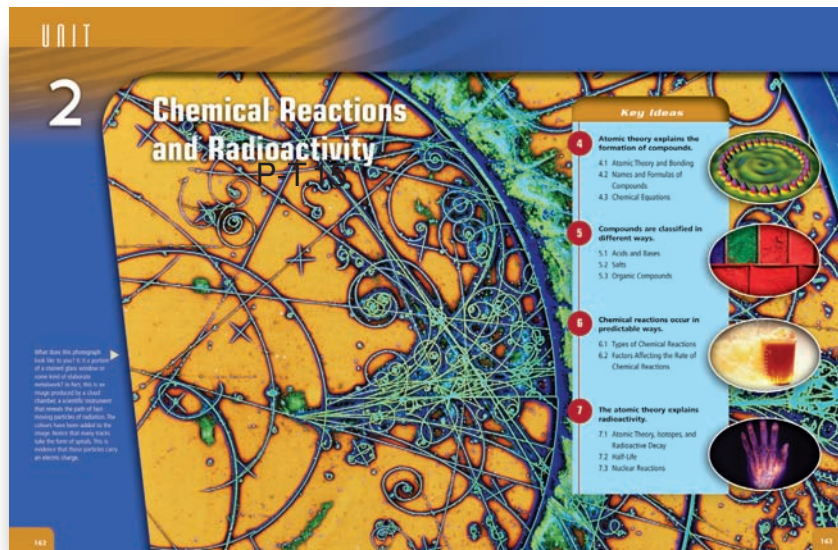


A Tour of Your Textbook

Welcome to *BC Science 10*. This textbook introduces you to the wonders of ecosystems, chemistry, motion, and heat in the environment. Take a brief tour of your textbook on the following pages. Then do the Scavenger Hunt on page xxi.

Unit Opener

- *BC Science 10* has four major units: Sustaining Earth's Ecosystems, Chemical Reactions and Radioactivity, Motion, and Energy Transfer in Natural Systems.
- Each unit opener photo is a window into the world of the Key Ideas you will study in the units. The caption explains the photo.
- The unit opener identifies each of the unit's Key Ideas. These are the chapter titles.
- The small photos next to the Key Ideas are from the beginning of each chapter.



Getting Started

- Getting Started helps you recall what you already know about the Key Ideas in the unit.
- Getting Started helps you prepare for studying the unit by giving you the following:

- a short reading about an interesting topic related to the unit
- an Internet Connect feature to take you to www.bccscience10.ca to learn more about the topic
- a short Find Out Activity so you can explore an idea related to the unit

Getting Started



Dr. Ross Chapman uses surface hydrates on the sea floor using ROV's, located out of Sidney, British Columbia.

Would it ever be possible to light chunks of ice on fire? The answer is yes, if the chunks contain methane hydrates. Hydrates are chemicals that easily react with water molecules. Methane is the principal component of the natural gas used to heat many homes in Canada. Methane hydrates can be found in ocean trenches, which are the deepest parts of the ocean where the sea floor is slowly moving down into Earth's crust. Along the west coast of British Columbia, the floor of the Pacific Ocean is sliding beneath North America. Deep inside Earth, heat and pressure cause the formation of methane gas. When the methane gas bubbles seep to the surface of the sea floor, they encounter ice and sink into it, becoming trapped in "water cages." This is why it is possible to literally light the special form of ice on fire—the methane trapped in the water beam.

Internet connect
Find out more about methane hydrates. Visit www.bccscience10.ca

Calcium Metal in Water **Find Out ACTIVITY**

In this activity, you will add calcium metal to water. Work safely and cooperatively. Use this opportunity to increase your laboratory skills.

Safety

- Avoid touching the calcium. Calcium reacts with moisture, including the moisture on your hands.
- Follow your teacher's directions regarding using open flames.
- Do not touch the calcium.
- Be sure to wear eye protection.
- Avoid touching all reactants and products.
- Wash your hands and equipment thoroughly after completing this activity.
- Do not remove any materials from the science room.

Materials

- medium-diameter test tube
- test tube rack
- large-diameter test tube (to fit over medium test tube)
- water
- matches or flame stickler
- candle or Bunsen burner
- sandpaper or triangular file
- calcium metal
- paper towel
- test tube tongs
- wooden splints

