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
The physical properties of compounds reflect the nature of the interactions among their molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them.

Teacher Materials

Learning Sequence Item:

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Physical Properties of Matter

March 1996
Adapted by: Ruth Mann, Brett Pyle, and Linda W. Crow

Molecules: Their Structure, Interactions, and Physical Properties. Students should be able to measure properties such as surface tension, vapor pressure, boiling and freezing points, and viscosity. They should offer their own qualitative explanations of variances in these properties in terms of hypothesized intermolecular forces. They should be able to distinguish between bonds within a molecule and interactions between molecules. *(Chemistry, A Framework for High School Science Education, p. 58.)*

Contents

This micro-unit was adapted by **Ruth Mann** (Northside H.S., Pinetown, N.C.), **Brett Pyle** (Grady Middle School, Houston), and **Linda W. Crow** (Baylor College of Medicine, Houston)

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Learning Sequence

Molecules: Their Structure, Interactions, and Physical Properties. Students should be able to measure properties such as surface tension, vapor pressure, boiling and freezing points, and viscosity. They should offer their own qualitative explanations of variances in these properties in terms of hypothesized intermolecular forces. They should be able to distinguish between bonds within a molecule and interactions between molecules. (*Chemistry, A Framework for High School Science Education, p. 58.)*

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
Sticky Situations **Activity 1**	Candy Factory **Assessment 1**	Bathtub Ring **Assessment 2**	
How Soluble Can You Be? **Activity 2**	Kettle Fur **Assessment 3**	Kettle Fur **Assessment 3**	
What's the Point? **Activity 3**	Desalination **Assessment 5**	Desalination **Assessment 4**	
How Hot Is It? **Activity 4**	Salt **Assessment 6**	Desalination **Assessment 5**	
Dive! Dive! **Activity 5**		Salt **Assessment 6**	

Suggested Sequence of Events

Event #1

Lab Activity

1. Sticky Situations (45 minutes)

Event #2

Lab Activity

2. How Soluble Can You Be? (30 minutes)

Event #3

Lab Activity

3. What's the Point? (25 minutes)

Alternative or Additional Experiments

4. How Hot Is It? (25 minutes)

Event #4

Lab Activity

5. Dive! Dive! (40 minutes)

Event #5

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

Suggested reading:

Bohren, C.F., "What Light Through Yonder Window Breaks?: *More Experiments in Atmospheric Physics*. New York: John Wiley and Sons, Inc., 1991.

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 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 c hanges in these items to suit their own c lassroom 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.

Teacher Sheet

Science as Inquiry

Sticky Situations

How do adhesion and cohesion affect surface tension?

Materials:

Per lab group:
Part A:
waxed paper
2 microscope slides
water
alcohol (not rubbing alcohol)
optional (see variations):
mercury in sealed vials

Part B:
400 or 500 milliliter beaker
tissue paper
needle
detergent
optional: alcohol

Procedure:

Part A:

Have students place a few drops of water and a few drops of alcohol on the waxed paper and record their observations. They should include drawings. Next they place a drop of water between two microscope slides and press them together. They should slide the slides apart, leaving an area that overlaps, and then try to lift them apart. Caution them to be very careful that the slides do not break. Have them record their results.

Part B:

Have students almost fill a clean beaker with water. They then carefully place a sewing needle on top of a piece of tissue paper, place the tissue and needle on a spatula, and lower them into the water. The paper and needle will float. Soon the paper will become soaked and sink, and the needle will be left floating on the surface. Next have students add a small amount of liquid detergent and observe the results. With a little practice one can also float a paper clip, a rubber band, or a thumbtack.

After these activities are completed, ask students to explain adhesion and cohesion in their own words in terms of the wetness or stickiness of the substance.

Background:

Do not use rubbing alcohol for the observations in part A. This product is only about 3% alcohol, and the large amount of water in the product makes it behave much like pure water. *tertiary butyl alcohol works well and is also used in another activity later in this series.*

The property of water that appears to be "stickiness" is called adhesion. The property occurs due to small electrical charges between water molecules. The pr operty of adhesion makes water feel wet. When electrical forces between substances are low, the wet or "sticky" quality is low. Cohesion is a property in which molecules show a strong affinity for other molecules in the same material.

