

## How does *Nelson Chemistry 11* match the curriculum?

# Balanced Instruction and Assessment

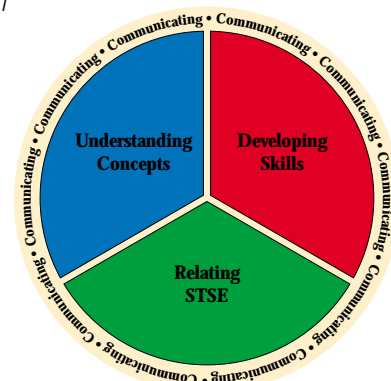
- Nelson Chemistry 11* reflects the overall aim of the secondary science program, which is to “ensure scientific literacy for every secondary school graduate.” (*The Ontario Curriculum, Grades 11 and 12, Science*, p. 6), as well as the primary objective of the *Chemistry, Grade 11, University Preparation* curriculum, which is to “equip students with the knowledge and skills they need to meet the entrance requirements for university programs.”

The Ontario Curriculum, Grades 9 to 12 Program Planning and Assessment, p. 3

- Nelson Chemistry 11* addresses 100% of the *Chemistry, Grade 11, University Science Preparation* (SCH3U) course curriculum expectations
- Nelson Chemistry 11* provides a balance of instruction and assessment, reflecting the three goals of secondary science curriculum, which are:

- Understand the basic concepts of science
- Develop the skills, strategies, and habits of mind required for scientific inquiry
- Relate science to technology, society, and the environment

The Ontario Curriculum, Grades 11 and 12, Science, p. 6



Chapter  
**4**

In this chapter, you will be able to

- explain the law of definite proportions and the significance of different proportions of elements in compounds
- explain the relationship between isotopic abundance and relative atomic mass
- describe and explain Avogadro's constant, the mole concept, and the relationship between the mole and molar mass
- determine empirical and molecular formulas using percentage composition obtained from given data and through experimentation
- describe technological skills for quantitative analysis
- solve problems involving quantities in moles, numbers of particles, and mass numbers

## Quantities in Chemical Formulas

When you read the list of ingredients on a package of cereal, do you also notice how much of each ingredient is contained in a serving? We can compare the quantities of sugar or fat or the percentage of daily requirements of vitamins and minerals in different brands (Figure 1). This quantitative information helps us decide which product to select to suit our needs.

Quantities in chemical formulas offer similar important information about the composition and properties of compounds. For example, water ( $H_2O$ ) and hydrogen peroxide ( $H_2O_2$ ) both contain the same types of atoms. The only difference is in the number of oxygen atoms. This difference, which appears small, actually results in significant differences in the properties of the two compounds. Water is very stable, can be stored safely for indefinite periods, and can be used for drinking and washing. It is an important ingredient of living cells and is essential for all life on Earth. Hydrogen peroxide, on the other hand, is so unstable that it must be stored in darkened containers to slow its decomposition. Concentrated solutions of hydrogen peroxide must be used with caution, because the chemical reacts readily with other substances and will cause blistering of the skin on contact. Because hydrogen peroxide is toxic it is used to kill bacteria—in low concentrations (0.05%) it is used as an antiseptic to treat minor cuts and abrasions. At higher concentrations (6%) it is used to bleach hair, pulp and paper, and synthetic and natural fibers. At even higher concentrations, its bactericidal properties can be applied as part of the treatment of waste water. At sufficiently high concentrations it is explosive.

How can we determine the chemical composition of a substance? Identifying the substance's properties is one method. In this chapter, you will learn other methods to do this. You will also learn how to measure and communicate quantities when dealing with entities as small as atoms, ions, and molecules.

**Reflect your Learning**

- The label on a bag of jelly beans states that the bag contains 40% large jelly beans and 60% small jelly beans, by mass. Do you think this information is sufficient if we want to know how many jelly beans of each size there are in the bag? Explain your answer.
- Given your knowledge of chemical reactions, list reasons why you think it is important to be able to communicate information about the number of atoms, ions, or molecules that are reacting or that are produced.
- Many fossil fuels that are burned in factories contain sulfur; when sulfur reacts with oxygen in the air, sulfur oxides—known air pollutants—are produced. Technicians use different methods to predict the masses of these and other chemical reactions that take place. Suggest reasons why it is important to be able to make these predictions. Speculate on how technicians can make this kind of analysis.

