SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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SCOPE, SEQUENCE, and COORDINATION

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National Science Education Standard—Physical Science
Structure and Properties of Matter

Matter, as found in nature, consists primarily of mixtures, compounds, and elements in various proportions. The observable properties of mixtures depend upon the nature of the components. A mixture can be separted into pure substances using the characteristic properties of the substances contained in the mixture.

Teacher Materials

Learning Sequence Item:

930

Recognition and Classification of Mixtures

March 1996
Adapted by: *Dorothy Gabel*

Mixtures, Elements, and Compounds. Students should recognize solutions as mixtures and classify mixtures as heterogeneous or homogeneous (gas, liquid, and solid solutions). They should be able to separate mixtures into purer substances by a variety of processes, such as chromatography, distillation, and crystallization. Students should also observe that properties of mixtues vary with relative proportions (percent by mass) of the components. (Chemistry, A Framework for High School Science Education, p.51.)

Contents

This micro-unit was adapted by **Dorothy Gabel** (Indiana University, Bloomington)

930

Learning Sequence

Mixtures, Elements, and Compounds. Students should recognize solutions as mixtures and classify mixtures as heterogeneous or homogeneous (gas, liquid, and solid solutions). They should be able to separate mixtures into purer substances by a variety of processes, such as chromatography, distillation, and crystallization. Students should also observe that properties of mixtues vary with relative proportions (percent by mass) of the components. (Chemistry, A Framework for High School Science Education, p.51.)

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
Margarine: The Best Value **Lab Activity 1**	Distillation **Assessment 5**	Mixtures **Assessment 4**	
Ink: A Single Substance? **Lab Activity 2**	Solar Still **Assessment 11**	Tap Water **Assessment 12**	
Purifying Seawater **Lab Activity 3**			
Solving the Mystery **Lab Activity 4**			
Separating Plant Pigments **Lab Activity 5**			
Melting Ice **Lab Activity 6**			
Crystals from Solutions **Lab Activity 7**			
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Solvents **Assessment 1**			
Saturated Solutions **Assessment 2**			
Solubility of a Gas **Assessment 3**			
Seawater **Assessment 6**			
Solubility of a Gas **Assessment 7**			
Saturated Solutions **Assessment 8**			
Paper Chromatography **Assessment 9**			
Heterogeneous Mixtures **Assessment 10**			
Tap Water **Assessment 12**			

Suggested Sequence of Events

Event #1

Lab Activities

1. Margarine: The Best Value?
2. Ink: A Single Substance
3. Purifying Seawater

Each of these activities uses a different separation technique. Each takes about one hour.

Alternative or Additional Experiments:

4. Solving the Mystery
5. Separating Plant Pigments

Event #2

Lab Activities

6. Melting Ice
7. Crystals from Solutions
8. Separating Mixtures

In the first two activities, mass composition is related to properties. The third summarizes concepts and techniques.

Event #3

Readings from Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science

Suggested readings:

Asimov, Isaac, "Crystallograhy." *Asimov's Chronology of Science and Discovery*, p. 1781. New York: Harper & Row, 1989. Permission pending.

Asimov, Isaac, "Paper Chromatography." *Asimov's Chronology of Science and Discovery*, p. 550. New York: Harper & Row, 1989. Permission pending.

Asimov, Isaac, "Distilled Liquor." *Asimov's Chronology of Science and Discovery*, p. 1304. New York: Harper & Row, 1989. Permission pending.

Assessment items are at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple-choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.

2. Open-ended questions asking for essay reponses.

3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Science as Inquiry

Margarine: The Best Value

Is margarine one substance or a mixture of substances?
If it is a mixture, which is best?

Materials:

3 sticks of very cold margarine (regular, 100%; light, < 100%; and extra light, << 100%), preferably all of the same brand (per class)
3 splints
1 roll of waxed paper (per class)
1 butter or cheese cutter (per class)
1 ruler
3 medium test tubes (20 mL minimum)
1 250 mL beaker
1 heating source (burner, ring stand and gauze or hot plate)
1 cooler containing ice
water

Overview:

Three different types of margarine are heated in test tubes placed in a water bath until they melt. A visual comparison of the three tests will indicate whether margarine is one substance or a mixture. Students compare the contents of the three tubes quantitatively by measuring the heights of the components, and using cost comparisons and other information, decide which is of greatest value.

Procedure:

Before class the margarine is cut into pats of equal volume using a butter cutter or a cheese cutter, and individual pats are placed on waxed paper. The margarine must be kept very cold or students will have difficulty getting it into the test tubes. It will help considerably if the margarine is stored in an ice chest and students get the pieces right before they add them to their test tubes.

The teacher needs to record the cost of each type of margarine, have the boxes of the different types available for later examination by the students, and know how many slices are cut from a single stick.

