1.1 The Study of Chemistry

Section Preview/ Specific Expectations

In this section, you will

- **identify** examples of chemistry and chemical processes in everyday use
- **communicate** ideas related to chemistry and its relationship to technology, society, and the environment, using appropriate scientific vocabulary
- **communicate** your understanding of the following terms: *chemistry, STSE*

Many people, when they hear the word "chemistry," think of scientists in white lab coats. They picture bubbling liquids, frothing and churning inside mazes of laboratory glassware.

Is this a fair portrayal of chemistry and chemists? Certainly, chemistry happens in laboratories. Laboratory chemists often do wear white lab coats, and they do use lots of glassware! Chemistry also happens everywhere around you, however. It happens in your home, your school, your community, and the environment. Chemistry is happening right now, inside every cell in your body. You are alive because of chemical changes and processes.

Chemistry **is the study of matter and its composition. Chemistry is also the study of what happens when matter interacts with other matter. When you mix ingredients for a cake and put the batter in the oven, that is chemistry. When you pour soda water on a stain to remove it from your favourite T-shirt, that is chemistry. When a scientist puts a chunk of an ice-like solid into a beaker, causing white mist to ooze over the rim, that is chemistry, too. Figure 1.1 illustrates this interaction, as well as several other examples of chemistry in everyday life.**

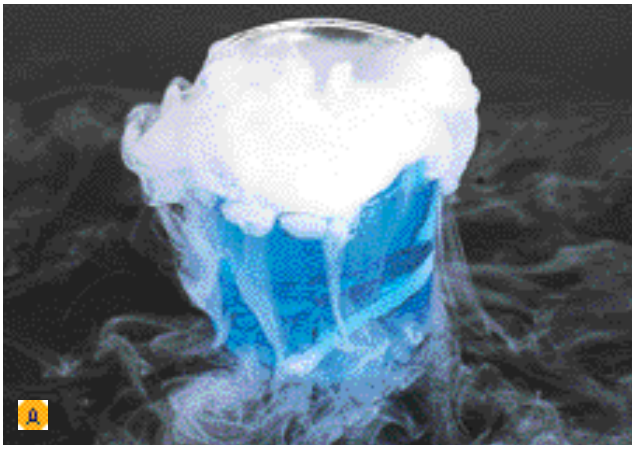


Figure 1.1

A Frozen (solid) carbon dioxide is also known as "dry ice." It changes to a gas at temperatures higher than −78°C. In this photograph, warm water has been used to speed up the process, and food colouring has been added.

B Dry ice is also used to create special effects for rock concerts, stage plays, and movies.

C Nitrogen gas becomes a liquid at –196°C. Liquid nitrogen is used to freeze delicate materials, such as food, instantly.

Chemistry: A Blend of Science and Technology

Like all scientists, chemists try to describe and explain the world. Chemists start by asking questions such as these:

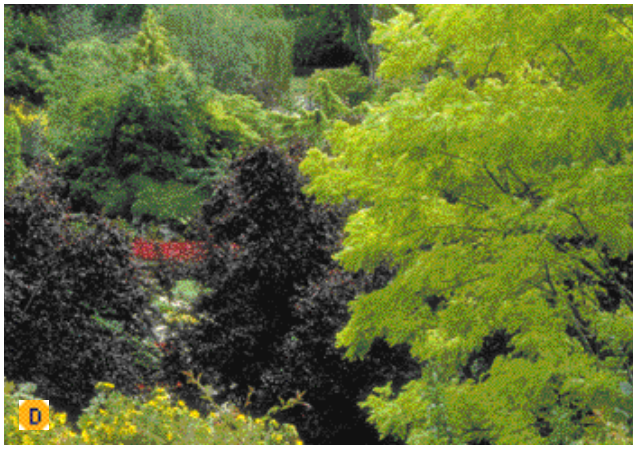
- **Why is natural gas such an effective fuel?**
- **How can we separate a mixture of crude oil and water?**
- **Which materials dissolve in water?**
- **What is rust and why does it form?**

To answer these questions, chemists develop models, conduct experiments, and seek patterns. They observe various types of chemical reactions, and they perform calculations based on known data. They build continuously on the work and the discoveries of other scientists.

