

SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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SS&C Research and Development Center

Bill G. Aldridge, *Principal Investigator
and Project Director**
Dorothy L. Gabel, *Co-Principal Investigator*
Erma M. Anderson, *Associate Project Director*
Stephen Druger, *Project Associate for
Micro-Unit Development*
Nancy Erwin, *Project Editor*
Rick McGolerick, *Project Coordinator*

Evaluation Center

Frances Lawrenz, *Center Director*
Doug Huffman, *Associate Director*
Wayne Welch, *Consultant*
University of Minnesota, 612.625.2046

Houston SS&C Materials Development and Coordination Center

Linda W. Crow, *Center Director*
Godrej H. Sethna, *School Coordinator*
Martha S. Young, *Senior Production Editor*
Yerga Keflemariam, *Administrative Assistant*
Baylor College of Medicine, 713.798.6880

Houston School Sites and Lead Teachers

Jefferson Davis H.S., Lois Range
Lee H.S., Thomas Goldsbury
Jack Yates H.S., Diane Schranck

California Coordination Center

Tom Hinojosa, *Center Coordinator*
Santa Clara, Calif., 408.244.3080

California School Sites and Lead Teachers

Sherman Indian H.S., Mary Yarger
Sacramento H.S., Brian Jacobs

Iowa Coordination Center

Robert Yager, *Center Director*
Keith Lippincott, *School Coordinator*
University of Iowa, 319.335.1189

Iowa School Sites and Lead Teachers

Pleasant Valley H.S., William Roberts
North Scott H.S., Mike Brown

North Carolina Coordination Center

Charles Coble, *Center Co-Director*
Jessie Jones, *School Coordinator*
East Carolina University, 919.328.6172

North Carolina School Sites and Lead Teachers

Tarboro H.S., Ernestine Smith
Northside H.S., Glenda Burrus

Puerto Rico Coordination Center**

Manuel Gomez, *Center Co-Director*
Acenet Bernacet, *Center Co-Director*
University of Puerto Rico, 809.765.5170

Puerto Rico School Site

UPR Lab H.S.

* * * * *

Pilot Sites

Site Coordinator and Lead Teacher
Fox Lane H.S., New York, Arthur Eisenkraft
Georgetown Day School, Washington, D.C.,
William George
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* Western NSTA Office, 894 Discovery Court, Henderson, Nevada 89014, 702.436.6685

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National Science Education Standards—Physical Science; Earth and Space

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 separated into pure substances using the characteristic properties of the substances contained in the mixture.

Energy in the Earth System

The outward transfer of Earth's internal heat drives convection circulation in the mantle that propels the plates comprising Earth's surface across the face of the globe.

Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

Teacher Materials

Learning Sequence Item:

910

Density Studies of the Earth

September 1996

Adapted by: Dorothy Gabel

(a) Mixtures, Elements and Compounds: Empirical Laws and Kinetic Theory. Students should determine the mass and volume of solids, liquids, and gases and develop the concept of density as a characteristic property. They should distinguish pure substances from mixtures as matter that has a single set of characteristic properties, including boiling point, freezing point, density, solubility, viscosity, and conductivity (*Chemistry, A Framework for High School Science Education*, p. 51).

(b) Convection in Earth's Mantle, Atmosphere, and Oceans: Sources and Effects. Much of the evidence supporting plate tectonics is connected to other areas of science. Some density studies could be conducted in grade nine to support later development of the model of Earth's interior (*Earth and Space Sciences, A Framework for High School Science Education*, p. 138).

Contents

Matrix

Suggested Sequence of Events

Lab Activities

1. Why Does It Float or Sink?
2. Are Density and Viscosity Related?
3. Do All Gases Have the Same Density?
4. Identifying Plastics Using Density
5. Separating Liquids Using Boiling Points
6. Melting Ice

Assessments

1. Location Boiling Temperature
2. Gold Density
3. Mass/Density Calculation
4. Freezing Point Change
5. Mystery Coins
6. Honey
7. Properties of Matter/Phase Changes
8. Determining the Density of a Liquid

910

Learning Sequence

(a) **Mixtures, Elements and Compounds: Empirical Laws and Kinetic Theory.** Students should determine the mass and volume of solids, liquids, and gases and develop the concept of density as a characteristic property. They should distinguish pure substances from mixtures as matter that has a single set of characteristic properties, including boiling point, freezing point, density, solubility, viscosity, and conductivity (*Chemistry, A Framework for High School Science Education, p. 51*).