Students add a piece of margarine of each variety to individual test tubes and force them to the bottom of the tube using a splint. They then place about 100 mL of water in a 250 mL beaker, place the test tubes containing the margarine in the water bath, and warm the water until the margarine melts. They should then measure the heights of each component in the three test tubes and record the data.

Given the relative volume of the pat (fractional part of the stick) and the cost per pound of each kind of margarine, students calculate the real cost of the margarine per pound. They then examine the labels and compare their results to that on the package. They decide if each kind of margarine is of equal value considering both cost and other dietary factors.

Background:

This activity demonstrates that all kinds of margarine, even though appearing to be homogeneous, contain in some cases three or more substances. Margarine is a good example of a mixture that appears homogeneous to the naked eye (macroscopic level) but is not homogeneous on the particle level and is therefore not a solution. To be a true solution, individual molecules do not clump together and are randomly scattered throughout the solvent. A true solid solution would be an alloy. For example, brass is a mixture of copper and zinc in various proportions, the atoms of each element being evenly distributed throughout the crystal structure. Because students do not see the different flecks of the individual substances in margarine, such as in an obviously heterogeneous mixture like salt mixed with pepper, they may classify the margarine inappropriately as a solution.

Another example that you may wish to use with students either here or in Activity 3 (the separation of seawater) is the composition of milk. It appears that homogenized milk is homogeneous, but it isn't. If it were, powered milk would dissolve in water to produce a clear solution. It is cloudy because particles sticking together are of sufficient size to reflect light. Hence it is classified as a heterogeneous mixture.

Because there are three states of matter, and these three states can be homogeneously mixed with one another, nine solutions result. The solute (lesser of the two substances) ordinarily takes the state of the solvent. An example of each type of solution is given as follows:

Solute	**Solvent**	**Example**
solid	solid	brass (copper and zinc)
liquid	solid	amalgam (mercury and silver)
gas	solid	hydrogen on platinum
solid	liquid	sugar in water
liquid	liquid	rubbing alcohol (water added)
gas	liquid	soft drinks (carbon dioxide)
solid	gas	sulfur in atmosphere
liquid	gas	water vapor in atmosphere
gas	gas	air (nitrogen, oxygen, +++)

Students should use the information provided from measuring heights of the margarines to determine the relative percentage of the entire pound of each kind of margarine. They can then compare this to the percentage given on the label. Using this information they can calculate the cost of a pound of the margarine without the water. They can then discuss the value of purchasing the various kinds of margarine in terms of convenience, health, calories consumed, and budget.

Even the 100 percent margarine is not one substance because the fat (if there is only one) has been mixed with a dye. The ingredient panel will list the substances present in each type.

Adapted by D. Gable (Indiana University) from:
Powerful Ideas in Physics. College Park, Maryland: AAPT, 1994.

Science as Inquiry

Ink: A Single Substance?

Is ink one substance or a mixture of substances?
Can inks from different pens be identified using chromatography?

Materials:

1 set of 8 felt-tip water soluble markers of various colors, preferably of the same brand (per class)
1 600 mL beaker
1 piece chromatography or filter paper (10 cm x 20 cm)
1 roll of plastic wrap (per class)
1 rubber band
1 ruler
1 25 mL graduated cylinder
1 pencil
1 stapler (per class)
rubbing alcohol (25 mL per group)

Overview:

The various color inks from felt-tipped pens are placed on chromatography paper which is then placed in rubbing alcohol. Most or all of the inks then separate into the substances of which they are composed, indicating that they are mixtures. A spot on the paper made by the teacher from two pens is identified using the chromatogram.

Procedure:

Students measure 25 mL of rubbing alcohol and pour it into a 600 mL beaker and cover this with a piece of plastic wrap using a rubber band. This allows the vapors to fill the beaker, and more uniform results are obtained.

With a pencil, students make a line 1 cm from the bottom along the length of the paper with a pencil. They then make small dots about 1.5 cm apart along the line, over which they will place a small dot of the ink from each pen. They make one extra dot. Students mark each dot with the initials of the color of the pen for identification purposes. These dots should be small, about 2 mm in diameter. The teacher takes two pens and superimposes the inks on the extra dot the student made (out of view of the student) and records this information for later use.

After placing the spots of ink from each pen on the paper, the paper is then carefully rolled into a cylinder by touching only the top and bottom edges and stapled so that the two ends do not overlap but yet are held by two staples. The spots should be on the outside of the cylinder.

The cylinder is placed in the beaker with the rubbing alcohol, covered with the plastic wrap, and allowed to stand until the ink travels to about 2 cm from the top of the paper. It is then removed and allowed to dry (30 to 40 minutes).

Students examine the data, and using the chromatogram, identify what two pens the teacher used to make the unknown dot.

Background:

This activity demonstrates that most inks are a mixture of various dyes. They can be separated by chromatography because substances of different molecular weights will travel up the paper at different rates, the lighter weight ones moving more quickly.