What to Do

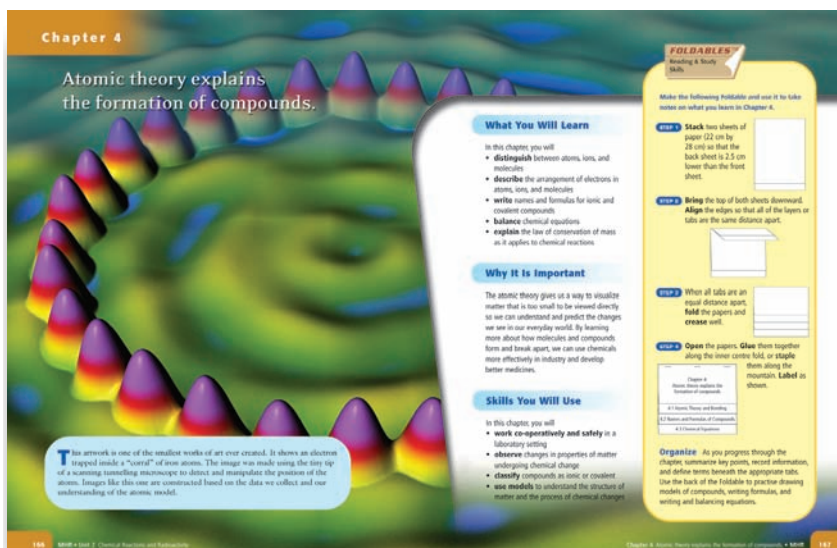
1. Your teacher will review the detailed safety information on pages IX to XX before you begin this activity.
2. Create a data table to record observations you make during the activity. Give your table a title.
3. Place the medium test tube in the test tube rack. Make sure the large test tube will fit over the medium test tube. Set the large test tube aside, such as in the space of your spaced notebook. Place water in the medium test tube to a depth of about 3 cm.
4. Set up a lit candle or Bunsen burner according to your teacher's instructions.
5. Use sandpaper or a triangular file to expose a fresh piece of the calcium metal surface. Do this over a piece of wet paper towel. Be sure to wear gloves. Do not touch the calcium with your bare hands. Observe.
6. Place the calcium metal into the water in the medium test tube. Slide the large test tube over the mouth of the medium one.
7. Observe for about 30 s, then use test tube tongs to lift the large test tube off the medium one. Keeping the large test tube turned upside down, bring it to window light near the mouth of the large test tube. Firmly hold on to the large test tube. Be prepared for a reaction, and do not drop the test tube!
8. Repeat the experiment again if time permits.
9. Record your observations.
10. Clean up and put away the equipment you have used. Follow your teacher's instructions for disposal of wastes.

What Did You Find Out?

1. Reflect on this activity in terms of laboratory safety. What safety issues are important to this activity?
2. **What physical changes did you observe?**
What chemical changes do you think happened? Explain.

Chapter Opener

- The chapter title sentence is the Key Idea that you will study in this chapter.
- The chapter opener outlines What You Will Learn, Why It Is Important, and Skills You Will Use in the chapter.
- The **Foldables** exercise is a fun way to develop your study skills. Look for a Foldables exercise at the beginning of every chapter.



Section Opener

- Each new section in a chapter begins with a new number and a short title.
- The shaded light brown box below the section title contains a summary of the science concepts you will study in the section.
- The list of Words to Know in the margin identifies important new science terms that you will learn in the section.
- The **Did You Know?** margin feature is an interesting bit of information related to the section's topic.
- Each section opener includes a **Find Out Activity** or a **Think About It**.

4.1 Atomic Theory and Bonding

Atoms are composed of protons and neutrons, which make up the nucleus, and electrons, which surround the nucleus in patterns. Bohr diagrams show the arrangement of protons, neutrons, and electrons in atoms and also in ions, ions are formed from atoms that have lost or gained electrons. Compounds can be ionic or covalent. Lewis diagrams show the arrangement of bonds within compounds.

Words to Know

- atomic number
- Bohr diagram
- covalent bonding
- ionic bonding
- ions
- Lewis diagram
- molecule
- valence electrons

Did You Know?

Imagine dumping sand onto an area the size of a hockey arena and the ice will be buried under 30 m of sand! Suppose that volume of sand represents 1 a half of the volume occupied by 0.5 a liter of water and would represent one femtomole (10⁻¹⁵ mol) of a femtomole would be one single grain of sand.

Figure 4.1A A researcher adjusts a component in a femtomole laser at the National Institute of Standards and Technology. The apparatus is used for measuring chemical changes.

In earlier science studies, you learned that a pure substance is made up of only one kind of matter. There are two categories of pure substances. An element is a pure substance that cannot be chemically broken down into simpler substances. A compound is a pure substance that is composed of two or more atoms combined in a specific way.

An atom is the smallest particle of any element that retains the properties of the element. How small is an atom? If you could line up 10 million atoms, the line would be about 1 cm long.

Because atoms are incredibly small, you cannot see an atom with regular light. With a femtomole laser, the energy from an extremely fine pulse of laser light is used to position atoms and detect chemical changes. Chemical changes are changes in the ways the atoms and molecules in a pure substance are arranged and interconnected. To help get the clearest image, the chemicals are usually cooled to much as possible to slow down the particles.

People believed that atoms existed long before we were able to capture images of them. Two hundred years ago, John Dalton imagined that an atom could exist. With the invention of femtomole laser technology, it is now possible to detect the movement of a single hydrogen atom (Figure 4.1B).

Figure 4.1B A digital microscope measures the speed and mass of the femtomole laser.

4-1A Observing Chemical Changes

In this demonstration, you will observe chemical changes and reflect on some of the chemistry you learned in earlier science studies.

Safety

- Use a flame hood.
- Follow your teacher's directions regarding using open flames.
- The sparks from the burning steel wool are hot enough to cause burns.
- The light from burning magnesium is very bright and releases UV rays. Observe the light only from a distance and through glass, which absorbs UV.
- Persons with medical conditions that make them prone to seizure should not look directly at the light.
- Avoid touching all materials and products.
- Wash your hands and equipment thoroughly after completing the activity.
- Do not remove any materials from the science room.

Materials

- flame hood
- steel wool
- 5.0 V dry cell
- magnesium ribbon
- large Pyrex® beaker
- tongs
- preparatory torch or Bunsen burner
- matches or flame color
- hot pad

Teacher Demonstration

What to Do

- Observe as your teacher uses the steel wool to make a short circuit between the terminals of the 5.0 V dry cell.
- Record your observations.
- Observe as your teacher sparks a small piece of magnesium ribbon over a large Pyrex® beaker.
- Record your observations.

What Did You Find Out?

