UNIT 1 OPENER, pp. 2–3

This unit-opening photograph features a tiny work of art called the "Stadium Corral". The photograph was made using a scanning tunnelling microscope (STM), which is not an optical microscope. The STM is an electrical probe with a point consisting of only a single atom, which is made to move with atomic scale precision over the surface of an object. The probe detects an electric current that is made to flow between the probe tip and the surface. After its invention by Gerd Binnig and Heinrich Rohrer of IBM in 1981 (for which they received the Nobel Prize in physics in 1986), it was discovered that the STM could be used to pick up individual atoms and move them around. A photograph of these scientists is on page 30 of the student textbook. The "Stadium Corral" photograph, therefore, represents many things: that art and creativity can go hand-in-hand with science, that nanotechnology has begun to move from science fiction into science reality, that human ingenuity seems boundless, that the theory of quantum mechanics is the best description of the atomic world that we have (the electric currents that flow between the surface and the probe depend on an effect called quantum tunnelling), and, for the Grade 9 student, that the material world is built out of atoms.

USING THE UNIT OPENER

The caption indicates that "Stadium Corral" is about 1 billionth of a metre across. Ask students "How big is this? For example, if the corral was expanded until it was the size of a pea, and if a pea was expanded by the same amount, how big would the pea be?" (about the size of Earth) You might wish to explain how such an image is created and how single atoms are moved around. Challenge students to find other images like this. They can start their search at www.discoveringscience.ca.

Extension: You may wish to let students know that the ripples in the middle of the corral floor represent electrons that are behaving as stationary waves. A very interesting feature about this is that the position of these waves can be predicted using a model called quantum mechanics that was developed 80 years ago. Certain equations can be solved that predict the high and low points of these waves. Why does this matter? The same theory predicted the existence of lasers, holograms, superconductivity, and the workings of microcircuits on computer chips. How a cellphone or computer works today will likely be different from how it will work in 10 years. But the foundation on which today's cellphones and computers are based, and the foundation on which the cellphones and computers in 10 years will be based, will be the same: quantum mechanics.

You may want to hand out BLM 1-1, Unit 1 Summary, and BLM 1-2, Unit 1 Key Terms, to help students record their understanding of the unit and important terms.

GETTING STARTED, pp. 4–5

USING THE TEXT

The beginning of this unit picks up on a major focus of the Grade 8 science curriculum, which is water. Not only do we drink it and play in it, a lot of chemistry (including the chemistry of life) occurs in it. Read through the Getting Started text with students. This information can lead to questions such as, "Are we using water responsibly?" "What happens to toxic chemicals that may be flushed down the sink instead of being put into a waste container for disposal?" Even when water is used responsibly, it may still need treatment. Creative, knowledgeable chemists can help find solutions for providing clean water for the world's population.

USING THE ACTIVITY

Find Out Activity

Combining Chemicals, p. 5

Purpose

- Students investigate the changes that occur when various chemicals are combined in a beaker.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Gather chemicals and equipment.	For each group: – 400 mL beaker – 50 mL water – 150 mL vinegar – 5 raisins – 25 g baking soda

Time Required

- 20 min

Safety Precautions

- Remind students not to eat or drink anything in the science room.

Science Background

This variation of baking soda and vinegar reactions is sometimes called "Dancing Raisins." The reaction is

$$CH_3COOH(aq) + NaHCO_3(aq) \rightarrow NaCH_3COO(aq) + H_2O(\ell) + CO_2(g)$$

The gas bubbles gather on the wrinkled sides of the raisins, clinging on and giving the raisins increased buoyancy. The raisins float to the surface where they lose the gas bubbles, and then sink. The raisins move up and down while the reaction is happening. Although the process may be simple, the explanation of what is going on may be quite difficult, especially since students will not know in advance whether the raisins are part of the chemical reaction or not.

Activity Notes

- Wrap up the activity by focussing on some skills in the course, such as safety ("What precautions would we need to take if these chemicals were toxic or corrosive?") or recording observations ("How can we record observations so that they are meaningful?").

Supporting Diverse Student Needs

- You may wish to partner students who have difficulty following written instructions with students who have strong language skills.
- As enrichment, try to find other objects that exhibit "dancing" behaviour. Any object that is slightly denser than water and has a rough surface should work. Try pieces of uncooked pasta (e.g., shells, penne). Alternatively, try using freshly opened carbonated water. You should get the same effect.

What Did You Find Out? Answers

1. Vinegar and water are clear, colourless liquids that do not change in appearance when combined, and are not affected by adding raisins to them. Adding baking soda causes bubbles to form in the liquid, particularly on the raisins, which begin to rise and sink.
2. The solid baking soda dissolved into the vinegar and water.
3. Adding baking soda caused the raisins to rise and fall as they built up and then released bubbles of gas on their surfaces.

CHAPTER 1 OPENER, pp. 6–7

USING THE PHOTO AND TEXT

The photograph of the fluorescent light sign with a stylized image of the Mona Lisa gives an opportunity to talk with students about the composition and the behaviour of matter. In this chapter, matter is represented as anything that has mass and volume and as atoms, which are made up of subatomic particles (beginning with Dalton's theory and following through to Bohr, which is new for students this year).

You might wish to discuss any of the following questions with students:

- Why do the gases glow? (The atoms absorb electrical energy and then release that energy in the visible spectrum.)
- Why do some gases glow one colour, while other gases glow a different colour? (There are different kinds of atoms in each gas.)
- How can atomic theory help to explain the behaviour of these materials? (Understanding the composition of atoms helps to explain how an atom can absorb or release energy.)
- The ability of certain gases to glow is just one example of properties of matter. The oil paints used by 16th century painters had physical properties that were of value in their paintings. Ask, "What were some of these properties?" (colour, lustre, ability to spread, slow drying time)
- How can atomic theory help explain the composition and behaviour of paints? (Differences between the atoms of various paints give rise to different properties. Atomic theory helps us understand these differences so that we can design new materials, such as brighter, more vibrant colours.)

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

Review the What You Will Learn points with students. You may want students to brainstorm answers to the following questions:

- What is matter?
- What are the three states of matter?
- How do particles of matter behave in each of the three states?
- What are some examples of physical properties?
- What is an atom?
- What is an atom made of?

The answers can help you determine students' prior knowledge of matter.

USING THE FOLDABLES™ FEATURE

See the Foldables section of this resource.

1.1 SAFETY IN THE SCIENCE CLASSROOM

BACKGROUND INFORMATION

A culture of safety is one in which rules that govern safe practice are learned and combined with an awareness of what is going on during a lab activity. It also includes knowing what to do should an accident or emergency occur. You can promote safe practice by strong emphasis on safety at the beginning of the course and consistent modelling and enforcement of safe practice throughout the entire course. Each new lab activity is an opportunity to practise working safely and a chance for a slightly different safety focus. Learning to look for, read, and understand hazard symbols is a real-world connection that every student needs to develop.

You can make your safety rules specific to your class. For example, how do you want students to react in your class to a chemical splash, a fire, or spilled acid? Where is the emergency equipment, and when and how should it be used? How can the alarm system be activated, and what are the escape routes?

COMMON MISCONCEPTIONS

- Some students may think that safety eyewear is optional, especially if prescription eyewear is worn, or if safety eyewear gives the student a headache. Safety eyewear has been made to fit over eyeglasses and contains splash shields that protect the eyes from liquids being splashed in from the side. If a student is not able to wear safety eyewear due to headaches or other reasons, that student should sit out of the activity.
- Some students may think that it is all right to engage in horseplay if nobody minds. It is never acceptable to engage in horseplay in the science room because such behaviour can lead to unexpected outcomes that can cause serious injury. For example, squirting someone with a water bottle may be based on the assumption that the liquid is water, which could easily be an incorrect assumption. Such behaviour also contributes to general chaos, which could lead to an injury.
- Students may feel that it is acceptable to take a shortcut involving an unsafe action in order to complete a lab on time or in a certain way. They may justify their actions by thinking that "the chance of an accident is low." This kind of thinking can lead to serious injury. Students should not put goals related to the day's lesson ahead of safety outcomes. Remind students of Murphy's law (a law attributed to an American engineer): If anything can go wrong, it will. To prevent an accident from eventually happening, the *opportunity* for it to happen must be eliminated.