For best results use chromatography rather than filter paper for this activity. Before class, cut the paper into 10 cm x 20 cm pieces, being careful to touch the paper only on the edges. The water soluble Flair® pens appear to work well. You will need to try out the pens in advance of the class to determine if there are sufficient colors in the inks to make the activity interesting. Challenging students to identify an unknown that you have placed on their papers makes the activity more exciting and requires making inferences and solving problems. Both the colors and the position of the colors in the column resulting from the dot from each pen are critical in identifying the pens used for the "unknown." You may need to discuss this and illustrate how the mixing of colors in the same position may result in a new color (such as yellow and blue producing green).

To save student time (but incur more teacher time) the 10 cm x 20 cm papers could be lined and marked with the "unknowns" in advance. These could be numbered and distributed to students.

Care must also be taken that students use the appropriate volume of rubbing alcohol. If too much is used, and the dots of ink are not above the top of the liquid, they will dissolve directly in the alcohol and not move up the paper.

Further Variation:

Students can be asked to make a prediction using their chromatogram of inks from two pens that they superimpose on a blank sheet of chromatography paper. Students could make a prediction of the resultant chromatogram with crayons or pastel felt-tip pens. You could prepare a 10 cm x 20 cm paper in advance with pencil dots for several students' predictions and pass it around the room. Students make a spot from two pens and place their initials under the spot they have made. You then develop the papers, return the appropriate portion to each student, and students determine how well they can make predictions.

Adapted by D. Gable (Indiana University) from:
Gabel, D., *Introductory Science Skills*, Prospect Heights, Ill.: Waveland Press, 1993.

Teacher Sheet

Science as Inquiry

Purifying Seawater

How can the salt from seawater be removed?

Materials:

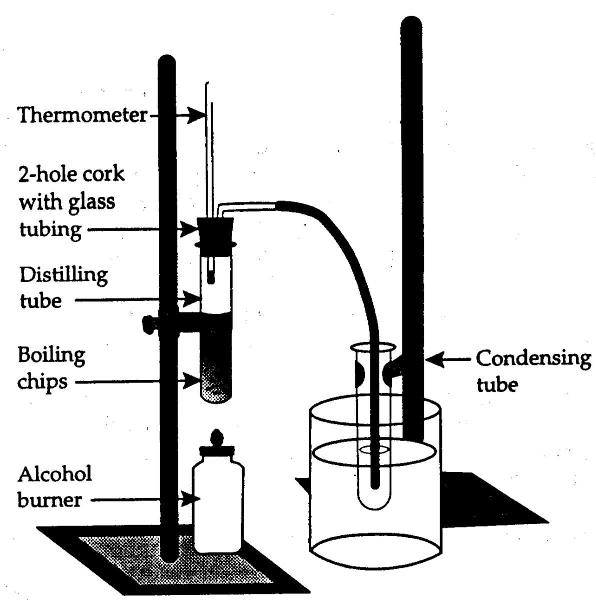
1 distillation apparatus using the test tube arrangement as shown in the figure (or substitute a condenser)
1 Bunsen burner or alcohol burner
2 large test tube (40 mL or larger)
1 400—600 mL beaker or other container
1 thermometer
1 ring stand
2 test tube clamps
1 rubber or plastic hose
1 100 mL graduated cylinder
3 boiling chips
cold water or ice
25 mL saltwater solution (3.5% by mass)

Overview:

Seawater contains about 3.5% salt plus many organisms and other solid matter. In this activity simulated seawater will be distilled to separate the water from the salt and other materials.

Procedure:

Prepare seawater by dissolving 3.5 grams of sodium chloride in 96.5 g of water. Other solid substances, such as small wood chips, could be added. Students measure 25 mL of the seawater and place it in a test tube that is attached to the distillation apparatus as shown in the figure. The thermometer and right angle bend should be inserted in the stopper by the teacher outside of class. Students add three boiling chips to the seawater before inserting the stopper. After placing the collecting tube in the ice water bath, students heat the water until almost all of the water has boiled into the collecting vessel. They should note the temperature at various points during the distillation. Students then remove the tubing from the collection vessel and turn off the burner.



Background:

This activity demonstrates that dissolved and undissolved solids can be separated from liquids by distillation. In this case, the energy to distill the water is either the burning of alcohol or natural gas. In countries that depend on the desalination of seawater to supply drinking water for their citizens, the use of these natural fuels would be too expensive. Instead, solar energy is used.

Distillation can be used for separations when the solute is nonvolatile, or in the case of liquids, when the liquids being separated have different boiling points. This is the case in the refining of crude oil by fractional distillation, and in the production of alcoholic beverages.

Further Variation:

This experiment could be done more quantitatively by having students collect and record the temperature of the system every half minute for the duration of the activity. They could then graph the data making a temperature versus time curve. They would then note that the boiling point of water was 100°C.

