Table, or page 50 of the student textbook

Time Required

- 10 min

Science Background

This activity allows students to discover patterns about the way ionic compounds are named in advance of direct instruction. The metal ion is named first and has the same name as the metal atom. The non-metal ion is named second, and the suffix "-ide" is used at the end. The metal (positive ion) is named first. The non-metal (negative ion) is named second. Ionic compounds always involve one metal and one non-metal.

Activity Notes

- Have students refer to a periodic table.

Supporting Diverse Student Needs

- For visual-spatial learners, you could make up coloured cards displaying the names of the compounds listed. Use one colour for the name of the metal atom. Use another colour for the name of the non-metal atom. Then make up small cards of a third colour that simply say "ide." Tape the "ide" cards onto the non-metal cards to cover up the end of the name of the non-metal atom. Show these cards only at the end of the activity, once students have had a chance to make their own suggestions about the naming pattern. These visual cues will solidify the idea of the naming pattern in their minds.
- This activity is good for logical-mathematical students.
- For enrichment, ask students to name these compounds: NaI, MgI_2, CaO, $AlBr_3$.

What Did You Find Out? Answers

1. Any two of the following: the compounds always involve one metal and one non-metal; the metal ion is named first; the metal ion has the same name as the metal atom; the non-metal ion is named second; and the suffix "-ide" is used at the end of the non-metal name.
2. (a) and (b) Students will compare answers. Accept all logical responses, which are typically similar to the answer to question 1.
3. For example, names of chemical compounds that appear to be the name of a metal atom followed by the name of a non-metal atom with the suffix changed to "ide" are likely to be ionic compounds. Names of chemical compounds that do not follow this pattern might represent covalent compounds.

TEACHING THE SECTION, pp. 81–83

Using Reading

Pre-reading—Key Term Concept Maps

Teach or review the following terms: "ionic compound," "covalent compound," "chemical name," "chemical formula." During reading, have students link these words to the text. After reading, have students create a concept map linking these terms.

During Reading—Think, Pair, Share

Ask students to read a section of text independently, record their thoughts, and then pair up with another student to discuss and share their thoughts on the text. In this case, students should come up with their own example of each type of ionic compound formula and then summarize how to change it into a chemical name. The examples on pages 81 and 82 can give an indication of the style. Partners can collaborate to come up with one shared response.

Using the Did You Know, p. 81

The Did You Know on page 81 serves three purposes. First, it gives a concrete example of when students might encounter chemical names "in the real world." Students who might otherwise find naming conventions tedious might be more receptive to learning these conventions if they can see a practical application. Second, it reinforces the fact that there are sometimes multiple names for a single compound. Third, it makes students think about the consequences of having multiple names for a compound and the importance of having one consistent, universally accepted chemical name for reference. You might ask students if they can think of examples of chemical names that they have encountered outside science class. Ask, "Are these official names given by the International Union of Pure and Applied Chemistry (IUPAC) or common names?"

After Reading—Reflect and Evaluate

Students can quietly review their notes and pick out three pieces of information they have learned that they find most interesting. These interesting facts can be shared in class discussion.

Supporting Diverse Student Needs

Students who need additional practice with names and formulas can complete BLM 1-33, Forming Ionic Bonds; BLM 1-34, Ionic Bonding.

Reading Check Answers, p. 83

1. Name the metal ion using the name of the metal atom from which it forms; add the name of the non-metal ion by taking the name of the non-metal atom from which it forms and replacing the suffix with "ide."
2. The names of covalent compounds, unlike those of ionic compounds, include prefixes to indicate the number of each atom in the compound.
3. The formula indicates that for every calcium ion, there are two chlorine ions. (Because there are no positive or negative charges in the formula, it must represent a compound. Because the first symbol in the formula is that of a metal element, the compound must be ionic.)

USING THE FEATURE

National Geographic: Visualizing Salt, p. 84

This feature explores the most common and important ionic compound on Earth. Sea salt is a mixture of many compounds but is primarily sodium chloride. Notice the diagram of a unit cell of salt, faithfully representing salt existing as a crystal lattice rather than a molecule. As a point of interest for students, the first rock salt mine in Canada was located on the East Coast, in Malagash, Nova Scotia.

SECTION 3.2 ASSESSMENT, p. 85

Check Your Understanding Answers

Checking Concepts

1. (a) Two
   (b) The first part names the metallic positive ion, while the second part names the non-metallic negative ion.
2. (a) Two
   (b) A prefix specifies how many of each atom appear in a covalent compound, with one exception: if there is only one of the first atom in the name of the compound, no prefix is used.
3. If there is a metal element in the formula for a compound, the compound must be ionic.
4. N^{3-}, oxide, F^-, phosphide, S^{2-}, Cl^-, sodium, magnesium

Understanding Key Ideas

5. (a) Lithium bromide
   (b) Sodium iodide
   (c) Potassium sulphide
   (d) Magnesium fluoride
   (e) Aluminum oxide
   (f) Calcium nitride
   (g) Dinitrogen tetrasulphide
   (h) Boron trifluoride
   (i) Nitrogen dioxide
   (j) Phosphorus pentabromide
   (k) Silicon tetrafluoride
6. Nitrogen trihydride
7. (a) Ionic
   (b) Ionic
   (c) Covalent
   (d) Covalent
   (e) Ionic
8. (a) H_2O
   (b) $C_{12}H_{22}O_{11}$
   (c) P_2O_5
   (d) CO_2

Pause and Reflect Answer

Accept all logical answers. Sample answer: The formula specifies the ratio in which the ions are combined, which the name does not. For example, in aluminum oxide, Al_2O_3, there are three oxide ions for every two aluminum ions. This information is not instantly apparent from the chemical name.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

3.3 PHYSICAL AND CHEMICAL CHANGES

BACKGROUND INFORMATION

Physical changes do not result in the formation of any new substances, because no chemical bonds are broken and no new bonds are formed. Chemical changes produce new substances with new properties as a result of the formation of new chemical bonds and the breaking of others.

