CHAPTER 2 OPENER, pp. 36–37

USING THE PHOTO AND TEXT

The computer model of a carbon nanotube is a good example of the kind of precise understanding we now have about how atoms combine to make novel materials. Inside the nanotube are other structures that are spherically shaped, making this a filled nanotube. This particular arrangement increases the nanotube's electrical conductivity. The diameter of the nanotube is given as 100 000 times smaller than a human hair. Students will need some help grasping these widely different sizes. A human hair is typically about 0.1 mm across. A typical nanotube diameter is about 1 nanometre. To make this measurement more meaningful, imagine a nanotube as large as a tree with a trunk 1 m in diameter. Imagine standing another tree upright beside it, with two trunks side-by-side, like posts in a fence. How far would this line of trees extend before it was the diameter of a hair? (100 km)

Share with students that nanotube technology is on the cutting edge of human knowledge about matter, and that making useful nanotubes is an area of active research. Nanotubes self-assemble under the right conditions and can now be grown up to several millimetres long. Their great tensile strength suggests many applications. Other kinds of non-traditional products, such as electrically conductive plastics, are being developed through application of our understanding of the properties of different elements. The text on page 36 gives some examples of these products. This development leads naturally to the importance of understanding matter by understanding its most basic building blocks—atoms and elements.

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

Use the bolded descriptors in What You Will Learn/Why It Is Important/Skills You Will Use to illustrate the variety of different opportunities for engagement that students will have in this chapter. Besides distinguishing and comparing, students will have an opportunity to classify, predict, and explain how the building blocks of matter are arranged in logical ways according to their properties and atomic structures.

USING THE FOLDABLES™ FEATURE

See the Foldables section of this resource.

2.1 ELEMENTS

BACKGROUND INFORMATION

Elements can be thought of as materials made of groups of atoms, all of which have the same number of protons. They can also be thought of as pure substances that cannot be converted into anything simpler by physical or chemical means. The Grade 9 science curriculum does not include a discussion of isotopes, so the idea that the same element can contain slightly different atoms (with more or fewer neutrons) is not a major focus here. It is discussed in a marginal feature on page 49 of the student textbook (section 2.2) to support students' understanding of atomic mass and mass number.

How many elements are there? The answer is always changing since atoms of new elements are produced regularly in particle accelerators using great amounts of energy to combine lighter elements. At the time of writing this resource, there have been claims for up to about 120 elements, although some have not yet been confirmed. The most recent version of the International Union of Pure and Applied Chemistry (IUPAC) periodic table is presented in Figure 2.13 on page 50 of the student textbook. It lists elements up to atomic number 118, with an empty space for element 117.

There is some debate about how to define "natural elements." Most sources claim that there are 92 naturally occurring elements (atomic numbers 1 to 92), and yet elements such as technetium (atomic number 43) and astatine (atomic number 85) are extremely rare in nature due to their radioactive decay. Students might find it interesting to know that while astatine is part of Earth's crust, it decays so quickly that it is not found outside of labs. The total amount of astatine produced in the world since its discovery in 1940 is approximately 0.05 μg (5×10^{-8} g). This information may help students understand why the number of naturally occurring elements is approximate.

The heaviest natural element is uranium, atomic number 92. There are about 100 metals and about 15 non-metals. Yet only about 50 elements make up most of Earth. Thirty-five of these are listed in Table 2.1, Thirty-five Common Elements, on page 40, and students are encouraged to be able to provide the symbol when given the name of these elements, and to provide the name when given the symbol.

The elements have an amazing diversity of properties. A tour of eight common elements (pp. 41–43) reveals some of these differences between the elements. It also sets the stage for looking for similarities in properties among the elements. The ideas in the tour are provided as an interesting introduction to some new and important materials rather than a list of properties and elements to be memorized.

COMMON MISCONCEPTIONS

- Students often begin this section with a skewed idea of what the typical properties of a metal are. This misconception is simply because structural metals (iron, aluminum) and coinage metals (copper, silver, gold) are so familiar to students. Reactive metals such as sodium and calcium are much less familiar.

ADVANCE PREPARATION

- A collection of elements should be made and stored as a set. This collection may be accumulated over several years. Add to the elements from time to time, making sure to abide by safety regulations for storage and handling for your school or district. The Department of Education has published a science safety resource manual, which may be found at www.discoveringscience.ca. In this manual, mercury is permitted but only in small amounts in sealed plastic containers.
- The day before, prepare the equipment and reagents for Activity 2-1B, on pages 44 and 45 of the student textbook.

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

INTRODUCING THE SECTION, pp. 38–39

Using the Text

Have students read the text on page 38. Challenge students to name elements that they know are present in common materials. (Possible answers: calcium in bones; silicon and oxygen in rocks and glass; carbon in pencil cores and diamond; copper, silver, gold, and zinc in coins) Are there any exotic elements that they may know of that have common uses? (Possible answers: americium in smoke detectors, rare earth elements such as neodymium in modern magnets, and platinum in automobile catalytic converters)

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. 38

Marie Curie was a giant among chemists and physicists. In 1903, she and her husband, Pierre, won the Nobel Prize in physics for their work with radioactivity. In 1911, she received a Nobel Prize in chemistry for her discovery of the elements radium and polonium. She had the unusual achievement of being at the head of her field in both theoretical work (understanding new ideas about atoms) as well as practical work in the laboratory (spending years to purify gram-sized amounts of chemicals). Such work is not without its risks—Curie died of a disease called aplastic anemia, almost certainly brought about by her exposure to radioactivity.

Using the Activity

Find Out Activity 2-1A

Meet the Elements, p. 39

Purpose

- Students examine a variety of elements, observing colour, state, lustre, electrical conductivity, and magnetic properties.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before (longer if set of elements must be collected)	Have a set of elements ready. Optional: Photocopy BLM 1-15, Meet the Elements.	For each class: – 1 set of elements – several conductivity testers – several magnet

Time Required

- 30 min

Safety Precautions

- Some elements need to be kept sealed in containers. Others can be picked up and touched by students. These precautions will be determined by which elements you actually use.
- Students should be sure to wash their hands, especially if they touch lead or antimony.

Science Background

This is a great opportunity for students to compare a variety of elements in their pure state. Most metals can be picked up by students, so conductivity and magnetism tests can be done on them. Students will link back to these observations when elements are discussed in the lesson. This is also a chance for students to connect some of the element names and symbols to their own personal experience.

Activity Notes

- You may wish to hand out BLM 1-15, Meet the Elements, for students to use to record their information.
- Have the elements set out around the work space so students can approach them in any order.
- Have a supply of magnets and conductivity apparatus set out among the elements.
- To test conductivity, a battery/light bulb/wires set-up works well. If the light goes on, the element is conductive.
- Examine the samples prior to the activity. If you think it will be difficult for students to determine the lustre of the available elements, you may wish to provide steel wool so students can polish the samples before examining them.

