Unit 3
MIXTURES AND SOLUTIONS
Suggested Time: 25 Hours
Unit Overview

Introduction
All matter can be classified as either mixtures or pure substances. By the end of grade 6, students have encountered and studied many of the properties of matter and how matter can change from one form to another. Through their study of mixtures and solutions, students will further refine their understanding of matter. They will also explore and develop an appreciation of how various types of matter are important in their daily lives and will be introduced to several techniques for separating mixtures into their constituent parts.

Focus and Context
The focus of this unit should be on inquiry and investigation. Students should be encouraged to identify and explore the variety of mixtures and pure substances they use or encounter in their daily lives. In particular, mixtures are so commonplace in our lives that they are virtually “transparent” in our daily experience. Students should be encouraged to explore the variety of mixtures that are important in our lives and to investigate how separating these mixtures into their constituent parts provides other valuable or important substances on which we depend.

Science Curriculum Links
In primary grades students are introduced to materials and their properties. By the end of elementary grades, students have developed an understanding of the chemical and physical properties of matter.

In this unit, the physical properties of matter will be used to discuss the nature of mixtures, solutions, and pure substances. These properties will also be used to investigate how mixtures can be separated into their constituent components. The concepts introduced in this unit will be expanded upon in Science 1206 and high school chemistry.
## Curriculum Outcomes

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<tr>
<th>STSE</th>
<th>Skills</th>
<th>Knowledge</th>
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<tbody>
<tr>
<td><strong>The student will be expected to</strong></td>
<td><strong>The student will be expected</strong></td>
<td><strong>The student will be expected to</strong></td>
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<tr>
<td><strong>Nature of Science and Technology</strong></td>
<td><strong>Initiating and Planning</strong></td>
<td>307-1 distinguish between pure substances and mixtures using the Particle Theory of Matter.</td>
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<tr>
<td>109-4 using distillation as an example show how refining and separation techniques have evolved.</td>
<td>208-1 develop a testable hypothesis on the effect of temperature on solubility.</td>
<td>307-2 identify and separate the components of mixtures</td>
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<td>109-7 identify different measures of concentration.</td>
<td>208-2 identify questions to investigate arising from practical problems and issues</td>
<td>307-3 describe the characteristics of solutions using the Particle Theory of Matter.</td>
</tr>
<tr>
<td><strong>Relationships Between Science and Technology</strong></td>
<td>208-3 define and delimit questions and problems to facilitate investigation</td>
<td>307-4 describe the concentrations of solutions qualitatively and quantitatively.</td>
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<tr>
<td>111-1 describe how our understanding of the properties of solutions has resulted in better road de-icing technologies.</td>
<td>209-1 carry out procedures controlling the major variables.</td>
<td>307-5 describe qualitatively the factors that affect the solubility of a solid and a gas.</td>
</tr>
<tr>
<td>111-5 describe the science underlying a distillation apparatus using the following terms: boiling, evaporation, condensation.</td>
<td>208-5 state a hypothesis based on background information or an observed pattern of events.</td>
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<tr>
<td><strong>Social and Environmental Contexts of Science and Technology</strong></td>
<td><strong>Performing and Recording</strong></td>
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<tr>
<td>113-1 identify some positive and negative effects and intended and unintended consequences of using salt on highways.</td>
<td>209-1 carry out procedures controlling the major variables to study the effect of temperature on solubility.</td>
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<tr>
<td>113-9 make an informed decision about the use of road salt as our main road de-icing chemical taking into account the environmental, social, and economics advantages and disadvantages.</td>
<td>209-3 use instruments effectively and accurately for collecting data</td>
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<td>209-6 use tools and apparatus safely.</td>
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<td><strong>Analysing and Interpreting</strong></td>
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<td>210-5 identify the line of best fit and interpolate or extrapolate based on the line of best fit.</td>
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<td>210-9 express concentration of solutions in g/L.</td>
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<td>210-16 answer new questions that result from the mixture separation activities</td>
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## Mixtures and Pure Substances - The Particle Theory

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Elaborations - Strategies for Learning and Teaching</th>
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<tbody>
<tr>
<td>Students will be expected to</td>
<td>Students will have encountered the Particle Theory of Matter in elementary science as well as in the Heat unit. Teachers should review this theory with students and highlight the following two important points: all matter is made up of extremely tiny particles; and each pure substance has its own kind of particle which is different than the particles of other pure substances.</td>
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<tr>
<td>- distinguish between pure substances and mixtures using the particle theory of matter. (307-1)</td>
<td>Teachers could have students write their thoughts and perceptions of the differences between pure substances and mixtures using a KWL activity (Appendix B). Later in this unit these ideas/thoughts can be revisited as students develop a more complete understanding of these terms. Teachers could have students start a mind map for this unit. At the centre put “Mixtures and Solutions”. As they encounter new information branches and detail could be added.</td>
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<tr>
<td>- define the Particle Theory of Matter.</td>
<td>Students should attempt to categorize substances into mixtures or pure substances. Students should be exposed to a variety of materials, both pure substances and mixtures. Teachers should note that at this point substances chosen should be obvious examples of mixtures (or mixed in front of the students) and pure substances. For example: mixtures - salt water, iron fillings and sand, muddy water, wood chips and marbles, vegetable oil and water; pure substances: salt, distilled water, aluminium bar (or other solid metal bar). Teachers should refrain from introducing the terms heterogeneous and homogeneous mixtures until later in the unit. From their observations, students should conclude:</td>
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<tr>
<td>- using observations, categorize substances as pure or mixtures</td>
<td>1. Mixtures may have distinct visible components;</td>
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<td>2. Mixtures may appear uniform throughout (like pure substances);</td>
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</table>
Mixtures and Pure Substances - The Particle Theory

<table>
<thead>
<tr>
<th>Tasks for Instruction and/or Assessment</th>
<th>Resources/Notes</th>
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<tr>
<td>• Create a KWL chart in which you write what you already known about pure substances and mixtures in the “K” column. In the “W” column, write two or three questions you would like answered or two or three things you “wonder” about mixtures and pure substances. (307-1)</td>
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<tr>
<td>• Create your own models of pure substances and common mixtures. (307-1)</td>
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<tr>
<td><strong>Journal</strong></td>
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<tr>
<td>• Students could record all examples of the solid, liquid, and gas pure substances they encounter in a day. (307-1)</td>
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### Mixtures and Pure Substances - The Particle Theory (continued)

#### Outcomes

Students will be expected to

- distinguish between pure substances and mixtures using the particle theory of matter.

