OVERVIEW

Chapter 1, Organic Compounds, introduces the historical concept of organic compounds as those compounds produced by living things. Students then learn that the current concept of organic chemistry is the study of carbon compounds. Each section of the chapter addresses a different group of organic compounds, related by structure. Throughout the chapter, tutorials provide a step-by-step procedure for naming and drawing structural diagrams. Each section also features important reactions of each compound class. Hands-on activities build an understanding of the relationship between structure and function through molecular modelling.

Chapter 2, Polymers, focuses on the application of organic reactions to producing natural and synthetic polymers, the role of polymers in society, and the impact of polymers on health and the environment. Students first learn general structural concepts of polymers and a brief history of synthetic polymers. Addition and condensation polymers are featured in more detail in separate sections. These sections focus on the history, synthetic reactions, applications, and environmental implications of each type of polymer. The final section presents an overview of natural polymers and their roles in living cells.

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’s Resource CD-ROM.
- Some lab activities require students to handle potentially harmful chemicals. As part of their lab preparation, instruct students to carefully read the MSDS for each reagent for an investigation. Always check student-designed procedures before allowing students to proceed with their investigations.
- Many of the concepts in this unit will be difficult for students who have trouble visualizing three-dimensional structures based on two-dimensional illustrations. Incorporate molecular modelling in your instruction, and encourage students to use molecular models to represent the structures of organic compounds.
- Students who are familiar with older nomenclature may have difficulty adapting to the current IUPAC conventions used in this text. Point out the consistency of the system between classes of compounds and the ability to build unambiguous names for compounds. Also have students note that some names in the polymer chapter do not follow the IUPAC conventions because they are legacies of older naming systems.

ENGAGE THE LEARNER

UNIT PREVIEW

- Bring in empty packaging from over-the-counter foods, cleaning products, and cosmetics. Have the class make a list of chemical names that are not familiar to them. As students study Chapter 1, have them identify the functional groups of as many of the compounds as possible.
- Explain that they will study polymers in Chapter 2 and that the different kinds of plastic used to make containers and sandwich wraps are polymers. Ask, What is the starting material for most kinds of plastic materials? (Most plastics are polymers synthesized from petroleum derivatives.)
- Almost all of the millions of known chemical compounds are organic compounds. The vast majority of these
Compounds are made from just four elements. Ask, *How can so few elements form so many different compounds?* (The properties of a chemical compound are determined by the arrangement of atoms as well as their identity.) As an analogy, point out that all the words in the English language are made up of only 26 letters.

- Most plastics are made of large, stable molecules that do not break down easily. Ask, *What happens to plastic materials that are not recycled?* (They remain in the environment for a very long time.)
- Have students read the Big Ideas on page 2 of the Student Book. Ask, *What are some significant implications that organic chemicals and processes could have for society, human health, and the environment?* (Sample answer: Many materials we use are made from organic materials; foods and medicines are almost all made of organic compounds; organic compounds can cause pollution in the environment when they are used or discarded.)
- Consider posting these Big Ideas in a prominent area of your classroom. Draw students’ attention to these ideas after each lesson, so that they see how their learning fits into the overall plan of the unit.

**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 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 in their own time?
  - How will the task fit into the overall assessment plan for the unit?
- Point out the Unit Task Bookmark found in some sections (the first Unit Task Bookmark appears in Chapter 1 on page 30 of the Student Book). Explain that these icons alert students to information or procedures that may be helpful in completing the task.
- The Unit Task involves investigating health and environmental hazards of volatile organic compounds and the efforts to reduce them. For further support with the Unit Task, refer to pages 49–50 of this resource.

**FOCUS ON STSE**

- This reading feature focuses on the process of finding new compounds that have pharmaceutical applications. More than half of the medications in use today are extracted from plants or based on plant compounds. Have the class discuss common medications and ask whether students know how any one of the medications was first discovered. Have small groups choose a common medication and use the Internet to research its original source.
- As shown in the opening photo, much of the effort of pharmaceutical researchers looking for new medications focuses on Earth’s rainforests. A major concern about loss of rainforests is the loss of potential sources of new medicines as plants become extinct. Have students form small discussion groups and consider reasons that plants would produce compounds that can be used to fight disease.

**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 to them. 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 or skills, so in many cases it will feel like a first-time introduction to them. 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.

**CAREER PATHWAYS PREVIEW**

- Formulate a plan for incorporating Career Pathways into the whole learning experience for the unit.
- Point out the Career Links found in some sections. (The first Career Link appears in Chapter 1 on page 25 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 36 and 48 of this resource.

**DIFFERENTIATED INSTRUCTION**

- Have students design a personal system for taking notes as they study the chapter. For example, visual learners could develop graphic organizers to connect the material in different sections, auditory learners could record notes as they study at home, and kinesthetic learners could develop hand signals as memory devices. Periodically, have students share their techniques with other students.

**ENGLISH LANGUAGE LEARNERS**

- As students learn the terminology in this unit, pair English language learners with students who are proficient in English so they can help each other learn the lesson vocabulary.
## Curriculum Correlation

### A: Scientific Investigation Skills and Career Exploration

<table>
<thead>
<tr>
<th>A1. SCIENTIFIC INVESTIGATION SKILLS</th>
<th>SECTIONS</th>
</tr>
</thead>
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<tr>
<td>OVERALL EXPECTATIONS</td>
<td>SPECIFIC EXPECTATIONS</td>
</tr>
<tr>
<td>A1. demonstrate scientific</td>
<td>1.4, 1.6, 1.4.1, 1.5.1, 1.6.1, 1.6.2, 1.6.3, Unit Task</td>
</tr>
<tr>
<td>investigation skills in the four</td>
<td>Unit Task</td>
</tr>
<tr>
<td>areas of skills</td>
<td>1.6, 1.5.1, 1.6.1, 1.6.2, 2.2, 2.3, Unit Task</td>
</tr>
<tr>
<td>A1.1 formulate relevant scientific</td>
<td>1.4, 1.6, 1.4.1, 1.5.1, 1.6.1, 1.6.2, 1.6.3, 2.4, 2.4.1</td>
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<tr>
<td>questions about observed</td>
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<tr>
<td>relationships, ideas, problems, or</td>
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<tr>
<td>issues, make informed predictions,</td>
<td></td>
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<tr>
<td>and/or formulate educated hypotheses to focus inquiries or research</td>
<td></td>
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<tr>
<td>A1.2 select appropriate instruments</td>
<td>2.4, 2.4.1</td>
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<tr>
<td>and materials, and identify</td>
<td></td>
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<tr>
<td>appropriate methods, techniques, and</td>
<td></td>
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<tr>
<td>procedures for each inquiry</td>
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<tr>
<td>A1.3 identify and locate a variety</td>
<td>1.6, 2.3</td>
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<tr>
<td>of print and electronic sources that</td>
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<td>enable them to address research</td>
<td></td>
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<tr>
<td>topics fully and appropriately</td>
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<tr>
<td>A1.4 apply knowledge and</td>
<td>1.4, 1.6, 1.4.1, 1.5.1, 1.6.1, 1.6.2, 1.6.3, 2.4, 2.4.1</td>
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<tr>
<td>understanding of safe laboratory</td>
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<td>practices and procedures when</td>
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<td>planning investigations by</td>
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<td>correctly interpreting Workplace</td>
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<td>Hazardous Materials Information</td>
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<td>System (WHIMS) symbols; by using</td>
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<td>appropriate techniques for</td>
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<td>handling and storing laboratory</td>
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<td>equipment and materials and</td>
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<td>disposing of laboratory and</td>
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<td>biological materials; and by using</td>
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<tr>
<td>appropriate personal protection</td>
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<tr>
<td>A1.5 conduct inquiries, controlling</td>
<td>1.4, 1.6, 1.4.1, 1.5.1, 1.6.1, 1.6.2, 1.6.3, 2.4, 2.4.1</td>
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<tr>
<td>relevant variables, adapting or</td>
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<td>extending procedures as required, and</td>
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<td>using appropriate materials and</td>
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<td>equipment safely, accurately, and</td>
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<td>effectively, to collect observations</td>
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<tr>
<td>and data</td>
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<tr>
<td>A1.6 compile accurate data from</td>
<td>2.4, 2.4.1</td>
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<tr>
<td>laboratory and other sources, and</td>
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<tr>
<td>organize and record the data, using</td>
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<tr>
<td>appropriate formats, including</td>
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<tr>
<td>tables, flow charts, graphs, and/or</td>
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<tr>
<td>diagrams</td>
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<tr>
<td>A1.7 select, organize, and record</td>
<td>1.6, 2.3</td>
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<tr>
<td>relevant information on research</td>
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<tr>
<td>topics from a variety of</td>
<td></td>
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<td>appropriate sources, including</td>
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<td>electronic, print, and/or</td>
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<td>human sources, using suitable</td>
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<td>formats and an accepted form of</td>
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<tr>
<td>academic documentation</td>
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<tr>
<td>A1.8 synthesize, analyse, interpret,</td>
<td>1.4, 1.6, 1.4.1, 1.5.1, 1.6.1, 1.6.2, Unit Task</td>
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<tr>
<td>and evaluate qualitative and/or</td>
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<td>quantitative data to determine</td>
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<td>whether the evidence supports or</td>
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<td>refutes the initial prediction or</td>
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<td>hypothesis and whether it is</td>
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<td>consistent with scientific theory;</td>
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<td>identify sources of bias and/or</td>
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<td>error; and suggest improvements to</td>
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<td>the inquiry to reduce the</td>
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<tr>
<td>likelihood of error</td>
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<td>A1.9 analyse the information</td>
<td>1.3, 2.3, Unit Task</td>
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<tr>
<td>gathered from research sources for</td>
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<tr>
<td>logic, accuracy, reliability,</td>
<td></td>
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<tr>
<td>adequacy, and bias</td>
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<tr>
<td>A1.10 draw conclusions based on</td>
<td>1.4, 1.6, 1.4.1, 1.6.1, 2.3, Unit Task</td>
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<tr>
<td>inquiry results and research</td>
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<tr>
<td>findings, and justify their</td>
<td></td>
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<tr>
<td>conclusions with reference to</td>
<td></td>
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<tr>
<td>scientific knowledge</td>
<td></td>
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<tr>
<td>A1.11 communicate ideas, plans,</td>
<td>1.4, 1.6, 1.7, 1.4.1, 1.5.1, 1.6.1, 1.6.2, 1.6.3, 1.7.1, 2.4, 2.4.1, Unit Task</td>
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<tr>
<td>procedures, results, and</td>
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<td>conclusions orally, in writing,</td>
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<td>and/or in electronic presentations,</td>
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<tr>
<td>using appropriate language and a</td>
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<td>variety of formats</td>
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<td>A1.12 use appropriate numeric,</td>
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<tr>
<td>symbolic, and graphic modes of</td>
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<tr>
<td>representation, and appropriate</td>
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<tr>
<td>units of measurement</td>
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<tr>
<td>A1.13 express the results of any</td>
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<tr>
<td>calculations involving data</td>
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<tr>
<td>accurately and precisely, to the</td>
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<tr>
<td>appropriate number of decimal places</td>
<td></td>
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<tr>
<td>or significant figures</td>
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</tbody>
</table>
## A2. CAREER EXPLORATION

<table>
<thead>
<tr>
<th>OVERALL EXPECTATIONS</th>
<th>SPECIFIC EXPECTATIONS</th>
<th>SECTION(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2. identify and describe careers related to the fields of science under study, and describe 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</td>
<td>1.1, 1.2, 1.6, 1.7, 2.1, 2.2, 2.4, 2.6</td>
</tr>
<tr>
<td>A2.2 describe the contributions of scientists, including Canadians to the fields under study</td>
<td></td>
<td>1.6, 1.7</td>
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</tbody>
</table>

## B: Organic Chemistry

### B1. RELATING SCIENCE TO TECHNOLOGY, SOCIETY, AND THE ENVIRONMENT

<table>
<thead>
<tr>
<th>OVERALL EXPECTATIONS</th>
<th>SPECIFIC EXPECTATIONS</th>
<th>SECTION(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1. assess the social and environmental impact of organic compounds used in everyday life, and propose a course of action to reduce the use of compounds that are harmful to human health and the environment</td>
<td>B1.1 assess the impact on human health, society, and the environment of organic compounds used in everyday life</td>
<td>1.6, 2.2, 2.3, 2.5, Unit Task</td>
</tr>
<tr>
<td>B1.2 propose a personal course of action to reduce the use of compounds that are harmful to human health and the environment</td>
<td></td>
<td>1.6, 2.3, 2.6, Unit Task</td>
</tr>
</tbody>
</table>

### B2. DEVELOPING SKILLS OF INVESTIGATION AND COMMUNICATION

<table>
<thead>
<tr>
<th>OVERALL EXPECTATIONS</th>
<th>SPECIFIC EXPECTATIONS</th>
<th>SECTION(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2. investigate organic compounds and organic chemical reactions, and use various methods to represent the compounds</td>
<td>B2.1 use appropriate terminology related to organic chemistry, including, but not limited to: organic compound, functional group, saturated hydrocarbon, unsaturated hydrocarbon, structural isomer, stereoisomer, and polymer</td>
<td>1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 2.1, 2.2, 2.4, 2.6, Unit Task</td>
</tr>
<tr>
<td></td>
<td>B2.2 use International Union of Pure and Applied Chemistry (IUPAC) nomenclature conventions to identify names, write chemical formulae, and create structural formulae for the different classes of organic compounds, including hydrocarbons, alcohols, aldehydes, ketones, carboxylic acids, esters, ethers, amines, amides, and simple aromatic compounds</td>
<td>1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 2.1, 2.2, 2.4, 2.6, Unit Task</td>
</tr>
<tr>
<td></td>
<td>B2.3 build molecular models for a variety of simple organic compounds</td>
<td>1.1, 1.7, 1.7.1</td>
</tr>
<tr>
<td></td>
<td>B2.4 analyse, on the basis of inquiry, various organic chemical reactions</td>
<td>1.5.1, 1.6.1, 1.6.2, 1.6.3, 2.4, 2.4.1</td>
</tr>
</tbody>
</table>

### B3. UNDERSTANDING BASIC CONCEPTS

<table>
<thead>
<tr>
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<th>SPECIFIC EXPECTATIONS</th>
<th>SECTION(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B3. demonstrate an understanding of the structure, properties, and chemical behaviour of compounds within each class of organic compounds</td>
<td>B3.1 compare the different classes of organic compounds, including hydrocarbons, alcohols, aldehydes, ketones, carboxylic acids, esters, ethers, amines, and amides, by describing the similarities and differences in names and structural formulae of the compounds within each class</td>
<td>1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7</td>
</tr>
<tr>
<td></td>
<td>B3.2 describe the similarities and differences in physical properties within each class of organic compounds</td>
<td>1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7</td>
</tr>
<tr>
<td></td>
<td>B3.3 explain the chemical changes that occur during various types of organic chemical reactions, including substitution, addition, elimination, oxidation, esterification, and hydrolysis</td>
<td>1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7</td>
</tr>
<tr>
<td>B3.4</td>
<td>explain the difference between an addition reaction and a condensation polymerization reaction</td>
<td>2.1, 2.2, 2.4, 2.6</td>
</tr>
<tr>
<td>B3.5</td>
<td>explain the concept of isomerism in organic compounds, and how variations in the properties of isomers relate to their structural and molecular formulae</td>
<td>1.1, 1.2, 1.3</td>
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</table>
# Unit Planning Chart