It can be difficult to determine from observations whether a certain specific change is physical or chemical. This difficulty is because both kinds of changes can result in materials appearing to be different. The melting of ice to water is a physical change because the water molecules are not altered in the process. Tearing a piece of paper into tiny pieces is also a physical change. Burning wood is a chemical change. When a banana gets overripe, both physical and chemical changes occur at the same time as the fluid evaporates (physical) and rotting produces new substances (chemical).

Evidence for chemical change includes colour changes; heat, light, or sound produced or absorbed; bubbles of gas forming; and the formation of a precipitate.

Some textbooks suggest that a rule of thumb is that physical changes are easy to reverse, whereas chemical changes are not; however, there are so many exceptions to this statement that it is not recommended to use (see Common Misconceptions, below). While difficulty of reversal can be used as a piece of evidence for chemical change, it is unreliable as the *only* piece of evidence for chemical change.

COMMON MISCONCEPTIONS

- Many textbooks state that chemical and physical changes can be distinguished by the fact that chemical changes are always difficult to reverse, while physical changes are easy to reverse. This is not always true, so this statement needs to be used with caution. For example, frying an egg (chemical change) is unarguably difficult to reverse, while the melting of ice (physical change) is quite simple to reverse through refreezing. However, there are many exceptions. For example, some sources might state that burning hydrogen gas and oxygen gas to make water, a chemical change, is easy to do but difficult to reverse. Reversing this chemical change is actually quite easy. Sprinkle some salt into the newly formed water and drop in a 9 V battery. Pure hydrogen and oxygen are immediately produced. On the other hand, cutting up paper into tiny pieces, a physical change, is difficult to reverse. That is why shredding documents is a good way to destroy information. Processes (either physical or chemical) become difficult to reverse when the products of the process escape (such as in an explosion, or evaporated water) or when the change causes a huge increase in randomness, also called entropy (such as in an explosion or in shredding paper). Remind students that ease of reversal might give them a clue to whether a change is physical or chemical, but they must also carefully weigh other factors.

ADVANCE PREPARATION

Magnesium ribbon and dilute hydrochloric acid solution are needed for Activity 3-3A, on page 87 of the student textbook. If you do not have any tubing on hand, you may also need to purchase rubber and glass tubing. The glass tubing should fit snugly into the opening of a rubber stopper, and the rubber tubing should fit snugly over the glass tubing.

- Vitamin tablets, fruit drinks, and some reagents are needed for Activity 3-3B, on page 91 of the student textbook.
- Reagents are needed for Activity 3-3C, on page 92 of the student textbook.
- A few days or a week are needed to see a reaction in the Unit Project, on page 100 of the student textbook.

Useful research materials for advance preparation can be found at www.discoveringscience.ca.

INTRODUCING THE SECTION, pp. 86–87

Using the Text

Place a ripe banana or other ripe fruit in view of the class and ask the class to imagine what it would look like after a few days or weeks. Then ask, “Which changes to the banana can be considered chemical and which changes can be considered physical?” (Drying out is physical, turning black and rotting are chemical.) After discussing these ideas, have students read pages 86 and 87.

Using the Key Terms and Section Summary

At the beginning of each section in the student textbook are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the Key Terms by scanning the text and using the Glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are important for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 1-2, Unit 1 Key Terms, which lists all the terms in the unit, can be used to assist students.

Using the Did You Know, p. 86

Demonstrate how a glow stick works by cracking one to make it glow. Ask students what they think is going on. "Why is it necessary to crack the stick?" (to mix chemicals) "Is this a chemical or a physical reaction?" (probably chemical since light is produced)

Using the Activity

Find Out Activity 3-3A

Magnesium in Dilute Acid, p. 87

Purpose

- Students observe a chemical reaction between magnesium metal and dilute hydrochloric acid, and then collect the gas that is produced in order to determine whether it is oxygen or hydrogen.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Get chemicals and equipment ready.	For each group: – one 400 mL beaker – 2 medium-sized test tubes – water – rubber stopper fitted with glass tubing – rubber tubing – another small piece of glass tubing to fit inside rubber tubing (optional) – dilute hydrochloric acid solution (1.0 M HCl) – magnesium metal – paper towel – test tube clamp or tongs – candle and lighter or matches – wooden splints

Time Required

- 30 min

Safety Precautions

- The hydrochloric acid is 1 M, meaning that it is medium strength. If some spills on skin, it will be sufficient simply to wash it off. If the spill is not noticed, it may cause a rash.
- Burning the hydrogen gas may cause a loud "pop" sound. Warn students of this sound to prevent them from dropping the test tube in surprise.
- Ensure that students wear gloves, goggles, and protective clothing.
- Remind students to be careful around open flames.
- Remind students to tie back long hair.

Science Background

Magnesium reacts very slowly with moisture from the air. For this reason, keep the lid closed on the magnesium except when using it.

The reaction of magnesium ribbon with hydrochloric acid is as follows:

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

The hydrochloric acid recommended is 1.0 M and is strong enough to react with the metal within several minutes. The hydrogen gas production can be seen by the formation of bubbles. Because the gas is completely invisible, it is hard to know when enough hydrogen has been collected. However, this will not be a problem since a little extra oxygen from the atmosphere that is left in the tube will actually help make a better "pop" sound.