Preparation/Disposal of Reagents

- Elements in your set need to conform to safety rules in your district. The Department of Education has published a safety manual for use in science classrooms, which may be found at www.discoveringscience.ca. In this manual, mercury is permitted but only in small amounts in sealed plastic containers.
- A typical set of elements includes:
  – unsealed: lead, gold, silver, silicon, magnesium, zinc, iron, aluminum, carbon, sulphur, antimony
  – sealed glass bottles (filled with air) labelled hydrogen, nitrogen, oxygen, helium, neon, argon
  – sealed: mercury, calcium turnings, iodine flakes
  – other elements as desired that do not conflict with your school's safety regulations

Supporting Diverse Student Needs

- Review the meanings of lustre, state, conductivity, and magnetism. This will help English language learners understand the instructions as well as remind all students of their meaning.
- This is a very good hands-on activity for body-kinesthetic and visual-spatial learners. Ensure that they take thorough notes about what they observe.
- This activity is an excellent jumping-off point for a student-prepared brochure on any one of the elements. Enthusiastic readers might wish to sample any of the following books:
  – *Uncle Tungsten*, by Oliver Sacks (literary)
  – *Nature's Building Blocks: An A-Z Guide to the Elements*, by John Emsley (factual)
  – *The Elements*, by John Emsley (factual)
  – *The Periodic Table*, by Primo Levi (literary)
  – *Discovery of the Elements*, by Jim Marshall (factual)
  – *Rediscovery of the Elements*, by Jim Marshall (factual)
  – *Living with Radiation: The First Hundred Years*, by William Kolb and Paul Frame (factual)

What Did You Find Out? Answers

1. Elements that conduct electricity are all metals (shiny and metallic-looking), with the exception of carbon (graphite).
2. Non-conducting elements are non-metals (not shiny or metallic-looking).
3. Students' groupings could include, for example, solids and gases, or metals and non-metals.

Using a Demonstration

- Place iodine flakes in a sealed test tube and place the test tube in hot water. A purple gas will form and then solid iodine will recrystallize on the inside wall of the test tube.
- Take a piece of lead and use it to write on a piece of paper. Use a hammer to make a very thin sheet of lead.

TEACHING THE SECTION, pp. 39–43

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. They can then write a statement as to why they found the information interesting. You may wish to distribute BLM 1-16, Symbols for Elements and BLM 1-17, Common Elements, for students to complete, to reinforce their understanding.

Supporting Diverse Student Needs

- After students have completed BLMs 1-16 and 1-17, have them identify any responses that they are unsure about. With a classmate, have them review the text for two minutes, looking for information to help compete or clarify each response. If they have not found the information in two minutes, they can flag the question, and then ask the rest of the class, or you, to identify the information that will help them. As well as helping students find the responses, this will model the process of extracting key information from the textbook.

Reading Check Answers, p. 43

1. Unlike iron, sodium melts at a low temperature, is soft, and is highly reactive in water.
2. Iron is strong and can be made stronger by adding carbon.
3. Mercury is the only metal that is liquid at room temperature.
4. Chlorine is added to water to kill bacteria. Chlorine also combines with sodium to make table salt.
5. Silver can be polished and moulded and is both malleable and ductile, making it useful for jewellery. Its conductivity makes it useful in electronics.

USING THE ACTIVITIES

- Find Out Activity 2-1A, on page 39 of the student textbook, is best used as an introductory activity. Detailed information about this activity can be found in Introducing the Section.
- Activity 2-1B, on pages 44 and 45 of the student textbook, is best used after reading about hydrogen on page 41.
- Activity 2-1C, on page 45 of the student textbook, is best used after reading and discussing the section.

Detailed notes on doing the activities follow.

Conduct an Investigation 2-1B

Generating and Burning Hydrogen Gas, pp. 44–45

Purpose

- Students generate hydrogen gas by combining a reactive metal with an acid and then burning the hydrogen in a procedure called the "pop" test.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Assemble the reagents and equipment. Optional: Photocopy BLM 1-18, Assessing Attitudes.	For each group: – medium-diameter test tube – large-diameter test tube (to fit over medium test tube) – test tube rack – candle – matches – wooden splints – dilute hydrochloric acid solution (1.0 M HCl) – zinc metal (mossy) – test tube holder – chemical waste container

Time Required

- 40 min

Safety Precautions

- Ensure that students wear safety eyewear and lab coats, handle chemicals safely, and wash hands thoroughly after the investigation.
- This activity uses open flames (from a candle). Remind students to be careful.
- Ensure that students dispose of materials safely.
- 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 result to prevent them from dropping the test tube in surprise.

Science Background

The reaction of zinc metal with hydrochloric acid is as follows:

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

The hydrochloric acid recommended is 1.0 M and is strong enough to react with the metal within a few 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 "pop" sound is the reaction of hydrogen with oxygen:

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

The product is water, which—although is produced as a gas—quickly condenses to liquid form, causing a vacuum. The quick rush of air into the test tube makes the "pop" sound. Because this reaction is an implosion, rather than an explosion, unsafe pressure build-ups inside the test tube do not occur.

Activity Notes

- Have students work in groups.
- Try this experiment by yourself first, and then complete it with students.
- Make sure the larger diameter test tube will easily slide over the smaller diameter test tube.
- Do not overfill the test tube with acid. The test tube should be no more than one third full.
- Often the second attempt to get a "pop" sound will not work as well as the first unless the student blows into the test tube. This action puts more oxygen into the test tube.
- You may wish to have students complete BLM 1-18, Assessing Attitudes, to help them assess their attitudes during lab activities.

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. Doing so will allow the zinc 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 hands-on activity for body-kinesthetic and visual-spatial learners. Encourage visual-spatial learners to describe the apparatus set-up to their partners or to you.
- For enrichment, have students repeat the experiment with magnesium (it will react more quickly) and copper (it will not react). A report or discussion on the relative reactivity of metals could follow.

Analyze Answers

1. Zinc metal tends to blacken as the reaction proceeds.
2. Accept all logical answers. The most likely result is that the hydrochloric acid will be used up before the zinc. In this case, the zinc is likely to remain unchanged indefinitely. Students often discover this result because after a while, the system stops producing hydrogen gas. Adding more zinc does not help, but adding more hydrochloric acid does. It is reasonable to predict that the zinc will continue to corrode until no solid zinc remains.

Conclude and Apply Answer

1. When a burning splint is brought near hydrogen gas in an inverted test tube, there may be a flash of red/orange flame and a popping sound. This result indicates that the gas is flammable and may be hydrogen.