Students could also be asked to devise a way to separate the salt from the seawater using solar energy.

Adapted by D. Gable (Indiana University) from:
Gabel, D., *Introductory Science Skills,* Prospect Heights, Ill.: Waveland Press, 1993.

an alternative/extension activity for Event 1

Teacher Sheet

Science as Inquiry

Solving the Mystery

Is ink one substance or a mixture of substances?
Can inks from different black pens be distinguished using chromatography?

Materials:

5 different black felt-tip water soluble markers (per class)
1 600 mL beaker
1 piece chromatography or filter paper (10 cm x 20 cm)
1 piece of filter paper with a mystery mark
1 roll of plastic wrap (per class)
1 rubber band
1 ruler
1 25 mL graduated cylinder
1 pencil
1 stapler (per class)
rubbing alcohol (25 mL per group)

Overview:

The black ink from felt-tipped pens from various manufacturers is placed on filter paper, which is then placed in rubbing alcohol. Most or all of the inks from the different pens then separate into the substances of which they are composed, indicating that they are mixtures. Because black inks from different manufacturers are frequently composed of different substances, they can be distinguished from one another and used to identify the ink from an unknown pen. This information can be used to solve the mystery of which student wrote the love note.

Procedure:

Students measure 25 mL of rubbing alcohol and pour it into a 600 mL beaker, covering this with a piece of plastic wrap and securing with a rubber band. This allows the vapors to fill the beaker, and more uniform results are obtained.

With a pencil, students make a line 1 cm from the bottom along the length of the paper. They then make a series of small dots about 1.5 cm apart along the line, over which they will place a small dot of the ink from each pen. Students mark each dot with the initials of the manufacturer of the pen for identification purposes. These dots should be small, about 2 mm in diameter. The teacher takes another sheet of paper and marks a dot from one of the five pens for each student in the class, keeping a record of which pen was used to mark each student's paper.

After placing the spots of ink from each pen on the paper, the paper is then carefully rolled into a cylinder by touching only the top and bottom edges, and stapled so that the two ends do not overlap yet are held by two staples. The spots should be on the outside of the cylinder.

The cylinder is placed in the beaker with the rubbing alcohol, covered with the plastic wrap, and allowed to stand until the ink travels to about 2 cm from the top of the paper. It is then removed and allowed to dry (30 to 40 minutes). The process is repeated with the paper containing the "unknown" pen.

Students examine the data, and using the chromatogram, identify who wrote the love note.

Background:

This activity demonstrates that most inks are a mixture of various dyes. They can be separated by chromatography because substances of different molecular weights will travel up the paper at different rates, the lighter weight ones moving more quickly.

For best results use chromatography paper rather than filter paper for this activity. Before class, cut the paper into 10 cm x 20 cm pieces, being careful to touch the paper only on the edges. You will need to try out the pens in advance of the class to determine if there are sufficient differences in the colors of the inks to make the activity interesting. Challenging students to identify a mystery ink makes the activity more exciting and requires making inferences and solving problems. Both the colors and the position of the colors in the column resulting from the dot from each pen are critical in identifying the pens used for the "unknown." You may need to discuss this and illustrate how the mixing of colors in the same position may result in a new color (such as yellow and blue producing green).

The teacher makes a marking of three x's at the bottom of another piece of filter paper for each student or group keeping a record of the pens used.

Care must also be taken that students use the appropriate volume of rubbing alcohol. If too much is used, and the dots of ink are not above the top of the liquid, they will dissolve directly in the alcohol and not move up the paper.

Adapted by D. Gable (Indiana University) from:
Barrow, L.H., Litherland, R., and Jackson, L., "Crime-lab Chromatography." *Science Scope*, May 1995.

an alternative/extension activity for Event 1

Teacher Sheet

Science as Inquiry

Separating Plant Pigments

Is the green color in plant leaves one substance or a mixture of substances?
Can the green color be separated using chromatography?

Materials:

green leaves from a variety of trees
3 100 mL beakers
1 piece filter paper (15 cm to 18 cm in diameter)
1 25 mL graduated cylinder
1 funnel
1 250 mL beaker for ice bath
1 crucible and pestle
1 toothpick
rubbing alcohol (50 mL per group)
acetone
scissors

Overview:

The chlorophyll is extracted from the leaves of various trees and placed on filter paper which is then placed in acetone. Observations are made to determine if the extracted color from the leaves separates into various components.