(continued)

- define the terms pure substance and mixture using the Particle Theory of Matter.

#### Elaborations - Strategies for Learning and Teaching

Students should recognize that matter is often categorized into two main groups: pure substances and mixtures. Pure substances contain only one kind of particle and are the same throughout. The particle can be a single atom or two or more atoms chemically combined to form a different particle. For example, gold is a pure substance composed of only gold atoms while distilled water is a pure substance composed of hydrogen and oxygen atoms bonded together to form water molecules. As earlier demonstrated, mixtures are the physical combination of two or more pure substances. For example, bread is a mixture of yeast, sugar, flour, carbon dioxide/air and other chemicals, and a soft drink is a mixture of water, sugar, carbon dioxide gas and other chemicals.

Students could summarize the information about heterogeneous and homogeneous mixtures in their mind map.

Teachers could use models to illustrate the difference between pure substances and mixtures at the particle level. For example, water particles can be represented with red balls (small styrofoam balls, ping pong balls, etc.). A container of these balls would represent the pure substance, distilled water. Similarly, sugar particles can be represented with blue balls and carbon dioxide gas particles with yellow balls. A container of the red, blue and yellow balls would represent a mixture such as a soft drink.

Teachers should clarify that a uniform mixing of the balls depicts one type of mixture while two or three distinct layers of balls represents a different type of mixture. This will lead into the concepts of homogenous and heterogeneous mixtures.

Teachers could have students engage in a think-pair-share in which they explain how they distinguish between pure substances and mixtures using the Particle Theory.
Mixtures and Pure Substances - The Particle Theory (continued)

<table>
<thead>
<tr>
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<tr>
<td><strong>Performance</strong></td>
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<td>• Create a KWL chart in which you write what you already known about pure substances and mixtures in the “K” column. In the “W” column, write two or three questions you would like answered or two or three things you “wonder” about mixtures and pure substances. (307-1)</td>
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<tr>
<td>• Provide students with a collection of pure substances and mixtures. Have them classify into two groups based on their observations. (307-1)</td>
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<td><strong>Journal</strong></td>
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<td>• How is the term “pure” used in everyday life? How is this different from how it is used in science?</td>
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<td>• Students could complete the following sentence: ‘The way I use the word “pure” in my everyday life is different from how I use it in science because...’ (307-1)</td>
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<td><strong>Outcomes</strong></td>
<td><strong>Elaborations - Strategies for Learning and Teaching</strong></td>
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<tr>
<td>Students will be expected to</td>
<td>Teachers should note that there is no need to discuss or illustrate chemical bonding or chemical ratios at this point. Commonly held misconceptions of students include the following: (i) a pure substance is one that is safe to ingest, (ii) a substance that is free of additives, (iii) only elements are pure substances, (iv) “pure” and “clear” are sometimes taken to mean the same thing. When using substances such as water, sugar and salt as examples of mixtures teachers should be aware of the possible misconceptions held by their students and to take care to emphasize the scientific use of “pure” in relation to these substances which are composed of two or more different types of particles or atoms. Teachers should be careful that the examples of pure substances covered are not limited to elements. For example, compounds such as salt, sugar and baking soda are all examples of pure substances because they contain different elements in fixed proportions. Teachers could have students brainstorm and identify examples of pure substances such as gold and distilled water. Many of the substances provided by students may be examples of elements. If so, teachers may view this as an opportunity to briefly present the Periodic Table of Elements. However, students will learn about the Periodic Table in grade nine. Although it is sometimes useful to identify pure substances using chemical formulae, it is not necessary for students to recognize a substance by its formula.</td>
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<tr>
<td>• distinguish between pure substances and mixtures using the particle theory of matter. (307-1)</td>
<td>Students could brainstorm to identify mixtures that are commonly used such as detergents, cleaners (formed by adding water to the cleaner), cake mixes and gasoline-oil mixtures (for example, lawn mower engines require specific amounts of oil to be mixed with gasoline). To determine if household products are mixtures or pure substances, students could be directed to view the ingredient list on the product label. Students may realize that many commonly used household substances are mixtures, and examples of pure household substances are extremely rare. As a means of providing time to process this information, teachers could have students create a journal entry in which they discuss the most important pure substance and the most important mixture they come in contact with each day.</td>
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<td>(continued)</td>
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<tr>
<td>- identify examples of various pure substances. Include:</td>
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<tr>
<td>(i) distilled water (H₂O)</td>
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<tr>
<td>(ii) sugar (C₁₂H₂₂O₁₁)</td>
<td></td>
</tr>
<tr>
<td>(iii) copper (Cu)</td>
<td></td>
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<td>(iv) oxygen (O₂)</td>
<td></td>
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<td>(v) carbon dioxide (CO₂)</td>
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<tr>
<td>- identify examples of various mixtures that are found in or around student homes. Include:</td>
<td></td>
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<tr>
<td>(i) salad dressing</td>
<td></td>
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<tr>
<td>(ii) chocolate chip cookie</td>
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<tr>
<td>(iii) Kool-aid</td>
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<tr>
<td>(iv) concrete</td>
<td></td>
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<tr>
<td>(v) air</td>
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</table>
Mixtures and Pure Substances - The Particle Theory (continued)

Tasks for Instruction and/or Assessment

Performance

• Write a letter to a friend explaining what a pure substance is. (307-1)

Journal

• Do you think our understanding of how the term “pure” is used in science will change how you use it in everyday life? Why/why not? (307-1)

• What are the most important mixtures and pure substances you come in contact with each day? Why do you think they are important? (301-1)
Homogeneous and Heterogeneous Mixtures

Outcomes

Students will be expected to

- distinguish between heterogeneous (mechanical) and homogeneous (solution) mixtures using the particle theory of matter. (307-3)

- identify that homogeneous mixtures appear as one substance and light will pass through unaffected.