<table>
<thead>
<tr>
<th>SECTION</th>
<th>HANDS-ON ACTIVITIES AND SKILLS</th>
<th>ASSESSMENT/EVALUATION OPPORTUNITIES</th>
<th>PROGRAM RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1 Opening Material p. 1 [Student Book p. 2]</td>
<td></td>
<td>• Focus on STSE p. 2 [Student Book p. 3]</td>
<td></td>
</tr>
<tr>
<td>Chapter 1 Organic Compounds p. 15 [Student Book p. 6]</td>
<td>Mini Investigation: An Enlightening Organic Compound p. 15 [Student Book p. 7] • Questioning • Observing • Evaluating</td>
<td>• Mini Investigation – Demonstrate a chemical reaction in which the product is a compound that emits light • Assessment of prior knowledge • Reading and answering questions</td>
<td>Skills Handbook A2.3 Observational Studies</td>
</tr>
<tr>
<td>1.1 Alkanes p. 16 [Student Book p. 8]</td>
<td>Mini Investigation: Arranging Carbon Atoms p. 17 [Student Book p. 10] • Performing • Observing • Communicating</td>
<td>• Mini Investigation – Investigating the structures of straight-chain, branched-chain, and cyclic alkanes • Completing practice problems • Completing the BLM • Reading and answering questions</td>
<td>BLM 1.1-1 Building Isomers Assessment Rubric 1: Knowledge and Understanding Assessment Rubric 2: Thinking and Investigation Assessment Rubric 3: Communication Assessment Summary 1: Knowledge and Understanding Assessment Summary 2: Thinking and Investigation Assessment Summary 3: Communication Skills Handbook A2.4 Activities</td>
</tr>
<tr>
<td>1.2 Alkenes and Alkynes p.17 [Student Book p. 19]</td>
<td>Mini Investigation: Isomers of Pentene p. 18 [Student Book p. 21] • Performing • Observing • Communicating</td>
<td>• Mini Investigation – Using molecular models to investigate isomerization in an alkene • Completing practice problems • Completing the BLM • Reading and answering questions</td>
<td>BLM 1.2-1 Reactions of Hydrocarbons Assessment Rubric 1: Knowledge and Understanding Assessment Rubric 2: Thinking and Investigation Assessment Rubric 3: Communication Assessment Summary 1: Knowledge and Understanding Assessment Summary 2: Thinking and Investigation Assessment Summary 3: Communication Skills Handbook A2.4 Activities</td>
</tr>
<tr>
<td>SECTION</td>
<td>HANDS-ON ACTIVITIES AND SKILLS</td>
<td>ASSESSMENT/EVALUATION OPPORTUNITIES</td>
<td>PROGRAM RESOURCES</td>
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</tbody>
</table>
| 1.3 Aromatic Hydrocarbons p. 19 [Student Book p. 28] | • Completing the BLM  
• Reading and answering questions | | BLM 1.3-1 Naming Aliphatic and Aromatic Hydrocarbons  
Assessment Rubric 1: Knowledge and Understanding  
Assessment Rubric 2: Thinking and Investigation  
Assessment Rubric 3: Communication  
Assessment Summary 1: Knowledge and Understanding  
Assessment Summary 2: Thinking and Investigation  
Assessment Summary 3: Communication |
| 1.4 Alcohols, Ethers, and Thiols p. 21 [Student Book p. 32] | • Reading and answering questions | | Assessment Rubric 1: Knowledge and Understanding  
Assessment Rubric 2: Thinking and Investigation  
Assessment Rubric 3: Communication  
Assessment Summary 1: Knowledge and Understanding  
Assessment Summary 2: Thinking and Investigation  
Assessment Summary 3: Communication |
• Researching  
• Hypothesizing  
• Predicting  
• Controlling Variables  
• Performing  
• Observing  
• Analyzing  
• Evaluating  
• Communicating  
• Developing and testing a hypothesis  
• Following safety procedures  
• Identifying variables  
• Making informed predictions  
• Drawing and justifying conclusions  
• Reading and answering questions | | BLM 0.0-11 Disposal of Hazardous Waste  
Assessment Rubric 5: Controlled Experiment  
Assessment Summary 5: Controlled Experiment  
Self-Assessment Checklist 1: Controlled Experiment  
Skills Handbook A1 Safety  
Skills Handbook A2.2 Controlled Experiments  
Skills Handbook A3.3 Using a Pipette |
| 1.5 Aldehydes and Ketones p. 22 [Student Book p. 40] | • Completing practice problems  
• Completing the BLM  
• Reading and answering questions | | Assessment Rubric 1: Knowledge and Understanding  
Assessment Rubric 2: Thinking and Investigation  
Assessment Rubric 3: Communication  
Assessment Summary 1: Knowledge and Understanding  
Assessment Summary 2: Thinking and Investigation  
Assessment Summary 3: Communication |
<table>
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<tr>
<th>SECTION</th>
<th>HANDS-ON ACTIVITIES AND SKILLS</th>
<th>ASSESSMENT/EVALUATION OPPORTUNITIES</th>
<th>PROGRAM RESOURCES</th>
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</thead>
<tbody>
<tr>
<td>1.5.1 Observational Study: Reactions of Three Isomers of Butanol p.28 [Student Book p. 63]</td>
<td>1.5.1 Observational Study: Reactions of Three Isomers of Butanol p.28 [Student Book p. 63] • Researching • Predicting • Performing • Observing • Analyzing • Evaluating • Communicating</td>
<td>• Analyzing data about the reactions of butanol and evaluating the data to determine if the evidence is consistent with scientific theory • Communicating conclusion using appropriate language and a variety of formats • Reading and answering questions</td>
<td>BLM 0.0-11 Disposal of Hazardous Waste Assessment Rubric 7: Observational Study Assessment Summary 7: Observational Study Self-Assessment Checklist 3: Observational Study Skills Handbook A1 Safety Skills Handbook A2.3 Observational Studies Skills Handbook A5.1 Research Skills</td>
</tr>
<tr>
<td>1.6 Carboxylic Acids, Esters, and Fats p.23 [Student Book p. 47]</td>
<td>Research This: Banning Trans Fat p. 25 [Student Book p. 54] • Questioning • Researching • Communicating • Defending a Decision</td>
<td>• Research This – Researching the uses and potential risks of trans fats • Completing practice problems • Reading and answering questions</td>
<td>BLM 1.6-1 Organic Compounds Containing Oxygen Assessment Rubric 1: Knowledge and Understanding Assessment Rubric 2: Thinking and Investigation Assessment Rubric 3: Communication Assessment Summary 1: Knowledge and Understanding Assessment Summary 2: Thinking and Investigation Assessment Summary 3: Communication Skills Handbook A5.1 Research Skills</td>
</tr>
<tr>
<td>1.6.1 Controlled Experiment: Properties of Carboxylic Acids p. 29 [Student Book p. 65]</td>
<td>1.6.1 Controlled Experiment: Properties of Carboxylic Acids p. 29 [Student Book p. 65] • Hypothesizing • Predicting • Controlling Variables • Performing • Observing • Analyzing • Communicating</td>
<td>• Conducting an inquiry into the properties of carboxylic acids and accurately collect observations and data • Interpreting and evaluating qualitative and quantitative data to determine if the evidence supports or refutes the initial prediction • Drawing and justifying conclusions • Reading and answering questions</td>
<td>BLM 0.0-11 Disposal of Hazardous Waste Assessment Rubric 5: Controlled Experiment Assessment Summary 5: Controlled Experiment Self-Assessment Checklist 1: Controlled Experiment Skills Handbook A1 Safety Skills Handbook A2.2 Controlled Experiment Skills Handbook A2.3 Lab Reports</td>
</tr>
<tr>
<td>1.6.2 Observational Study: Synthesizing Esters p. 31 [Student Book p. 66]</td>
<td>1.6.2 Observational Study: Synthesizing Esters p. 31 [Student Book p. 66] • Performing • Observing • Analyzing • Communicating</td>
<td>• Conducting an inquiry and making observations about chemical reactions between carboxylic acids and alcohols • Analyzing chemical reactions and writing chemical equations • Reading and answering questions</td>
<td>BLM 0.0-11 Disposal of Hazardous Waste Assessment Rubric 7: Observational Study Assessment Summary 7: Observational Study Self-Assessment Checklist 3: Observational Study Skills Handbook A1 Safety Skills Handbook A2.3 Observational Studies</td>
</tr>
<tr>
<td>SECTION</td>
<td>HANDS-ON ACTIVITIES AND SKILLS</td>
<td>ASSESSMENT/EVALUATION OPPORTUNITIES</td>
<td>PROGRAM RESOURCES</td>
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| 1.6.3 Observational Study: Making Soap (Teacher Demonstration) p. 32 [Student Book p. 67] | 1.6.3 Observational Study: Making Soap (Teacher Demonstration) p. 32 [Student Book p. 67] | • Analyzing the chemical reactions involved in the conversion of fat to soap  
• Completing the BLM  
• Reading and answering questions | BLM 0.0-11 Disposal of Hazardous Waste  
BLM 1.6.3-1 Observational Study: Safe Soap  
BLM 1.6.3-2 Safe Soap Teaching Notes (for teacher use)  
Assessment Rubric 7: Observational Study  
Assessment Summary 7: Observational Study  
Self-Assessment Checklist 3: Observational Study  
Skills Handbook A1 Safety  
Skills Handbook A2.3 Observational Studies  
Skills Handbook A3.2 Using a Laboratory Balance |
| 1.7 Amines and Amides p. 25 [Student Book p. 56] |  | • Completing practice problems  
• Completing the BLM  
• Reading and answering questions | BLM 1.7-1 Identification and Naming of Organic Compounds  
Assessment Rubric 1: Knowledge and Understanding  
Assessment Rubric 2: Thinking and Investigation  
Assessment Rubric 3: Communication  
Assessment Summary 1: Knowledge and Understanding  
Assessment Summary 2: Thinking and Investigation  
Assessment Summary 3: Communication |
| 1.7.1 Observational Study: Building Organic Molecular Models p. 34 [Student Book p. 69] | 1.7.1 Activity: Building Organic Molecular Models p. 34 [Student Book p. 69] | • Building models to represent a variety of simple organic chemical molecules  
• Communicating conclusions about representing molecules with models, using appropriate language and a variety of formats  
• Completing the BLM  
• Reading and answering questions | Assessment Rubric 8: Activity  
Assessment Summary 8: Activity  
Self-Assessment Checklist 4: Activity  
Skills Handbook A2.4 Activities  
Skills Handbook B3 Elements and Compounds |
| Chapter 1 Summary p. 35 [Student Book p. 62] |  | • Summary questions  
• Chapter 1 Self-Quiz  
• Chapter 1 Review | BLM 1.Q Chapter 1 Quiz  
BLM 0.0-10 Careers  
Assessment Rubric 1: Knowledge and Understanding  
Assessment Rubric 2: Thinking and Investigation  
Assessment Rubric 4: Application  
Assessment Summary 1: Knowledge and Understanding  
Assessment Summary 2: Thinking and Investigation  
Assessment Summary 4: Application  
Skills Handbook A7 Choosing Appropriate Career Pathways |
<table>
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<th>HANDS-ON ACTIVITIES AND SKILLS</th>
<th>ASSESSMENT/EVALUATION OPPORTUNITIES</th>
<th>PROGRAM RESOURCES</th>
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</table>
- Predicting  
- Performing  
- Observing  
- Evaluating  
- Communicating | Mini Investigation – Observing the formation of cross-linking polymer chains by converting soluble sodium alginate into an insoluble form  
Assessment of prior knowledge  
Reading and answering questions | Skills Handbook A1 Safety |
| 2.1 Introducing Polymers p. 38 [Student Book p. 80] | Research This: Paying with Plastic p. 40 [Student Book p. 86]  
- Researching  
- Analyzing  
- Evaluating  
- Communicating  
Mini Investigation: Guar Gum Slime p. 40 [Student Book p. 92]  
- Performing  
- Observing  
- Analyzing | Completing practice problems  
Reading and answering questions | Assessment Rubric 1: Knowledge and Understanding  
Assessment Summary 1: Knowledge and Understanding |
| 2.2 Synthetic Addition Polymers p.39 [Student Book p. 84] | Research This: Paying with Plastic p. 40 [Student Book p. 86]  
- Researching  
- Analyzing  
- Evaluating  
- Communicating  
Mini Investigation: Guar Gum Slime p. 40 [Student Book p. 92]  
- Performing  
- Observing  
- Analyzing | Research This – Demonstrating a practical use of synthetic polymers  
Mini Investigation – Making and observing the physical changes that occur during polymerization  
Completing practice problems  
Completing the BLM  
Reading and answering questions | BLM 0.0-11 Disposal of Hazardous Waste  
BLM 2.2-1 Familiar Addition Polymers  
BLM 2.2-2 Addition Polymers  
Assessment Rubric 1: Knowledge and Understanding  
Assessment Rubric 3: Communication  
Assessment Rubric 4: Application  
Assessment Summary 1: Knowledge and Understanding  
Assessment Summary 3: Communication  
Assessment Summary 4: Application  
Skills Handbook A1 Safety  
Skills Handbook A2.1 Skills of Scientific Inquiry  
Skills Handbook A5.1 Research Skills  
Skills Handbook B3 Elements and Compounds |
| 2.3 Explore an Issue in Polymer Technology p. 41 [Student Book p. 94] | 2.3 Explore an Issue in Polymer Technology p. 41 [Student Book p. 94]  
- Researching  
- Identifying Alternatives  
- Analyzing  
- Communicating  
- Evaluating | Planning and executing research  
Justifying conclusions about the need to replace phthalates  
Summarizing conclusions and using language appropriate for the intended audience  
Completing the BLM  
Reading and answering questions | BLM 0.0-2 Compare and Contrast Chart  
Assessment Rubric 9: Explore an Issue  
Assessment Summary 9: Explore an Issue  
Self-Assessment Checklist 5: Explore an Issue  
Skills Handbook A5 Exploring Issues and Application |
| 2.4 Synthetic Condensation Polymers p. 42 [Student Book p. 95] | | Completing practice problems  
Completing the BLM  
Reading and answering questions | BLM 2.4-1 Condensation Reactions  
Assessment Rubric 1: Knowledge and Understanding  
Assessment Summary 1: Knowledge and Understanding |
<table>
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<tr>
<th>SECTION</th>
<th>HANDS-ON ACTIVITIES AND SKILLS</th>
<th>ASSESSMENT/EVALUATION OPPORTUNITIES</th>
<th>PROGRAM RESOURCES</th>
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<tbody>
<tr>
<td>2.4.1 Observational Study: Preparation of a Polyester p. 46 [Student Book p. 106]</td>
<td>2.4.1 Observational Study: Preparation of a Polyester p. 46 [Student Book p. 106] • Performing • Observing • Analyzing • Evaluating • Communicating</td>
<td>• Investigating properties of glyptal • Following safety precautions • Charting and tabulating the data learned from the observations • Completing the BLM • Reading and answering questions</td>
<td>BLM 0.0-11 Disposal of Hazardous Waste BLM 2.4.1-1 Observational Study: Preparation of a Polyester Assessment Rubric 7: Observational Study Assessment Summary 7: Observational Study Self-Assessment Checklist 3: Observational Study</td>
</tr>
<tr>
<td>2.5 Chemistry Journal: The Invention of Nylon p. 44 [Student Book p. 100]</td>
<td>• Reading and answering questions</td>
<td></td>
<td>BLM 0.0-4 Concept Map BLM 0.0-8 Reading Strategies Checklist Skills Handbook A4 Scientific Publications</td>
</tr>
<tr>
<td>2.6 Natural Polymers p. 44 [Student Book p. 101]</td>
<td>• Completing practice problems • Reading and answering questions</td>
<td></td>
<td>Assessment Rubric 1: Knowledge and Understanding Assessment Summary 1: Knowledge and Understanding</td>
</tr>
<tr>
<td>Chapter 2 Summary p. 47 [Student Book p. 108]</td>
<td>• Summary questions • Chapter 2 Self-Quiz • Chapter 2 Review</td>
<td></td>
<td>BLM 2.0 Chapter 2 Quiz BLM 0.0-10 Careers Assessment Rubric 1: Knowledge and Understanding Assessment Summary 1: Knowledge and Understanding Skills Handbook A7 Choosing Appropriate Career Pathways</td>
</tr>
<tr>
<td>Unit 1 Closing p. 49 [Student Book p. 116]</td>
<td>Unit Task: Using Safer Solvents p. 49 [Student Book p. 116] • Unit Task – exploring the use of volatile organic compounds (VOCs) in household products and making recommendations for alternatives • Unit 1 Self-Quiz • Unit 1 Review</td>
<td></td>
<td>BLM U1.0 Unit 1 Quiz Unit 1 Task Assessment Rubric: Using Safer Solvents Unit 1 Tasks Assessment Summary: Using Safer Solvents Unit 1 Task Self-Assessment Checklist: Using Safer Solvents</td>
</tr>
</tbody>
</table>
The quantity of equipment and materials for activities and investigations is based on the groups suggested in the specific sections. The quantities are based on a standard class size of 32 students, broken down into groupings of two or four students. Where the term “quantity” is inappropriate—such as for a piece of tubing, masking tape, and so on—you will have to check the individual activity or investigation to obtain appropriate quantities. In the table below, “Equipment” refers to actual equipment or hardware, such as microscopes, metre sticks, glassware; and “Materials” refers to consumable items, such as chemicals, tape, water, or paper.