ADVANCE PREPARATION

- Have a clear understanding of the location and operation of all safety equipment, as well as knowledge of safety and emergency procedures that relate to your specific classroom.
- Bring in some household items that have safety hazard labels on them, such as a bottle of spray paint and a container of household cleaner.

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

INTRODUCING THE SECTION, pp. 8–9

Using the Text

Have students read the text on pages 8 and 9. Ask them what they need to think of before and during a lab activity, as well as what needs to happen in an emergency. Have them consider whether any activity in a science room could be more important than safeguarding their eyesight, or more important than their own safety and that of their classmates.

Before turning to page 10 to look at the safety rules, have students brainstorm ideas about what the most important safety rules are.

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. 9

Ask students if they are surprised to learn that accident rates are high for new and young employees. The most common type of injury for young workers in Newfoundland and Labrador is overexertion from incorrectly lifting heavy objects. In 2005, this injury accounted for 22 percent of workplace accidents for people aged 15 to 24. Students should keep in mind that safe practice is important and failure to follow it can cause injuries.

More information can be found at www.discoveringscience.ca.

Using the Activity

Think About It Activity 1-1A

Science Lab Safety, p. 9

Purpose

- Students identify safe and unsafe behaviour in a laboratory setting.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	Have a clear policy regarding the place of backpacks, electronic devices, and suitable attire in your lab setting.	None

Time Required

- 15 min

Science Background

This activity is intended as a launch point for students to identify unsafe or inappropriate behaviours, to visualize the negative consequences that might follow from those behaviours, and to create a set of rules about safe and acceptable conduct during lab activities.

Activity Notes

- Safety hazards or inappropriate behaviours include: talking on a cellphone, not wearing safety eyewear, squirting a liquid at another student, placing chemical containers on the floor, taking up space with backpack, leaving a book hanging out of a backpack, leaving a Bunsen burner unattended, wearing safety eyewear over forehead, playing with a fire extinguisher, pouring chemicals down the sink, making a public display of affection, pouring at eye level, listening to portable music players, eating/drinking, and spilling liquid.

Supporting Diverse Student Needs

- Students who have weak reading and writing skills will not be at a disadvantage here due to the highly visual context. Students can orally describe inappropriate behaviours.
- This is an excellent activity for visual-spatial learners.
- For enrichment, ask students to imagine a scenario not shown. "What other inappropriate behaviours could the illustrator have shown?"

What Did You Find Out? Answers

1. and 2. Answers will vary but may include:

UNSAFE PRACTICE	POSSIBLE OUTCOME	SAFER WAY
No safety eyewear	Eye damage	Use safety eyewear
Eating, drinking in lab	Poisoning	No food or drink
Smelling chemical	Nose, lung poisoning	Waft odours when smelling
Horseplay	Injury to self or others	No horseplay
Cellphone use	Inattention to surroundings	No cellphone use
Headphones	Distracting, cannot hear	No headphones
Spraying water from bottle	May be an acid or a base	No horseplay
Chemical stored on floor	Broken bottles, spilled chemicals	Store chemicals on bench
Backpack in the lab	Lab clutter promotes accidents	No backpacks in work area
Unattended Bunsen burner	Fire	Always attend open flames
Pouring chemicals down sink	Poisons into environment	Use chemical disposal containers
Playing with fire extinguisher	Unable to fight fire	Use only in emergency Only teacher handles fire extinguisher
Public display of affection	Distracting to others, inattention to surroundings	No public displays of affection
Pouring chemicals at eye level	Injury to eye, spill down front of clothing	Pour at counter level, below eye level

TEACHING THE SECTION, pp. 10–13

Using Reading

Pre-reading—Predict-Read-Verify

Before reading, students can predict the answers to the following questions:

- What needs to happen before starting work in the lab?
- What precautions need to be taken with all chemical substances?
- What are the safety issues involved with using open flames and uncontrolled fires?
- How is glass, including broken glass, to be handled?
- What special precautions are necessary when using electrical equipment?

- How many WHMIS symbols are there?
- What are the other safety hazard symbols?

During Reading—Note Taking

As students read this section, they can answer the questions provided in the Pre-reading section.

After Reading—Reflect and Evaluate

Have students summarize the points under each heading in the "Safety Rules for the Science Lab" section as briefly as possible. For example, for the General heading, a list might be: work with permission, know your procedure and equipment, dress properly, do not consume food or drink, do not engage in horseplay, and know emergency equipment and procedures. Students could complete any or all of BLM 1-3, Safety Symbols; BLM 1-4, Using Material Safety Data Sheets; BLM 1-5, Safety Scavenger Hunt; BLM 1-6, Using a Bunsen Burner; BLM 1-7, Using a Hot Plate; BLM 1-8, Using a Balance; and BLM 1-9, Science Equipment.

Supporting Diverse Student Needs

- The student textbook explains 11 key Science Skills, beginning on page 480. As you have students read the textbook for the first time, examine the list of study skills on page 480. Invite students to identify a couple of skills that they might need help with through the year. Tell students that they can refer to this appendix whenever they need a reminder about one of these skills. Consider looking at one or two sections together now.
- Interpersonal learners, and students who have difficulty extracting information from written text, may find it helpful to summarize the safety rules with a partner.

Reading Check Answers, p. 11

1. Before starting a science activity, know the safety rules that apply to your laboratory as well as any safety guidelines that apply to the specific lab activity you are about to begin.
2. Report any nick or chip in glassware to your teacher.
3. Never taste a chemical in the science lab, even if it is a food item.
4. Take a container with an obscured label to your teacher.
5. Hold the chemical you are about to smell at arm's length and waft the fumes toward you.

Reading Check Answers, p. 13

1. Workplace Hazardous Materials Information System
2. (a) Compressed gas
   (b) Flammable and combustible material
   (c) Dangerously reactive material
3. (a) Explosive container
   (b) Corrosive product
   (c) Poisonous product

USING THE ACTIVITIES

- Think About It Activity 1-1A, on page 9 of the student textbook, is best used as an introductory activity. Detailed information about this activity can be found in Introducing the Section.
- Activity 1-1B, on page 13 of the student textbook, is best used after students have read the safety rules on pages 10 and 11 of the student textbook and discussed them in class. Detailed notes on doing the activity follow.

Think About It Activity 1-1B

Safety Guidelines for Your Lab, p. 13

Purpose

- Students present an important safety rule on a safety poster and create a safety contract that is specific to their own class.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Gather materials.	For each group: – poster paper (could be legal-sized paper) – coloured markers, pencils, crayons, or paints

Time Required

- 20 min

Science Background

Part 1 of this activity provides students with a way to convert a long list of safety rules into a few images that can increase the impact of the rules. Part 2 involves sharing poster ideas and using these ideas to produce a safety contract.

Activity Notes

Part 1

- The posters need not be large. A standard legal-sized sheet of paper can be quite effective.
- Discuss elements of an effective poster, such as: large and dark lettering can be seen from a distance of at least 2 m; fewer words often have the most impact; and simple drawings also can have a high impact.

- Have students sign up for the rule they wish to represent, or else assign rules to students.
- Have students display their posters on the class wall.
- You may wish to have students select the best three posters. This selection method may add gentle peer pressure to do well, without drawing attention to the less effective posters.