- Reflect on this activity in terms of laboratory safety. What safety issues are important to the activity?
- Suggest which gas or gases in the air may have been responsible for the chemical changes that you saw.
- How pure substances were formed in these chemical changes. Suggest what pure substances or substances formed in:
 - the first demonstration
 - the second demonstration

Find Out Activity

- This short, informal inquiry activity involves hands-on exploration, using simple materials and equipment.
- In these activities and in the investigations, you will use important science process skills, such as predicting, estimating, and hypothesizing.

Science Skills

- This box directs you to one of 13 Science Skills sections at the back of your textbook. The Science Skills sections can help you with graphing, writing an hypothesis, using a microscope, and other skills.

Think About It

- The Think About It activities look similar to Find Out activities, but you do them at your desk. They do not require any special equipment.
- For these activities, you think about a particular idea related to the concepts you are studying in the section.
- You work on your own, with a partner, or in a group, and share your thoughts with your group or class.

Section Text and Activities

- The text of each section is divided into “chunks” to help you understand the content. Each chunk has a title.
- Each picture has a caption that explains what the picture is about.
- Terms you need to know are boldfaced in the text. Each boldfaced term is defined in the text and in the **Glossary** at the back of the textbook.

- **Reading Checks** contain questions that help you test your understanding of what you have just read.
- Find Out and Think About It activities may appear throughout the text. Longer, more formal investigations are at the end of the section.

Conservation of Mass in Chemical Change

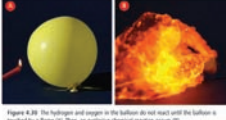


Figure 4.28 The hydrogen and oxygen in the balloon do not react until the balloon is touched by a flame (A). Then, an explosive chemical reaction occurs (B).

What happens to atoms of hydrogen and oxygen as they are brought together and ignited (Figure 4.30)? Are new atoms created in the flask? Are some destroyed?

These are questions that the English chemist John Dalton (1766–1844) thought about 200 years ago (Figure 4.31). He imagined that tiny particles called atoms rearranged themselves in new ways during chemical reactions (Figure 4.32). He also imagined that during chemical reactions no atoms are created or destroyed. The total number of each kind of atom present at the start of the reaction equaled the total number of each kind of atom after the reaction. Dalton used these ideas to draw symbols for compounds as combinations of the atoms of different elements (Figure 4.33).




Figure 4.29 Dalton thought of atoms as combining when compounds form.




Figure 4.30 The reaction of oxygen molecules with hydrogen molecules creates rearranging atoms in new ways.




Figure 4.31 Antoine Lavoisier and his wife Marie-Anne performed a hydrogen combustion experiment.

Other researchers, such as Antoine Lavoisier (Figure 4.34) (1743–1794), who was a French chemist, and his wife, Marie-Anne, made careful measurements of the masses of reactants and products in many chemical reactions (Figure 4.34). They found that the total mass of the system never changed during a chemical change. Antoine Lavoisier identified and named oxygen in 1778 and hydrogen in 1783. He is credited with determining that water results from the combination of the elements oxygen and hydrogen. Lavoisier also devised a system of naming the elements.

Building on the work of other scientists and on the results of his own carefully controlled experiments, Lavoisier formulated the law of conservation of mass. The law of conservation of mass states that mass is conserved in a chemical reaction; the total mass of the products is always equal to the total mass of the reactants in a chemical reaction. The idea that atoms are conserved (neither made nor destroyed) is believed to be true for all chemical reactions (Figure 4.35).

Conservation of Mass




Figure 4.35 Mass is conserved in a chemical reaction.

Mass A $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$

Mass B $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$

Reading Check

1. What is the definition of a chemical reaction?
2. What are two ways a chemical equation may be written?
3. What ratio can you determine using the coefficient in a chemical formula?
4. What are the four abbreviations for a compound's state of matter?
5. According to the law of conservation of mass, what does the total mass of the products in a chemical reaction equal?

Word Connection

“Conservation” means keeping or protecting. In science, there are many conservation laws. In each conservation law, some quantity, such as mass or energy, remains unchanged under all conditions.

Figure 4.32 Dalton had imagined the way atoms can join to form compounds; he could picture how these atoms might rearrange in a chemical reaction.

Figure 4.33 Dalton had imagined the way atoms can join to form compounds; he could picture how these atoms might rearrange in a chemical reaction.

Gamma Radiation

Gamma radiation consists of rays of high energy, short wavelength radiation (Figure 7.13). Gamma radiation is represented by the symbol γ . Because gamma radiation has almost no mass and no charge, the release of gamma radiation does not change the atomic number or the mass number of a nucleus.

If you turn back to Figure 7.1 on page 287, you will notice that gamma rays are the highest energy form of electromagnetic radiation. Gamma rays have much more energy than ultraviolet rays or X rays and are more dangerous than other forms of electromagnetic radiation. Gamma radiation has the greatest penetrating power of the three types of radiation. Thick blocks of dense materials, such as lead and concrete, are needed to stop gamma rays.

Gamma decay results from a redistribution of energy within the nucleus. A high energy gamma ray is given off as the isotope falls from a high energy state to a lower energy state. For example, high energy nickel-60 can decay to nickel-60 by gamma decay:



The “**” means that the nickel nucleus has extra energy. This extra energy is released as a gamma ray. Many kinds of radioactive decay can release gamma rays. For example, gamma rays accompany the alpha decay of uranium-238.



The 2 in front of the γ symbol indicates that two gamma rays are emitted.