The exothermic reaction is:

$2H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$

Activity Notes

- Try this experiment on your own before attempting it with students. If you have trouble keeping the rubber tubing in the mouth of the submerged test tube, insert a small piece (approximately 3 cm in length) of glass tubing into the free end of the rubber tubing. This glass tubing will help to keep the rubber tubing in place.
- Be the gatekeeper between students and the magnesium supply. Never set it down unless it is in a secure location. Do not let students get their own magnesium from the container. Put it onto a piece of paper towel for them.
- Encourage students to figure out for themselves how to invert their test tube full of water into the beaker full of water without letting any air in. Perhaps have a box of suitably sized rubber stoppers nearby in full view.

Preparation/Disposal of Reagents

- To prepare 1 M HCl from concentrate, mix 83 mL of concentrated HCl (12 *M*) with sufficient water to make 1 L.
- Students should not pour the reagents directly down the sink but instead put them into a waste container. This will allow the magnesium to settle out. HCl can be rendered harmless by diluting it with lots of water and then washing it down the sink with extra water.

Supporting Diverse Student Needs

- This is a good activity for body-kinesthetic and visual-spatial learners.

What Did You Find Out? Answers

1. The hydrochloric acid solution remains clear and colourless throughout. The solid magnesium ribbon, which is grey in colour, decreases in size or disappears completely. Gas bubbles are formed in the stoppered test tube. (Students might also mention the "pop" sound that the hydrogen makes when lit with the splint.)
2. Accept any logical answer. Students might think that the magnesium metal disappears because it dissolves in the hydrochloric acid. This would be a physical change. However, the flame test should demonstrate to students that hydrogen gas is formed. They should recognize that this is a new substance that was not present among the reactants, and therefore this is a chemical change.
3. The gas causes a "pop" when brought near a flaming splint, indicating that it is hydrogen gas.

Using a Demonstration

- Place a piece of magnesium ribbon (which is in the same family as calcium) into a beaker full of water. Nothing will appear to happen. Add a few drops of phenolphthalein pH indicator and wait half an hour or overnight. Magnesium reacts with water according to the following equation:

  $$Mg(s) + 2H_2O \rightarrow Mg(OH)_2(aq) + H_2(g)$$

  Hydroxide ions in the solution will cause it to be basic, so the addition of phenolphthalein will turn the solution pink. This is a good demonstration to remind students that chemical changes are not always easily observable, so chemists must use special methods to find evidence for chemical change.

TEACHING THE SECTION, pp. 88–90

Using Reading

Pre-reading—Predict-Read-Verify

Break up the section into manageable chunks for students. Some suggested chunks are:

- Physical Changes
- Evidence of Chemical Changes
- Applications of Chemical Changes

During Reading—Note Taking

Encourage students to take notes as they read through each of the chunks. They can reword the topic titles as questions and then take notes as a means of answering the questions.

Supporting Diverse Student Needs

To support students with difficulty reading and summarizing, have groups of three students write summaries of this section as a write-around. Each student begins a summary of one chunk. Then the students pass their summaries to other group members, who add to it and comment on it. As a result, the group has a complete and thorough summary of each chunk of the section.

After Reading—Reflect and Evaluate

Students can quietly review their notes and pick out three pieces of information they have learned that they find most interesting. These interesting facts can be shared in class discussion.

Reading Check Answers, p. 89

1. Reactants: propane, oxygen gas; Products: carbon dioxide, water
2. Look for evidence of chemical change: colour change; production of heat, light, or sound; formation of gas bubbles; formation of precipitate; difficulty of reversal
3. (a) Physical
   (b) Physical
   (c) Chemical
   (d) Chemical

USING THE ACTIVITIES

- Find Out Activity 3-3A, on page 87 of the student textbook, is best used as an introductory activity. Detailed information about this activity can be found in Introducing the Section.
- Activity 3-3B, on page 91 of the student textbook, is best used after discussing chemical and physical change.
- Activity 3-3C, on pages 92 and 93 of the student textbook, is best used after discussing chemical and physical change.

Detailed notes on doing the activities follow.

Design an Investigation 3-3B

Detecting Vitamin C in Fruit Drinks, p. 91

Purpose

- Students investigate how chemical changes can be used to detect vitamin C in fruit drinks.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Make the chemical solutions and ensure all equipment is ready.	For each group: – 1 vitamin C tablet, 100 mg or less – mortar and pestle – 100 mL beaker – water – stirring rod – 10 mL graduated cylinder – 2 medicine droppers – iodine-starch solution – up to 8 medium test tubes – samples of fruit juices or other beverages

Time Required

- 40 min

Safety Precautions

- Ensure that students handle chemicals safely. Iodine and starch solutions will cause stains.
- Ensure that students wear safety eyewear and protective clothing.
- Remind students to wash hands thoroughly after this investigation.
- Remind students not to taste or drink anything in the science room.

Science Background

Vitamin C reacts with deep blue/purple iodine, reducing it to colourless iodide. When iodine is added to a solution containing vitamin C, the purple colour immediately disappears because the vitamin C destroys it. Of course, some of the vitamin C is also destroyed at the same time. Eventually, when all the vitamin C is destroyed, adding iodine will cause the solution to turn deep blue/purple, because the iodine is no longer being destroyed. When iodine is added to a measured amount of vitamin C solution, the more drops of iodine that are needed to make the solution turn deep blue/purple, the more vitamin C there must have been in the solution. This is the basis of a comparative test for the amount of vitamin C in a fruit drink.