- identify that heterogeneous mixtures may appear as one substance and light will scatter as it passes through

Elaborations - Strategies for Learning and Teaching

The ball analogy described previously can be used to illustrate the differences between heterogeneous and homogenous mixtures. Teachers should have students observe various mixtures to recognize that some mixtures appear as one substance, (i.e., they are the same throughout) while other mixtures are obviously the combination of two or more substances.

Students should recognize that the particles of a homogeneous mixture mix so that none of the original substances are visible, even with a microscope. Homogeneous mixtures are referred to as solutions which are discussed in the next topic of the unit.

In a heterogeneous mixture the substances are clearly visible because the particles do not mix evenly. Teachers could prepare a known set of solutions and non-solutions in front of the students. For example, solutions: copper (II) sulfate solution (teachers could use both the anhydrous and hydrated forms to demonstrate that the color of the crystal does not always indicate the color of solution), salt water, sugar water, (if available, potassium permanganate and potassium chromate could be used to create dilute solutions that demonstrate coloured solutions); non-solutions: vegetable oil and water, pepper and water, sugar and vegetable oil, vinegar and salad oil. In order to compare and contrast, a list of characteristics could be developed to describe the solutions and non-solutions in the set. Teachers should note that using water to prepare the majority of solutions and non-solutions in the previous activity may lead students to believe that water is a common component of solutions and non-solutions. However, this is not the case, so teachers should clarify that water is only used because of accessibility. There are many other solvents used to make solutions. For example, lemon juice can dissolve in vinegar to make a solution.

The characteristic of light scattering or not scattering is one way to distinguish between these two mixtures. In the homogeneous mixture (solutions), light will pass through unaffected. In a heterogeneous mixture light will scatter as it is reflected off the particles in the mixture. This phenomenon is known as the Tyndall Effect. Note: it is not important that they be able to explain the effect. By turning off the lights in the classroom and using a light source such as a flashlight, teachers can demonstrate that while “pure air”, such as that contained in a breathing apparatus, is a homogeneous mixture of oxygen, nitrogen, carbon dioxide, and other gases, the air in the classroom is actually a heterogeneous mixture because light from the flashlight will reflect off the dust particles. The hairs and moisture in our nose and related organs filter out the dust so that normally pure air enters our lungs.
Homogeneous and Heterogeneous Mixtures

Tasks for Instruction and/or Assessment

Performance

- Create a poem, song, rap or rant about the types of mixtures you encounter or use on a regular basis. (307-3, 109-10)
- Create a booklet of labels from household products which are mixtures, include the household hazard symbols. (109-10)
- Using a “Draw” application or illustration by hand, highlight the differences between
  - pure substances and mixtures
  - heterogeneous mixtures and homogenous mixtures (307-1, 307-3)
- Describe the appearance of a beam of light as it is shone through:
  (a) a glass of cola, (b) a glass of orange juice, (c) a glass of milk
  (d) a glass of water, (e) an empty glass
  What can you conclude about each substance based on the appearance of the light beam? (307-3)

Paper and Pencil

- Make a list of 15-20 solutions and mixtures that you encounter in a day and identify those that may pose any safety risks. (109-10)
- Name one example of a heterogeneous mixture and one example of a homogeneous mixture. Explain how you are able to tell the two types of mixtures apart. (307-3, 109-10)
- Using the table below, make a list of 20 substances you use or encounter in your daily life. Categorize each as “pure substances”, “heterogeneous mixture”, or “homogeneous mixture”. Briefly describe your reason for each classification, (307-1)

<table>
<thead>
<tr>
<th>Substance Name</th>
<th>Category</th>
<th>Reason</th>
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<tbody>
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</tbody>
</table>

Journal

- Mixtures that we sometimes separate are....(109-10)
- The most important solution in my everyday life is....(109-10)
Homogeneous and Heterogeneous Mixtures (continued)

Outcomes
Students will be expected to

- distinguish between heterogeneous (mechanical) and homogeneous (solution) mixtures using the particle theory of matter. (307-3)

(continued)

- identify some mixtures as combinations of heterogeneous and homogeneous mixtures. Include:
  (i) orange juice
  (ii) milk
  (iii) soft drink

Elaborations - Strategies for Learning and Teaching

Students should recognize that a large number of mixtures cannot be classified as either homogenous or heterogeneous but rather are combinations of both. For example, orange juice is a complex combination of solid orange pulp, water, sugars and so on. The pulp in water implies a heterogeneous mixture, while the sugars in water constitute a homogeneous mixture. Teachers should clarify that mixtures fall on a continuum from homogeneous to heterogeneous dependent on particle size. Since many mixtures do not fit neatly into these categories, teachers should limit classification questions to simple examples that are clearly heterogeneous or homogeneous.

If time permits, as enrichment, teachers could have students investigate other categories of mixtures on this continuum such as dispersions, emulsions, and colloids. While these concepts are not core to this unit, this would provide an opportunity for teachers to illustrate that science concepts and terminology are sometimes not clear cut as we are led to believe by the simplification that often occurs in media reports (nature of science).
Homogeneous and Heterogeneous Mixtures (continued)

Tasks for Instruction and/or Assessment

Performance

- Create a chart, in which you list the various homogeneous and heterogeneous mixtures in your household. (307-3)
- Use coloured discs or coins to model particle arrangement in:
  - (a) pure substances
  - (b) homogeneous mixtures
  - (c) heterogeneous mixtures. (307-3)

Paper and Pencil

- As enrichment, research the term “colloid” and explain how it is a special type of mixture. (307-3)
Solutions

**Outcomes**

**Students will be expected to**

- describe dissolving as a characteristic of solutions using the Particle Theory of Matter. (307-3)

  - define:
    - (i) dissolving
    - (ii) solute
    - (iii) solvent
    - (iv) solubility (soluble/insoluble)

  - identify that solutions can form between the three states of matter. Include:
    - (i) solid solute - liquid solvent
    - (ii) gas solute - liquid solvent
    - (iii) gas solute - gas solvent
    - (iv) solid solute - solid solvent
    - (v) liquid solute - liquid solvent

**Elaborations - Strategies for Learning and Teaching**

Students could dissolve colored sugar crystals or a sugar cube into warm water and observe what happens to the sugar using light microscopes or dissecting scopes. Students could then be encouraged to explain what they believe is happening to the sugar at the particle level. Teachers could use models to help students gain an emergent understanding of the characteristics of solutions. To ensure students have the appropriate vocabulary to describe what they see, teachers may wish to introduce the terms dissolving, solute, solvent, and solubility first.