The surface tension of a liquid is the energy required to increase the surface area. A property of tension causes the surface to act as if it had a membrane. This property is due to the fact that surface molecules are pulled inward and other molecules in the liquid are pulled equally in all directions. When detergent is added, the energy is decreased and the needle sinks.

Further Variations:

If available, mercury also can be used to demonstrate cohesion (and very low adhesion). Small amounts in sealed vials can be used so that students can roll the mercury around in the vials and observe the results. Caution them that the vials must remain sealed, as mercury is toxic and can be absorbed through the skin.

For Part B the students could be asked to try to float a needle on alcohol using the same procedure as they did with water.

Adapted from:

Kardos, T., *Physical Science Labs Kit.* New York: Center for Applied Research in Education, 1993.

Summerlin, L.R., Borgford, C., and Ealy, J. *Chemical Demonstrations*, *Volume 2*. Washington D.C.: American Chemical Society, 1988.

Science as Inquiry

How Soluble Can You Be?

How does temperature affect solubility?

Materials:

Per lab group:
sodium chloride
calcium acetate
potassium chloride (or sodium nitrate or potassium nitrate)
three 250 mL beakers
hot plate or Bunsen burner with ring stand
stirring rod
pan balance
graduated cylinder
thermometer

Procedure:

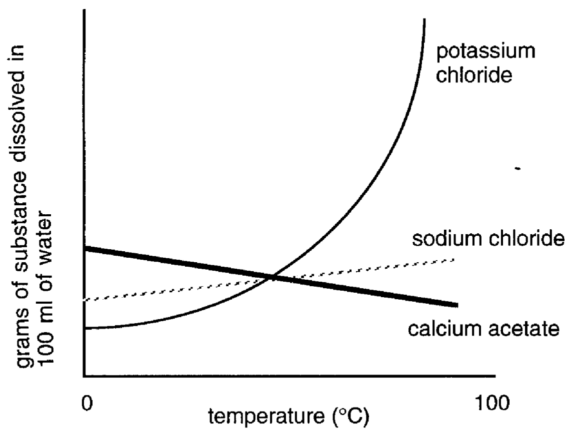
Have students turn on the hot plate and set it on a low setting. The hot plate should not be set so high that the water will boil. They should let the hot plate warm up so that it will be at a constant temperature when it is needed. Next have them measure 100 mL of water into each beaker and record the starting temperature of each. They then measure 1 gram of potassium chloride, place it in beaker 1, and stir until dissolved. Have them repeat this process until some of the solid remains in the bottom of the beaker and record how much has been added. They should then repeat this process for the sodium chloride (beaker 2) and the calcium acetate (beaker 3).

Students now place beaker 1 on the hot plate, allow it to heat up until the temperature stops rising, and record the new temperature. They add potassium chloride, 1 gram at a time, until solid remains on the bottom, stirring after each gram is added. They should then record how much was added. Have them repeat this process for sodium chloride and calcium acetate.

Note: When placed on the hot plate the calcium acetate will begin precipitating out, and the students will not have to add any more. Do not tell them this ahead of time.

Background:

The solubility of a substance generally increases with increasing temperature. This holds true for sodium chloride, potassium chloride, sodium nitrate, and potassium nitrate. Of these four the sodium chloride is less soluble than the rest. Calcium acetate is an exception in that its solubility in water increases slightly with decreasing temperature. This is very rarely encountered. The f ollowing figure shows the solubility curves for these substances.



Potassium chloride is less reactive than sodium nitrate or potassium nitrate and thus is the preferred choice.

Further Variations:

If time allows, the solubility of each substance can be determined at a series of temperatures (i.e., 0°C, 25 °C, 40 °C, 60 °C, 80 °C) and the results graphed to yield solubility curves for each substance.

Adapted from Liem, T. (1987) *Invitations to Science Inquiry, 2nd ed.* Chino Hills, Calif.: Science Inquiry Enterprises, 1987.