Iodine is not very soluble in pure water, but it will dissolve well in a solution of KI (commercially available or you can make it—see "Stock tincture of iodine solution" on the following page). In order to intensify the colour of iodine in solution, starch is added to the mix. Starch does not cause a chemical reaction—it just makes the iodine colour more intense.

Activity Notes

- A multivitamin tablet is best because it usually has less than 100 mg vitamin C.
- Students should discover in Part 1 that the more vitamin C in the fruit drink, the greater the number of drops needed to turn the solution purple. For water, this will happen immediately.
- The trick to finding out the relative amounts of vitamin C in various juices is to always measure out the same volume and repeat each test in exactly the same manner each time.

Preparation/Disposal of Reagents

- **Stock starch solution:** Place 2 g of cornstarch in 200 mL of water and bring the mixture to a full boil. Only 10 mL of this solution will be needed. The rest may be kept refrigerated if desired.
- **Stock tincture of iodine solution:** Add 2 g of iodine to 45 mL of ethanol and dissolve. Add 55 mL of deionized water. Then add 2.4 g KI to this mixture. Only 1 mL of this solution will be needed. The rest may be stored at room temperature if desired.
- **Iodine-starch solution for use by students:** To 1 L of water, add 10 mL of the stock starch solution and 1 mL of the stock tincture of iodine solution. The colour of the iodine-starch solution should be royal blue. Prior to doing the lab, check that a reasonable number of drops of vitamin C solution or fresh orange juice (5 to 30 drops) turns the solution from blue to colourless.

Supporting Diverse Student Needs

- Review the procedure carefully with struggling readers to make sure they understand the procedure. This investigation is written to allow students more control in designing the investigation.
- This is a good hands-on activity for body-kinesthetic and visual-spatial learners.
- For enrichment, have students bring in their own fruit drinks or try other kinds of foods such as ground-up fruits.

Conclude and Apply Answers

1. When vitamin C reacts chemically with iodine, it changes the colour from purple to colourless. The more vitamin C present, the more iodine solution that will be needed. This is the basis for the vitamin C test.
2. Accept students' results based on their data. The fewer the drops of juice needed to destroy the iodine, the more vitamin C present.

Core Lab Conduct an Investigation 3-3C

Observing Changes in Matter, pp. 92–93

Purpose

Students produce two new substances in a chemical reaction and then separate and identify them.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Make solutions and assemble equipment.	For each group: – calcium chloride solution ($CaCl_2$) – two 100 mL beakers – 100 mL graduated cylinder – 3 small test tubes, labelled "Ca^{2+} ion" "Li^{+} ion," and "unknown ion" – 3 wooden splints – lithium carbonate solution (Li_2CO_3) – ring stand and ring – funnel – filter paper – Bunsen burner – crucible tongs – felt pen – test tube rack

Time Required

- 40 min

Safety Precautions

- Remind students to be careful around open flames.
- Ensure that students handle chemicals safely. Lithium carbonate is mildly toxic.
- Ensure that students tie back long hair.
- Ensure that students wear safety eyewear and protective clothing.
- Remind students to wash their hands thoroughly after finishing the activity.

Science Background

Lithium carbonate solution and calcium chloride solution combine in a double replacement reaction to produce aqueous lithium chloride and solid calcium carbonate. The reaction is the following:

$$Li_2CO_3(aq) + CaCl_2(aq) \rightarrow 2LiCl(aq) + CaCO_3(s)$$

The two products are easily separated by filtration, but which product is which if it is not known in advance which became solid? A flame test can be used to trace the fate of the metal ions. Lithium solutions turn crimson and calcium solutions turn yellow/red in flame tests. Students discover this (or recall it, if they have done earlier flame testing) by testing the starting solutions. By also testing the filtrate, they can discover that lithium remained with the aqueous product. The solid white powder can also be held in the flame with crucible tongs. The yellow/red colour indicates that calcium formed the solid.

Activity Notes

- If Bunsen burners are not available, the flame tests in this activity can be performed with a portable propane burner.
- Soaking the splints prior to the flame test should make them wet enough to resist catching fire themselves. However, wires can also be used for the flame test. Using wires such as nichrome prevents the burning of the splint itself from influencing the colour of the flame.
- This activity requires mixing solutions, filtering, and doing flame tests. It is an excellent activity to do near the end of the unit.
- Make sure students label their test tubes or wooden splints so they do not get materials mixed up.
- Demonstrate the procedure for folding a round, fluted filter paper. Instructions are also available on page 500 of the student textbook. The fluted filter paper will have a tendency to rise up out of the funnel. Remind students to place a drop of solution on the paper to hold it in place while they pour the remainder of the solution through.
- Depending on how well the filtration goes, there can be a mixture of colours in the products. However, by comparing the two products using the flame test, it should be possible to determine that lithium passed through and calcium was caught in the filter.
- Students have not studied chemical equations, but with a little coaching and encouragement to scramble the name of the reactants together, they should be able to see that the expected products are lithium chloride and calcium carbonate.

Supporting Diverse Student Needs

- For struggling readers, review the procedure carefully and check for understanding.
- This is a good hands-on activity for body-kinesthetic and visual-spatial learners. Remind each group to read each instruction carefully and follow the instructions methodically.
- For enrichment, have students write out word equations, naming the products and indicating states (aqueous and solid). Point out that "aqueous" means similar to, containing, or dissolved in, water. Remind students that ionic compounds are solids at room temperature. If they are in liquid form, it is because they are dissolved in solution. This state is called "aqueous."