Reading Check

1. What is radioactive decay?
2. What is a radioisotope?
3. What are the names of the three main types of radiation?
4. What is the electric charge of each of the three kinds of radioactive decay?
5. List the symbols used for:
 - (a) alpha radiation (two symbols)
 - (b) beta radiation (two symbols)
 - (c) gamma radiation

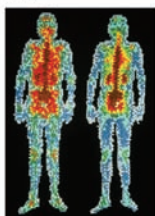


Figure 7.13 Here (right) and back (left) of a non-radioactive substance that concentrates in the bones. The colors are ordered according to the strength of the gamma radiation, energy level due to the bones because they store the highest amount.

Suggested Activity

- These small margin features indicate related activities your teacher may have you do from the end of the section.

Conduct an Investigation

- These formal labs give you the opportunity to develop science skills using various equipment and materials.
- In these investigations, you can ask questions about science, make observations, and obtain results.
- You then analyze your results to determine what they tell you about the topic you are investigating.
- Photographs help you do the investigation.
- Safety icons and safety warnings alert you to any special precautions you should take to help maintain a safe classroom environment.
- Each investigation has one of the following focuses: inquiry, decision-making, or problem-solving.
- You will also have opportunities to design your own investigation.

End-of-Section Features

- These features give you an opportunity to learn about applications or explorations of the topic you have studied in the section.
- **Science Watch** features provide information on past and current scientific topics and research.
- The “www” in “**www science**” stands for “wild, weird, wonderful.” These features describe interesting and unusual science.
- **National Geographic Visualizing Science** features are exciting visual representations of a science topic.
- **Science-Math Connect** features connect the science you learned in the section to math concepts.
- **Career Connect** features are interviews with people who have a career related to the unit.

7-3C Evaluating Nuclear Waste Storage **Conduct an INVESTIGATION**

Skills & Concepts

- 1. Communicating
- 2. Analyzing
- 3. Evaluating Information

Issue

Burning fossil fuels, such as coal, is contributing to global climate change, including dramatic changes in the Canadian Arctic. Should we consider using nuclear power as a “green” energy source for Canada?

Background Information

There are many considerations regarding the production of nuclear energy. One of them is how to manage and store nuclear waste over thousands of years. Nuclear energy production is based on fission technology that uses uranium isotopes for the production of electrical energy. As these isotopes decay through use in the nuclear reactors, other products are made. Some of these isotopes have very long half-lives. They will remain radioactive for thousands of years, producing dangerously high levels of radiation should they ever be released to the environment. CANDU nuclear power stations have been built in Ontario, Quebec, and New Brunswick. These provinces have decades of experience in generating nuclear power but are still awaiting a solution to the problem of waste storage.

Identify and Analyze Alternatives

Consider these two viewpoints on this issue. The pro-nuclear energy group believes that nuclear power is a green technology that should be promoted in order to supply electrical energy needs in British Columbia because the technology does not contribute to carbon emissions. The question of nuclear waste storage is a technological one and will eventually be solved.

The anti-nuclear power group believes it is dangerous to keep producing nuclear waste that will last more than 10 times longer than recorded human history. Other solutions need to be found to provide environmentally friendly energy sources.

Your task is to choose one side of the argument and research the issue. You will present your findings as either a debate or a class presentation. Your teacher will provide more details about how to present your information.

Begin your research using the following resources:

1. Go to www.bccbc.ca/energy to begin your search for information. Also use search engines, key words such as “nuclear power,” “CANDU,” and “Canadian Nuclear Safety Commission.” You may also wish to use print materials such as magazines, newspapers, and books.
2. Summarize the information you find in a short report for presentation to your class or to use in a debate. Be sure to include only information that supports your viewpoint or reflects the opposite view.

Evaluate

Present your findings and conclusions to your classmates either in a presentation or as a debate.

Chapter 7 The atomic theory explains radioactivity • MHR 133

Science Watch

Pursuing the Dream of Fusion Power



Plasma from solar winds on the Sun's surface and follows the path of powerful magnetic fields.

Nuclear fusion reactions that occur in our Sun produce huge amounts of energy. Is there any way to harness nuclear fusion reactions here on Earth to produce electricity? No commercial nuclear fusion power plants currently exist, but some researchers hope that technology can be invented to bring fusion power into production in an environmentally friendly way. Many governments have the same hope and have invested billions of dollars in pursuit of the dream.

The center of our Sun is very hot—about 15 million degrees Celsius. For many decades, researchers have looked for a practical way to recreate the conditions at the center of our Sun. They have produced extremely hot temperatures during nuclear explosions, but this is not a practical way of producing electricity. An added challenge is that no container made of matter can contain plasma that is as hot as the center of our Sun. Any type of container would melt long before reaching these temperatures. However, there is another way to contain hot gases—with a strong magnetic field.

How can you use a magnetic field to hold gases? Hot gases lose electrons, turning all the atoms into ions. An atom that is called plasma.

In a fusion power reactor, a magnetic field traps hydrogen plasma. One reactor design uses an electromagnet positioned in the shape of a doughnut. The hot plasma stays inside the doughnut and away from the reactor used to generate the magnetic field. Currently, a number of existing experimental facilities are using this technology.

Given these tremendous challenges, as well as huge development costs, why even bother to try to build a fusion power facility if it could be made to work. Fusion power is expected to have a number of advantages. The materials needed for fusion—mixtures of hydrogen—are as plentiful as the oceans themselves. Also, the products of nuclear fusion are expected to be stable isotopes, meaning that there might be no radioactive wastes to worry about. Finally, a small amount of fusion produces a tremendous amount of energy.

Questions

1. What conditions are necessary before isotopes of hydrogen can combine in a fusion reaction?
2. How do the hot plasma conditions that can be millions of degrees get the fuel to combine?
3. List three possible advantages of a successful fusion power reactor.