Think About It Activity 2-1C

Essential Elements, p. 45

Purpose

- Students research an element and present their findings.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Book the library or computer lab, if desired. Decide what sort of format(s) will be accepted for this investigation. Consider whether assessment rubrics will be used.	For each student: – access to the Internet and/or other research material

Time Required

- 30–60 min

Science Background

Many resources on elements are available in the library and on the Internet. See www.discoveringscience.ca.

Activity Notes

- Given that there are more than 100 elements, it should be fine to let students pick their own element. You may wish to have students work in pairs.
- Let students know which forms of presentation are acceptable, or you may wish to select one format, such as a poster.

Supporting Diverse Student Needs

- Many texts and electronic resources are written well above grade level. Scout out a number of resources in advance that will be more straightforward for struggling readers.
- By varying the acceptable form of presentation, almost every learning style can be represented. Some students may wish to present their information in the form of poetry, visual art, a debate, a monologue, or a model.
- Have students review the research of other students and make a brief report on any four of the elements covered by members of their class.

USING THE FEATURE

www Science: Getting Metal from Stone, p. 46

This feature explores the development of processes to efficiently extract elements and compounds from nature. It touches on bauxite and copper mining, as well as the extraction of elemental aluminum and copper from the compounds in which they are found naturally. It is important for students to understand that "naturally-occurring elements" often need to undergo industrial processing to reach their elemental form. Aluminum metal was once so difficult to extract that it was more expensive than gold. Chemists have since developed industrial processes, such as the Bayer process, which purifies aluminum oxide from bauxite ore, and the Hall-Heroult reaction, which extracts aluminum metal from aluminum oxide. With the development of reliable methods to extract aluminum from ore, global production of the metal increased, and its price decreased.

The final paragraph of this feature can be used to demonstrate to students why it is still important for chemists to explore new methods of extraction, even though reliable methods already exist. Point out to students that elements are finite resources. Recycling offers a new opportunity for chemists to influence how elements and compounds are harvested.

SECTION 2.1 ASSESSMENT, p. 47

Check Your Understanding Answers

Checking Concepts

1. (a) An element is a substance made up of only one type of atom. More precisely, all atoms of the same element have the same number of protons.
   (b) There are about 92 naturally occurring elements (about 115–120 elements in total).
2. Chemical symbols allow scientists to communicate about elements in a way that is understood by scientists all over the world.
3. (a) Hydrogen, nitrogen, oxygen, fluorine
   (b) Bromine, mercury
   (c) Students' answers could include four of the following: potassium, carbon, phosphorus, sulphur, iodine.
   (d) Lithium, sodium, rubidium, cesium
4. Any two of strontium, magnesium, copper
5. (a) Cobalt, Co
   (b) Bromine, Br
   (c) Iodine, I
   (d) Beryllium, Be
   (e) Fluorine, F
   (f) Neon, Ne
   (g) Chlorine, Cl
   (h) Mercury, Hg
   (i) Rubidium, Rb
   (j) Cesium, Cs
   (k) Phosphorus, P
6. Hydrogen
7. Silver
8. Iron and carbon make steel. Other metals are usually added in as well.
9. The atmosphere is about 21 percent oxygen.
10. Oxygen in our atmosphere was produced by plants over the past 3 billion years.
11. Sodium metal reacts violently with water, making it unsuitable for use in drinking glasses.
12. Chlorine in swimming pools is effective at killing bacteria and other pathogens in the water.
13. Hydrogen makes up more than 90 percent of the atoms in the universe.
14. Silicon combines with oxygen to make quartz, or sand.

Understanding Key Ideas

15. Sodium reacts with water many times faster than iron does. (Iron rusts when exposed to water—a process that occurs gradually—while sodium reacts violently with water on contact.)
16. Students' answers could include the following:
    (a) Mercury and sodium both conduct electricity and heat, are shiny, and are silver coloured.
    (b) At room temperature, mercury is a liquid but sodium is a solid.
17. (a) Mercury is not fundamentally different from other metals. Given enough heat, all metals will become liquid.
    (b) Mercury is used in sparkless switches. (Students may also mention its use in thermometers.)
    (c) Mercury vapour is a gas that forms over liquid mercury, and it is toxic.
18. Accept all logical answers. For example: Wood contains carbon, hydrogen, and oxygen; wires contain copper, steel, silver, or gold; magnets contain iron as well as rare earth elements such as neodymium.

Pause and Reflect Answer

The atoms of different elements have different numbers of protons. Since atoms have an equal number of protons and electrons, atoms of different elements also differ in the number of electrons they possess.

(**Note:** Neutrons are a different situation. Not all atoms of the same element need to possess exactly the same number of neutrons. This means that atoms of two different elements may contain the same number of neutrons. Isotopes are discussed briefly in the next section.)

Other Assessment Opportunities

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

2.2 THE PERIODIC TABLE AND CHEMICAL PROPERTIES

BACKGROUND INFORMATION

This section of the textbook sets out the central theme of this unit, which is that the elements can be organized according to their chemical and physical properties. The very existence of a periodic table indicates that there are many patterns in chemistry, which goes a long way toward making the subject comprehensible, despite the millions of kinds of materials and chemical reactions.

Mendeleev was not the first person to try to sort out the elements according to properties, but he was not driven to arrange them exactly according to increasing atomic mass. When the chemical properties suggested switching two adjacent elements (when listed by increasing atomic mass), Mendeleev made the switch. (Later, Henry Mosely showed that it was the atomic number, not the atomic mass, that determined the order.) Mendeleev also made the assumption that some elements were still undiscovered, so when necessary, he left blanks in his table. While these steps may now seem obvious, Mendeleev was the first person to employ these ideas. His method was soon shown to be correct when his table predicted the properties of an as-yet undiscovered element, later called germanium.

Each box in the periodic table gives the element's name, symbol, atomic number, and atomic mass. Students should be made aware of both the existence of these pieces of information as well as the trends in the table.

Atomic mass, which is defined as the average mass of atoms of an element, implies that there are different kinds of atoms of the same element. The concept of isotopes is introduced as a marginal feature on page 49 to explain this point. While all isotopes of an element will have the same average atomic mass, each isotope will have a different mass number, which indicates the number of protons and neutrons in the atoms of that isotope. Isotopes are placed in a marginal feature here to satisfy the curiosity of high-level students, but isotopes are not actually part of the Grade 9 course. They will be discussed further in science courses to come. It may be helpful to stress that all atoms of the same element have the same number of protons. The number of neutrons has virtually no impact on the element's physical or chemical properties except that some atoms of the same element have slightly different masses. The atomic mass is the average of the masses of all the atoms in a sample of the element.

The periodic table is divided into metals and non-metals by the metalloids (which is really a third part, or can be thought of as the boundary between the metals and non-metals). Students should know to look left for metals and right for non-metals.

Periods run horizontally through the table, and families (or groups) run vertically. Elements in the same family tend to have similar properties.