Teacher Sheet

Science as Inquiry

What's the Point?

How can the melting point of a substance be determined?

Materials:

1 large test tube
1 thermometer (-10 °C to + 110 °C)
two 400 mL beakers
1 hot plate or Bunsen burner with ringstand, ring, and wire gauze
safety goggles
napthalene (moth balls)
P-dichlorobenzene (toilet bowl deodorant)
centigram balance
apron

Procedures:

Have students weigh and record the mass of two grams of napthalene or P-dichlorobenzene, then place the substance in a test tube, sealing it with aluminum foil. Have them fill a 400 mL beaker 2/3 full with water and place the sealed test tube in the beaker. They should heat the beaker until the substance is completely melted. Once melted, have them insert a thermometer through the foil, turn off the heat, and place the test tube containing the thermometer in an empty 400 mL beaker. They next measure and record the temperature of the substance each minute until it becomes solid, without removing the thermometer from the test tube. Have them plot the data on a graph and repeat for 4 and 6 grams of substance.

Background:

When a substance melts, it changes from a solid state to a liquid state. When a substance freezes the change is from a liquid to a solid state. The melting and freezing points of a substance occur at the same temperature.

Alternate chemicals for naphthalene: cetyl alcohol, 1-octadecanol, palmitic acid, stearic acid.

Alternate chemical for P-dichlorobenzene: acetamide.

This experiment must be performed under a fume hood.

Adapted from Oklahoma State Department of Education, *Top Chem*. State Board of Affairs, 1987.

an alternate/extension activity for Event 3

Teacher Sheet

Science as Inquiry

How Hot Is It?

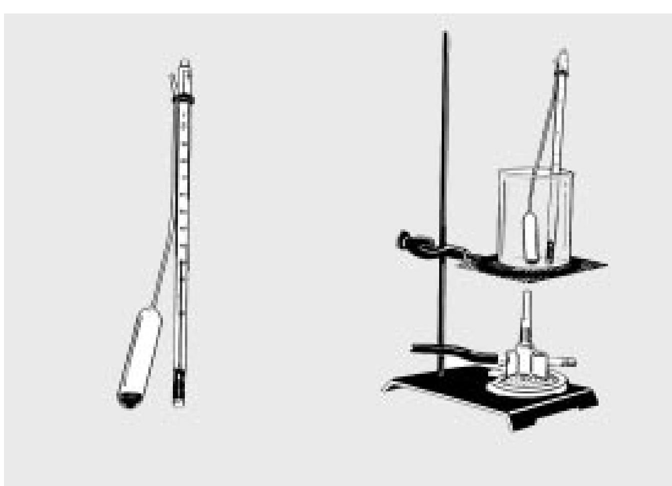
How can the boiling point of a substance be determined?

Materials:

thermometers (-10 ºC to 110 ºC)
beral pipets (thin stem/long)
rubber bands (very small)
beakers (250 mL)
hot plate or Bunsen burner with ringstand, ring, and wire gauze
6 mL isopropyl alchohol
6 mL unknown substance
110 mL graduated cylinder

Procedure:

Have students add 1 mL of isopropyl alcohol to a clean dry beral pipet, and attach a thermometer using a small rubber band (see figure below). They should fill the beaker 3/4 full of warm water, place the beral pipet/thermometer setup in the beaker, and begin heating. Caution them to stir frequently to insure even heating. When they observe a ring of condensation, have them remove the heat source. When the uppermost condensation ring becomes stationary, they should record the temperature. Have them repeat this process using 2 mL then 3 mL. Finally, they should try to determine the boiling point of the unknown, using the table to identify the unknown.



Boiling Points of Common Organic Liquids

Substance	Boiling Point
acetone	56.2 degrees
methanol	65.0 degreees
2-propanol	82.4 degrees
ethanol	78.5 degrees

Temperature measurements are based on the Celsius temperature scale.

Background:

The boiling point of a liquid is the temperature at which a liquid changes to a vapor. At this point the vapor pressure of the liquid becomes equal to the pressure at the surface of the liquid. Thus, the boiling point changes relative to the atmospheric pressure. Boiling point does not depend on quantity and can be used as a characteristic property in identifying substances.

