

Let's Do Science

Grade Five

Classroom Chemistry



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Classroom Chemistry Before You Begin

Students learn about the properties and interactions of some safe to handle household liquids and solids. They test a variety of materials to see what happens when things are mixed together: what dissolves, what reacts and what remains unaffected. They discover that when a solid material dissolves, it can be recovered as a crystal by evaporating the liquid. They also learn that when two materials react to form a new material, the original materials cannot be recovered. As an example of a chemical reaction, students learn to produce carbon dioxide gas and show that this gas differs from ordinary air.

Topic C: Classroom Chemistry

(Suggested time: 6-8 weeks)

This unit can be taught at any time of the year. A number of household items and substances can be used to teach this unit. Safety goggles are needed for some activities and you may want to have children wear “lab coats” (old shirts from home) to protect their clothing. Plan to do the activities in a room where water is available and have ways to confine and easily clean up messes in the classroom. Since teachers will be using common household substances, disposal of the chemicals should not be a problem.

Safety Issues

Ensure that students recognize the household product warning labels before starting this unit. Have students wash hands after handling any chemical product. Teach children to waft one hand to fan odour toward nose rather than put nose directly over chemical.

Background Information

In this unit, we will look at the changes that take place when substances are mixed together or dissolved in solution, and we will distinguish these *changes in form* (physical changes) from the *changes in substance* (chemical changes) that occur during chemical reactions.

At room temperature, substances exist in one of three forms: solid, liquid or gas. These substances can mix in a variety of ways, including two or more solids, a solid and liquid or two or more liquids. When substances mix, one of two things may occur. First, they may intermingle yet retain their original form, identity and specific properties. This is a physical change and the original substances can be recovered. Second, they may change at a molecular level with atoms being redistributed to make entirely new substances. This is a chemical change and it is usually irreversible. We will first take a look at mixtures involving physical change.

Mixtures

There are two types of mixtures—mechanical and solutions.

Mechanical mixture

- Distinct particles are visible so substance is heterogeneous, e.g., salt and sugar, concrete

Solution

- One substance dissolves in another so it looks homogeneous but particles can be separated, e.g., salt water, air

Separating Mechanical Mixtures and Solutions

Two or more solids, for example, salt and sugar. These components can be separated by manually removing one substance, by dissolving one substance through floatation, using sieves if particles are different sizes, or using magnets.

Solid and liquid, for example, sugar and water. If the solid does not dissolve, it is easy to separate by simply pouring off the liquid. If the substance does dissolve (forming a solution) you can use filtration (for example, coffee filter), centrifugation (revolving at a high speed to separate solid, for example, blood samples), sedimentation (allowing heavier particles to settle out over time), or evaporation/crystallization (allow liquid to evaporate leaving solid behind (for example, salt water).

Two or more liquids, for example, water and alcohol. Components can be separated using distillation where one substance is boiled off, leaving the other substances behind, or by density if one liquid floats on top of another.

Crystallization

Let's take a closer look at the process of crystallization. Sugar and many other substances form crystals as they "come out of solution." This can be observed if you dissolve as much sugar as possible in a jar of warm water (water holds more of a substance in solution when it is warm). You will know you have added as much sugar as the solution will take when newly added sugar grains simply sit on the bottom of the jar rather than dissolve. At this point, the solution is said to be *supersaturated*. Now let the water cool to room temperature. As it cools, it can hold less and less of the sugar in the solution, so the excess sugar is deposited in crystalline form at the bottom of the jar. You can also observe crystal development by placing a small amount of supersaturated solution onto a plate and letting it evaporate. The crystals will form on the plate.

Crystals provide a unique "fingerprint" of a substance. They reflect the underlying molecular pattern of the material and, thus, provide an important way of identifying materials, particularly minerals. Just look at the many shapes and colours of crystalline minerals at your local natural history museum!

Interesting Properties of Water

In most solutions, the *solvent* (the substance that dissolves another substance into it) is water. In fact, water is called the universal solvent because, given enough time, there are only a few substances it can't dissolve. These stubborn, water-resistant substances include oils and greases. Substances like detergent *emulsify* oils and greases, transforming them into small droplets that will mix with water.