Procedure:

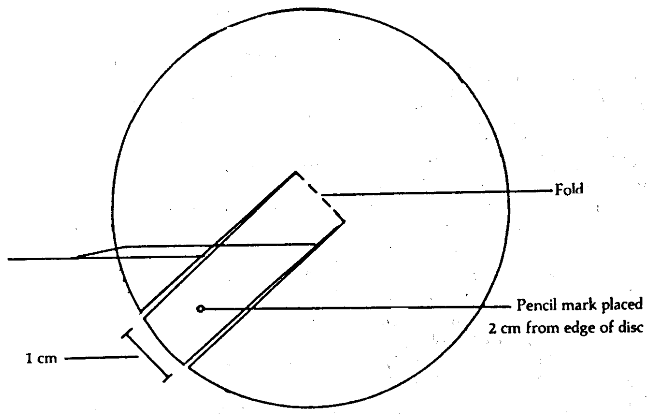
Students measure 50 mL of rubbing alcohol and pour it into a 100 mL beaker which is placed in a hot water bath and heated until the alcohol is near boiling. *Students should be careful not to heat the alcohol directly with an open flame because it is very flammable.*

To extract the chlorophyll from the leaves, students cut up several leaves and place them in a crucible. They transfer the hot alcohol into the crucible and grind with a pestle until the alcohol becomes dark green.

The mixture is filtered into a 100 mL beaker that has been placed in an ice bath and cooled until the dark green solution reaches room temperature.

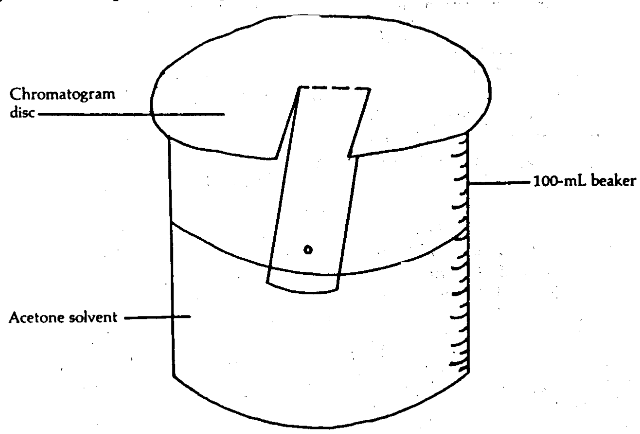
A round filter paper is prepared for use in making the chromatogram by cutting a strip 1 cm in width from the circumference to the center. This strip, which is still attached to the filter paper, will be used to contain the dot of chlorophyll that you will place about 2 cm from the bottom. Use a toothpick to place the dot. Students allow this dot to dry and superimpose successive dots on the original spot until it becomes a very dark green.

Figure 1. Leaf Pigment Chromatogram Disc



To develop the chromatogram, students bend the strip so that it is at right angles with the rest of the circular paper. Acetone is added to a clean 100 mL beaker until it is below the spot but above the tip of the strip when the circular paper rests on top of the beaker. The paper is placed on top of the beaker as shown in the figure, and students observe what occurs as the acetone travels up the strip.

Figure 2. Development Set-up for Leaf Pigment Chromatogram Disc



Background:

This activity demonstrates that most chlorophyll is a mixture of at least five different substances because five different colored regions appear on the chromatogram. These are: carotene (yellow-orange); xanthophylls I and II (yellow-green); carotenes and xanthophylls combined (light green); chlorophyll a (dark green); and chlorophyll b (blue green).

Adapted by D. Gable (Indiana University) from:
Scharmann, L.C., " Autumn leaf chromatography," *Science and Children,* September, 1984.

Teacher Sheet

Science as Inquiry

Melting Ice

Which salt makes the best solution for melting ice?

Materials:

1 Bunsen burner or alcohol burner
2 large test tubes (30 mL or larger)
2 stoppers to fit test tubes
2 spoons/spatulas for salts
2 stirring rods
1 400—600 mL beaker or other container
2 thermometers
1 ring stand
1 25 mL graduated cylinder
4 boiling chips
cold water or ice
sodium chloride, 25 g
calcium chloride, anhydrous, powered, 25 g
balance (nearest gram)

Overview:

Salt is sometimes thrown on roads during the winter to melt the ice. Various salts can be used. Which is the better salt to use—sodium chloride or calcium chloride? To find out, students prepare percent by mass solutions of each salt and note differences in solubility, boiling point, and freezing behavior.

Procedure:

Have students make a 10% solution by mass of sodium chloride in water at room temperature. In the second test tube, they should make a 10% solution of calcium chloride, also in water at room temperature. They should continue to add measured quantities of the salts to the test tubes until the solutions are saturated, noting any changes in temperature during the dissolution process. From the data, they calculate the percentage compositions of the solutions at each addition. They should then place the solutions in a hot water bath and heat them to about 50ºC. They continue adding salt, increasing the concentration by 10% at each step until saturated. The solutions are boiled and the boiling temperature noted. Solutions are then cooled by placing them in a freezer overnight. Once frozen, they are melted in cold water, and the order in which they melt is noted.