(b) **Convection in Earth's Mantle, Atmosphere, and Oceans: Sources and Effects.** Much of the evidence supporting plate tectonics is connected to other areas of science. Some density studies could be conducted in grade nine to support later development of the model of Earth's interior (*Earth and Space Sciences, A Framework for High School Science Education, p. 138*).

| Science as Inquiry | Science and Technology | Science in Personal and Social Perspectives | History and Nature of Science |
|--|--|--|-------------------------------|
| <p>Why Does It Float or Sink? Activity 1</p> <p>Are Density and Viscosity Related? Activity 2</p> <p>Do All Gases Have the Same Density? Activity 3</p> <p>Separating Liquids Using Boiling Points Activity 5</p> <p>Location Boiling Temperature Assessment 1</p> <p>Gold Density Assessment 2</p> <p>Mass/Density Calculation Assessment 3</p> <p>Mystery Coins Assessment 5</p> <p>Honey Assessment 6</p> <p>Properties of Matter/Phase Changes Assessment 7</p> <p>Determining the Density of a Liquid Assessment 8</p> | <p>Gold Density Assessment 2</p> <p>Freezing Point Change Assessment 4</p> <p>Distillation of Alcohol Reading 2</p> | <p>Identifying Plastics Using Density Activity 4</p> <p>Melting Ice Activity 6</p> <p>Honey Assessment 6</p> <p>The Soap That Floats Reading 1</p> | |

Suggested Sequence of Events

Event #1

Lab Activities

1. Why Does It Float or Sink? (1 hour)
2. Are Density and Viscosity Related? (40 minutes)
3. Do All Gases Have the Same Density? (30 minutes)

Alternate or Additional Experiment for Activity 1

4. Identifying Plastics Using Density (45 minutes)

Event #2

Lab Activities

5. Separating Liquids Using Boiling Points (1 hour)
6. Melting Ice (45 minutes)

Event #3

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

The following readings are included in the student version of the unit:

- Reading 1 The Soap That Floats
Reading 2 Distillation of Alcohol

Assessment items can be found 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 responses.
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

Why Does It Float or Sink?**What happens when a can of cola is placed in water, alcohol, or saltwater?****Overview:**

Cans of diet cola and regular cola are placed in containers of water, rubbing alcohol, and saltwater to see if they sink or float. Students measure differences in densities of the two colas and in the densities of the three liquids in which they are placed.

Materials:**Per lab group:**

cola (diet), 1 bottle
cola (regular), same brand as diet cola, 1 bottle
graduated cylinder, 25 mL
metal shears
balance (to the nearest 0.1 g) (per group or class)
water
graph paper

Per class:

soft drink bottles, 2-liter with upper fourth of the plastic removed
and calibrated in 100-mL divisions up to 1800 mL, 6
rubbing alcohol, 400 mL
saturated saltwater solution, 400 mL
graduated cylinder, 1000 mL

Procedure:

Place 400 mL of each of the three liquids in the cut-off, calibrated soft drink bottles. Then demonstrate to the class the placement of the two different colas in these liquids. This needs to be carefully done so that air bubbles beneath the cans are eliminated. The higher the percentage of isopropyl alcohol in the rubbing alcohol, the more distinctive will be the results. Students can be asked to predict the outcome. They are then directed to explain the results, based on their qualitative and quantitative observations, by obtaining the densities of the entire system and all parts of the system. This includes the rubbing alcohol, water, saltwater, diet cola, regular cola, diet can, and regular can.

Densities include the four solids (regular can, diet can, regular-can system, diet-can system) and the five liquids mentioned above. To save time, it is suggested that the teacher obtain the densities of the metal cans (this can be done by cutting up the cans and using water displacement). Groups of students can then obtain the density of one of the systems and one of the liquids.

Students obtain the densities of the cola-can systems by obtaining the mass of each unopened can to the nearest 0.1 g and the volume by water displacement by carefully lowering the can into a 1000-mL graduated cylinder containing 400 mL of water. By dividing mass by volume, the density of each system can be obtained.

The density of the three floating/sinking liquids and also the colas can be obtained by measuring the mass of several volumes of the liquid assigned to each group and making a graph of mass versus volume. A discussion of why the slope of the graph is a better way of determining density than simply using one value, or even an average of values obtained by several groups of students, would be profitable for students.