Part 2

- The safety contract could have a repetition of some or all of the rules or simply more general statements such as: "Objects that can cause clutter, distraction, or inattention are not permitted." This eliminates backpacks, cellphones, and music players. A contract should have an area for signatures by the student and parent.
- The safety guidelines need not simply be a repetition of the safety rules from pages 10 and 11. A contract might focus on broader themes, such as good behaviour and display of a safety-conscious attitude.
- You can find examples of contracts from equipment supply houses at www.discoveringscience.ca.

Supporting Diverse Student Needs

- Help students who have difficulty with reading comprehension to focus on the most important safety guidelines for your lab.
- This is a good hands-on activity for verbal-linguistic and interpersonal learners. Try to place students with each type of skill in every group for Part 2.
- For enrichment, have students create a poetic phrase (such as a couplet, haiku, or limerick) that embodies a safety message. Post these poems in the classroom or in a school display area.

What Did You Find Out? Answers

1. Students' answers may vary but could include instructions to make the poster more visible from a distance, by being neater, making the text larger, simplifying the image, focussing on just one rule, writing in a larger font, or choosing colours that stand out better.
2. Accept all logical answers. Students typically forget some important rule or include too many small rules.

USING THE FEATURE

Science Watch: Chemistry in a House Fire, p. 14

This feature is excellent for reinforcing the safety guidelines related to fire hazards and procedures that have been studied while working through the safety section. All of the safety tips covered in this feature apply to fires at school as well as fires at home. The fire safety information is presented through the lens of chemistry, and some chemical concepts are imbedded into the language of the feature.

Science Watch Answers

1. Four ways to make your home safer from fire include: keep hallways clear of flammable clutter; use working smoke and carbon monoxide detectors (do not forget to check the batteries in them); keep fire extinguishers in the kitchen, laundry room, and garage; and practise escape from every room in the house.
2. Crawl low with your face near the floor when moving through smoke.
3. Toxic fumes can be poisonous and can cause loss of consciousness or suffocation.

SECTION 1.1 ASSESSMENT, p. 15

Check Your Understanding Answers

Checking Concepts

1. (a) False. Broken or chipped glassware should be disposed of in the broken glass disposal.
   (b) True
   (c) False. If the label on a chemical container is missing or not readable, take it to the teacher.
   (d) False. Leftover chemicals should never be returned to their original containers because this causes contamination of the stock. Discard the chemicals as your teacher directs.
   (e) True
   (f) False. Gum chewing is not permitted in the lab.
2. (a) Dangerously reactive material
   (b) Poisonous or infectious material causing immediate and serious toxic effects
   (c) Poisonous material causing other toxic effects
   (d) Corrosive material
   (e) Compressed gas
   (f) Flammable and combustible material
3. (a) Explosive container
   (b) Flammable product
   (c) Corrosive product
   (d) Poisonous product

Understanding Key Ideas

4. Knowledge of procedures means knowing what to do (even before the lab starts), and awareness of safety hazards refers to paying attention to what is happening during the lab, including watching for things that might go wrong or things that are going wrong.

5. Accept all logical answers. For example, the direction of exit from the classroom might change depending on the specific location of a hazard, such as a fire.
6. (a) Unplug the hot plate and evacuate following your teacher's instructions.
   (b) Tell the teacher about the chip in your test tube. You might be instructed to use another test tube right away or to finish using the test tube and then place it in the broken glass disposal.
   (c) Call "Fire!" Smother the flames (possibly using the "Stop, Drop, and Roll" technique and a fire blanket). Ensure the accident is reported to the teacher.
7. Accept all logical drawings. The drawings should include emergency exits, fire extinguishers, alarm pull stations, eyewash stations, and any other emergency equipment.

Pause and Reflect Answer

Accept all logical responses. Sample answer: Hazard symbols are for consumer products and can be easily understood without training. For example, the explosion hazard symbol clearly conveys this danger. The WHMIS symbols are more technical in nature, and there is an expectation that people in the workforce are trained to understand them. It does not really matter if there is more than one way to indicate danger, as long as the danger message is clearly conveyed.

Other Assessment Opportunities

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

1.2 INVESTIGATING MATTER

BACKGROUND INFORMATION

Chemical change produces new substances with new properties, such as when fireworks explode. Physical changes may change the appearance of a material, but no new substance is formed. This occurs because no chemical bonds are formed or destroyed in a physical change. Changes of state between solid, liquid, and gas do not produce new substances and are examples of physical changes. More information on these distinctions will be given in Chapter 3. These concepts are introduced here briefly just to set the stage for investigating the nature of matter.

Matter can be described by making a list of physical and chemical properties. Physical properties are observations or measurements of a substance on its own. Chemical properties are observations or measurements of a substance when it reacts with another substance(s). Properties can be qualitative or quantitative.

Qualitative properties (from "quality") are descriptions that are not measured with a number, such as malleability, ductility, and magnetic properties. Quantitative properties (from "quantity") are descriptions that have a number attached to them, such as conductivity, density, melting point, and boiling point. The materials studied in the Grade 9 science curriculum are pure substances—substances that are made up of only one kind of matter. These include elements (cannot be broken down into something simpler) and compounds (can be broken down into two or more elements).

COMMON MISCONCEPTIONS

- Students may have difficulty distinguishing between physical/chemical properties and physical/chemical changes. They may believe that a physical property is the same as a physical change. In fact, a physical property is a characteristic of a substance, while a physical change is a process that the substance goes through. It might help students to think of this distinction in terms of language. A property is like an adjective, which describes something: the liquid is *blue*. A change is like a verb, which expresses an action: the liquid is *boiling*.
- Even though the melting point and freezing point are both the same temperature for a substance, students will often think that melting happens just above the melting point and freezing happens just below the freezing point. For example, the freezing/melting point of water is 0°C. Both freezing and melting happen at exactly this temperature, neither above nor below it. If this result were not true, then liquid water and ice could not coexist in the same glass of ice water.
- Many people use the terms "freezing" and "solidification" interchangeably. Any time a liquid or a gas becomes a solid, it is correct to call this process solidification. For example, liquid glue becoming a solid is the process of solidification. If the solidification is a result of removing heat and/or the application of pressure, then the term "freezing" is appropriate. In other words, freezing is just one kind of solidification. Metallurgists (people who work with metal) are more likely to use the term "solidification" than "freezing," perhaps because many metals become solids at several thousand degrees. However, when water turns into a solid, freezing is the more common term.

ADVANCE PREPARATION

- Order chemicals for Find Out Activity 1-2A, Bag of Change, well in advance.

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

INTRODUCING THE SECTION, pp. 16–17

Using the Text

Have students read the text on page 16. Lead a discussion on fireworks. Ask students about fireworks displays they have seen and what sorts of colours are common (the red, blue, and green of Roman candles, the bright white of sparklers). Connect the idea of chemical change to the way fireworks produce light and sound.

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. 17

The field of pyrotechnics represents a fusion between science and art. With military, industrial, and entertainment applications, it is an example of how chemistry operates within the mainstream of society. The field of pyrotechnics can include the effects of sparks, flames, sounds, colours, and smoke.

Using the Activity

Find Out Activity 1-2A

Bag of Change, p. 17

Purpose

- Students investigate and describe the physical and chemical changes that occur when three substances are mixed.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Gather materials and apparatus. Practise the activity so you can identify the changes and observe what happens when a bag over-inflates.	For each group: – Chemical A (sodium hydrogen carbonate powder, $NaHCO_3$) – Chemical B (calcium chloride powder, $CaCl_2$) – Chemical C (bromothymol blue indicator solution) – 2 small spoons for measuring A and B – 50 mL graduated cylinder – 2 resealable plastic bags – water

Time Required

- 30 min

Safety Precautions

- Remind students to be careful not to get any chemicals near the eyes or mouth. Students must wear protective eyewear and may wear a lab coat.
- Ask students to check that their bags are tightly sealed before they start.
- Remind students to squeeze the bags gently to ensure they do not burst.
- As gas is produced, the bags tend to fill up. Take care to prevent excessive gas build-up or the bags may burst. Have students stop and open the bags if the bags appear like they are about to burst.