Long before humans developed a scientific understanding of the world, they invented chemical techniques and processes. These techniques and processes included smelting and shaping metals, growing crops, and making medicines. Early chemists invented technological instruments, such as glassware and distillation equipment.

Present-day chemical technologists continue to invent new equipment. They also invent new or better ways to provide products and services that people want. Chemical technologists ask questions such as the following:

- **How can we redesign this motor to run on natural gas?**
- **How can we contain and clean up an oil spill?**
- **What methods can we use, or develop, to make water safe to drink?**
- **How can we prevent iron objects from rusting?**



D Green plants use a chemical process, called photosynthesis, to convert water and carbon dioxide into the food substances they need to survive. All the foods that you eat depend on this process.

E Your body uses chemical processes to break down food and to release energy.

F Your home is full of products that are manufactured by chemical industries. The products that are shown here are often used for cleaning. Some of these products, such as bleach and drain cleaner, can be dangerous if handled improperly.

Chemistry, Technology, Society, and the Environment

Today we benefit in many ways from chemical understanding and technologies. Each benefit, however, has risks associated with it. The risks and benefits of chemical processes and technologies affect us either directly or indirectly. Many people—either on their own, in groups, or through their elected government officials—assess these risks and benefits. They ask questions such as the following:

- **Is it dangerous to use natural gas to heat my home?**
- **Why is the cost of gasoline so high?**
- **Is my water really clean enough to drink and use safely?**
- **How does rust degrade machinery over time?**

During your chemistry course this year, you will study the interactions among science, technology, society, and the environment. These interactions are abbreviated as STSE. Throughout the textbook—in examples, practice problems, activities, investigations, and features—STSE interactions are discussed. The issues that appear at the end of some units are especially rich sources for considering STSE interactions. In these simulations, you are encouraged to assess and make decisions about important issues that affect society and the environment.

STSE Issue: Are Phosphates Helpful or Harmful?

Phosphorus is an essential nutrient for life on Earth. Plants need phosphorus, along with other nutrients, in order to grow. Phosphorus is a component of bones and teeth. In addition, phosphorus is excreted as waste from the body. Thus, it is present in human sewage.

Since phosphorus promotes plant growth, phosphates are excellent fertilizers for crops. (*Phosphates* are chemicals containing phosphorus. You will learn more about phosphates later in this unit.) Phosphates are also used as food additives, and as components in some medicines. In addition, they are an important part of dishwasher and laundry detergents. For example, sodium tripolyphosphate (STPP) acts to soften water, and keep dirt suspended in the water. Before the 1970s, STPP was a major ingredient in most detergents.

Phosphates Causing Trouble

In the 1960s, residents around Lake Erie began to notice problems. Thick growths of algae carpeted the surface of the water. Large amounts of the algae washed onto beaches, making the beaches unfit for swimming. The water in the lake looked green, and had an unpleasant odour. As time passed, certain fish species in Lake Erie began to decrease.

In 1969, a joint Canadian and American task force pinpointed the source of the problem. Phosphates and other nutrients were entering the lake, causing algae to grow rapidly. The algae used up dissolved oxygen in the water. As a result, fish and other water species that needed high levels of oxygen were dying off.

The phosphate pollution arrived in the lake from three main sources: wastewater containing detergents, sewage, and run-off from farms carrying phosphate fertilizers. The task force recommended reducing the amount of phosphate in detergents. They also suggested removing phosphorus at wastewater treatment plants before the treated water entered the lake.

Detergent manufacturers were upset by the proposed reduction in phosphates. Without this chemical, their detergents would be less effec-

tive. Also, it would be expensive to develop other chemicals to do the same job. After pressure from the government, detergent companies reduced the amount of phosphate in their products by about 90%. Cities on Lake Erie spent millions of dollars adding phosphorus removal to their waste treatment. Today, Lake Erie has almost completely recovered.