By comparing group data, conclusions about the relationship between the floating/sinking solutions and the cola-can systems can be made. The differences between the diet and regular colas' densities will explain the differences in the cola-can systems.

Background:

This activity develops students' understanding of density as a characteristic property. In addition, students come to understand that when the density of an object is greater than the density of the liquid in which it is placed, it will sink, and when less, it will float.

In all cases, the volume is obtained by water displacement. Students could obtain the volume of the can-system by multiplying the area of the base by the height. Some students might try this as a check on measuring it by water displacement. After the mass is determined, the density is obtained by multiplying mass by volume.

An ideal way for students to obtain the density of the liquids is to obtain the mass of successive portions and then graph mass versus volume. By drawing the best-fit line, and then taking the slope of the line, density values are likely to contain fewer errors than by simply taking the mean. This would be an excellent application from mathematics, as slope is commonly taught or reviewed during freshmen algebra.

The density of the liquids will vary according to the percent composition and can be calculated. This might be a useful exercise for students. Isopropyl alcohol has a density of 0.78 g/mL, water 1.00 g/mL, and saturated saltwater 1.3 g/mL. Because artificial sweeteners have about 1000 times the sweetening power of ordinary sugar, diet cola is less dense than regular cola.

Although you could give students the exact procedure to follow for this activity, it is relatively simple and students might be asked to come up with their own procedures for obtaining the masses and volumes.

Making a chart on the board containing mass, volume, and density for each material in the experiment may help explain student errors in collecting the data or in arithmetic and graphing. Students have been known to read the volume of the cola off the bottle and to assume that this is the volume of the can-system.

Adapted from:

AAPT, *Powerful Ideas in Physical Science*. College Park, Md., 1994.

Science as Inquiry

Are Density and Viscosity Related?**Do liquids that are viscous (thick) have a greater mass than liquids of lower viscosity?****Overview:**

In this activity the densities of four colored liquids are tested by forming layers of the liquids in a straw and noting the four distinct colors that indicate they are floating on top of one another. Students obtain the relative viscosities by noting how quickly the liquids run down a piece of waxed paper (or some other way). Comparisons are then made between the densities and the viscosities.

Materials:**Per lab group:**

glycerin, 50 mL
rubbing alcohol, 50 mL
saturated saltwater solution, 50 mL
oil (vegetable or mineral), 50 mL
clay
clear straws cut in half
pipettes (Beral work well)
waxed paper
food coloring

Procedure:

Before class, color the liquids so that students can see distinctive layers when they have completed the activity. Students identify the liquids by color rather than by name. They determine the relative densities by dropping about 2 cm of various liquids into half of a clear straw, which has been sealed on one end by sticking it into a piece of modeling clay that rests on a piece of paper. If the straw is at about a 45 degree angle to the desk and a Beral pipette is used, the liquid goes into the straw quite easily. By trial and error (hopefully in a systematic way), students determine the order of the four liquids by noting which do not pass through others and which together produce a column of four distinctive colors. The most dense is at the bottom of the column.

Students should then come up with a method by which they can determine the relative viscosity or thickness of each of the four liquids. They may suggest stirring, making puddles of equal volume and seeing which spreads most, or letting liquids run down waxed paper that has been placed at a slight angle. They then compare the relative viscosities with the relative densities.

Background:

This activity helps students distinguish between viscosity and density. You might think that they would know this because they have seen oil slicks indicating that thick oil floats on the more dense water. However, many do not make these connections unless it is made explicit to them.

The viscosity of a liquid, a measure of its resistance to flow, can be due to intermolecular forces. These frequently arise from hydrogen bonding. In the case of glycerin, its structure has three OH groups, which form hydrogen bonds with other glycerin molecules. Molecular complexity also leads to higher viscosity. For example, gasoline, which is nonviscous, contains chains of 5 to 10 carbon atoms. However, in molecules of grease these chains become much longer (22–27 carbon atoms), and the tangling of these chains is thought to cause the increased viscosity.

Density also depends to some degree on intermolecular bonding. However, the mass of individual atoms and the closeness of the molecules or atoms in the liquid or solid states will determine density.

Adapted from:

AAPT, *Powerful Ideas in Physical Science*. College Park, Md., 1994.

