OVERVIEW
Unit 3 helps students gain understanding about the importance of quantities in the analysis of chemical reactions. In Chapter 6, Quantities in Chemical Formulas, students consider the importance of the types of chemicals involved in a reaction, as well as the quantities of those chemicals. The chapter begins with a discussion of the consequences of inappropriate quantities of medication, and the implications for a patient’s health. The importance of tracking the quantities of certain chemicals in the environment and in our bodies is also discussed. To solidify understanding of this concept, students then explore the consequences of taking in dangerously high quantities of salt, a substance that is essential to health in small amounts. Later in the chapter, molarity and Avogadro’s constant are defined, and students practise calculating molar mass for both elements and compounds. Students also learn to use Avogadro’s constant to determine the number of entities in a sample, and they practise determining the percentage composition and empirical formulas for compounds.

Tutorials and investigations throughout the chapter provide students with opportunities to explore these concepts more fully.

In Chapter 7, Stoichiometry in Chemical Reactions, students delve further into the calculations used to determine the amounts of reactants and products in a chemical reaction. First, mole ratios and mass relationships, along with their usefulness in creating chemical equations, are explained. Students learn about limiting and excess reagents and how manipulation of the quantities of these reagents can control reactions. Theoretical and actual reaction yields are discussed, and the factors that can diminish percentage yield are briefly explored. Tutorials throughout the chapter provide students with opportunities to practise stoichiometric calculations. Additionally, a variety of investigations give students the chance to apply stoichiometry to everyday situations.

TEACHING NOTES
• Have students look at the Key Concepts and the Starting Points at the beginning of each chapter and at the Summary Questions in the Chapter Summary at the end of each chapter. Ask students, How could you use these two features to help you understand the ideas presented in the unit?
• This unit includes hands-on activities and has students working with scientific equipment. Review laboratory safety procedures and refer students to Appendix A1 Safety. Also review the importance of reading and checking directions before beginning an activity, thinking about the purpose of an activity or the testable question, and directing questions to other members of their group before asking you.
• You may want to use or adapt the assessment rubrics found in the Assessment Tools section on the Teacher eSource.

ENGAGE THE LEARNER
UNIT PREVIEW
• Bring in empty packages from over-the-counter medications or toiletries such as antacids, pain relievers, toothpaste, or vitamins. Have students examine the ingredients listed on the packages. Tell students that in this unit they will begin to learn about the chemical reactions that are used to create everyday products such as these.
• Have students read the Big Ideas on page xx of the Student Book. Ask, What do we mean when we talk about qualitative results? (These results refer to the qualities of the result or product; they describe what the product looks, feels, smells, tastes, or sounds like.)
• Ask, What are quantitative results? (These results tell us about amounts. They might refer to the volume, mass, size, growth, temperature, or density of the product. They can be measured and recorded numerically.)
• Ask, Why is it important to consider the amounts involved in chemical reactions? (You need to have enough of an
ingredient to complete the reaction, but it may be dangerous or too expensive to use too much.)

- Ask, *What everyday activities involve the use of chemicals in specific quantities?* (cooking, cleaning, taking medications or supplements)

**UNIT TASK PREVIEW**

- Formulate a plan for incorporating the **Unit Task** into the whole learning experience for the unit. Whenever possible, highlight ideas that relate to or might be helpful in carrying out the **Unit Task**. Consider the following questions to help you decide how to manage the **Unit Task**:  
  - Will students begin the **Unit Task** early in the unit or toward the end of the unit?  
  - Will students work on the **Unit Task** as individuals, in pairs, or in small groups?  
  - Will you set aside class time for students to work on the task or will students be expected to complete it on their own time?  
  - How will the task fit into the overall assessment plan for the unit?  

- Point out the **Unit Task Bookmark** found within some sections. (The first **Unit Task Bookmark** appears in **Career Pathways**.) Explain that these icons alert students to information or procedures that may be helpful in completing the task.

- The **Unit Task** involves comparing the amount of baking soda found experimentally in an antacid tablet with the amount indicated on the product label.

- For further support with the **Unit Task**, refer to pages **XX-XX** of this resource.

**FOCUS ON STSE**

- Have students examine the photograph on pages **XX-XX** of the Student Book and read the article’s title. Ask them to predict the topic of the article and how it relates to the study of chemistry. (Answers will vary, but students can be guided into a general discussion about industrial processes that rely on chemical reactions.)

- As a class, brainstorm and list on the board steps that manufacturers can take to minimize their impact on the environment. Activities such as decreasing pollution, using clean, renewable energy sources, using renewable resources, and improving efficiency might be listed.

- Direct students to read the article, and select a student volunteer to summarize it. Have students share their reactions to the article, and as a class discuss their thoughts and ideas.

- Point out to students that one way to keep costs down is to use larger amounts of the cheapest ingredients, which ensures that the entire quantities of the most expensive ingredients will be used up. Explain to students that they will learn more about how this works in Chapter 7.

**ARE YOU READY?**

- You can use the questions in this feature as a quick review of relevant concepts and skills and as a means of assessing student understanding of them. Several years may have elapsed since students last encountered some of these concepts or skills, so in many cases it will feel like a first-time introduction for students. Use this feature as an instructional opportunity and do not assume students will know the answers.

- Use student responses to identify concepts and subject areas that students may need to review.

- Should weaknesses or needs be identified, you may want to set aside time for review before students begin to work on the unit. Alternatively, you might review the targeted concepts as they present themselves in the unit.

**CAREER PATHWAYS PREVIEW**

- Formulate a plan for incorporating **Career Pathways** into the whole learning experience for the unit.

- Point out the **Career Links** found within some sections. (The first **Career Link** appears in **Career Pathways** on p. **XXXX** of the Student Book.) Explain that these icons alert students to information or procedures that may be helpful in completing the **Career Pathways** assignment.

- For further support with **Career Pathways**, refer to pages **XX-XX** of this resource.

**DIFFERENTIATED INSTRUCTION**

- Divide students into groups, and have them create a review lesson or illustration of the topic of ratios. Encourage each group to include strategies that will appeal to all types of learners. Visual learners will benefit from graphic representations of the concept. Kinesthetic learners can demonstrate different ratios found in their group, such as the number of girls compared to boys or the numbers of blondes compared to brunettes. Auditory learners will benefit from discussing the concept with their peers and giving verbal examples.

**ENGLISH LANGUAGE LEARNERS**

- Pass out copies of **BLM 0.0-6 Science Idea Box** to students. As they work through the unit, students should use this BLM to record the main ideas of each section. Encourage English language learners to include terms or phrases in their native languages that may help them remember the concepts by writing them on the lines around each box.
## Curriculum Correlation

### A: Scientific Investigation Skills and Career Exploration

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<thead>
<tr>
<th>OVERALL EXPECTATIONS</th>
<th>SPECIFIC EXPECTATIONS</th>
<th>SECTIONS</th>
</tr>
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<tbody>
<tr>
<td>A. demonstrate scientific investigation skills in the four areas of skills</td>
<td>A1.1 formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research</td>
<td>6.6.1; 6.6.2; 6.9; 6.9.1; 7.1; 7.2.1; 7.4.1; 7.5.1; Unit Task</td>
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<tr>
<td></td>
<td>A1.2 select appropriate instruments and materials, and identify appropriate methods, techniques, and procedures, for each inquiry</td>
<td>6.5; 6.6.1; 6.6.2; 6.9; 6.9.1; 7.1; 7.2.1; 7.3; 7.4.1; 7.5.1</td>
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<td></td>
<td>A1.3 identify and locate a variety of print and electronic sources that enable them to address research topics fully and appropriately</td>
<td>6.2</td>
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<td></td>
<td>A1.4 apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting Workplace Hazardous Materials Information System (WHMIS) symbols; by using appropriate techniques for handling and storing laboratory equipment and materials and disposing of laboratory materials; and by using appropriate personal protection</td>
<td>6.1; 6.4; 6.6.2; 6.9.1; 7.2.1; 7.3; 7.4.1; 7.5.1; Unit Task</td>
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<td></td>
<td>A1.5 conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data</td>
<td>6.1; 6.3; 6.4; 6.6; 6.6.1; 6.6.2; 6.9; 6.9.1; 7.1; 7.2.1; 7.3; 7.4.1; 7.5.1; Unit Task</td>
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<td>A1.6 compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables, flow charts, graphs, and/or diagrams</td>
<td>6.1; 6.5; 6.6.2; 6.9.1; 7.2.1; 7.3; 7.4.1; 7.5.1; Unit Task</td>
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<tr>
<td></td>
<td>A1.7 select, organize, and record relevant information on research topics from a variety of appropriate sources, including electronic, print, and/or human sources, using suitable formats and an accepted form of academic documentation</td>
<td>6.2</td>
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<td></td>
<td>A1.8 synthesize, analyze, interpret, and evaluate qualitative and quantitative data; solve problems involving quantitative data; determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and error; and suggest improvements to the inquiry to reduce the likelihood of error</td>
<td>6.1; 6.3; 6.4; 6.6; 6.6.1; 6.6.2; 6.9.1; 7.2.1; 7.3; 7.4.1; 7.5.1; Unit Task</td>
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<td></td>
<td>A1.9 analyze the information gathered from research sources for logic, accuracy, reliability, adequacy, and bias</td>
<td>6.2</td>
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<td>A1.10 draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge</td>
<td>6.1; 6.2; 6.3; 6.5; 6.6; 6.6.1; 6.6.2; 6.9; 6.9.1; 7.1; 7.2.1; 7.3; 7.4.1; 7.5.1; Unit Task</td>
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<td></td>
<td>A1.11 communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats</td>
<td>6.2; 6.6.1; 6.6.2; 6.9.1; 7.1; 7.2.1; 7.3; 7.4.1; 7.5.1; Unit Task</td>
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<td></td>
<td>A1.12 use appropriate numeric, symbolic, and graphic modes of representation, and appropriate units of measurement</td>
<td>6.4; 6.5; 6.6; 6.6.1; 6.6.2; 6.9; 6.9.1; 7.2.1; 7.4.1; 7.5.1; Unit Task</td>
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<td>A1.13 express the results of any calculations involving data accurately and precisely, to the appropriate number of decimal places or significant</td>
<td>6.4; 6.5; 6.6.1; 6.6.2; 6.9.1; 7.2.1; 7.4.1; 7.5.1; Unit Task</td>
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### A2. CAREER EXPLORATION

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<tr>
<td>A2. identify and describe careers related to the fields of science under study, and describe the contributions of scientists, including Canadians, to those fields</td>
<td>A2.1 Identify and describe a variety of careers related to the fields of science under study and the education and training necessary for these careers 6.1; 6.8</td>
</tr>
<tr>
<td></td>
<td>A2.2 describe the contributions of scientists, including Canadians, to the fields under study 6.3; 6.5; 6.6; 6.9</td>
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### D: Quantities in Chemical Reactions

#### D1. RELATING SCIENCE TO TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

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<tbody>
<tr>
<td>D1. analyze processes in the home, the workplace, and the environmental sector that use chemical quantities and calculations, and assess the importance of quantitative accuracy in industrial chemical processes</td>
<td>D1.1 Analyze processes in the home, the workplace, and the environmental sector that use chemical quantities and calculations 6.1; 6.2; 6.8; 6.9; 7.2; 7.2.1; 7.3; 7.4; 7.5; Unit Task</td>
</tr>
<tr>
<td></td>
<td>D1.2 assess, on the basis of research, the importance of quantitative accuracy in industrial chemical processes and the potential impact on the environment if quantitative accuracy is not observed 6.1; 7.3; 7.5</td>
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#### D2. DEVELOPING SKILLS OF INVESTIGATION AND COMMUNICATION

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<th>OVERALL EXPECTATIONS</th>
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<tbody>
<tr>
<td>D2. investigate quantitative relationships in chemical reactions, and solve related problems</td>
<td>D2.1 Use appropriate terminology related to quantities in chemical reactions, including, but not limited to: stoichiometry, percentage yield, limiting reagent, mole, and atomic mass 6.3; 6.4; 6.5; 6.6.2; 6.7; 6.9.1; 7.1; 7.2; 7.2.1; 7.3; 7.4; 7.4.1; 7.5; 7.5.1; Unit Task</td>
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<tr>
<td></td>
<td>D2.2 Conduct an inquiry to calculate the percentage composition of a compound 6.6; 6.6.1; 6.6.2; 6.9.1</td>
</tr>
<tr>
<td></td>
<td>D2.3 Solve problems related to quantities in chemical reactions by performing calculations involving quantities in moles, number of particles, and atomic mass 6.6; 6.7; 7.2; 7.4; 7.4.1; 7.5</td>
</tr>
<tr>
<td></td>
<td>D2.4 Determine the empirical formulae and molecular formulae of various chemical compounds, given molar masses and percentage composition or mass data 6.7</td>
</tr>
<tr>
<td></td>
<td>D2.5 Calculate the corresponding mass, or quantity in moles or molecules, for any given reactant or product in a balanced chemical equation as well as for any other reactant or product in the chemical reaction 7.1; 7.2; 7.2.1; 7.4; 7.4.1; 7.5; 7.5.1</td>
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<tr>
<td></td>
<td>D2.6 Solve problems related to quantities in chemical reactions by performing calculations involving percentage yield and limiting reagents 7.5; 7.5.1</td>
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<td></td>
<td>D2.7 Conduct an inquiry to determine the actual yield, theoretical yield, and percentage yield of the products of a chemical reaction, assess the effectiveness of the procedure, and suggest sources of experimental error 7.5; 7.5.1; Unit Task</td>
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#### D3. UNDERSTANDING BASIC CONCEPTS
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<tr>
<td>D3. demonstrate an understanding of the mole concept and its significance to the</td>
<td>D3.1 explain the law of definite proportions</td>
</tr>
<tr>
<td>quantitative analysis of chemical reactions</td>
<td>6.6</td>
</tr>
<tr>
<td>D3.2 describe the relationship between Avogadro’s number, the mole concept, and the</td>
<td>D3.2 describe the relationship between Avogadro’s number, the mole concept, and the molar mass of any given substance</td>
</tr>
<tr>
<td>molar mass of any given substance</td>
<td>6.4; 6.5</td>
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<tr>
<td>D3.3 explain the relationship between the empirical formula and the molecular</td>
<td>D3.3 explain the relationship between the empirical formula and the molecular formula of a chemical compound</td>
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<tr>
<td>formula of a chemical compound</td>
<td>6.7; 6.9</td>
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<tr>
<td>D3.4 explain the quantitative relationships expressed in a balanced chemical</td>
<td>D3.4 explain the quantitative relationships expressed in a balanced chemical equation, using appropriate units of measure</td>
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<td>equation, using appropriate units of measure</td>
<td>7.1; 7.2; 7.2.1; 7.3; 7.4; 7.4.1; 7.5; 7.5.1; Unit Task</td>
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## Unit Planning Chart