Analyze Answers

1. Lithium carbonate solution and calcium chloride solution are combined and a cloudy white solid forms (chemical); white solid is separated from the solution by filtration (physical); Ca^{2+} ion solution burns yellow/red in flame (chemical); Li^{+} ion solution burns crimson in flame (chemical); white solid burns yellow/red in flame (chemical); unknown ion solution burns crimson in flame (chemical)
2. Formation of a precipitate is evidence of a chemical change because two aqueous solutions produce a new substance that does not dissolve in solution. Separation by filtration is a physical change—substances are separated but no new substances are formed. Burning of substances in the flame test is a chemical change because the substances are combining with oxygen through the process of combustion. A clue to this chemical change is the colour change that occurs during the flame test.

Conclude and Apply Answer

1. The white powder is calcium carbonate, and the liquid that passed through the filter is a solution of lithium chloride.

USING THE FEATURE

www Science: Simulating Core Chemicals, p. 94

Suggest to students the amazing ingenuity that has gone into this experiment. To begin with, there is the concept of trying to replicate something occurring in a totally inaccessible place at the metal-rock boundary 2900 km below the surface of Earth. Note also that the highest pressures obtainable by humans are accomplished with the simple turn of the hand on a screw. Even the vise is ingenious. Two diamonds pressed together represent the hardest material known placed under the greatest force obtainable, yet because diamonds are clear, a laser can be used to heat the object held by the diamond vise without directly heating up the diamonds. Using this technique, scientists are discovering the chemistry that is happening deep below our feet.

SECTION 3.3 ASSESSMENT, p. 95

Check Your Understanding Answers

Checking Concepts

1. (a) Chemical changes and physical changes
   (b) Chemical change
   (c) Physical change
2. (a) Answers may vary. Sample answer: the exploding of fireworks is a chemical change that produces new substances with new properties.
   (b) Answers may vary. Sample answer: the melting of a chocolate candy is a physical change that causes the solid candy to turn into a melted puddle.
3. (a) Reactants: magnesium, oxygen gas
   Product: magnesium oxide
   (b) Chemical
4. (a) Physical change: a change of state does not involve producing new substances.
   (b) Physical: cutting into smaller pieces and crushing do not involve producing new substances.
   (c) Chemical: vapour reacting with your eye to cause discomfort.
   (d) Both: frying causes water to evaporate or boil in a physical change, while the heat causes chemicals in the food to break down into other substances.
   (e) Physical: mixing does not produce new substances.
   (f) Both: heating up your tongue is a physical change, but the complex series of events that allows you to feel your tongue burning involves chemical change. (If students answer only physical, this answer is acceptable.)
5. (a) Physical: flattening, drying out; chemical: chemicals in the flower slowly breaking down into new molecules
   (b) Physical: decomposing usually involves drying out; chemical: ripening involves the production of new chemicals, as does decomposing.
   (c) Physical: baking causes gases to heat up and expand, as well as turning liquids into gases by boiling; chemical: chemicals in the bread, such as baking powder, react to form carbon dioxide gas.
6. When liquid water changes into steam, the individual water molecules are not changed. They do not break up or get larger. They simply move apart from each other. Since no new materials are formed, this is just a physical change.

Understanding Key Ideas

7. Physical changes: grinding the powder, dissolving the powder, evaporation of the water, forming crystals
8. The process of forming the white powder is likely to be a chemical change because it was the sudden result of mixing two solutions. Formation of a precipitate is one piece of evidence for chemical change.

Pause and Reflect Answer

Accept all logical responses. For example: the tomato begins to soften (chemical breakdown of cells) and change colour (chemical changes in pigment molecules); the tomato begins to sag (physical evaporation of water from the tomato); mould grows on the tomato (chemical production of the new compounds associated with the mould).

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

CHAPTER 3 ASSESSMENT, pp. 96–97

PREPARE YOUR OWN SUMMARY

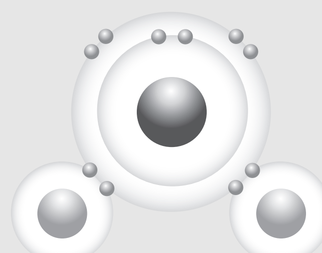
Students' summaries should incorporate the following main ideas:

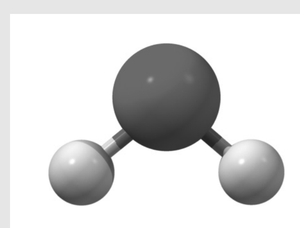
1. Distinguishing Between Ionic and Covalent Compounds
   - There are two kinds of bonds: covalent and ionic.
   - Two kinds of compounds are covalent and ionic.
   - Compounds form from covalent bonds (molecules) or ionic bonds (ionic lattices).
2. Names of Ionic Compounds
   - The chemical name indicates the two ions present in the compound.
   - The name of the positive ion is always mentioned first, followed by the negative ion.
   - The suffix of the negative ion is changed to "ide."
3. Names of Covalent Compounds
   - The chemical name indicates the atoms present in the molecule.
   - Prefixes are added to each part of the name to indicate how many of each atom are present.
4. Comparing Chemical and Physical Change
   - Chemical change results in the formation of new substances with new properties.
   - Physical changes do not produce new substances.
   - Colour change; production of heat, light or sound; bubble formation; and precipitate formation may indicate a chemical change is occurring. Difficulty of reversal is also a clue.
5. Applications of Chemical Change
   - Combustion involves a substance combining with oxygen to release a large amount of energy. It can be harnessed to provide useful mechanical and heat energy.
   - Corrosion is a process in which metals react with oxygen. Chemical techniques are used to prevent it.
   - Traditional products are prepared using both chemical and physical change.