**Unit 1: Organic Chemistry**

<table>
<thead>
<tr>
<th>INVESTIGATION/ACTIVITY</th>
<th>QUANTITY</th>
<th>EQUIPMENT</th>
<th>QUANTITY</th>
<th>MATERIALS</th>
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<tbody>
<tr>
<td>Chapter 1 Mini Investigation: An Enlightening Organic Compound p. 15 [Student Book p. 7]</td>
<td>32</td>
<td>• chemical safety goggles</td>
<td>—</td>
<td>• distilled water</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>• lab apron, plastic, measuring 68 cm x 89 cm</td>
<td>—</td>
<td>• solution A [2.0 g sodium carbonate, Na₂CO₃; 0.1 g luminol, C₈H₇O₂N₃(s); 12.0 g sodium bicarbonate, NaHCO₃(s); 0.25 g ammonium carbonate monohydrate, (NH₄)₂CO₃·H₂O(s); 0.2 g copper(II) sulfate pentahydrate, CuSO₄·5H₂O(s)]</td>
</tr>
<tr>
<td>Student groupings: 8 groups of 4 students</td>
<td>16</td>
<td>• 1 L Erlenmeyer flask (2 per group)</td>
<td>—</td>
<td>• solution B [25 mL 3% hydrogen peroxide, H₂O₂(aq)]</td>
</tr>
<tr>
<td>1.1 Mini Investigation: Arranging Carbon Atoms p. 17 [Student Book p. 10]</td>
<td>16</td>
<td>• retort stand and ring clamp</td>
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<td></td>
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<tr>
<td>Student groupings: 16 groups of 2 students</td>
<td></td>
<td>• funnel</td>
<td>—</td>
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<tr>
<td></td>
<td></td>
<td>• utility clamp (3 per group)</td>
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<tr>
<td></td>
<td></td>
<td>• 1 metre length of plastic tubing</td>
<td>—</td>
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</tr>
<tr>
<td>1.2 Mini Investigation: Isomers of Pentene p. 19 [Student Book p. 21]</td>
<td>16</td>
<td>• molecular modelling kit</td>
<td>—</td>
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<tr>
<td>Student groupings: 16 groups of 2 students</td>
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<tr>
<td>1.4.1 Controlled Experiment: Properties of Alcohols p. 27 [Student Book p. 63]</td>
<td>32</td>
<td>• chemical safety goggles</td>
<td>8</td>
<td>• 3 mL calibrated disposable pipette</td>
</tr>
<tr>
<td>Student groupings: 8 groups of 4 students</td>
<td>32</td>
<td>• lab apron, plastic, measuring 68 cm x 89 cm</td>
<td>—</td>
<td>• stoppered bottle of butan-1-ol</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>• MSDS for each chemical used</td>
<td>—</td>
<td>• stoppered bottle of ethanol</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>• test tube (3 per group)</td>
<td>—</td>
<td>• stoppered bottle of propan-1-ol</td>
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<td>8</td>
<td>• test-tube rack</td>
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<td>• stoppered bottle of cyclohexane</td>
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<td>8</td>
<td>• wax pencil</td>
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<td>• distilled water</td>
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<td>8</td>
<td>• wash bottle</td>
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<tr>
<td>1.5.1 Observational Study: Reactions of Three Isomers of Butanol p. 28 [Student Book p. 64]</td>
<td>32</td>
<td>• chemical safety goggles</td>
<td>—</td>
<td>• dropper bottle of butan-1-ol</td>
</tr>
<tr>
<td>Student groupings: 8 groups of 4 students</td>
<td>32</td>
<td>• lab apron, plastic, measuring 68 cm x 89 cm</td>
<td>—</td>
<td>• dropper bottle of butan-2-ol</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>• protective gloves</td>
<td>—</td>
<td>• dropper bottle of 2-methylpropan-2-ol</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>• test tube (3 per group)</td>
<td>—</td>
<td>• dropper bottle of potassium permanganate solution, KMnO₄(aq) (0.01 mol/L)</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>• test-tube rack</td>
<td>—</td>
<td>• dropper bottle of concentrated hydrochloric acid, HCl(aq) (12 mol/L) (for teacher use only)</td>
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<tr>
<td></td>
<td>8</td>
<td>• eye dropper</td>
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<td>INVESTIGATION/ACTIVITY</td>
<td>QUANTITY</td>
<td>EQUIPMENT</td>
<td>QUANTITY</td>
<td>MATERIALS</td>
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<td>1.6.1 Controlled Experiment: Properties of Carboxylic Acids p. 29 [Student Book p. 65]</td>
<td>32</td>
<td>• chemical safety goggles</td>
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<td>• distilled water</td>
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<td>32</td>
<td>• lab apron, plastic, measuring 68 cm x 89 cm</td>
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<td>• vegetable oil</td>
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<td></td>
<td>32</td>
<td>• MSDS for each chemical used</td>
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<td>• dropper bottle of concentrated ethanoic acid (glacial acetic acid) CH₃COOH(l) (for teacher use only)</td>
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<tr>
<td></td>
<td>8</td>
<td>• 10 mL graduated cylinder</td>
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<td>• dropper bottle of dilute ethanoic acid (vinegar)</td>
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<td></td>
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<td>• dropper bottle of sodium hydrogen carbonate solution, NaHCO₃(aq) (saturated)</td>
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<td>8</td>
<td>• test-tube holder</td>
<td>—</td>
<td>• octadecanoic acid (stearic acid, solid)</td>
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<td>• test-tube brush</td>
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<td></td>
<td>8</td>
<td>• pH meter</td>
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<td>• wash bottle</td>
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<td></td>
<td>8</td>
<td>• beaker</td>
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<td>Student groupings: 8 groups of 4 students</td>
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<td>• dropper bottle of ethanol</td>
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<td>• dropper bottle of propan-2-ol</td>
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<td>8</td>
<td>• 500 mL beaker</td>
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<td>• dropper bottle of pentan-1-ol</td>
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<tr>
<td></td>
<td>8</td>
<td>• utility stand and ring clamp</td>
<td>—</td>
<td>• dropper bottle of concentrated ethanoic acid (glacial acetic acid), CH₃COOH(l) (for teacher use only)</td>
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<tr>
<td></td>
<td>8</td>
<td>• hot plate</td>
<td>—</td>
<td>• dropper bottle of 2 mL concentrated sulfuric acid, H₂SO₄(aq) (for teacher use only)</td>
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<td></td>
<td>8</td>
<td>• wax pencil</td>
<td>—</td>
<td>• cold tap water</td>
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<td>• test-tube holder (3 per group)</td>
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<td>• test-tube rack</td>
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<td>8</td>
<td>• Petri dish</td>
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<td>1.6.2 Observational Study: Synthesizing Esters p. 31 [Student Book p. 66]</td>
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<td>• utility stand and ring clamp</td>
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<td>• hot plate</td>
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<td>8</td>
<td>• wax pencil</td>
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<td>24</td>
<td>• test tube (3 per group)</td>
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<td>24</td>
<td>• test-tube holder (3 per group)</td>
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<td>• test-tube rack</td>
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<td>8</td>
<td>• Petri dish</td>
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<td>Student groupings: 8 groups of 4 students</td>
<td>32</td>
<td>• chemical safety goggles</td>
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<td>32</td>
<td>• lab apron, plastic, measuring 68 cm x 89 cm</td>
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<td>32</td>
<td>• protective gloves</td>
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<td>• forceps</td>
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<td>• 50 mL graduated cylinder</td>
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<td>• hot plate</td>
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<td>• beaker tongs</td>
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<td>• heat resistant mat</td>
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<td>• thermometer</td>
<td>—</td>
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<td></td>
<td>1</td>
<td>• filter funnel and paper</td>
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<tr>
<td></td>
<td>1</td>
<td>• wash bottle</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1.6.3 Observational Study: Making Soap (Teacher Demonstration) p. 32 [Student Book p. 66]</td>
<td>32</td>
<td>• chemical safety goggles</td>
<td>—</td>
<td>• fats (lard or vegetable shortening)</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>• lab apron, plastic, measuring 68 cm x 89 cm</td>
<td>—</td>
<td>• oils (cooking oils such as corn oil, canola oil, olive oil)</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>• protective gloves</td>
<td>—</td>
<td>• sodium hydroxide pellets, NaOH(s) (for teacher use only)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>• wax pencil</td>
<td>—</td>
<td>• ethanol</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>• 100 mL beaker</td>
<td>—</td>
<td>• vinegar, CH₃COOH(aq)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>• 250 mL beaker</td>
<td>—</td>
<td>• sodium chloride crystals, NaCl(s)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>• forceps</td>
<td>—</td>
<td>• distilled water</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>• 50 mL graduated cylinder</td>
<td>—</td>
<td>• food colouring (optional)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>• glass stirring rod</td>
<td>—</td>
<td>• perfume (optional)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>• balance</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>• utility stand with ring clamp</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>• hot plate</td>
<td>—</td>
<td>—</td>
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<td></td>
<td>1</td>
<td>• beaker tongs</td>
<td>—</td>
<td>—</td>
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<tr>
<td></td>
<td>1</td>
<td>• heat resistant mat</td>
<td>—</td>
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<td>1</td>
<td>• thermometer</td>
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<td>1</td>
<td>• filter funnel and paper</td>
<td>—</td>
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<tr>
<td></td>
<td>1</td>
<td>• wash bottle</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>• molecular modelling kit</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

| 1.7.1 Observational Study: Building Organic Molecular Models p. 34 [Student Book p. 69] | 32 | • molecular modelling kit | — | — |

Student groupings: Individual
<table>
<thead>
<tr>
<th>INVESTIGATION/ACTIVITY</th>
<th>QUANTITY</th>
<th>EQUIPMENT</th>
<th>QUANTITY</th>
<th>MATERIALS</th>
</tr>
</thead>
</table>
| **Chapter 2 Mini Investigation: Making Polymer Worms**  
  p. 37 [Student Book p. 79]                          | 32       | • chemical safety goggles                         | —        | • approximately 250 mL of 1% solution of calcium chloride                   |
|                                                 | 32       | • lab apron, plastic, measuring 68 cm × 89 cm     | —        | • dropper bottle of 5–10 mL of 2% solution of sodium alginate              |
| Student groupings: 8 groups of 4 students         | 8        | • beaker or small bowl                            | —        | • paper towel                                                              |
|                                                 | 8        | • tongs or spoon                                   | —        |                                                                           |
| **2.2 Mini Investigation: Guar Gum Slime**  
  p.40 [Student Book p. 92 ]                          | 32       | • chemical safety goggles                         | —        | • food colouring (optional)                                                |
|                                                 | 32       | • lab apron, plastic, measuring 68 cm × 89 cm     | —        | • wooden stir stick                                                        |
| Student groupings: 8 groups of 4 students         | 8        | • 250 mL beaker                                    | —        | • 100 mL warm distilled water                                               |
|                                                 | 8        | • 100 mL measuring cylinder                       | —        | • 1.0g guar gum powder                                                     |
|                                                 | 8        | • electronic balance                               | —        | • 0.4g sodium borate, Na₂B₄O₇(s)                                          |
|                                                 | 8        | • 100 mL beaker                                    | —        |                                                                           |
|                                                 | 8        | • aluminum pie plate                               | —        |                                                                           |
| **2.4.1 Observational Study: Preparation of a Polyester**  
  p. 40 [Student Book p. 106]                          | 32       | • chemical safety goggles                         | —        | • paper towel                                                              |
| Student groupings: 16 groups of 2 students        | 32       | • lab apron, plastic, measuring 68 cm × 89 cm     | —        | • 3 g 2-benzofuran-1,3-dione (phthalic anhydride powder)                    |
|                                                 | 32       | • protective gloves                                | —        | • 2 g propane-1,2,3-triol (glycerol)                                       |
|                                                 | 32       | • glass stirring rod                               | —        | • 5 mL paint thinner or nail polish remover                                |
|                                                 | 16       | • hot plate                                        | —        |                                                                           |
|                                                 | 16       | • utility stand with ring clamp                    | —        |                                                                           |
|                                                 | 16       | • watch glass to fit beaker, 2 per group           | —        |                                                                           |
|                                                 | 32       | • beaker tongs                                     | —        |                                                                           |
|                                                 | 32       | • shallow metal container                          | —        |                                                                           |
|                                                 | 16       | • small covered beaker (3 per group)               | —        |                                                                           |
|                                                 | 16       | • small covered beaker                              | —        |                                                                           |

**TOTAL QUANTITY**: 32

**TOTAL EQUIPMENT**: 32

**TOTAL MATERIALS**: 8
OVERALL EXPECTATIONS: A1; B1; B2

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A1.1; A1.2; A1.3; A1.8; A1.9; A1.10; A1.11
Relating Science to Technology, Society and the Environment: B1.1; B1.2
Developing Skills of Investigation and Communication: B2.1; B2.2

The full Overall and Specific Expectations are listed on pages 3–5.

• 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 for students to explore the use of volatile organic compounds (VOCs) in household products and make recommendations for alternatives.

ASSESSMENT RESOURCES
Unit 1 Task Assessment Rubric: Using Safer Solvents
Unit 1 Task Assessment Summary: Using Safer Solvents
Unit 1 Task Self-Assessment Checklist: Using Safer Solvents

PROGRAM RESOURCES
BLM U1 Q Unit 1 Quiz
Skills Handbook A5 Exploring Issues and Applications Chemistry 12 Online Teaching Centre Chemistry 12 website
www.nelson.com/onseniorscience/chemistry12u

RELATED RESOURCES

EVIDENCE OF LEARNING
Look for evidence that students can
• plan and execute research.
• explain the purpose of volatile organic compounds in the identified household product.
• identify the significance of the risks in using volatile organic compounds.
• condense research notes into a few key points.
• justify their conclusions about their “green” alternative to a product that uses a volatile organic compound.
• summarize their conclusions using language appropriate for the intended audience.
• communicate their findings clearly and in an engaging manner.

SCIENCE BACKGROUND
• Volatile organic compounds (VOCs) are organic chemicals that evaporate readily into the air. They have a high vapour pressure. Many volatile organic compounds are toxic.

• Some common examples of volatile organic compounds are benzene (C₆H₆), acetone (H₃CCOCH₃), formaldehyde (CH₂O), and ethylene glycol (HOCH₂CH₂OH).

• Household products, industry, transportation, and natural gas wells are all major sources of volatile organic compounds.

• Some trees, such as certain oak trees, sweet gums, and poplars, also release volatile organic compounds.

• If still in the very early stages of life, many aquatic organisms will perish upon contact with volatile organic compounds that reach water ecosystems.

• Volatile organic compounds play a role in the formation of smog over large cities: in the presence of ultraviolet radiation from the sun, NO₂ already present in the air can react with volatile organic compounds to form smog.

TEACHING NOTES
THE ISSUE
• Many household products are hazardous or potentially toxic, but the reasons vary. You may want to have students confirm with you the product they have chosen to explore before they begin their research.

Possible products:
• Clothing-related products—dry cleaned items, fabric and leather cleaners, spot removers, mothballs
• Personal care products—nail polish and nail polish remover, colognes and perfumes, hair spray
• Cleaning products—scented cleaners, solvents, furniture polishes, deodorizers, air fresheners
• Construction/repair/home products—stains and paints, paint thinner, PVC cement and primer, some adhesives, degreasers, spray lubricants, carpeting
• Fuels—containers of gasoline, kerosene, fuel oil
ROLE
• Students should discuss with the other members of their group the role they plan to play when they present at the conference. Point out to students that their presentation should reflect the group or company they will be representing.
• Have students brainstorm a list of expectations for a presenter at a conference. You may wish to have students research basic presentation skills and incorporate one or more of these techniques in their presentation.

AUDIENCE
• Help students create a list of possible attendees of the conference and their characteristics. For example, people who attend the conference would likely include environmentalists, heads of corporations who make “green" products, and representatives of government agencies, as well as consumers and people who run smaller niche businesses. These people are likely to be environmentally conscious, informed on the technology, and interested in new techniques or products. Have students tailor their presentation to one or more of these groups.

GOAL
• Have students discuss with the other members of their group their preliminary ideas on achieving the goal set out in the task. Encourage students to think of additional benefits of their solution that would provide added support for their position.
• Some groups may struggle with sharing the workload equally among their members. Circulate throughout the classroom and offer suggestions to any group that could use your help in this regard.

RESEARCH AND IDENTIFY SOLUTIONS
• Have students work in groups to identify several products that have significant levels of volatile organic compounds and to select one for further research. After you approve their choice, instruct students to consider various VOCs within the particular product that might be replaced with a different solvent.

MAKE A DECISION
• Point out to students that they should consider how the conventional product depends on the properties and behaviour of each VOC in order to be effective. Then, students need to consider whether their suggested change is likely to work.

COMMUNICATE
• You may wish to provide time in class for each group to work on its presentation. Have students discuss what grabs and holds their attention during a presentation, such as images, videos, graphic organizers, or charts. Have students try to incorporate one or more of their ideas into their presentation.
• Have each group then share its presentation with classmates. Instruct students to act the parts of the attendees of the International Alliance on Green Alternatives by asking probing questions where more information is desired.
• Have students complete the questions found in the Unit Self-Quiz and the Unit Review in the Student Book.
• Have students complete BLM U1.Q Unit 1 Quiz for an additional review of the material.