Adapted from Ciardullo. Carmen, V.C.M. *Micro Action Chemistry* (Teacher and Student Editions). Flinn Scientific Inc., 1990.

Science as Inquiry

Dive! Dive!

How can you determine the viscosity of a substance?

Materials:

Per lab group:

4 plastic columns (~60 cm tall) with caps for both ends
4 samples of liquids having different viscosities such as water, cooking oil, Karo® syrup, vinegar, alcohol, liquid detergent, shampoo, glycerin
4 ball bearings or magnetic marbles
stop watch
ring stand
meter stick
permanent marker
magnet

Procedure:

The four columns should be filled with four different liquids. Place one ball bearing or magnetic marble in each column and place caps on both ends, trapping as little air as possible. The caps should fit tightly and should be sealed with clear packing tape. These should be prepared before class.

Give the columns to the students and have them mark two points 50 cm apart on the columns with the permanent marker.

To conduct the experiment, students place the magnet next to the ball bearing and hold it in place while they invert the column. They should move the ball bearing with the magnet until it is at the top mark. They then release the ball bearing and record the time it takes to fall through the liquid to the bottom mark (50 cm). Have them repeat the process three times and find the average time. They should repeat this process for each of the four liquids and compare the average times for all liquids. They then should calculate the speed of the ball through each liquid. Speed = distance traveled ÷ time for travel. This calculation will be the basis for a comparison of viscosity.

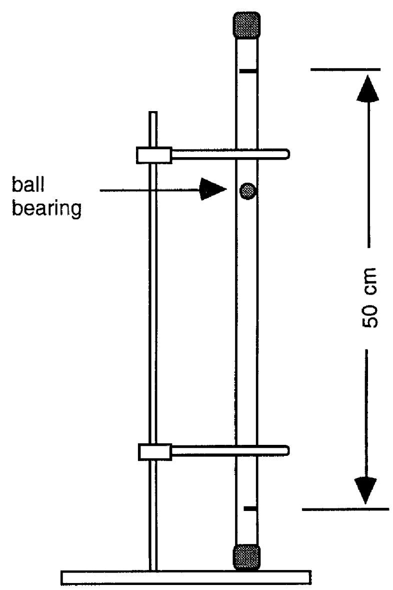


Figure 1. Laboratory setup for viscosity determination.

Background:

Make sure that clear liquids are used in the columns so that the ball bearing can be easily seen and timed. It is also helpful if you choose liquids that are of different colors to avoid confusion. If water and alcohol are both used, the water can be colored using food coloring for easy identification. If resources are limited, a set of eight or twelve columns (two or three of each liquid) can be assembled and lab groups can rotate these among them.

This activity allows students to measure viscosity indirectly. Viscosity is defined as the ease or difficulty with which a liquid flows. In order for the ball bearing to fall through the liquid, the liquid must flow around it. Thus, the lower the viscosity (or the faster and easier the liquid flows) the faster the ball will fall.

Further Variations:

The plastic tubes will work best because of the length and ease in handling. Graduated cylinders can be used, but some of the materials used (oils, detergents, syrups, etc.) will be difficult to clean out of the cylinders thoroughly. The tubes can be thrown away, or in some cases, if sealed well, they can be stored for use again the following year.

Adapted from Crow, L., *Streams*. Houston: Baylor College of Medicine, 1993.

Science and Technology

Candy Factory

Item:

Two identical sugar candies are unwrapped and placed in beakers of water. Fifteen minutes later the experimenter returns to the room and sees that one piece of candy has disappeared and the other is nearly the same volume as at the start. Which of the following was most likely different about the two beakers?

A. temperature of the water
B. purity of the water
C. water was swirled more
D. amount of water

Justification:

Which beaker had the candy that dissolved? Explain the effect.

Answer:

A. Change in temperature has a much greater effect on rate of dissolving, and on all chemical reactions, than do most other factors (it is exponential). Rates are much higher as temperature gets higher because of both collision factors (faster rates) and activation, or critical energy factors. The beaker that dissolved the candy will have the higher temperature.