Detergent also has a unique effect on water. It weakens the "skin" that forms at the boundary between water and air. Look at a drop of water. It appears as though the water is contained within an invisible sack. This is due to *surface tension*, a special property of liquid-gas interfaces that confine liquid to the smallest possible volume. Water has a very high surface tension. Surface tension pulls liquid up the walls of a small-diameter tube—a *capillary tube*. Surface tension is also responsible for the relative absorbency of various materials. The pores of an absorbent material act like innumerable tiny capillary tubes and draw liquid up inside: the larger the number of small pores, the greater the absorbency of the material. Materials like detergents, when added to water, drastically reduce surface tension. Detergent-treated water can't bead into drops, so it doesn't leave ugly spots on dishes when it dries.

Chemical Reactions

Now that we have examined physical changes in form that take place in mixtures and solutions, let's look at changes in substance that take place

during chemical reactions. A *chemical reaction* occurs when two or more substances combine at the molecular level to produce one or more completely different substances. For example, when vinegar is added to baking powder, a gas called carbon dioxide is produced. You can capture this gas and prove it is not air by demonstrating that a flame, which will burn in air, will not burn in carbon dioxide gas. Why is this the case?

Oxygen molecules, which are present in air but absent in carbon dioxide gas, react easily with other substances. In some circumstances this process is slow, as when oxygen reacts with iron to form rust (corrosion). Under other circumstances, the reaction can happen very quickly, releasing energy in the form of heat and light. A good example of this would be burning wood in a fire (combustion). It is an *exothermic reaction*—a reaction that gives off energy. *Endothermic reactions* absorb energy as they proceed. Commercial cold packs are an example of endothermic reactions. Fire is also a spectacular example of an *irreversible chemical reaction*.

Evidence of Chemical Reactions

There are certain types of evidence that let you know a new substance has been formed (a chemical reaction has occurred). However, it is important to distinguish these from similar observations involving physical change.

Evidence of Chemical Change	Not to be confused with...
Temperature change—heat emitted (exothermic) or heat required (endothermic), for example, fire, cold packs	heat energy coming from another source
Colour change—unpredictable change, for example, cabbage juice turns pink in acid	adding colours to obtain a predictable blend
Precipitate—formation of one solid (usually a powder), for example, potassium iodide and lead nitrate form solid potassium nitrate	forming a solid through freezing (state change)
Effervescence—formation of a gas, for example, adding baking soda to vinegar to produce carbon dioxide gas	creating a gas through evaporation (state change)
Odor change—for example, cooking	adding a scent from outside source

Acids and Bases

Some of the most common chemical reactions we see are between acids and bases. These can be distinguished by looking at some characteristic properties or by using indicators which turn different colours in acids and bases.

	Characteristics	Examples	Indicators
Acids	sour taste excess H ⁺ ions neutralize bases	lemon juice vinegar hydrochloric acid	red litmus stays red blue litmus turns red universal paper green to red, cabbage juice turns pink
Bases	bitter taste slippery feel excess OH ⁻ ions neutralize acids	baking soda ammonium household cleaners	red litmus turns blue blue litmus stays blue universal paper green to blue, cabbage juice turns yellow

The relative strength of acids and bases are measured using a logarithmic pH scale (potential hydrogen). On this scale (see Fig. 1) neutral is found in the middle (pH 7). Solution with pH < 7 are acidic while pH > 7 indicates a base.

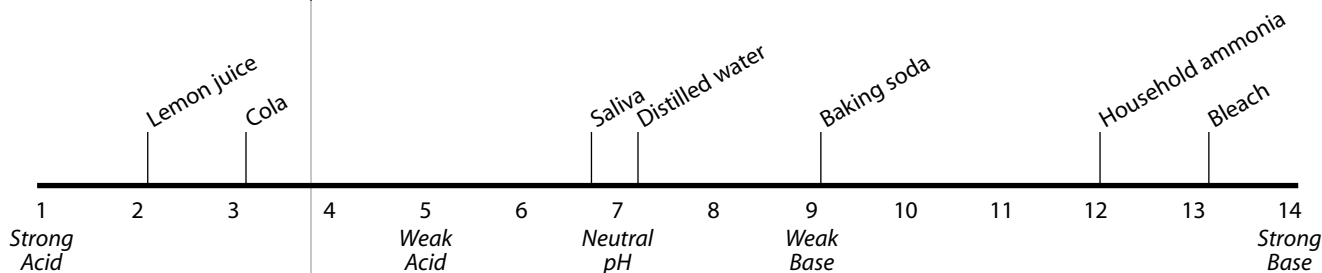


Figure 1. The pH scale.