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<td>SECTION</td>
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</tbody>
</table>
| 6.4 Molar Mass | Mini Investigation: The Mole Exhibit | • Completing practice problems  
• Mini Investigation – Calculating molar mass and measuring moles  
• Reading and answering questions | Assessment Rubric 1: Knowledge and Understanding  
Assessment Rubric 2: Thinking and Investigation  
Assessment Summary 1: Knowledge and Understanding  
Assessment Summary 2: Thinking and Investigation  
Skills Handbook A2 Scientific Inquiry  
Chemistry 11 website  
www.nelson.com/onseniorscience/chemistry11u |
| 6.5 Mass and Number of Entities | Mini Investigation: Determining Numbers of Everyday Entities | • Completing practice problems  
• Mini Investigation – Calculating the number of entities in a sample based on mass  
• Completing the BLM  
• Reading and answering questions | BLM 6.5-1 Mass, Mole, and Entity  
Assessment Rubric 1: Knowledge and Understanding  
Assessment Summary 1: Knowledge and Understanding  
Skills Handbook A2 Scientific Inquiry  
Skills Handbook A6 Math Skills  
Chemistry 11 website  
www.nelson.com/onseniorscience/chemistry11u |
| 6.6 The Composition of Unknown Compounds | Mini Investigation: Determining Percentage Composition of a Compound | • Completing practice problems  
• Mini Investigation – Developing a method of calculating percentage composition of a hypothetical compound  
• Reading and answering questions | Assessment Rubric 1: Knowledge and Understanding  
Assessment Rubric 2: Thinking and Investigation  
Assessment Summary 1: Knowledge and Understanding  
Assessment Summary 2: Thinking and Investigation  
Skills Handbook A2 Scientific Inquiry  
Skills Handbook A3 Laboratory Skills and Techniques  
Chemistry 11 website  
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| 6.6.1 Observational Study: Popping Percentage Composition | Mini Investigation: Popping Percentage Composition | • Designing and conducting an experimental procedure  
• Following safety precautions  
• Performing calculations and analyzing data  
• Reading and answering questions | Assessment Rubric 7: Observational Study  
Assessment Summary 7: Observational Study  
Self-Assessment Checklist 3: Observational Study  
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Skills Handbook A6 Math Skills  
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| 6.6.2 Controlled Experiment: Percentage Composition of Magnesium Oxide | Mini Investigation: Percentage Composition of Magnesium Oxide | • Developing and testing a hypothesis  
• Following safety precautions  
• Making observations and analyzing results  
• Reading and answering questions | Assessment Rubric 5: Controlled Experiment  
Assessment Summary 5: Controlled Experiment  
Self-Assessment Checklist 1: Controlled Experiment  
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<tr>
<td><strong>Chapter 7 Introduction</strong>&lt;br&gt;Stoichiometry in Chemical Reactions&lt;br&gt;p. [xx] (Student Book p. [xxx])</td>
<td>Mini Investigation: Precipitating Ratios&lt;br&gt;p. [xx] (Student Book p. [xxx])&lt;br&gt;- Performing&lt;br&gt;- Observing&lt;br&gt;- Communicating</td>
<td>- Chapter 6 Review</td>
<td>Assessment Rubric 1: Knowledge and Understanding&lt;br&gt;Assessment Rubric 3: Communication&lt;br&gt;Assessment Summary 1: Knowledge and Understanding&lt;br&gt;Assessment Summary 3: Communication&lt;br&gt;Skills Handbook A7 Choosing Appropriate Career Pathways&lt;br&gt;Chemistry 11 website&lt;br&gt;www.nelson.com/onseniorscience/chemistry11u</td>
</tr>
<tr>
<td><strong>7.1 Mole Ratios in Chemical Equations</strong>&lt;br&gt;p. [xx] (Student Book p. [xxx])</td>
<td>Mini Investigation: One Plus One Does Not Always Equal Two&lt;br&gt;p. [xx] (Student Book p. [xxx])&lt;br&gt;- Predicting&lt;br&gt;- Performing&lt;br&gt;- Observing&lt;br&gt;- Analyzing&lt;br&gt;- Communicating</td>
<td>- Mini Investigation – Analyzing the relationship between reagent quantity and product yield&lt;br&gt;- Assessment of prior knowledge and possible misconceptions&lt;br&gt;- Reading and answering questions</td>
<td>Assessment Rubric 1: Knowledge and Understanding&lt;br&gt;Assessment Summary 1: Knowledge and Understanding&lt;br&gt;Skills Handbook A2 Scientific Inquiry&lt;br&gt;Chemistry 11 website&lt;br&gt;www.nelson.com/onseniorscience/chemistry11u</td>
</tr>
<tr>
<td><strong>7.2 Mass Relationships in Chemical Equations</strong>&lt;br&gt;p. [xx] (Student Book p. [xxx])</td>
<td></td>
<td>- Completing practice problems&lt;br&gt;- Completing the BLM&lt;br&gt;- Reading and answering questions</td>
<td>BLM 7.2-1 Calculating Mass in Chemical Reactions&lt;br&gt;Assessment Rubric 1: Knowledge and Understanding&lt;br&gt;Assessment Summary 1: Knowledge and Understanding&lt;br&gt;Skills Handbook A6 Math Skills&lt;br&gt;Chemistry 11 website&lt;br&gt;www.nelson.com/onseniorscience/chemistry11u</td>
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| 7.3 Which Reagent Runs Out First? | Mini Investigation: Balloon Stoichiometry | • Mini Investigation – Determining the limiting and excess reagents in a reaction  
• Reading and answering questions | Assessment Rubric 1: Knowledge and Understanding  
Assessment Rubric 2: Thinking and Investigation  
Assessment Summary 1: Knowledge and Understanding  
Assessment Summary 2: Thinking and Investigation  
Skills Handbook A1 Safety  
Skills Handbook A2 Scientific Inquiry  
Chemistry 11 website  
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| 7.4 Calculations Involving Limiting Reagents | • Completing practice problems  
• Completing the BLM  
• Reading and answering questions | BLM 7.4-1 Limiting Reagents  
Assessment Rubric 1: Knowledge and Understanding  
Assessment Summary 1: Knowledge and Understanding  
Skills Handbook A6 Math Skills  
Chemistry 11 website  
www.nelson.com/onseniorscience/chemistry11u |
| 7.4.1 Observational Study: Copper Collection Stoichiometry | 7.4.1 Observational Study: Copper Collection Stoichiometry | • Measuring masses of reactants and products  
• Following safety precautions  
• Performing calculations and analyzing data  
• Interpreting results and identifying a chemical reaction  
• Reading and answering questions | Assessment Rubric 7: Observational Study  
Assessment Summary 7: Observational Study  
Self-Assessment Checklist 3: Observational Study  
Skills Handbook A1 Safety  
Skills Handbook A2 Scientific Inquiry  
Skills Handbook A3 Laboratory Skills and Techniques  
Skills Handbook A6 Math Skills  
Chemistry 11 website  
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| 7.5 Percentage Yield | 7.5.1 Controlled Experiment: What Stopped the Silver? | • Completing practice problems  
• Reading and answering questions | Assessment Rubric 1: Knowledge and Understanding  
Assessment Summary 1: Knowledge and Understanding  
Skills Handbook A6 Math Skills  
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<td>• Controlling Variables</td>
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<td>• Performing</td>
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<td>• Observing</td>
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<td>Chapter 7 Summary</td>
<td>• Summary questions</td>
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<td>BLM 7.Q Chapter 7 Quiz</td>
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<td>p. xx [Student Book p. xxx]</td>
<td>• Chapter 7 Self-Quiz</td>
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<td>BLM 0.0-10 Careers</td>
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<td>• Chapter 7 Review</td>
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<td>Assessment Summary 1: Knowledge and Understanding</td>
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<td><a href="http://www.nelson.com/onseniorscience/chemistry11u">www.nelson.com/onseniorscience/chemistry11u</a></td>
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<tr>
<td>Unit 3 Closing</td>
<td>• Unit Task – Analyzing the amount of sodium hydrogen carbonate</td>
<td></td>
<td>BLM U3.Q Unit 3 Quiz</td>
</tr>
<tr>
<td>p. xxx [Student Book p. xxx]</td>
<td>present in an Alka-Seltzer tablet</td>
<td></td>
<td>Unit 3 Task Assessment Rubric : Fizz Check</td>
</tr>
<tr>
<td></td>
<td>• Unit 3 Self-Quiz</td>
<td></td>
<td>Unit 3 Task Assessment Summary : Fizz Check</td>
</tr>
<tr>
<td></td>
<td>• Unit 3 Review</td>
<td></td>
<td>Unit 3 Task Self-Assessment Checklist : Fizz Check</td>
</tr>
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<td></td>
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<td>Skills Handbook A2 Scientific Inquiry</td>
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<td></td>
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<td>Skills Handbook A6 Math Skills</td>
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<td>Chemistry 11 website</td>
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<td><a href="http://www.nelson.com/onseniorscience/chemistry11u">www.nelson.com/onseniorscience/chemistry11u</a></td>
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</table>
### Unit 3: Quantities in Chemical Reactions

<table>
<thead>
<tr>
<th>INVESTIGATION/ACTIVITY</th>
<th>QUANTITY</th>
<th>EQUIPMENT</th>
<th>QUANTITY</th>
<th>MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chapter 6 Mini Investigation: Comparing Salty Snacks</strong>&lt;br&gt;p. xx [Student Book p. 176]</td>
<td>32</td>
<td>chemical safety goggles</td>
<td>32</td>
<td>pairs of gloves</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lab apron, plastic, student aprons</td>
<td></td>
<td>dropper bottle of distilled water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>measure 68 cm × 89 cm</td>
<td></td>
<td>1 cm slice of hot dog, chopped</td>
</tr>
<tr>
<td></td>
<td></td>
<td>test tubes, 4 per group</td>
<td></td>
<td>into small pieces</td>
</tr>
<tr>
<td>Student groupings:</td>
<td>8</td>
<td>test-tube rack</td>
<td>—</td>
<td>potato chips, crushed</td>
</tr>
<tr>
<td>8 groups of 4 students</td>
<td>8</td>
<td>scoopula</td>
<td>—</td>
<td>sodium chloride, NaCl(s)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>balance</td>
<td>—</td>
<td>massing paper</td>
</tr>
<tr>
<td></td>
<td>10 mL graduated cylinder</td>
<td></td>
<td>8</td>
<td>dropper bottle of silver nitrate, AgNO₃(aq), 0.1 mol/L</td>
</tr>
<tr>
<td><strong>6.1 Mini Investigation: Testing for Sugar</strong>&lt;br&gt;p. xx [Student Book p. 176]</td>
<td>32</td>
<td>chemical safety goggles</td>
<td>8</td>
<td>glassware marker or labels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lab apron, plastic, student aprons</td>
<td>8</td>
<td>dropper bottle of distilled water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>measure 68 cm × 89 cm</td>
<td>—</td>
<td>1 % starch suspension, in a small beaker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 mL graduated cylinder</td>
<td>—</td>
<td>1 % glucose solution, in a small beaker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>test tubes, 4 per group</td>
<td>—</td>
<td>10 % glucose solution, in a small beaker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>test-tube rack</td>
<td>—</td>
<td>Benedict’s solution, in a small beaker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kettle</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>test-tube clamp</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>250 mL beaker</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6.3 Mini Investigation: Counting Estimates</strong>&lt;br&gt;p. xx [Student Book p. 176]</td>
<td>8</td>
<td>balance</td>
<td>400</td>
<td>dry beans, 50 per group</td>
</tr>
<tr>
<td></td>
<td></td>
<td>small plastic cup or beaker</td>
<td>400</td>
<td>dry rice, 50 grains per group</td>
</tr>
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<td></td>
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<td></td>
</tr>
<tr>
<td><strong>6.4 Mini Investigation: The Mole Exhibit</strong>&lt;br&gt;p. xx [Student Book p. 176]</td>
<td>32</td>
<td>chemical safety goggles</td>
<td>—</td>
<td>samples of pure substances such as water, sodium chloride, or copper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lab apron, plastic, student aprons</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>measure 68 cm × 89 cm</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>balance</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>scoopula</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>250 mL beaker</td>
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<td></td>
</tr>
<tr>
<td><strong>6.5 Mini Investigation: Determining Numbers of Everyday Entities</strong>&lt;br&gt;p. xx [Student Book p. 176]</td>
<td>32</td>
<td>lab apron, plastic, student aprons</td>
<td>—</td>
<td>chalk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>measure 68 cm × 89 cm</td>
<td>16-24</td>
<td>water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>blackboard</td>
<td></td>
<td>disposable cups, 2-3 per group</td>
</tr>
<tr>
<td></td>
<td></td>
<td>balance</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>dropper</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>graduated cylinder</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>penny</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>6.6 Mini Investigation: Determining Percentage Composition of a Compound</strong></td>
<td>8</td>
<td>balance</td>
<td>molecules of the paperclip</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>compound, 3 per group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INVESTIGATION/ACTIVITY</td>
<td>QUANTITY</td>
<td>EQUIPMENT</td>
<td>QUANTITY</td>
<td>MATERIALS</td>
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<td>------------------------</td>
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<td>-----------</td>
</tr>
<tr>
<td>p. xx [Student Book p. 176]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student groupings: 8 groups of 4 students</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

| 6.6.1 Observational Study: Popping Percentage Composition | 8 | hot air popcorn maker | 8 | large clear plastic bag |
| | | balance | | popping corn |

| 6.6.2 Controlled Experiment: Percentage Composition of Magnesium Oxide | 32 | chemical safety goggles | 16 | 8 cm strips of magnesium ribbon, Mg(s), 2 per group |
| | 32 | lab apron, plastic, student aprons | 8 | dropper bottle containing distilled water |
| | | measure 68 cm x 89 cm | | water |
| | | ceramic crucible and lid | | glass stirrer, 2 per group |
| | | balance | | tongs |
| | | steel wool or sandpaper | | glass stirring rod |
| | | ring clamp | | graduated cylinder |
| | | clay triangle | | spark lighter |
| | | 8 | | |
| | | 8 | | |
| | | 8 | | |
| | | 8 | | |
| | | 8 | | |
| | | 8 | | |
| | | 8 | | |
| | | 8 | | |

| 6.9 Mini Investigation: Comparing Molecules and Molecular Formulas | 8 | molecular model kit | | |
| | | | | |

| 8.9.1 Observational Study: Determining the Formula of a Hydrate | 32 | chemical safety goggles | 16 | gauze pad |
| | 32 | lab apron, plastic, student aprons | 16 | 2.00 to 4.00 g of hydrated |
| | | measure 68 cm x 89 cm | | copper(II) sulfate, CuSO₄•xH₂O |
| | | heat-resistant safety gloves | | cobalt chloride paper, 2 strips per |
| | | large test tube | | group |
| | | plastic scoopula | | |
| | | balance | | |
| | | utility clamp | | |
| | | clay triangle | | |
| | | 16 | | |
| | | 16 | | |
| | | 16 | | |
| | | 16 | | |
| | | 16 | | |
| | | 16 | | |

<p>| Chapter 7 Mini Investigation: Precipitating Ratios | 32 | chemical safety goggles | 32 | pairs of gloves |
| | 32 | lab apron, plastic, student aprons | 16 | zinc chloride, ZnCl₂(aq), 0.1 mol/L |
| | | measure 68 cm x 89 cm | | sodium carbonate, Na₂CO₃(aq), |
| | | test-tube rack | | 0.1 mol/L |
| | | numbered test tubes, 6 per pair | | silver nitrate, AgNO₃(aq), |
| | | 10 mL graduated cylinder | | 0.1 mol/L |
| | | | | sodium phosphate, Na₃PO₄(aq), |
| | | | | 0.1 mol/L |</p>
<table>
<thead>
<tr>
<th>INVESTIGATION/ACTIVITY</th>
<th>QUANTITY</th>
<th>EQUIPMENT</th>
<th>QUANTITY</th>
<th>MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1 Mini Investigation: One Plus One Does Not Always Equal Two</td>
<td>16</td>
<td>molecular model kit</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.2.1 Observational Study: What Is Baking Soda Doing in Your Cake?</td>
<td>32</td>
<td>chemical safety goggles</td>
<td>8</td>
<td>wooden splint</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>lab apron, plastic, student aprons</td>
<td>—</td>
<td>sodium hydrogen carbonate, NaHCO$_3$(s)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>measure 68 cm × 89 cm</td>
<td>8</td>
<td>test tube half-filled with limewater, Ca(OH)$_2$(aq)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>heat-resistant test tube</td>
<td>—</td>
<td>cobalt chloride paper</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>balance</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>8</td>
<td>Bunsen burner clamped to a retort stand</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>8</td>
<td>spark lighter</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>8</td>
<td>test-tube holder</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>8</td>
<td>scoopula</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>test-tube rack</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.3 Mini Investigation: Balloon Stoichiometry</td>
<td>32</td>
<td>chemical safety goggles</td>
<td>32</td>
<td>medium-sized balloons, 4 per group</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>lab apron, plastic, student aprons</td>
<td>—</td>
<td>sodium hydrogen carbonate (baking soda)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>measure 68 cm × 89 cm</td>
<td>—</td>
<td>ethanoic acid solution (vinegar)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>permanent marker</td>
<td></td>
<td></td>
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<td></td>
<td>8</td>
<td>500 mL plastic bottles, 4 per group</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>8</td>
<td>funnel</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>8</td>
<td>teaspoon</td>
<td></td>
<td></td>
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<tr>
<td>7.4.1 Observational Study: Copper Collection Stoichiometry</td>
<td>32</td>
<td>chemical safety goggles</td>
<td>—</td>
<td>copper(II) sulfate pentahydrate, CuSO$_4$•5H$_2$O</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>lab apron, plastic, student aprons</td>
<td>—</td>
<td>warm distilled water (about 40 °C)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>measure 68 cm × 89 cm</td>
<td>—</td>
<td>iron filings, Fe</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>scoopula</td>
<td>—</td>
<td>squeeze bottle of distilled water</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>balance</td>
<td>—</td>
<td>filter paper</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>50 mL graduated cylinder</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>250 mL beaker</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>8</td>
<td>stirring rod</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>8</td>
<td>retort stand and ring clamp</td>
<td></td>
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<tr>
<td></td>
<td>8</td>
<td>funnel</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>8</td>
<td>drying oven or hot plate</td>
<td></td>
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<tr>
<td>7.5.1 Controlled Experiment: What Stopped the Silver?</td>
<td>32</td>
<td>chemical safety goggles</td>
<td>—</td>
<td>sandpaper</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>lab apron, plastic, student aprons</td>
<td>8</td>
<td>wooden splint</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>measure 68 cm × 89 cm</td>
<td>8</td>
<td>30 cm length of copper wire</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>latex or rubber gloves</td>
<td>8</td>
<td>silver nitrate, AgNO$_3$(s)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>balance</td>
<td>8</td>
<td>wash bottle of distilled water</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>100 mL beaker</td>
<td>—</td>
<td>aluminum foil</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>stirring rod</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>250 mL beaker</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Unit 3 Unit Task: Fizz Check</td>
<td>32</td>
<td>chemical safety goggles</td>
<td>—</td>
<td>vinegar (dilute ethanoic acid, HC$_2$H$_3$O$_2$(aq))</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>lab apron, plastic, student aprons</td>
<td>56</td>
<td>Alka-Seltzer tablets, 7 per group</td>
</tr>
<tr>
<td></td>
<td></td>
<td>measure 68 cm × 89 cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>balance</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 mL Erlenmeyer flasks or plastic cups, 7 per group</td>
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<tr>
<td></td>
<td></td>
<td>50 mL graduated cylinder</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>dropper</td>
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</table>
CHAPTER 6
Quantities in Chemical Formulas

PROGRAM RESOURCES
Skills Handbook A1 Safety
Skills Handbook A2 Scientific Inquiry
Skills Handbook A3 Laboratory Skills and Techniques
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

TEACHING NOTES
• Have students examine the Chapter Opener photograph. Ask, What is the quantity that this researcher is carefully measuring? (volume)
• Ask students to relate what they know about chemical reactions to the key question at the start of the chapter: Why Is Accuracy Important When Measuring Quantities of Chemicals? (Students might discuss the importance of quantities of chemicals in industrial processes to minimize waste and maximize profit. Or they might discuss how medicines can be useful or harmful, depending on the quantity ingested.)

ENGAGE THE LEARNER
CHAPTER INTRODUCTION
• To preview the major ideas that will be explored in the chapter, review the Key Concepts. Ask a student volunteer to read each Key Concept aloud before it is discussed. Ask prompting questions to assess students’ prior knowledge and to engage students in the topics. Examples are given:

1. What are some chemicals that are measured and analyzed in a person's body? (Sample answer: blood sugar, oxygen, and steroids) What are some chemicals that are measured and analyzed in foods? (Sample answer: sodium content, fat, sugar)
2. What are possible consequences if measurements of chemicals are not made accurately? (Sample answers: Sickness and death are possible if an incorrect measurement results in the wrong dose of medicine. Excess waste can form if an industrial process uses too much of a starting material.)
3. What is a proportion? (Sample answers: a ratio; a comparison of one amount to another)
4. What type of chemical substance has the atom as its smallest particle? (an element) What type of chemical substance has the molecule as its smallest particle? (a molecular compound)

5. How do you calculate a percentage, such as the percentage of students in the class who have black hair? (Sample answer: Divide the part by the whole and multiply by 100. Divide the number of students with black hair by the total number of students and then multiply by 100 to get the percentage.)

6. What does the average atomic mass describe about an element? (Sample answer: The average atomic mass is the average mass of 1 atom of the element expressed in atomic mass units. An average is used because there are typically several naturally occurring isotopes of any given element and each has a different mass.)
• Instruct students to answer the Starting Points questions on notebook paper. Collect their responses, and save them to revisit at the end of the chapter.
• Have students complete Mini Investigation: Comparing Salty Snacks.

MINI INVESTIGATION: COMPARING SALTY SNACKS
Skills: Performing, Observing, Communicating
Purpose: Students will use a chemical test to compare the salt content of hot dogs and potato chips.
Equipment and Materials (per student): chemical safety goggles; lab apron; gloves (per group); 4 test tubes; test-tube rack; scoopula; balance; 10 mL graduated cylinder; dropper bottle of distilled water; 1 cm slice of hot dog chopped into small pieces; sample of crushed potato ships; sodium chloride, NaCl(s); massing paper; dropper bottle of silver nitrate, AgNO₃(aq) (0.1 mol/L)
Student Safety: Students should wear chemical safety goggles and lab aprons. Remind students to never eat or taste anything in a lab setting. Avoid contact with silver nitrate as it will stain skin and clothing. Wash any skin that comes into contact with silver nitrate with large amounts of cool water.