Science Background

When the three unknown substances (baking soda, road salt, and an acid-base indicator) are mixed in a resealable plastic bag, several chemical and physical changes happen in a few minutes, causing colour changes from blue to green to yellow, formation of gas, warming, and also cooling.

Baking soda is sodium hydrogen carbonate ($NaHCO_3$). As it dissolves, energy is absorbed and the solution cools. Road salt is calcium chloride ($CaCl_2$). As it dissolves, energy is released and the solution warms. In solution, the $NaHCO_3$ and $CaCl_2$ react in a way that releases carbon dioxide gas. $NaHCO_3$ is a mild base (causing the bromothymol blue indicator to be blue), but as the reaction continues, the solution becomes mildly acidic, leading to a green and then yellow colour.

Activity Notes

- Have students work in groups.
- Divide up the chemicals so there is one set of three chemicals per group.
- Use spoons that hold about 30 mL when heaping.
- Watch out for sealed bags that fill to bursting.

Preparation/Disposal of Reagents

- Chemical A is sodium hydrogen carbonate ($NaHCO_3$), commonly known as baking soda. It is available at a scientific supply house or at any grocery store. For this activity, about 500 g is sufficient. If you encourage students to do step 3 of What Did You Find Out, have an extra 500 g on hand.
- Chemical B is calcium chloride ($CaCl_2$), commonly known as road salt. For this activity, about 500 g is sufficient. If you encourage students to do step 3 of What Did You Find Out, have an extra 500 g on hand.
- Bromothymol blue indicator is 3',3"-dibromothymolsulfonephthalein (BTB) and can be purchased in solution form or made up from powder according to the manufacturer's instructions. If no instructions are available, use the following procedure. Mix about 0.1 g of bromothymol blue powder in 10 mL of a 4% solution (0.4 g per 10 mL) of sodium hydroxide. Add 20 mL of alcohol, and dilute to 1 L with deionized water. (Diluting with alcohol will prolong the shelf-life of the solution.) The solution should be deep blue. If it is green, add sodium hydroxide solution drop-by-drop until the solution turns blue. Making your own solutions allows bulk volumes to be prepared very cheaply.
- All of the chemicals used in this experiment can safely go into solid waste or be rinsed down the sink with water.

Supporting Diverse Student Needs

- Encourage English language learners and students who have weak writing skills to describe their observations to you orally.
- This is a good activity for body-kinesthetic and visual-spatial learners. Ensure that these learning skills are represented in as many groups as possible.
- For enrichment, consider having students do step 3 of What Did You Find Out? The advantage of this activity is that no knowledge of the specific chemicals is required, just good observation skills and the ability to think of and follow a logical procedure for sorting out which chemicals led to which observations. Remind students that the blue solution is just a blue chemical dissolved in water and that they might wish to substitute water for it.

What Did You Find Out? Answers

1. The objective here is to get students thinking about physical and chemical changes, not to identify them accurately. They will learn more about chemical changes in Chapter 3. Accept all logical answers, which may include: Solids appear to dissolve (physical change), producing bubbles (chemical change). The blue colour turned green and then yellow (chemical change). A gas was produced that filled up the bag (chemical change). The region around Chemical B warmed up (chemcial change). The region around Chemical A cooled down (chemical change). **Note:** The actual temperature changes observed will depend on the relative amounts and timing of the combination of all of the chemicals.
2. Students share their observations.
3. Chemical A (baking soda) is sodium hydrogen carbonate ($NaHCO_3$). As it dissolves, energy is absorbed and the solution cools. Chemical B (road salt) is calcium chloride ($CaCl_2$). As it dissolves, energy is released, and the solution warms. In solution, the $NaHCO_3$ and $CaCl_2$ react in a way that releases carbon dioxide gas. $NaHCO_3$ is a mild base (causing the bromo-thymol to be blue) but as the reaction continues, the solution becomes mildly acidic, leading to a green and then yellow colour.

TEACHING THE SECTION, pp. 18–23

Using Reading

Pre-reading—Predict-Read-Verify

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

- Describing Matter: Physical Properties
- Describing Matter: Chemical Properties

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.

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 use BLM 1-10, Physical and Chemical Properties of Matter, as an overhead projection to aid discussion.

Supporting Diverse Student Needs

- Visual-spatial learners may wish to use a graphic organizer such as a concept map to organize their notes.
- As an extension, encourage students to research to learn more about some of the areas they found interesting.

Reading Check Answers, p. 19

1. Malleability describes the ability of a metal to be bent or beaten into sheets.
2. Smell is a qualitative property.
3. Chemical properties are characteristics that can be observed only when substances react with each other, while physical properties can be observed or measured for a single substance.

USING THE ACTIVITIES

- Find Out Activity 1-2A, on page 17 of the student textbook, is best used as an introductory activity. Detailed information about this activity can be found in Introducing the Section.
- Activity 1-2B on page 19, and Activity 1-2C, on page 20 of the student textbook, are best used after students have read and discussed the sections on describing matter on pages 18 and 19.

Detailed notes on doing the activities follow.

Think About It Activity 1-2B

A Chemical Family, p. 19

Purpose

- Students investigate the concept of a chemical family—a group of elements connected by similar physical and chemical properties.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	Optional: Photocopy BLM 1-11, A Chemical Family.	None

Time Required

- 20 min

Science Background

Aluminum and iron might be grouped in the same family based on similarities of their physical and chemical properties. Specifically, their reactivity with acid to produce hydrogen gas unites them in this activity and distinguishes them from copper, silver, and gold. Electrical conductivity comparisons could result in a similar classification. Not all properties distinguish between the metals. Malleability is quite similar in all the metals.

Activity Notes

- You may want to hand out BLM 1-11, A Chemical Family, or use it as an overhead projection.
- Students could work in pairs.

Supporting Diverse Student Needs

- For visual-spatial or body-kinesthetic learners, display any samples of these metals that you have. Reasonable-sized pieces of silver or gold (or silver- or gold-plated objects) may be cost-effectively purchased if they are made available to all members of the science department and used over many years.
- This activity is well suited to logical-mathematical problem solving.
- For enrichment, you may wish to demonstrate some of these properties. If you bend copper and iron wire of similar diameter, the copper wire will bend more readily. Placing any of aluminum, copper, gold, iron, or silver into 3 M HCl will produce the following results: Aluminum will react quickly. Iron will react slowly. Copper, silver, and gold will not react. Remind students to be careful using acids and to wear safety eyewear.

What Did You Find Out? Answers

1. Effect of acid on the metal and formation of a compound with oxygen are chemical properties. Malleability and electrical conductivity are physical properties.
2. Copper, silver, and gold are united into one family in this activity because they are all unreactive with most acids, they do not readily form compounds with oxygen, and they are all superior conductors of electricity.
3. Aluminum is similar to the coinage metals in that it is very malleable, like copper and silver, and it is a very good conductor—better than iron and nearly as good as gold. Aluminum differs from the coinage metals in its reaction with acid and oxygen.
   Iron conducts electricity and is malleable, which are similar properties to the coinage metals. Iron is neither as conductive nor as malleable as the coinage metals. Iron reacts with acid and oxygen in a very different way than the coinage metals react with acid and oxygen.
4. Answers may vary as different reasonable classification schemes could be proposed that put iron and aluminum in the same and in different groups. Iron and aluminum share reaction with acid and oxygen, and both are malleable and conductive. However, aluminum is more malleable and more conductive than iron.