Students may question why some substances do not dissolve at all. Teachers could illustrate that the degree of solubility exists on a continuum. That is, some solutes have low solubility where as other solutes have high solubility. The degree of solubility depends on several factors, one of which is the strength of the forces holding the particles of the substance together. A more complete explanation of why certain substances dissolve and other do not, will be addressed in high school chemistry.

Students could engage in a 2 minute review of these terms (Appendix B). Teachers could have students do a quiz-quiz-trade activity that includes the terms and concepts covered to this point.

Even though the majority of solutions presented to students involve a solid dissolved in a liquid, students should recognize that solutions can exist in solid, liquid or gaseous states and can be formed in different ways. For example, brass is a solid in a solid solution (zinc in copper), antifreeze is a liquid in a liquid solution (alcohol in water), soda water is a gas in a liquid solution (carbon dioxide in water) and air is a gas in a gas solution (oxygen and other gases in nitrogen).

Students could create a new branch for their mind map and label it “solutions” from this they could create sub-branches for “dissolving”, “solute”, “solvent”, “solubility”, “soluble”, and “insoluble”. They would then define/describe these terms using mind map guidelines (refer to Appendix B).
**Solutions**

### Tasks for Instruction and/or Assessment

*Journal*

- “It is important to use the terms solute and solvent properly when creating or separating solutions because...” (307-3)

*Paper/Pencil*

- Explain/illustrate what happens to both the solute and the solvent in a solution. (307-3)
- Create a list of the different solvents and solutes found around your home. (307-3)
- List three solutions found at home and identify the solute and solvent of each. (307-3)
- Using the diagram below as the first step, sketch what the solution might look like when thoroughly mixed. Indicate the particles representing the solute and the solvent. (307-3)

![Diagram of solute and solvent](image)

*Performance*

- Create a flip book to show what happens as a solute is added to a solvent. (307-3)
- Write a poem, song or rap that describes or explains that solutions can form between the three states of matter. (307-3)

*Portfolio*

- Using a table similar to the one below complete as many blocks as possible with household examples of mixtures that students encounter in one day. (109-10)

<table>
<thead>
<tr>
<th></th>
<th>Solid</th>
<th>Liquid</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid</td>
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<td></td>
<td></td>
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<tr>
<td>Gas</td>
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</tbody>
</table>
Solutions (continued)

Outcomes

Students will be expected to

- describe dissolving as a characteristic of solutions using the Particle Theory of Matter. (307-3)

(continued)

- given an example of a solution and its components, identify the solute and solvent.

Elaborations - Strategies for Learning and Teaching

When given the relative or specific amounts of the components of a solution, students should be able to identify which is the solvent and which is the solute. Examples:

- vinegar is a solution composed of 5% acetic acid and 95% water (acetic acid is the solute and water is the solvent)
- when given the percentage composition of air, students should be able to recognize nitrogen as the solvent and the other gases as solutes
- when informed that a student put a teaspoon of sugar into a cup of hot water, they should identify sugar as the solute and the water as the solvent;
- a 100 g sample of brass is a solution of 35 g of zinc in copper, they should recognize that zinc is the solute and copper is the solvent.

Teachers could have students engage in a quiz-quiz-trade activity (see Appendix B) using the terminology encountered thus far.
Solutions (continued)

Tasks for Instruction and/or Assessment

**Performance**

- Test the solubility of different substances such as sodium chloride, sugar, copper (II) sulphate, and calcium hydroxide by dissolving the substances in 100mL of water. Record the number of ¼ teaspoons of each substance that can be added to water before the saturation point is reached. Ensure to stir the solution between each addition. (307-4)
  - Students should create a table to record the number of ¼ teaspoons required for each solution to reach its saturation point.
  - Students should create a bar graph comparing the number of ¼ teaspoons of each substance that could be dissolved before the saturation point is reached.

- create a comic strip to illustrate dissolving, soluble substances, and/or insoluble substances. (307-3)

**Portfolio**

- In an advice column about science fair projects in a school newspaper, explain the importance of knowing what the following words mean when doing a related activity: (109-14)
  - Solute - Solvent
  - Dissolving - Soluble

**Presentation**

- Students could create a dramatization of how a solution forms. A small number of boys on one side of the room can represent the solute. A larger number of girls on another side of the room can represent the solvent. Have the two groups mix together and while constantly moving making note of the positioning of the particles. (307-1)

**Journal**

- Can water act as a solute? If yes, can you think of an example? (109-14)
### Concentration of Solutions

#### Outcomes

Students will be expected to

- describe the concentrations of solutions qualitatively and quantitatively. (307-4)
  - define:
    - (i) concentrated
    - (ii) dilute
    - (iii) concentration
  - distinguish between concentrated and dilute solutions

- describe the concentrations of solutions qualitatively using the terms:
  - (i) saturated
  - (ii) unsaturated
  - (iii) dilute
  - (iv) concentrated

#### Elaborations - Strategies for Learning and Teaching

Students will have some experience using quantitative and qualitative descriptions of solution concentrations in everyday activities such as: gas/oil mixtures, cooking, chlorine in swimming pools, mixing beverages such as concentrated juices and Kool-Aid. Note: Teachers may want to impress upon students that scientists often require precise quantitative descriptions of solution concentrations.