• Students should complete this activity in small groups.
• To make one litre of the silver nitrate solution, measure out 16.99 g of silver nitrate and dissolve in distilled water to a total volume of 1.0 L. Store this solution in a brown bottle or else cover a clear bottle with aluminum foil to prevent light exposure.

DIFFERENTIATED INSTRUCTION
• You may want to have students who are interested in computers set up a class blog, wiki, or website for posting reports, lab results, presentations, images, videos, links, and other forms of information.

ENGLISH LANGUAGE LEARNERS
• Have English language learners keep a notebook in which they write unfamiliar terminology. Beside each term, students can write the definition in their first language.
6.1 Qualitative and Quantitative Analysis

OVERALL EXPECTATIONS: A1; D1; D2; D3

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A1.4; A1.5; A1.6; A1.8; A1.10
Career Exploration: A2.1
Relating Science to Technology, Society, and the Environment: D1.1; D1.2

The full Overall and Specific Expectations are listed on pages xx–xx.

VOCABULARY
• qualitative analysis
• quantitative analysis

SKILLS
Controlling Variables Analyzing
Performing Evaluating
Observing Communicating

EQUIPMENT AND MATERIALS
per student:
• chemical safety goggles
• lab apron
per group:
• 10 mL graduated cylinder
• 4 test tubes
• glassware marker or labels
• test-tube rack
• kettle
• test-tube clamp
• 250 mL beaker
• dropper bottle of distilled water
• small beakers containing samples of:
  • 1% starch suspension
  • 1% glucose solution
  • 10% glucose solution
  • Benedict’s solution

ASSESSMENT RESOURCES
Assessment Rubric 1: Knowledge and Understanding
Assessment Summary 1: Knowledge and Understanding

PROGRAM RESOURCES
Skills Handbook A1 Safety
Skills Handbook A2 Scientific Inquiry
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre

Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

RELATED RESOURCES

EVIDENCE OF LEARNING
Look for evidence that students can
• compare qualitative analysis with quantitative analysis
• classify observations as examples of qualitative analysis or quantitative analysis
• describe medical and environmental processes that rely on accurate quantitative data

SCIENCE BACKGROUND
• Diabetes is a group of diseases. Blood glucose levels are high in people who have diabetes as a result of problems related to how the body produces or uses insulin. In Type 1 diabetes, the body does not produce insulin. In Type 2 diabetes, which is the most common type, the body either does not produce enough insulin or the cells do not properly recognize it. Risk factors for developing Type 2 diabetes include age, ethnic background, family history, and being very overweight.

POSSIBLE MISCONCEPTIONS
Identify: Students might think that they can measure a quantity only to the smallest marking on a measuring device.
Clarify: Emphasize that to take advantage of the greatest precision available, students should visually subdivide the space between the smallest markings on the measuring device to estimate an additional place value.
Ask What They Think Now: At the end of this discussion show students a graduated cylinder that has markings every millilitre and ask, To what place value should you record measurements when using this device? (Each millilitre is marked, so we could estimate the volume to the nearest tenth of a millilitre.)

TEACHING NOTES
ENGAGE
• Write the terms Quality and Quantity on the board. Challenge students to brainstorm descriptions or examples for each term. Ask, Which term do you associate with numbers? (quantity)

EXPLORE AND EXPLAIN
• Have students read the text about Sonja at the beginning of Section 6.1 in the Student Book. Ask, Were Sonja and the physician discussing blood glucose levels based on quality or quantity? (quantity) Why was there confusion
about her blood glucose levels? (Although they were discussing a measurable quantity, each person used a different unit of measurement.) What does this mean for how you handle measurements? (Sample answer: we should always include the unit with our measurements to avoid confusion.)

• Have students complete Mini Investigation: Testing for Sugar.

MINI INVESTIGATION: TESTING FOR SUGAR

Skills: Controlling Variables, Performing, Observing, Analyzing, Evaluating, Communicating

Purpose: Students will qualitatively detect the presence of glucose, using Benedict’s solution.

Equipment and Materials (per student): chemical safety goggles; lab apron; (per group): 10 mL graduated cylinder; 4 test tubes; glassware marker or labels; test-tube rack; kettle; test-tube clamp; 250 mL beaker; dropper bottle of distilled water; small beakers containing samples of 1% starch suspension, 1% glucose solution, 10% glucose solution, and Benedict’s solution

Student Safety: Be sure that students wear safety goggles and aprons during all parts of this activity. Point out to students that Benedict’s solution contains both sodium carbonate, an irritant, and copper(II) sulfate, a poison through ingestion. If contact with skin occurs, flush the area with large amounts of cool water. Instruct students to take care when working with the hot water and to report any spills. If contact with skin occurs, flush the area with large amounts of cool water.

Notes
• Students should complete this activity in small groups.
• If safe to do so, pour the warm water from the beakers back into the kettle to shorten the time needed to reheat the water for the next class. You may wish to point out to students the green chemistry aspect of reusing the water.
• A positive test with Benedict’s solution indicates the presence of a monosaccharide, such as glucose, or of the disaccharides lactose and maltose. Starch is a long chain of monosaccharides, but only the sugars on the end of a chain might react with Benedict’s solution, so starch has at most a weak reaction with Benedict’s.

Ask, Why are quantitative data important when trying to determine whether a pollutant may cause a certain condition? (Sample answer: Quantitative data are needed to show whether higher levels of the pollutant correspond to more cases or more severe cases of the condition.)

Ask, What does the example of doping in cycling illustrate about quantitative tests? (Sample answer: Quantitative data are subject to manipulation. Results are only accurate if the measurements are made under the right conditions.)

EXTEND AND ASSESS
• Have students work in pairs to develop lists of qualitative data and quantitative data. Direct students to list examples from this section and add as many others as they can.

Have students compare lists and record any additional examples.
• Have students complete the Questions on page xxx of the Student Book.

DIFFERENTIATED INSTRUCTION
• Visual learners will benefit from the use of drawings to depict concepts covered in this section. Allow kinesthetic learner to compare qualitative and quantitative concepts by identifying differences in the shapes of objects versus numbers or masses of objects. Allow auditory learners to discuss concepts with a partner.

ENGLISH LANGUAGE LEARNERS
• Tell English language learners that the vocabulary terms qualitative and quantitative are derived from the words quality and quantity. Have students work in pairs to look up the definitions of quality and quantity and explain to each other how the meanings of the two terms differ.

6.2 Explore an Issue in Chemical Quantities

OVERALL EXPECTATIONS: A1; D1

SPECIFIC EXPECTATIONS

Scientific Investigation Skills: A1.3; A1.7; A1.9; A1.10; A1.11

Relating Science to Technology, Society, and the Environment: D1.1

The full Overall and Specific Expectations are listed on pages xx–xx.

SKILLS
Researching Analyzing
Identifying Alternatives Communicating

ASSESSMENT RESOURCES
Assessment Rubric 9: Explore an Issue
Assessment Summary 9: Explore an Issue
Self-Assessment Checklist 5: Explore an Issue

PROGRAM RESOURCES
Skills Handbook A5 Exploring Issues and Applications
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u
RELATED RESOURCES

EVIDENCE OF LEARNING
Look for evidence that students can
• identify medical conditions that are linked to an excess of dietary salt
• identify foods that are high in salt
• recommend changes that would likely reduce the salt intake of students in the school cafeteria
• communicate their findings and recommendations in a persuasive report

SCIENCE BACKGROUND
• Some sodium is necessary for good health. It plays an important role in maintaining body fluid levels, transmitting nerve impulses, and contracting and relaxing muscles.
• The recommended daily consumption of sodium is 1500 mg. One teaspoon of salt, or sodium chloride, contains 2300 mg of sodium. Baking soda—sodium hydrogen carbonate—contributes 1000 mg of sodium per teaspoon.

POSSIBLE MISCONCEPTIONS
Identify: Students might think that table salt itself, and not sodium, is the root of the problem.
Clarify: Emphasize that although table salt is the main source of sodium in most diets, other ionic substances that are composed of sodium also contribute to the problem. Remind students that in Mini Investigation: Comparing Salty Snacks, they found that hot dogs contain high levels of sodium nitrate/nitrite.
Ask What They Think Now: At the end of this discussion, ask, Sodium nitrate is used as a preservative in processed meats. If the meat is cooked and served without table salt, is it a sodium-free meal? (The sodium nitrate contributes sodium even when no table salt is added.)

TEACHING NOTES
• Have a student volunteer read aloud "Overdosing on Salt." Instruct students to make a list of information from the text that they already knew about salt and a list of information that they did not know before. Point out that the information that was new to them would likely be unknown to others as well. (Students might be surprised by the statistics about the number of lives saved by a 15% reduction in daily salt intake and the fact that 90% of dietary salt is consumed from processed foods.)

THE ISSUE
• Point out to students that food labels provide information about sodium content and that many restaurants provide nutrition information for their foods. Say, Having this information available is the first step to adopting a healthier lifestyle. Ask, what further steps need to be taken in order for this information to make a difference? (Sample answer: People must be aware of the information, seek it out, and use it to make healthier decisions.)

GOAL
• In groups, have students discuss their preliminary ideas on achieving the goal set out in the section. Direct students to include ideas for both food prepared at home and food prepared in the school cafeteria.

RESEARCH
• Have students work in groups to research why and where salt occurs in the diet and the medical conditions associated with too much dietary salt.
• Help students to examine their sources for bias. Point out that information concerning medical conditions and treatment must come from a trusted, reliable source to avoid potential harm.

IDENTIFY SOLUTIONS
• Encourage students to determine the information that they want to share, the actions they wish to achieve, and the major groups they wish to address. Suggest that groups brainstorm solutions and determine which of these areas each best addresses.

MAKE A DECISION
• In their groups, have students decide which solution they think is best.

COMMUNICATE
• Have the groups present their ideas to the class.
• Organize a class debate regarding which solutions are practical and which are not.

PLAN FOR ACTION
• Help students locate resources about healthy cooking, especially ones that focus on reducing salt, to help plan two comparable lunches.

DIFFERENTIATED INSTRUCTION
• Weigh different quantities of table salt into clear plastic bags. Make it so that one bag contains the recommended daily allowance of salt for an adult, and the others contain varying quantities above and below this amount. Allow visual learners to observe the models and kinesthetic learners to hold them to compare their relative sizes. Auditory learners can use the models to describe the quantities to another student.

ENGLISH LANGUAGE LEARNERS
• Provide English language learners with a few extra days to prepare for this activity. Allow them to take the reading home so that they have the opportunity to make any
necessary translations and can prepare any questions they may wish to ask.

6.3 The Mole—A Unit of Counting

OVERALL EXPECTATIONS: A1; A2: D2

SPECIFIC EXPECTATIONS

Scientific Investigation Skills: A1.5; A1.8; A1.10
Career Exploration: A2.2
Developing Skills of Investigation and Communication: D2.1

The full Overall and Specific Expectations are listed on pages xx–xx.

VOCABULARY

• mole
• Avogadro’s constant

SKILLS

Performing
Observing
Analyzing
Communicating

EQUIPMENT AND MATERIALS

per group:
• balance
• small plastic cup or beaker
• 50 dry beans
• 50 grains of dry rice

ASSESSMENT RESOURCES

Assessment Rubric 1: Knowledge and Understanding
Assessment Summary 1: Knowledge and Understanding

PROGRAM RESOURCES

Skills Handbook A1 Safety
Skills Handbook A2 Scientific Inquiry
Skills Handbook A3 Laboratory Skills and Techniques
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
    www.nelson.com/onseniorscience/chemistry11u

RELATED RESOURCES


EVIDENCE OF LEARNING

Look for evidence that students can
• identify the mole as the SI base unit for the amount of a substance
• describe the entities (atoms, ions, molecules, or formula units) that make up a substance
• relate the physical basis of Avogadro's constant to carbon-12

SCIENCE BACKGROUND

• Amedeo Avogadro, an Italian chemist, hypothesized in the early 1800s that the number of particles per unit volume was the same for any gas at a given temperature and pressure. Although he had no way to measure what this ratio was, Avogadro's work on reacting gas volumes established a foundation for the work of other chemists, such as Jean Perrin. In 1909, Perrin proposed that the number of entities in a mole be named in honour of Avogadro.
• The term Avogadro's constant was not immediately accepted. In fact, it began to appear in high school chemistry texts in the 1950s. The mole was recognized as the SI base unit for the amount of a substance in 1971.

TEACHING NOTES

ENGAGE

• On the board, write the counting units from Table 1 on page xx of the Student Book, but do not write the examples. Challenge students to identify the number that is associated with each unit. Ask, How many objects are in a gross? (12 dozen or 144) Point out that in this section, students will learn about a similar unit in chemistry that makes it easier to count entities of substances.

EXPLORE AND EXPLAIN

• Have a student volunteer read aloud the Learning Tip on page xx of the Student Book. Review with students the specific use of each type of entity and point out that the text uses the term entity when referring in general to the basic particles that make up a substance.
• Have students complete Mini Investigation: Counting Estimates.

MINI INVESTIGATION: COUNTING ESTIMATES

Skills: Performing, Observing, Analyzing, Communicating
Purpose: Students will use mass measurements to estimate the number of beans or grains of rice in 1.0 kg of the material.
Equipment and Materials (per group): balance; small plastic cup or beaker; 50 dry beans; 50 grains of dry rice
Student Safety: Remind students that they must not eat anything in the laboratory.

Notes
• Students should complete this activity in small groups.
• Any type of bean would work. Pinto beans are easily purchased.
in bulk and are small enough for easy storage.

- Clearly mark any containers of rice and beans that are used for this activity to prevent human consumption.

- Direct the students to examine Figure 4. Ask, Which quantities are the same and which are different when comparing one mole each of carbon and of sulfur? (The number of atoms of each element is the same, but the mass and volume of each sample are different.)

- Draw students' attention to Tutorial 1: Working with Powers of 10 on page xxx of the Student Book.

- Work through the Sample Problems with the class. Help students correctly handle the exponents. Ask, When you multiply numbers expressed in scientific notation, what do you do with the exponents? (Add the exponents.) When you divide numbers expressed in scientific notation, what do you do with the exponents? (Subtract the exponents.) Explain that the reason we treat exponents in this way is that, with powers of 10, the exponent represents the number of zeroes in the number. Write the following example on the board: 100 × 1000 = 100,000. Point out that 1× 10^2 = 100, 1× 10^3 = 1000, and 1× 10^5 = 100,000. Rewrite the equation using scientific notation to illustrate that adding the exponents yields the same answer as the original equation.

- Help students learn the correct way to use the EE or EXP button on their calculators to enter numbers expressed in scientific notation. Point out that use of this button will help prevent errors because the calculator handles the number as a single entity rather than as two separate values multiplied together.

- Allow students time to work through the Practice Problem. Address any questions or issues that arise.

**EXTEND AND ASSESS**

- Have students calculate how many planets, each with a population of 6,000,000,000 people, would be needed to hold a mole of people. (1 × 10^{14} planets)

- Have students complete the Questions on page xxx of the Student Book.

**DIFFERENTIATED INSTRUCTION**

- Have students work individually or in groups to design and create an illustration, song, skit, or model that describes a mole of a substance.

**ENGLISH LANGUAGE LEARNERS**

- Remind English language learners that the term mole is used differently in chemistry than in everyday speech. Explain that the use of mole in this context is believed to have been derived from the German word *molekül* (molecule).

**VOCABULARY**

- molar mass

**SKILLS**

- Performing
- Analyzing
- Observing
- Communicating

**EQUIPMENT AND MATERIALS**

*per student:*
- chemical safety goggles
- lab apron

*per group:*
- balance
- scoopula
- 250 mL beaker
- samples of different substances

**ASSESSMENT RESOURCES**

Assessment Rubric 1: Knowledge and Understanding
Assessment Rubric 2: Thinking and Investigation
Assessment Summary 1: Knowledge and Understanding
Assessment Summary 2: Thinking and Investigation

**PROGRAM RESOURCES**

Skills Handbook A2 Scientific Inquiry
*Chemistry 11 ExamView® Test Bank*
*Chemistry 11 Online Teaching Centre*
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

**EVIDENCE OF LEARNING**

Look for evidence that students can

- relate the molar mass to the average atomic mass of an element
- calculate the molar mass of a compound from the chemical formula of the compound
• calculate the amount in moles, the molar mass, or the mass of a pure substance when given the other two quantities

SCIENCE BACKGROUND

• The atomic mass unit (u) is used to express the average atomic mass of elements. Since 1961, it has been defined as 1/12 of the mass of a carbon-12 nuclide. However, before 1961, chemists and physicists used different values for the atomic mass unit. Physicists defined an atomic mass unit as 1/16 the mass of an oxygen-16 nuclide. Chemists defined it as 1/16 of the average mass of the atoms in naturally occurring oxygen, which is a mixture of oxygen-16, oxygen-17, and oxygen-18 nuclides.

TEACHING NOTES

ENGAGE

• Direct students to examine the chemical equation for the reaction of methane and steam (CH₄ + H₂O ↔ CO + 3H₂). Present a model of a methane molecule and a model of a water molecule. Ask, Based on the equation, would you expect 1 kg of each compound or 1 mol of each compound to react completely? (Because each contains the same number of entities and the equation shows that one molecule of each compound reacts, 1 mol of each compound should react completely.) You may wish to explain to students that this reaction yields carbon monoxide, and therefore it would be dangerous to demonstrate this reaction in the classroom.

EXPLORE AND EXPLAIN

• Direct students to cover the third column of Table 2 on page xx of the Student Book. Instruct students to write an equation to calculate the molar mass of each substance using the chemical formula and model as guides. Have students check one another's work.
• Draw students' attention to Tutorial 1: Determining Molar Mass on page xxx of the Student Book.
• Work through the Sample Problems with the class. Help students to write the initial equation that shows the number of atoms of each element correctly.
• Direct students to examine how the water of hydration in Sample Problem 4 is handled. Ask, How is the mass of the two water molecules handled? (The molar mass of water is calculated and then multiplied by the coefficient.) Point out that a similar technique can be used to handle a polyatomic ion that is followed by a subscript, such as in Ca(OH)₂.
• Allow students time to work through the Practice Problems. Address any questions or issues that arise.
• Have students complete Mini Investigation: The Mole Exhibit.