Science as Inquiry

Do All Gases Have the Same Density?**How does the density of carbon dioxide compare to that of air?****Overview:**

Two empty balloons are counterbalanced on the pans of an equal-arm balance. Air is blown into one balloon and carbon dioxide into the other until they are visually equal in volume to one another. The difference in mass represents the mass of the carbon dioxide. Its density is calculated after determining the volume of the balloon.

Materials:**Per group:**

tube (fire-polished glass or plastic), 10–12 cm long
one-holed rubber stoppers to fit glass and flask, 2
small balloons of equal capacity, 2
equal-arm balance (0.01 g)
source of carbon dioxide (dry ice; or chalk and
0.1 M hydrochloric acid with thistle tube)
plastic Erlenmeyer flask, 260 mL
metric measuring tape
graduated cylinder (1-liter) or graduated beaker (2-liter)
tongs

Procedure:

Students place two small balloons of the same capacity on the pans of the balance and add masses until they balance. They then blow air into one balloon and seal it by knotting the end. They fill another balloon with carbon dioxide until it is of the same approximate volume as the balloon with air. Masses are added to the appropriate pan until it balances. The difference in mass represents the mass of the carbon dioxide.

Students should then devise a way of determining the volume of the balloon. This can be done by measuring the circumference and using it to calculate volume. Another approach is to use water displacement by sinking the balloon in a wide 1000-mL graduated cylinder or graduated two-liter beaker containing water. Students then calculate the density using the mass and volume measurements and compare it to the density of solid carbon dioxide (dry ice).

Background:

The easiest way to collect carbon dioxide is to place about 50 mL of water in a plastic Erlenmeyer flask and, using tongs, drop a small piece of dry ice into the water. Place the stopper assembly on top of the flask while holding the balloon on the rubber stopper (see figure). You might generate all of the carbon dioxide by this method and help fill the balloons of students at the lecture table.

Alternate ways of producing carbon dioxide are to obtain a demonstration cylinder containing it or to generate it using a thistle tube assembly and pouring dilute hydrochloric acid onto chalk covered with a small quantity of water (to cover the bottom of the stem of the thistle tube).

The difference in the mass of the two balloons represents the mass of the volume of the carbon dioxide. The mass of the air in the other balloon compensates for the buoyancy effect.

The volume of the balloon can be obtained by measuring the diameter of the balloon using a metric tape measure. For example, if the circumference measures 22.0 cm, this is substituted in the formula:

$$\begin{aligned} C &= 2\pi r \\ 22.0 \text{ cm} &= 2 \times 3.14 r \\ r &= 22.0 \text{ cm}/6.28 \\ r &= 3.50 \text{ cm} \end{aligned}$$

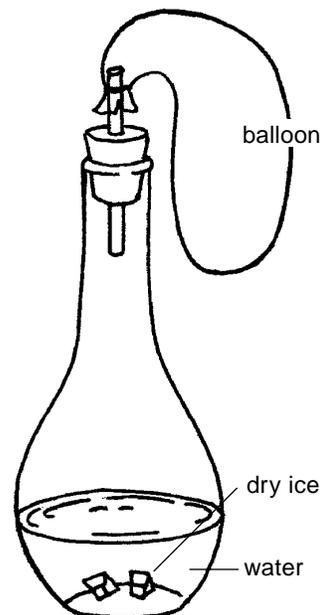
To calculate the volume, the formula for the volume of a sphere is used:

$$\begin{aligned} V &= 4/3\pi r^3 \\ V &= 1.33 \times 3.14 (3.50 \text{ cm})^3 \\ V &= 179 \text{ cm}^3 \end{aligned}$$

If the mass was 0.35 g, then:

$$\begin{aligned} D &= 0.35 \text{ g}/179 \text{ mL} \\ D &= 0.00195 \text{ g/mL} \end{aligned}$$

The density of solid carbon dioxide is 1.10 g/mL at -37°C . Therefore, the solid is 1.10/00195 g/mL or 564 times more dense!



Adapted from:

Gabel, D., *Introductory Science Skills*. Prospect Heights, Ill.: Waveland Press, 1993.

alternative/extension activity for Activity 1

*Teacher Sheet*Science in Personal
and Social Perspectives**Identifying Plastics Using Density****How can plastics be identified using density?****Overview:**

In this activity students determine the relative densities of seven different types of plastics according to the way they sink or float in various liquids. By calculating the exact density of each, they can then categorize an unknown plastic according to one of the types.