Throughout this chapter, note any changes in your ideas as you learn new concepts and develop your skills.

Figure 1  
Quantities in a list of ingredients help us compare and select products to suit our needs.

**Do Ions Combine in Definite Ratios?**

In this activity you will mix copper(II) ions and carbonate ions in different ratios and see how they combine. The solutions of ions will each contain the same number of ions per unit volume.

**Materials:** lab apron, eye protection, 5 small test tubes of equal size, test-tube rack, eyedropper, 10 mL copper(II) sulfate solution (0.10 mol/L), 10 mL sodium carbonate solution (0.10 mol/L), distilled water.

- Number the test tubes from 1 to 5, and place in the test-tube rack.
- Using the dropper, add drops of copper(II) sulfate solution to each test tube, according to Table 1.
- Wash the dropper thoroughly with distilled water and use the same dropper to add drops of sodium carbonate solution to each test tube, according to Table 1. After you have finished putting drops in each tube, the test tubes should be filled to equal depth since they contain the same number of drops (10 drops total).
- Swirl each test tube gently to mix the contents. Allow the precipitates to settle for about 5 min.
- Wash your hands thoroughly.

(a) What is the ratio of  $Cu^{2+}$  ions to  $CO_3^{2-}$  ions in each test tube?  
(b) Which test tube contains the most precipitate ( $CuCO_3$ )? What is the ratio of  $Cu^{2+}$  ions to  $CO_3^{2-}$  ions in this test tube?  
(c) From what you learned in Unit 1 about ionic bonds, does this ratio agree with a prediction of how copper(II) ions and carbonate ions would combine to form a compound?  
(d) Which test tubes contain the smallest amount of precipitate? Suggest reasons why the ratios of ions in these test tubes produced the least amounts.  
(e) What evidence is there that some copper ions remain unused in solution in some tubes?  
(f) Explain how the evidence suggests that ions combine in definite ratios.  
(g) Dispose of the materials according to your teacher's instructions.

Chapter 4 Summary

**Key Expectations**

Throughout the chapter, you have had the opportunity to do the following:

- Explain how different stoichiometric combinations of elements in compounds can produce substances with different properties. (4.1)
- Explain the law of definite proportions. (4.1)
- Explain the relationship between isotopic abundance and relative atomic mass. (4.2)
- Demonstrate an understanding of Avogadro's constant, the mole concept, and the relationship between the mole and molar mass. (4.3)
- Use appropriate scientific vocabulary to communicate ideas related to chemical calculations. (4.3, 4.4, 4.5, 4.6, 4.7)
- Solve problems involving quantity in moles, number of particles, and mass. (4.4, 4.5, 4.6, 4.7)
- Determine percentage composition of a compound through experimentation, as well as through analysis of the formula and a table of relative atomic masses. (4.5)
- Give examples of the application of chemical quantities and calculations. (4.5, 4.6, 4.7)
- Distinguish between the empirical formula and the molecular formula of a compound. (4.6, 4.7)
- Determine empirical formulas and molecular formulas, given molar masses and percentage composition or mass data. (4.6, 4.7)

**Key Terms**

atomic mass unit  
Avogadro's constant  
diatomic  
empirical formula  
isotopic abundance  
law of definite proportions  
molar mass  
mole  
molecular formula  
relative atomic mass

The **Chapter Opener** describes the key student expectations for the unit. Curricular expectations are synthesized into an easy-to-understand “student language” format.

The chapter-ending **Summary** feature lists the specific Key Expectations addressed, and points to where the expectations have been addressed in the chapter. The expectations are expressed in the same language used in the curriculum document.



# B Develop the Skills, Strategies, and Habits of Mind Required for Scientific Inquiry

Investigations, Activities, Lab Exercises (“Dry labs”), and Try This Activities give students the opportunity to develop scientific inquiry and communications skills. “Directed” investigations strategically integrated throughout the text engage students in observing and experimenting. “Open-ended” investigations require students to plan and conduct their own investigations, form hypotheses, or choose their own questions to investigate. *Inquiry Skills Menus* indicate the skills being developed in investigations. Additional lab-based activities, including computer interface labs, are provided in the teacher support materials.