MINI INVESTIGATION: THE MOLE EXHIBIT

Skills: Performing, Observing, Analyzing, Communicating

Purpose: Students will calculate the molar mass of a pure substance and measure 1.00 mol of that substance.

Equipment and Materials (per student): chemical safety goggles; lab apron; (per group): balance; scoopsula; 250 mL beaker; samples of substances assigned

Student Safety:
• Remind students to always wear their lab apron and safety goggles when working with chemicals.

Notes
• Students should complete this activity in small groups.
• Choose substances that pose little to no safety concerns. Examples that are readily available include water, sodium chloride, sucrose, aluminum, iron, copper, Epsom salts (magnesium sulfate heptahydrate), calcium carbonate, and sodium hydrogen carbonate.
• Provide an additional beaker to any team that is assigned sucrose, to hold the required amount.
• To enhance the sense of creating an exhibit, you may wish to have students create an informational card to set near their substance. Information such as the chemical formula, name, and molar mass would require no additional research. Additional information, such as source and uses, would require time for research.

• Draw students' attention to Tutorial 2: Converting Among Amount, Mass, and Molar Mass on page xxx of the Student Book.
• Direct students to examine the symbols used for each quantity. Ask, What symbol represents amount? (n) Ask, What is the difference between the symbols for mass and for molar mass? (The symbol for mass is a lowercase m and the symbol for molar mass is an uppercase M.)
• Work through the Sample Problems with the class. Point out how to use the units to help check that the work is done correctly.
• Inform students whether they need to write a concluding statement to report their answers.
• Allow students time to work through the Practice Problems. Address any questions or issues that arise.

EXTEND AND ASSESS

• Have students place the following substances in order from least to greatest mass: 1.50 mol NH₃, 4.36 mol F₂; 0.754 mol Al(OH)₃; (F₂: 46.7 g; NH₃: 49.6 g; Al(OH)₃: 58.8 g)
• Have students complete the Questions on page xxx of the Student Book.

DIFFERENTIATED INSTRUCTION

• Work with students to calculate the volume of one mole of water using its molar mass (18.0 g/mole) and density (1.0 g/mL). (The volume of one mole of water is 18 mL) Then provide students with three separate measured quantities of water (9 mL, 36 mL, and 27 mL) in graduated cylinders and ask, How many moles of water are represented in each? (0.5 moles, 2 moles, and 1.5 moles) Visual learners will benefit from seeing the
samples and auditory learners will benefit from discussing the answers. In another demonstration, fill a balloon with 180 g water and a second balloon with 360 g water and have students determine the mass and the number of moles of water in each (10 moles and 20 moles). Kinesthetic learners will benefit from manipulating the balloons to observe their relative masses.

ENGLISH LANGUAGE LEARNERS

• Bring in some common household products that have labels in languages other than English. Have all students study the ingredient labels and try to determine and write out the chemical formulas for some of the simple compounds they find. All students will learn about chemical formulas from the exercise, and English language learners will be able to see other students experience the language barriers they face every day.

6.5 Mass and Number of Entities

OVERALL EXPECTATIONS: A1; A2; D2; D3

SPECIFIC EXPECTATIONS

Scientific Investigation Skills: A1.2; A1.10; A1.12; A1.13
Career Exploration: A2.2
Developing Skills of Investigation and Communication: D2.1
Understanding Basic Concepts: D3.2

The full Overall and Specific Expectations are listed on pages xx–xx.

SKILLS

Planning Analyzing
Performing Communicating
Observing

EQUIPMENT AND MATERIALS

per student:
• lab apron

per group:
• balance
• dropper
• graduated cylinder
• chalk
• water
• disposable cups
• penny

ASSESSMENT RESOURCES

Assessment Rubric 1: Knowledge and Understanding
Assessment Summary 1: Knowledge and Understanding

PROGRAM RESOURCES

BLM 6.5-1 Mass, Mole, and Entity
Skills Handbook A2 Scientific Inquiry
Skills Handbook A6 Math Skills
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

RELATED RESOURCES


EVIDENCE OF LEARNING

Look for evidence that students can
• calculate the number of entities in a sample
• calculate the number of atoms or ions in a sample of a compound

SCIENCE BACKGROUND

• In 1867, J. Loschmidt determined an estimate for the number of molecules per unit volume of gas that was one-thirtieth the correct value. In 1911, Albert Einstein calculated Avogadro's constant as $6.56 \times 10^{23}$ based on the diffusion of sugar solutions. Modern determinations of Avogadro's constant use x-ray diffraction patterns and the density of crystals.
• Each year on October 23, chemists around the world celebrate International Mole Day beginning at 6:02 a.m. and ending at 6:02 p.m

TEACHING NOTES

ENGAGE

• Challenge students to calculate the number of various objects. Ask, How many eggs are in 3 dozen? (36) How many cans of pop are in 8 six-packs? (48) How did you calculate each of these quantities? (Sample answer: I took the number of groups and multiplied by the number of items in that kind of group.) Point out to students that they will be doing the same type of calculation with moles and the number of entities of a substance.

EXPLORE AND EXPLAIN

• Draw students’ attention to Tutorial 1: Calculating the Number of Entities in a Sample on page xxx of the Student Book.
• Work through the Sample Problems with the class. Point out how to use the units to help check that the work is done correctly.
• Instruct students that although the name for the specific entity changes depending on the type of substance, the method for calculating the number of entities does not. The same steps used to calculate the atoms in an element are used to calculate the molecules in a molecular compound.
• Allow students time to work through the Practice Problems. Address any questions or issues that arise.
• Draw students' attention to Tutorial 2: Calculating the Number of Atoms or Ions in a Sample on page xxx of the Student Book.
• Work through the Sample Problem with the class. Point out that the outcome of Steps 1 to 4 is the number of entities of the compound and is the same process students learned in Tutorial 1. Help students see that finding atoms or ions in a sample is simply a one-step extension of finding the number of entities of a compound.
• Direct students to examine the chemical formula for benzaldehyde, C₆H₅CHO. Ask, How many atoms of carbon are present in one molecule of benzaldehyde? (7) Point out how this ratio is used in Step 5 to convert from molecules to atoms of carbon.
• Allow students time to work through the Practice Problems. Address any questions or issues that arise.
• Have students complete Mini Investigation: Determining Numbers of Everyday Entities.

MINI INVESTIGATION: DETERMINING NUMBERS OF EVERYDAY ENTITIES
Skills: Planning, Performing, Observing, Analyzing, Communicating
Purpose: Students will use mass to calculate the number of entities (either molecules or formula units) that make up samples of common substances.
Equipment and Materials (per student): lab apron; (per group): balance; dropper; graduated cylinder; chalk; water; disposable cups; penny
Student Safety: To avoid the perception that drinking in the lab is acceptable, you may wish to provide water from a source other than from faucets in the room. Point out to students that the water is not from the lab and that the cups are disposable, not lab glassware.
Notes
• Students should complete this activity in small groups.
• Student Sample Procedures: (i) Find the mass of the chalk. Write your name. Find the mass of the chalk again. Subtract the masses to find the mass of chalk in your name. (ii) Fill a disposable cup with water. Find the mass of the cup and water. Take a mouthful of water from the cup. Find the mass of the cup and water again. Subtract the masses to find the mass of the water that you held in your mouth. (iii) Fill a dropper with water. Find its mass. Place drops of water on a penny until one drop causes the water to overflow. Find the mass of the dropper and remaining water. Subtract the masses to find the mass of water that was used.

EXTEND AND ASSESS
• Distribute BLM 6.5-1 Mass, Mole, and Entity, and have students complete it.
• Have students place the following substances in order from least to greatest number of entities: 3.05 g Ca(NO₃)₂; 0.899 g CO₂; 0.377 g Na. (Na: 9.87 × 10²¹ atoms; Ca(NO₃)₂: 1.12 × 10²² formula units; CO₂: 1.23 × 10²² molecules)
• Have students complete the Questions on page xxx of the Student Book.

DIFFERENTIATED INSTRUCTION
• Work with students having difficulty carrying out calculations to find a method that works for them. Visual learners may prefer to see the steps written out so that they can see how to cancel units. Auditory learners may prefer to work through problems by talking about the steps as a partner or coach provides feedback and prompting.

ENGLISH LANGUAGE LEARNERS
• Remind English language learners to include units in all parts of their calculations.

6.6 The Composition of Unknown Compounds

OVERALL EXPECTATIONS: A1; A2; D2; D3

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A1.5; A1.8; A1.10; A1.12
Career Exploration: A2.2
Developing Skills of Investigation and Communication: D2.2; D2.3
Understanding Basic Concepts: D3.1

The full Overall and Specific Expectations are listed on pages xx–xx.

VOCABULARY
• percentage composition
• law of definite proportions

SKILLS
Planning Analyzing
Performing Communicating
Observing
EQUIPMENT AND MATERIALS

per group:
• balance
• 3 molecules of paperclip “compound”

ASSESSMENT RESOURCES

Assessment Rubric 1: Knowledge and Understanding
Assessment Rubric 2: Thinking and Investigation
Assessment Summary 1: Knowledge and Understanding
Assessment Rubric 2: Thinking and Investigation

PROGRAM RESOURCES

Skills Handbook A2 Scientific Inquiry
Skills Handbook A3 Laboratory Skills and Techniques
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

RELATED RESOURCES


EVIDENCE OF LEARNING

Look for evidence that students can
• identify the percentage composition of a compound as the proportion of each element in the compound, by mass
• calculate the percentage composition of a compound from experimental data
• calculate the percentage composition of a compound from the chemical formula of the compound
• explain the law of definite proportions in terms of the uniform percentage composition of any size sample of a compound

SCIENCE BACKGROUND

• In the late 1800s, French chemist Joseph Louis-Proust conducted numerous experiments on the composition of substances that supported the law of definite proportions. The Scottish chemist Thomas Thomson confirmed some of Proust's results, which reinforced the idea.
• The atomic theory put forth by John Dalton in 1803 helped to provide a framework in which definite proportions of elements in compounds made sense.

TEACHING NOTES

ENGAGE
• Instruct students that a key step in determining the chemical formula of an unknown compound is to determine the composition of the compound. Direct students to examine Figure 2. Ask, Why is excess oxygen important for this analysis? (The combustion must be complete, so that only water and carbon dioxide are produced.) How does knowing the mass of water produced help to determine the mass of hydrogen in the original sample? (The water is composed of all of the hydrogen atoms from the original sample, so the mass of hydrogen can be determined from the mass of water because all of the hydrogen is used up, and now appears in the water.) If we know the mass of the excess oxygen, why is it not possible to determine the mass of the water formed? (Only some of the oxygen appears in the water; the rest is left over and is not in the water.)

EXPLORE AND EXPLAIN

• Draw students' attention to Table 1 and Table 2. Have students describe any patterns they see in the masses of the elements and in the percentages of the elements. (Sample answers: The mass of carbon always falls between the masses of hydrogen and oxygen, but the mass of carbon in each sample is different. The percentage of each element is identical in all three samples.)
• Direct students to think of a percentage as a part divided by the whole. For percentage composition, the part is the mass of an element and the whole is the mass of the sample.
• Draw students' attention to Tutorial 1: Calculating Percentage Composition on page xxx of the Student Book.
• Work through Sample Problem 1 with the class. Point out that using lab data requires either the mass of each element in the compound or the total mass of the sample and the mass of each element but one.
• Allow students time to work through the Practice Problems. Address any questions or issues that arise.
• Work through Sample Problem 2 with the class. Point out to students that they calculate the mass of each individual element in a chemical formula when calculating the molar mass.
• Allow students time to work through the Practice Problems. Address any questions or issues that arise.
• Have students complete Mini Investigation: Determining Percentage Composition of a Compound.

MINI INVESTIGATION: DETERMINING PERCENTAGE COMPOSITION OF A COMPOUND

Skills: Planning, Performing, Observing, Analyzing, Communicating

Purpose: Students will determine a method to calculate the percentage composition of a simulated compound that is represented by a model made of paper clips.

Equipment and Materials (per group): balance; 3 molecules of the paper clip "compound"

Notes
• Students should complete this activity in small groups.
• Sample Procedure: Separate the 3 paper clip molecules and find the mass of each type of paper clip. Divide the mass of each type of paper clip by the total mass of the models and multiply by 100 to calculate the percentage composition of each element in the compound.
EXTEND AND ASSESS
• Have students determine which iron ore has a higher percentage of iron: magnetite (Fe₃O₄) or hematite (Fe₂O₃). (magnetite; 72.36 % versus 69.94 %)
• Have students complete Investigation 6.6.1. Applicable teaching notes can be found on page xx of this resource.
• Have students complete Investigation 6.6.2. Applicable teaching notes can be found on page xx of this resource.
• Have students complete the Questions on page xxx of the Student Book.

DIFFERENTIATED INSTRUCTION
• Have students work in groups to analyze a simple recipe they have brought from home as an analogy for the law of definite proportions. As part of their analysis, students can discuss the recipe and draw illustrations to show how ingredients are present in definite proportions.

ENGLISH LANGUAGE LEARNERS
• Have English language learners create a concept map of the concepts that have been introduced thus far in the chapter. They can add to it as they work through the chapter. Have them explain their map to another student.

OVERALL EXPECTATIONS: D2; D3

SPECIFIC EXPECTATIONS
Developing Skills of Investigation and Communication: D2.1; D2.3; D2.4
Understanding Basic Concepts: D3.3

Vocabulary
• empirical formula
• molecular formula

ASSESSMENT RESOURCES
Assessment Rubric 1: Knowledge and Understanding
Assessment Summary 1: Knowledge and Understanding

PROGRAM RESOURCES
Skills Handbook A6 Math Skills
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

RELATED RESOURCES

EVIDENCE OF LEARNING
Look for evidence that students can
• classify a chemical formula that shows the simplest whole-number ratio of elements as an empirical formula
• determine the empirical formula of a compound from percentage composition data
• determine whether a chemical formula is an empirical formula, a molecular formula, or both

SCIENCE BACKGROUND
• Although percentage composition can be used to eliminate possible chemical formulas for a compound, it cannot be used to verify a chemical formula. Often, especially with organic compounds, more than one compound has the same percentage composition. Compounds that have the same composition have the same empirical formula.
• Empirical formulas may or may not represent the chemical formula for an actual substance. The chemical formulas of many ionic compounds are empirical formulas because the lowest whole-number ratio of ions is shown. However, the subscripts in the chemical formulas of many molecular compounds are not in the lowest whole-number ratio. Thus, the chemical formulas and the empirical formulas differ.

TEACHING NOTES
ENGAGE
• Before class, construct a model from plastic building blocks composed of multiple copies of repeating units. For example, a model could contain four units composed of one large blue block attached to two small red blocks. Draw students' attention to the model. Ask, What is the simplest unit that can be used to construct this model? (Sample answer: one large blue block attached to two small red blocks) Point out that chemists describe the composition of compounds in a similar way by finding the smallest whole-number ratio of atoms in a compound.

EXPLORE AND EXPLAIN
• Point out to students that in the paragraph above Table 1, the text describes 100.0 g of the compound as being a convenient mass. Ask, When you are given the percentage composition, why is 100.0 g a convenient mass to consider? (Sample answer: By imagining a sample that has a mass of 100.0 g, we can change the percentage of each element directly into grams.)
• Point out the formulas shown in Table 2. Ask, How does each molecular formula compare with the empirical...
formula? (The molecular formula of methanal is the same as the empirical formula. The molecular formula of ethanoic acid is double the empirical formula.) Point out that calculating molecular formulas is the topic covered in Section 6.9.

- Draw students’ attention to Tutorial 1: Determining the Empirical Formula from Percentage Composition on page xxx of the Student Book.
- Work through Sample Problem 1 with the class. Point out that in Step 3, the amount of each element is divided by the smallest amount, so that no value less than 1 will result. Review with students the unit used for amount. Ask, When you calculate an amount of an element, what unit of measure does your answer have? (mol)
- Before working through Sample Problem 2, point out to students that dividing by the smallest amount does not always result in a whole number for each element. Direct students to examine the equivalent decimals and fractions in Table 3 and how multiplying by the denominator of the fraction results in a whole number. Ask, Why is it necessary to multiply every subscript, if any element has a decimal subscript? (Sample answer: You must multiply every subscript so that the ratio of the elements remains the same.)
- Work through Sample Problem 3 with the class.
- Allow students time to work through the Practice Problem. Address any questions or issues that arise.

**Extend and Assess**

- As an extension activity, tell students that hydrocarbons with one double bond between two carbon atoms have a general formula of \( \text{C}_n\text{H}_{2n} \) while hydrocarbons with one triple bond between two carbon atoms have a general formula of \( \text{C}_n\text{H}_n \). Ask, Based on these general formulas, what is the empirical formula for each group of compounds? (CH₂ and CH)
- Have students complete the Questions on page xxx of the Student Book.

**Differentiated Instruction**

- Allow students to work in pairs with colored plastic building blocks. Have each partner assemble a representative “molecule” and then trade with their partner to determine the empirical formula and molecular formula of their partner’s “molecule.” Student pairs can then discuss their results to reach consensus. Follow up by checking to make sure that their analyses are correct.

**English Language Learners**

- Have English language learners research the word “empirical” to learn that an empirical process is one that involves experiment. Help them understand that experimental work (e.g., elemental analysis) is typically done to determine the empirical formula for a compound.

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**Overall Expectations:** A2; C1; C2; C3

**Specific Expectations**

- Career Exploration: A2.1
- Relating Science to Technology, Society, and the Environment: D1.1

The full Overall and Specific Expectations are listed on pages xx–xx.

**Program Resources**

BLM 0.0-8 Reading Strategies Checklist
Skills Handbook A4 Scientific Publications
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

**Related Resources**


**Teaching Notes**

- Distribute BLM 0.0-8 Reading Strategies Checklist and have students complete it as they read the article.
- Have student brainstorm ideas about what they might learn from the article before reading its title. Write their ideas on the board.
- Ask a student volunteer to read the abstract aloud. Ask students what is meant by the word “illicit.” Ask students for suggestions of other words with similar meaning. (Sample answers: illegal, forbidden)
- After students read the article, discuss whether technology made it possible to tell if banknotes are contaminated with drugs. (Sample answer: Yes, because the quantities of drugs on banknotes are so small that they cannot be detected without the aid of technology.)
- Have students brainstorm other ways of detecting small quantities of substances. (Sample answers: Train dogs to recognize substances or develop a reactive spray that changes colour when it contacts a substance.) Follow up with a class discussion about the pros and cons of using the suggested methods.
- Ask, What is revealed in the photographs shown in Figure 1? (the two kinds of paper are similar in structure)
- Ask, Why does the researcher wear gloves in Figure 2? (to avoid adding any compounds from the skin to the sample being analyzed)
• Ask, How are Figures 3 and 4 related? (Figure 3 shows the instrument used to detect cocaine, and Figure 4 shows the output of the instrument when cocaine is detected.)
• Have students complete the Questions on page xxx of the Student Book.