Materials**Per lab group:**

vegetable oil, 100 mL
rubbing alcohol, 100 mL
glycerin, 100 mL
water, 100 mL
plastics identified according to types 1–7, 4 pieces of each type
plastic cups to hold the liquids, 4
scissors
plastic unidentified by type, 1 piece
graduated cylinder, 25–100 mL
balance (0.1 g)

Procedure:

Students obtain four pieces of each of the seven types of plastics. The four liquids are poured into plastic cups, and students then drop in samples of plastics 1–7 and record whether they sink or float. Data are organized into chart form indicating the behavior of each of the plastics. Students then obtain an unidentified piece of plastic that the teacher provides. These unidentified pieces are numbered, and the teacher knows which number corresponds to each of the seven plastics. Students identify the plastic by its behavior in the liquids.

In addition to obtaining the relative densities by sinking and floating behavior, students can also calculate density by obtaining the mass and volume of a given sample. The plastic of a given number can be cut into several pieces so the sample will fit into a graduated cylinder and the volume of the sample obtained by volume displacement. The density is then calculated by dividing mass by volume.

Students can be asked to bring in samples of as many different forms of plastic (of the types 1–7) that they can find to expand the list of examples of the various types.

Background:

This activity shows students a practical use for density while simultaneously emphasizing density as a characteristic property. Plastics are coded according to type. The accompanying chart gives the type with examples and chemical formulas.

| Code | Type | Example | Monomer |
|------|----------------------------|----------------------|--|
| 1 | polyethylene terephthalate | soft drink bottles | $\text{OOC-C}_6\text{H}_4\text{-COOCH}_2\text{CH}_2$ |
| 2 | high-density polyethylene | milk bottles | $\text{CH}_2=\text{CH}_2$ |
| 3 | vinyl/polyvinyl chloride | cooking oil bottles | $\text{CH}_2=\text{CH-Cl}$ |
| 4 | low-density polyethylene | wrapping film | $\text{CH}_2=\text{CH}_2$ |
| 5 | polypropylene | yogurt containers | $\text{CH}_2=\text{CH-CH}_3$ |
| 6 | polystyrene | foam cups and plates | $\text{CH}_2=\text{CH-C}_6\text{H}_5$ |
| 7 | all others | catsup bottles | — |

The formulas of the plastics shown in the chart are monomers. A monomer is the building block of the plastic. Many of these monomers combine to form long chains of molecules called polymers. Notice that the monomer for plastics 2 and 4 are identical. In both of these, the chain length can vary from several thousand monomer units to millions. When the chains are packed tightly together, high-density plastic 2 is formed. Other formations of the same monomer chains result in low-density plastic 4.

Plastics do not break down naturally in the environment. To recycle, the types must be separated so that they can be treated by the appropriate chemicals.

Adapted from:

Operation Chemistry, Washington, D.C.: American Chemical Society, 1994

Woodward, L., *Polymers All Around You*. Middleton, Ohio: Terrific Science Press (undated).

Science as Inquiry

Separating Liquids Using Boiling Points**How can a solution of alcohol and water be separated?****Overview:**

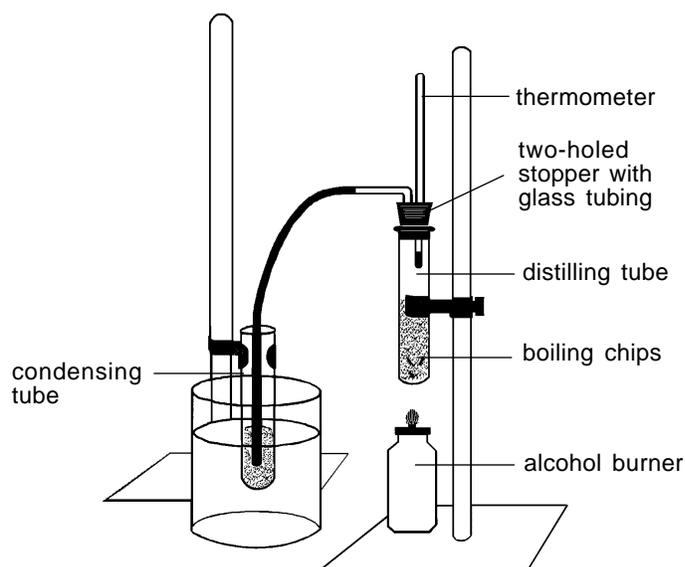
Rubbing alcohol is a mixture of water and alcohol. In this activity students separate water and alcohol from rubbing alcohol by boiling the solution and collecting fractions of the components at their boiling points.