CHAPTER REVIEW ANSWERS

Checking Concepts

1. In an element, only one type of atom is present. In a compound, atoms or ions from two or more different elements are chemically combined.
2. (a) Ionic and covalent
   (b) In ionic compounds, one or more electrons transfer between atoms, producing positive and negative ions. These ions are attracted together because of their opposite charges. In covalent compounds, two atoms share the same pair of electrons, and this sharing acts as a bond to hold them together.
3. (a) Students' drawings may vary but could include either of the following:





   (b) The covalent bond is represented by the "sticks" connecting the balls together or the shared pair of electrons.
   (c) There are two hydrogen atoms and one oxygen atom in a water molecule.
4. Ionic compounds are solid at room temperature, have high melting and boiling points, and conduct electricity in an aqueous form (all physical properties).

5. Covalent compounds can be solids, liquids, or gases at room temperature and they do not conduct electricity (physical properties).
6. All positive ions in an ionic lattice are attracted to all other negative ions anywhere in the lattice. However, the attraction decreases with distance, and most of the attraction is to the nearest negative ions.
7. (a) $CaCO_3$
   (b) NaCl
   (c) C_3H_8
   (d) $C_{12}H_{22}O_{11}$
   (e) CO_2
8. (a) Ionic
   (b) Ionic
   (c) Covalent
   (d) Covalent
   (e) Ionic
9. If the same chemical name applied to more than one compound, this would lead to confusion about which chemical is being referred to.
10. (a) International Union of Pure and Applied Chemistry
    (b) One important responsibility is to develop rules for naming compounds.
11. (a) A reactant is a starting material in a chemical reaction.
    (b) A product is a material that is made during a chemical reaction. The reactants turn into products.
12. Evidence for chemical change includes colour change; production of heat, light, or sound; formation of gas bubbles, formation of precipitate; and difficulty of reversal.

Understanding Key Ideas

13. (a) Sodium iodide
    (b) Magnesium nitride
    (c) Zinc oxide
    (d) Aluminum fluoride
14. (a) Potassium nitride
    (b) Calcium sulphide
    (c) Silver sulphide
    (d) Aluminum phosphide
    (e) Strontium nitride
    (f) Cesium oxide
15. (a) Sulphur dioxide
    (b) Nitrogen trifluoride
    (c) Nitrogen monoxide
    (d) Dinitrogen oxide
    (e) Phosphorus pentachloride
    (f) Nitrogen trihydride (Ammonia)
    (g) Dinitrogen tetrahydride
    (h) Phosphorus trihydride
16. (a) Physical
    (b) Chemical
    (c) Physical
    (d) Physical
    (e) Chemical
    (f) Physical
    (g) Chemical
17. During a chemical change, elements combine with other elements, and the atoms in compounds rearrange themselves to form new substances.

Pause and Reflect Answer

Chemical changes during a construction blast include explosive chemicals combining either with each other or with oxygen to form new substances. The chemical change is indicated by the light, heat, and sound produced by the blast. Physical changes include the heating of newly formed gas molecules, which causes them to move around more quickly and expand, and the rapid movement of dirt and dust particles in all directions, creating a large cloud of debris.

UNIT 1 ASSESSMENT

PROJECT

Corroding Nails, p. 100

Purpose

- Students will investigate what conditions cause the most corrosion of an iron nail.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Assemble reagents and equipment.	For each group: – 6 test tubes – 6 iron nails – cotton ball – water – calcium chloride – vegetable oil – 2 stoppers – test tube holder

Time Required

- 30 min to get started, then several minutes per day for up to a week to make observations

Safety Precautions

- Do not allow students to mix chemicals without your approval.
- Ensure that students wear safety eyewear.

Science Background

The corrosion of iron happens when iron is attacked by oxygen. The oxygen strips electrons away from the iron atoms, turning them into positive iron ions. We see this as rust. Just as iron will not rust in the desert (lots of oxygen, no water), iron will not rust in pure water (lots of water, no oxygen). The corrosion of iron occurs in water in the presence of dissolved oxygen gas. The process is electrochemical and is aided by the presence of dissolved salts, which is why cars tend to rust quickly if salt is used on roads in the winter. Varying the amount of available water, oxygen, and salt varies the rate of corrosion of an iron nail. Students are asked to come up with one other combination of reactants. Several suggestions are the following: no cork, water, salt (speeds corrosion); vegetable oil only (retards corrosion); any of the arrangements already used, but at a higher temperature (speeds corrosion); using a fish tank pump to continuously bubble air through water (speeds corrosion); wrapping the nail in magnesium ribbon (retards corrosion because the magnesium corrodes before the iron, even if there is exposed iron—this is like a galvanized nail).

Activity Notes

- A few days or a week will be necessary to see an effect.
- Make sure the nails are made of iron, not stainless steel, or you will not get a good rusting effect.
- Encourage students to use diagrams to show their procedure.
- Encourage students to use a table format for recording data.

Supporting Diverse Student Needs

- Encourage struggling readers to summarize the procedure in a flowchart and describe the apparatus set-up to their partners or to you.
- This is a good hands-on activity for body-kinesthetic and visual-spatial learners.
- For enrichment, suggest putting the nail in contact with magnesium (retards corrosion), zinc (retards corrosion), copper (promotes corrosion), or tin (promotes corrosion). Basically, the most active metal corrodes first.