A continued exploration and investigation into the particle theory of matter as it relates to mixtures and particularly solutions could be accomplished with opportunities for students to explore the concentrations of solutions both qualitatively and quantitatively. Students could create solutions of varying concentrations of food coloring and water. Next, they can quantitatively and qualitatively describe the solutions they create. For example, teachers could place one drop of food coloring in 100 ml of water. This solution would have a quantitative concentration of 1 drop/100ml. Next, they may choose to place 5 drops of food coloring in 100 ml of water which would have a quantitative concentration of 5 drops/100ml. Qualitatively, the latter solution would be more concentrated (darker) than the previous solution. As an extension, teachers could have students prepare the following two solutions - 1 drop of food coloring in 20mL of water and 5 drops of food coloring in 100mL of water. By comparing these two solutions, students should realize that these two solutions are the same in qualitative and quantitative concentrations.

Students could add branches to their mind map to summarize information about concentration, concentrated, and dilute.

Discussion of everyday experiences related to the terms dilute and concentrated such as “orange juice from concentrate” and “weak Kool-Aid” could allow for a better appreciation of the students’ understanding of the terms before formal investigations and learning activities. For example, a solution with 20g of salt in 100mL of water is less concentrated than a solution with 10g of salt in 25mL of water. Students should recognize that the ability of a solvent to dissolve a particular solute at a given temperature is limited.

A popular misconception students may have is that concentrated only means adding more solute and keeping the amount of solvent the same. Teachers should make the students aware that concentrated solutions can be prepared by keeping the amount of solute the same and reducing the amount of solvent. Teachers could use the example of simmering a sauce in an open pan as an example. Teachers should ensure students understand that a solution could be considered “concentrated” and still be unsaturated. Students could engage in a 2-minute review to clarify their understanding of these terms.
Concentration of Solutions

Tasks for Instruction and/or Assessment

*Paper and Pencil*

- Describe a household mixture both qualitatively and quantitatively. (307-4)
- How are the pairs of terms related: dilute-unsaturated, concentrated-saturated? (307-4).
- You have been chosen to teach the concept of concentration to a Grade 5 class. What analogy (teacher explanation may be necessary for the term analogy) could you use to help them understand the difference between a concentrated solution versus a dilute solution? (307-4).

*Journal*

- “A concentrated solution is always saturated.” Do you agree or disagree with this statement? Explain your reasons? (307-4).

*Performance*

- Create a poster or collage that explains the differences between the terms dilute, concentrated, saturated and unsaturated (307-4)
- Taste Test: prepare salt or sugar solutions of concentrations ranging from 0 ppm - 6000 ppm at 1000 ppm intervals. Have students place one drop of each solution on their tongue starting with the 0 ppm solution through to the 6000 ppm solution. Have them note when they first detect the salt/sugar. This is a qualitative detection for salt/sugar. Prepare a bar graph of class results showing when students first detected salt/sugar versus the number of students at each detection level. (109-7, 210-9, 307-4)
- Given unknown masses of a solute and unknown volumes of a solvent, have students take mass and volume measurements of each sample. Combine solutes and solvents to create a variety of solutions with different concentrations. Have students then calculate the concentration of each prepared solution in g/L and rank them from least concentrated to most concentrated. (210-9, 307-4)
Concentration of Solutions (continued)

Outcomes

Students will be expected to

- describe the concentrations of solutions qualitatively and quantitatively. (307-4)
  (continued)

- describe the concentrations of solutions quantitatively as the amount of solute per unit volume.
- express concentration of solutions in g/L. (210-9)
- identify different measures of concentration. (109-7). Include:
  (i) percentage by mass
  (ii) ppm (parts per million)

Elaborations - Strategies for Learning and Teaching

After they have developed a qualitative appreciation of concentration (dilute/concentrated) students should recognize that the concentration of a solution can be expressed numerically. This can be expressed as the amount of solute per unit volume.

Students should recognize that the ratio of solute to solvent determines the concentration. Students could add different amounts of solute to varying volumes of solvent and then determine a way to compare the results. For example, a solution with a concentration of 20g/100 mL is more dilute than solutions with concentrations of 25 g/100 mL or 20g/80 mL. Teachers could help student make the connection that a common volume of solute or solvent would be required to make accurate comparisons. Teachers may wish to use 100 mL of solvent rather than 1L if restricted by the size of lab equipment.

Teachers could extend this concept so that if students found that a particular solution had a concentration of 60 g/100 mL, they should be able to devise and use a method to express the concentration in g/L (which is the same as g/1000 mL). After students have devised their own methods for calculating the concentration in g/L, teachers may wish to review metric conversions of g to mg and L to mL.

Teachers should ensure that students realize that there are different ways to express concentration of a solution (e.g. g/L, g/mL, ppm, etc). Students could investigate more quantitative descriptions of concentrations by noting or bringing to class various commercial product labels and/or newspaper articles in which the concentrations are indicated. Examples of concentrations described in ppm (parts per million) and percentage by mass would permit students to see that concentrations can be described in various ways. It is not expected that students calculate either of these concentration values.

Teachers could add the new terms to this point to the quiz-quiz-trade collection and engage students in a review.
Concentration of Solutions (continued)

Tasks for Instruction and/or Assessment

Performance

- Create a collage to show the different concentrations of common household solutions. (109-7).
- Students could weigh four samples of Kool-Aid (1g, 2g, 3g, 4g) dissolve them each in 100mL of water. Students should create a table of their observations, recording any differences in colour and taste of the solutions and relate them to concentration. Students should then calculate the concentration of each solution in g/L. (210-9, 109-7).

Paper and Pencil

- When would the use of ppm be important to describe the amount of solute in a solution? (109-7).
- Swimming pools must maintain a specific ppm range of chlorine in order to keep the water clean. Would you use a quantitative or qualitative test to determine if it is safe to swim in the water? Explain your answer. (307-4)
- Given a solution with a 4.0 g of solute in 50.0 mL of solvent, calculate the concentration of the solution in g/L. (109-7, 210-9)

Portfolio

- Collect newspaper or magazine articles that use quantitative descriptions of concentrations of various solutions. (109-7, 210-9)
- Ask students to complete a table, like the one show below, from the information given on labels of household items.