DIFFERENTIATED INSTRUCTION
• Encourage students to present their results in a variety of formats. Have them complete the assignment in multimodal groups and assign roles and responsibilities to use the different strengths of all individuals to best advantage.

ENGLISH LANGUAGE LEARNERS
• All students will benefit from practising with what they intend to say about their findings before presenting the final product.
CHAPTER 1
Organic Compounds

PROGRAM RESOURCES
Skills Handbook A1 Safety
Skills Handbook A2.3 Observational Studies
Chemistry 12 ExamView® Test Bank
Chemistry 12 Online Teaching Centre
SMART Notebook lesson
PowerPoint lesson
Chemistry 12 Solutions Manual
Chemistry 12 website
www.nelson.com/onseniorscience/chemistry12u

TEACHING NOTES
• Have students examine the Chapter Opener photograph. Ask, What causes the starfish to have such different colours? (Sample answer: the way that light interacts with different chemical compounds in their bodies) You could tell them that most fabric dyes are organic compounds.
• Ask students to relate the occurrence of life on Earth to the key question at the start of the chapter: Why Is Carbon So Ubiquitous? (Students might speculate that living things make many different carbon compounds and that those compounds are spread around the planet as organisms move and grow. They might also discuss the ability of carbon to form multiple covalent bonds as the reason for the large number of possible carbon compounds.)

ENGAGE THE LEARNER

CHAPTER INTRODUCTION
• An interesting way to initiate the topic of organic chemistry is to ask students to explain how they would go about categorizing items for sale in a large supermarket. Ask them why it might be important to organize the store into various sections (e.g., produce, frozen goods) and then subdivide these specific sections further. Connect this discussion to the importance of establishing a classification system within the extensive field of organic chemistry.
• 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.
1. How are organic compounds necessary for human life? (Sample answers: Food is made of organic compounds. Most of the compounds that make up the human body are organic compounds.)

MINI INVESTIGATION: AN ENLIGHTENING ORGANIC COMPOUND (TEACHER DEMONSTRATION)
Skills: Questioning, Observing, Evaluating
Purpose: Demonstrate a chemical reaction in which the product is a compound that emits light.
Equipment and Materials (teacher): chemical safety goggles; lab apron; two 1 L Erlenmeyer flasks; retort stand and ring clamp; funnel; 3 utility clamps; 1 m length of clear plastic tubing; distilled water; Solution A [2.0 g sodium carbonate, Na2CO3; 0.1 g luminol, C8H7O2N3(s); 12.0 g sodium bicarbonate, NaHCO3(s); 0.25 g ammonium carbonate monohydrate, (NH4)2CO3•H2O(s); 0.2 g copper(II) sulfate pentahydrate, CuSO4•5H2O(s)]; Solution B [25 mL 3 % hydrogen peroxide, H2O2(aq)]
Student Safety: Copper(II) sulfate pentahydrate is toxic and an irritant. Avoid skin and eye contact.
Notes
• This reaction is similar to the chemical reaction that causes fireflies to glow.
• Most exothermic reactions release energy as heat, but chemiluminescent reactions release energy in the form of light.
• Chemiluminescence and bioluminescence have become the basis of many sensitive analytical techniques or assays used to quantify particular compounds in biological samples.

DIFFERENTIATED INSTRUCTION
• Students who are interested in computers could 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
• Point out to English language learners that the noun “organism” and the adjective “organic” are words related to life. They illustrate how a change in suffix can produce a word that has a different meaning or is a different part of speech.

How can organic compounds have a negative effect on the environment?
(Sample answer: Harmful compounds can pollute the air or water.)
2. What might cause two organic compounds with the same chemical formula to have different properties?
(Sample answer: There is a difference in the way the atoms of the compounds are arranged into molecules.)
3. Which chemical property of many organic compounds makes them useful as fuels? (Sample answer: exothermic combustion reaction with oxygen)
4. What are some elements besides carbon that are likely to occur in organic compounds? (Think of elements that readily form covalent bonds.) (Sample answers: hydrogen, nitrogen, oxygen, chlorine)
• Have students answer the Starting Points questions.
• Carry out the Teacher Demonstration Mini Investigation: An Enlightening Organic Compound.
• Suggest that all students might want to create a card glossary, sticky-note collection, word wall, or other vocabulary device and add to it throughout the chapter.

### 1.1 Alkanes

**OVERALL EXPECTATIONS:** A2; B2; B3

**SPECIFIC EXPECTATIONS**

**Career Exploration:** A2.1

**Developing Skills of Investigation and Communication:** B2.1; B2.2; B2.3

**Understanding Basic Concepts:** B3.1; B3.2; B3.3; B3.5

*The full Overall and Specific Expectations are listed on pages 3–5.*

**VOCABULARY**

- organic compound
- hydrocarbon
- saturated hydrocarbon
- alkane
- alkyl group
- substituent group
- structural isomer
- complete combustion
- cyclic alkane
- alkyl halide

**SKILLS**

Performing
Observing
Communicating

**EQUIPMENT AND MATERIALS**

* per student: *
  - molecular modelling kit

**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**

BLM 1.1-1 Building Isomers
Skills Handbook A2.4 Activities
Chemistry 12 Online Teaching Centre
  - Animation: Classifying Hydrocarbons
  - Animation: Structure and Nomenclature of Alkanes
  - Simulation: Nomenclature of Alkanes
Chemistry 12 Solutions Manual
Chemistry 12 website
  - www.nelson.com/onseniorscience/chemistry12u

**RELATED RESOURCES**

*Chemistry 12 Teacher Web Links (available on CD-ROM)*

**EVIDENCE OF LEARNING**

Look for evidence that students can
- explain structural isomers.
- name and draw structures of alkanes.
- describe the reactions of alkanes, including reaction conditions and products.

**SCIENCE BACKGROUND**

- As shown by the ball-and-stick model, the hydrogen atoms of methane are arranged as far apart as possible. The tetrahedral shape results from repulsion of the electrons surrounding each hydrogen nucleus.
- The electronegativity values of carbon and hydrogen are very similar, so all the bonds in an alkane are non-polar.
- Most combustion fuels are primarily alkanes. Although natural gas and petroleum have small amounts of other compounds, they are predominantly mixtures of alkanes.
- In fractional distillation, crude petroleum is heated and changed into a gas. The gas cools in a distillation column, and compounds are separated by boiling point. Crude petroleum contains only 30–40 % gasoline. To meet the demand for transportation fuels, some of the large molecules are broken apart by “cracking” (breaking down large molecules of heavy heating oil).

**POSSIBLE MISCONCEPTIONS**

*Identify:* Students may think that longer-chain alkanes have higher melting points than shorter-chain alkanes due to the greater number of hydrogen bonds between carbon and hydrogen atoms.

*Clarify:* Emphasize that hydrogen bonding only occurs when polar bonds exist in the molecule. The pattern of melting points in alkanes is a result of van der Waals forces.

*Ask What They Think Now:* At the end of this discussion ask, *Why do alkane molecules not form hydrogen bonds?* (All the bonds in an alkane are non-polar.)

**TEACHING NOTES**

**ENGAGE**

- Activate prior knowledge by having the class brainstorm the differences between ionic and covalent chemical bonds. Have volunteers record all answers on the board.
  - *Ask, Why are carbon atoms likely to form covalent*
bonds? (Carbon atoms have four valence electrons, so they can fill their orbital better by sharing electrons rather than by forming ions).

• You might want to have students do the modelling exercise (Mini Investigation: Arranging Carbon Atoms) prior to reading the text. This will make it a complete discovery exercise.

EXPLORE AND EXPLAIN

• Use molecular models to review the structures and naming conventions of hydrocarbons, so that students can visualize these compounds by building and manipulating them. Ask, Why are molecular models better than structural diagrams for representing an alkane molecule? (Sample answer: Molecular models show the three-dimensional arrangement of atoms.)

• Have students complete Mini Investigation: Arranging Carbon Atoms.

MINI INVESTIGATION: ARRANGING CARBON ATOMS

Skills: Performing, Observing, Communicating

Purpose: Students will use molecular models to investigate the structures of straight-chain, branched-chain, and cyclic alkanes.

Equipment and Materials (per group): molecular modelling kit

Notes

• Students should complete this activity in pairs.
• Have students predict the number of isomers that can be formed with 4 carbon and 10 hydrogen atoms. (two)
• Have students compare the bond angles of cyclic alkanes to the bond angle of straight-chain or branched alkanes. (For small—3- to 5-carbon—molecules, the bonding angles are changed.)
• Ask, Why does twisting the shape of a long straight-chain model not form a different isomer? (Atoms are able to rotate around the chemical bonds.)

• Draw students’ attention to Tutorial 1 on page 11 of the Student Book.
• Work through the Sample Problems with the whole class. Point out to students that when organic structures are drawn this way (showing all H atoms), the bonds between carbon atoms may be lengthened to make the structure look less crowded on the page, but that doesn’t mean the bonds are actually different lengths. That is, these diagrams are not drawn to scale.
• Allow students time to answer Practice Problems.
• Give students an opportunity to check their Practice Problem responses orally as a class, in pairs, or in small groups.
• Sample answers are provided in the Solutions Manual.

EXTEND AND ASSESS

• Students should have studied VSEPR theory in previous chemistry courses. According to VSEPR, a molecule has the shape that minimizes electrostatic repulsion of valence electrons. Ask, Why do the bonds around the carbon of an alkane have a tetrahedral arrangement? (A tetrahedral arrangement maximizes the distance between pairs of electrons.)
• For additional practice with structures and names of isomers, distribute BLM 1.1-1 Building Isomers.
• Have students complete the Questions on page 17 of the Student Book.

UNIT TASK BOOKMARK

• Remind students that what they have learned in this section about the volatility of alkanes will be useful when they complete the Unit Task: Using Safer Solvents.

DIFFERENTIATED INSTRUCTION

• Ask students to review the naming of straight-chain and branched compounds in the lesson and think about a strategy they could use to teach someone about isomers. Kinesthetic learners might prepare a presentation using large models, visual learners might work with structural diagrams, and auditory learners might write an outline for explaining the concepts orally.

ENGLISH LANGUAGE LEARNERS

• Review with English language learners the prefix conventions for naming alkanes. Point out that all the names indicating a chain of more than 4 carbon atoms are based on Greek root names.

1.2 Alkenes and Alkynes

OVERALL EXPECTATIONS: A2; B2; B3

SPECIFIC EXPECTATIONS

Career Exploration: A2.1
Developing Skills of Investigation and Communication: B2.1; B2.2
Understanding Basic Concepts: B3.1; B3.2; B3.3; B3.5

The full Overall and Specific Expectations are listed on pages 3–5.

VOCABULARY

• unsaturated hydrocarbon • cis isomer
• alkene • trans isomer
• alkyne • functional group
• aliphatic hydrocarbon • addition reaction
• stereoisomer • Markovnikov’s rule

SKILLS

Performing

Observing

Communicating
EQUIPMENT AND MATERIALS
**per student:**
- molecular modelling kit

ASSESSMENT RESOURCES
Assessment Rubric 1: Knowledge and Understanding
Assessment Rubric 2: Thinking and Investigation
Assessment Rubric 3: Communication
Assessment Summary 1: Knowledge and Understanding
Assessment Summary 2: Thinking and Investigation
Assessment Summary 3: Communication

PROGRAM RESOURCES
BLM 1.2-1 Reactions of Hydrocarbons
Skills Handbook A2.4 Activities
Chemistry 12 Online Teaching Centre
Animation: Addition Reaction: $H_2$ and Propene
Animation: Reaction: $Br_2$ and Bacon Fat
Animation: Bromination of an Alkene
Simulation: Addition Reactions of Alkenes
Chemistry 12 Solutions Manual
Chemistry 12 website
www.nelson.com/onseniorscience/chemistry12u

RELATED RESOURCES
Chemistry 12 Teacher Web Links (available on CD-ROM)

EVIDENCE OF LEARNING
Look for evidence that students can
- name and draw structures of unsaturated hydrocarbons.
- explain *cis-trans* isomerism.
- describe the reactions of alkenes and alkynes, including reaction conditions and products.
- apply Markovnikov’s rule in addition reactions.

SCIENCE BACKGROUND
- A double or triple bond between two carbons is not as strong as two single bonds. As a result, unsaturated hydrocarbons are generally much more reactive than saturated hydrocarbons. Alkynes are more reactive than alkenes.
- Atoms cannot rotate around double or triple bonds as they do around a single covalent bond.
- Alkenes are an important starting material for the production of many of the polymers used to make fabrics and containers.
- Most small-chain alkenes and alkynes are produced during the “cracking” process, in which long-chain hydrocarbons from petroleum are broken down into smaller compounds.
- Although alkenes and alkynes are not generally considered fuels because they are less common than alkanes, these compounds do undergo combustion. Acetylene (ethyne) releases enough energy during combustion that it is used as a fuel for cutting torches.

POSSIBLE MISCONCEPTIONS
Identify: After reading the section, students may think that Markovnikov’s rule, since it is called a rule, always predicts the product of an addition reaction of an alkene.
Clarify: Markovnikov’s rule is useful for predicting the general tendency of addition reactions, but it is not absolute. In most reactions, both possible products are formed; however, the rule predicts the major product. There are some reactions for which the rule does not apply at all. Markovnikov’s “rule” should actually be considered a general guideline.
Ask What They Think Now: At the end of this discussion, ask, *Why is Markovnikov’s rule useful?* (It generally predicts the major product of an addition reaction.)

TEACHING NOTES

ENGAGE
- Activate prior knowledge by asking the students if they have heard of saturated, unsaturated, and polyunsaturated fats. Have students share what they know or can deduce about the differences among the types of fat. If necessary, point out that the carbon atoms of a saturated hydrocarbon have only single bonds.
- If you have students complete the modelling exercise (Mini Investigation: Isomers of Pentene) prior to reading the text, it will become a total discovery exercise.

EXPLORE AND EXPLAIN
- Draw students’ attention to Tutorial 1 on page 18 of the Student Book.
- Work through the Sample Problems with the whole class.
- Allow students time to answer the Practice Problems.
- Give students an opportunity to check their Practice Problem responses orally as a class, in pairs, or in small groups.
- Have students complete Mini Investigation: Isomers of Pentene.

MINI INVESTIGATION: ISOMERS OF PENTENE

Skills: Performing, Observing, Communicating
Purpose: Students will use molecular models to investigate isomerization in an alkene.
Equipment and Materials (per group): molecular modelling kit
Notes
- Students should complete this activity in pairs.
• Have students predict the number of isomers that can be formed with 4 carbon and 8 hydrogen atoms. (two isomers of butane and one of cyclobutane)
• Have students compare the bond angles of carbon atoms at the double bond to the bond angles on carbon atoms with four single bonds. (Bonds form 120° planar angles in carbons with a double bond, compared to about 109° non-planar angles on other carbon atoms.)

VOCABULARY
• aromatic hydrocarbon
• phenyl group

ASSESSMENT RESOURCES
Assessment Rubric 1: Knowledge and Understanding
Assessment Rubric 2: Thinking and Investigation
Assessment Rubric 3: Communication
Assessment Summary 1: Knowledge and Understanding
Assessment Summary 2: Thinking and Investigation
Assessment Summary 3: Communication

PROGRAM RESOURCES
BLM 1.3-1 Naming Aliphatic and Aromatic Hydrocarbons
Chemistry 12 Online Teaching Centre
Animation: Electrophilic Aromatic Substitution
Chemistry 12 Solutions Manual
Chemistry 12 website
www.nelson.com/onseniorscience/chemistry12u

RELATED RESOURCES

EVIDENCE OF LEARNING
Look for evidence that students can
• explain the nature of aromatic chemical bonds.
• name and draw structures of aromatic hydrocarbons.
• describe the reactions of aromatic hydrocarbons, including reaction conditions and products.

SCIENCE BACKGROUND
• An aromatic hydrocarbon is any carbon and hydrogen compound containing one or more benzene rings. Many aromatic compounds have multiple rings that are either fused together by sharing carbon atoms or connected to the same atom or chain of atoms.
• The term “aromatic” comes from the strong, sharp odour that is characteristic of many of the compounds discussed in this unit.
• The aromatic ring structure is very stable, so addition reactions to benzene and its derivatives only occur under very energetic reaction conditions.
• Aromatic compounds readily undergo substitution reactions in which a hydrogen atom is replaced by a halogen atom or some other functional group.
POSSIBLE MISCONCEPTIONS
Identify: Because benzene rings are frequently drawn as having alternating single and double bonds, students may think there are two distinct types of bonds in a ring.
Clarify: Measurements of bond strength and bond angle have shown that the six bonds in the benzene ring are exactly the same. The strength of each bond is about an average of the strengths of single and double bonds. The valence electrons are delocalized and move within a bonding orbital that encompasses the entire ring. Many texts use an illustration that shows a circle inside a hexagon to represent the six aromatic bonds.