Report Out Answers

1. Accept all logical responses. For example: What are some factors affecting the rate of corrosion of an iron nail?
2. An acceptable procedure shows the conditions in each test tube (diagrams are good) as well as a method for deciding on how much corrosion has occurred.
3. Data should be collected in a table and should be understandable by someone who has not seen the experiment.
4. Accept all logical responses. Conclusions should be consistent with data collected.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

INTEGRATED RESEARCH INVESTIGATION

Chemical Contents, p. 101

Purpose

- Students develop research skills by finding out about a specific chemical and reporting on it through a pamphlet or Web page.

Activity Notes

- Discuss different presentation formats with your class. Encourage students to try something new for the activity, and discuss their ideas before beginning the activity.
- If computer class time or library time is not available, it may be suitable to spread the activity out over a week.
- Students can start their Internet research at www.discoveringscience.ca.

Supporting Diverse Student Needs

- English language learners or struggling readers should be partnered with students who have strong communication skills.
- For enrichment, adjust the depth of presentation expected.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

UNIT 1 REVIEW ANSWERS, pp. 102–105

Visualizing Key Ideas

1. Pure substances: *compounds* and *elements* composed of *atoms* that contain *protons*, *electrons*, and neutrons.
2. chemical; colour change; production of heat, light, or sound; formation of gas bubbles; formation of precipitate; process is difficult to reverse

Using Key Terms

3. (a) False. Matter is anything that has volume and mass.

(b) True
(c) False. The three types of subatomic particles in an atom are the proton, the electron, and the *neutron*. (**Note:** The statement is arguably true, if the nucleus is taken to be a subatomic particle.)
(d) False. Elements can be divided into metals, metalloids, and *non-metals*.
(e) False. A group of elements that have similar chemical properties is called a *family* (or *group*).
(f) False. The atomic number counts the number of *protons* in the nucleus of an atom.
(g) True
(h) True
(i) False. *Combustion* is a chemical change that results in the release of heat.

Checking Concepts

4. A physical property is a characteristic of matter that is easily observed or measured.
5. A chemical property can only be observed when a substance undergoes a chemical reaction.
6. A law is a statement of observations, while a theory is an explanation of observations. A law remains constant and is true in all situations, while a theory may change if new evidence emerges to contradict the theory. Examples of laws: law of gravity, laws of attraction in electricity, law of reflection. Examples of theories: theory of evolution, atomic theory.
7. (a) Electron, proton, neutron
   (b) Protons and neutrons are located in the nucleus, while electrons occupy energy levels surrounding the nucleus.
8. (a) In the nucleus
   (b) The region surrounding the nucleus containing electrons
9. (a) An element is a pure substance that cannot be broken down or separated into simpler substances. It is also a substance in which all the atoms contain the same number of protons.
   (b) About 92 elements occur naturally. (Approximately 115 to 120 elements have been identified including those created in the laboratory.)
10. Metallic elements are typically shiny, silver or grey coloured, conduct electricity, conduct heat, and are malleable and ductile.
11. Any four of the following: Non-metals may be in any of the three states of solid, liquid, and gas at room temperature; the solids are not shiny, malleable, or ductile; they tend not to conduct heat or electricity very well; they are brittle; and if they react, they tend to form negative ions.
12. Elements in the same column of the periodic table tend to share similar physical and chemical properties.
13. (a) Period
    (b) Family
14. Name, symbol, atomic number, atomic mass
15. (a) Alkali metals (column 1) and alkaline earth metals (column 2)
    (b) Halogens (column 17) and noble gases (column 18)
16. 2, 8, 2
17. (a) One
    (b) Seven
18. The outer electron shell is full.
19. A compound is a pure substance made up of two or more elements that have been chemically combined.
20. (a) Ionic
    (b) Covalent
21. The name of the metal ion goes first, followed by the name of the non-metal ion, on which the suffix is changed to "ide."
22. A positive metal ion and a negative non-metal ion
23. In a chemical change, old chemical bonds are broken and new chemical bonds are formed, which produces new substances with new properties. In a physical change, there is no breaking or forming of bonds and a new material is not formed.
24. In a combustion reaction, a substance reacts with oxygen and a large amount of energy is released, usually in the form of heat, light, and electrical or mechanical energy.

Understanding Key Ideas

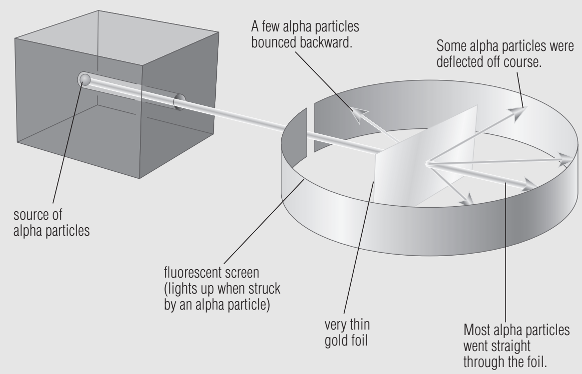
25. For example, water is a colourless liquid (qualitative) that has no tendency to be attracted to a magnet (qualitative). Pure water has a melting point of 0°C and a boiling point of 100°C (both quantitative). Water conducts heat and electricity (both could be quantitative, but in this case, since these properties have not been measured, they are qualitative).
26. (a) Quantitative
    (b) Quantitative
    (c) Quantitative
    (d) Qualitative