Background:

This activity provides an opportunity for students to prepare concentrated solutions of various percent composition. It illustrates that the boiling and freezing points of solutions are dependent on the solvent and on the nature of the substance dissolved (although a discussion of ions would be inappropriate here).

Calcium chloride melts ice more effectively than sodium chloride for two reasons. First, it produces more ions per gram on dissolution than sodium chloride, and second, it produces more heat when it dissolves. (For the calcium chloride, three ions are produced for every two of the sodium chloride. It is also more soluble than sodium chloride at 0ºC. When these two factors are considered in combination with the molecular mass of each salt, calcium chloride is 1.3 times more effective than sodium chloride).

The molal freezing point depression (1.86ºC) and boiling point elevation (0.52ºC) depend on the molality of the solution. Although this topic is too complex for most students in grade nine to understand in a mathematical way, it could be presented qualitatively, explaining that as more particles are added to a solution, the more they interfere with the crystal lattice formation of the solid ice and the vaporization of the water at the boiling point.

In preparing the solutions using mass percentage, students will begin with 1 g of salt and dissolve it in 9 g (mL) of water to make a 10% solution. Using this same test tube, when an additional 1 g is added, the per cent concentration becomes 2 g salt/11 g solution or 18%. To make a 20% solution, students would calculate the mass of the salt needed as follows:

$$\frac{X \text{ (g salt)}}{X \text{ (g salt)} + 9 \text{ g water}} = .20$$

$$X = 1.8 \text{ g} + 0.2\, X$$
$$0.8\, X = 1.8 \text{ g}$$
$$X = 2.25 \text{ g}$$

Created by D. Gable (Indiana University)

Teacher Sheet

Science as Inquiry

Crystals from Solutions

Do all salts look the same under a microscope?

Materials:

1 Bunsen burner or alcohol burner
1 250 mL beaker
1 spoon for salt
1 stirring rod
1 ring stand
1 250 mL graduated cylinder
1 wire gauze
1 watch glass
2 microscope slides
1 mortar and pestle
hydrated copper sulfate
alum
potassium sulfate
ammonium ferric sulfate
epsom salts
sodium ferrocynanide
table salt
kosher salt
1 balance (nearest gram)
1 microscope (low power)

Overview:

After comparing the shapes of large and small sodium chloride crystals, students prepare and compare crystals of other salts.

Procedure:

Students first observe the shape of small (table salt) and large (kosher salt) crystals of sodium chloride by placing several grains of each on a microscope slide and viewing them through a microscope.

Next students will prepare other crystals by making saturated solutions and allowing the solution to evaporate in the beaker overnight, or by heating a smaller quantity on a watch glass. Another alternative is to place a small quantity of the solution on a microscope slide that can be projected to the class. As the solution cools, the crystals will appear. All of these methods will achieve the same effect. Some students may have had the experience of growing crystals in elementary school science or for a science fair project.

To prepare the saturated solution, take the quantity of solid suggested, grind using a mortar and pestle if necessary, and dissolve in 30 mL of hot distilled water.

Salt	Formula	Quantity
alum	$Kal(SO_4)_2 \cdot 12H_2O$	5g
copper sulfate	$CuSO_4 \cdot 5H_2O$	6g
potassium sulfate	K_2SO4	5g
ammonium ferric sulfate	$(NH_4Fe(SO_4)_2 \cdot 12H_2O$	40g
sodium ferrocyanide	$Na_4Fe(CN)_6 \cdot 10H_2O$	10g
magnesium sulfate	$MgSO_4$	14g

Background:

Students will observe sodium chloride (table salt and kosher salt) crystals through a microscope, noting their cubic shape. Although the shape of crystals does not provide direct evidence for the existence of atoms, the explanation that crystals are made of layers of atoms in different arrangements that keep building in the same order does explain the difference in shapes and volumes of crystals.

The smallest repeating unit of atoms in a crystal is called its unit cell. There are seven different basic shapes for unit cells, resulting in seven crystal systems. These include cubic, tetragonal, orthorhombic, monoclinic, hexagonal, rhombohedral, and triclinic. Within these unit cells, different arrangements of atoms are possible. For example, within a cubic unit cell atoms can be arranged as simple cubic, body-centered cubic and face-centered cubic. Crystals have many important uses due to their unique properties.

For more in-depth coverage of this topic, the following book is recommended: Ellis, A.B., Geselbracht, M.J., Johnson, B.J., Lisensky, G.C. and Robinson, W.R.(1993). *Teaching General Chemistry*. Washington, DC: The American Chemical Society.

Created by D. Gable (Indiana University)

Teacher Sheet

Science as Inquiry

Separating Mixtures

What method can be used to separate different kinds of mixtures?