Ask What They Think Now: At the end of this discussion, ask, How many different types of bonds occur between carbon atoms in a benzene ring? (There is one type of bond between all of the carbon atoms.)

TEACHING NOTES
ENGAGE
• Copy Figure 2(a) from page 28 of the Student Book onto the board before reading the text. Have the class discuss the implications of all the angles and bond lengths in the benzene molecule being equal. Ask, What would the molecule look like if there were alternating bonds of different lengths? (The hexagon would not be equilateral, because single bonds are longer than double bonds.) Then explain that a benzene molecule is best represented as a planar equilateral hexagon. Have the class explore the meaning of Figure (b) and why Figure (c) may be a better representation of the benzene molecule.
• Relate the story of August Kekulé’s determination of the structure of benzene in his own words: “I was sitting writing at my text book, but the work did not progress; my thoughts were elsewhere. I turned my chair to the fire, and dozed. Again the atoms were gamboling before my eyes. This time the smaller groups kept modestly in the background. My mental eye, rendered more acute by repeated visions of this kind, could now distinguish larger structures of manifold conformations; long rows, sometimes more closely fitted together; all twisting and turning in snake-like motion. But look! What was that? One of the snakes had seized hold of its own tail, and the form whirled mockingly before my eyes. As if by a flash of lightning I woke.... I spent the rest of the night working out the consequences of the hypothesis. Let us learn to dream, gentlemen, and then perhaps we shall learn the truth … but let us beware of publishing our dreams before they have been put to proof by the waking understanding.” (Japp, 1898, p. 100)

EXPLORE AND EXPLAIN
• The discussion on the benzene ring also provides an opportunity to review the concepts of resonance, bond length, and bond strength. The carbon–carbon bonds in the benzene ring are identical and somewhere between a single and double bond in length and strength, supporting a delocalized resonant arrangement.
• Draw students’ attention to Tutorial 1 on page 29 of the Student Book.
• Work through the Sample Problems with the whole class.
• Allow students time to answer Practice Problems.
• Give students an opportunity to check their Practice Problem responses orally as a class, in pairs, or in small groups.
• After finishing the tutorial, have students assess their understanding of naming hydrocarbons using BLM 1.3-1 Naming Aliphatic and Aromatic Hydrocarbons.
• Sample answers are provided in the Solutions Manual.

EXTEND AND ASSESS
• Two aromatic hydrocarbons that may be familiar to students are toluene, commonly used as a solvent in model glue, and naphthalene, a common ingredient in mothballs. Naphthalene consists of two benzene rings fused together so that they share two carbon atoms.
• Have students complete the Questions on page 31 of the Student Book.

UNIT TASK BOOKMARK
• Remind students that what they have learned about the volatility of aromatic compounds in this lesson will be useful when they complete the Unit Task.
• Aromatic compounds tend to be volatile, which is one reason that many of them are easily detected by their odour.

DIFFERENTIATED INSTRUCTION
• Allow auditory learners to work through the tutorial in this section with a partner. Visual learners may benefit by summarizing the steps in a flow chart.

ENGLISH LANGUAGE LEARNERS
• English language learners may not be aware that “aroma”—from which “aromatic” is derived—is a synonym for “odour,” so they may miss the connection to volatility. On a separate page of their journals, have students record this and other examples of scientific terms derived from everyday words.
1.4 Alcohols, Ethers, and Thiols

OVERALL EXPECTATIONS: A1; B2; B3

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A1.1; A1.4; A1.5; A1.8; A1.10; A1.11
Developing Skills of Investigation and Communication: B2.1; B2.2
Understanding Basic Concepts: B3.1; B3.2; B3.3

The full Overall and Specific Expectations are listed on pages 3–5.

VOCABULARY
• alcohol • dehydration reaction
• primary alcohol • ether
• secondary alcohol • condensation reaction
• tertiary alcohol • thiol
• hydrogen bonding

ASSESSMENT RESOURCES
Assessment Rubric 1: Knowledge and Understanding
Assessment Rubric 2: Thinking and Investigation
Assessment Rubric 3: Communication
Assessment Summary 1: Knowledge and Understanding
Assessment Summary 2: Thinking and Investigation
Assessment Summary 3: Communication

PROGRAM RESOURCES
Chemistry 12 Online Teaching Centre
Simulation: Nomenclature of Alcohols
Simulation: Nomenclature of Ethers
Video: Ethanol Use in Brazil
Chemistry 12 Solutions Manual
Chemistry 12 website
www.nelson.com/onseniorscience/chemistry12u

RELATED RESOURCES
Chemistry 12 Teacher Web Links (available on CD-ROM)

EVIDENCE OF LEARNING
Look for evidence that students can
• name and draw structures of alcohols, ethers, and thiols.
• describe the reactions of alcohols, including reaction conditions and products.
• explain how hydrogen bonding affects the properties of alcohols.

SCIENCE BACKGROUND
• Alcohols and ethers are studied together in this section because of their structural similarities. An alcohol is characterized by the hydroxyl –OH functional group; an ether is characterized by two hydrocarbon groups joined together by an oxygen atom. These two groups of organic compounds are extremely important. Ethanol (the alcohol in wine and beer), glycerol (a key component in many fats and oils), and cholesterol (a significant health concern) belong to the alcohol family, and diethyl ether (an early anesthetic) belongs to the ether family. The polarity of thiols makes them analogous to alcohols.
• In Canada, many gas stations sell ethanol-blended fuels, using alcohol distilled from grain. As well as the alcohol being a renewable resource, the blend results in a cleaner-burning fuel that does not require a gasoline antifreeze additive.
• Thiols often have strong odours. The characteristic smells of onion and garlic come from thiol compounds. Ethanethiol is added to natural gas to give it an odour that can warn of leaks.

TEACHING NOTES
ENGAGE
• Have students work in pairs with molecular models. Direct them in making several models of water and several models of ethanol. Have students model hydrogen bonding in water and ethanol, as well as hydrogen bonding between the two compounds. Ask, How would you expect the strength of hydrogen bonds in ethanol to compare to the strength of hydrogen bonds in water? (The hydrogen bonds of ethanol are weaker because of the nonpolar ethyl group.)

EXPLORE AND EXPLAIN
• Remind students about the importance of identifying functional groups and making appropriate predictions about physical and chemical properties. The presence of the hydroxyl group makes alcohol molecules polar and gives them the capacity to form hydrogen bonds. This in turn means that alcohols will be more soluble in water and have relatively higher melting and boiling points than comparable alkanes. Ask, How does a hydroxyl group differ from a hydroxide ion? (The hydroxyl group forms covalent bonds with carbon, whereas the hydroxide ion forms ionic bonds.)
• Point out that breaking a double bond of the alkene in an addition reaction makes two sites available for new bonds to form. Ask, How might the acid catalyst affect addition of water to an alkene? (The acid causes the water molecule to break apart into ions.)
• Have the class discuss hydrogen bonding and the structural requirements for a compound to form hydrogen bonds. Ask, *Besides hydrogen bonds, what other interactions can occur between molecules?* (dipole interactions, van der Waals interactions) Ask, *Based on molecular interactions, what order would you predict for water solubilities of a similar-sized alkane, alcohol, and ether?* (alkane < ether < alcohol).
• Draw students’ attention to Tutorials 1, 2, and 3 on pages 33, 36, and 38 of the Student Book.
• Work through the Sample Problems with the whole class.
• Allow students time to answer Practice Problems.
• Sample answers are provided in the Solutions Manual.

EXTEND AND ASSESS
• Have students complete Investigation 1.4.1. Applicable teaching notes can be found on page 27 of this resource.
• Have students complete the Questions on page 39 of the Student Book.

UNIT TASK BOOKMARK
• Remind students that what they have learned about the volatility of alcohols and ethers in this section will be useful when they complete the Unit Task.

DIFFERENTIATED INSTRUCTION
• Students may find it useful to create a cue card for each family of organic compounds studied. Visual learners may wish to include a flow chart and diagram. Auditory learners may wish to discuss the important concepts with a partner before writing out the card.

ENGLISH LANGUAGE LEARNERS
• Provide visual references to support English language learners as students work through the section. Draw the structures of several examples of each class of organic compound in the section under a class heading. Emphasize the relationship between functional group and compound name.

1.5 Aldehydes and Ketones

OVERALL EXPECTATIONS: B2; B3

SPECIFIC EXPECTATIONS
Developing Skills of Investigation and Communication:
B2.1; B2.2
Understanding Basic Concepts: B3.1; B3.2; B3.3

The full Overall and Specific Expectations are listed on pages 3–5.

VOCABULARY
• carbonyl group
• aldehyde
• ketone

ASSESSMENT RESOURCES
Assessment Rubric 1: Knowledge and Understanding
Assessment Rubric 2: Thinking and Investigation
Assessment Rubric 3: Communication
Assessment Summary 1: Knowledge and Understanding
Assessment Summary 2: Thinking and Investigation
Assessment Summary 3: Communication

PROGRAM RESOURCES
Chemistry 12 Online Teaching Centre
Animation: Rotating Diethylketone Molecule (no sound); Rotating Propanal Molecule (no sound)
Simulation: Nomenclature of Aldehydes and Ketones

Chemistry 12 Solutions Manual
Chemistry 12 website
www.nelson.com/onseniorscience/chemistry12u

RELATED RESOURCES
Chemistry 12 Teacher Web Links (available on CD-ROM)

EVIDENCE OF LEARNING
Look for evidence that students can
• describe the carbonyl group.
• name and draw structures of aldehydes and ketones.
• describe the reactions of aldehydes and ketones, including reaction conditions and products.

SCIENCE BACKGROUND
• Ketones and aldehydes share the carbonyl functional group –C=O, which contains a carbon atom joined with a double covalent bond to an oxygen atom. They are differentiated by the fact that a ketone has a carbonyl group bonded to 2 carbon atoms, whereas an aldehyde has a terminal carbonyl functional group—that is, a carbonyl group bonded to at least 1 H atom.
• Because aldehydes and ketones do not contain the hydroxyl –OH functional groups, they have weaker intermolecular attractions, resulting in lower melting and boiling points than their analogous alcohols. The presence of the polar carbonyl –C=O group, however, makes aldehydes and ketones more polar than comparative hydrocarbons.
POSSIBLE MISCONCEPTIONS

Identify: Students may think that ketones and aldehydes form hydrogen bonds similar to those of alcohols.

Clarify: Like ethers, aldehydes and ketones are somewhat polar molecules that have dipole interactions between molecules, but, also like ethers, they do not have hydrogen atoms with polar bonds. All the hydrogen atoms are involved in non-polar bonds with carbon atoms. Therefore, a hydrogen bond—which is an attraction between a hydrogen atom with a partial positive charge and an atom with a partial negative charge—cannot form.

Ask What They Think Now: At the end of this discussion, ask, Can every polar organic molecule form hydrogen bonds? (No, the molecule must also contain a hydrogen atom involved in a polar bond.)

TEACHING NOTES

ENGAGE

• Connect everyday ketones and aldehydes with the students’ world and with what they already know. Before starting this section, have students brainstorm chemicals they already know that end with –one and –hyde. They will most likely come up with various hormones (testosterone, progesterone), organic solvents (acetone), and biological preservatives (formaldehyde).

• Have students complete Investigation 1.5.1. Applicable teaching notes can be found on page 28 of this resource.

EXPLORE AND EXPLAIN

• Tell students that the smallest ketone, propanone (acetone), is an important industrial and commercial solvent. It is used as a solvent for resins, varnishes, and even nail polish. Ask, How does the structure of propanone make it a useful solvent for both polar and non-polar molecules? (Sample answer: The two methyl groups will interact with non-polar molecules, and the carbonyl group will interact with polar molecules.)

• The structural difference between ketones and aldehydes is the location of the carbonyl group on the chain. Have students build molecular models or draw the structures of a 5-carbon aldehyde and a 5-carbon ketone. Ask, Why do longer ketones need a number in their names, while longer aldehydes do not? (The carbonyl of an aldehyde is always on carbon number 1, but the ketone carbonyl can be in one of several locations on the chain).

• Direct students to study the reactions shown on pages 43 and 44 of the Student Book. Discuss whether the terms “oxidation” and “hydrogenation” have the same meaning but with different elements involved. Hydrogenation is always an addition reaction in which hydrogen is added to the molecule. Oxidation, however, refers to reactions in which the oxidation number of an atom or molecule changes. In the oxidation of alcohols, hydrogen atoms are removed from the alcohol. So in this case, oxidation is an inverse reaction to hydrogenation. (The corollary to hydrogenation would be called oxygenation.)

• Draw students’ attention to Tutorials 1, 2, and 3 on pages 41, 42, and 45 of the Student Book.

• Work through the Sample Problems with the whole class.

• Allow students time to answer Practice Problems.

• Sample answers are provided in the Solutions Manual.

EXTEND AND ASSESS

• Have students complete the Questions on page 46 of the Student Book.

UNIT TASK BOOKMARK

• Remind students that what they have learned about the volatility of propanone in this section will be useful when they complete the Unit Task.

DIFFERENTIATED INSTRUCTION

• Have students make a presentation summarizing all the classes of organic compounds discussed so far, emphasizing the functional group or feature that is used in classification. Students can present information using models, structural diagrams, charts, or other tools.

ENGLISH LANGUAGE LEARNERS

• Have English language learners work with English-proficient students when reading the section, answering questions, and completing Practice Problems. Encourage all students to use proper scientific terminology when they summarize the section with their partners.

1.6 Carboxylic Acids, Esters, and Fats

OVERALL EXPECTATIONS: A1; A2; B1; B2; B3

SPECIFIC EXPECTATIONS

Scientific Investigation Skills: A1.1; A1.3; A1.4; A1.5; A1.7; A1.8; A1.10; A1.11

Career Exploration: A2.1, A2.2

Relating Science to Technology, Society, and the Environment: B1.1; B1.2

Developing Skills of Investigation and Communication: B2.1; B2.2

Understanding Basic Concepts: B3.1; B3.2; B3.3

The full Overall and Specific Expectations are listed on pages 3–5.
VOCABULARY
• carboxylic acid  • lipid
• carboxyl group  • fatty acid
• ester  • triglyceride
• esterification  • saponification
• hydrolysis

SKILLS
Questioning  Communicating
Researching  Defending a Decision

ASSESSMENT RESOURCES
Assessment Rubric 1: Knowledge and Understanding
Assessment Rubric 2: Thinking and Investigation
Assessment Rubric 3: Communication
Assessment Summary 1: Knowledge and Understanding
Assessment Summary 2: Thinking and Investigation
Assessment Summary 3: Communication

PROGRAM RESOURCES
BLM 1.6-1 Organic Compounds Containing Oxygen
Skills Handbook A5.1 Research Skills
Chemistry 12 Online Teaching Centre
  Simulation: Nomenclature of Carboxylic Acids
  Simulation: Nomenclature of Esters
Chemistry 12 Solutions Manual
Chemistry 12 website
  www.nelson.com/onseniorscience/chemistry12u

RELATED RESOURCES
Chemistry 12 Teacher Web Links (available on CD-ROM)

EVIDENCE OF LEARNING
Look for evidence that students can
• name and draw structures of carboxylic acids, esters, and fats.
• identify and explain the properties of carboxylic acids.
• describe esterification, saponification, and hydrolysis reactions.
• identify and explain the properties of fats and oils.

SCIENCE BACKGROUND
• Like inorganic acids, carboxylic acids have a sour, tangy taste and typically very distinctive odours. Carboxylic acids react as other acids do—in neutralization reactions, for example—and they also undergo a variety of organic reactions.
• Esters are the product of a dehydration reaction between an organic acid and an alcohol. Many esters have strong odours and are the active ingredients in a number of flavourings and perfumes. Some esters play an important role in insect communication. For example, 2-pentyl acetate, the main component of banana aroma, is also the alarm pheromone of the honeybee.
• Some very common plastics—Plexiglas, for example—are made by the formation of long chains of esters. Dacron, a fibre used for fabrics, is also a polyester.
• Animal and vegetable fats and oils are basically very large esters. The difference between a fat and an oil is the melting points of the mixture of esters they contain. At room temperature, an oil is liquid and a fat is solid.

POSSIBLE MISCONCEPTIONS
Identify: Students may think that because carboxylic and inorganic acids are studied separately, their acidity results from different mechanisms.
Clarify: The acidity of organic acids comes from the very polar nature of the hydrogen–oxygen bond in the carboxyl group. This allows hydrogen ions to be removed from the molecules when the acid is dissolved in water, forming hydronium ions and organic anions in solution.
Ask What They Think Now: At the end of this discussion, ask, How do carboxylic acids form ions in aqueous solution? (Sample answer: The molecule separates into a hydrogen ion and a large, negatively charged ion.)