134 MHR • Unit 2: Chemical Reactions and Radioactivity

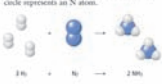
Check Your Understanding

Checking Concepts

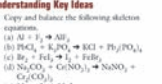
1. Most commercial trucks use diesel fuel. Consider the following reaction that occurs during the combustion of diesel fuel.

$$C_{12}H_{26} + 19.5 O_2 \rightarrow 12 CO_2 + 13 H_2O$$

(a) List the names of the reactants.
 (b) Give the formula of the products.
 (c) What is the coefficient of the carbon dioxide?
 (d) What is the meaning of the “s” symbol on the left side of the equation?
 (e) Write the formula of the reactants and then write a skeleton equation for the reaction it represents. A blue circle represents an H atom. A blue circle represents an S atom.



2. Study the following diagram, and then write a skeleton equation for the reaction it represents. A white circle represents an H atom. A blue circle represents an S atom.



Understanding Key Ideas

3. Copy and balance the following skeleton equations.

- (a) $Al + F_2 \rightarrow AlF_3$
- (b) $PbCl_2 + H_2PO_4 \rightarrow HCl + Pb_3(PO_4)_2$
- (c) $Fe + FeCl_3 \rightarrow FeCl_2 + FeCl_4$
- (d) $Na_2CO_3 + Cu(NO_3)_2 \rightarrow NaNO_3 + Cu_2(CO_3)_2$
- (e) $Mg + Fe \rightarrow MgCl_2 + FeCl_2$
- (f) $K_2SO_4 + AgNO_3 \rightarrow K_2SO_4 + AgNO_3$
- (g) $Ca(OH)_2 + HCl \rightarrow CaCl_2 + H_2O$
- (h) $Mg_3N_2 + Mg \rightarrow Mg_2N_2$
- (i) $Fe + CaCl_2 \rightarrow FeCl_2 + Ca$

4. Write skeleton equations for the following chemical reactions and then balance them. Be sure to check your formulas carefully before you begin to balance.

- (a) lithium sulphate + magnesium sulphate → lithium sulphate + magnesium phosphate
- (b) zinc iodide + copper(I) nitrate → zinc nitrate + copper(I) iodide
- (c) mercury(II) nitrate + sodium hydrogen carbonate → sodium nitrate + mercury(II) hydrogen carbonate
- (d) nickel(III) iodide and iron(II) sulphide → nickel(II) sulphide + iron(II) iodide
- (e) aluminum hydroxide + hydrogen fluoride → aluminum fluoride + water
- (f) hydrogen chloride + barium hydroxide → barium chloride + water
- (g) calcium bromide + potassium carbonate → calcium carbonate + potassium bromide
- (h) titanium(III) fluoride + sodium sulphate → titanium(III) sulphate
- (i) barium sulphate + sodium hydroxide → sodium sulphate + barium hydroxide
- (j) calcium chloride + potassium potassium chloride → calcium potassium chloride + potassium
- (k) hydrogen nitrate + strontium carbonate → strontium nitrate + water + carbon dioxide

Pause and Reflect

The law of conservation of mass was developed after many experiments consistently showed that mass is neither gained nor lost during a chemical reaction. How does our understanding of atoms help explain why mass does not change during chemical reactions?

Chapter 4 Atomic theory explains the formation of compounds • MHR 213

Check Your Understanding

- These section review questions test your new knowledge.

Pause and Reflect

- Pause and Reflect features help you stop and think about what you now know about the topics explained in the chapter. They also make connections among ideas throughout your book.

Prepare Your Own Summary

In this chapter, you learned to classify reactions as one of six different types as well as predict the identity of the products of the reaction. You investigated the factors that affect the rate of chemical reaction and examined the role of catalysts in reaction rate. Create your own summary of the key ideas from this chapter. You may include graphic organizers or illustrations with your notes. (See Science Skill 11 for help with graphic organizers.) Use the following headings to organize your notes.

- Six Types of Chemical Reactions
- Classifying and Predicting Products of Reactions Based on the Reaction Only
- Examples of Reactions Occurring at Different Rates
- Four Factors Affecting the Rates of Reactions

Checking Concepts

- Identify each of the following reactions as synthesis, decomposition, single replacement, double replacement, neutralization (acid-base), or combination.
 - $(\text{H}_2\text{PO}_4)_2 + 3\text{NaOH} \rightarrow \text{Na}_3\text{PO}_4 + 3\text{H}_2\text{O}$
 - $\text{P}_4 + 5\text{O}_2 \rightarrow 2\text{P}_2\text{O}_5$
 - $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$
 - $2\text{HBr} \rightarrow \text{H}_2 + \text{Br}_2$
 - $\text{HF} + \text{KOH} \rightarrow \text{KF} + \text{H}_2\text{O}$
 - $\text{AgNO}_3 \rightarrow \text{Ag} + \text{HNO}_3 + \text{KNO}_3$
 - $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$
 - $2\text{TiCl}_3 + 3\text{H}_2\text{O} \rightarrow 2\text{Ti} + \text{H}_2\text{SiO}_3 + 3\text{HCl}$
 - $2\text{NH}_4\text{CO}_3 \rightarrow \text{MnCO}_3 + \text{H}_2\text{O}$
 - $2\text{NH}_4\text{NO}_3 \rightarrow \text{MnCO}_3 + \text{H}_2\text{O}$
 - $\text{C}_2\text{H}_6 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
- Each reaction below has been identified by type. Use this information to help predict products. Copy and then complete each equation by writing the products of the reactions. Hint: Use the charges shown on the periodic table in Figure 4.3 on page 172. Remember to include subscripts and parentheses where required.
 - $\text{M} + \text{F}_2 \rightarrow \text{MF}_3$ (metal)
 - $\text{K} + \text{O}_2 \rightarrow \text{K}_2\text{O}$ (metal)
 - $\text{C}_2\text{H}_4 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$ (combination)
 - $\text{BaCl}_2 + \text{Na}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + \text{NaCl}$ (double replacement)
 - $\text{Fe} + \text{Ni} \rightarrow \text{FeNi}$ (single replacement, element is a non-metal)
 - $\text{Cl}_2 + \text{Mg}_2\text{N}_2 \rightarrow \text{MgCl}_2 + \text{N}_2$ (single replacement, element is a non-metal)
 - $\text{HCl} + \text{Mg}(\text{OH})_2 \rightarrow \text{MgCl}_2 + \text{H}_2\text{O}$ (neutralization, acid-base)
 - $\text{Al} + \text{CuCl}_2 \rightarrow \text{AlCl}_3 + \text{Cu}$ (single replacement, element is a metal)
 - $\text{Mg} + \text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$ (single replacement, element is a metal)
- Which type(s) of reactions match the following descriptions?
 - There is only one reactant.
 - There is only one product.
 - The reactants are an acid and a base.
 - The products are an element and a compound.
 - The products are carbon dioxide and water.
 - Both reactants are compounds.
 - One reactant is an element. The other is a compound.