COMMON MISCONCEPTIONS

- Some students may conclude that hydrogen is a member of the alkali metal family because of its position in the table. It is not. Hydrogen is in a family of one because of its unique properties—it has the ability to either lose or to gain an electron. Pure hydrogen is clearly a non-metal (gas, non-conductor), but chemically it often behaves in a manner similar to the alkali metals. This behaviour results from the tendency of all these elements to lose an electron to form a 1+ ion.
- Atomic mass does not give the number of neutrons in the nucleus of an atom. The atomic mass is an average representing the mass of a given atom of an element. Students need to know this so that they can use the term appropriately. Notice that the atomic masses are all decimal numbers (counting neutrons and protons involves only integers). In many cases, the decimal is zero (as in oxygen, atomic mass = 16.0 amu); however, if a more precise value were given, it would be seen to have non-zero digits (15.9994 amu).
- In Activity 2-2A, on page 49, students will use the mass number to calculate the number of neutrons in an atom. However, the mass number is not reported on the periodic table. For the purposes of this calculation, students will need to assume that the mass number can be approximated by rounding off the atomic mass. It is important to point out, though, that atomic mass and mass number have different meanings. It is not possible to count the number of neutrons in a given atom by using only the information from the periodic table.

- In a misconception that is related to the previous one, totalling the numbers of protons and neutrons in an atom does not give the atomic mass. (It seems to work in some cases, but this is just a coincidence.) The reason this method does not work is that when protons and neutrons are moved together, some of their mass converts to energy. The mass of the combined protons and neutrons is never the same as their individual masses.
- Students may learn (correctly) that cesium is more reactive than lithium, and that chemical reactivity increases moving down the group. This trend holds true for all metals, but it is not true for the non-metals. In fact, the trend is reversed. For example, fluorine, at the top of the halogen family, is much more reactive than iodine, at the bottom.
- Students may believe that noble gas elements can never form compounds. In fact, hundreds of noble gas compounds have been created since the first one was discovered in the early 1960s by Neil Bartlett at the University of British Columbia in Vancouver. There is a feature on Bartlett's work in the student textbook on page 65. The discovery of a compound containing xenon reinforces the idea of chemical families because similar kinds of compounds have been found with other noble gases.

ADVANCE PREPARATION

- It will be useful for students to have their own copy of the periodic table. BLM 1-19, The Modern Periodic Table, is a copy of the periodic table from page 50 of the student textbook.

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

INTRODUCING THE SECTION, pp. 48–49

Using the Text

Read through the text on page 48 with students. The state of affairs in chemistry in the 19th century was such that, given the regular discovery of new elements, there seemed to be a bewildering array of fundamental building blocks of nature. One common analogy about the understanding of elements at this time was that matter seemed to be like a big jigsaw puzzle and the elements were the pieces. The problem was that there was no overall picture of the puzzle available to show how things should go together. Even worse, some pieces of the puzzle were missing (undiscovered elements) and others were not in the correct form (water was thought to be an element). It all seemed to be a confusing mess, and many people were working on how to sort things out.

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. 48

Harriet Brooks did not discover radon. In fact, radon had been discovered a few years earlier, but Harriet detected it in a new place—among the radioactive products of the elements radium and thorium. This discovery was evidence of transmutation (one element turning into another). Harriet Brooks was one of Canada's first nuclear physicists. She studied at McGill University in Montréal and was Ernest Rutherford's first graduate student. For a short time, she worked under the supervision of Marie Curie.

Using the Activity

Think About It Activity 2-2A

Understanding the Periodic Table, p. 49

Purpose

- Students relate information found in the periodic table—such as element name, symbol, and atomic number—to other information about elements—such as mass number, number of protons, number of neutrons, and number of electrons.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	No advance preparation necessary	None

Time Required

- 15 min

Science Background

Understanding the periodic table requires students to draw on their knowledge of atomic theory from section 1.3. They will need to think about subatomic particles and how these particles are related to each other. The number of electrons is always equal to the number of protons in an atom. Therefore, if a student knows the atomic number of an atom, he or she automatically knows two pieces of information: the number of protons and the number of electrons. The number of neutrons must be calculated by subtracting the atomic number from the mass number.

The atomic mass given in the periodic table is a weighted average based on the mass and relative abundance of each isotope of an element. By using the atomic mass to approximate the mass number for this activity, students will be estimating the number of neutrons in the most common isotope of an element.

Activity Notes

- Students can easily find the element name, symbol, and atomic number on the periodic table on page 50 of the student textbook. This information can be used to derive the missing information in the table in What to Do step 1. Students will need to use the equation *number of neutrons = mass number – atomic number* to calculate missing information about elements.

Supporting Diverse Student Needs

- Encourage students to perform the calculations in this activity without a calculator. Doing the calculations in their head or on a piece of paper will strengthen their number-sense skills. Provide calculators for students who struggle with math.

What to Do Answers

1, 2. Answers are shown in bold.

ELEMENT NAME	SYMBOL	ATOMIC NUMBER	MASS NUMBER	# PROTONS	# NEUTRONS	# ELECTRONS
potassium	K	19	39	**19**	**20**	**19**
argon	**Ar**	18	**40**	**18**	22	**18**
radium	Ra	**88**	226	**88**	**138**	**88**
silver	**Ag**	**47**	**108**	**47**	61	47
mercury	**Hg**	**80**	201	80	**121**	**80**
hydrogen	**H**	**1**	1	**1**	**0**	**1**

TEACHING THE SECTION, pp. 49–53

Using Reading

Pre-reading—Predict-Read-Verify

Have students preview the text features to predict what they might learn about in each section. Break up the section into manageable chunks for students. Some suggested chunks are:

- The Periodic Table
- Metals, Non-metals, and Metalloids
- Periods and Families
- Transition Metals

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

- Visual-spatial learners may wish to organize their notes in a graphic organizer such as a concept map, or a blank sketch of the periodic table.
- To help ensure that students have understood the information about various groups of elements, and to provide practice scanning text for information, have pairs of students quiz each other, using riddle-like questions. For example, “I am a non-metal that is highly reactive. What group am I in?” Students can look for the answer in the textbook.

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 a class discussion.

Reading Check Answers, p. 53

1. Atomic number, atomic mass
2. (a) 14
   (b) 24
   (c) 53
3. From lightest to heaviest: carbon (12.0), calcium (40.1), nickel (58.7), cobalt (58.9), zinc (55.4)
4. Hydrogen is a non-metal, yet it appears on the left side of the periodic table where metals are normally found.
5. (a) Metals are located on the left side.
   (b) Non-metals are located on the right side.
   (c) Metalloids form a diagonal line toward the right side, between the metals and non-metals.

USING THE ACTIVITIES

- Think About It Activity 2-2A, on page 49 of the student textbook, is best used as an introductory activity. Detailed information about this activity can be found in Introducing the Section.
- Activity 2-2B, on page 54 of the student textbook, may be used any time during this section. For a

greater challenge, do this activity before reading about or discussing chemical families. Detailed notes on doing the activity follow.