DIFFERENTIATED INSTRUCTION
• Have students work in pairs to discuss the experimental process described in the article, and then make a flowchart to summarize it. Auditory learners will benefit from the discussion and visual learners will benefit from creating a flowchart to represent the process.

ENGLISH LANGUAGE LEARNERS
• Pair English language learners with students proficient in English language skills. Have students work together to create a flowchart to summarize the experimental process discussed in the article.

6.9 Molecular Formulas

OVERALL EXPECTATIONS: A1; A2; D1; D3

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A1.1; A1.2; A1.5; A1.10; A1.12
Career Exploration: A2.2
Relating Science to Technology, Society, and the Environment: D1.1
Understanding Basic Concepts: D3.3

The full Overall and Specific Expectations are listed on pages xx–xx.

SKILLS
Predicting Analyzing
Performing Communicating
Observing

EQUIPMENT AND MATERIALS
per group:
• molecular model kit

ASSESSMENT RESOURCES
Assessment Rubric 1: Knowledge and Understanding
Assessment Summary 1: Knowledge and Understanding

PROGRAM RESOURCES
BLM 0.0-3 Two-Column Table
BLM 6.9-1 Determining Molecular Formulas
Skills Handbook A2 Scientific Inquiry
Skills Handbook A6 Math Skills

Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

RELATED RESOURCES

EVIDENCE OF LEARNING
Look for evidence that students can
• compare a molecular formula of a compound with the empirical formula of the compound
• calculate the multiplier needed to determine a molecular formula by dividing the molar mass of the compound by the molar mass of the empirical formula
• determine the molecular formula of a compound from the empirical formula and the molar mass of the compound
• determine the molecular formula of a compound from the percentage composition and molar mass of the compound

SCIENCE BACKGROUND
• As seen in Section 6.8, molecules in a sample analyzed in a mass spectrometer are ionized, and some molecules break into smaller fragments. Most of the ions have a single charge, so the separation at the detector is based on the mass of the fragments. The largest molecular mass detected corresponds to the mass of the original molecule. Mass spectrometers are sensitive enough to distinguish fragments that differ by a single atomic mass unit.

TEACHING NOTES
ENGAGE
• On a balance, place a connected unit of plastic building blocks, such as the repeating unit from the model used in Section 6.7. Have a student read the mass of the blocks. Ask, If I build a model that is made up of several of these basic units, what could you predict about the model's mass? (Sample answer: The model's mass must be a multiple of the unit's mass because the model is made up of more than one of the unit.) Point out that the molecular mass of an actual chemical compound has a similar relationship to the mass of the empirical formula of the compound.

EXPLORE AND EXPLAIN
• Draw students' attention to Figure 2. Instruct students that each bar on the graph marks the mass of one of the fragments created during the analysis. Point out to students the structural formula of ethyl ethanoate. Ask, How would you explain the presence of a fragment that has a molecular mass of 43 u? (Sample answer: The molecule broke apart at the single bond between the second carbon atom from the left and the oxygen atom.)
The fragment containing two carbon atoms, three hydrogen atoms, and one oxygen atom has a molecular mass of 43 u.) *Why is the pattern of the fragments important for identifying a compound?* (Sample answer: Even if two compounds have the same molecular formula, their atoms will be connected in different ways, so the molecules will break into different fragments.)

• Point out to students that the molar mass of each compound in **Table 1** is a whole-number multiple of the molar mass of the empirical formula.

• Have students complete **Mini Investigation: Comparing Molecules and Molecular Formulas**.

### MINI INVESTIGATION: COMPARING MOLECULES AND MOLECULAR FORMULAS

**Skills:** Predicting, Performing, Observing, Analyzing, Communicating

**Purpose:** Students will use a molecular model kit to build models of molecules that have the same empirical formula but different molecular formulas.

**Equipment and Materials (per group):** molecular model kit

**Notes**

- Students should complete this activity in small groups.
- Consider using clay or plastic foam balls with toothpicks in place of molecular model kits. You need materials to represent a total of 3 carbon atoms, 6 hydrogen atoms, and 3 oxygen atoms for each group.
- Although it is not necessary for this investigation, you may wish to instruct students to build each model to show a reasonable structure and bonding pattern.

• Draw students' attention to **Tutorial 1: Determining a Molecular Formula from an Empirical Formula** on page xxx of the Student Book.

• Work through **Sample Problem 1** with the class. Direct students to examine Step 3. Ask, *Why is it necessary to multiply every subscript by the factor x?* (Sample answer: You must multiply every subscript so that the molar mass of the molecular formula matches the molar mass given while keeping the ratio of the elements the same as it is in the empirical formula.)

• Allow students time to work through the **Practice Problem**. Address any questions or issues that arise.

• Work through **Sample Problem 2** with the class. Point out to students that Steps 1 to 5 are the same steps that they learned in **Section 6.7** to determine an empirical formula.

• Allow students time to work through the **Practice Problem**. Address any questions or issues that arise.

### EXTEND AND ASSESS

• Distribute **BLM 6.9-1 Determining Molecular Formulas**, and have students complete it.

• Distribute **BLM 0.0-3 Two-Column Table**. Instruct students to consider two compounds with the same molecular formula. Direct students to list characteristics that are the same for the two substances in the first column. (Sample answers: molar mass, empirical formula, percentage composition) Then, have students list characteristics of the compounds that can differ in the second column. (Sample answers: structural formula, mass spectrum, melting point, and boiling point)

• Have students complete **Investigation 6.9.1**. Applicable teaching notes can be found on page xx of this resource.

• Have students complete the **Questions** on page xxx of the Student Book.

### DIFFERENTIATED INSTRUCTION

• Have students work in pairs to use coloured plastic blocks or molecular models to construct examples of molecules with the same empirical formula but different molecular formulas. Ask each pair to predict how the molar masses will be related and then have pairs use a balance to compare the masses of their models. The use of models helps visual and kinesthetic learners apply these concepts, and the verbal exchange between partners is helpful for auditory learners.

### ENGLISH LANGUAGE LEARNERS

• English language learners will find this section helpful for making the distinction between an empirical formula and a molecular formula. As you conclude this section, have them write one to two sentences describing each term and how they are related to one another.

### 6 Investigations

#### 6.6.1 Observational Study: Popping Percentage Composition

**OVERALL EXPECTATIONS:** A1; D2

**SPECIFIC EXPECTATIONS**

**Scientific Investigation Skills:** A1.1; A1.2; A1.5; A1.6; A1.8; A1.10; A1.11; A1.12; A1.13

**Developing Skills of Investigation and Communication:** D2.2

_The full Overall and Specific Expectations are listed on pages xx–xx._

**SKILLS**

<table>
<thead>
<tr>
<th>Planning</th>
<th>Analyzing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performing</td>
<td>Evaluating</td>
</tr>
<tr>
<td>Observing</td>
<td>Communicating</td>
</tr>
</tbody>
</table>
EQUIPMENT AND MATERIALS

per group:
- hot air popcorn maker
- balance
- large clear plastic bag (to catch the popcorn)
- popping corn

ASSESSMENT RESOURCES

Assessment Rubric 7: Observational Study
Assessment Summary 7: Observational Study
Self-Assessment Checklist 3: Observational Study

PROGRAM RESOURCES

Skills Handbook A2 Scientific Inquiry
Skills Handbook A6 Math Skills
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

EVIDENCE OF LEARNING

Look for evidence that students can
- calculate a percentage by mass from experimental data
- plan a procedure to collect the mass data necessary for calculating a percentage by mass
- identify sources of error in their procedure
- predict how a source of error could affect the final calculated value of the percentage by mass of water

SCIENCE BACKGROUND

- The oldest ears of popcorn were discovered in the United States in the Bat Cave in New Mexico. The oldest ears are roughly 5600 years old. A popped kernel of popcorn dated at 1000 years old was found in the United States in a cave in southwestern Utah.
- Popcorn must be harvested and dried to an optimum moisture level of 13.5 % to 14 %. Unpopped popcorn kernels should be stored in an airtight container to prevent them from drying out.

TEACHING NOTES

STUDENT SAFETY

Remind students of the following safety procedures.
- Do not eat anything in the laboratory.
- Be careful with hot surfaces.
- Keep the popcorn maker dry and away from water. Handle the appliance and cord with dry hands. Do not pull on the cord.
- Students will conduct this investigation in small groups.

PURPOSE

- Explain that students will be collecting data and using it to calculate the percentage by mass of water in popping corn. Stress that each group must determine the quantities

they need to use to calculate the percentage by mass and then plan a procedure that allows the accurate measurements of those quantities.

EQUIPMENT AND MATERIALS

- It is a good idea to pre-test the hot air popcorn maker to check its operation before using it in class.
- Monitor the use of the popcorn maker to prevent accidents and to ensure that groups collect all popcorn kernels (popped and unpopped) in their samples.

PROCEDURE

- Instruct each group to write a step-by-step description for the procedure they design.
- **Student Sample Procedure:**
  1. Measure the mass of the empty plastic bag.
  2. Add kernels of popping corn to the bag and measure the mass of the bag and kernels.
  3. Determine the mass of the kernels of popping corn used.
  4. Pop the popping corn and collect the popped and unpopped kernels in the plastic bag.
  5. Measure the mass of the bag and the popcorn.
  6. Calculate the mass of the popped and unpopped kernels.
  7. Calculate the mass of water that escaped from the kernels by subtracting the mass of kernels before popping to the mass of kernels after popping.
  8. Calculate the percentage by mass of water by dividing the mass of water that escaped by the mass of the original unpopped kernels and then multiplying by 100.

OBSERVATIONS

- You may wish to ask groups to write a brief lab report summarizing their data and conclusions.
- Students should observe water percentages of about 14 %.

DIFFERENTIATED INSTRUCTION

- Students can work cooperatively in their groups to first discuss the procedure they will use (assisting auditory learners) and then to construct a flowchart illustrating the steps to be used (assisting visual learners). Two samples of popcorn illustrating before-and-after popping would help both visual and kinesthetic learners compare the relative volumes and masses of the popcorn in its two states.

ENGLISH LANGUAGE LEARNERS

- Ask English language learners to define the word “percentage” and to write their numerical results in words following the investigation.
6.6.2 Controlled Experiment: Percentage Composition of Magnesium Oxide

OVERALL EXPECTATIONS: A1; D1; D2

SPECIFIC EXPECTATIONS

Scientific Investigation Skills: A1.1; A1.2; A1.4; A1.5; A1.6; A1.8; A1.10; A1.11; A1.12; A1.13

Developing Skills of Investigation and Communication: D2.1; D2.2

SKILLS

Researching Observing
Hypothesizing Analyzing
Predicting Evaluating
Controlling Variables Communicating
Performing

EQUIPMENT AND MATERIALS

per student:
• chemical safety goggles
• lab apron

per group:
• ceramic crucible and lid
• balance
• steel wool or sandpaper
• ring clamp
• Bunsen burner clamped to a retort stand
• clay triangle
• tongs
• glass stirring rod
• graduated cylinder
• spark lighter
• two 8 cm strips of magnesium ribbon, Mg(s)
• dropper bottle containing distilled water

ASSESSMENT RESOURCES

Assessment Rubric 5: Controlled Experiment
Assessment Summary 5: Controlled Experiment
Self-Assessment Checklist 1: Controlled Experiment

PROGRAM RESOURCES

Skills Handbook A1 Safety
Skills Handbook A2 Scientific Inquiry
Skills Handbook A3 Laboratory Skills and Techniques
Skills Handbook A6 Math Skills
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre

EVIDENCE OF LEARNING

Look for evidence that students can
• calculate the theoretical percentage composition of a compound from its chemical formula
• calculate the percentage composition of a compound from experimental data
• identify sources of error in the experiment
• predict how a source of error could affect the final calculated value of the percentage by mass

SCIENCE BACKGROUND

• If each compound in a mixture has the same empirical formula, the percentage composition of each element would be the same for the mixture as it would be for any individual compound in the mixture. Because this is unlikely to occur, it is important to account for any possible contaminants in a sample to determine an accurate percentage composition of a desired substance.

TEACHING NOTES

STUDENT SAFETY

Remind students of the following safety procedures.
• Wear chemical safety goggles and apron for the entire investigation.
• Secure long hair and loose clothing while working around an open flame.
• Be careful with hot surfaces.
• Do not look at the flame that forms as magnesium burns as it can cause eye damage.

• Students will conduct this investigation in small groups.

TESTABLE QUESTION

• Pose the Testable Question in class. Direct students to examine the chemical equations for the possible reactions of magnesium. Ask, What type of reaction is occurring in this experiment? (synthesis)

HYPOTHESIS

• Make sure the hypothesis is a prediction written as a statement, along with a reason for the prediction. Sample hypothesis: The formation of magnesium nitride will cause the percentage composition found in the experiment to differ from the calculated result. If some of the product is not magnesium oxide, the masses will not allow accurate calculation of the percent composition of magnesium oxide.

VARIABLES

• The mass of magnesium used is a manipulated and measured variable. The pressure at which the reaction occurs is a controlled variable because it is not changed. The mass of the product is the responding variable.
EXPERIMENTAL DESIGN
• Consider doing this investigation as a teacher demonstration to reduce the risk of accident and the amount of material needed.
• If students run their own experiments, have them use one magnesium strip in one crucible to carry out both Part A and Part B in sequence.

EQUIPMENT AND MATERIALS
• You may wish to demonstrate the proper technique for using tongs to manipulate a crucible and lid to help reduce the chance of accidentally dropping a crucible and spilling its contents.

PROCEDURE
Part A
• Polishing the magnesium strips removes any oxidation from their surfaces.
• Demonstrate the correct set up and use of the clay triangle and the crucible.
• Ask students to have you check their set-ups before they begin heating their samples. At that time, have them demonstrate their technique for moving the crucible lid with tongs before allowing them to begin the procedure.

Part B
• Make sure students rinse all solid material from the stirring rod, collecting it in the crucible. Ask, What would happen to your results if you do not rinse the stirring rod? (Sample answer: You would lose some of the product, which would alter the percentage composition results.)
• You may wish to ask groups to provide a brief lab report that summarizes their data, clearly and systematically presents the calculations performed, and accurately presents their conclusions.
• The reaction of magnesium with oxygen produces a bright flame. After the reaction comes to an end, the flame is no longer visible; this can be used to gauge the end of the procedure. Students can also look to see if the magnesium strip has fully reacted by looking for traces of solid metal among the ashes of magnesium oxide following the reaction.

OBSERVATIONS
• If some of the magnesium reacts with nitrogen instead of oxygen, then Mg₃N₂ (magnesium nitride) will form instead of MgO. Magnesium nitride has a lower molar mass than MgO, so the mass of the product will be lower than expected.

DIFFERENTIATED INSTRUCTION
• Have groups discuss and prepare a flowchart of the procedure before they begin describing the calculations they will perform. Have them do a “dry run” of the experiment to allow kinesthetic and visual learners to think about how the experiment will proceed.

ENGLISH LANGUAGE LEARNERS
• This experiment has many steps, which may be challenging for English language learners to follow. Have them consider the experiment as a series of smaller parts that they can work through and summarize in their own words a day or so before the investigation.

6.9.1 Observational Study: Determining the Formula of a Hydrate

OVERALL EXPECTATIONS: A1; D2

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A1.1; A1.2; A1.4; A1.5; A1.6; A1.8; A1.10; A1.11; A1.12; A1.13
Developing Skills of Investigation and Communication: D2.1; D2.2

The full Overall and Specific Expectations are listed on pages xx–xx.

SKILLS
Performing Evaluating
Observing Communicating
Analyzing

EQUIPMENT AND MATERIALS
per student:
• chemical safety goggles
• lab apron
• heat-resistant safety gloves
per pair:
• large test tube
• scoopula
• balance
• utility clamp
• Bunsen burner clamped to a retort stand
• spark lighter
• gauze pad
• 2.00 to 4.00 g of hydrated copper(II) sulfate, CuSO₄•xH₂O
• 2 strips of cobalt chloride paper

ASSESSMENT RESOURCES
Assessment Rubric 7: Observational Study
Assessment Summary 7: Observational Study
Self-Assessment Checklist 3: Observational Study

PROGRAM RESOURCES
Skills Handbook A1 Safety
Skills Handbook A2 Scientific Inquiry
Skills Handbook A3 Laboratory Skills and Techniques
Skills Handbook A6 Math Skills
Chemistry 11 ExamView® Test Bank
EVIDENCE OF LEARNING

Look for evidence that students can

• calculate the percentage composition of water in a hydrate from experimental data
• determine the chemical formula of a hydrate from experimental data
• identify sources of error in the experiment
• predict how a source of error could affect the final calculated value of the percentage by mass of water

SCIENCE BACKGROUND

• The chemical formula of a hydrate indicates the number of water molecules that are joined to each formula unit of the ionic compound within a crystal of the substance. The water can be driven out of the crystal to leave the anhydrous ionic compound behind.
• Because water is bound within the crystals of a hydrate it must be taken into account when calculating the molar mass, such as when mixing a solution of a given concentration.
• The cobalt chloride paper detects the presence of water by changing from blue to pink through a change in hydration. The blue form is anhydrous, and the pink form is a hexahydrate.

TEACHING NOTES

STUDENT SAFETY

Remind students of the following safety procedures.

• Tie back long hair and secure loose clothing when working around an open flame.
• Be careful with hot surfaces.
• Avoid contact with copper(II) sulfate as it is toxic and a skin and eye irritant. Flush any skin that contacts copper(II) sulfate with large amounts of cool water.
• Make sure the mouth of the test tube points away from people at all times during heating.
• At the end of the experiment, place all copper(II) sulfate in the designated container.

• Students should conduct this investigation in pairs.

PURPOSE

• Explain that students will be collecting data and using it to calculate the percentage by mass of water in a hydrate of copper(II) sulfate. In addition, point out that they will use the same mass measurements to determine the chemical formula of the hydrate.

EQUIPMENT AND MATERIALS

• Assign different amounts of the hydrate to each pair to allow for a better comparison of the results.
• To reduce the time needed in class, you may wish to measure out the hydrate samples before class.
• Have students record the mass as precisely as possible, using the equipment available.