TEACHING NOTES
ENGAGE
• Have the class brainstorm a list of common carboxylic acids. Ask them to name any compounds they know that end with –ic acid. They will typically already know citric acid, acetylsalicylic acid, acetic acid (ethanoic acid), and possibly ascorbic acid (vitamin C). If hydrochloric acid or sulfuric acid appears on the list, ask, What is the chemical formula for that acid? (HCl; H₂SO₄). Ask, Can that be an organic acid? (No, it does not have carbon atoms.) If not, propose them to the class and discuss.
• Bring to class a bottle of commercial vinegar and a bottle of vitamin C tablets. Investigate the ingredients as a class. If the label on the vinegar states that it is 5 % acetic acid, ask, What is the remaining 95 %? (water)

EXPLORE AND EXPLAIN
• Have the class discuss why small carboxylic acids, such as ethanoic acid, are completely soluble in water. Then have them predict whether very large carboxylic acids will also be soluble in water. If necessary, remind students that most of a large carboxylic acid consists of an alkyl chain.
• Have the class read labels on foods, flavourings, and cosmetics and write down any ingredients that appear to be esters because they have the suffix –oate. Have the class try to determine the purpose of the ester as an ingredient in the product.

• On the board, write the general chemical reactions for esterification and hydrolysis (page 51 in the Student Book). Have students study the relationship between the parts of the ester. Ask, Is it possible to “switch” the R and R’ between acid and alcohol during a series of esterifications and hydrolyses? (No, one group is attached to the carboxyl carbon and the other to the oxygen.)

• Have students complete the activity Research This: Banning Trans Fat.

**RESEARCH THIS: BANNING TRANS FAT**

**Skills:** Questioning, Researching, Communicating, Defending a Decision  
**Purpose:** Students will use published materials to research the uses and potential risks of trans fats.  
**Notes**  
• Trans fats are artificial fats made by the partial hydrogenation of polyunsaturated oils. They are used to extend the shelf life and enhance the “mouth feel” of foods such as crackers, icing, potato chips, margarine, and microwave popcorn.  
• Public health experts warn that these kinds of fats can clog arteries and cause obesity.

• Sample answers are provided in the Solutions Manual.

**EXTEND AND ASSESS**

• Have students complete Investigations 1.6.1, 1.6.2, and 1.6.3. Applicable teaching notes can be found on pages 29–33 of this resource.

• Have students complete the Questions on page 55 of the Student Book.

• Assess students’ understanding of Sections 1.4 through 1.6 using BLM 1.6-1 Organic Compounds Containing Oxygen.

**DIFFERENTIATED INSTRUCTION**

• Allow students to work in pairs with a molecular modelling kit. Have each partner assemble an organic molecule. Then trade with their partner to determine the type of molecule represented by their partner’s model. Student pairs can then discuss their results to reach consensus. Follow up by checking to make sure their analyses are correct.

**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 native speakers of English will experience something akin to the language barriers that English language learners face every day.

**1.7 Amines and Amides**

**OVERALL EXPECTATIONS:** A1; B2; B3

**SPECIFIC EXPECTATIONS**

**Career Investigation:** A2.1, A2.2  
**Scientific Investigation Skills:** A1.11  
**Developing Skills of Investigation and Communication:** B2.1, B2.2, B2.3  
**Understanding Basic Concepts:** B3.1; B3.2; B3.3

*The full Overall and Specific Expectations are listed on pages 3–5.*

**VOCABULARY**

• amine  
• amide

**ASSESSMENT RESOURCES**

Assessment Rubric 1: Knowledge and Understanding  
Assessment Rubric 2: Thinking and Investigation  
Assessment Rubric 3: Communication  
Assessment Summary 1: Knowledge and Understanding  
Assessment Summary 2: Thinking and Investigation  
Assessment Summary 3: Communication

**PROGRAM RESOURCES**

BLM 1.7-1 Identification and Naming of Organic Compounds  
Chemistry 12 Online Teaching Centre  
Animation: Rotating Molecular Structure of C₆H₅NH₂  
Chemistry 12 Solutions Manual  
Chemistry 12 website  
www.nelson.com/onseniorscience/chemistry12u

**RELATED RESOURCES**

Chemistry 12 Teacher Web Links (available on CD-ROM)  

**EVIDENCE OF LEARNING**

Look for evidence that students can

• name and draw structures of amines and amides.  
• describe the reactions of amines and amides, including reaction conditions and products.
**SCIENCE BACKGROUND**

- Amines and amides are characterized by the presence of nitrogen atoms. Nitrogenous organic compounds are components of proteins, the building blocks of life. An amine is an ammonia molecule, NH₃, in which one or more hydrogen atoms are substituted by alkyl or aromatic groups. An amide is characterized by the presence of a carbonyl functional group bonded to the nitrogen atom.
- Amines are used extensively in the synthesis of medicines. A group of amines found in many plants are called alkaloids. Many alkaloids can influence the function of the central nervous systems of animals. For example, the opium alkaloids are a group of more than 20 amines found in the residue left from the evaporation of the juice of the opium poppy. These alkaloids are powerful painkillers but are also highly addictive.
- The bond between nitrogen and hydrogen is not quite as polar as the hydroxyl bond between oxygen and hydrogen, so amine hydrogen bonds are weaker than alcohol hydrogen bonds. Primary and secondary amines have lower boiling points than alcohols of similar molecular weight. Tertiary amines do not have hydrogen bonds, so their boiling points are similar to those of hydrocarbons of the same molecular weight.

**TEACHING NOTES**

**ENGAGE**

- Review the nomenclature of primary, secondary, and tertiary alcohols. Have students look at Table 1 on page 56 of the Student Book. Ask, *How is the classification of amine types similar to the classification of alcohols?* (Sample answer: Both classify the compound by the number of alkyl groups attached to a key atom in the chain.)

**EXPLORE AND EXPLAIN**

- Note that each chain of a secondary or tertiary amine is numbered from the nitrogen atom. Draw a structural diagram of N-ethylbutan-1-amine (CH₃CH₂NHCH₂CH₂CH₃) on the board. Point out that, including the nitrogen atom, the molecule has a 7-atom chain, but that the nomenclature treats the separate alkyl groups as substituents of the nitrogen atom.
- Ask, *What type of amine cannot form hydrogen bonds?* (tertiary) Ask, *If their sizes are similar, which type of amine will have the highest boiling point?* (primary)
- Have the class compare the naming of amines to the naming of esters. Invite a volunteer to record differences and similarities on the board.
- Draw students’ attention to Tutorials 1 and 2 on pages 57 and 59 of the Student Book.
- Work through the Sample Problems with the whole class.
- Allow students time to answer Practice Problems.

**EXTEND AND ASSESS**

- Give students an opportunity to check their Practice Problem responses orally as a class, in pairs, or in small groups.
- Have students use BLM 1.7-1 Identification and Naming of Organic Compounds to review organic chemistry naming conventions.
- Sample answers are provided in the Solutions Manual.

**DIFFERENTIATED INSTRUCTION**

- For visual learners, it would be helpful to use a molecular modelling kit when comparing types of amines with types of alcohols. Encourage auditory learners to discuss the similarities and differences of the different organic families studied.

**ENGLISH LANGUAGE LEARNERS**

- Remind English language learners to examine root words, suffixes, and prefixes when trying to remember or determine the meaning of chemical names.

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### 1.4.1 Controlled Experiment: Properties of Alcohols

**OVERALL EXPECTATIONS:** A1

**SPECIFIC EXPECTATIONS**

**Scientific Investigation Skills:** A1.1; A1.4; A1.5; A1.8; A1.10; A1.11

*The full Overall and Specific Expectations are listed on pages 3–5.*

**SKILLS**

- Researching
- Hypothesizing
- Predicting
- Controlling Variables
- Performing
- Observing
- Analyzing
- Evaluating
- Communicating

**EQUIPMENT AND MATERIALS**

*per student:*

- chemical safety goggles
- lab apron
per group:
• MSDS for each chemical used
• 3 test tubes
• test-tube rack
• wax pencil
• 3 mL calibrated disposable pipette (or similar pipetting device)
• small stoppered bottles containing
  − butan-1-ol
  − ethanol
  − propan-1-ol
  − cyclohexane
• wash bottle containing distilled water

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

PROGRAM RESOURCES
BLM 0.0-11 Disposal of Hazardous Waste
Skills Handbook A1 Safety
Skills Handbook A2.2 Controlled Experiments
Skills Handbook A3.3 Using a Pipette
Chemistry 12 Online Teaching Centre
Chemistry 12 Solutions Manual
Chemistry 12 website
www.nelson.com/onseniorscience/chemistry12u

EVIDENCE OF LEARNING
Look for evidence that students can
• apply knowledge and understanding of safe laboratory practices and procedures.
• formulate relevant scientific questions about observed relationships and make informed predictions.
• use appropriate materials and equipment safely and accurately to collect observations and data.
• draw conclusions based on their results and justify those conclusions.

SCIENCE BACKGROUND
• The properties of alcohols depend on two factors: hydrogen bonding between molecules due to the polar hydroxyl group, and non-polar interactions between the hydrocarbon part of the molecule. As the length of the carbon chain increases, the latter effect grows more prominent.
• Alcohols with three or fewer carbon atoms are completely soluble in water but not in a non-polar solvent, such as hexane. Longer alcohols, such as butan-1-ol, are less soluble in water but more soluble in hexane.
• In organic molecules, the melting point and boiling point tend to increase as the number of carbons increases because of greater intermolecular forces of attraction.

TEACHING NOTES
STUDENT SAFETY
Remind students of the following safety procedures.
• Wear chemical safety goggles and lab apron for the entire investigation.
• Alcohols and cyclohexane are flammable. They should be used only in a well-ventilated area. There should be no open flames or other sources of ignition in the laboratory.
• These chemicals may be corrosives, toxins, and/or irritants. Do not touch your eyes. Immediately wash any spills on the skin, in the eyes, or on clothing with plenty of cold water. Report any spills to your teacher.
• Wash your hands before leaving the laboratory.
Remember:
• Follow your school’s procedures for disposal. Follow BLM 0.0-11 Disposal of Hazardous Waste for further disposal instructions.
• Minimize the quantities used to reduce treatment and disposal costs.

Have students work in small groups for this activity.
Sample answers are found in the Solutions Manual.

TESTABLE QUESTION
• Pose the Testable Question in class. Have students consider the three alcohols being investigated. Ask, What factor distinguishes the three alcohols from one another? (size; molecular mass)

HYPOTHESIS
• The hypothesis should be written as a statement and followed by a reason for the prediction. Sample hypotheses:
  − If an alcohol has a greater mass, then it will have a higher melting point and boiling point because the intermolecular forces are greater.
  − If an alcohol has a greater mass, then it will be less soluble in water and more soluble in hexane because it is less polar.

VARIABLES
• The independent (manipulated) variable is the length of the carbon chain of the alcohol.
• The dependent (responding) variables are melting point, boiling point, and solubility. Controlled variables include the way in which pH is tested.

EXPERIMENTAL DESIGN
• Melting and boiling points are determined from reference sources. The relative solubilities in water and hexane are determined by mixing samples with solvents.

EQUIPMENT AND MATERIALS
• Remind students to keep the top of the test tube pointed away from their faces.

PROCEDURE
• The alcohols should be added to the solvents cyclohexane and water a few drops at a time, swirling to mix to observe the interaction between the liquids.
• Instruct students to dispose of all solutions in a container provided for that purpose.

OBSERVATIONS
• Sample observations table:

<table>
<thead>
<tr>
<th>Alcohol</th>
<th>ethanol</th>
<th>propan-1-ol</th>
<th>butan-1-ol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting point</td>
<td>–117.3</td>
<td>–126.5</td>
<td>–89.5</td>
</tr>
<tr>
<td>Boiling point</td>
<td>78.5</td>
<td>97.4</td>
<td>117.3</td>
</tr>
<tr>
<td>Formula</td>
<td>C₂H₅OH</td>
<td>C₃H₇OH</td>
<td>C₄H₉OH</td>
</tr>
<tr>
<td>Solubility in</td>
<td>least</td>
<td>intermediate</td>
<td>greatest</td>
</tr>
<tr>
<td>cyclohexane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solubility in</td>
<td>greatest</td>
<td>intermediate</td>
<td>least</td>
</tr>
<tr>
<td>water</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DIFFERENTIATED INSTRUCTION
• Visual learners may find it more useful to design their procedure using a flow chart. Auditory learners will benefit from discussing their testable question and hypothesis with their partners.

ENGLISH LANGUAGE LEARNERS
• Have English language learners work with a partner who is proficient in English to review the MSDS and other reference materials.

1.5.1 Observational Study: Reactions of Three Isomers of Butanol

OVERALL EXPECTATIONS: A1; B2

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A1.1; A1.3; A1.4; A1.5; A1.8; A1.11
Developing Skills of Investigation and Communication: B2.4

The full Overall and Specific Expectations are listed on pages 3–5.

SKILLS
Researching  Analyzing
Predicting   Evaluating
Performing   Communicating
Observing

EQUIPMENT AND MATERIALS
per student:
• chemical safety goggles
• lab apron
• protective gloves

per group:
• 3 test tubes
• test-tube rack
• eye dropper
• dropper bottles containing
  – butan-1-ol
  – butan-2-ol
  – 2-methylpropan-2-ol
  – potassium permanganate solution, KMnO₄(aq) (0.01 mol/L)
  – concentrated hydrochloric acid, HCl(aq) (12 mol/L)
  (for teacher use only)

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

PROGRAM RESOURCES
BLM 0.0-11 Disposal of Hazardous Waste
Skills Handbook A1 Safety
Skills Handbook A2.3 Observational Studies
Skills Handbook A5.1 Research Skills
Chemistry 12 Online Teaching Centre
Chemistry 12 Solutions Manual
Chemistry 12 website
www.nelson.com/onseniorscience/chemistry12u

EVIDENCE OF LEARNING
Look for evidence that students can
• obtain qualitative data about the reactions of butanol and evaluate the data to determine whether the evidence is consistent with scientific theory.
• communicate conclusions using appropriate language and a variety of formats.

SCIENCE BACKGROUND
• The reactivity of alcohols depends partly on the type of alcohol. In many chemical reactions, tertiary alcohols behave very differently from primary and secondary alcohols.
• During oxidation of an alcohol, hydrogen atoms leave the hydroxyl group and the adjacent carbon atom and a double bond forms between the carbon and oxygen atoms, making a carbonyl group. Primary and secondary alcohols can be oxidized by potassium permanganate. There is no hydrogen atom bonded to the adjacent carbon in a tertiary alcohol, so it cannot be oxidized.
• During a substitution reaction with HCl, the hydroxyl group is removed and a halogen atom replaces it, forming an alkyl halide. This substitution is rapid for tertiary alcohols but proceeds slowly or not at all with primary and secondary alcohols.
TEACHING NOTES

STUDENT SAFETY
Prior to the lab, review the safety routines that pertain to chemical spills and broken glassware. Make sure all students know what to do in case of an emergency. Remind students of the following safety procedures:
• Wear chemical safety goggles, protective gloves, and lab apron for the entire investigation.
• Concentrated hydrochloric acid is very corrosive. It should only be handled by the teacher in a fume hood or fume cupboard.
• Potassium permanganate is corrosive and may stain the skin. Wash the affected area with lots of cool water.
• Alcohols are flammable. They should be used only in a well-ventilated area. There should be no open flames or other sources of ignition in the laboratory.
• Follow your school’s procedures for disposal. Follow BLM 0.0-11 Disposal of Hazardous Waste for further disposal instructions.

• During the first reaction (HCl), students should observe a cloudiness as the tertiary alcohol (2-methylpropan-2-ol) reacts with the acid to form a chloroalkane (2-chloro-2-methylpropane). The primary and secondary alcohols do not react with hydrochloric acid, so no change will be observed.
• During the second reaction (KMnO₄), students should observe the pinkish purple colour of the permanganate disappearing as the reagent reacts with the primary alcohol (butan-1-ol) and with the secondary alcohol (butan-2-ol). The tertiary alcohol is not oxidized, so no change will be observed.
• Allow ample time for cleanup and waste disposal.

PURPOSE
• To test the reactions of primary, secondary, and tertiary alcohols with acid and with an oxidizing agent

EQUIPMENT AND MATERIALS
• Prepare 0.1 mol/L KMnO₄ stock solution by dissolving 15.8 g KMnO₄ in 100 mL deionized or distilled water. Then prepare 0.01 mol/L KMnO₄ by pipetting 10 mL of the stock solution into a 100 mL volumetric flask and diluting to 100 mL with water.
• Do not allow students to handle concentrated HCl.

PROCEDURE
• Test tubes should be shaken gently with a swirling motion.
• Remind students never to point the top of the test tube toward their faces and never to place a thumb over the opening of the test tube during mixing.