Think About It Activity 2-2B

The Modern Periodic Table, pp. 54–55

Purpose

- Students use a simplified periodic table to discover the patterns of properties of elements.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	Photocopy BLM 1-21, Simplified Periodic Table. Optional: Photocopy BLM 1-19, The Modern Periodic Table; and BLM 1-20, Groups in the Periodic Table.	For each group/student: BLM 1-21, Simplified Periodic Table

Time Required

- 30 min

Science Background

This activity is intended to help students become familiar with the location of some chemical families and elements in the periodic table and to help them understand the arrangement of elements within it. The central organizing feature, as always, is that elements with similar chemical properties tend to appear in the same column of the table.

Activity Notes

- Distribute BLM 1-21, Simplified Periodic Table, for students to use in recording their information.
- Review students' responses at the end of the activity, placing emphasis on the usefulness of the periodic table as it is currently arranged.
- You may also wish to distribute BLM 1-20, Groups in the Periodic Table, or use it as an overhead.

Supporting Diverse Student Needs

- English language learners and struggling readers may find this activity very "text heavy." You may wish to photocopy the activity for these students and have students read through, underlining science words that they feel comfortable with and putting a box around vocabulary words that they are not sure of. They can then review these words with you or a fellow student.
- This activity is well suited to logical-mathematical problem solving. As much as possible, ensure that each group includes students with skills in these areas.
- For enrichment, have students take a new copy of whatever periodic table they have been given to put in their notebooks (such as BLM 1-19, The Modern Periodic Table), but this time have them cut it out and paste it together again with the lanthanide and actinide series elements pasted into periods 6 and 7. Ask, "How many elements are in period 6?" (32) "How many are *predicted* to be in period 7?" (32)

What to Do Answers

3. (a) Silicon (Si)—it is below carbon (C).
   (b) Phosphorous (P)—it is to the right of silicon (Si).
   (c) Sodium (Na)—it is below beryllium (Be).
4. (a) Barium (Ba)
   (b) Barium would have more protons, and atomic mass almost always increases with the number of protons.
5. (a) Ga (gallium), In (indium), Tl (thallium), and possibly B (boron) although it is a metalloid
   (b) Li (lithium), Na (sodium), Rb (rubidium), Cs (cesium), but not hydrogen as it is a non-metal
   (c) Sn (tin) and possibly Ge (germanium) and Si (silicon) although they are metalloids, and possibly also C (carbon) although it is a non-metal. Different groupings are possible. For example, all five elements form ionic compounds with sodium, one of the few times carbon forms an ionic compound.
6. (a) Copper, silver, and gold are in the same group (vertical column), often called the coinage metals because of their use in coins.
   (b) There is good reason to expect they would be in the same group because of their use in similar functions such as jewellery making, coinage, and as conductors.
   (c) These elements are transition metals. They have a complex arrangement of electrons that differs from that of the metals in group 1 or 2. Students might also note that they are less reactive than the metals in group 1 or 2.
7. In the periodic table, elements with similar properties line up in columns. This arrangement does not happen in the grid diagram on page 54.

USING THE FEATURE

www Science: Peculiar Periodic Tables, p. 58

This feature is an excellent exercise in "thinking outside the box" or, more specifically, changing the shape of the box. Besides its rather futuristic look, this periodic table shows that reading from left to right and top to bottom is not at the core of finding patterns among the elements.

SECTION 2.2 ASSESSMENT, p. 59

Check Your Understanding Answers

Checking Concepts

1. The periodic table organizes the elements according to their physical and chemical properties.
2. Atomic number = number of protons in each atom of the element
3. Atomic number
4. (a) 2
   (b) 8
   (c) 26
   (d) 79
   (e) 92
   (f) 101
5. An atom of potassium
6. Atomic mass is the average mass of the atoms of an element.
7. Atomic mass units
8. Atomic mass generally increases from left to right and from top to bottom through the table.
9. (a) 6.9 amu
   (b) 28.1 amu
   (c) 55.8 amu
   (d) 63.5 amu
   (e) 200.6 amu
10. Lead
11. The element is phosphorus. It has 15 electrons and 16 neutrons.
12. The mass number is 85. It has 37 electrons.
13. Atomic number is the number of protons in the nucleus, and it is always a whole number. Atomic mass is the average mass of an atom of an element. It includes the mass of protons and neutrons in the nucleus, and it is written as a decimal number.
14. Hydrogen is unique because it reacts like a metal in some situations, and like a non-metal in others.
15. Like other metals, transition metals conduct heat and electricity, and they are malleable and ductile.
16. Alkali metals are very reactive, so they are almost always found in compounds with other elements.
17. Metals, non-metals, and metalloids
18. (a) Alkali metals, alkaline earth metals, halogens, and noble gases
    (b) Alkali metals and alkaline earth metals
    (c) Halogens and noble gases
19. Any five of boron, silicon, germanium, arsenic, antimony, tellurium, polonium, and astatine
20. Periods
21. Families or groups

Understanding Key Ideas

22. Alkali metals
23. Alkaline earth metals
24. Halogens
25. Chemically unreactive (usually), gases, colourless and odourless at room temperature
26. Mass number is the number of protons and neutrons in the nucleus of an atom, and it is always a whole number. Atomic mass is the average mass of an atom, and it is a decimal number.

Pause and Reflect Answer

Francium is predicted to be silver coloured and very soft, with a low melting point, possibly lower even than room temperature, making it a liquid. It should react vigorously with air and water.

Other Assessment Opportunities

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

2.3 THE PERIODIC TABLE AND ATOMIC THEORY

BACKGROUND INFORMATION

This section connects a very simplified Bohr-Rutherford model of electron arrangements in the atom to the properties of elements in the periodic table.

Ernest Rutherford was awarded the Nobel Prize in chemistry in 1908 "for his investigations into the disintegration of the elements, and the chemistry of radioactive substances." He also contributed to atomic theory, as outlined in section 1.3 of the student textbook. Niels Bohr won the Nobel Prize for physics in 1922. The Nobel committee said this was "for his services in the investigation of the structure of atoms and of the radiation emanating from them." Today, we reap the benefits of these scientists' work, and it is especially influential in understanding the arrangement of elements in the periodic table.

The patterns in electron arrangement and physical/chemical properties are closely associated with the number of electrons in the highest occupied energy level (valence shell) and whether that energy level is full. Elements in the same family have the same number of valence electrons, with metals typically having one, two, or three electrons, and non-metals having more than this. When a valence shell is or becomes full, the atom (neutral) or ion (charged) becomes stable. Noble gas atoms have filled valence shells and are so stable that they are virtually unreactive. The atoms of metals tend to lose their few valence electrons and become positive ions. Non-metal atoms tend to fill their valence shell and become negative ions. Bohr-Rutherford diagrams are used to show the arrangements of electrons in atoms and ions.