<table>
<thead>
<tr>
<th>ppm</th>
<th>% mass</th>
<th>g/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Chemical</td>
<td>Item</td>
</tr>
<tr>
<td>Multi vitamin iron</td>
<td>Vinegar</td>
<td>Acetic Acid</td>
</tr>
<tr>
<td>etc...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Journal

- When is it okay to use qualitative measures of the amount of solute in solution and when should quantitative measures be used? (109-7, 210-9, 307-4)
Outcomes

Students will be expected to

- state a hypothesis based on background information or an observed pattern of events. (208-5)
- identify and delimit questions and problems to facilitate investigation. (208-2, 208-3)
- identify the line of best fit and interpolate or extrapolate based on the line of best fit. (210-5)
- develop a testable hypothesis on the effect of temperature on solubility. (208-1)
- carry out procedures controlling the major variables to study the effect of temperature on solubility. (209-1)

Elaborations - Strategies for Learning and Teaching

Core Laboratory Activity: How Does Temperature Affect Solubility?

The laboratory outcomes 208-1, 208-2, 208-3, 208-5, 209-1, 210-5, and, in part, 307-5 are addressed by completing CORE LAB 8-2A “How Does Temperature Affect Solubility?”

Teachers may have to provide some structure to assist students as they develop and plan their own solubility study. Students could work in groups to develop their study. Teachers could lead a whole class discussion using the plans from each group to develop one or several “class plans” for students to use in part 2. Teachers should ensure students consider which variables need to be controlled, the type of data they need to collect, as well as safety. The data collected could be quantitative or qualitative depending on the procedure used.

As they work to complete Part 2 of the Core Lab 8-2A, students should be encouraged to develop testable hypotheses and also to recognize and control the major variables in any of the tests carried out. By collecting and recording data observed during the procedures and organizing data in the forms of graphs for example, students should be able to make predictions regarding the amount of solute that could be dissolved in a particular solvent. The temperature vs. the amount of solute being dissolved should be highlighted here.

Teachers could demonstrate the use of a hydrometer as an alternative way to calculate solubility.

Teachers should note that the relationship between temperature and solubility is not simple. The solubility of some solutes go down as temperature rises (calcium acetate), whereas the solubility of some others are relatively unaffected by increased temperatures (sodium chloride and calcium carbonate). Other solutes (potassium chloride, sugar) have increased solubility with an increasing temperature.

Working with computer spread sheets would enable students to organize data and to possibly create graphs from which to predict the value of a variable such as the amount of solute in a solvent.
Solutions and Solubility

Tasks for Instruction and/or Assessment

Performance

- Observation checklist for the assessment of the effect of temperature on solubility. (210-9)

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wear property safety equipment.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Follow safety rules.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Safely transfer chemicals.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Uses weight scales properly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Reads and uses glassware properly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Reads and uses thermometers properly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Organizes data collection.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Communicates well with partners.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Journal

- Use a specific example to explain why there is only one manipulated variable (independent) in an experiment but there can be more than one responding (dependent) variable. (209-1)
## Outcomes

Students will be expected to:

- describe qualitatively the factors that affect the solubility of a solid and a gas.

(307-5) Include:

(i) temperature

(ii) pressure

## Elaborations - Strategies for Learning and Teaching

Many students will have had experiences with soft drinks and the effects pressure has on the solubility of carbon dioxide in the water. When students open a bottle or can of pop, the gas solute comes out of solution (that is, its solubility decreases) due to a decrease in pressure. Students could investigate the effect that changing temperature has on the solubility of gases in pop. Many students will have experienced tasting “flat” pop after a bottle of pop is left open for a period of time or is warm. No expectation is made at this point that students be able to explain these processes in terms of the particle theory of matter.

Students should recognize that as temperature increases, the solubility of a solid generally increases and the solubility of a gas generally decreases. Also, as pressure increases, the solubility of a gas generally increases and vice versa.

Students could add this information to their mind map.
### Solutions and Solubility (continued)

#### Tasks for Instruction and/or Assessment

*Performance*

- Design an experiment to determine the mass of a given amount of solute (salt, sugar) that will dissolve at different temperatures. (208-1, 209-1)

- Unit review game. Have students prepare quiz cards containing a multiple choice question and answer. Collect all the cards and randomly choose contestants for a game of “Who Wants to be a Millionaire”. (307-5, 112-7)

- Design an experiment to determine whether a bottle of soda pop will go flat faster in your refrigerator or if left on the counter. Be sure to include a hypothesis, manipulated variable (independent), responding variable (dependent), and at least five controls for this experiment. (209-1)

*Journal*

- How does an increase in temperature usually affect the solubility of: (307-5)
  - a gas in a liquid
  - a solid in a liquid

#### Resources/Notes

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## Separating Mixtures

### Outcomes

**Students will be expected to**

- using apparatus safely, identify and separate the components of a variety of mixtures. (209-6, 307-2)

Include:

(i) mechanical sorting (flotation, magnetism, etc.)
(ii) filtration
(iii) evaporation
(iv) distillation
(v) paper chromatography

- describe how to use different methods to separate a variety of mixtures. Include:

(i) mechanical sorting (flotation, magnetism)
(ii) filtration
(iii) evaporation
(iv) distillation
(v) paper chromatography

### Elaborations - Strategies for Learning and Teaching

Teachers could have students engage in an activity or series of activities in which mixtures are separated. The intent of these activities would be to expose students to different separation techniques and to have them conclude that some techniques which might be successful in some cases may not be successful in others. For example, a coffee filter is used to separate coffee grounds from coffee, but can not be used to separate sugar from water; a magnet could be used to separate iron filings from sand but not salt from sand. This activity will result in the identification of new questions and will lay the groundwork for future concept development relating particle size to the type of mixture. For example, “Are there mixtures that can not be separated?”, “Are there mixtures in and around your home that you do not want separated?”, or “Why can one mixture be separated with a filter while another can not?”

It more important that students focus on the properties of the materials being separated when they describe how to use the various methods. For example, it is not sufficient to have students explain and describe the process of evaporation but rather to understand that it is used as a separation method when parts of the mixture have different boiling points. Likewise, filtration is used when there is a liquid and solid part to the mixture.

Teachers may emphasize that the separation of mixtures occurs in many branches of science. For example, separation techniques can be associated with food science (tea bags), chemistry (water softeners), engineering (oil and gas filters) and life science (bogs, often considered natural filters, remove impurities from water).