Conduct an Investigation 1-2C

Physical and Chemical Properties, p. 20

Purpose

- Students investigate the properties of various metals and distinguish between physical and chemical properties.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before 1 day before	Ensure that all of the metal samples are ordered/available. Gather apparatus and materials. Prepare hydrochloric acid solution. If Bunsen burners are available, ensure students know how to use them. Optional: Photocopy BLM 1-6, Using a Bunsen Burner.	For each group: – Bunsen burner or propane burner – 5 cm metal strips of aluminum, magnesium, iron, copper, silver, lead – small pieces of aluminum, magnesium, iron, copper, silver, lead – steel wool – hydrochloric acid (1.0 mol/L solution) in a dropper bottle – bar magnet – tongs – heat resistant pad – electrical conductivity kit

Time Required

- 40 min

Safety Precautions

- Ensure that students wear a lab coat, goggles, and protective gloves.
- Remind students to handle hot objects and corrosive objects with care.
- Ensure that students keep hair and loose clothing away from the flame.
- Remind students to not look directly at a metal when it is in the flame.
- Remind students that magnesium will catch fire and burn with a blinding light.
- Ensure that students exercise caution when performing the flame test.
- Remind students that lead melts VERY quickly, producing drops of hot liquid metal and toxic fumes.
- Remind students that thin strips of iron will burn.

Science Background

The properties examined in this investigation are described in Table 1.1, Physical Properties, on page 18 of the student textbook and Table 1.2, Chemical Properties, on page 19 of the student textbook. They include both chemical and physical properties:

- lustre (physical)—degree to which the material reflects light, before and after polishing
- malleability (physical)—degree to which the material can be bent or beaten into sheets
- magnetism (physical)—degree to which the material is attracted to a bar magnet
- electrical conductivity (physical)—degree to which the material conducts electricity
- reactivity to acid (chemical)—degree to which the material reacts with acid
- reactivity to air when heated (chemical)—degree to which the material reacts with air when heated

A flame test will be used to assess reactivity to air when heated.

Properties are summarized in the table below:

CHEMICAL AND PHYSICAL PROPERTIES OF METAL ELEMENTS

	METAL					
PROPERTY	ALUMINUM	MAGNESIUM	IRON	COPPER	SILVER	LEAD
Lustre (before polishing)	Yes	Moderate (may be tarnished if there is humidity in the air)	No	Yes	Yes	Yes
Lustre (after polishing)	High	High	Moderate	High	High	High
Malleability	High	High	No	High	High	High
Magnetism	No	No	Yes	Yes	No	No
Electrical conductivity	Moderate	Moderate	Low	High	Very high	Low
Reactivity to acid	Yes	Yes	Yes	No	No	Yes
Reactivity to air when heated	Yes	High	Yes	Moderate	Moderate	Moderate

Activity Notes

- Students can work in groups of two or three.
- Remind students to quickly jot down predictions of their observations before starting the lab. Allow only a couple of minutes for this task. This is merely a tool for students to assess how much they know about the properties of these metals before performing the investigation. They will compare their actual results to these predictions.
- If available, ensure that students know how to use a Bunsen burner correctly. You should check with your School District on regulations concerning their use. You may wish to have students complete BLM 1-6, Using a Bunsen Burner, before doing this investigation.
- Hot metal does not always *appear* hot. Ensure that students use crucible tongs when holding metal samples and place the samples on a heat-resistant pad afterwards to allow the metal to cool.
- Ensure that students hold the lead sample in the flame for no more than a few seconds to see whether it burns. Prolonged heating will melt the lead and release toxic fumes. Perform this test in a well-ventilated area or under a fume hood if possible. Given the potential hazards, you should consider doing this test as a demonstration.

Supporting Diverse Student Needs

- This is a good hands-on activity for visual-spatial or body-kinesthetic learners. Encourage visual-spatial learners to describe the apparatus set-up to their partners or to you. Logical-mathematical learners will be well-suited to performing and/or recording the conductivity measurements.
- For enrichment, ask students to research one additional metal and describe its properties.
- If time is limited or if you are concerned about students' ability to perform this investigation safely, you may wish to remove magnesium and lead from the list of metals to be tested. Alternatively, you could perform the flame test as a demonstration and allow students to carry out the other tests on their own.

Analyze Answers

1. Lustre, malleability, magnetism, and electrical conductivity are physical properties. Reactivity to acid and reactivity to air when heated are chemical properties.
2. All of the metals are lustrous to some degree and all demonstrate some electrical conductivity, although iron and lead are poor conductors.
3. All of the metals react with air when heated. Most, with the exception of copper and silver, react with acid.

Conclude and Apply Answer

1. Students' answers may vary but could include: The physical properties were those that could be observed without performing any special treatment on the materials. The chemical properties required observation of how the samples reacted chemically.

   Students may give examples of some of their observations to support their answers in the analysis section. Answers should include a comparison of students' predictions with their observations.

USING THE FEATURES

National Geographic: Visualizing Matter, p. 21

This feature is an excellent starting point for discussing matter. The elements as basic building blocks of matter are a central concept of this unit, and this feature follows naturally from Activity 1-2B (A Chemical Family), on page 19, where the focus was the properties of metallic elements. The thrust of this feature is that knowledge of the properties of matter has allowed people to develop a wide range of commercial products (such as aluminum), as well as exotic elements (such as gold), or unfamiliar elements (such as americium).

www Science: Liquid Crystals, p. 22

Liquid crystals are an important state of matter that is often ignored because it does not fit into the solid-liquid-gas paradigm. However, liquid crystals exist as close to us as the nearest portable music player, calculator, computer screen, or wristwatch. This feature highlights novel uses, such as temperature-sensitive liquid crystals.

Answers to www Science Questions

1. In solids, particles can vibrate in place but cannot move past each other. In liquids, the particles can move past each other but cannot separate from each other. In liquid crystals, the particles can slide past each other in some circumstances but cannot slide past each other in different circumstances. One example of this behaviour is when an electric current causes the liquid crystal particles to behave like a solid.
2. Some liquid crystals change colour when temperature changes occur.
3. Electricity applied to selected sections of a liquid crystal display makes the liquid crystals twist and line up in such a way that light cannot pass through. This process creates the dark areas that form numbers.

SECTION 1.2 ASSESSMENT, p. 23

Check Your Understanding Answers

Checking Concepts

1. Mass and volume
2. In a chemical change, substances combine to form new substances.
3. In a physical change, such as a change of state, there may be a change in appearance but no new substances form.
4. Combustibility describes how much a substance reacts with air or pure oxygen—the degree to which it burns.
5. Chemical properties of aluminum (any one): reacts with acid to release hydrogen gas, reacts with oxygen
   Physical properties of aluminum (any one): solid at room temperature, silver/grey in colour, very malleable, good conductor of electricity
6. (a) Physical
   (b) Physical
   (c) Physical
   (d) Physical
   (e) Physical
   (f) Chemical
7. Accept any logical answer. Sample answer: Properties that could be described without a chemical reaction taking place were physical properties.