Elementary Science Program of Studies

General and Specific Learner Expectations

The following general and specific learner expectations have been taken directly from the 1996 Elementary Science Program of Studies. The specific learner expectations (SLEs) are referred to by number in the second column of the activities table.

General Learner Expectation

Students will be able to:

Describe the properties and interactions of various household liquids and solids, and interpret their interactions.

Specific Learner Expectations

Students will be able to:

1. Recognize and identify examples of the following kinds of mixtures:
 - two or more solids; e.g., sand, sugar
 - a solid and a liquid; e.g., sugar, water
 - two or more liquids; e.g., milk, tea
2. Apply and evaluate a variety of techniques for separating different materials.
3. Distinguish substances that will dissolve in a liquid from those that will not, and demonstrate a way of recovering a material from solution.
4. Demonstrate a procedure for making a crystal.
5. Recognize that the surface of water has distinctive properties, and describe the interaction of water with other liquids and solids.
6. Produce carbon dioxide gas through the interaction of solids and liquids and demonstrate that it is different from air.
7. Distinguish reversible and irreversible changes of materials and give examples of each.
8. Recognize and describe evidence of a chemical reaction. Explain how the products of a reaction differ from the original substances.
9. Use an indicator to identify a solution as being acidic or basic.

Cross-curricular Connections

Art

- Make gelatin ornaments and invisible ink.
- Create rubbings of a variety of crystals grown in the classroom.

Health

- Analyze foods and reactions resulting from mixing substances.

Children's Alternative Frameworks

Mathematics

- Geometric solids (looking at different crystal forms).
- Balance neutralization reactions (positive, negative integers).

Language Arts

- *Explorations in Science, Explore!* student book, Levels 5 and 6.
- *Innovations in Science, Process and Inquiry*, student book, Levels 5 and 6.
- create a poem that will serve as a memory cue for components of the pH scale.

Children have some misconceptions about matter. These include:

- gases are not matter because they are invisible and therefore must not have mass;
- chemical changes are additive, rather than interactive;
- reactants remain even though they are changed;
- oil is more dense than water because it is thicker; and
- air and oxygen are the same.

Activities

Classroom teachers have identified the following activities that may be done to address the Specific Learner Expectations (SLEs) in the Program of Studies. The list is not prescriptive and teachers may select activities that are most appropriate for their students.

Activities have been listed under two headings: Key Activities and Extension Activities. Key activities are supported by authorized resources and identify “powerful and practical” means for achieving learner expectations. Extension activities represent alternative ways of achieving or supporting learner expectations.

Key Activities

Key Activity	SLE	Print Resources	Essential Materials	Comments
Investigating the mixing of solids and liquids	1, 2, 3, 7	<i>Explorations in Science, Level 5, Stir It Up! (Free Exploration)</i> , p. 7 <i>Explorations in Science, Level 5, Stir It Up! (Stir Stir)</i> , p. 10; include <i>Extending the Activity</i> <i>Innovations in Science, Level 5, Chemistry Kaleidoscope (Mix It Up!)</i> , p. 8	sand, flour, sugar, salt, baking soda, cornstarch, coffee, jars or plastic cups, spoons, water, paper towels	Use this activity as a springboard for discussing what students already know about chemicals and solutions. Have students develop concept maps and work together to list questions that can be explored through the unit.
Investigating ways to separate two solids	1, 2, 3	<i>Explorations in Science, Level 5, Stir It Up! (Sand/Salt Shake)</i> , p. 28 <i>FOSS: Mixtures and Solutions (Lawrence Hall of Science) Activity 1 (Separating Mixtures)</i>	jars, water, salt, sand, spoons, filters	
Investigating solutions and solubility	1, 3, 7	<i>Innovations in Science, Level 5, Chemistry Kaleidoscope (Mix It Up)</i> , p. 8 <i>Explorations in Science, Level 5, Stir It Up! (Sweet Stir)</i> , p. 13 <i>FOSS: Mixtures and Solutions (Lawrence Hall of Science) Activity 3 (Concentration)</i>	sugar, salt, flour, vegetable oil, tea, milk, etc., two different kinds of hard candy, water, measuring cups and spoons, stir sticks or spoons, timing devices different types of sugar, coffee, jars, spoons, thermometers, measuring cup, Popsicle sticks, magnifying lenses, stopwatch, water	

