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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Student Materials

Learning Sequence Item:

910

Density Studies of the Earth

September 1996
Adapted by: Dorothy Gabel

Contents

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

Student Sheet

Science as Inquiry

Why Does It Float or Sink?

What happens when a can of cola is place in water, alcohol, or seawater?

Overview:

Cans of diet cola and regular cola are placed in containers of water, rubbing alcohol, and saltwater. Do they sink or float? Obtaining the densities of the two colas, the densities of the two can-systems, and the densities of the three liquids in which they are placed will enable you to explain your findings.

Procedures:

Make qualitative and quantitative observations as your teacher places regular cola and diet cola into three different liquids—water, rubbing alcohol, and saltwater. Make a data table for your observations.

Your teacher will assign you at least one liquid and one can-system for which you will need to determine the density. You will need to obtain the mass and the volume for each density determination, which is calculated by dividing the mass by the volume.

To obtain the density of the liquid with the most accurate results, you will need to graph the data. It will therefore be necessary for you to obtain the mass and volume of successive portions of the liquid. Devise a way of doing this relatively quickly. Before using your method, check with your instructor. Then graph the mass versus the volume. By calculating the slope of the line, you have calculated the density.

To obtain the density of the can-system, measure its mass and then obtain the volume by water displacement using a 1000-mL graduated cylinder. Add about 400 mL of water to the cylinder before adding the can of cola. Tilt the graduated cylinder and add the can very carefully so as not to let the water splash out or the can hit the bottom so quickly that it breaks.

Enter your data on the chart that your teacher has provided, and use your data and the class data in answering the following questions.

Questions:

1. Describe the results of the activity in terms of the densities of all of the components.

2. Compare the density of diet cola with that of regular cola. Why does this difference exist?

3. What is the advantage of obtaining the density of the liquids in the activity by taking the slope of a mass-versus-volume graph rather than by using the average reading?

4. A student decides to determine whether either regular cola or diet cola will float in oil. What would you predict will happen?

5. The density of rubbing alcohol is 0.78 g/mL at room temperature. Using the class data for the density of water and the density of the rubbing alcohol you used in this experiment, calculate the percentage of water in your rubbing alcohol.

6. The density of an unknown solution is 1.5 g/mL. If you have 200 mL of the solution, determine its mass.

7. The density of a piece of metal is 14.0 g/mL. If its mass is 50.0 grams, what volume does it occupy?

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 you will compare the densities and viscosities of four colored liquids.

Procedure:

Determine the relative density of each of the four colored liquids by layering them in a straw. Obtain half of a straw and stick it in a piece of clay at a 45 degree angle to seal one end. Using a Beral pipette, add about two centimeters of a liquid to the straw. Add another liquid and determine which is heavier by noting whether they mix or form two layers. Continue the process in a systematic way until you have four layers and have determined the relative densities of the four liquids.

Next create a method by which you can determine the relative viscosity or thickness of each of the four liquids. Before using the method, have it approved by your teacher.

Compare the relative viscosities with the relative densities.

Questions:

1. Describe the results of the activity in terms of the densities and viscosities. Are the most dense liquids the most viscous?

2. Does the quantity of a liquid or of a solid determine whether it will sink or float? What evidence do you have from this experiment or any others you have done?

3. A student doing this activity decides to place twice as much of one of the liquids in the straw. What effect will this have on the layering?

Student Sheet

Science as Inquiry

Do All Gases Have the Same Density?

How does the density of carbon dioxide compare to that of air?

Overview:

In this activity you'll determine the mass, volume, and density of carbon dioxide using a balloon filled with carbon dioxide, a balloon containing air, and a balance.

Procedure:

Place two small balloons of the same capacity on the balance pans (one per pan) and add masses until they balance. Blow air into one balloon until it is the size of a large orange and tie with a knot. Fill the other balloon with carbon dioxide as directed by your teacher until it is of the same volume as the air-filled balloon. Place both balloons back on the same balance pans as before (without removing any of the masses used originally). Add masses to the appropriate pan until the scale balances. Record the difference in the mass of the two balloons. The difference in mass represents the mass of the carbon dioxide.

Now devise a way of determining the volume of the carbon dioxide in the balloon. This can be done by measuring the circumference of the balloon 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.

Calculate the density using the mass and volume measurements and compare it to the density of solid carbon dioxide (dry ice), which is 1.10 g/mL at –37 °C.

Questions:

1. How does the density of the carbon dioxide compare to the density of air?

2. How does the density of solid carbon dioxide compare to the density of gaseous carbon dioxide?

3. Explain why it is impossible to obtain the mass of the air by weighing it on a two-pan balance.

4. If the carbon dioxide is made up of particles (molecules), explain why the solid has a greater density than the gas.

Science in Personal
and Social Perspectives

Identifying Plastics Using Density

How can plastics be identified using density?