Which of the four factors affecting reaction rate is most important in each example below?

- Choose from among concentration, temperature, surface area, and catalyst.
- Extra dish soap is added to help cut the grease when washing a frying pan.
- Firewood is chopped up into kindling (small pieces) to help start a fire.
- A lighted match is brought near a candlewick in order to light the candle.
- Leaves just to be rubbed on an iron sink to help remove rust.
- The accelerator pedal in a car is pressed, resulting in a faster consumption of fuel in the engine.
- The reaction of oxygen with sucrose in human cells takes place in the presence of an enzyme.
- In order to reduce the damage of garlic when frying it in oil, the garlic is crushed and ground.
- A mild stain dissolvent containing hydrogen peroxide is prepared in a 1 percent solution, while a stronger formulation is prepared in a 6 percent solution.

- butane bromide + heat(IV) bromide \rightarrow butane bromide + heat(IV) bromide
- glycerine ($\text{C}_3\text{H}_8\text{O}_3$) \rightarrow oxygen + carbon dioxide + water
- nitrogen + oxygen \rightarrow nitrogen dioxide

Applying Your Understanding

7. Suppose a chemist performed an experiment showing equal masses of marble in hydrochloric acid. The results of the three trials are shown in the table below.

Trial	Hydrochloric Acid Concentration	Marble	Temperature
1	Dilute	Large	20°C
2	Concentrated	Large	20°C
3	Dilute	Large	40°C

The marble dissolved fastest in Trial 3, and slowest in Trial 2. List concentration, surface area, and temperature in decreasing order of their importance to increasing the rate of this reaction.

Pause and Reflect

Many chemical reactions happen in your daily life. What might be important to you in terms of knowledge of speed of or slowing down chemical reactions? How could you use your knowledge?

Understanding Key Ideas

- Classify each of the following reactions, and write a balanced formula equation for each.
 - Iron(III) oxide + oxygen \rightarrow iron(III) oxide
 - Magnesium + aluminum chloride \rightarrow magnesium chloride + aluminum
 - Iron(III) oxide + water \rightarrow iron(III) hydroxide + water
 - Hydrochloric acid + lithium hydroxide \rightarrow lithium chloride + water
 - Aluminum oxide + aluminum + oxygen \rightarrow iron + gold(III) nitrate \rightarrow iron(IV) nitrate + gold

Chapter Review

- At the end of each chapter, the Chapter Review can help you study for a chapter test.
- The guide under the heading “Prepare Your Own Summary” can help you summarize what you have learned in the chapter.
- The review questions help you recall, think about, and apply what you have learned.

Unit Summary

- This is a summary of the Key Ideas and Key Terms covered in the unit.
- The photographs next to the Key Terms are from the chapter openers to remind you of what you covered in that chapter.

End-of-Unit Project and Integrated Research Investigation

- Each Project lets you apply key concepts and skills from the unit. You complete the Project as part of a team.
- For the Integrated Research Investigation, you explore a unit-related topic. You have an opportunity to use information that you have researched to do a report or presentation about that topic.

Unit Summary

1.1 Atomic theory explains the formation of compounds.

- Atoms are neutral. In an ion, the number of electrons and protons differs, giving the ion an electrical charge. (4.1)
- Compounds containing a metal and a non-metal usually form ionic compounds in which positive and negative ions are connected by ionic bonds. Compounds containing only non-metals form molecules in which the atoms are connected by covalent bonds. (4.2)
- Chemical equations are words or symbols that identify the reactants and products in a chemical reaction. (4.3)
- The law of conservation of mass states that the total mass of all the reactants in a chemical reaction is equal to the total mass of all the products. (4.3)

1.2 Compounds are classified in different ways.

- The formula of an acid has an H on the left side. The formula of a base has an OH on the right of a metal. A salt is an ionic compound formed from an acid-base neutralization. (5.1)
- The pH scale is a way of measuring the concentration of the H⁺ ion. A neutral solution has a pH = 7, an acidic solution has a pH < 7, and a basic solution has a pH > 7. (5.2)
- Oxides that contain a metal react with water to form basic solutions. Oxides that contain only non-metals react with water to form acidic solutions. (5.2)
- Organic compounds are compounds that contain carbon and usually also contain hydrogen. (5.3)