## Inquiry Skills Menu

**INQUIRY SKILLS**

- Questioning
- Hypothesizing
- Predicting
- Planning
- Conducting
- Recording
- Analyzing
- Evaluating
- Communicating

### Investigation 9.2.1

#### Pressure and Volume of a Gas

The purpose of this investigation is to determine the general relationship between the pressure and volume of a gas. Complete the **Design, Evidence, Analysis,** and **Evaluation** sections of the lab report.

**Question**  
What effect does increasing the pressure have on the volume of a gas?

**Experimental Design**  
(a) Using the Procedure and Figure 2, write a brief plan to summarize this experiment.  
(b) Identify the independent, dependent, and two controlled variables.  
(c) Design a table to record your observations.

**Materials**  
Boyle’s law apparatus or 35 mL plastic syringe  
large rubber stopper  
cork beer  
5 textbooks or equal masses (1 kg)  
utility stand  
mass balance

**Procedure**  
1. Pull out the syringe plunger so that 30 mL of air is inside the cylinder.  
2. If a syringe cap is not provided, bore a small hole deep enough in the rubber stopper so that the tip of the syringe is inside the stopper. This should be a tight fit. Make sure the tip of the syringe does not leak.  
3. Hold the syringe barrel vertical and measure the initial volume. Clamp the syringe on a retort stand.  
4. While holding the syringe securely, carefully place one textbook or mass on the end of the plunger (Figure 2). (Your partner should balance the mass and be prepared to catch it if it starts to fall.) Record the mass and new volume of air.  
5. Repeat step 4 for a total of 4 or 5 books or masses.  
6. If time permits, repeat steps 3 to 5 for an additional one or two trials.

**Analysis**  
(a) Plot a graph of gas volume (or average volume from trials) versus mass added and draw a best fit line.  
(b) How does changing the mass on the syringe plunger affect the pressure on the air inside the syringe?  
(c) According to the evidence you have collected, what effect does increasing pressure have on the volume of a gas?

**Figure 5**  
Gatorade is a drink that its manufacturer recommends to athletes to replace electrolytes to the body.

**INQUIRY SKILLS**

- Questioning
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### Lab Exercise 6.1.1

#### Identification of Solutions

For this investigation assume that the labels on the four containers have been removed (perhaps washed off as a flood). Your task as a laboratory technician is to match the labels to the containers, using a litmus indicator and conductivity apparatus to identify the solutions.  
You are provided with the **Evidence** gathered. Complete the **Analysis** section of this report.

**Question**  
Which of the solutions labelled 1, 2, 3, and 4 is hydrobromic acid, which is ammonium sulfate, which is lithium hydroxide, and which is methanol?

**Experimental Design**  
Each solution is tested with both red and blue litmus paper and with conductivity apparatus. The temperatures of the solutions and the procedures are controlled.

**Evidence**

Solution	Red Litmus	Blue Litmus	Conductivity
1	red	blue	none
2	red	red	high
3	red	blue	high
4	blue	blue	high

**Analysis**  
(a) Analyze the Evidence and use it to answer the Question: Which of the solutions labelled 1, 2, 3, and 4 is hydrobromic acid, which is ammonium sulfate, which is lithium hydroxide, and which is methanol? Justify your answer.

**Figure 2**  
As the pressure on a gas increases, the volume of the gas decreases.

**Table 4: Pressure and Volume of Gas Samples**

Pressure (kPa)	Volume (L)	$PV$ (kPa·L)
100	1.20	120
200	1.20	240
300	1.00	300
400	0.75	300
500	0.60	300

**Boyle’s law:** as the pressure on a gas increases, the volume of the gas decreases proportionally, provided that the temperature and amount of gas remain constant. The volume and pressure of a gas are inversely proportional.