Understanding Key Ideas

8. Accept any logical answer that lists two physical and two chemical properties. Answer could include some of the following: A material intended to carry liquids would need to be non-reactive with the liquids it is to carry, non-combustible, and preferably non-toxic. It should be solid at room temperature, malleable, and should not be soluble in the liquid it is intended to carry.
9. Accept any logical answer that lists one physical and one chemical property. Melting point, boiling point, density, and colour are physical properties that might distinguish gasoline from water. (Gasoline may be colourless or it may have a slight yellow or brown hue.) Combustibility is a chemical property that could distinguish gasoline from water. Odour is also a chemical property that would stand out between them, but students may not be aware that it is a chemical property.
10. Any two of: density, melting point, boiling point
11. (a) Malleability is the ability to be beaten into sheets.
    (b) Boiling point is the temperature of boiling (at which a liquid becomes a gas).
    (c) Ductility is the ability to be drawn into wires.
    (d) Conductivity is the ability of a material to conduct electricity or heat.
    (e) Solubility is the ability to dissolve in water.
    (f) Texture is the appearance and feel of the material's surface.
    (g) Viscosity is the resistance to flow.
12. Density
13. (a) For example: gold is shiny, yellow, malleable, and ductile.
    (b) For example: sugar is non-magnetic, colourless, solid, and soluble.
    (c) For example: water is liquid and colourless and has low viscosity and low conductivity.
14. Only a physical property of the water—its state—has changed. It is still the same substance.
15. Physical property of a candle (any one): solid at room temperature, description of colour, description of texture
    Chemical property of a candle: combustible
16. Physical properties (any two): state, colour, texture, density
    Chemical properties (any one): reactivity of ingredients (for example, baking soda reacts to make the cookies rise; eggs, flour, and sugar react in the oven to change dough into cookies)

Pause and Reflect Answer

Accept all logical responses. Sample answer: We identify substances and distinguish them from other substances by observing and comparing their properties. This is how we know the difference between salt, sugar, and arsenic. Sample answer: Chemistry involves manipulating matter in useful ways. We know if we have converted one form of matter into another form of matter only by examining changes in the properties of the matter.

Other Assessment Opportunities

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

1.3 ATOMIC THEORY

BACKGROUND INFORMATION

Atomic theory is one of the foundations of modern science. Richard Feynman, a Nobel Prize winning physicist and educator, said this: "If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generations of creatures, what statement would contain the most information in the fewest words? I believe it is the atomic hypothesis..." (Feynman, 1995) (See www.discoveringscience.ca.)

No one knows when the first discussion about the fundamental nature of matter occurred. Two ideas that come from the ancient Greek philosophers were that there might be the smallest piece of matter, from which we get the modern word "atom," and that the material world might be built up of combinations of a few fundamental materials called elements. These ideas were proposed by Democritus and Empedocles, respectively. The "elements" proposed by Empedocles were earth, air, wind, and fire—not the ones that make up the present-day periodic table.

The contribution of alchemists to the development of science is usually simplified to a few basic statements: that they were concerned primarily with making gold cheaply, that they did not share their ideas, and that they did not use the scientific method. However, they did develop many new experimental methods along the way, such as techniques for making mineral acids.

Four pivotal points in the early development of atomic theory turn on the work of Dalton, Thomson, Rutherford, and Bohr. Today, each of these personalities has become associated with a particular atomic model. Each model was based on experimentation and reasoning, and one model led to the next. For Dalton, atoms were indivisible, and different elements were made from different atoms. New substances could be made from combinations of atoms. Thomson's work led to the idea that atoms were, in fact, divisible and contained negative charges, which later came to be known as electrons. This also implied that atoms contained positive charges. His student, Rutherford, used a gold foil experiment to show that the positive charges in an atom were located at a tiny region with great mass, which he called the nucleus. Rutherford's student, Bohr, produced a model in which electrons occupy nergy levels surrounding the nucleus.

The model of the atom used in this text includes the contributions of Dalton, Thomson, Rutherford, and Bohr as well as many others. This model includes the following points: Each element is made of one type of atom. (The idea of isotopes is not included in the Grade 9 curriculum. It is introduced in a marginal feature in Chapter 2 to support the concepts of average atomic mass and mass number.) Different kinds of atoms can combine to make compounds. Atoms are made of protons, neutrons, and electrons. Electrons can be transferred or shared between atoms to form chemical bonds, but protons and neutrons are locked in the nucleus. It is the number of protons that determines which element an atom belongs to. Electrons exist in a region surrounding the nucleus. Electrons in an atom are arranged around the nucleus in the pattern 2, 8, 8, and 18. This pattern matches the number of elements in each of the first four periods of the periodic table and places the electrons with similar energies in the same groupings.

These concepts are simplified from modern quantum mechanics. In quantum mechanics, terms such as "occupy," "energy level," "shell," "orbital," and even "electron" have very specific, technical meanings, often described in purely statistical or other mathematical ways. The manner in which these terms are defined in this unit is not rigorous. Students will encounter many refinements in later courses.

COMMON MISCONCEPTIONS

- Bohr proposed several models of the atom. An early model, which partly worked for atoms or ions containing one electron, was that an electron is a particle that orbits the nucleus. Bohr quickly discarded this "planetary" model. However, it is a compelling image, and it has continued to be used by some educators. It is recommended that this model not be used. In particular, avoid using the term "orbit."
- Many students picture electrons as tiny spheres. How should the electron be correctly described within the atom? The only truly correct description is mathematical. However, here is a suggested way to think of electrons: Electrons can be thought of as occupying the whole energy level all at once, forming a region or cloud of negative charge. Each cloud has a specific energy. The cloudlike region is denser in some areas and less dense in others. The farther away you get from the atom, the thinner the cloud gets. More than one electron can exist in the same cloud.
- It is a misconception that atoms are mostly empty space. This belief follows from the misconception that electrons in atoms behave like tiny, fast-moving particles whizzing around quickly through a vacuum. Because electrons occupy energy levels that exist spread out in a region of space mostly near the nucleus, the atom cannot be accurately said to be mostly empty space.

ADVANCE PREPARATION

- Activity 1-3A presents an extensive list of scientists and philosophers who contributed to the development of atomic theory. Review this list before you present it to students. You may wish to exclude some of the more obscure names on the list.

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

INTRODUCING THE SECTION, pp. 24–25

Using the Text

Have students read the introduction and Early Ideas about Matter. Discuss the idea that neither the Greeks nor the alchemists had the scientific method available to them to help answer their questions.

Have students look at Figure 1.8, on page 24. The first images of individual atoms, like the one shown here, were not available until the mid-1980s. How might it have been possible to know of the existence of atoms before this time? (It was necessary to use indirect evidence to infer the existence of atoms.)

Share with students that a tiny drop of milk placed under a high-power optical microscope gave the first indisputable evidence that atoms did exist. In a perfectly still drop of milk, tiny fat globules always keep moving around in a random way, never ceasing their movement. It was concluded that the only correct explanation for this movement was because the fat globules were being struck by tiny, invisible particles, themselves in motion because of the heat energy in the room. These invisible particles were widely considered by scientists at the time (1905–1915) to be conclusive evidence for the existence of atoms.

The focus of this section is atomic theory. It is important that students understand the difference between a theory and a law. Ask students if they know of any laws or theories. They may mention the law of gravity or the theory of evolution. Remind them also of the Grade 8 optics unit, in which they studied the law of reflection, and the Grade 8 water systems unit, in which they learned about the theory of plate tectonics. These examples may help them distinguish between laws, which describe observations, and theories, which propose explanations for observations. You can point out that laws enable scientists to predict observations and events. For a theory to become accepted, it must be able to do the same—to reliably predict observations for novel situations.

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. 24

Students may be interested to learn about other ancient views of the elements that composed matter.

- Ancient Chinese philosophers: earth, water, fire, metal, and wood
- Ancient Greek philosophers: earth, water, fire, air
- Ancient Japanese philosophers: earth, water, fire, wind, and void (heaven)
- Ancient Hindu and Buddhist philosophers: earth, water, fire, air, and space (ether)

Students could research the understandings of local Aboriginal peoples or other cultures about the composition of matter.