Overview:

The densities of the seven types of plastics that you will study here differ from one another. By determining the relative densities of the different types of plastics according to the way they sink or float in various liquids, and by calculating the exact density of each, you will be able to categorize the density of an unknown piece of plastic according to one of the types.

Procedure:

Obtain four pieces of each of the seven types of plastics and drop them into 100 mL of four different liquids, recording whether each sinks or floats. Organize the data into chart form indicating the behavior of each of the plastics.

Now collect data to calculate the exact density of one of the types of plastics assigned by your teacher. Devise a procedure to obtain the mass and volume of the plastic. Calculate the density and record your results on your table of class data.

Next obtain an unidentified piece of plastic from your teacher. Record the identifying number so that your teacher can check your results. Identify the number of the unknown plastic by comparing its floating/sinking behavior to that of plastics 1 through 7. To confirm your results, collect data to calculate its actual density and compare this to the actual densities of plastics 1 through 7 on the class data table.

Check around your home to determine what types of plastics are available. Make a list of what you find. Your teacher may ask you to bring to class samples of different forms of plastic (1–7) that you have found.

Questions:

1. Give the number of your unknown plastic and the number of the plastic of which it is made. How does the actual density compare with the density of the plastic that you identified from its sinking and floating behavior?

2. What is meant by “characteristic property”? How does this experiment show that density is a characteristic property?

3. Make a list of common household containers and other items made from the different kinds of plastic.

Science as Inquiry

Separating Liquids Using Boiling Points

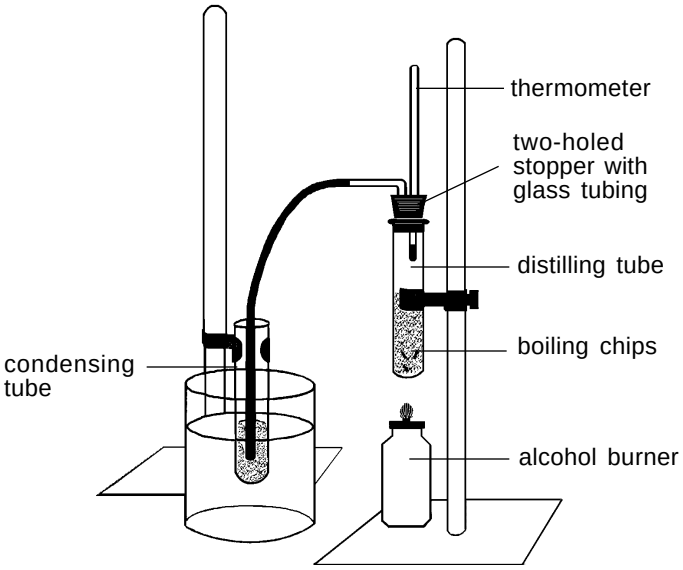
How can a solution of alcohol and water be separated?

Overview:

Rubbing alcohol is a mixture of water and alcohol. The two substances can be separated by boiling them.

Procedure:

Put 20 mL of rubbing alcohol into a large test tube, add a few boiling chips, and set up the distillation apparatus as shown in the figure. Half fill the large beaker with water and a few ice cubes. Place an empty test tube in the ice water to collect the liquid as shown.



You will be heating the alcohol and recording the temperature every half minute so it will be necessary to prepare a data table before beginning to distill the rubbing alcohol.

Once you begin heating the alcohol, it is important to always remove the tubing that extends into the test tube in the large beaker of cold water before removing the heat source. Otherwise, the cold liquid you have collected will be drawn back into the original test tube and may crack it.

Heat the tube gently by moving the burner flame back and forth so as to maintain steady boiling. Record the temperature every half minute.

As you heat the liquid the temperature will gradually rise and then remain constant. After the temperature remains constant and some liquid has boiled off, replace the collecting tube with an empty one and label the first test tube "fraction 1." Continue collecting fraction 2 until the temperature again becomes constant. Replace the collecting tube again and begin to collect fraction 3 while the liquid boils at constant temperature. Continue to collect the last fraction until there is almost no liquid left in the tube. Remove the tubing from the test tube before turning off the burner.

Obtain an additional 5 mL of the original solution and then test it and 5 mL of each fraction you have collected for flammability and solubility of sugar. Test for flammability by placing a piece of filter paper in the liquid and observing whether it ignites with a match. Test for solubility by placing a pinch of sugar in the liquid and stirring.