**Figure 3**  
If  $p_1$  and  $v_1$  represent the initial conditions, the other values of pressure and volume from Table 4 may be stated as follows:  
 $(p_1, v_1)$   $(2p_1, \frac{1}{2}v_1)$   $(3p_1, \frac{1}{3}v_1)$   $(4p_1, \frac{1}{4}v_1)$   $(5p_1, \frac{1}{5}v_1)$

For all the conditions listed above, the product of the pressure and volume is equal to  $p_1 v_1$ . Mathematically, the relationship is represented as  $p_1 v_1 = k$ , where  $k$  is a constant. This simple relationship was first determined by Robert Boyle in 1662 (Figure 4). Boyle’s law states that as the pressure on a gas increases, the volume of the gas decreases proportionally, provided that the temperature and amount of gas remain constant. In other words, the volume of a gas is inversely proportional to the pressure of the gas, provided that the temperature and amount of gas are held constant. Boyle’s law can be conveniently written comparing any two sets of pressure and volume measurements:  
 $p_1 v_1 = p_2 v_2$  (Boyle’s law)

This can also be expressed as a calculation of a new pressure inversely related to the volumes ratio:  
 $p_2 = \frac{p_1 v_1}{v_2}$

The Gas State 17

**Lab Exercises (Dry Labs)** give students an opportunity to analyze experimental evidence and answer questions based on the evidence supplied. The students do not actually carry out a “real” experiment. Students may be asked to evaluate the procedure, the experimental design, provide alternatives, and possibly even arrive at a synthesis of ideas using knowledge gained from various previous experiences.

**Try This Activity boxes** are short hands-on activities using readily available materials. These activities appear periodically throughout each chapter and give students an informal opportunity for skill development.

## Try This Activity

### What Makes Popcorn Pop?

In each kernel of popping corn, there is a small drop of water in a circle of soft starch. When heated, the water expands and builds up pressure against the hard outer surface, eventually exploding and turning the kernel inside out.

**Materials:** popping corn, hot-air popcorn popper, balance

- Measure the mass of some unpopped popping corn.
  - Pop the popping corn.
  - Allow the popcorn to cool and measure the mass again.
  - Assume that any difference in masses is caused by loss of water from the kernels. Calculate the percentage of water in the sample of popcorn.
  - Repeat the activity with kernels of popping corn that have been cut in half either lengthwise or crosswise.
  - Record the percentage of popped kernels from each cutting method.
- (a) Do the results confirm the given reason why popcorn pops? Explain.

### Specific Expectation Addressed

• determine through experimentation the quantitative and graphical relationships among the pressure, volume, and temperature of an ideal gas.  
Ontario Curriculum, Grades 11 and 12, Science, p. 51

# C Relate Science to Technology, Society, and the Environment

The important goal of relating science to technology, society, and the environment (STSE) is integrated throughout the student text and is linked to students' learning of scientific concepts and skills in real-world contexts.

## Specific Expectation Addressed

- give examples of the application of chemical quantities and calculations  
Ontario Curriculum, Grades 11 and 12, Science, p. 48

### Explore an Issue

## Debate: Are Natural Vitamins Better for Your Health?

- Visit a health food store and a drugstore and note the sources and costs of different brands of vitamin and mineral supplements. If possible, interview the owner of the store, the pharmacist, and several consumers to find out their opinions.
- In small groups, discuss the issue from several perspectives. Keep notes and organize your ideas into supportive arguments for each side.
- Your teacher will divide the class into two teams for the debate on the resolution "Natural vitamins are better for your health."
- Return to your first group; discuss the issue again and arrive at a position that is agreed upon by every member of the group.
  - (a) Prepare a one-page summary of your group's position on the issue.

Follow the links from Nelson Chemistry 11, 4.7.  
GO TO [www.science.nelson.com](http://www.science.nelson.com)

## DECISION-MAKING SKILLS

- |   |  |
|---|--|
| <ul style="list-style-type: none"> <li>• Define the Issue</li> <li>• Identify Alternatives</li> <li>• Research</li> </ul> | <ul style="list-style-type: none"> <li>• Analyze the Issue</li> <li>• Defend the Position</li> <li>• Evaluate</li> </ul> |
|---|--|

## Decision Making Skills Menu

4.7

## Investigation 4.7.1

## Specific Expectation Addressed

- identify technological products and safety concerns associated with compressed gases.  
Ontario Curriculum, Grades 11 and 12, Science, p. 52

## 9.3 Compressed Gases

Not only are gases a major part of our lives, but compressed gases, that is, gases at pressures above atmospheric pressure, are particularly useful.