The Bohr-Rutherford model does not do a very good job of indicating the number of valence electrons in metal atoms beyond calcium (atomic number 20). Accordingly, the Grade 9 curriculum requires students to draw Bohr-Rutherford diagrams for only the first 18 elements. At this point, it may be best just to say that all noble gases below helium have eight valence electrons and all halogens have seven valence electrons. For example, although iodine has 53 electrons, another atom bumping into it would detect only the outer seven.

COMMON MISCONCEPTIONS

- Although popular literature tends to portray the Bohr-Rutherford model as a planetary model, Bohr himself moved on from this early version of his model because it simply did not work. In his Nobel lecture, he stated, "As soon as we try to trace a more intimate connexion between the properties of the elements and atomic structure, we encounter profound difficulties, in that essential differences between an atom and a planetary system show themselves…" The student textbook incorporates Bohr's difficulty with his own planetary model by making no reference to a planetary model or movement of electrons inside an atom. The planetary model is such a powerful (and incorrect) visual analogy that some students latch onto it and will not let it go. This can interfere with later learning. Therefore, students should refrain from drawing concentric circles around the nucleus in their models. It is recommended that statements about electron motion within an atom, other than electrons changing from one energy level to another, be completely omitted. This method is consistent with the theory of quantum mechanics. Even the question of where an electron is during its transition from one energy level to another, which seems a reasonable question on the surface, does not make sense in the theory of quantum mechanics. An electron is in one energy state or another, never in-between.
- Noble gases are stable because they have filled energy levels. While this statement is true, it certainly does not answer the main question of why filled energy levels make an atom stable. It may be better to say that experiments show that atoms or ions with filled energy levels are stable. The connection between filled energy levels and stability is explored in later science courses.
- The electrons are not arranged around the nucleus of an atom in concentric spheres, as suggested by some Bohr-Rutherford diagrams. The question of the position of the electrons is not well handled in this model. What the diagram does well is indicate the number of electrons of approximately the same energy level (2, 8, 8, 18), as well as the number of valence electrons (for elements with atomic numbers 1 to 20).

ADVANCE PREPARATION

- Prepare solutions and get diffraction-grating glasses (optional) for Activity 2-3B, on page 64 of the student textbook.

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

INTRODUCING THE SECTION, pp. 60–61

Using the Text

Read the text on page 60 and then show a few examples of Bohr-Rutherford diagrams. Have students try their own diagrams up to calcium (atomic number 20). One interesting note about the photograph of Niels Bohr is how young he was when he made his most important discoveries. This has been a bit of a trend among physicists. Einstein was only 25 years old when he proposed relativity theory.

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. 61

In the 1950s, Glenn Seaborg fired heavy atoms together to synthesize six new elements, discovering more than any other individual. Plutonium, used in both nuclear weapons and the production of nuclear energy in some kinds of reactors, was first synthesized by Seaborg. Later, element 106, seaborgium, was named in his honour. New elements are still being synthesized.

Using the Activity

Think About It Activity 2-3A

Looking for Patterns in Atoms, p. 61

Purpose

- Students draw a Bohr-Rutherford model for an atom and then compare the electron arrangements among a variety of atoms.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Photocopy BLM 1-22, Bohr-Rutherford Diagram Template; BLM 1-23, Looking for Patterns in Atoms; and BLM 1-26, Electron Arrangements in the First 20 Elements.	For each student/ group: – coloured pencils or felt pens – Optional: BLM 1-22, Bohr-Rutherford Diagram Template; BLM 1-23, Looking for Patterns in Atoms; and BLM 1-26, Electron Arrangements in the First 20 Elements

Time Required

- 15 min

Science Background

Students are asked to draw Bohr-Rutherford models for atoms. The arrangement of electrons in each atom is shown on BLM 1-26, Electron Arrangements in the First 20 Elements, but it is best to hand out this blackline master only after students have completed the activity. If BLM 1-23, Looking for Patterns in Atoms, is used, or if regular-sized diagrams are made, then posting all the diagrams on the wall in the same arrangement as the periodic table will show that elements in the same family have the same number of electrons, while elements in the same period have valence electrons in the same energy level.

Activity Notes

- You may wish to have students use BLM 1-23, Looking for Patterns in Atoms.
- If the highlighting of the valence shell and of the valence electrons can be done in a consistent way, then the patterns in the electron structure will emerge with greater impact.

Supporting Diverse Student Needs

- Students who have difficulty drawing small diagrams can draw their Bohr-Rutherford models on BLM 1-22, Bohr-Rutherford Diagram Template.
- Encourage struggling readers to describe their observations to you.
- This is a good activity for body-kinesthetic and visual-spatial learners. You may want to assign these students the task of collecting the sketches from the class and arranging them on the wall.

What Did You Find Out? Answers

1. Moving down a family, each new element has the same number of valence electrons but in the next higher energy level.
2. Elements in the same period have their valence electrons in the same energy level. When moving left to right across a period, each new element has one more electron than the previous element.

TEACHING THE SECTION, pp. 61–63

Using Reading

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

Ask students to record their answers to the question "What do we know about the arrangement of electrons in atoms?" Then ask them to review their answer and record questions they have about atoms. Later, students can share their questions as a class and discuss the answers together.

During Reading—GIST

As students read the paragraphs of this section, have them write short summaries after they read about Valence Electrons and Chemical Families, Noble Gas Stability, and How Elements React.

The term "valence shell" is used intermittently throughout the section so that students become accustomed to it. However, it is not a Key Term and students are not required to memorize it. The key point for students to understand is that electrons in the outermost electron shell determine the properties of an element.

Supporting Diverse Student Needs

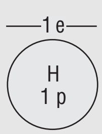
- Ask students who have difficulty summarizing text to work in a small group and create their summaries as write-arounds. One student writes one key idea from the text, and then another student adds one more, until the summary is complete. Students can each choose one point from their summary to share with the class, giving every student an opportunity to make a meaningful contribution. These group summaries can also be used as starting points for the reflection in After Reading.

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. You may wish to distribute any or all of BLM 1-24, Bohr-Rutherford Diagrams; BLM 1-25, Bohr-Rutherford Diagrams of the First 18 Elements; and/or BLM 1-26, Electron Arrangements in the First 20 Elements.

Reading Check Answers, p. 63

1. 2, 8, 8
2. (a)



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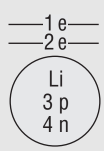

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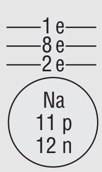

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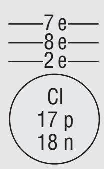


3. (a) 1
   (b) 2
   (c) 7
   (d) 8
4. The number of electrons in the outermost electron shell influences reactivity. Atoms with a full outer shell are virtually unreactive, while atoms with one or seven electrons in the outer shell are extremely reactive.