PROCEDURE

• Draw a data table on the board for each group to record the mass of their hydrated copper(II) sulfate and the percentage of water (by mass) in the sample.
• Monitor students to be sure that they are heating the test tube safely.
• Instruct students that improper heating could cause the copper(II) sulfate to decompose into copper(II) oxide. Ask, Which other product would form during this decomposition? (sulfur trioxide gas)

OBSERVATIONS

• The deep blue colour of the hydrated copper(II) sulfate will pale as water is driven off. The anhydrous copper(II) sulfate is white. If the solid begins to turn from white to black, then decomposition of the sulfate has begun. Have students record if they see any black solid in their test tube, as it may affect their results.
• The cobalt chloride paper will turn from blue to pink in the presence of water.
• Students should determine that the formula for the hydrate of copper sulfate is CuSO4•5H2O, which is 36.1 % water by mass.
• You may wish to ask groups to provide a brief lab report that summarizes their data, clearly and systematically presents the calculations performed, and accurately presents their conclusions.

DIFFERENTIATED INSTRUCTION

• Before carrying out the investigation, have pairs discuss each step of the procedure. Also, have them discuss and prepare a table to be used recording data and observations. This will help both auditory learners and visual learners better prepare for the investigation.

ENGLISH LANGUAGE LEARNERS

• Have English language learners research the words “hydrate” and “anhydrous.” Have them look up other examples of hydrates and write out their names and formulas. They may also benefit from exploring the prefixes used to indicate the number of water molecules in a hydrate (e.g., copper(II) sulfate pentahydrate).
SUMMARY QUESTIONS

- Return to students the Starting Points answers that they wrote before studying the chapter. Have them read over their responses and make any changes they wish. Afterwards, read each question aloud and discuss students’ answers. Consider the following points:
  1. Make sure students refer to patient safety. (For example, more than one person should check the dosage calculation to make sure that all amounts and units of measure are correct to maintain patient safety.)
  2. Make sure students refer to significant digits. (For example, rounding off answers incorrectly without regard to proper significant digits will result in misrepresentation of experimental results or errors in calculated amounts that could become worse with subsequent calculations.)
  3. Make sure students refer to advances in scientific understanding of the contaminants and their effects as well as improvements in detection. (For example, as detection and measuring tools become more sensitive and as scientific knowledge of contaminants and their effects improve, government agencies may need to adjust the quantities to reflect these changes.)
  4. Make sure students refer to differences in effect based on dosage. (For example, the effect of a toxin is difficult to generalize because it might differ based on many factors, including dosage, delivery method, and age of the person.)
  5. Make sure students refer to the potential for chemicals to persist in the environment and the possibility of problems that stem from long-term exposure. (For example, a chemical that is not acutely toxic might persist in the environment and cause problems through long-term exposure.)

- Ask one or two questions that will prompt student recall of each Key Concept. Have students explain and support their responses.

1. What types of chemical quantities in foods are important to measure? (Sample answers: sodium, fat, sugar)
2. What health problems could arise if the wrong dose of a medicine is taken? (Sample answer: Too low a dose may not provide the amount necessary to be effective, and too high a dose could be toxic.)
3. What does the law of definite proportions state? (The elements in a compound are always present in the same proportion by mass.)
4. What is the number of atoms in 1 mole? \( (6.02 \times 10^{23}) \)
5. What laboratory data must you have to calculate the percentage composition of an element in a compound? (Sample answer: You must have the total mass of the sample of the compound and the mass of the element in that sample.)
6. What must you do to find the moles of sodium in a given mass of sodium? (Sample answer: Divide the given mass of the sample by the molar mass of sodium.)

- Have students complete the questions found in the Chapter Self-Quiz and Chapter Review in the Student Book.

- Have students complete BLM 6.Q Chapter 6 Quiz for an additional review of the material.

CAREER PATHWAYS

- Distribute BLM 0.0-10 Careers and have students complete it as they complete their research.

- Oceanography includes many different areas of study and so provides jobs in many areas of interest. Inform students who express interest in oceanography that people with an interest in chemistry, geology, physics, and biology can find careers as oceanographers. Chemical oceanography involves analyzing ocean water to determine the identities, quantities and origins of chemical constituents present, as well as the reactions those chemicals undergo. Oceanographers should enjoy the sea, as they sometimes must be at sea for long periods of time to gather data.

- Pollution control technologists look for contaminants in water, soil, and air. Inform students who express interest in the field of pollution control that most jobs in this field focus on preventing and controlling pollution. However, some jobs involve conducting inspections and enforcing regulations. They should be prepared to work both indoors and outdoors for data collection and report preparation.

DIFFERENTIATED INSTRUCTION

- Provide students with the option of using their own preferred methods for summarizing aspects of this chapter that they find most helpful. Auditory learners may prefer using an outline form, visual learners may find a concept map most useful, and kinesthetic learners may want to...
experiment with using stacked overhead transparencies to layer information in a useful way.

ENGLISH LANGUAGE LEARNERS

- Direct English language learners to include drawings or notes on their concept maps to aid them in making connections between the many terms.
ENGAGE THE LEARNER

• Have student volunteers read the chapter introduction.

• To preview the major ideas that will be explored in the chapter, review the Key Concepts. Ask a student volunteer to read each Key Concept aloud before it is discussed. Ask prompting questions to assess students’ prior knowledge and to engage students in the topics. Examples are given:

  1. What are some processes in the home that involve chemical quantities and calculations? (Sample answers: baking, fertilizing plants, taking medication)
  2. What is the molar mass of a substance? (Sample answer: Molar mass is the mass for each mole of a substance.)
  3. What unit will your answer have if you predict the amount of product expected in a chemical reaction? (moles)
  4. If a reagent is something that is used in a chemical reaction, what do you think limiting reagents and excess reagents might be? (Sample answer: A limiting reagent might somehow prevent the reaction from continuing, and the excess reagent would be present in a greater quantity than what is used in the reaction.)
  5. What can you manipulate to affect the outcome of a chemical reaction? (Sample answers: amounts of the limiting and excess reagents, temperature, pH, pressure)

  6. The percentage yield of a reaction is the ratio of what to what? (actual yields to theoretical yields)

  7. What are some things that people would analyze about an industrial chemical reaction that could affect the health and safety of local populations? (Sample answers: People might analyze how reagents and products are stored and transported to prevent leaks or spills that could harm people in the area. People might analyze the processes used to carry out the reactions to see if there are ways to make them safer.)

DIFFERENTIATED INSTRUCTION

• Allow students to choose their preferred method for working through an explanation of their observations during the Mini Investigation: Precipitating Ratios. Visual learners may prefer to draw diagrams, kinesthetic learners may wish to use molecular models, and auditory learners may wish to talk through their ideas with a partner.

• You may want to have students who are interested in computers set up a class blog, wiki or website for posting their responses.
reports, lab results, presentations, images, videos, links, and other forms of information.

ENGLISH LANGUAGE LEARNERS
• As English language learners encounter vocabulary terms, have them make an index card for each term. They should also make an index card for any unfamiliar terms. Index cards should include a definition and sample sentence.

7.1 Mole Ratios in Chemical Equations

OVERALL EXPECTATIONS: A1; D2; D3

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A1.1; A1.2; A1.5; A1.10; A1.11
Developing Skills of Investigation and Communication: D2.1; D2.5
Understanding Basic Concepts: D3.4

The full Overall and Specific Expectations are listed on pages xx–xx.

VOCABULARY
• mole ratio

SKILLS
Predicting, Performing, Observing, Analyzing, Communicating

ASSESSMENT RESOURCES
Assessment Rubric 1: Knowledge and Understanding
Assessment Summary 1: Knowledge and Understanding

PROGRAM RESOURCES
Skills Handbook A2 Scientific Inquiry Skills
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

RELATED RESOURCES
Ewing, Rex A. Hydrogen—Hot Stuff Cool Science.

EVIDENCE OF LEARNING
Look for evidence that students can
• define the mole ratio as the ratio of the amounts of reactants and/or products in a chemical reaction
• use the coefficients in a balanced chemical equation to determine a mole ratio
• predict the amount of reactant required or product formed using the mole ratio, given the amount of one substance in a chemical reaction

SCIENCE BACKGROUND
• The concept of mole ratio is the basis for performing calculations of quantities of chemicals involved in a chemical reaction. Previous calculations that involved quantities, entities, and masses were based on a single substance. Thus, students calculated the mass in grams of a certain number of entities of a particular substance. The coefficients of a balanced chemical equation make it possible to relate the amounts of reactants to the amounts of products in a particular chemical reaction.

TEACHING NOTES
ENGAGE
• Challenge students to describe their ideas about ratios. Ask, When you think about ratios, what comes to mind? (Answers might include descriptions of fractions or a comparison of one thing to another.) Ask, Can you think of some examples of ratios that you see or use? (Sample answer: Test scores are a ratio of the number of correct answers to the total number of possible correct answers.)

EXPLORE AND EXPLAIN
• Direct the students to examine Figure 2. Ask, How do the number of molecules of hydrogen compare with the number of molecules of oxygen in each circled group? (There are two hydrogen molecules for one oxygen molecule.) How many water molecules form from each circled group of reactants? (Two water molecules form from each group.) Reinforce that they are describing the ratios of these substances as shown in the figure and also in the balanced chemical equation.
• Have students complete Mini Investigation: One Plus One Does Not Always Equal Two.

MINI INVESTIGATION: ONE PLUS ONE DOES NOT ALWAYS EQUAL TWO
Skills: Predicting, Performing, Observing, Analyzing, Communicating
Purpose: Students will use models of the reactant and product molecules to gain a better understanding of the proportions of substances in chemical reactions.
Equipment and Materials (per pair): molecular model kit
Notes
• Students will conduct this investigation in pairs.
• You may wish to have students write the reactants for a chemical equation after they build the models of the reactants but before they break up the models to build the products.
• To reinforce the concept that the products are composed of the same atoms as those in the reactants, have students break apart the models of the reactants. Then, have them use the same atoms to build models of the products.

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• Draw students' attention to Tutorial 1: Using Mole Ratios to Determine Amounts on page xxx of the Student Book.

• Work through Sample Problem 1 with the class. Help students correctly set up the problem using units. Ask, Where do the coefficients from the balanced chemical equation belong in the calculation? (in the conversion factor shown as a fraction) How do you know which coefficient to use in the numerator and which to use in the denominator of the conversion factor? (Sample answer: Place the coefficient for the given amount in the denominator and the coefficient for the required amount in the numerator. Then multiply this by the given amount.)

• Point out to students that the balanced chemical equation is provided for each Practice Problem here. Instruct students that if a balanced equation is not provided, the students will need to write and balance the chemical equation for the reaction based on the description in the problem.

• Allow students time to work through the Practice Problems. Address any questions or issues that arise.

EXTEND AND ASSESS
• Have students refer to the analogy of making s'mores and to Table 1 on page xxx of the Student Book. Have them use the ratios in the table to calculate the number of each reactant needed to make a s'more for each person in the class and for each person in the school.

• Have students complete the Questions on page xxx of the Student Book.

DIFFERENTIATED INSTRUCTION
• As a multi-modal activity, have students work directly with samples of graham crackers, chocolate chips, and marshmallows as you use the s'more analogy to introduce the concept of mole ratios. Allow students to choose either models, illustrations, or verbal explanations as a means for demonstrating their understanding of the mole ratio concept. Do not allow students to eat their materials unless you conduct the class in the cafeteria.

ENGLISH LANGUAGE LEARNERS
• Review what is meant by a coefficient in a balanced chemical equation. Discuss the concept of a ratio and take a few minutes to have all students practise making ratios using coefficients from a balanced equation. Point out that they may also encounter these terms in their math courses. In this course, the terms represent mathematical relationships in chemistry.

7.2 Mass Relationships in Chemical Equations

OVERALL EXPECTATIONS: D1; D2; D3

SPECIFIC EXPECTATIONS
Relating Science to Technology, Society, and the Environment: D1.1
Developing Skills of Investigation and Communication: D2.1; D2.3; D2.5
Understanding Basic Concepts: D3.4

The full Overall and Specific Expectations are listed on pages xx–xx.

VOCABULARY
• stoichiometry
• stoichiometric amount

ASSESSMENT RESOURCES
Assessment Rubric 1: Knowledge and Understanding
Assessment Summary 1: Knowledge and Understanding

PROGRAM RESOURCES
BLM 7.2-1 Calculating Mass in Chemical Reactions
Skills Handbook A6 Math Skills
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

RELATED RESOURCES

EVIDENCE OF LEARNING
Look for evidence that students can
• describe stoichiometry as the study of the relationships between the amounts of reactants and products in chemical reactions
• identify that amounts of products in a chemical reaction can be predicted directly but that masses of products cannot
• solve stoichiometry problems involving masses
• identify stoichiometric amounts of chemicals as being in the same ratio as given by the balanced equation
• describe that stoichiometric amounts of reactants are theoretically completely used up in a chemical reaction

SCIENCE BACKGROUND
• The coefficients of a balanced chemical equation provide the ideal ratio for the complete reaction of the reactants.
However, the stoichiometric amounts shown by the coefficients are rarely used in practice. For example, in reactions that are designed to reduce harmful gas emissions, such as the scrubbing of sulfur dioxide from exhaust fumes using calcium carbonate, an excess of a reactant is used to ensure that no harmful gas escapes.

**TEACHING NOTES**

**ENGAGE**
- Ask, *If you are planning to go on a hike, what are some criteria that will guide your choices for what you bring?* (Sample answers: The length of the trip, the weight of the supplies, and whether I have easy access to restock will help to determine what I bring.) Point out that these are the same criteria that factor into the decision about the quantity and type of chemical used to scrub carbon dioxide from the air of a spacecraft.

**EXPLORE AND EXPLAIN**
- Direct students to examine the balanced chemical equations for the reactions of carbon dioxide with lithium hydroxide and calcium hydroxide on page xxx of the Student Book. Ask, *How many moles of each hydroxide are needed to remove one mole of carbon dioxide from the air?* (two moles of lithium hydroxide and one mole of calcium hydroxide) *How do these quantities compare in terms of mass?* (Two moles of lithium hydroxide have a mass of 47.90 g. One mole of calcium hydroxide has a mass of 74.10 g.)
- Draw students' attention to Tutorial 1: Using Stoichiometry to Find Mass on page xxx of the Student Book.
- Work through Sample Problem 1 with the class. Point out to students that these problems combine calculations that they have previously learned, so there is no new material to learn.
- Draw students' attention to Figure 3 on page xxx of the Student Book. Ask, *In Step 1, what quantity are you finding?* (the amount in moles) *In Step 3, what quantity are you finding?* (the mass in grams)
- Allow students time to work through the Practice Problems. Address any questions or issues that arise.

**EXTEND AND ASSESS**
- Distribute BLM 7.2-1 Calculating Mass in Chemical Reactions, and have students complete it.
- Direct students' attention to Figure 4. Ask, *Why must the mass of sodium azide be carefully measured for use in an airbag?* (Sample answer: If either too much or too little sodium azide were used, the safety of the driver or passenger would be at risk. Too little sodium azide would not inflate the airbag enough, and too much sodium azide would overinflate the bag.) Point out that airbags are designed to protect adults and that the location of the bag and the rate of inflation can result in serious injury and death of children.
- Ask, *Would stoichiometric amounts be used when a solution that contains cyanide is employed to leach gold from ore? Explain your reasoning.* (Sample answer: Stoichiometric amounts would likely not be used whenever cyanide is employed to leach gold. It would be difficult to predict the amount of gold in the ore. Excess cyanide would be used to extract as much gold as possible.)
- Have students complete Investigation 7.2.1. Applicable teaching notes can be found on page xx of this resource.
- Have students complete the Questions on page xxx of the Student Book.

**DIFFERENTIATED INSTRUCTION**
- Have students use Figure 3 on page xxx of the Student Book as a basis for developing their own method for summarizing the steps involved in calculating stoichiometric mass amounts. Visual learners may use other graphic organizers or flowcharts; kinesthetic learners may create dances or skits to understand steps; auditory learners may create a song or rap.

**ENGLISH LANGUAGE LEARNERS**
- Direct students to use terms such as *ratio*, *reactant*, *product*, and *excess* in a few sentences describing what occurs during a chemical reaction. Then have pairs of students work together to strengthen each of their sentences to share with the class. Pair English language learners with students who have strong language skills.

7.3 Which Reagent Runs Out First?

**OVERALL EXPECTATIONS:** A1; D1; D2; D3

**SPECIFIC EXPECTATIONS**
- **Scientific Investigation Skills:** A1.2; A1.4; A1.5; A1.6; A1.8; A1.10; A1.11
- **Relating Science to Technology, Society, and the Environment:** D1.1; D1.2
- **Developing Skills of Investigation and Communication:** D2.1
- **Understanding Basic Concepts:** D3.4

The full Overall and Specific Expectations are listed on pages xx–xx.

**VOCABULARY**
- limiting reagent
- excess reagent
MINI INVESTIGATION: BALLOON STOICHIOMETRY

**Skills:** Predicting, Planning, Controlling Variables, Performing, Observing, Analyzing, Communicating

**Purpose:** Students will compare how much carbon dioxide gas is produced from different proportions of sodium hydrogen carbonate (baking soda) and ethanoic acid (in vinegar) to determine the limiting and excess reactants.

**Equipment and Materials (per student):**
- Chemical safety goggles
- Lab apron (per group): 4 medium-sized balloons
- Permanent marker
- 4 plastic 500 mL bottles
- Teaspoon
- Sodium hydrogen carbonate (baking soda)
- Ethanoic acid solution (vinegar)

**Student Safety:** Remind students to never eat or taste anything in a lab setting. Have students wear their lab aprons and safety goggles at all times when working with chemicals.

**Notes:**
- Students will conduct this investigation in groups of four.
- You may wish to have all reactions started simultaneously within each group, so that the balloons can be compared side by side over the time of reaction. This can be done if each student within a group takes responsibility for one reaction.
- You may also wish to demonstrate the proper technique of placing the sodium hydrogen carbonate into a balloon and covering it with a layer of baking soda and vinegar.

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**Skills**
- Predicting
- Planning
- Controlling Variables
- Performing

**Assessment Resources**
- Assessment Rubric 1: Knowledge and Understanding
- Assessment Rubric 2: Thinking and Investigation
- Assessment Summary 1: Knowledge and Understanding
- Assessment Summary 2: Thinking and Investigation

**Program Resources**
- Skills Handbook A1 Safety
- Skills Handbook A2 Scientific Inquiry
- Chemistry 11 ExamView® Test Bank
- Chemistry 11 Online Teaching Centre
- Chemistry 11 website www.nelson.com/onseniorscience/chemistry11u

**Evidence of Learning**
- Look for evidence that students can:
  - Identify the limiting reagent as the reactant that runs out first in a chemical reaction.
  - Relate the amounts of a limiting reagent and an excess reagent to the predicted amount of product.
  - Identify the excess reagent as the reactant that remains after a chemical reaction is complete.
  - Relate the control of limiting and excess reagents to consumer, health, and environmental applications.