Students could add information about separation techniques to their mind maps.
Separating Mixtures

Tasks for Instruction and/or Assessment

Performance

• Observation checklist for assessment of separation of mixtures. (209-6, 307-2)

<table>
<thead>
<tr>
<th></th>
<th>Rarely</th>
<th>2</th>
<th>3</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follows safety rules.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Stays on task.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Carefully observes and records observations.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Distinguishes between inferences and observations.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

• Create a poem/song/rap that explains how or when to use the various techniques of separating mixtures. (307-2)

Paper and Pencil

• How might a person make maple syrup from maple sap without boiling? (307-4)
• Give an example of how some of the methods of separating mixtures are used in everyday life. (307-4)

Journal

• Which of the five methods for separating mixtures do you think is the most widely used at home? Why? (307-2)
**Separating Mixtures (continued)**

### Outcomes

**Students will be expected to**

- identify common separation techniques used to separate the components of a variety of mixtures. (209-6, 307-2). Include:
  
  (i) straining spaghetti in a colander
  
  (ii) skimming fat off soup
  
  (iii) drying clothes (separating water from fabric)
  
  (iv) window screens allowing air in while keeping insects out
  
  (v) making coffee using ground coffee beans

- choose an appropriate separation technique when given a known mixture where students know the identity of the components

### Elaborations - Strategies for Learning and Teaching

Students may not realize how many examples of separating mixtures exist in their home. For example, dust from carpet, water from clothes, rocks from topsoil, cigarette smoke from air. Students could begin by identifying situations where two or more substances are separated. Students could also identify the various devices used for separating mixtures in or around their homes. For example, colanders, cheese cloth, coffee filters, and vacuum cleaners.

Throughout this section, students could generate a bulletin board display of mixtures and how they can be separated. Examples could include separating out sand-size particles from sediment (mechanical sorting), salad spinner removing water from the lettuce (filtration), drying clothes in a dryer (evaporation), refining oil (distillation), and separating ink mixtures (paper chromatography).

Students could research traditional separation techniques such as mesh size in fishing nets, and how Vikings extracted iron from bog at L’Anse aux Meadows. Students could also research modern separation techniques such as the hydromet process which will be used to extract copper, cobalt, and nickel from Voisey’s Bay ore, or the separation of petroleum products from crude oil using fractional distillation.

Students should be able to choose an appropriate separation technique when given the identity of the components of the mixture. Such mixtures may contain three components that would require two different separation techniques. For example, students could be given a mixture of salt, sand and water. Students could be challenged to develop a method to separate unknown mixtures through a trial and error process when the identity of the two components is not known. Students could be given an unknown mixture such as salt and sand. Since the students are unaware of the materials they may choose a separation technique such as magnetism, which they will discover will not work. Now, they must proceed with a trial and error process until they have successfully separated the components of the mixture.

Other separation activities might include using filter-lined funnels for sand and water, boiling or evaporating salt water, and using magnets to separate iron filings and sand (magnets should be put inside a plastic bag to prevent the filings from sticking directly to the magnet surface).

Teachers could ask students to speculate on the efficiency of their separation techniques, and, if appropriate, suggest better alternatives. Teachers could probe students about the composition of the components they have separated by asking: “Are the components you have separated still mixtures, or are they pure? Why or why not?”
## Separating Mixtures (continued)

<table>
<thead>
<tr>
<th>Tasks for Instruction and/or Assessment</th>
<th>Resources/Notes</th>
</tr>
</thead>
</table>

### Performance

- Create a poster or collage that describes the various techniques used to separate mixtures at home or in the work place. (307-2, 209-7)
- Separate the component substances from the following mixtures:
  - sand and water
  - salt water
  - oil and water (109-10)
- Using software, such as Inspiration, create a mind map illustrating separation techniques in the household. (109-10)
- Using a variety of materials, create a device for separating coins. (307-2)

### Presentation

- Prepare a slide show or other multimedia presentation that shows some of the common techniques used to separate mixtures around the home. (307-2)

### Journal

- What is the most important piece of information you need before you choose a separation technique. Explain why it is necessary. (307-2)

### Paper and Pencil

- Describe three methods you could use to separate stray/unwanted leaves from a bucket of blueberries you have just picked. (307-2)
- How would you separate each of the following mixtures?
  - water, salt, marbles
  - sawdust, sand, salt
  - iron filings, broken pencil “leads”, popping corn
- Describe the different separation techniques we use in the home to separate the components of various mixtures. (307-2)
- Describe how you would separate the component substances from the following mixtures:
  - sand and water
  - salt water
  - oil and water (109-10)
Distillation

Outcomes

Students will be expected to

- describe the science underlying a distillation apparatus, using the following terms: boiling, evaporation, condensation. (111-5)

  - define distillation
  - explain how a distillation apparatus is used to separate a solution.
  - describe where boiling, evaporation and condensation occurs in a distillation apparatus.

Elaborations - Strategies for Learning and Teaching

Prior to having students engage in activities using distillation apparatus, teachers should demonstrate the technique of distillation using a commercial distillation apparatus or one they develop themselves.

Students should recognize that the solvent and the solute are separated and both can be reclaimed by the evaporation and the subsequent condensation of the solvent. Some examples of distillation are: (1) separating crude oil, (2) alcohol from water and (3) salt from water.

An additional class demonstration to show a distillation apparatus could involve a tub with 3 cm of dirty water in it (e.g. soil mixed in water). Put a heavy pot in the middle of the tub. Cover the tub with plastic wrap, and put a stone on the wrap so it is positioned directly over the open pot below. The stone will make an indentation on the plastic wrap. Clean water will condense on the plastic wrap and drip down into the pot. Teachers could connect this to real life by indicating that this method will allow a person to extract water from the surrounding air. The method is to use a sheet of plastic or tarp, positioned on four, one metre long sticks. A container is placed in the centre and a rock is put on the centre of the plastic directly over the container. Over night, as the air temperature cools, water will condense from the air and drip down into the container. This will even work in very dry areas such as deserts!