Materials:

1 Bunsen burner or alcohol burner
1 250 mL beaker
2 test tubes (25 mL capacity)
1 spoon for each material
1 stirring rod
1 ring stand
1 25 mL graduated cylinder
1 wire gauze
1 watch glass
1 mortar and pestle
1 funnel
1 distillation apparatus
1 magnet
filter paper
screens of various mesh cut into 10 cm squares
chromatography paper cut in 20 cm x 10 cm pieces
rubbing alcohol
boiling chips
iron filings
sulfur
table salt
copper sulfate
Kool-Aid®
gravel
sand
chalk (calcium carbonate)
sugar

Overview:

Given a list of materials that form mixtures, students determine the properties used to separate them, and identify a method of separation. They then perform one of the separations.

Procedure:

Students first complete the sheet indicating the properties on which they would base their separation, and identify the method of separation based on the property. They then select one mixture and separate it.

The teacher may wish to assign particular separations to different students to make certain that all are performed or that too much duplication does not occur.

Separations will include techniques used previously, such as distillation and chromatography, and others such as use of a magnet and filtration followed by evaporation.

Background:

This lab is primarily a review of separation techniques performed in earlier activities or in the elementary school (filtration, screening, and use of a magnet).

Adapted by D. Gable (Indiana University) from a worksheet in:
Classification of Matter, Tampa: M.L. Educational, 1990.

Science as Inquiry

Solvents

Item:
Why is the statement “Water is the solvent in any solution” not always true? List at least three examples to support your answer.

Justification:

Answer:
"Water is the solvent in any solution" is not always true because all substances are not water soluble. Grease will dissolve in dry cleaning fluid but not in water. In this case, dry cleaning fluid is the solvent. Iodine will dissolve in alcohol but not in water. In this case, alcohol is the solvent. All solutions are not solutions of liquids. There are gaseous solutions and solid solutions. In each case, water is not a part of the solution; therefore, it cannot always be the solvent.

Science as Inquiry

Saturated Solutions

Item:
At constant temperature, what effect would the addition of additional crystals of a salt have on a saturated aqueous solution of the same salt?

A. It would dissolve and the solution would become supersaturated.
B. It would float on top, because the solution is too dense and will not allow the salt to dissolve.
C. It would cause all of the salt to precipitate out of the water.
D. Salt would precipitate out of the water in an equal amount to the amount added.

Justification:
Explain: What happens to the salt in a saturated solution as the water evaporates?

Answer:
D. The salt will precipitate out of the solution.

Science as Inquiry

Solubility of a Gas

Item:
In general terms, the solubility of a gas in water:

A. increases as the temperature of water increases
B. is independent of the temperature of the water
C. increases with an increase in pressure of the gas over the water
D. is independent of both temperature and pressure

Justification:
Explain why carbonated soft drinks that have been left opened for a period of time have a tendency to go “flat.”

Answer:
When the container is opened, the carbon dioxide will escape from the liquid at the reduced pressure. As the drink loses its carbonation, it will seem to become “flat.”

Science in Personal and
Social Perspectives

Mixtures

Item:
You need to explain to a class of sixth grade students that substances that they find in their homes can be single substances, or heterogeneous or homogeneous mixtures. To help them understand, you plan to have them carefully observe various single substances and then prepare different types of mixtures. Each student should be asked to make one heterogeneous and one homogeneous mixture.

You have the following different substances: balloons, carbon dioxide from exhaled air, water, salt, different colors of modeling clay, sugar.

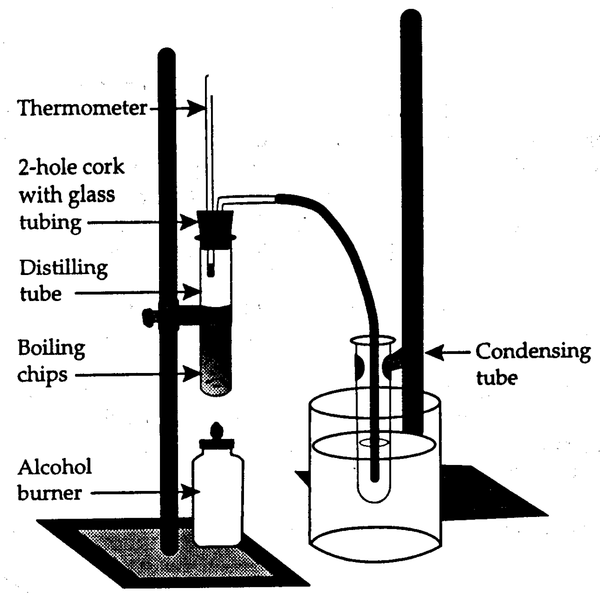
Write a set of directions for the students. Prepare a handout that will explain how observations can tell them which category a substance belongs to. Prepare a key that lists every possible combination of the binary (two-substance) mixtures students could make and what the classifications would be. Test your instructions and keys by carrying out the experiment yourself, recording all the results as if you had not seen the experiment before. Comment on how well it works.

Suggest two other substances that could be added to make the demonstration more interesting.