Key Activity	SLE	Print Resources	Essential Materials	Comments
Comparing water to other liquids	5	<p><i>Explorations in Science, Level 6, Water Works (Looking at Liquids)</i>, p. 26</p> <p><i>Innovations in Science, Level 5, Waterworld (Do You Know Water?)</i>, p. 8</p>	<p>clear liquids (water, rubbing alcohol, vinegar, corn syrup, cooking oil, etc.), various sizes of clear containers, eye droppers, straws, dishes</p> <p>chart paper, coloured markers, clear and colourless liquids, plates and containers, plastic knives, rulers or tape measure, water, ice cubes, self-closing sandwich bags</p>	
Exploring the surface tension of water and other liquids	5	<p><i>Explorations in Science, Level 6, Water Works (A Tense Situation!)</i>, p. 20</p> <p><i>Explorations in Science, Level 6, Water Works (Testing Tension)</i>, p. 22</p> <p><i>Explorations in Science, Level 6, Water Works (Sticky Streams)</i>, p. 23</p>	<p>shallow dishes, 1-L containers, pepper, liquid detergent, water supply bucket, paper towels</p> <p>pennies, eye droppers, small containers of assorted liquids the students wish to test</p> <p>containers and empty detergent bottles filled with water, oil and syrup, empty milk cartons, large open containers, nails, modelling clay, water supply, sink, safety goggles</p>	Review safety procedures for dealing with liquids.
Investigating the use of yeast and sugar to produce carbon dioxide gas	6, 8	<p><i>Innovations in Science, Level 5, Chemistry Kaleidoscope (Rise Up)</i>, p. 28</p> <p><i>Explorations in Science, Level 5, Stir It Up! (Yeast the Beast)</i>, p. 25</p>	sugar, yeast, clear plastic cups, water, ice, kettle or pot	Caution: Hot water must be handled with care.

Key Activity	SLE	Print Resources	Essential Materials	Comments
Investigating various chemical reactions that produce gases	6, 7, 8	<i>Explorations in Science, Level 5, Stir It Up! (Blowing Up the Bag)</i> , p. 21	sandwich-size Ziploc bags, baking soda, vinegar, measuring spoons and cups	
		<i>Explorations in Science, Level 5, Stir It Up! (Dancers)</i> , p. 22	jars, water, vinegar, baking soda, raisins, corn kernels, measuring spoons, measuring cup, magnifying lenses	
		<i>Innovations in Science, Level 5, Chemistry Kaleidoscope (It's a Real Gas)</i> , p. 24 <i>FOSS: Mixtures and Solutions (Lawrence Hall of Science) Activity 4 (Fizz Quiz)</i>	pennies, vinegar, baking soda, raisins or rice, tall clear glass, plastic wash tub, liquid detergent, food colouring, water, clear plastic bags, plastic cups, twist ties, measuring spoons and cups	
Making and testing a chemical product	8	<i>Innovations in Science, Level 5, Chemistry Kaleidoscope (Chemistry at Work)</i> , p. 40	materials vary for each recipe. See p. 40, 41.	Students can create a class recipe book for all of the things they have created that involve a chemical reaction.
		<i>Explorations in Science, Level 5, Stir It Up! (Friendly Cleaners)</i> , p. 27	cloth container, baking soda, vinegar, water, measuring spoon	
Making indicators to identify solutions as acidic or basic	9	<i>Innovations in Science, Level 5, Chemistry Kaleidoscope (The Definite Difference)</i> , p. 19	red cabbages (1/4 cabbage per group), graters, sauce pans, hot water, wooden spoons, strainers, large beakers or pitchers, clear plastic cups or clear plastic film canisters, variety of liquids and powders for testing (e.g., tap water, dish detergent, vinegar, Milk of Magnesia, skim milk, tonic water, rain water, salt, sugar, etc.), medicine droppers, measuring spoons, stir sticks or spoons	<p>Schedule two classes on consecutive days: day 1 to discuss how to prepare indicators and what household substances to test, and day 2 to do the activity.</p> <p>Indicator recipe: boil red cabbage in small amount of water for 10 minutes. Strain, cool and refrigerate.</p> <p>Caution: Do not allow students to test potentially dangerous substances.</p> <p>Litmus or pH paper can be used if available.</p>