OBSERVATIONS
• Expected observations during the reaction with HCl are the appearance of cloudiness as an insoluble alkyl halide forms by reaction with the tertiary alcohol, and no change (no reaction) with the primary or secondary alcohols.

DIFFERENTIATED INSTRUCTION
• Before students carry out the investigation, have them develop a diagram, flow chart, outline, or verbal explanation showing the procedure they will follow.

ENGLISH LANGUAGE LEARNERS
• Allow English language learners to work with partners to create their chosen presentation.

1.6.1 Controlled Experiment: Properties of Carboxylic Acids

OVERALL EXPECTATIONS: A1; B2

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A1.1; A1.3; A1.4, A1.5; A1.8; A1.10; A1.11
Developing Skills of Investigation and Communication: B2.4
The full Overall and Specific Expectations are listed on pages 3–5.

SKILLS
Hypothesizing
Predicting
Controlling Variables
Performing
Observing
Analyzing
Communicating

EQUIPMENT AND MATERIALS
per student:
• chemical safety goggles
• lab apron
per group:
• MSDS for each chemical used
• 10 mL graduated cylinder
• 2 test tubes
• test-tube holder
• test-tube rack
• test-tube brush
• pH meter or universal indicator paper
• wash bottle containing distilled water
• vegetable oil in a beaker
• dropper bottles containing
  – dilute ethanoic acid (vinegar)
  – sodium hydrogen carbonate solution, NaHCO₃(aq) (saturated)
  – concentrated ethanoic acid (glacial acetic acid) CH₃COOH(l) (for teacher use only)
  – octadecanoic acid (stearic acid, solid)
ASSESSMENT RESOURCES
Assessment Rubric 5: Controlled Experiment
Assessment Summary 5: Controlled Experiment
Self-Assessment Checklist 1: Controlled Experiment

PROGRAM RESOURCES
BLM 0.0-11 Disposal of Hazardous Waste
Skills Handbook A1 Safety
Skills Handbook A2.2 Controlled Experiments
Skills Handbook A2.5 Lab Reports
Chemistry 12 Online Teaching Centre
Chemistry 12 Solutions Manual
Chemistry 12 website
   www.nelson.com/onseniorscience/chemistry12u

EVIDENCE OF LEARNING
Look for evidence that students can
• apply knowledge and understanding of safe laboratory practices and procedures.
• conduct an inquiry into the properties of carboxylic acids and accurately collect observations and data.
• interpret and evaluate qualitative and quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis.
• draw conclusions based on their results and justify those conclusions.

SCIENCE BACKGROUND
• The properties of carboxylic acids are determined by the combination of a carboxyl functional group that is very polar and a hydrocarbon chain that is non-polar. Acids that have short hydrocarbon chains dissolve easily in water. In acids with long hydrocarbon chains, the carboxyl groups of two molecules tend to pair together due to hydrogen bonding. These pairs of molecules (dimers) have properties similar to long-chain hydrocarbons: low solubility in water, high melting point, and low reactivity.
• Carboxylic acids with five or fewer carbon atoms are soluble in water. Larger acids are not soluble.
• Acidity of aqueous solutions of carboxylic acids decreases as molecular mass increases, because longer-chain acids tend to form dimers and do not dissociate.

TEACHING NOTES
STUDENT SAFETY
Remind students of the following safety procedures:
• Wear chemical safety goggles and lab apron for the entire investigation.
• Concentrated ethanoic acid (glacial acetic acid) is very corrosive. It should only be handled by the teacher in a fume hood or fume cupboard.
• Do not touch your eyes after handling chemicals. Immediately use plenty of cold water to wash any spills on the skin, in the eyes, or on clothing. Report any spills to your teacher.
• Wash your hands before leaving the laboratory.

Remember:
• Follow your school’s procedures for disposal. Follow BLM 0.0-11 Disposal of Hazardous Waste for further disposal instructions.
• Minimize the quantities used to reduce treatment and disposal costs.
• Have students work in small groups for this activity.
• Sample answers are found in the Solutions Manual.

TESTABLE QUESTION
• Pose the Testable Question in class. Direct students to draw the structures of the two carboxylic acids in the materials list. Ask, Which acid is likely to have greater polarity? (ethanoic acid)

HYPOTHESIS
• The hypothesis should include both a prediction and a reason for the prediction based on scientific theory. Sample hypothesis: If a carboxylic acid has a greater mass, then it will have a higher melting point, higher pH, and lower reactivity with a base because the long carbon chain has properties resembling those of a long-chain hydrocarbon.

VARIABLES
• The independent (manipulated) variable is the type of carboxylic acid used in the investigation. The dependent (responding) variables are melting point, solubility, pH, and reactivity with base.

EXPERIMENTAL DESIGN
• Melting and boiling points are determined from reference sources. The relative solubilities in water, reactivity with base, and pH are determined by observation and measurement.

EQUIPMENT AND MATERIALS
• Remind students to keep the top of the test tube pointed away from their faces at all times.

PROCEDURE
• Distribute the solution bottles around the classroom so that student movement and congestion are minimized.
• Instruct students to dispose of all solutions in a container provided for that purpose.

OBSERVATIONS
• Sample observations table:

<table>
<thead>
<tr>
<th>Acid</th>
<th>ethanoic acid</th>
<th>octadecanoic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternate name</td>
<td>acetic acid</td>
<td>stearic acid</td>
</tr>
<tr>
<td>Formula</td>
<td>CH₃COOH</td>
<td>CH₃(CH₂)₁₆COOH</td>
</tr>
<tr>
<td>Melting point °C</td>
<td>16.6</td>
<td>71.5</td>
</tr>
<tr>
<td>Boiling point °C</td>
<td>117.9</td>
<td>decomposes at or above 360</td>
</tr>
<tr>
<td>Solubility in water</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Reaction with NaHCO₃</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Acidity higher</td>
<td>lower</td>
<td></td>
</tr>
</tbody>
</table>
DIFFERENTIATED INSTRUCTION
• Encourage students to use analytical strategies that are most useful to them. Visual learners will benefit from a drawing that illustrates the given information. Kinesthetic learners might use models to represent the molecules.

ENGLISH LANGUAGE LEARNERS
• Check to be sure English language learners are clear on the purpose of the MSDS and are able to access the information contained in the document.

1.6.2 Observational Study: Synthesizing Esters

OVERALL EXPECTATIONS: A1; B2

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A1.1; A1.3; A1.4; A1.5; A1.8; A1.11
Developing Skills of Investigation and Communication: B2.4
The full Overall and Specific Expectations are listed on pages 3–5.

SKILLS
Performing Analyzing
Observing Communicating

EQUIPMENT AND MATERIALS
per student:
• chemical safety goggles
• lab apron
per group:
• 500 mL beaker
• utility stand and ring clamp
• hot plate
• wax pencil
• 3 test tubes
• 3 test-tube holders
• test-tube rack
• Petri dish
• dropper bottles containing
  − ethanol
  − propan-2-ol
  − pentan-1-ol
  − concentrated ethanoic acid (glacial acetic acid), CH₃COOH(l) (for teacher use only)
  − 2 mL concentrated sulfuric acid, H₂SO₄(aq) (for teacher use only)
• wash bottle containing cold tap water

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

PROGRAM RESOURCES
BLM 0.0-11 Disposal of Hazardous Waste
Skills Handbook A1 Safety
Skills Handbook A2.3 Observational Studies
Chemistry 12 Online Teaching Centre
Chemistry 12 Solutions Manual
Chemistry 12 website
  www.nelson.com/onseniorscience/chemistry12u

EVIDENCE OF LEARNING
Look for evidence that students can
• conduct an inquiry and make observations about chemical reactions between carboxylic acids and alcohols.
• analyze chemical reactions and write chemical equations.

SCIENCE BACKGROUND
• Esters are derived from carboxylic acids, which contain the carboxyl group –COOH. In an ester, the hydrogen in this group is replaced by a hydrocarbon group.
• Esters are produced when carboxylic acids are heated with alcohols in the presence of an acid catalyst—in this experiment, concentrated sulfuric acid. The hydrogen of the carboxyl group and the hydroxyl group (–OH) of the alcohol combine to form water. The hydrocarbon part of the alcohol replaces the hydrogen of the carboxylic acid, forming an ester.
• Many esters are noted for their strong odours. Some small esters are familiar as solvents in glues. Many larger esters are the active ingredients in fruit and flower aromas, and they are frequently used in perfumes and flavourings.

TEACHING NOTES
STUDENT SAFETY
Remind students of the following safety procedures:
• Wear chemical safety goggles and lab apron for the entire investigation.
• Alcohols are flammable. They should be used only in a well-ventilated area. There should be no open flames or other sources of ignition in the laboratory.
• The acids are corrosive and flammable. Avoid skin and eye contact.
• If you spill chemicals on your skin, wash the affected area with a lot of cool water.
• Use caution around the hot plate. Avoid touching the heating surface with your hands. To unplug the hot plate, pull on the plug itself rather than the cord.
• Wash your hands before leaving the laboratory.
Remember:
• Follow your school’s procedures for disposal. Follow BLM 0.0-11 Disposal of Hazardous Waste for further disposal instructions.
• Sulfuric acid and concentrated ethanoic acid are corrosive and poisonous. Only the teacher should handle these reagents.
• Have students work in small groups for this activity.
• Sample answers are found in the Solutions Manual.
PURPOSE
• Explain that the purpose of the lab is to cause the reaction of alcohols and carboxylic acids to form esters. One way to detect the presence of many esters is by their odour.

EQUIPMENT AND MATERIALS
• Do not allow students to handle sulfuric acid or concentrated ethanoic acid.
• Test tubes are hot and contain sulfuric acid. Make sure that students use test-tube holders.

PROCEDURE
• Draw students’ attention to the photo at the top of page 67 in the Student Book, which demonstrates the safe procedure for smelling a lab sample. Emphasize that students should never place solutions directly under their noses. Instead, they should gently wave a hand over the top of the dish to waft the odour toward the face. Unreacted acetic acid is a strong irritant that should not be inhaled directly into the nasal passages.
• Emphasize safety precautions for using a hot plate together with flammable organic compounds.
• Test tubes should be shaken gently with a swirling motion. Remind students never to point the top of the test tube toward their faces and never to place a thumb over the opening of the test tube during mixing.

OBSERVATIONS
• Students should observe that the reaction mixtures have detectable fruity odours. The esters made from ethanol and from propan-2-ol smell like peaches. The product of the reaction with pentan-1-ol smells similar to apples or bananas. Some people cannot detect the odour of this compound.
• Students should observe that the smaller esters (those of ethanol and propan-2-ol) are miscible with water. Pentyl ethanoate is not miscible with water, so the mixture appears hazy.

DIFFERENTIATED INSTRUCTION
• Allow students to work in groups to discuss their observations. This will be particularly helpful to verbal learners.

ENGLISH LANGUAGE LEARNERS
• Encourage English language learners to participate in group discussions of the lab results. Have them determine which fruit the odour reminds them of and share with the class its name in their first language.

1.6.3 Observational Study: Making Soap (Teacher Demonstration)

OVERALL EXPECTATIONS: A1; B2

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A1.1; A1.4; A1.5; A1.11
Developing Skills of Investigation and Communication: B2.4

The full Overall and Specific Expectations are listed on pages 3–5.

SKILLS
Researching Analyzing
Observing Communicating

EQUIPMENT AND MATERIALS
per student:
• chemical safety goggles
• lab apron
• protective gloves
for teacher demo:
• wax pencil
• two 100 mL beakers
• 250 mL beaker
• forceps
• 50 mL graduated cylinder
• 2 glass stirring rods
• balance
• utility stand with ring clamp
• hot plate
• beaker tongs
• heat-resistant mat
• thermometer
• filter funnel and paper
• fats (lard or vegetable shortening)
• oils (cooking oils such as corn oil, canola oil, olive oil)
• sodium hydroxide pellets, NaOH(s) (for teacher use only)
• ethanol
• vinegar, CH₃COOH(aq)
• sodium chloride crystals, NaCl(s)
• wash bottle containing distilled water
• food colouring (optional)
• perfume (optional)
• paper towel

ASSESSMENT RESOURCES
Assessment Rubric 7: Observational Study
Assessment Summary 7: Observational Study
Self-Assessment Checklist 3: Observational Study
EVIDENCE OF LEARNING
Look for evidence that students can
• explain the chemistry of making soap from fat.
• analyze the chemical reactions involved in the conversion of fat to soap.
• relate saponification to esterification.

SCIENCE BACKGROUND
• Natural plant and animal fats and oils are triglycerides. Glycerol (propan-1,2,3-triol) is an alcohol that has one hydroxyl group bonded to each of its three carbon atoms. Triglycerides are formed by esterification of each hydroxyl group with a long-chain carboxylic acid (fatty acid). The resulting compound is non-polar. Depending on the source of the fat or oil, the fatty acids (and resulting triglycerides) may contain carbon chains ranging from 14 to 22 carbon atoms.
• During saponification, a triglyceride reacts with a strong base to form glycerol and the salt of the fatty acid. This fatty-acid salt is soap.
• Many traditional methods of making soap have used potassium hydroxide extracted from wood ashes as a base to saponify animal fats or plant oils. This “lye soap” has been used for thousands of years.

TEACHING NOTES
• This investigation offers an excellent opportunity to connect chemistry to a historical process.
• An alternative lab, BLM 1.6.3-1 Observational Study: Safe Soap, does not require heating the caustic mixture but does take more time.
• Teacher’s notes for BLM 1.6.3-1 Observational Study: Safe Soap are given on BLM 1.6.3-2 Safe Soap Teaching Notes (for teacher use).

STUDENT SAFETY
This is a teacher demonstration, so students will not handle any of the chemicals. Observing the following safety precautions will protect you and the students.
• Sodium hydroxide pellets are extremely corrosive to eyes and skin. They must only be handled with forceps, and gloves must be worn.

• If sodium hydroxide comes into contact with your skin, wash the affected area with a lot of cool water. If sodium hydroxide contacts the eyes, it can cause blindness. Flush the eyes with water at an eyewash station for at least 10 min, and seek medical attention as soon as possible.
• Ethanol is flammable. It should be used only in a well-ventilated area. There should be no open flames or other sources of ignition in the laboratory.
• Do not use the soap produced in this lab on your skin. It may contain unreacted sodium hydroxide. Protective gloves must be worn when handling the soap.

• Students should not handle this soap without gloves because it might contain residual sodium hydroxide. You might want to bring in some commercial hand-made bar soaps for comparison to manufactured detergent-based soaps.
• Allow ample time for cleanup and waste disposal. Follow your school’s procedures for disposal. Follow BLM 0.0-11 Disposal of Hazardous Waste for further disposal instructions.
• Sample answers are found in the Solutions Manual.

PURPOSE
• To produce soap from the saponification of lard, vegetable shortening, or oils

PROCEDURE
• This demonstration lab is fairly long and involved, so if you have not done it previously, it may be worthwhile to practice before the class demonstration.
• A few drops of perfume or other scent and food colouring can be added to the soap to make it more like familiar manufactured soaps.

OBSERVATIONS
• Students should observe the soap and compare its properties to those of commercial soaps.

DIFFERENTIATED INSTRUCTION
• Have students summarize the steps in the saponification process in a format that is helpful for them. Visual learners may use a flow chart, kinesthetic learners may wish to use molecular models, and auditory learners may wish to discuss the steps with a partner before writing out the steps.

ENGLISH LANGUAGE LEARNERS
• Review with English language learners the chemical reaction as shown on page 67 of the Student Book. Be sure they understand all the terms in the labels.
1.7.1 Activity: Building Organic Molecular Models

OVERALL EXPECTATIONS: A1; B2

SPECIFIC EXPECTATIONS
Scientific Investigation Skills: A.1.11
Developing Skills of Investigation and Communication: B2.3

The full Overall and Specific Expectations are listed on pages 3–5.

SKILLS
Planning            Analyzing
Performing          Evaluating
Observing           Communicating

EQUIPMENT AND MATERIALS
per student:
• molecular modelling kit

ASSESSMENT RESOURCES
Assessment Rubric 8: Activity
Assessment Summary 8: Activity
Self-Assessment Checklist 4: Activity

PROGRAM RESOURCES
Skills Handbook A2.4 Activities
Skills Handbook B3 Elements and Compounds
Chemistry 12 Online Teaching Centre
Chemistry 12 Solutions Manual
Chemistry 12 website
www.nelson.com/onseniorscience/chemistry12u

EVIDENCE OF LEARNING
Look for evidence that students can
• build models to represent a variety of simple organic chemical molecules.
• communicate conclusions about representing molecules with models, using appropriate language and a variety of formats.