Science and Technology

Distillation

Item:
In certain parts of the world, fresh drinking water is in short supply. One method of meeting the ever increasing demand for fresh water is to remove the salt from ocean water. This process is called desalination.



Looking at the design for distillation shown above, design an improved method of distillation using similar equipment. Examine your design for ***safety*** and have it approved by your teacher.

How are you going to decide how effective it is?

When you know how you are going to test it, carry out the test and prepare a brief report.

What about your design seemed to work best?

Evaluate your design as compared to others. Decide which is the best design and explain why you think it works better.

Science as Inquiry

Seawater

Item:
There is current interest in seawater as a potential source of fresh water as well as salt if the fresh water and salt can be separated out in an affordable way. Which of the following classifications would you assign to seawater?

A. element
B. compound
C. mixture
D. polymer

Justification:
If you were successful in obtaining pure water from the salt water, which classification would you assign to the pure water? Explain your decision.

Answer:
An element is composed of a single type of atom; a compound is formed when two or more kinds of atoms bind together chemically in fixed proportions; a mixture can be separated into pure substances without resorting to any chemical processes; a polymer has a highly organized structure of chains or rings in repeating units throughout the substance. Seawater has no such overall structure, so the correct choice is C.

Science as Inquiry

Saturated Solutions

Item:

Jacobus van't Hoff, Nobel prize winner in chemistry, studied the behaviors of solutions. One type of solution involves a solid, such as salt, dissolved in a liquid, such as water. At constant temperature, what effect would the addition of additional crystals of a salt have on a saturated aqueous solution of the same salt?

A. It would dissolve and the solution would become supersaturated.
B. It would float on top, because the solution is too dense and will not allow the salt to dissolve.
C. It would cause all of the salt to precipitate out of the water.
D. The salt crystals would appear not to dissolve, but would sink to the bottom of the solution.

Justification:

What would you expect to happen in a cup of hot coffee or tea that is saturated with sugar as the solution cools down to room temperature?

Answer:

The correct choice is D. The sugar will precipitate out of the solution as the temperature of the water decreases.

Science as Inquiry

Paper Chromatography

Item:

It is obvious that there are many different colors, or pigments, seen in plants. Describe how the technique of paper chromatography provides evidence for differences between the pigments found in different plants.

Science as Inquiry

Heterogeneous Mixtures

Item:
Which of the following is a heterogeneous mixture?

A. brass
B. soda water
C. sea water
D. granite

Justification:
Are all of the above substances mixtures? For those that are, give at least two main components, and explain why the three you did not choose are homogenous.

Answer:
"D" is the answer. "A" is copper and zinc in a homogenous alloy; "B" is carbon dioxide and water (or, perhaps sugar if a “soda”; "C" is water and salts, but students might answer algae, seaweed, sand, mud, etc.m, are included (the stem doesn’t say filtered, so this could be correct; "D" is a mixture of minerals (including silicates, mica, etc.) and is very observably heterogeneous.

Science and Technology

Solar Still

Item:

You have been shipwrecked on a small island where there seems to be enough food to survive for a while, but it doesn't seem to rain, and there are no streams or other signs of fresh water. You have salvaged a few items, including some plastic raincoats, and a bucket and a drinking cup. The sun shines a lot, but trees give you shade when you need it. Answer the following questions:

1. Why do you need fresh water? What is wrong with drinking ocean water?

2. Draw up a diagram and instructions as to how you could make some fresh water given the above circumstances.

3. Explain the scientific principles by which the method you propose would work.

Answer:

A solar still can be built with a plastic sheet to hold water on hot sand, with another above it sloped to catch, condensate, and drain the evaporated water into a drinking cup. The top sheet could be cooled with a trickle of sea water on top, if needed, although clever use of sun and shade might be proposed. The explanation should include evaporation and condensation steps.

Science as Inquiry/
Science in Personal and
Social Perspectives

Tap Water

Item:

The water from the kitchen faucet can be classified as a pure substance or a mixture. Which do you think it is? What evidence can you give to support your answer? How would your answer affect the water's desirability for the following uses? Explain why.

A. as drinking water
B. in a steam iron
C. in a car battery

How could you make water "pure" if you determined that it wasn't?

Answers:

Tap water is a mixture since the water contains dissolved salts and air. Evidence includes watching it in a glass (bubbles often form) or boiling a vessel dry and observing a residue of salts.

A. Actually drinking water needs to contain salts for our health (also distilled water tastes terrible!).

B. Pure water is helpful because residues aren't left. However, pure water is more corrosive to alumi num parts, and so some steam iron manufacturers ***recommend*** tap water!!

C. Pure water is better for topping up batteries, so salts don't get added unnecessarily. However, some students may know about "sealed" batteries that never get topped up that are now very popular, so they may miss this one!

Methods for water purification include distillation, deionization, and charcoal filters (for gases and organics).