(e) Quantitative
(f) Qualitative

27. Sodium cannot be used as a container to boil water because it melts at 98°C, below water's boiling point. It also reacts explosively with water and forms a toxic compound in water.
28. The periodic table is arranged in increasing order by atomic number. New rows are added in such a way that elements with similar properties line up one below the other, forming columns, or families, of elements.
29. (a) Metals tend to be on the left.
(b) Non-metals tend to be on the right.
(c) Metalloids form a diagonal line from left to right toward the right side of the table between the metals and the non-metals.
30. (a) Metal
(b) Non-metal
(c) Metal
(d) Metalloid
(e) Metalloid
(f) Non-metal
(g) Metal
(h) Metal
31. Hydrogen has one electron in its outermost (and only) electron shell. It can lose one electron to obtain a noble gas configuration. In this case, it acts like a metal, forming a positive ion. Alternatively, it can gain one electron to obtain the same outer electron configuration as helium. In this case, it acts like a non-metal, forming a negative ion. Because it can behave either as a metal or a non-metal, it appears on the left side of the periodic table, but it is separated from the other metals.
32. # of neutrons = mass number – atomic number
# of neutrons = 12 – 6
# of neutrons = 6
33. # of neutrons = mass number – atomic number
mass number = # of neutrons + atomic number
mass number = 11 + 11
mass number = 22
34. 25 protons, 25 electrons
35. Noble gases
36. (a) Ionic
(b) Covalent
(c) Ionic
(d) Covalent
(e) Covalent
37. (a) Sodium chloride
(b) Potassium oxide
(c) Cesium phosphide
(d) Calcium fluoride
(e) Aluminum bromide
(f) Magnesium nitride
38. (a) Carbon disulphide
(b) Phosphorus trifluoride
(c) Dinitrogen pentasulphide
(d) Silicon monoxide
(e) Phosphorus trichloride
(f) Tricarbon octahydride (propane)

Thinking Critically

39. (a)

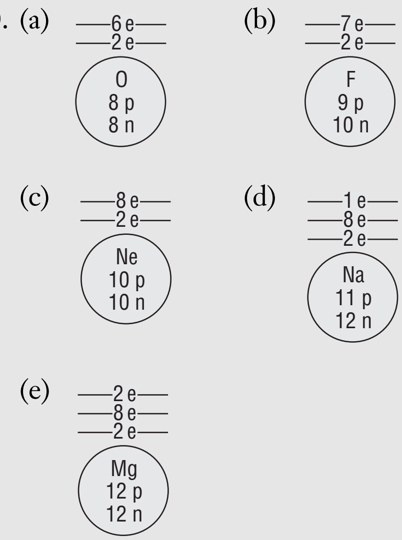


(b) The deflection indicated gold atoms contained a tiny, massive, positively charged nucleus.
40. Mercury is a liquid metal, and like all metals, it conducts electricity very well. Because it can also flow, it can be made to flow between two wires to allow electricity to pass through the switch and also to flow away from the two wires to prevent creating current. The position of the mercury is controlled by tilting the switch in the correct way. Because a mercury switch is always contained inside a glass container, no spark can ever get out.
41. Mendeleev noticed that there appeared to be a missing element below silicon and above tin in the periodic table. Mendeleev looked at the properties of these elements to make predictions about a new element that would have properties in between the properties of silicon and tin.
42. (a) The atomic number is the number of protons in each atom of an element.
(b) As you move left to right through each row of the periodic table (from the top row through to the bottom), the atomic number increases smoothly by a value of one with each new element.

43. (a) Column 1: alkali metals; column 2: alkaline earth metals; column 17: halogens; column 18: noble gases.
    (b) Answers may vary but could include the following:
    Alkali metals—react quickly with air and water
    Alkaline earth metals—react slowly with air and water
    Halogens—coloured, form ions with a charge of 1–
    Noble gases—chemically inert (unreactive), colourless
44. All of the halogens have seven electrons in their outermost electron shell.
45. In a covalent compound, atoms of two different elements are connected by covalent bonds, which means two atoms share a pair of electrons. In an ionic compound, atoms exchange an electron and form oppositely charged ions. These ions are connected to each other by the attraction of their opposite electric charges.

Developing Skills

46. The diagram should show seven protons and eight neutrons together in a nucleus. There should be two electrons in the first energy level and another five electrons in the second energy level.
47. Sodium atoms have one electron in their valence shell that is loosely held. When a sodium atom contacts a chlorine atom, with seven valence electrons and room for one more, an electron is easily transferred from the sodium to the chlorine. This makes both atoms chemically reactive. Once the electrons have been transferred, both ions have complete outer electron shells and, similar to the noble gases, are no longer reactive.
48. (a) Iron: atomic number 26, 55.8 amu, 26 electrons
    (b) Gold: atomic number 79, 197.0 amu, 79 electrons
    (c) Cu: atomic number 29, 63.5 amu, 29 electrons
    (d) U: atomic number 92, 238.0 amu, 92 electrons
49. (a) Calcium
    (b) Chlorine
    (c) Aluminum
    (d) Fluorine

50.


Pause and Reflect Answer

Accept all logical answers. For example: We can picture atoms only through the use of models. Even the scanning tunnelling microscope images that appear in this unit (such as on the opening page of the unit) is a model of the atoms that are represented.
J. J. Thomson's model showed that atoms were divisible because they contained electrons. Rutherford's model showed that atoms contain a nucleus, and led to the discovery of the proton and the neutron. Bohr's model gave an idea of how electrons exist inside an atom. His model shows how electrons are arranged in energy levels, which helps us to explain chemical properties and the patterns within the periodic table.