Questions:

1. Make a temperature vs. time graph of your data. What are the boiling points of alcohol and water as shown on your graph?

2. How do the solubility and flammability tests indicate that you have separated the rubbing alcohol into its components?

3. Explain the distinctive sections of your graph in terms of what is happening to the energy being added and to the molecules of alcohol and water present in the rubbing alcohol.

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, you will note the behavior of solutions of the two salts.

Procedure:

Place 9 mL of water in each of two test tubes. These will be used for making your solutions of each salt. You will be adding successive masses of salt to each test tube to make 10%, 20%, etc., solutions until the solutions are saturated (point where no more solid will dissolve).

Make a 10% solution of each salt by weighing out and adding the appropriate mass of salt to each test tube. Stir until the salt dissolves and note any temperature changes that occur. Now calculate the mass of salt needed to prepare 20%, 30%, and 40% solutions. Add the mass of salt to make a 20% solution of each salt and stir vigorously. Continue this process until the solutions become saturated. (Note: both may not require the same quantity of salt, and you may need to make even more concentrated solution.) Record your observations.

Place the solutions in a hot water bath and heat the water until the solutions reach about 50 ^{o}C. Continue adding salt, increasing the concentration by 10% until saturated.

Now boil the solutions and note the boiling temperatures. Cool the solutions overnight by placing them in a freezer. During the next lab session, note the contents of each tube. Let the test tubes with the solutions stand in a warm room and observe.

Questions:

1. Which salt would be most effective for melting ice on highways? Give reasons for your answer.

2. What other factors must be considered in addition to the freezing temperature of a salt solution when determining which salt to use on highways?

3. Consider the other factors by doing some research outside of class and then come to some conclusion about the better salt to use.

4. Which salt solution produced the higher boiling point? Do you think that the same solution would have the lower freezing point?

5. Explain on the particle level why adding a salt to a liquid elevates the boiling point and depresses the freezing point.

6. Give other examples where solutions are made to increase the boiling point or lower the freezing point.

7. Name three characteristic properties of the two salts used in this activity to distinguish one from the other.

Science in Personal
and Social Perspectives

The Soap That Floats

Advertisers use a variety of gimmicks and claims in order to entice you to purchase a particular product. With so many different brands of soap on the market today, it is hard to distinguish one bar from the next. If you are like me, a quick smell in the aisle of a supermarket is the deciding factor. However, one claim has made a lasting impression over the years. You probably have heard it a million times, and it is very impressive. Procter and Gamble, the makers of Ivory Soap™, have been claiming for years that their product is 99 and 44/100 percent pure. But this almost-pure soap has a unique characteristic that truly makes it rise to the top—it actually floats instead of sinking.

The discovery of this soap was an accident. A worker, eager to begin his lunch break, left a stirring machine on. The machine whipped too much air into the batch of soap. Hating to waste the whole batch, Procter and Gamble decided to make it into bars and sell it anyway. Much to their surprise, people started writing and requesting more of that "floating soap."

This was the beginning of a marketing strategy that is still around today. Procter had the product analyzed and found that the soap contained very few impurities. He advertised its multiple uses in the laundry and bath, while cashing in on the claim that it was the purest of soaps—99 and 44/100 percent pure to be exact!

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By Rick McGolerick, SS&C Project, National Science Teachers Association, Arlington, Va.

Science and Technology

Distillation of Alcohol

Nature has its own process of fermentation. Yeasts and other micro organisms produce alcohol when fruit or other substances ferment. During this period, the alcohol accumulates, eventually killing the microorganisms that cause the fermenting to take place. As the amount of alcohol increases, the sugar content decreases as it is converted into alcohol. So, theoretically speaking, the more sugar that is present the more alcohol will be produced. While this concept sounds great, it only works in theory because there is a limit to the amount of alcohol that can be produced. However, it is possible to make a stronger liquor using the process of distillation.

The process of distillation was discovered by alchemists. A simple example is distilling seawater in order to make it drinkable. Seawater is not very tasty in its natural form due its high concentration of salt. If for some unfortunate reason this is the only water source you have access to, you could distill it and it would be drinkable. This can be done by heating the water and trapping and cooling the water vapors that evaporate. The salt that remains may be used for other things.

This process was finally applied to alcoholic beverages. Arnold de Villanova, a Spanish alchemist, distilled wine in 1300 and obtained a reasonably pure alcohol. The boiling temperature of alcohol is lower than that of water, so the first vapors from the beverage contain a higher concentration of alcohol than does the original liquid. When these vapors are condensed, you obtain a much stronger liquor.

De Villanova had created brandy—a form of distilled wine—and brandy and whiskey (from distilled grain) soon became available in mass volume.

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