**Science Background**
- In an industrial chemical process in which a desired product is synthesized, non-stoichiometric amounts are often used to help shift the equilibrium position of a reaction toward products to increase yield. If one reactant is much more expensive than the other, non-stoichiometric amounts can help use up the more expensive reactant by making it the limiting reagent in the reaction. However, the use of excess reagents in these ways tends to increase waste as well. The principles of green chemistry call for the use of catalysts rather than excess reagents to speed up reactions and avoid waste.

**Possible Misconceptions**
- Identify: Students might believe that because excess reagents remain at the end of a reaction they should be represented in the chemical equation as a product.

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**Ask What They Think Now:**
- At the end of this discussion, ask, *Are the same amounts of excess reactants always left at the end of a reaction?* (No, the amounts and the identities of the excess reactants can change each time the reaction is performed.)

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**Teaching Notes**

**Engage**
- Direct students' attention to Figure 1. Challenge students to describe the cause of the differences between the flames. Ask, *What is visibly different about the flames?* (The flame on the left is orange, and the flame on the right is blue.) *What does the difference in colour indicate about the combustion reactions taking place?* (Incomplete combustion is occurring in the burner on the left. Complete combustion is occurring in the burner on the right.) *Which reactant is in short supply in the burner on the left?* (oxygen) Introduce the term “limiting reagent” as a way of describing this condition.

**Explore and Explain**
- Direct students to examine Figure 2. Ask, *What is the limiting reagent?* (marshmallows) *What are the excess reagents?* (graham crackers and chocolate chips)
- Have students complete Mini Investigation: Balloon Stoichiometry.
• Instruct students to create flashcards for the applications of limiting reagents. Direct them to include an example of a process that illustrates each application. Have students identify the limiting reagent, the excess reagent, and whether the application helps to make the industrial process greener.

**EXTEND AND ASSESS**

• Ask, *In what situation is it not desirable to have fuel as the limiting reagent?* (Sample answer: If combustion of the fuel is providing light rather than heat, then limiting the oxygen instead of the fuel will produce a bright orange flame.)
• Have students complete the Questions on page xxx of the Student Book.

**UNIT TASK BOOKMARK**
Remind students that what they have learned about stoichiometric amounts of a solid reactant with a reactant in solution in this section will be useful when they complete the Unit Task.

**UNIT TASK BOOKMARK**
Remind students that what they have learned about limiting reagents and excess reagents in neutralization reactions in this section will be useful when they complete the Unit Task.

**DIFFERENTIATED INSTRUCTION**

• Have students work directly with samples of graham crackers, chocolate chips, and marshmallows as you teach the concept of limiting reagent. Allow students to choose either models, illustrations, or verbal explanations as a means for demonstrating their understanding of the limiting reagent concept. Do not allow students to eat their materials unless you conduct the class in the cafeteria.

**ENGLISH LANGUAGE LEARNERS**

• To be sure that all students connect the meaning of the term “limiting reagent” with the concept of a limit, use simple scenarios as analogies. For example, explain that the task of taking notes requires both paper and a pencil. A student must have paper and a pencil to complete the task. They can continue taking notes for as long as they have both supplies. Ultimately, they will run out of paper and cannot continue to take notes even if they still have a pencil. Conversely, if they have ample paper but the tip of the pencil breaks, they cannot take notes unless they have another pencil. Have students explain how a limit can be placed on a chemical reaction. English language learners may wish to write in their notes the analogy they find easiest to understand.

### 7.4 Calculations Involving Limiting Reagents

**OVERALL EXPECTATIONS:** D1; D2; D3

**SPECIFIC EXPECTATIONS**

Relating Science to Technology, Society, and the Environment: D1.1
Developing Skills of Investigation and Communication: D2.1; D2.3; D2.5
Understanding Basic Concepts: D3.4

The full Overall and Specific Expectations are listed on pages xx–xx.

**ASSESSMENT RESOURCES**
Assessment Rubric 1: Knowledge and Understanding
Assessment Summary 1: Knowledge and Understanding

**PROGRAM RESOURCES**
BLM 7.4-1 Limiting Reagents
Skills Handbook A6 Math Skills
*Chemistry 11 ExamView® Test Bank*
*Chemistry 11 Online Teaching Centre*
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

**RELATED RESOURCES**

**EVIDENCE OF LEARNING**

Look for evidence that students can

• determine the limiting reagent when given the amounts of reactants
• predict the amount of product formed in a reaction based on the amount of the limiting reagent
• determine the limiting reagent when given the masses of reactants
• predict the mass of product formed in a reaction given the mass of the limiting reagent

**SCIENCE BACKGROUND**

• Continuing the study of quantities in chemical reactions, students combine stoichiometric calculations with the concept of limiting reagents. One method of determining the limiting reagent requires the calculation of the stoichiometric amount of a reactant that would exactly react with the available amount of a second reactant. The
TEACHING NOTES

ENGAGE

Direct students’ attention to Figure 1 on page xxx of the Student Book. Ask, What happens if a bicycle manufacturer runs out of seats? (The manufacturer cannot make any more bicycles.) How does this relate to chemical processes? (Sample answer: Seats are a limiting reagent for bicycle building. A chemical process in which a reactant runs out will stop.)

EXPLORE AND EXPLAIN

Draw students’ attention to Tutorial 1: Solving Limiting Reagent Problems Involving Amounts on page xxx of the Student Book.

Work through Sample Problem 1 with the class. Point out to students the information given in the Sample Problem. Ask, How does the information given compare with the information given in the Sample Problem in Section 7.2? (Sample answer: Both Sample Problems give amounts of a reactant, but this Sample Problem gives an amount of two reactants instead of just one.) Point out that when a problem gives information about the amounts of two or more reactants, the first step is to determine which reactant runs out first.

Direct students to examine the use of the mole ratio to calculate the amount of the second reactant. Instruct students to think of this calculated amount as the amount that is needed for both reactants to completely react. Ask, If the amount needed of reactant A is more than the amount that is actually available, and there is as much of reactant B available as is needed, which reactant is the limiting reagent? (A)

If a student can solve stoichiometry problems but has trouble determining the correct limiting reagent, you may wish to offer an alternative method of solving these problems. Rather than determining the limiting reagent using the mole ratio, have students calculate the amount of product that each reactant could form. The limiting reagent is whichever yields the smaller amount of product. This is because the reaction would cease once the limiting reagent was used up, so there would be no further product accumulation.

EXTEND AND ASSESS

Distribute BLM 7.4-1 Limiting Reagents, and have students complete it.

Instruct student to examine Sample Problem 1: Predicting the Mass of Product on page xxx of the Student Book. Ask, How do the masses of the reactants compare with the mass of product that forms? (Students will likely point out that the total mass of the reactants listed is greater than the mass of product that forms.) Does this situation contradict the law of conservation of mass? Explain your reasoning. (Answers should point out that the difference in mass is a result of an excess of carbon monoxide. Only 9.00 g of carbon monoxide reacts. The total mass of reactants that actually react equals the mass of product formed, which supports the law of conservation of mass.) You may wish to suggest that students calculate the mass of carbon monoxide that reacts.

Have students complete Investigation 7.4.1. Applicable teaching notes can be found on page xx of this resource.

Have students complete the Questions on page xxx of the Student Book.
DIFFERENTIATED INSTRUCTION
• Have students use Figure 2 on page xxx of the Student Book as a basis for developing their own method for summarizing the steps involved in using limiting reagent calculations to determine expected product mass. Methods will vary between students such as: Visual learners may prefer flowcharts and diagrams; Kinesthetic learners may develop skits, dance steps or models; and Auditory learners may develop mnemonics, stories or songs. Have the students share them to solidify their model.

ENGLISH LANGUAGE LEARNERS
• To strengthen understanding of the term “limiting agent,” have all students write a summary sentence to describe why the concept of a limiting reagent must be used if they are given starting amounts of two reactants and asked to calculate how much product can be expected to be formed. Allow English language learners to work in pairs to complete this exercise.

7.5 Percentage Yield

OVERALL EXPECTATIONS: D1; D2; D3

SPECIFIC EXPECTATIONS
Relating Science to Technology, Society, and the Environment: D1.1; D1.2
Developing Skills of Investigation and Communication: D2.1; D2.3; D2.5; D2.6; D2.7
Understanding Basic Concepts: D3.4

The full Overall and Specific Expectations are listed on pages xx–xx.

VOCABULARY
• theoretical yield
• actual yield
• percentage yield

ASSESSMENT RESOURCES
Assessment Rubric 1: Knowledge and Understanding
Assessment Summary 1: Knowledge and Understanding

PROGRAM RESOURCES
Skills Handbook A6 Math Skills
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

RELATED RESOURCES

EVIDENCE OF LEARNING
Look for evidence that students can
• identify the theoretical yield as the quantity of product as predicted by the stoichiometry of the chemical equation
• identify the actual yield of a reaction as the actual quantity of product collected
• compare the actual yield with the theoretical yield and suggest possible causes for any differences between them
• calculate the percentage yield of a reaction given the amounts or the masses of reactants and the actual yield of the desired product

SCIENCE BACKGROUND
• Percentage yield compares how much product a reaction actually produces to how much product the reaction could theoretically produce. The theoretical yield is an ideal value that is calculated based on the ratio of moles represented in the balanced chemical equation.
• A theoretical yield assumes that every entity of the limiting reagent is converted into product. Thus, there would be no side reactions, and the limiting reagent was 100 % pure.
• The actual yield is how much product is produced under actual laboratory conditions. The actual yield can be much higher or lower than the theoretical yield as a result of a number of factors such as the occurrence of side reactions, impurities in the original reactant, a loss of product during collection and purification steps, or a failure to completely dry the product.
• Although a percentage yield of 90 % is quite good for a single chemical reaction, an industrial process that requires several steps can have a very low percentage yield overall. A principle of green chemistry describes the need to find processes that require fewer steps, which helps to improve the percentage yield by reducing loss of product between steps.

TEACHING NOTES
ENGAGE
• Challenge students to compare the types of yield. Ask, How would you describe the difference between something that is theoretical and something that is actual? (Answers might include descriptions of something that is theoretical as being ideal or not real, whereas something that is actual is real and tangible.)

EXPLORE AND EXPLAIN
• Direct students’ attention to the arrow used in Figure 2. Explain that this type of arrow signifies a reaction that
is reversible. Ask, Would the reactants ever be completely used up in a reversible reaction? Why or why not? (No. Some of the product that forms turns back into reactants, so there are always some reactants still present.)

- Model how the experimental procedure can decrease the yield using coloured water and graduated cylinders. Place a volume of water in a graduated cylinder and record its volume as precisely as possible. Using five graduated cylinders, pour the water from one graduated cylinder to the next. Direct students’ attention to the water that remains behind in each cylinder. Point out that at each step, a little water is left behind and the actual yield decreases with each step of the process.
- Draw students’ attention to Tutorial 1: Determining Percentage Yield on page xxx of the Student Book.
- Point out to students the bullet points of helpful tips. Ask, Why is the calculated amount of the desired product described as a theoretical yield? (Sample answer: It is theoretical because it is the amount of product that could form if all of the given reactant could react completely.)
- Work through Sample Problem 1 with the class. Help students recognize the steps that are identical to ones they have learned in previous sections.
- Allow students time to work through the Practice Problems. Address any questions or issues that arise.

EXTEND AND ASSESS
- Have students determine the overall percentage yield for an industrial process that requires five steps, each of which has a 90.0 % yield. (59.0 %)
- Have students complete Investigation 7.5.1. Applicable teaching notes can be found on page xx of this resource.
- Have students complete the Questions on page xxx of the Student Book.

DIFFERENTIATED INSTRUCTION
- Check student understanding of the concepts of theoretical yield, actual yield, and percentage yield by asking them to explain how these concepts can be applied to the process of making ice cream sundaes. Allow students to use diagrams, flowcharts, manipulatives, written descriptions, or verbal explanations to convey their thoughts.

ENGLISH LANGUAGE LEARNERS
- Have English language learners investigate the meaning of the term “yield” as it is used to describe the results of farming (crop yield) or baking (recipe yield) and compare it with how it is used in chemistry.

7.2.1 Observational Study: What Is Baking Soda Doing in Your Cake?

OVERALL EXPECTATIONS: A1; D1; D2; D3

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A1.1; A1.2; A1.4; A1.5; A1.6; A1.8; A1.10; A1.11; A1.12; A1.13
Relating Science to Technology, Society, and the Environment: D1.1
Developing Skills of Investigation and Communication: D2.1; D2.5
Understanding Basic Concepts: D3.4

The full Overall and Specific Expectations are listed on pages xx–xx.

SKILLS
Predicting Analyzing
Planning Evaluating
Performing Communicating
Observing

EQUIPMENT AND MATERIALS

per student:
- chemical safety goggles
- lab apron

per group:
- heat-resistant test tube
- balance
- Bunsen burner clamped to a retort stand
- spark lighter
- test tube holder
- scoopula
- test-tube rack
- wooden splint
- sodium hydrogen carbonate, NaHCO₃(s)
- test tube half-filled with limewater, Ca(OH)₂(aq)
- cobalt chloride paper

ASSESSMENT RESOURCES
Assessment Rubric 7: Observational Study
Assessment Summary 7: Observational Study
Self-Assessment Checklist 3: Observational Study

PROGRAM RESOURCES
Skills Handbook A1 Safety
Skills Handbook A2 Scientific Inquiry
Skills Handbook A3 Laboratory Skills and Techniques
Chemistry 11 ExamView® Test Bank
**EVIDENCE OF LEARNING**
Look for evidence that students can
- plan and conduct tests to identify gases produced during a reaction
- measure masses of reactants and products accurately
- conclude which of four possible reactions occurs based on collected data

**SCIENCE BACKGROUND**
- The decomposition of sodium hydrogen carbonate generates carbon dioxide, water, and anhydrous sodium carbonate.

**TEACHING NOTES**

**STUDENT SAFETY**
Remind students of the following safety procedures.
- Do not eat or drink anything in the laboratory.
- While working with an open flame, tie back long hair and secure loose clothing. Never leave the flame unattended.
- Wear chemical safety goggles and apron for the entire investigation.
- Make sure the mouth of the test tube points away from people at all times during heating.
- Avoid contact with limewater, which is an irritant. Wash skin that comes into contact with this solution with a large amount of cool water.

- Students will conduct this investigation in pairs.

**PURPOSE**
- Explain that students will be conducting a chemical investigation to determine which of four possible reactions is actually taking place as sodium hydrogen carbonate is heated. Stress that students should keep returning to the Purpose and reviewing the four possible chemical equations as they carry out their procedures.

**EQUIPMENT AND MATERIALS**
- To be effective, limewater should always contain some undissolved calcium hydroxide. Limewater absorbs carbon dioxide from the air over time, so it should be stored in containers that close tightly. Test any limewater that has been stored to see if it still turns cloudy when carbon dioxide is bubbled into it.

**PROCEDURE**
- Instruct groups to provide a step-by-step description for the chemical tests they will use to identify the gas produced in this reaction. Have students identify what result they would expect from their chosen test for each possible reaction.
- Point out to students that the directions say to use roughly 3 g of sodium hydrogen carbonate and then to measure the mass to the nearest 0.01 g.
- Review the proper method to heat a test tube over a Bunsen burner. Make sure students are following safe laboratory technique.

**OBSERVATIONS**
- Water may be observed condensing on the upper part of the test tube in the early heating stages. Water vapour exiting the tube will cause the cobalt chloride paper to turn purple or red.
- Carbon dioxide formation will extinguish a lit splint.
- You may wish to ask groups to provide a brief lab report that summarizes their data and their conclusions.

**DIFFERENTIATED INSTRUCTION**
- To ensure student understanding of the procedure, have students rehearse the steps in a format of their choice. Visual learners may draw a flow chart. Auditory learners may discuss the steps with their partners; kinesthetic learners may prefer to manipulate the equipment.

**ENGLISH LANGUAGE LEARNERS**
- Before beginning the investigation, have all students write out their calculations for Step 4 of the Procedure. Check with English language learners to assess their understanding of the term “stoichiometric calculations” as it is used in Step 4 directions. Provide support to students in understanding terms as needed.

**7.4.1 Observational Study: Copper Collection Stoichiometry**

**OVERALL EXPECTATIONS:** A1; D2; D3

**SPECIFIC EXPECTATIONS**

**Scientific Investigation Skills:** A1.1; A1.2; A1.4; A1.5; A1.6; A1.8; A1.10; A1.11; A1.12; A1.13

**Developing Skills of Investigation and Communication:** D2.1; D2.3; D2.5

**Understanding Basic Concepts:** D3.4

*The full Overall and Specific Expectations are listed on pages xx-xx.*
SKILLS
Predicting  Analyzing
Planning   Evaluating
Performing Evaluating
Observing  Communicating

EQUIPMENT AND MATERIALS
per student:
• chemical safety goggles
• lab apron
per group:
• scoopsula
• balance
• 50 mL graduated cylinder
• 250 mL beaker
• stirring rod
• retort stand and ring clamp
• funnel
• drying oven or hot plate
• copper(II) sulfate pentahydrate, CuSO₄•5H₂O
• warm distilled water (about 40 °C)
• iron filings, Fe
• squeeze bottle of distilled water
• filter paper

ASSESSMENT RESOURCES
Assessment Rubric 7: Observational Study
Assessment Summary 7: Observational Study
Self-Assessment Checklist 3: Observational Study

PROGRAM RESOURCES
Skills Handbook A1 Safety
Skills Handbook A2 Scientific Inquiry
Skills Handbook A3 Laboratory Skills and Techniques
Skills Handbook A6 Math Skills
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
  www.nelson.com/on seniorscience/chemistry11u

EVIDENCE OF LEARNING
Look for evidence that students can
• measure masses of reactants and products accurately
• calculate the amount of iron needed to completely react with the mass of copper(II) sulfate pentahydrate
• determine a mass of iron that causes iron to be a limiting reagent in each reaction
• conclude which of two possible reactions occurs based on collected data

SCIENCE BACKGROUND
• Toxic metal ions can be removed from solution through a single displacement reaction with a more active metal.