Key Activity	SLE	Print Resources	Essential Materials	Comments
Making indicators to identify solutions as acidic or basic (cont'd)		<p><i>Explorations in Science, Level 5, Stir It Up! (Wash It Out)</i>, p. 20</p> <p><i>Explorations in Science, Level 5, Stir It Up! (In the Pink and in the Yellow)</i>, p. 18</p>	<p>additional test materials could be used, such as baking soda, baking powder, lemon juice, window cleaner, distilled water, shampoo, toothpaste, clear pop, soda water, etc.</p> <p>shampoo samples, clear film or pill canisters, water, eye droppers, indicator (red cabbage juice), pH chart</p> <p>clear small jars or film canisters, water, measuring spoons, eye droppers, red cabbage, safe substances for testing</p>	
Exploring saturated solutions and making crystals	1, 3, 4	<p><i>Explorations in Science, Level 5, Stir It Up! (Dissolve a Substance)</i>, p. 12; include <i>Extending the Activity</i></p> <p><i>Explorations in Science, Level 5, Rock Solid (Crystal Clear)</i>, p. 17</p> <p><i>Explorations in Science, Level 5, Rock Solid (Do They Grow Up or Down?)</i>, p. 19</p> <p><i>Explorations in Science, Level 5, Rock Solid (Growing a Better Crystal!)</i>, p. 20</p> <p><i>FOSS: Mixtures and Solutions (Lawrence Hall of Science) Activity 2 (Reaching Saturation)</i></p>	<p>salt, water, measuring cup, spoons, jars or plastic cups, sugar, Epsom salts, thermometers</p> <p>clear jar, string, Popsicle sticks, paper clips, kettle, sugar, magnifying lenses, food colouring (optional)</p> <p>Epsom salts, baby food jars, cotton string, kettle, water, shallow container, small weights, paper</p> <p>containers of various sizes, alum, salt, sugar, pickling salt, water, kettle</p>	

Extension Activities

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Exploring the properties of water and the three states of matter	1, 5	<i>Explorations in Science, Level 6, Water Works (What a State!),</i> p. 10	beaker, thermometer, candle or hot plate, ice cubes, graph paper	This activity will allow teachers to determine what students know about water and states of matter.
Exploring chemical reactions	1, 7, 8	<i>Innovations in Science, Level 5, Chemistry Kaleidoscope, Activity Card 54: On the Rise</i>	oven, 250 mL flour, 250 mL cornmeal, 80 mL sugar, 15 mL baking powder, 25 mL salt, 250 mL milk, 80 mL cooking oil, 1 egg	Use caution around the oven.
		<i>Innovations in Science, Level 5, Chemistry Kaleidoscope, Activity Card 55: Colour Watch</i>	a variety of fruits: apple, banana, etc.	To avoid wasting the fruit, a fruit shake could be made after the experiment.
		<i>Innovations in Science, Level 5, Acid Ink, Activity Card 51</i>	tea bags, steel wool, jar, vinegar, boiling water	Hot water must be handled carefully, preferably by an adult.
Mixing liquids together to make mayonnaise	1, 7, 8	<i>Innovations in Science, Level 5, Chemistry Kaleidoscope, (Secret Agents),</i> p. 15	pie plates or wide flat dishes, 0.5 L milk, green, yellow and red food colouring, liquid dish detergent, vegetable oil, water, large clear glass jars with lids, lemon juice, salt, dry mustard, eggs, small airtight jars or equivalent containers	If students wish to take the mayonnaise home, they may bring most of the ingredients. They should be warned to immediately refrigerate this product since it can “go bad” very quickly.
Using distillation to clean polluted water	2, 3	<i>Explorations in Science, Level 6, Water Works (Recycled Water),</i> p. 14	clear plastic bags, paper cups, string, twist ties, salt, muddy water	
Exploring thixotropic mixtures (emulsions or concentrated suspensions)	1, 7	<i>Innovations in Science, Level 5, Chemistry Kaleidoscope (Through Thick and Thin),</i> p. 12	warm water, cornstarch, bowls or plastic containers, wooden spoons, coins or metal washers	