Materials:**Per lab group:**

burner (Bunsen or alcohol)
test tubes 30 mL or larger with stoppers, 3
test tube 30 mL or larger
two-hole rubber stopper with glass tubing and rubber hose
thermometer (for two-hole stopper above)
stirring rods, 2
beaker or other container, 400–600 mL
ring stands, 2
graduated cylinder, 25 mL
boiling chips, 4
cold water or ice
graph paper
timer or clock with second hand
sugar, 1 g
filter paper

Procedure:

Students heat the rubbing alcohol in a test tube plugged by a rubber stopper containing a thermometer and a glass tube to which a rubber hose has been attached (see figure). As the liquid boils it changes to a gas, which is condensed by catching it in a test tube that has been placed in a cold water bath. Students heat the tube gently by moving the burner flame back and forth so as to maintain steady boiling. When the temperature remains constant at 78 °C, the alcohol is boiling off.



As soon as the temperature rises, students move the hose to a second test tube and continue collecting this fraction until the temperature becomes steady again at 100 °C. They then move the hose to the third test tube and collect the last fraction until there is almost no liquid left in the tube they are heating. It is important that students not remove the flame from the tube while the hose is in the collecting vessel because the liquid will be drawn back into the hot test tube and may crack it.

Students should record the temperature every half minute and graph the temperature versus the time. After the three fractions are collected, they should obtain five additional milliliters of the original solution, and then test it and equal volumes of the three fractions collected for the solubility of sugar and flammability.

Background:

In this activity students separate a solution using the boiling points of the two components. The alcohol is first collected as it boils at 78 °C. The water boils over at 100 °C. The middle fraction that students collect contains a mixture of both alcohol and water. Students test each liquid for flammability and solubility of sugar, thus enabling them to infer that the solution has been separated because of the differences of these characteristic properties of the two liquids.

The temperatures remain constant at the boiling points because the heat being added to the system is used to break the intermolecular bonds among the molecules when the liquid changes to a gas.

Adapted from:

AAPT, *Powerful Ideas in Physical Science*. College Park, Md., 1995.

Science in Personal and
Social Perspectives

Melting Ice

Which salt makes the best solution for melting ice?

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.

Materials:

Per lab group:

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

Procedure:

Students make 10% solutions by mass of sodium chloride and calcium chloride in water at room temperature. They should continue to add measured quantities of the salts to the respective test tubes until the solutions are saturated, noting any changes in temperature during the dissolution process. From the data, they calculate the percentage composition of solution on each addition. They then place the solutions in a hot water bath and heat them to about 50 °C. They should continue adding salt, increasing the concentration by 10% until saturated. The solutions are then boiled and the boiling temperatures noted. Solutions are 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 compositions. 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. 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 0 °C. 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 (1.86 °C) and boiling point elevation (0.52 °C) 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 water at the boiling point.

In preparing the solutions using mass percentage, students begin with 1 g of salt, dissolving 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 percent 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:

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

$$\begin{aligned} X &= 1.8 \text{ g} + 0.2 X \\ 0.8 X &= 1.8 \text{ g} \\ X &= 2.25 \text{ g} \end{aligned}$$

Adapted from: none

Science as Inquiry

Location Boiling Temperature**Item:**

Students noticed that whenever they heated water in the lab it always began boiling at less than 100 °C. Their teacher told them their thermometers were accurate and told them that there was another explanation for their observation. The temperature at which water will boil at any location is:

- A. That temperature at which the vapor pressure equals 760 mm of mercury.
- B. That temperature at which the vapor pressure equals the atmospheric pressure.
- C. That temperature at which the vapor pressure drops to zero.
- D. When the temperature is 100 times greater than the freezing point.

Justification:

Explain how the boiling point of water at your location will compare to the boiling point of water at Pike's Peak in Colorado, at an elevation of 14,110 ft.

Answer:

The correct choice is B. The boiling point of a liquid is that temperature at which the vapor pressure of the liquid equals the atmospheric pressure at that location. Vapor pressure is directly proportional to temperature. The lower the atmospheric pressure, the lower the boiling point. Atmospheric pressure decreases with elevation. Our atmospheric pressure should be higher than that at Pike's Peak. Since our location is at a lower elevation, we should have a higher boiling point.