Using the Activity

- Activity 2-3B, on page 64 of the student textbook, may be done at any time that is convenient. Detailed notes on doing the activity follow.

Conduct an Investigation 2-3B

Flaming Metal Ions, p. 64

Purpose

- Students heat several compounds in the flame of a Bunsen burner and take note as the flame takes on a colour characteristic of the metal ion in the compound.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2 days before	Make the chemical solutions and ensure all equipment is ready.	For each group: – felt pen – 9 small test tubes – test tube rack – wooden splints that have been soaked in a selection of solutions containing metal ions – Bunsen burner – diffraction-grating glasses (optional)

Time Required

- 30 min

Safety Precautions

- Ensure that students wear safety eyewear and protective clothing.
- Ensure that students handle chemicals safely.
- This activity uses open flames. Remind students to be careful. Caution students to make their observations quickly so that the wooden splints do not have time to catch fire.
- Have students tie back long hair.
- Make sure that students wash their hands thoroughly after this investigation.

Science Background

Every element glows a characteristic colour when heated sufficiently. In modern analytical methods, a diffraction grating is used to generate a spectrum that is unique to every element. This is precisely how sensitive tests for tiny concentrations of metals (such as mercury in fish) are done. The two main types of analysis are called atomic emission spectroscopy and atomic absorption spectroscopy. Both methods are used in chemical analysis. However, simply heating a solution containing the salt of a metal ion in a hot flame will often do the trick. The elements in this investigation have been selected because they have easily distinguishable colours.

The wooden splints will soak up the solution including the metal ion. The fact that the wood has been soaking in solution means that the metal ion has a chance to heat up in the flame before the wood catches fire.

The colours really need to be seen to be appreciated, but the following list records the approximate colours of the expected results:

METAL	COLOUR
Na	Bright orange
Ca	Yellow/red
K	Lilac/purple
Li	Scarlet
Ba	Yellow
Sr	Red
Cu	Blue/green

Activity Notes

- Keep in mind that people see colours differently, and that 8 percent of the male population is red-green colour-blind.
- Wooden splints used as stir sticks for coffee tend to be economical, as well as quite long, which is good.
- Soak the wooden splints for at least 20 min—overnight is fine.
- Make the soaking solution about two fingers deep so that a sufficient portion of the wooden splint gets wet. This will help prevent the splint from burning too easily.
- Darken the room as much as is practical.
- The use of diffraction-grating glasses is an interesting addition to the activity, as it will separate the light produced by the flame test into a specific pattern of coloured lines.
- Have extra wooden splints prepared so that students can repeat the tests.
- The unknowns can be any of the metal ions tested, but the copper solution will be blue-green, revealing its identity. Li and K work well.

Preparation/Disposal of Reagents

- Consider making up 1 L of each solution to have on hand. All solutions are 0.1 M.
- Metal chlorides may be used as well.

REAGENT	FORMULA	G/L TO MAKE 0.1 M
potassium nitrate	KNO_3	10.1 g/L
sodium nitrate	$NaNO_3$	8.5 g/L
calcium nitrate tetrahydrate	$Ca(NO_3)_2 \cdot 4H_2O$	24 g/L
lithium nitrate	$LiNO_3$	7.0 g/L
barium nitrate	$Ba(NO_3)_2$	26.1 g/L
strontium nitrate	$Sr(NO_3)_2$	21.2 g/L
copper(II) nitrate trihydrate	$Cu(NO_3)_2 \cdot 3H_2O$	24.2 g/L

- Copper, barium, and strontium solutions should not go down the sink. Add sodium carbonate to their waste solutions to precipitate the metals, and then filter, putting the liquid down the sink. The solid metals that have been collected should be disposed of as hazardous waste. Refer to the MSDS for each of the carbonates.

Supporting Diverse Student Needs

- This is a good hands-on activity for body-kinesthetic and visual-spatial learners. Students will also need to use logical-mathematical skills to systematically test and identify each solution.
- For enrichment, have students pour out their own solutions into test tubes and put three wooden splits in each test tube to soak. Soak for at least 20 min—overnight is fine.

Analyze Answers

1. Each metal ion has its own distinctive colour, so the colour of the unknown solution can be compared to that of the known samples.
2. Accept all logical answers, keeping in mind that different people see colours differently, not only red/green (strontium and copper) but other shades as well. Calcium and sodium may be hard to distinguish as well as lithium and strontium. However, these colours are not identical and it is possible to see the differences.
3. Diffraction-grating glasses will produce a spectrum that will differ even between elements that are a similar colour. The pattern of the diffraction will be like a fingerprint for the colour of each element.

Conclude and Apply Answer

1. The unknown metal ions matched two of the colours found among the group of metal ions tested.

USING THE FEATURES

Science Watch: Compounds of the Noble Gases, p. 65

Noble gas compounds have a Canadian connection because the first one, $XeFPtF_6$, was made at the University of British Columbia in 1962 by Neil Bartlett. The actual chemical formula of the compound can be written several different ways because the mixture that Bartlett produced actually contained several forms of Xe compounds. One point not mentioned in the feature was that Bartlett did not just stumble upon the new compound. Based on information that was freely available to chemists at the time, Bartlett predicted that Xe should be able to react with fluorine under the right conditions (even though the current theory of bonding strictly forbade such an occurrence). The day he made the compound, he had purposely set out to see if it could be done. Later, after his success, bonding theory was altered to accommodate the new results. And of course, every chemistry book in the world had to be updated.

Science Watch Answers

1. Noble gases had filled valence shells, leading to the belief that it was not possible for them to form compounds.
2. Bartlett first made a compound with xenon. Radon and argon compounds were produced shortly after that.
3. Noble gas compounds have been used in lasers and as anti-tumour agents.

www Science: Helium—More Than Just Balloons, p. 66

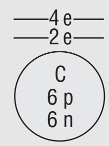
This feature provides an excellent addition to the tour of elements in section 2.1. Students may have thought that helium is used mainly for party balloons and blimps. However, helium is a valuable resource that comes from deep inside Earth along with natural gas. Its use in MRI machines, welding, and nuclear reactors makes it a very valuable commodity.