1.3 Chemical reactions occur in predictable ways.

- Chemical reactions can be classified as synthesis, decomposition, single replacement, double replacement, neutralization (acid-base), or combination. (6.1)
- It is possible to predict the identity of the products of a reaction based on its classification and knowledge of the reactants. (6.1)
- Factors that affect the rate of a reaction include temperature, concentration, surface area, and the presence of a catalyst. (6.2)
- A catalyst is a substance that speeds up the rate of a chemical reaction but is not present in its original amount at the end of the reaction. (6.2)

1.4 The atomic theory explains radioactivity.

- Isotopes are atoms of the same element that differ in the number of neutrons that they possess. (7.1)
- Radioactive decay results from changes in the nucleus of an atom and can produce alpha, beta, and gamma radiation. (7.1)
- A half-life is the length of time required for half the nuclei in a sample of a radioactive isotope to decay into its products. (7.2)
- Nuclear reactions involve the splitting of heavy nuclei (fission) or the joining together of lightweight nuclei (fusion) and the joining together of lightweight nuclei. (7.2)
- Radioactive decay, fission, and fusion reactions can be harnessed using nuclear equations. (7.3)

Key Terms

- atom
- atomic number
- balanced chemical equation
- binary covalent compound
- ion
- chemical equation
- chemical reaction
- compound
- ionization energy
- product
- precipitation reaction
- ionic bonding
- ionic compounds
- subscript
- synthesis
- valence electron

Key Terms

- acid
- alcohol
- base
- biomolecule
- fuel
- concentration
- hydrocarbon
- indefinite mixture
- mercury
- linen paper
- metal oxide
- metal sulfate
- non-metal oxide
- organic
- organic chemistry
- oxide
- pH indicator
- phosphobutane
- salt
- solvent

Key Terms

- neutralization (acid-base)
- precipitate
- rate of reaction
- single replacement
- surface area
- synthesis

Key Terms

- alpha particle
- beta particle
- chain reaction
- daughter nuclide
- decay curve
- fusion

Key Terms

- gamma radiation
- half-life
- light
- mass number
- nuclear equation
- parent nuclide
- radiation
- radioactive decay
- radioactive dating

Project

Chemical Reactions Involving Magnesium

Magnesium is a metal that takes part in many different chemical reactions. Most chemical reactions involving magnesium fall into one of the six types of reactions you have studied, but others do not. In this activity, you will choose several chemical reactions involving magnesium to investigate. You will also attempt to classify and write equations for the chemical reactions.

Problem
What are some of the chemical reactions involving magnesium?

Safety

- Do not mix any chemicals without your teacher's approval.
- Wear safety goggles and protective clothing.
- Avoid breathing all reactions and products.
- Follow your teacher's directions regarding the reaction.
- Never taste or eat anything in the science room.
- Wash your hands and equipment thoroughly after completing this activity.
- Do not remove any materials from the science room.

Materials

- three 2 cm strips of Mg ribbon
- laboratory equipment necessary to weigh, mix, combine, and heat your chemicals
- Some of the following:
 - dilute hydrochloric acid solution (HCl (aq))
 - magnesium sulphate powder (MgSO₄)
 - sodium carbonate (Na₂CO₃)
 - potassium chlorate powder
 - magnesium carbonate
 - phosphobutane indicator
 - water

Integrated Research Investigation

Chemicals Among Us

Many of the organic and inorganic chemicals we use in daily life are fairly recent inventions that humans have designed to serve a purpose. However, some of these chemicals have created health or environmental problems. Your teacher will assign you a chemical or group of chemicals to research, or you can choose your own. Research the structure, uses, and any negative effects or problems this chemical might cause. You can take a position regarding whether you think the pros outweigh the cons of using the chemical. Try to be as balanced as possible in your descriptions. Several possible choices of chemicals are outlined below.

Diisphenol A
Diisphenol A is used in the manufacture of rigid plastics such as polycarbonate water bottles, eyeglass lenses, CDs, and showerproof baby bottles. Some tests on animals suggest it brings an increased risk of cancer as well as hyperactivity, and mimics the hormone oestrogen, which may have health implications. Do we need to change our use of this chemical?

DDT
DDT is an insecticide that was widely used in the middle of the 20th century to combat mosquito populations. It was used around the world and spread to vast quantities. However, a worldwide ban on the use of DDT was created after it was discovered that DDT caused problems throughout the food chain. There has been an increase in malaria, a disease spread by mosquito bites, and now DDT is again being used in India, Korea, and on mosquito nets. Should DDT be allowed, a wide use?

Phthalates
Phthalates are a class of compounds that can be found in everyday items, flexible containers, and plastic tubing used in hospitals to deliver medicine. Heat can cause the release of phthalates from plastics. We readily absorb phthalates but may also quickly eliminate them from our body. Is there any danger in their use?

PBDEs
Flame retardants, such as PBDEs, are chemicals added to prevent the spread of fire. They can be found in products such as pillows and mattresses, furniture, clothing, and plastic covers for objects such as radios and automobile dashboard. Some studies show that high doses of PBDEs can cause nerve damage and cause reproduction problems in animals. Does the potential for saving lives outweigh the possible harmful effects?

Find Out More
Choose one particular chemical or group of chemicals and research about what is known (and also what is not known) about its effect on human health or its environmental effects. Use the Internet (start at www.bowdoin.edu), the encyclopedia, or interviews with experts to gather facts on your topic. Be sure that our all-reviews will give a balanced view of a given topic. Be sure to provide a bibliography of your sources of information, including websites. Follow the guide that your teacher provides for crediting sources of information.