TEACHING THE SECTION, pp. 25–29

Using Reading

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

Ask students to record their answers to the question "What do I know about 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 together discuss the answers.

During Reading—GIST

As students read the paragraphs of this section, have them write short summaries after the sections on Dalton, Thomson, Rutherford, Bohr, and Inside the Atom. Encourage students to keep their summaries to 20 words or fewer to help them connect the facts.

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. Students can complete either or both BLM 1-12, Parts of the Atom Concept Map, and BLM 1-13, Subatomic Particles.

Supporting Diverse Student Needs

- Visual-spatial learners may create more effective and useful summaries if they make use of diagrams, or graphic organizers such as a time line or flowchart.
- Have students who have difficulty extracting the main ideas prepare their summaries as a write-

around, with each student in a group drafting a summary of one chunk and then passing those around to suggest additions and deletions from the others until the group has created a set of summaries for the entire section.

Reading Check Answers, p. 29

1. Alchemists wanted to turn common metals such as lead and mercury into gold.
2. The atoms in Dalton's model were indivisible; in Thomson's model, atoms were made up of subatomic particles, such as the electron.
3. Rutherford discovered the nucleus, a dense, positively charged region in the centre of the atom.
4. In Thomson's model, the positive charge was spread out over the whole atom; in Rutherford's model, the positive charge was concentrated into a tiny nucleus.
5. Bohr discovered that electrons in an atom are arranged in energy levels, or shells, within the atom.
6. Positive
7. Negative

USING THE ACTIVITIES

- Activity 1-3A, on page 30 of the student textbook, is best used after reading the text in this section and discussing the work of Dalton, Thomson, Rutherford, and Bohr.
- Activity 1-3B, on page 31, may be done anytime during this section and is good for breaking up the theory with some active involvement.

Detailed notes on doing the activities follow.

Think About It Activity 1-3A
The People Behind the Atom, p. 30

Purpose

- Students investigate researchers to discover ideas, experiments, debates, and human drama that helped to shape the development of the atomic theory.

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

- 40 min

Science Background

Each of the people listed has a connection to ideas, experiments, theories, or debates about atomic theory. There are 28 names listed. Use your discretion on whether to present this entire list to students, or only a small selection of scientists.

Activity Notes

- Encourage students to use multiple sources and to cite the sources of their information.
- Students will find that tremendous amounts of information exist about all of these people. They should choose one specific topic to focus on and explore.

Supporting Diverse Student Needs

- You may wish to assign names to students based on the students' specific interests and abilities. Students who like a challenge may appreciate the opportunity to research the more obscure names on the list, such as William Crookes or Murray Gell-Mann. Existential learners could be assigned one of the Greek philosophers. Struggling students may do better with scientists such as John Dalton or Niels Bohr, who have a more direct connection to the content of the course.
- English language learners might wish to research in their first language and translate the ideas into English. A slide show or information poster that emphasizes pictures over text might make this task more manageable and enjoyable for these students. Students might wish to find a person from their families' country of origin to feature. The development of atomic theory was and continues to be a very international effort. Many people from many countries have contributed.
- Various kinds of performances are possible with this project, from slide show, to monologue, to mock debate. This report provides opportunities for multiple intelligences.
- Enrichment can take the form of extra research on a particular topic, novel forms of reporting, or investigating scientists who are not in the provided list of names.

Conduct an Investigation 1-3B
Slivers of Silver, p. 31

Purpose

- Students investigate how to produce a sample of silver by growing slivers of it atom-by-atom and observe the process using a microscope.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Prepare silver nitrate solution and get pieces of copper ready. Ensure a class set of microscopes and slides is available.	For each group: – microscope slide – microscope – copper ribbon – silver nitrate solution in dropper bottle

Time Required

- 20 min

Safety Precautions

- Ensure students use safety eyewear when using silver nitrate solution, even when looking through a microscope.
- Ensure students wear goggles, protective gloves, and lab coats.
- Ensure students wash their hands thoroughly after completing the investigation.

Science Background

Silver nitrate solution reacts with copper metal in a single replacement reaction that produces copper(II) nitrate solution and silver metal. The silver grows into long, thin needles in the space of a few seconds to a few minutes. Although this result can be seen with the naked eye, it is many times more dramatic when viewed through a microscope.

Activity Notes

- Have students focus on a piece of copper ribbon before adding any silver nitrate to it. Doing so will ensure that they get to see the growing slivers of silver with the microscope in focus.
- Have 5 to 15 small bottles of silver nitrate solution available for this activity. You could use a digital flex camera if completing this activity as a demonstration.

Preparation/Disposal of Reagents

- Prepare a solution of silver nitrate (0.1 M $AgNO_3$) (17.0 g/L). Be sure to use deionized water, since tap water contains dissolved salts that will react with the silver ions, causing unwanted precipitation. Silver nitrate solution should be kept in dark containers for long-term storage, but this step is not necessary for the short time needed for this lab.
- The amounts of silver nitrate used in this activity are tiny. Clean up by wiping the slide clean and throwing the paper towel with the copper and solution from the slide into the garbage.
- Do not put large quantities (5 mL or more) of silver nitrate down the sink.

Supporting Diverse Student Needs

- Pair students who struggle with reading and writing with students who have strong language skills and who can help in answering questions in the Analyze, and Conclude and Apply sections.
- As an extension, have students put silver nitrate as well as copper(II) chloride on magnesium ribbon and view this through a microscope.

Analyze Answer

1. Answers may vary. Sample answer: Silver slivers are growing on the copper metal, but new silver can grow just as easily on the silver slivers as on the copper metal itself. The slivers of silver stick out into the solution, so the silver in solution has a greater opportunity to attach there than on the copper metal itself.

Conclude and Apply Answer

1. Putting copper metal into a solution should be the last step in producing pure silver, since it can separate the pure silver from a silver compound in solution.

USING THE FEATURE

Science Watch: Inquiring about Quarks, p. 32

This feature is a natural extension of the main text of the section and will help students realize that the story of the atom does not end with electrons, protons, and neutrons. Sometimes, new particles were predicted and then found. Other times, the particles were discovered and new theories and models had to be invented to include them. These discoveries have a connection to Rutherford. He was unable to postulate why protons and neutrons were able to bond together to form a nucleus. Later, the strong nuclear force was discovered. It binds together three quarks into either a proton or an electron. A tiny residual bit of strong force can act between the quarks in adjacent protons and neutrons, provided they are within one proton diameter of each other.

One very nice pattern that connects quarks to the Grade 9 science curriculum is that the sum of the charges of the three quarks in either a proton or a neutron gives the electric charge on the proton or neutron. This pattern is featured in question 2. Some science teachers may feel that talking about quarks is beyond their own comfort range. However, quarks are not really any more abstract than electrons and protons. Since the first experimental evidence for quarks was collected at the Stanford Linear Accelerator Center in 1968, quarks have become part of the mainstream of atomic theory.

Science Watch Answers

1. Two subatomic particles made up of quarks are protons and neutrons.
2. The charge on two up quarks and one down quark adds up to 1, which is the charge on the proton. Similarly, the charge on two down quarks and one up quark adds up to 0, the charge on a neutron.
3. Individual quarks are never found alone because the strong force, which binds quarks, increases in strength as quarks get farther apart. This force holds quarks together.