Science in Personal
and Social Perspectives

Bathtub Ring

Item:

After you take a bath, a "bathtub ring" appears around the tub. Which of the following is the most likely cause?

A. Tap water contains many solutes, and some of these solutes combine with soap, come out of the solution, and absorb dirt and oil to make a ring of scum.
B. You use too much soap and the leftover soap makes a ring.
C. The soap absorbs the dirt from your body, and the soap and dirt deposits itself as a scum.
D. The water has minerals in it that react with the tub metal to create a ring.

Justification:

You go on a stay-over visit to a friend's house in another part of the country. After taking a bath, you notice the ring is much less than when you take a bath at home. Explain why this might be.

Answer:

A. Ions from the water, especially calcium and magnesium, form insoluble compounds with the ester part of soap and stick as a scum. These compounds have absorbant surfaces, so tend to absorb any unreacted oil or grease. B is less likely, though not impossible. Oil and grease are mostly held *in solution* by soap, which is why C is incorrect. D is incorrect; tubs do not react with tap water.

Science and Technology/
Science in Personal and
Social Perspectives

Kettle Fur

Item:

Tania’s mother boils a lot of water to make tea at home. When Tania looks inside her mother’s kettle she sees lots of hard gray deposits inside. She writes about this to her pen pal Tina in another state, who says she doesn’t see much deposit in her mother’s kettle. Which of the following is the most likely reason?

A. The house where Tina lives has plastic pipes for water plumbing; Tania’s has copper plpes.
B. The tap water in different parts of the country contains different amounts of dissolved salts.
C. Tania’s kettle is made of a different metal than Tina’s.
D. Tania’s mother always pours all of the water out when making tea. Her friend’s mother leaves some water in the kettle all the time.

Justification:

Deposits in kettles can be chemically cleaned. Suggest and explain how this is done.

Answer:

B. Dissolved substances vary a lot in different parts of the country because of different minerals near the water source. Most deposits will dissolve if treated with dilute acids, since they are usually carbonates such as calcium and magnesium carbonate. An acid such as acetic acid (vinegar) makes carbon dioxide evolve and dissolves the calcium ions.

Science in Personal and
Social Perspectives

Desalination

During an expedition to a remote desert island, you learn that there is no fresh water. You have a teakettle, a camp stove, and a few bottles.

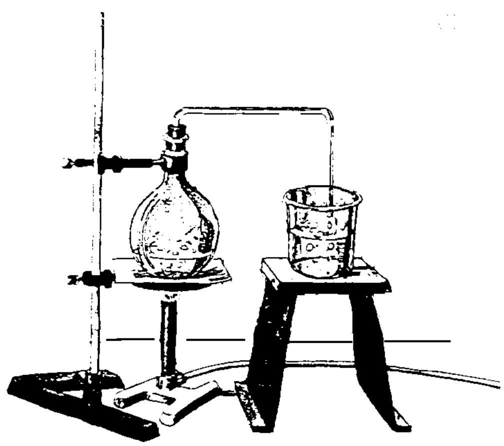
Draw a labeled diagram to show how you could use them to obtain drinking water.

Science and Technology/
Science in Personal and
Social Perspectives

Desalination

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, describe what you think needs to be improved in order to make this routine for producing water for home use.

Science and Technology/
Science in Personal and
Social Perspectives

Salt

Item:

Cibwa salt is found mainly in the country of Zambia. This kind of salt is prepared from leaves of a grass. The grass is dried, then burned. The ash that is left is poured into water in a clay pot. Anything that does not dissolve is removed, and the water is then boiled, leaving behind the salt.

Explain each step of this process in terms of combustion, solubility, boiling point, and evaporation. Draw a diagram of the sequence of steps to help you prepare your answer.

Answer:

Should include steps as follows:

- Combustion removes the carbon-containing (organic) compounds as carbon dioxide and water.
- Salts do not "burn" or combust with oxygen, so remain in the ash.
- Salts are water soluble, so other impurities, fibers, and unburned grass are removed.
- Water goes to vapor on boiling, so salts are left behind.