SCIENCE BACKGROUND
• This investigation is a review of the arrangement of atoms in organic molecules.
• Models help students visualize how atoms are rearranged during a chemical reaction.

TEACHING NOTES
• Have students work in small groups for this activity.
• Sample answers are found in the Solutions Manual.

PURPOSE
• To help differentiate between the molecular structures of the reactant and the product of a reaction

PROCEDURE
• In Part A, students will examine each reaction on the table, determine the reactants and products, and use molecular models to manipulate the changes that occur during the reaction.
• In Part B, students make a flow chart to show the synthesis of ethanoic acid from ethene.

The reactions are:
ethene (addition of water) →
ethanol (controlled oxidation) →
ethanal (controlled oxidation) →
ethanoic acid

• After drawing the flow chart, students use molecular models to follow the changes that occur during the synthesis.

OBSERVATIONS
• Below is the completed table.

<table>
<thead>
<tr>
<th>Reaction number</th>
<th>Reactant</th>
<th>Reaction type</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>alkane</td>
<td>substitution</td>
<td>halo alkane</td>
</tr>
<tr>
<td>2</td>
<td>alkene</td>
<td>addition</td>
<td>dihaloalkane</td>
</tr>
<tr>
<td>3</td>
<td>alcohol (primary)</td>
<td>controlled oxidation</td>
<td>aldehyde</td>
</tr>
<tr>
<td>4</td>
<td>2 alcohols</td>
<td>condensation or dehydration</td>
<td>ether</td>
</tr>
<tr>
<td>5</td>
<td>aldehyde</td>
<td>controlled oxidation</td>
<td>carboxylic acid</td>
</tr>
<tr>
<td>6</td>
<td>benzene</td>
<td>aromatic substitution</td>
<td>chlorobenzene</td>
</tr>
<tr>
<td>7</td>
<td>secondary alcohol</td>
<td>controlled oxidation</td>
<td>ketone</td>
</tr>
<tr>
<td>8</td>
<td>carboxylic acid plus alcohol</td>
<td>esterification</td>
<td>ester + water</td>
</tr>
<tr>
<td>9</td>
<td>carboxylic acid + amine</td>
<td>amide formation</td>
<td>amide</td>
</tr>
<tr>
<td>10</td>
<td>aromatic compound</td>
<td>aromatic substitution</td>
<td>aromatic halide</td>
</tr>
</tbody>
</table>

DIFFERENTIATED INSTRUCTION
• This activity as written addresses multiple learning styles, including visual and kinesthetic. Encouraging groups to work together on the exercises can also address verbal styles.
ENGLISH LANGUAGE LEARNERS
• Have English language learners draw a chart showing the
prefixes and suffixes used to name organic compounds.

CHAPTER 1
Summary

ASSESSMENT RESOURCES
Assessment Rubric 1: Knowledge and Understanding
Assessment Rubric 2: Thinking and Investigation
Assessment Rubric 4: Application
Assessment Summary 1: Knowledge and Understanding
Assessment Summary 2: Thinking and Investigation
Assessment Summary 4: Application

PROGRAM RESOURCES
BLM 0.0-10 Careers
BLM 1.Q Chapter 1 Quiz
Skills Handbook A7 Choosing Appropriate Career Pathways
Chemistry 12 ExamView® Test Bank
Chemistry 12 Online Teaching Centre
Chemistry 12 website
www.nelson.com/onseniorscience/chemistry12u

RELATED RESOURCES

SUMMARY QUESTIONS
• Direct students to work in pairs to complete the Summary Questions. Suggest they discuss each Key Concept before creating their study guides.
• Return to students the Starting Points answers they wrote before studying the chapter. Have them make any changes they wish. Then read each question aloud and discuss students’ answers. Consider the following points:
  1. Students should refer to the relationship between organic and living things in everyday language. They should also note that carbon is the key element in the compounds that make up organisms.
  2. Students should relate the properties of carbon to those of other elements that primarily form covalent bonds, such as nitrogen and oxygen, and to elements with four valence electrons, such as silicon.
  3. Sources of organic compounds include fossil materials such as petroleum and coal reserves, and materials derived from living sources.

  4. Students should cite hydrogen, carbon, and oxygen as elements commonly found in organic compounds. Organic compounds containing oxygen and/or nitrogen tend to be polar, while compounds containing only carbon and hydrogen are non-polar.
• Ask three to five questions that will prompt students’ recall of each Key Concept. Have students explain and support their responses.
  1. What type of compound provides most combustion fuels? (hydrocarbons or alkanes)
  2. What is the name of the compound whose formula is CH₃CH₂CHOCH₂CH₃? (ethoxypropane)
  3. How does the structure of a ketone differ from the structure of an aldehyde? (In a ketone, 2 carbon atoms are bonded to the carbonyl carbon. In an aldehyde, 1 carbon atom and 1 hydrogen atom are bonded to the carbonyl carbon.)
  4. How many isomers of butane are there? (two)
  5. Which 4-carbon alcohol cannot be a reactant in a dehydration reaction? (2-methylpropan-2-ol)
  6. What types of atoms are included in an amide molecule? (carbon, hydrogen, nitrogen, and oxygen)
• Have students complete the questions in the Chapter Self-Quiz and Chapter Review in the Student Book.
• Have students complete BLM 1.Q Chapter 1 Quiz for an additional review of the material.

CAREER PATHWAYS
• Distribute BLM 0.0-10 Careers and have students complete it as they do their research.
• Organic chemists work in many sciences involving materials we use every day. These areas include petroleum engineering, food and polymer sciences, and pharmaceutical research.
• Environmental chemists and engineers develop methods to analyze and monitor chemicals, protect the environment, and clean polluted sites. Many environmental chemists are also organic chemists.
• Many careers in organic chemistry do not require advanced degrees. Examples include laboratory technologists, process operators, and chemical engineers.

DIFFERENTIATED INSTRUCTION
• Challenge students to form groups to work together to create and present a summary of the chapter in multiple learning styles. For example, an auditory learner could write a song, and a pair of visual learners could draw a flow chart, which a group of kinesthetic learners would then interpret in a play or physical demonstration.
ENGLISH LANGUAGE LEARNERS

• Have English language learners write the names of the classes of compounds studied in this chapter on one set of cards and draw structural diagrams of examples of each class on a second set. Then have them match the two sets, identifying the functional group that defines each pair.

• Have students review the card glossary, sticky-note collection, word wall, or other vocabulary tool they built throughout the chapter. Groups of students could share their collections, with each student adding any important vocabulary terms that might have been missed.
1.1-1 Building Isomers

1. Determine the number of isomers that can exist for each indicated alkane. You can use the space below to draw structures, if necessary.

(a) CH₄  

(b) C₂H₆  

(c) C₃H₈  

(d) C₄H₁₀  

(e) C₅H₁₂  

(f) C₄H₈ (cycloalkane)

2. Write the chemical formula for each of the following compounds.

(a) hexane  

(b) 2-methylhexane  

(c) 4-ethyl-2-methylhexane  

(d) methylcyclohexane

3. Write the name of each compound below.

(a)  

(b)  

(c)
1.2-1 Reactions of Hydrocarbons

Write a balanced equation for each of the following reactions. Use molecular and structural formulas, and classify the reaction as combustion, addition, substitution, hydrogenation, hydration, or a type of halogenation.

1. Octane burns with oxygen gas.

2. 2-methylpent-1-ene reacts with hydrogen.

3. Ethyne and oxygen react.

4. 3-methylbut-1-yne reacts with excess hydrogen.

5. Chlorine reacts with ethane.


7. Cyclohexene reacts with hydrogen.

8. Water and ethane are placed in concentrated sulfuric acid as a catalyst.
1.3-1 Naming Aliphatic and Aromatic Hydrocarbons

1. For each of the following IUPAC names, draw a structural diagram.

(a) 2-methylpentane  
    (e) propyne

(b) ethylbenzene  
    (f) methylpropene

(c) 2,2,3-trimethylpentane  
    (g) cyclohexane

(d) ethene  
    (h) 1,2-dimethylbenzene

2. For each of the following structural diagrams, write the IUPAC name.

(a) \( \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}≡\text{CH}_2 \)

(b) \( \text{CH}_3-\text{CH}≡\text{C}-(\text{CH}_3)\text{CH}≡\text{C}-(\text{CH}_3)\text{CH}_3 \)

(c) \( \text{CH}_3-\text{C}≡\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_3 \)

(d) \( \text{CH}_3 \)

(e) \( \text{Cl} \text{C}_6\text{H}_4\text{Cl} \)

(f) \( \text{H}_2\text{C}_6\text{H}_4\text{CH}_2-\text{CH}_3 \)
1.6-1 Organic Compounds Containing Oxygen

1. For each of these classes of compounds, write the name of the functional group that defines the class.
   (a) alcohol ________________________________________________________________
   (b) aldehyde ______________________________________________________________
   (c) carboxylic acid __________________________________________________________
   (d) ketone _________________________________________________________________

2. Write the IUPAC name of each of these compounds.
   (a) CH₃OCH₂CH₃ __________________________________________________________
   (b) CH₃COCH₂CH₃ _________________________________________________________
   (c) CH₃COOCH₂CH₃ ________________________________________________________
   (d) CH₃CH₂CH₂CHO _______________________________________________________
   (e) CH₃CH₂CH₂COOH ____________________________________________________

3. In order, what are the two products of the controlled oxidation of a propan-1-ol?
   (a) ______________________________________________________________________
   (b) ______________________________________________________________________

4. What is the product of the reaction between pentanoic acid and ethanol?
   _______________________________________________________________________

5. What are the products of the hydrolysis of 2-methylpropyl octanoate?
   (a) ______________________________________________________________________
   (b) ______________________________________________________________________
1.7-1 Identification and Naming of Organic Compounds

1. The IUPAC names of a variety of organic compounds are provided. Draw a structural diagram for each compound and identify the class of organic compound to which it belongs.

(a) butanoic acid  
(b) 1-butanol  
(c) 1,1-dichloro-2,2-difluoroethane  
(d) 2-methylpropan-2-ol  
(e) ethyl methanoate  
(f) propanal  
(g) trimethylamine  
(h) propanamide

2. Give the IUPAC name for the following organic compounds.

(a) \(\text{CH}_3\text{CH}\equiv\text{CHCH}_3\)  
(b) \(\text{CH}_3\text{C}\equiv\text{OCH}\)  
(c) \(\text{ClCH}_2\text{CH}_2\text{CH}_2\text{Cl}\)  
(d) \(\text{CH}_3\text{COCH}_3\)
1.6.3-1 Observational Study: Safe Soap

This is an old method that pioneers used to make soap. They covered a pan of rendered fat with ashes and left it to stand for several weeks. The basic materials in the ashes [potassium hydroxide (KOH), sodium hydroxide (NaOH), potassium carbonate (K₂CO₃), sodium carbonate (Na₂CO₃)] reacted with the rendered fat to produce soap and glycerol [1,2,3-propanetriol].

![Chemical reaction diagram]

**Purpose**
To produce soap from vegetable oil and a base

**Equipment and Materials**
- chemical safety goggles
- lab apron
- protective gloves
- 100 mL beaker
- 10 mL graduated cylinder
- balance
- scoopula
- 10 mL vegetable oil (olive oil gives the best results)
- 1.25 g sodium hydroxide bead or powder
- stirring rod
- mortar and pestle (if sodium hydroxide bead is not available)
- 10 mL distilled or deionized water
- 2 test tubes
- 2 stoppers for test tubes
- 0.5 mL vegetable oil
- graduated dropping pipette
- pH paper or red litmus paper

**Safety**
Sodium hydroxide is very caustic. If spilled on clothing, remove garment immediately. If spilled on skin, wash under running water for at least 10 minutes. If sodium hydroxide gets into the eyes, flush them with water for at least 20 minutes. Seek immediate medical attention for exposure to skin or eyes.

Do not expose any part of your body, including your hands, to the soap produced during this investigation, because it may contain residual sodium hydroxide.

**Procedure**
1. Measure 10 mL of vegetable oil into a clean dry 100 mL beaker.
2. Add 1.25 g of sodium hydroxide bead or powder to the vegetable oil.
3. Gently stir to mix the two components.
4. Let the mixture stand until next class.
5. Observe the product.

**Testing the Product**
1. Place 5 mL of distilled or deionized water in a clean test tube.
2. Add a small amount of the soap to the water.
3. Stopper the test tube and shake up the contents. What do you observe?
4. Test the soap solution with pH paper or red litmus paper. What do you observe?
5. Repeat the above steps using 0.5 mL of vegetable oil in place of the soap. Use a graduated dropping pipette to add the oil to the water. What do you observe after shaking the mixture?
6. Now add a small amount of soap to the oil-and-water mixture and shake up the contents. What do you observe? Explain.
7. Clean and return all equipment.
1.6.3-1 Observational Study: Safe Soap (continued)

**Analyze and Evaluate**

(a) Describe the changes that took place in the beaker overnight.

(b) Describe the behaviour of the soap in water and with water and oil.

(c) Is the soap solution acidic, neutral, or basic? Explain.

(d) Assume that the vegetable oil used has a density of 0.899 g/mL and a molar mass of 885.5 g. Calculate the mass of sodium hydroxide that should be used to saponify the oil.

(e) A reaction equation for the production of soap is given at the beginning of the lab outline. What type of reaction is this?

**Apply and Extend**

(f) In addition to soap, what other compound is a product of this reaction? What are some uses of this compound?

(g) Predict what would happen if you used a fat instead of an oil in this experiment.

(h) How are the reactions of esterification and saponification related?

(i) Why is sodium hydroxide used to unclog drains?

(j) Describe how soap mixed with water works to remove oils.

(k) Why are substances with structures similar to soaps added to gasoline?

(l) Research the use of animal fats and ashes in the past. Why don’t we use these materials today the way people did in the past? Present your findings in a format of your choice.

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1.6.3-2 Safe Soap Teaching Notes (for teacher use)

1. *BLM 1.6.3-1 Observational Study: Safe Soap* is an alternative to Investigation 1.6.3 Making Soap. In this alternative lab, no heating is necessary, and handling of the sodium hydroxide is minimized.

2. For best results, use fresh sodium hydroxide.

3. Sodium hydroxide bead may not be available, as some recent containers labelled “bead” in fact contain pellets. Pellets have too little surface area to produce a fast-enough reaction. If you must use pellets, crush them first using a mortar and pestle.

4. Flake sodium hydroxide is easier and safer than pellets to powder in a mortar and pestle. The teacher should do this prior to class.

5. Use 1.75 g of KOH if NaOH is unavailable, or if you wish to compare a sodium soap and a potassium soap. Potassium soaps tend to be softer than sodium soaps.

6. If you use olive oil, use the least expensive you can find.

7. The 10 mL of soap produced will be enough for the class to do the testing.

8. If you have a low crystallizing dish, you can speed up the reaction by heating the reaction beaker and its contents in an 80 ºC to 90 ºC water bath, stirring the mixture as it heats. Ask students, *What will heating do to the reaction rate?* (speed it up) This mixture may be dyed and scented while stirring.

9. You may want to refer to aspects of this lab as you come to various points in the curriculum, such as reaction rates, molecular structures, intermolecular forces, and strong and weak acids and bases.

10. For part (a), explain to students that oil and water are liquids that do not mix to form a solution. They are *immiscible* liquids. Soap causes oil to mix with water to form an *emulsion*. In such a case, soap is an *emulsifying agent*. Liquids that mix to form solutions in all proportions, such as ethanol and water, are called *miscible* liquids.

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Chapter 1 Quiz

For each question, select the best answer from the four alternatives.

1. Which class of compounds includes CH₃CH₂CH₂CHO?
   (a) aldehyde    (b) alcohol    (c) ether    (d) ketone

2. Which class of compound will be formed in the following reaction?
   CH₂CH₂CH₂COOH + CH₃NH₂ →
   (a) amide    (b) amine    (c) ester    (d) ether

3. Which of these compounds is a structural isomer of 2-ethyl-3-methylheptane?
   (a) 3-ethylhexane
   (b) 2,2,4-trimethylhexane
   (c) 2-ethyl-3-methyloctane
   (d) 4-methylnonane

4. Which of these compounds could be the product of the hydrolysis of an ester?
   (a) propanal    (b) propanol    (c) propanone    (d) propyne

Indicate whether each statement is true or false. If you think the statement is false, rewrite it to make it true.

5. Markovnikov’s rule can be used to predict the products of the substitution reactions of an alkene.

6. The generic formula for a cycloalkane is CₙH₂ₙ.

7. For similar-sized compounds, the correct polarity order is: alcohol > carboxylic acid > ether > amine.

Write a short answer to each question.

8. Explain why the original depiction of benzene—a 6-carbon ring with alternating single and double bonds—is not considered accurate.

9. How does the product of hydrogenation of a ketone differ from the product of hydrogenation of an aldehyde?