Science as Inquiry/
Science and Technology

Gold Density

Item:

A man offers to sell you a heavy, shiny, hard rock he claims is gold. Elements such as gold have certain characteristic properties that can be used to identify them. Which of the following properties would help you the most in deciding whether or not the rock is pure gold?

- A. density
- B. mass
- C. color
- D. shape

Justification:

Explain why the answers you did not choose are not characteristic properties that would help identify an unknown substance.

Answer:

The correct choice is A. Mass is a measure of the amount of matter in a given sample, and one could have many different substances with the same mass. Similarly, color and shape are not distinctive or specific enough to be used to identify an unknown substance.

Science as Inquiry

Mass/Density Calculation**Item:**

An experiment to be conducted aboard the space shuttle requires the use of 15 cm^3 of a common metal. Two appropriate choices for the experiment are copper and aluminum. You must use the sample of metal that has the lowest mass. The density of copper is 9.0 g/cm^3 , and the density of aluminum is 2.7 g/cm^3 . Which 15 cm^3 sample of these two metals would be the best choice for the experiment? Show all calculations, if used.

Answer:

Computation method: $\text{mass} = \text{volume} \times \text{density}$.

Mass of copper sample = $15 \text{ cm}^3 \times 9 \text{ g/cm}^3 = 135 \text{ g}$.

Mass of aluminum sample = $15 \text{ cm}^3 \times 2.7 \text{ g/cm}^3 = 40.5 \text{ g}$.

Aluminum would have the lower mass (by 94.5 g) and, therefore, should be used.

Reasoning method: density of copper $>$ density of aluminum. Since mass is density times volume, and since there are equal volumes of each metal, we can say that mass of copper $>$ mass of aluminum.

Science and Technology

Freezing Point Change**Item:**

Your city officials have come to you for some advice. Will a 25% solution of MgCl_2 depress the freezing point of water the same amount as a 25% solution of CaCl_2 ? If not, what causes them to be different?

Answer:

The freezing point depression is dependent on the number of particles that are present in the aqueous solution. Since a 25% solution would imply that the solution contains 25 grams of the salt in 75 grams of water, magnesium chloride would have more particles than would calcium chloride. The mass of a mole of magnesium chloride is 95.3 g, and of calcium chloride is 111.1 g. Therefore, you would have about 1.2 times as many particles of magnesium chloride as you would calcium chloride.

Science as Inquiry

Mystery Coins**Item:**

You have found several coins in an old trunk that appear to be either gold or copper. Because of their potential value you would like to know as soon as possible which of these elements was actually used in making the coins. How could you determine which metal you have without destroying the coins?

Justification:

Describe a strategy and procedure you could follow to determine which metal was used in making the coins.

Answer:

An easy way of determining the element is to do a density test on the coins. The density of gold is 19.3 g/cm^3 and that of copper is 8.96 g/cm^3 .

Science as Inquiry/
Science in Personal and Social Perspectives

Honey

Item:

The honey made by bees comes from nectar, which is a solution that is mainly sugar and water. The bees gather nectar from flowers and store it in open cells in the beehive. The bees then often fan their wings in front of the cells.

Which of the following is the most likely reason the bees would do this?

- A. They are trying to form wax by changing the nectar to another substance through changing its molecular movement.
- B. They are trying to evaporate the water and concentrate the sugar to become honey.
- C. They are causing the lighter water to be move faster, spread out, and thus leave the heavier sugar behind.
- D. They are trying to use up excess energy in their bodies so they can secrete honey that is left after all the water in their bodies is used.

Justification:

After honey has been deposited in the cells, why would bees seal over the cells in the beehive? Base your answer on the information discussed above.

Answer:

B. The nectar needs to be concentrated to form honey. Fanning air over the dilute sugar solution helps the water molecules leave more rapidly from the surface, as it brings in less humid air to replace that which may be saturated with water vapor over the cell.

Science as Inquiry

Properties of Matter/Phase Changes**Item:**

Matter can be best described by its properties. Some physical properties of matter include volume, density, color texture, and boiling point.

Which properties of matter are directly related to phase changes?

Answer:

Boiling point, melting point, freezing point, condensation point.

Science as Inquiry

Determining the Density of a Liquid**Item:**

Determine the density of an unknown liquid when the only resources that you have available are a balance, an unmarked flask, an unlimited amount of water, and an unlimited amount of the unknown liquid. Describe both your method and your results.