The connection between technology (human-made chemical products) and the environment (Lake Erie) is an obvious STSE connection in this issue. What other connections do you see?

Canadians in Chemistry

John Charles Polanyi was born in Berlin, Germany, into a family of Hungarian origin. Polanyi was born on the eve of the Great Depression, shortly before the Nazi takeover. His father moved to England to become a chemistry professor at Manchester University. Polanyi was sent to Canada for safety during the darkest years of World War II.

John Polanyi went back to England to earn a doctorate in chemistry at Manchester University in 1952. He returned to Canada a few years later. Soon after, he took up a position at the University of Toronto. There Dr. Polanyi pursued the research that earned him a share of the Nobel Prize for chemistry in 1986. He pioneered the field of reaction dynamics, which addresses one of the most basic questions in chemistry: What happens when two substances interact to produce another substance? Polanyi's father had once investigated the same question.

Dr. Polanyi tried to provide some answers by studying the very faint light that is given off by molecules as they undergo chemical changes. This light is invisible to the unaided eye, because it is emitted in the infrared range of energy. It can be detected, however, with the right instruments. Dr. Polanyi's work led to the invention of the laser. As well, his research helped to explain what happens to energy during a chemical reaction.

Dr. Polanyi believes that people must accept the responsibility that comes with scientific understanding and technological progress. He believes, as well, that a vital element of hope lies at the heart of modern science. To Dr. Polanyi, human rights are integral to scientific success. "Science must breathe the oxygen of freedom," he stated in 1999.

This is why Dr. Polanyi says that scientists must take part in the debate on technological, social, and political affairs. Dr. Polanyi points to the political role played by scientists such as Andrei Sakharov in the former Soviet Union, Linus Pauling in the United States, and Fang Lizhi in China.

Make Connections

1. Research the scientists whom Dr. Polanyi mentioned: Andrei Sakharov, Linus Pauling, and Fang Lizhi. What work distinguished them as scientists? What work distinguished them as members of society?
2. Throughout history, chemists have laboured to present the truth as they know it to their fellow scientists and to society. Some of them, such as Linus Pauling, have been scorned and ridiculed by the scientific community. Do further research to discover two other chemists who have struggled to communicate their ideas, and have succeeded.

Section Wrap-up

During this chemistry course, your skills of scientific inquiry will be assessed using the same specific set of criteria (Table 1.1). You will notice that all review questions are coded according to this chart.

Table 1.1 Achievement Chart Criteria, Ontario Science Curriculum

Knowledge and Understanding (K/U)	Inquiry (I)	Communication (C)	Making Connections (MC)
• understanding of concepts, principles, laws, and theories • knowledge of facts and terms • transfer of concepts to new contexts • understanding of relationships between concepts	• application of the skills and strategies of scientific inquiry • application of technical skills and procedures • use of tools, equipment, and materials	• communication of information and ideas • use of scientific terminology, symbols, conventions, and standard (SI) units • communication for different audiences and purposes • use of various forms of communication • use of information technology for scientific purposes	• understanding of connections among science, technology, society, and the environment • analysis of social and economic issues involving science and technology • assessment of impacts of science and technology on the environment • proposing of courses of practical action in relation to science-and technology-based problems

Section Review

1. K/U **Based on your current understanding of chemistry, list five ways in which chemistry and chemical processes affect your life.**
2. I **Earlier in this section, you learned that fertilizers containing phosphorus can cause algae to grow faster. Design an investigation on paper to determine the effect of phosphorus-containing detergents on algae growth.**
3. C **Design a graphic organizer that clearly shows the connections among science, technology, society, and the environment.**
4. MC **For each situation, identify which STSE interaction is most important.**
   - (a) **Research leads to the development of agricultural pesticides.**
   - (b) **The pesticides prevent insects and weeds from destroying crops.**
   - (c) **Rain soaks the excess pesticides on farm land into the ground. It ends up in groundwater systems.**
   - (d) **Wells obtain water from groundwater systems. Well-water in the area is polluted by the pesticides. It is no longer safe to drink.**