- The tires of vehicles contain pressurized air.
- Many people use gas barbecues with a pressurized propane fuel tank.
- Aerosol cans contain a propellant that carries the contents of the can out the nozzle; the propellant is a pressurized gas.
- Major surgery usually involves oxygen administered from a pressurized oxygen tank and is often accompanied by an anesthetic, which may also be a pressurized gas, such as dinitrogen monoxide.

Certain occupations require some work with pressurized gases. In the medical field, paramedics and doctors use oxygen tanks. Firefighters use compressed air tanks like those used by underwater divers. Some welders use oxyethylene torches (Figure 1). This form of welding requires both a pressurized oxygen tank and a pressurized acetylene tank. Many scientists and their graduate students routinely use pressurized gases for research because the gas is part of the reaction system or because it provides an inert (nonreactive) environment. Noble gases, such as argon, are also used to provide an inert environment in the computer chip industry, where oxygen would cause undesirable reactions.

The chemical safety hazards of some gases are similar to those of many other chemicals, which may be corrosive, toxic, flammable, dangerously reactive, or oxidizing agents. What makes compressed gases much more dangerous is the physical hazard of a potential rocket. In commercial gas cylinders, gas pressures can be as high as 15 MPa (about 150 atm). The hole in the tank, to which the valve stem and valve are connected, is the diameter of a pencil. If the gas is suddenly released through such a small opening, the very great pressure propels the tank, making it a formidable projectile. If the tank is mislabeled, dropped, or falls over and the valve stem breaks, the tank can fly through solid brick walls and cause considerable damage.



Figure 14 Geysers are unusual and dramatic examples of geothermal energy used to heat water in a confined space.



Figure 1 The use of a controlled mixture of oxygen and acetylene provides the best conditions and very high temperatures necessary for cutting or welding metal. Note the hose boxes leading to the torch.

## Career Solutions

The training requirements for careers that involve solutions vary from high school chemistry for a job as a tree planter to a Ph.D. degree in chemistry for a career in pure research chemistry.



**Water-Quality Analyst**  
A water-quality analyst or technician in a water treatment plant works with aqueous solutions every day. Physical and chemical tests are routinely done to determine the total amount of the raw water and to monitor the quality of the final treated water. Many chemical tests (such as the analysis of dissolved iron ions, calcium ions and chlorides) require the preparation of other reagent (reactant) solutions to conduct the tests. Both solution preparation and reactions in solution are important parts of the job of a water-quality analyst.



### Chemistry Teacher

A chemistry or physical science teacher must have a knowledge of solutions, and be able to transfer this ability to the course and many of your previous science courses, you will have some acid solutions in many occasions. At most schools, the teachers prepare the solutions that you use, plan the reactions that you do, and sometimes need to be very successful in cleaning some stains from glassware by reacting the stain with other chemicals such as acids and bases. Chemistry and other physical science teachers need a good understanding of solutions in order to prepare for lab activities. These teachers also do great research in schools and universities.

### Environmental Chemist

Environmental chemists often specialize in particular aspects of the air, water, or soil. Many of them use solutions as either reactants or samples in chemical analysis. The concentrations of these samples is usually critically important. This career requires a higher degree of chemistry training than technicians and teachers. To do an environmental researcher requires considerable perseverance and optimism as well as an ability to ask questions and design experiments. Some of the research involves understanding the components and processes in the environment and some research may focus on the nature and effects of pollution.

### Practice

#### Making Connections

2. Choose one of the careers discussed that you might be interested in and use the Internet to research this career. What are the specific educational requirements? Does this occupation require certification by some organization? If so, state the organization. What are the job prospects in this area?

Follow the links for Nelson Chemistry 11, 8.3.  
GO TO [www.science.nelson.com](http://www.science.nelson.com)

## Specific Expectation Addressed

- identify and describe science- and technology-based careers related to the Solutions and Solubility.  
Ontario Curriculum, Grades 11 and 12, Science, p. 45