Answer:

1. Determine the volume of the flask with water.
 - a. The density of water is 1.00 g/mL.
 - b. Find mass of the empty flask.
 - c. Fill the flask with water.
 - d. Determine the mass of water used.

2. Determine the density of the unknown liquid.
 - a. Fill the dry flask with the unknown liquid.
 - b. Find the mass of the unknown liquid.
 - c. Calculate the density of the unknown liquid.

| Consumables | | |
|--|-------------------------------|-----------------|
| Item | Quantity per lab group | Activity |
| boiling chips | 4 | 5, 6 |
| calcium chloride (anhydrous, powdered) | 25 g | 6 |
| clay | — | 2 |
| cola (diet) | 1 bottle | 1 |
| cola (regular) | 1 bottle | 1 |
| cold water or ice | — | 5, 6 |
| food coloring | — | 2 |
| filter paper | — | 5 |
| glycerin | 50 mL | 2 |
| glycerin | 100 mL | 4* |
| graph paper | — | 1, 5 |
| oil (vegetable or mineral) | 50 mL | 2 |
| oil (vegetable) | 100 mL | 4* |
| plastic cups | 4 | 4* |
| plastics identified according to 7 types | 4 pieces of each type | 4* |
| rubbing alcohol | 400 mL (per class) | 1 |
| rubbing alcohol | 50 mL | 2 |
| rubbing alcohol | 100 mL | 4* |
| saturated saltwater solution | 400 mL (per class) | 1 |
| saturated saltwater solution | 50 mL | 2 |
| small balloons of equal capacity | 2 | 3 |
| sodium chloride | 25 g | 6 |
| soft drink bottles, 2-liter plastic with upper fourth removed and calibrated in 100-mL divisions up to 1800 mL | 6 (per class) | 1 |
| source of carbon dioxide (dry ice, or chalk and 0.1 M hydrochloric acid with thistle tube) | — | 3 |
| straws (clear), cut in half | — | 2 |
| sugar | 1 g | 5 |
| water | — | 1 |
| water | 100 mL | 4* |
| waxed paper | — | 2 |

| Nonconsumables | | |
|---------------------------------------|-------------------------------|-----------------|
| Item | Quantity per lab group | Activity |
| balance (0.1 g) | 1 (per group or class) | 1, 4* |
| balance, equal-arm (0.01 g) | 1 | 3 |
| balance (1 g) | 1 | 6 |
| beaker or other container, 400–600 mL | 1 | 5, 6 |
| burner (Bunsen or alcohol) | 1 | 5, 6 |
| Erlenmeyer flask (plastic), 260 mL | 1 | 3 |
| graduated cylinder, 25 mL | 1 | 1, 5, 6 |
| graduated cylinder, 1000 mL | 1 (per class) | 1 |

| Nonconsumables (continued) | | |
|---|-------------------------------|-----------------|
| Item | Quantity per lab group | Activity |
| graduated cylinder (1-liter) or graduated beaker (2-liter) | 1 | 3 |
| graduated cylinder, 25–100 mL | 1 | 4* |
| metal shears | 1 | 1 |
| metric measuring tape | 1 | 3 |
| pipettes (Beral work well) | — | 2 |
| ring stand | 1 | 6 |
| ring stands | 2 | 5 |
| rubber stoppers, one-holed to fit glass and flask | 2 | 3 |
| rubber stopper, two-holed with glass tubing and rubber hose | 1 | 5 |
| scissors | 1 | 4* |
| spoons/spatulas for salts | 2 | 6 |
| stirring rods | 2 | 5, 6 |
| test tube, 30 mL or larger | 1 | 5 |
| test tubes, 30 mL or larger with stoppers | 2 | 6 |
| test tubes, 30 mL or larger with stoppers | 3 | 5 |
| thermometer | 1 | 5 |
| thermometers | 2 | 6 |
| timer/clock with second hand | 1 | 5 |
| tongs | 1 | 3 |
| tube (fire-polished glass or plastic), 10–12 cm long | 1 | 3 |

* alternate or additional experiment

Key to activities:

1. Why Does It Float or Sink?
2. Are Density and Viscosity Related?
3. Do All Gases Have the Same Density?
4. Identifying Plastics Using Density
5. Separating Liquids Using Boiling Points
6. Melting Ice

Activity Sources

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