Report Out
Design and make a pamphlet, including illustrations and/or photographs, and a description of the chemical or class of chemicals you researched. Include a model such as a drawing or computer simulation of the structure of the chemical. You may wish to use a chart indicating pros and cons for its use.

Unit Review

- At the end of each unit, the Unit Review can help you study for a unit test.
- The review questions help you recall, think about, and apply what you have learned.

Unit Review

Unit 2

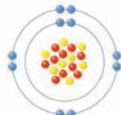
Developing Skills

56. Classify each of the following chemical reactions as one of the five types of reactions. Write a balanced chemical equation for each.

- Chromium combines with oxygen gas to form chromium(III) oxide.
- Copper combines with silver nitrate to make copper(II) nitrate and silver.
- Lead(II) nitrate and potassium iodide produce potassium nitrate and lead(II) iodide.
- Ethane (C_2H_6) reacts with oxygen to produce carbon dioxide and water.
- An electric current is passed through liquid sodium chloride. This results in the production of sodium and chlorine.
- Hydrochloric acid and sodium hydroxide produce sodium chloride and water.

57. Consider the following diagram. Identify the atom or ions that are represented.

- The yellow particles are protons, the red particles are neutrons, and the blue particles are electrons.
- The yellow particles are neutrons and the red particles are protons.



Applying Your Understanding

58. A piece of red litmus is placed into a solution and it remains red. Blue litmus is placed into the same solution, and it remains blue. What is the pH of the solution?

- 2
- 7
- 10
- 12

59. The pH cannot be determined.

60. What is the pH of a solution that is methyl red indicator?

- 3.5
- 4
- 4.5
- 5

61. A solution of unknown identity is tested using acid-base indicators. The solution causes phenolphthalein to turn pink and causes indigo carmine to turn blue. Which of the following is consistent with these results?

- nitrous
- ammonia
- water
- oxalic acid

62. A large sample of rock contains 6.0 g of uranium-235. How much of the radioactive isotope will remain after three half-lives?

- 0.80 g
- 0.82 g
- 0.84 g
- 1.24 g

63. When a sample of volcanic rock solidified from magma, no argon-40 was present. How old is the sample of rock if it now contains 0.1 g of potassium-40 and 0.1 g of argon-40? Use the Common Isotope Pair Chart, Table 7.6 on page 307, to help you determine your answer.

- 10 000 years
- 2.0 billion years
- 1.3 billion years
- 3 billion years

64. A pill for the treatment of acid spills contains magnesium oxide and sodium carbonate. Why are these chemicals useful for neutralizing acids?

- Both are bases.
- Both are acids.
- Magnesium oxide is an acid and sodium carbonate is a base.
- Magnesium oxide is a base and sodium carbonate is an acid.

65. Suppose that element "M" is a metal with two valence electrons. Element "X" is a non-metal with five valence electrons. When they combine chemically, they form an ionic compound. What could be the chemical formula of this compound?

- M_2X
- M_5X_2
- Ca_2N
- Ca_5N_2

66. You may have noticed on cold days that there is often liquid dripping from the tailpipes of cars. Which of the following explains this observation?

- The liquid is gasoline, which is being blown from the gas tank due to the cold temperature.
- The liquid is gasoline, which is being blown from the engine due to the cold temperature.
- The liquid is water, which condenses from the cold air outside the car.
- The liquid is water, which is produced during the combustion of gasoline.

67. When copper is exposed to the weather, it slowly turns blue-green. When silver tarnishes, it becomes black. What class of chemical reaction is illustrated by these observations?

- synthesis
- decomposition
- double replacement
- combustion

68. Nitrogen monoxide is a poisonous gas that is produced during the combustion of gasoline. However, in the presence of platinum metal, the reaction occurs instantly. What is the role of platinum in speeding up this reaction?

- Platinum heats up the nitrogen monoxide.
- Platinum cools down the nitrogen monoxide.
- Platinum increases the concentration of the nitrogen monoxide.
- Platinum is a catalyst that decomposes the nitrogen monoxide.

69. Many countries rely on the burning of coal for the production of electrical energy. Coal often contains sulphur, which forms sulphur dioxide when it is burned. How does the burning of coal contribute to precipitation that has a low pH?

- Sulphur is an acid.
- Sulphur oxides form acidic solutions.
- Sulphur is a base.
- Sulphur oxides form basic solutions.

70. Baking powder is used in baking because it contains both an acid and a base mixed together. During the baking process, the acid and base react to produce a gas, water, and, most importantly, carbon dioxide, the gas responsible for making baked goods rise-up and become light and fluffy. Which of the following could be reasons why the acid and base in the baking powder do not react with each other before they are mixed with the other ingredients?

- The acid and base must dissolve into solution before they can react.
- The acid and base need to be heated before they can react.
- Mixing with flour increases the concentration of the acid.
- I only.
- III only.
- I, II, and III.

Pause and Reflect

Go back to the beginning of the unit and look again at the opening photograph of the image of the cloud chamber. How would you describe the particles moving through the cloud chamber now that you have investigated the topics in this chapter?

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Other Features

Word Connect

- The Word Connect margin feature gives you additional information on scientific terms.

Explore More

- You can “Explore More” by following the suggestions in these features to investigate further a topic you have studied.

internet connect

- These features help you research more information about a topic.
- The *BC Science 10* website links you to other websites related to the topic you are researching.



- Safety icons are included in many activities and investigations. The safety icons are extremely important. They alert you to any safety precautions you should take. Safety icons used in *BC Science 10* are shown on page 552.