SECTION 2.3 ASSESSMENT, p. 67

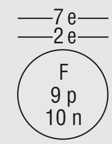
Check Your Understanding Answers

Checking Concepts

1. Boron (B)
2. (a)



(b)



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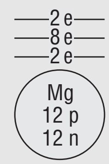

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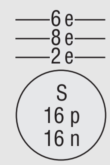
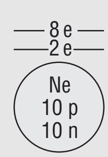


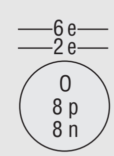
3. (a) An electron shell is a region surrounding the nucleus of an atom that can contain electrons.
   (b) 2, 8, 8
4. 2, 8, 8
5. (a) Any one of: hydrogen, lithium, sodium, potassium, rubidium, cesium, or francium
   (b) Any one of: nitrogen, phosphorus, arsenic, antimony, bismuth
   (c) Any one of: fluorine, chlorine, bromine, iodine, astatine
6. Neon
7. Helium
8. All alkaline earth metals have two electrons in their outermost electron shells.
9. The third electron shell fills up one electron at a time from one at sodium to eight at argon.

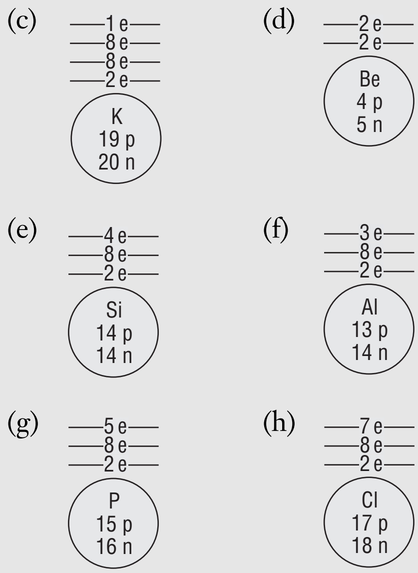
Understanding Key Ideas

10. Sodium and lithium both have one electron in their outermost electron shell, while calcium has two electrons in its outer shell. The number of electrons in the outer shell affects the chemical and physical properties of an atom.
11. Noble gases have filled valence energy levels.
12. (a) Metal atoms lose their valence electrons, revealing a filled electron shell below it.
    (b) Non-metal atoms gain electrons until their valence electron shell is filled.
13. (a)



(b)





14. (a) Argon
    (b) 39.9 amu
    (c) Non-metal; it is a noble gas.

Pause and Reflect Answer

Hydrogen can behave like a metal by losing one electron, or it can behave like a non-metal by gaining one electron to attain a full outer electron shell. This unique ability allows hydrogen to react either as a metal or a non-metal.

Other Assessment Opportunities

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

CHAPTER 2 ASSESSMENT, pp. 68–69

PREPARE YOUR OWN SUMMARY

Students' summaries should incorporate the following main ideas:

1. Characteristics of Some Common Elements
   - Metals such as iron, sodium, and silver are shiny, silver/grey coloured, malleable, ductile, and conductive.
   - Non-metals such as hydrogen, oxygen, and chlorine are gases. However, they differ markedly in their reactivity.
   - Metalloids, such as silicon, have properties resembling both metals and non-metals.
2. Information Given in the Periodic Table
   - Each element has its own unique name and symbol.
   - The atomic number indicates how many protons are in an atom of the element.
   - The atomic mass gives the mass in atomic mass units (amu) of an average atom of that element.

   The number of neutrons in an atom's nucleus can be calculated by subtracting the atomic number from the mass number. (The mass number is the number of protons and neutrons in an atom—or the mass of a particular isotope of an atom, rounded to a whole number.)
3. Chemical Families
   - Chemical families are groups of elements with similar properties.
   - Chemical families are found in vertical columns in the periodic table.
   - Four families are the alkali metals (group 1), the alkaline earth metals (group 2), the halogens (group 17), and the noble gases (group 18).
4. Bohr-Rutherford Diagrams
   - Bohr-Rutherford diagrams show the number and arrangement of electrons in an atom or ion.
   - Electron arrangements are in the pattern 2, 8, 8 for the first 18 elements.
5. How Outer Electrons Relate to Chemical Families
   - Elements in the same chemical family have the same number of valence electrons.
   - Noble gases have filled valence energy levels, making them chemically inert.
   - Metals lose valence electrons until their ion forms with a filled outside energy level.
   - Non-metals gain electrons until their ion forms with a filled valence energy level.

CHAPTER REVIEW ANSWERS

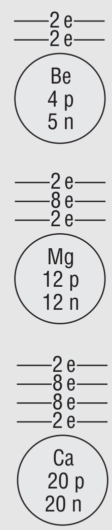
Checking Concepts

1. An element is a pure substance made of only one kind of atom. Specifically, all the atoms of the element have the same number of protons.
2. Accept all logical answers. For example, pennies contain copper and zinc, and ice cubes contain hydrogen and oxygen.
3. (a) Nickel
   (b) Sodium
   (c) Potassium
   (d) Copper
4. (a) Zn
   (b) W
   (c) Fe
   (d) Mg
   (e) Ca
5. Mercury and bromine
6. Shiny, silver coloured, malleable, ductile, conduct electricity, conduct heat (any four)

7. (a) Carbon, other metals
   (b) Steel
8. Mercury is liquid at room temperature and is not as good a conductor as silver. Students might also mention that mercury is highly toxic, and silver is not.
9. Periodic table
10. Atomic mass measures the average mass of an atom of the element.
11. Number of protons = atomic number
12. Number of neutrons = mass number – atomic number
13. A chemical family is a group of elements that have similar chemical and physical properties. They occur in columns of the periodic table.
14. Alkali metals, alkaline earth metals, halogens, noble gases
15. Alkaline earth metals are less reactive than alkali metals.
16. They are typically unreactive.
17. A Bohr-Rutherford diagram represents the arrangement of electrons in an atom.
18. (a) The periodic table organizes the elements into periods (rows) and groups (columns) according to chemical and physical properties.
    (b) An energy level is a region surrounding the nucleus of an atom. It may contain electrons.
19. (a) 1
    (b) 3
    (c) 6
    (d) 8
20. (a) Noble gases
    (b) Their filled valence shells make the atoms of the noble gases virtually unreactive.

Understanding Key Ideas

21. A physical property is an observation that can be made of a substance without altering the substance's identity in the process. A chemical property is an observation that can be made only by reacting one substance with another.
22. Atomic numbers increase from left to right and from top to bottom through the periodic table.
23. (a) 51
    (b) 33
    (c) 25
    (d) 34
24. Hydrogen (1.0 amu)
    Oxygen (16.0 amu)
    Nitrogen (14.0 amu)
    Rhenium (186.2 amu)
    (a) Rhenium
    (b) Hydrogen
25. (a) Nickel, niobium, iridium
    (b) Iridium
    (c) Germanium
    (d) Nickel, germanium
    (e) Nickel
26. (a) Americium
    (b) Iron, ruthenium
27. H has the same number of valence electrons as Li, Na, and K.
28.



29. (a) Aluminum
    (b) Silicon
    (c) Fluorine
    (d) Neon

Pause and Reflect Answer

Accept all logical answers. For example, the periodic table helps not only by summarizing facts conveniently but also by showing patterns and trends in physical and chemical properties.