SECTION 1.3 ASSESSMENT, p. 33

Check Your Understanding Answers

Checking Concepts

1. Greek philosophers considered the idea of the smallest piece of matter, which gave rise to the modern word "atom."
2. (a) Alchemists were researchers who worked in Europe and the Middle East during the Middle Ages.
   (b) They tried to turn common metals like lead and mercury into gold.
3. Two atoms of gold in Dalton's model would have the same mass and size.
4. Atoms of gold and lead would have different sizes and masses and might link together in different ways.
5. J. J. Thomson discovered that atoms were themselves made up of other particles, such as the electron.
6. Rutherford's gold foil experiment led to the discovery of the nucleus—the dense, positively charged centre of an atom.
7. Protons and electrons both have mass and an electric charge.
8. Protons and neutrons
9. Electrons
10. A law is simply a statement of consistently observed events, while a theory is an explanation of observed events.
11. New theories are developed as scientists put forward alternative explanations for events, often in an attempt to explain new evidence. In order for a new theory to become generally accepted, it must be reviewed by other experts and it must stand the test of time.

Understanding Key Ideas

12. (a) Alchemists conducted research by doing experiments, while the Greek philosophers tended to spend more efforts on debating.
    (b) Alchemists combined their investigations with mystical thinking and often worked in secret. This slowed progress.
13. Thomson's studies showed that Dalton's idea that atoms cannot be divided into smaller particles was incorrect.
14. Rutherford exposed a thin sheet of gold to a stream of high-speed, heavy particles that had a positive charge, called alpha particles. Most particles went right through the gold, but some bounced back, indicating the presence of a dense, tiny, positive centre with great mass, which he called the nucleus.
15. (a) Proton
    (b) Neutron (the proton is a close second)
    (c) Electron
    (d) Proton
    (e) Electron
    (f) Neutron
    (g) Electron
    (h) Neutron
16. Atoms have equal numbers of protons and electrons, so the positive and negative charges balance each other.
17. The whole atom would be larger than the baseball park and its surroundings.

Pause and Reflect Answer

Answers may vary but will likely include the following points: The current model of the atom contains three particles, the proton (positive), the neutron (neutral), and the electron (negative). The proton and neutron have nearly equal mass and exist together in the nucleus, a tiny, dense region in the centre of the atom. The electrons occupy specific energy levels around the nucleus.

Other Assessment Opportunities

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

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PREPARE YOUR OWN SUMMARY

Students' summaries should incorporate the following main ideas:

1. Safety in the Science Classroom
   - Make safety your first priority.
   - Know the rules before starting a lab, and follow safe procedures while doing a lab.
   - Know what to do in case of an emergency.
   - Recognize WHMIS and other safety hazard symbols.
2. Properties of Matter
   - Physical properties are characteristics of matter that can be observed or measured for a single substance.
   - Chemical properties are characteristics of matter that can be observed only when substances react chemically.
   - Qualitative properties can be described, while quantitative properties can be measured.
   - Some qualitative properties include state, colour, malleability, ductility, texture, lustre and magnetism.
   - Some quantitative properties include solubility, conductivity, viscosity, density, melting point, and boiling point.
3. Models of the Atom
   - In Dalton's model, atoms are indivisible, differ between elements, and can combine to form new compounds.
   - In Thomson's model, the atom is composed of negative and positive charges.
   - In Rutherford's model, the atom has a dense, positively charged nucleus, surrounded by electrons.
   - In Bohr's model, the electrons occupy energy levels in regions surrounding the nucleus.
4. Subatomic Particles in the Atom
   - Atoms are composed of three subatomic particles called protons, neutrons, and electrons.
   - Most of the mass of the atom is contained in the nucleus by protons (positive) and neutrons (neutral).
   - Most of the volume of the atom is occupied by electrons (negative), which occupy energy levels near the nucleus.

CHAPTER REVIEW ANSWERS

Checking Concepts

1. (a) Call "Fire!" Inform your teacher. Smother the fire (possibly by using Stop, Drop, and Roll or with a fire blanket).
   (b) Rinse your eye immediately for 15 min. Inform your teacher. Seek medical help if necessary.
   (c) Take the container to your teacher.
   (d) Make sure your hands are dry. Pull the cord by the plug, not the cord.
2. Accept all logical answers. Sample answer: Failure to use safety eyewear could result in chemicals entering the eye and causing blindness. Horseplay could lead to spilling a chemical such as acid and causing damage to skin. Leaving a Bunsen burner or other heat source unattended could lead to a fire or an explosion.
3. Workplace Hazardous Materials Information System
4. (a) Flammable and combustible material
   (b) Poisonous material causing other toxic effects
   (c) Biohazardous infectious material
   (d) Corrosive material
5. (a) Container can explode.
   (b) Product inside container is corrosive—it will burn the throat or stomach if swallowed and will burn skin or eyes on contact.
6. A chemical change is a change in matter that occurs when substances recombine to form new substances. When physical changes occur, there may be a change in appearance but no new substances form.
7. (a) Physical
   (b) Chemical
   (c) Physical
   (d) Physical
   (e) Chemical
8. (a) Physical
   (b) Physical
   (c) Chemical
9. An atom is the smallest particle of an element that retains the properties of the element.
10. (a) Thomson
    (b) Rutherford
    (c) Dalton
    (d) Thomson
    (e) Bohr
    (f) Dalton
    (g) Thomson
    (h) Rutherford

11. (a) A subatomic particle is a particle that is found in an atom and that combines with other particles to form atoms.
    (b) protons, electrons, neutrons
12. Protons and neutrons
13. (a) Proton and electron
    (b) Neutron (although it is only slightly more massive than a proton)
    (c) Electron
    (d) Neutron
    (e) Proton and neutron
    (f) Proton and neutron
    (g) Proton
    (h) Electron
    (i) Protons and electrons
14. The nucleus measures approximately $\frac{1}{10\ 000}$ of the diameter of an atom. It occupies less than 0.01 percent of the whole volume of the atom.
15. The nucleus of every atom contains one or more protons, giving every nucleus a positive charge. There may be neutrons in the nucleus, but they have no effect on its electric charge.

Understanding Key Ideas

16. Accept all logical answers. Sample answer: No horseplay. This allows people to work in a safe environment and be able to focus on their work and watch for potential hazards.
17. (a) Density (physical property), boiling or melting point (physical property), flammability (chemical property), odour (chemical property)
    (b) Density (physical property), boiling or melting point (physical property)
    (c) Appearance (physical property), density (physical property), boiling or melting point (physical property)
18. (a) Qualitative physical properties of water (any one): liquid at room temperature, clear, and colourless
    (b) Quantitative physical properties of water (any one): freezing point is 0°C, boiling point is 100°C, density is 1 g/mL (bonus points if students know the density of water)
19. (a) Physical properties of iron (any one): solid at room temperature, greyish or reddish-brown in colour, may be lustrous, hard surface, magnetic, conducts heat and electricity, high density, high melting and boiling points
    (b) Chemical property of iron: reacts with oxygen to form rust
20. (a) A law is a statement that describes consistently observed events, while a theory is an explanation of events that is generally accepted.
    (b) Accept any logical answer. Sample answer: A law is useful in science because it states reliable information that applies in all situations. For example, in optics, the law of reflection states that light will be reflected from a surface at the same angle that it strikes that surface. A theory is useful in science because it helps us to understand how something works. For example, atomic theory helps us understand the behaviour and characteristics of matter by explaining what matter is made of.
21. Rutherford exposed a very thin sheet of gold foil to a stream of fast moving, heavy particles that had a positive charge, called alpha particles. He put a detector screen around the gold foil so that an alpha particle became visible whenever it struck the screen. Rutherford's results indicated that most of the alpha particles went right through the gold atoms without being affected. A few alpha particles rebounded from the foil much as a ball rebounds from a solid wall. Rutherford concluded that atoms contain a nucleus—the tiny, dense, positively charged centre of an atom.

Pause and Reflect Answer

Accept all logical responses. Sample answer: Thomson demonstrated that atoms were made of simpler particles, such as electrons. Rutherford showed that atoms contained a dense positive nucleus and later showed that the nucleus contained neutrons. Bohr proposed that electrons surround the nucleus in specific energy levels.