To provide time for processing this information, teachers could have students make a journal entry in which they describe how they distinguish between the terms boiling, evaporation and condensation.
## Distillation

### Tasks for Instruction and/or Assessment

**Performance**

- Given a specific list of materials (i.e., 2 L pop bottles, plastic wrap, styrofoam plate, rocks, etc.) in small groups, design and build a distillation apparatus. Present your results to the class to determine who produces the largest quantity of pure distillate. (111-5)

**Paper/Pencil**

- Given the following materials, write the directions for a survival manual to put together a distillation apparatus. (111-5)
  - cup
  - plastic sheet
  - large bowl
- Draw a distillation apparatus and describe the function of each part from the point of view of the distillation process. (111-5)
- Pretend you are a water particle in a sugar solution about to be separated by a distillation. Describe your voyage from the solution to the distillate. (111-5)

**Journal**

- Describe how you would distinguish between the terms boiling, evaporation, and condensation. (111-5)
Distillation (continued)

Outcomes
Students will be expected to

• carry out procedures controlling the major variables to answer questions arising from practical problems (208-2, 209-1)

• use tools and instruments safely and accurately when carrying out procedures and collecting data. (209-3, 209-6)

• answer new questions that result from the mixture separation activities. (210-16)

• using distillation as an example show how refining and separation techniques have evolved. (109-4)

Elaborations - Strategies for Learning and Teaching

Core Laboratory Activity: Separating Homogeneous Mixtures

The laboratory outcomes 208-2, 209-1, 209-3, 209-6, 210-16 and, in part 307-2 are addressed by completed CORE LAB 9-1C “Separating Homogeneous Mixtures”.

Safety Note: It is recommended that the flask, in the diagram on page 287 of the student textbook, be secured with a clamp and ring stand to prevent accidental spilling of the hot salt solution.

Many of the technologies and techniques associated with the creation and separation of mixtures and solutions have been developed through trial and error.

Students should recognize that simple distillation generally separates a single solute from its solvent, while fractional distillation separates a mixture of liquids based on their varying boiling points. Students could investigate the difference between simple distillation and fractional distillation to come to understand how refining and separation techniques have evolved. A discussion on the use of distillation technology would help students see the connection between science and technology in their everyday environment.

Teachers could mention that most everyday mixtures require chemical and engineering methods in their formation and separation. Students could be asked if they have ever turned on a tap and noticed dirty water. Questions and discussion could focus on ways in which water is made fit for human consumption. This could provide an opportunity to explore students’ understanding of some chemical and engineering techniques used in the separation of mixtures and solutions. Other examples that could be discussed include separating crude oil and extracting minerals from ore.
Distillation (continued)

Tasks for Instruction and/or Assessment

Interview

- What types of mixtures cannot be separated by settling, sifting, filtering, and distillation? Explain why. (210-16)
- Identify potential problems with the separation of mixtures. (210-16)

Presentation

- Working in groups, prepare a slide show that describes:
  1. The separation of mixtures such as iron from its ore, petroleum products from crude oil, or dust particles from air.
  2. The formation of mixtures such as alloys used in jewelry, ice cream, or cement.

  Include a slide of the careers involved in the formation/separation of the mixture. (109-10)

- Make a poster of various mixtures and the industries/services that might be associated with them. (109-10)

Performance

- Conduct research on how the science relating to mixtures and solutions are related to jobs that involve chemistry or engineering.

  Present your findings to the class. (109-10, 112-7)
### Applications of Mixture-Science

#### Outcomes

Students will be expected to

- provide examples of how science, related to mixtures and solutions, affect our lives. (112-7)

- identify some positive and negative effects and intended and unintended consequences of using salt on highways. (113-1)

- describe how our understanding of the properties of solutions has resulted in better road de-icing technologies. (111-1)

- make an informed decision about the use of road salt as our main road de-icing chemical taking into account the environmental, social, and economics advantages and disadvantages. (113-9)

#### Elaborations - Strategies for Learning and Teaching

Students should be encouraged to bring forth and discuss various examples of how the knowledge and use of mixtures and solutions affect our lives. Students could investigate one of the examples discussed and present their findings to the class. Examples could include but are not limited to: sewage treatment, water purification, using solvents to extract stains from clothes, sorting recyclable materials, screening topsoil, smog, or the use of road salt on highways.

Some of these effects may be intentional while others are unintentional. Examples such as the use of road salt on our highways and salt to make ice cream would enable students to see the utility and application of the science involved with mixtures and solutions. Discussing the positive safety aspects of improved driving conditions and the negative effects that salt water solutions have on roadside vegetation, contamination of wells and waterways, and the corrosion of metal in cars would give the students the occasion to bring out the positive and negative effects of using science and technology to solve problems.

The **CORE STSE** component of this unit incorporates a broad range of Grade 7 outcomes. More specifically, it targets (in whole or in part) 111-1, 112-7, 113-1, and 113-9. The STSE component “Would you like salt on that? Improving winter driving conditions with road salt.” can be found in Appendix A.

Students could use the “What? So What? Now What?” format to write a journal entry using what they have learned about de-icing roads technology/methods.

Teachers could cover this CORE STSE by having students research various de-icing methods for roads. This could be expanded to an exploration of de-icing methods used by airlines, how wind shield wash helps keep automobile wind shields from icing up, etc.
Applications of Mixture-Science

Tasks for Instruction and/or Assessment

Journal

• Using the “What”, “So what”, “Now what” method, choose an example of how the science of mixtures and solutions affects us in our daily lives. (112-7)

• An understanding of how to separate the different components of mixtures is important in my daily life because... (117-7, 307-2)

Presentation

• Conduct research on the pros and cons of using salt on roads and present your findings to the class. (111-1, 113-1)

• Present on the alternatives to using salt to de-ice our roads in winter. (111-1, 113-6)

• Create a song, jingle, rap or rant about the use of salt to de-ice our roads in winter. (112-7, 113-6, 113-9)

Paper/Pencil

• Research how different industries separate mixtures, and present your findings to the class using diagrams, pictures, or demonstrations to illustrate, for example, extraction of salt from water, separation of aluminium cans, cardboards, and so forth at a recycling depot. (112-7)

Performance

• Create a brochure illustrating the various separation techniques used in the process of water purification. (112-7)