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Doing a household chemical search and looking at chemical safety			drawing paper, pencils and other drawing materials	Students search through their house for chemicals and, after creating a map of the house, identify on the map where the various chemicals were found. This could be done as a homework assignment (perhaps with parents), and the results of the search could be shared with the class.
Cleaning up oil spills	1, 7	<i>Explorations in Science, Level 5, Into the Deep (Oil and Water)</i> , p. 308	tubs of water, vegetable oil, materials identified by students	Teachers could take this opportunity to look at environmental issues and the chemicals involved, e.g., greenhouse effect—carbon dioxide; acid rain—oxides of nitrogen and sulfur; hole in the ozone (O ₃) layer—chlorofluorocarbons.
Exploring the density of liquids	1, 5	<i>Explorations in Science, Level 6, Water Works (Discovering Density)</i> , p. 25	clear liquids such as water, rubbing alcohol, vinegar, corn syrup, cooking oil, etc., various sizes of clear containers, eye droppers, straws, dishes, an assortment of objects such as grapes, pieces of plastic, corks	This is a good time to dispel the common misconception that thicker liquids (for example, oil) are more dense than thinner, less viscous liquids.
Testing for the presence of limestone in rocks	6	<i>Explorations in Science, Level 5, Rock Solid (Does It Bubble and Fizz?)</i> , p. 16	limestone, vinegar, lemon juice, streak plate, seashell, hammer, steel file, small dishes	
Mixing acid with steel wool to create a usable ink	5	<i>Innovations in Science, Level 6, Acid Ink</i> , Activity Card 51	tea bags, steel wool, jar, vinegar, boiling water	Hot water must be handled carefully—preferably by an adult.
Using water to determine the volume of objects		<i>Explorations in Science, Level 6, Water Works (Detecting Displacement)</i> , p. 16	graduated cylinders or measuring cups, water, bucket, paper towels, an assortment of waterproof irregularly shaped objects to measure	As an enrichment activity, have students calculate the density of objects. Density = $\frac{\text{mass}}{\text{volume}}$

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Determining the best amount of water to make jelly		<i>Explorations in Science, Level 5, Stir It Up! (Jelly Mold), p. 15</i>	jelly crystals, boiled water, cups or containers, measuring spoons and cups, Popsicle sticks	Adult supervision when pouring hot water into containers.
Exploring chemistry and foods	6	<i>Explorations in Science, Level 5, Stir It Up! (Pop Makers), p. 23</i>	lemons, juicer, knife, sugar, baking soda, water, glasses, measuring cups and spoons	
		<i>Explorations in Science, Level 5, Stir It Up! (Soda Bread), p. 24</i>	recipe for bread and ingredients, measuring spoons and cups, bowls, mixing spoon, pie plate	
		<i>Explorations in Science, Level 5, Stir It Up! (Yeast the Beast), p. 25</i>	yeast, sugar, water, measuring cups and spoons, Ziploc bags, magnifying lenses	
Researching chemistry careers		<i>Explorations in Science, Level 5, Stir It Up! (Chemistry Careers), p. 29</i>	as required	

Assessment

For a broader discussion of science classroom assessment techniques see *Assessing Student Learning* in the introduction of this publication on p. 15. Good places to begin looking for the unit-related ideas are *Explorations in Science* assessment handbooks, *Innovations in Science* teaching notes, Unit tests and Portfolio ideas, Alberta Education sample tests at www.education.gov.ab.ca and Alberta Assessment Consortium at www.aac.ab.ca

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