Iron is more active than copper and can displace the copper(II) ions from the solution.
• This investigation models the remediation of a body of water that is contaminated by copper(II) ions. However, during a real remediation, the goal is to remove as many copper(II) ions as possible. Thus, the iron would be used in excess. Because the goal of this investigation is to determine which reaction actually happens, students must be able to collect copper metal that has no unreacted iron pieces mixed in. By making iron the limiting reagent, there should be no unreacted iron remaining when the reaction stops.

TEACHING NOTES

STUDENT SAFETY
Remind students of the following safety procedures.
• Wear chemical safety goggles and apron for the entire investigation.
• Avoid contact with copper(II) sulfate, as it is toxic and a skin and eye irritant. Flush any skin that contacts copper(II) sulfate with large amounts of cool water.
• Keep the hot plate or drying oven dry and away from water. Handle the appliance and cord with dry hands. Do not pull on the cord.
• Never eat or taste anything in a lab setting.

• Students will conduct this investigation in pairs.

PURPOSE
• Explain that students will be conducting a chemical investigation to determine which of two possible reactions is actually taking place when iron metal is used to displace toxic copper(II) ions from solution. Stress that each group should keep returning to the Purpose and the balanced chemical equation for each possible reaction as they carry out their procedures.

EQUIPMENT AND MATERIALS
• You may wish to have an example filtering apparatus on display if students do not have much experience filtering mixtures.

PROCEDURE
• You may wish to maximize the time that students have in class to perform the investigation by instructing students to perform the calculations in Steps 1 to 3 of the Procedure as pre-lab homework the day before the lab. Have students in each group compare their answers and determine what mass of iron they plan to use. Alternatively, you may wish to omit Steps 1 to 3 and inform students to use 1.00 g of iron filings.
• Dry the solids at a low temperature. High temperatures could cause the copper to oxidize, which would increase the mass of the sample. One option is to allow samples to dry overnight at room temperature. If you choose this
option, samples should be left in a secure place where they will not be disturbed.

**OBSERVATIONS**
- Direct students to note any changes in the colour of the solution. Although the solution should be blue when the reaction stops, it will likely appear lighter than the original solution.
- Have students note the colour and consistency of the dried copper product. It should appear as very fine particles and dark orange in colour.
- You may wish to ask groups to provide a brief lab report that summarizes their data and their conclusions.

**DIFFERENTIATED INSTRUCTION**
- Instruct students to show, using models, how the copper: iron ratios compare for the two reaction possibilities. Visual and kinesthetic learners may benefit from the use of models, and auditory learners may benefit from the student discussion needed to work with the models.

**ENGLISH LANGUAGE LEARNERS**
- Have all students make a summary flowchart or other diagram before the investigation to show the procedure they will use. Allow English language learners to work with partners to create the flowchart.

### 7.5.1 Controlled Experiment: What Stopped the Silver?

**OVERALL EXPECTATIONS:** A1; D2; D3

**SPECIFIC EXPECTATIONS**
- **Scientific Investigation Skills:** A1.1; A1.2; A1.4; A1.5; A1.6; A1.8; A1.10; A1.11; A1.12; A1.13
- **Developing Skills of Investigation and Communication:** D2.1; D2.5; D2.6; D2.7
- **Understanding Basic Concepts:** D3.4

*The full Overall and Specific Expectations are listed on pages xvi–xx.*

**SKILLS**
- Questioning
- Performing
- Hypothesizing
- Observing
- Predicting
- Analyzing
- Planning
- Evaluating
- Controlling Variables
- Communicating

**EQUIPMENT AND MATERIALS**

**per student:**
- chemical safety goggles
- lab apron
- latex or rubber gloves

**per group:**
- sandpaper
- balance
- 100 mL beaker
- wooden splint
- stirring rod
- 250 mL beaker
- 30 cm length of copper wire
- silver nitrate, AgNO₃(s)
- wash bottle of distilled water
- aluminum foil

**ASSESSMENT RESOURCES**
- Assessment Rubric 5: Controlled Experiment
- Assessment Summary 5: Controlled Experiment
- Self-Assessment Checklist 1: Controlled Experiment

**PROGRAM RESOURCES**
- Skills Handbook A1 Safety
- Skills Handbook A2 Scientific Inquiry
- Skills Handbook A3 Laboratory Skills and Techniques
- Skills Handbook A6 Math Skills
- Chemistry 11 ExamView® Test Bank
- Chemistry 11 Online Teaching Centre
- Chemistry 11 website
  
  www.nelson.com/onseniorscience/chemistry11u

**EVIDENCE OF LEARNING**
- Look for evidence that students can
  - identify a limiting reagent based on observations
  - calculate theoretical yield and percentage yield from experimental data
  - conduct an experiment to quantitatively collect the product formed

**SCIENCE BACKGROUND**
- Single displacement reactions can be used to remove toxic metal ions from a solution. They can also be used to collect a valuable metal dissolved in solution. In this investigation, silver is collected, using copper metal.
- Gold that is dissolved in solution after it has been chemically leached from its ore is recovered in its elemental form, using zinc metal.

**TEACHING NOTES**

### STUDENT SAFETY

Remind students of the following safety procedures.
- Wear chemical safety goggles and apron for the entire investigation.
- Avoid contact with silver nitrate, as it will stain skin and clothing. Wash any skin that comes into contact with silver nitrate with large amounts of cool water.
- Avoid contact with copper(II) sulfate, as it is toxic and a skin and eye irritant. Flush any skin that contacts copper(II) sulfate with...
large amounts of cool water.

- Keep the hot plate or drying oven dry and away from water.
- Handle the appliance and cord with dry hands. Do not pull on the cord.
- Never eat or taste anything in a lab setting.

- Students will conduct this investigation in pairs.

**TESTABLE QUESTION**

- Have students write a Testable Question in class. Stress that each group should keep returning to the Testable Question as they design and carry out their procedures. At each step of the way, urge students to ask themselves, Will this help answer the Testable Question?

**HYPOTHESIS**

- Make sure the hypothesis is a prediction written as a statement, along with a reason for the prediction. Sample hypothesis: As long as the silver nitrate is the limiting reagent, the mass of silver nitrate used will not have an effect on the percentage yield of silver produced during the reaction because all of the silver present should be isolated.

**VARIABLES**

- Guide students in a discussion to ensure they understand that controlled variables include temperature, pressure, and the reactants. The manipulated variable is the mass of silver nitrate. Responding variables include the mass of silver that forms and the mass of copper that reacts.

**EXPERIMENTAL DESIGN**

- Discuss the goal of the experiment in class. Point out that groups need to carefully collect the silver produced to avoid any loss of the product. Stress that the procedure should be carried out systematically, and that each trial should be conducted with the same care and attention.

**EQUIPMENT AND MATERIALS**

- To reduce the quantity of silver nitrate used during this investigation, assign a different mass of silver nitrate to each group. Rather than each group conducting multiple trials, have each group record the data from other groups to analyze.

**PROCEDURE**

- Point out to students the need to polish the copper wire with sandpaper. Explain that polishing the copper removes any surface oxidation. Instruct students that this must be done before measuring the mass of the copper because some mass is removed by polishing.

**OBSERVATIONS**

- As the reaction progresses, the copper wire will become coated with long, grey, needle-like strands and the solution will become blue. The blue colour of the solution indicates the presence of copper(II) ions.

- You may wish to ask groups to provide a brief lab report that summarizes their data and their conclusions.

**UNIT TASK BOOKMARK**

Remind students that what they have learned about identifying limiting reagents and calculating actual and theoretical yields in this section will be useful when they complete the Unit Task.

**DIFFERENTIATED INSTRUCTION**

- Direct students to develop a diagram, flowchart, outline, or verbal explanation for the procedure they will follow in advance of the investigation.

**ENGLISH LANGUAGE LEARNERS**

- Several terms appearing in the directions for this experiment may be unfamiliar to English language learners. Have them read the section a day or so before the investigation and highlight any words, phrases, or sentences they do not understand. Review their notes and focus on ways to illustrate the meanings of highlighted terms during preliminary class discussion prior to the investigation. Follow up with English language learners to assess their understanding before they begin lab work.

**ASSESSMENT RESOURCES**

Assessment Rubric 1: Knowledge and Understanding
Assessment Summary 1: Knowledge and Understanding

**PROGRAM RESOURCES**

BLM 7.Q Chapter 7 Quiz
BLM 0.0-10 Careers
Skills Handbook A7 Choosing Appropriate Career Pathways
Chemistry 11 ExamView® Test Bank
Chemistry 11 Online Teaching Centre
Chemistry 11 website
www.nelson.com/onseniorscience/chemistry11u

**RELATED RESOURCES**


**SUMMARY QUESTIONS**

- Direct students to work in pairs to complete the Summary Questions. Suggest that they discuss each Key Concept before creating their 20 quiz questions.
- Return to students the Starting Points answers that they wrote before studying the chapter. Have them read over
1. Make sure students refer to the desired product. (For example, incorrect amounts of reagents will be out of proportion and will result in a different amount of product, or a bad-tasting product.)
2. Make sure students refer to calculations based on the balanced chemical equation. (For example, calculate the amount of product that should be produced based on the amount of each reactant and the ratios shown in the balanced chemical equation.)
3. Make sure students refer to the factors presented in Section 7.5. (For example, the nature of the reaction, the experimental procedure, impurities in the reagents, and competing side reactions affect the amount of product that forms.)
4. Make sure students refer to benefits that would apply to a company. (For example, one benefit would be cost savings through more efficient processes that result in reduced amounts of reactants and lower expenses for waste management.)

- Ask one or two questions that will prompt student recall of each Key Concept. Have students explain and support their responses.

1. **What are some ways in which chemical quantities and calculations are important in preventing environmental damage?** (Sample answers: using the correct quantity of a neutralizing agent on an acid or base spill or for scrubbing sulfur dioxide gas from the exhaust stream of a chemical plant)
2. **What units are used to express a molar mass?** (grams per mole)
3. **What type of yield do you find when you predict the mass of product expected in a chemical reaction?** (theoretical yield)
4. **Which reagent must be used to calculate the amount of product expected in a chemical reaction?** (limiting reagent)
5. **Why does manipulating the limiting reagent affect the outcome of a chemical reaction?** (Sample answers: Changing the amount of limiting reagent will change the amount of product expected. Changing the identity of the limiting reagent, as in the combustion of a hydrocarbon, could result in a change in products formed.)
6. **What is an example of a factor that could cause theoretical yield to be different from actual yield?** (Sample answer: Impurities in the reactants could cause side reactions to occur, leading to a higher or lower actual yield.)
7. **How does the use of excess oxygen in flash smelting impact the environment?** (Sample answer: The oxygen combines with all of the sulfur in the ore to form sulfur dioxide in quantities that are economically favourable to collect and use rather than to discard or allow to escape into the environment.)

- Have students complete the questions found in the Chapter Self-Quiz and Chapter Review in the Student Book.
- Have students complete BLM 7.Q Chapter 7 Quiz for an additional review of the material.

**CAREER PATHWAYS**
- Distribute copies of BLM 0.0-10 Careers for students to use as they research various careers.
- Coroners must have a strong background in biology, medicine, and chemistry. In Ontario, coroners are medical doctors who have received specialized training in investigating deaths. They must understand the properties and chemical composition of substances and the changes the substances undergo. They must keep accurate, detailed notes on their findings and should be able to present those findings in court when needed. Coroners carry out autopsies to determine the cause of death or to help identify the responsible party in deaths that are violent, accidental, or have no obvious explanation. Based on the results of an investigation, a coroner tries to identify the deceased person, when and where the person died, what part of their body failed that led to death, and any events that may have caused the body part to fail.
- Chemical engineers are employed by pharmaceutical companies, pulp and paper companies, engineering consulting companies, industrial chemical manufacturers, and the federal government. They may work indoors, outdoors, or both indoors and outdoors. Chemical process engineers research, evaluate, design, and test methods, equipment, and processes to try to improve the processes and reactions being used.

**DIFFERENTIATED INSTRUCTION**
- Encourage students to create a review for the unit in a format that supports their learning. Visual learners may use graphic organizers, while kinesthetic learners may mime lab procedures and summarize their results. Auditory learners may create raps or a series of questions for each type of calculation. Encourage students to share their review materials with other learners of similar styles.

**ENGLISH LANGUAGE LEARNERS**
- Allow English language learners who struggle the option of using verbal or pictorial explanation to complete Summary Question 4 on p xxx of the Student Book.
OVERALL EXPECTATIONS: A1; D1; D2; D3

SPECIFIC EXPECTATIONS

Scientific Investigation Skills: A1.1; A1.4; A1.5; A1.6; A1.8; A1.10; A1.11; A1.12; A1.13

Relating Science to Technology, Society, and the Environment: D1.1

Developing Skills of Investigation and Communication: D2.1; D2.7

Understanding Basic Concepts: D3.4

The full Overall and Specific Expectations are listed on pages xx–xx.

• The Unit Task is a culminating task that provides students with an opportunity to demonstrate that they understand the concepts and can apply the skills developed in this unit. The Unit Task is also a means for students to show that they understand and appreciate how the science addressed in this unit influences their society and the environment.

• The challenge in this Unit Task is to determine the actual mass of sodium hydrogen carbonate in an Alka-Seltzer tablet by measuring the mass of carbon dioxide that is produced in reactions with water and vinegar when the sodium hydrogen carbonate is the limiting reagent.

EQUIPMENT AND MATERIALS

per student:
• chemical safety goggles
• lab apron

per group:
• balance
• seven 250 mL Erlenmeyer flasks or plastic cups
• 50 mL graduated cylinder
• dropper
• vinegar (dilute ethanoic acid, HC₂H₃O₂(aq))
• 7 Alka-Seltzer tablets

ASSESSMENT RESOURCES

Unit 3 Task Assessment Rubric : Fizz Check
Unit 3 Task Assessment Summary : Fizz Check
Unit 3 Task Self-Assessment Checklist : Fizz Check

PROGRAM RESOURCES

BLM U3.Q Unit 3 Quiz
Skills Handbook A2 Scientific Inquiry
Skills Handbook A6 Math Skills
Chemistry 11 ExamView® Test Bank


EVIDENCE OF LEARNING

Look for evidence that students can
• distinguish between the limiting reagent and excess reagents when an Alka-Seltzer tablet reacts in water and in vinegar
• design and conduct a procedure to determine the mass of sodium hydrogen carbonate in an Alka-Seltzer tablet.
• identify and manipulate variables in a controlled study
• present results of quantitative measurements in an organized manner, such as in a graph
• suggest improvements to the experimental design through the identification of likely sources of error
• explain the importance of quality control measures in the pharmaceutical industry

SCIENCE BACKGROUND

• The discomfort caused by excess stomach acid is often referred to as acid indigestion, sour stomach, or upset stomach. Symptoms may include abdominal fullness, belching, or heartburn, which is a feeling of warmth or burning below the breastbone. Although heartburn can mimic the pain of angina, it does not involve the heart.

• Alka-Seltzer tablets are effervescent. They fizz and bubble as they dissolve. The term effervescent is often used to describe a person who is enthusiastic and has a bubbly personality.

• The reaction of the solid acids in the tablet with the sodium hydrogen carbonate takes place only in solution. As the compounds dissolve in water, the acid molecules ionize and the sodium ions and hydrogen carbonate ions dissociate. The pattern of double displacement reactions suggests that carbonic acid, H₂CO₃(aq), should form. However, carbonic acid is unstable and immediately decomposes into water and carbon dioxide.

• You can speed up the reaction of an effervescent tablet by crushing it (increasing its surface area) or by using warmer water.

• Each tablet must contain enough sodium hydrogen carbonate to react with the citric acid and acetylsalicylic
acid, with enough left over to provide relief from excess stomach acid.

TEACHING NOTES
• Students should conduct this task in small groups.

STUDENT SAFETY
Remind students of the following safety procedures.
• Wear chemical safety goggles and lab apron for the entire investigation.
• Never eat or taste anything in a lab setting.
• Have students complete BLM U3.Q Unit 3 Quiz for an additional review of the material.

PURPOSE
• Explain the purpose of the investigation to the class. Point out to students that they must plan to gather data that will allow them to calculate the mass of sodium hydrogen carbonate in each tablet. Stress that each group should keep returning to the Purpose as they design and carry out their procedures.

VARIABLES
• Guide students in a discussion to ensure they understand that controlled variables include the mass of solid reactants, the volume of liquid, the temperature, and the pressure under which the reaction takes place. The manipulated variable is best described as the proportion of water to ethanoic acid or the concentration of the ethanoic acid solution. The responding variable is the mass of carbon dioxide that leaves the flask.
• Have students create their Results table as they design their procedures. This will help them to organize their thoughts and identify confusing points.

EQUIPMENT AND MATERIALS
• Tablets that have been exposed to moisture through a small hole in the packaging may appear discoloured, crumbly, or might not fizz well. Replace such tablets to improve student results.
• Provide students with the appropriate MSDS information as they design their investigations. Ask them to include in their procedures a summary of the safety precautions and protective equipment they will need to use during their experiments.

PROCEDURE
• Require that students turn in their procedures for approval before beginning their testing.
• Using the data collected from flask 1, have students calculate the mass of citric acid and acetylsalicylic acid in the tablet. Point out to students who need help which material is the limiting reagent, based on their experimental design.
• To help students plan their procedures, you may wish to demonstrate the reaction of a tablet using the materials that students will be using. Point out that students need to plan carefully with regard to when and how they will measure the masses. Also, draw students' attention to the bubbles of gas that cling to the sides of the flask. Suggest that students include instructions for handling this possibility.

Sample Student Procedure:
1. Put on chemical safety goggles and lab apron.
2. Number the flasks 1–7.
3. Use a graduated cylinder to add the volumes of water and of ethanoic acid to each flask as noted in the table.
4. Measure and record the initial mass of each flask and its contents.
5. Measure and record the mass of one Alka-Seltzer tablet and place it into flask 1. Repeat with an additional tablet for each remaining flask.
6. Observe each flask. When the reaction in a flask has stopped, gently swirl the flask to be sure the reaction is complete and to dislodge any gas bubbles on the sides of the flask.
7. Measure and record the final mass of each flask and its contents.
8. Determine the mass of carbon dioxide lost from each flask by subtracting the final mass of the flask and its contents from the combined mass of the tablet and the initial mass of the flask and its contents.

DIFFERENTIATED INSTRUCTION
• Before students begin their investigations, have them summarize the procedures they have created in a method of their choosing. Visual learners may choose to sketch illustrations for each step or draw a flow chart. Kinesthetic learners may want to walk through the steps and arrange the lab table. Auditory learners can summarize their procedures verbally.

ENGLISH LANGUAGE LEARNERS
• Encourage English language learners to use their native languages when completing the activity. Enlist student help in labelling equipment and materials in both languages.