SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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SCOPE, SEQUENCE, and COORDINATION

SS&C Research and Development Center
Gerry Wheeler, *Principal Investigator*
Erma M. Anderson, *Project Director*
Nancy Erwin, *Project Editor*
Rick McGolerick, *Project Coordinator*
Arlington, Va., 703.312.9256

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*
University of Houston-Downtown, 713.221.8583

Houston School Sites and Lead Teachers
Jefferson Davis H.S., Lois Range
Lee H.S., Thomas Ivy
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*
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
Flathead H.S., Montana, Gary Freebury
Clinton H.S., New York, John Laffan*

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National Science Education Standard—Physical Science
Conservation of Energy and the Increase in Disorder
Heat consists of random motion and the vibrations of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion

Teacher Materials

Learning Sequence Item:

925

Gas Pressure, Volume, and Temperature

March 1996
Adapted by: Linda W. Crow and Bill G. Aldridge

Heat, Internal Energy, and the Kinetic-Theory. This is a good opportunity to build an empirical base for subsequent theoretical work. At this level some kinetic theory can be developed descriptively and qualitatively, leading students to understand how gases exert pressures, how temperature increases change the volume or pressure of a gas under various contraints, etc. The concept of atoms and of molecules can be developed as they relate to vibrations and random motion. *(Physics, A Framework for High School Science Education, p. 34.)*

Contents

This micro-unit was adapted by: **Linda W. Crow** (Baylor College of Medicine, Houston) and **Bill G. Aldridge** (SS&C Project Director)

925
Learning Sequence

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Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
Descartes' Rules of Inquiry **Reading 1** Antoine Arnauld on Method in Scientific Investigation **Reading 2** The Mysterious Effects of Hands **Activity 1** Balloon and Bottle **Activity 2** Fountain Machine **Activity 3** A Reacting Bottle **Activity 4** Coin Tricks **Activity 5** The Hot Can Trick **Activity 6** Radiometer **Activity7**	Gas Laws and Scuba Diving **Reading 3** Hot Air **Assessment 2** Car Tire Pressures **Assessment 3** Bread Dough **Assessment 4**	Hot Air **Assessment 3**	Galileo, on the Effect of a Vacuum **Readings 4 and 4a** Torricelli on the Weight of the Atmosphere **Readings 5 and 5a** Some Experiments of the Academia del Cimento **Reading 6** Guy-Lussac **Assessments 5, 6, and 7** Gas Molecules **Assessment 8** Galileo **Assessment 9**

Suggested Sequence of Events

Event #1

Lab Activity

1. The Mysterious Effects of Hands (10 minutes)

Alternative or Additional Experiments

2. Balloon and Bottle (20 minutes)
3. Fountain Machine (15 minutes)
4. A Reacting Bottle (10 minutes)
5. Coin Tricks (20 minutes)
6. The Hot Can Trick (20 minutes)

Event #2

Lab Activity

7. Radiometer (10 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 with the Student Materials:

Reading 1 Descartes' Rules of Inquiry
Reading 2 Antoine Arnauld on Method in Scientific Investigation
Reading 3 Gas Laws and Scuba Diving
Reading 4 Galileo, on the Effect of a Vacuum
Reading 4a Galileo, on the Effect of a Vacuum (second version)
Reading 5 Torricelli on the Weight of the Atmosphere
Reading 5a Torricelli, on the Weight of the Atmosphere (second version)
Reading 6 Some Experiments of the Academia del Cimento

Suggested additional readings:

"Gases: Atoms Set Free." Pp. 100–101 in *Science Explained* (C.A. Ronan, ed.). New York: Henry Holt and Co., 1993.
Sutton, Carolyn, "How Do They Steer Balloons?" Pp. 94–95 in *How Do They Do That?* New York: Quill, 1982.
Sutton, Carolyn, "How Do They Get the Foam into a Can of Shaving Cream?" P. 127 *in How Do They Do That?* New York: Quill, 1982.
Sutton, Carolyn, "How Do They Get Natural Gas to Your House?" Pp. 148–149 in *How Do They Do That?* New York: Quill, 1982.
"Gas Volume and Temperature," P. 177 *in Asimov's Chronology of Science and Discovery*. New York: Harper & row, 1989.
"Boyle's Law," P. 155 *in Asimov's Chronology of Science and Discovery*. New York: Harper & row, 1989.

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 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

The Mysterious Effects of Hands

How do temperature changes affect a confined volume of liquid water and air?

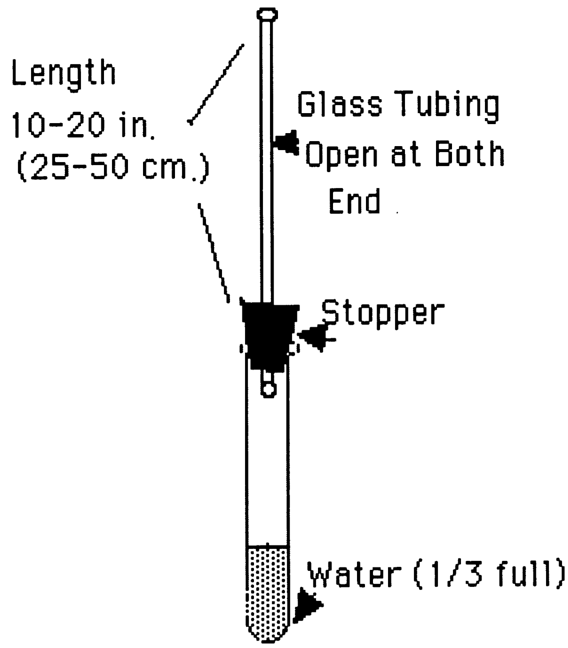
Materials:

test tube
1-hole stopper to fit test tube
piece of glass tubing (12-20 inches long)
water
food coloring (optional)
ice

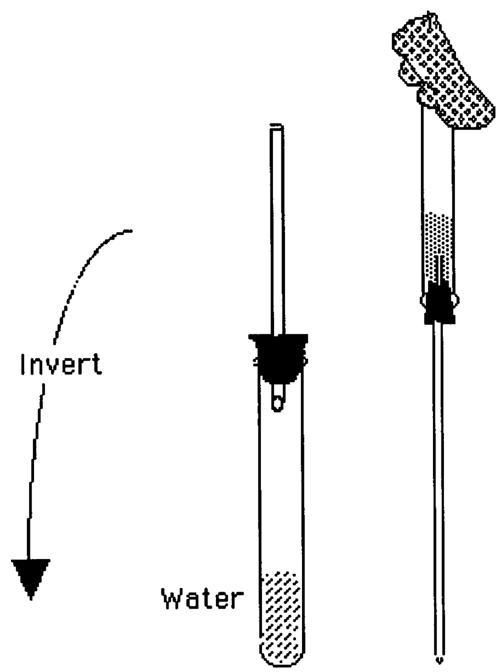
Procedure:

Insert tubing into the one-hole stopper. Have the majority of the tubing sticking out of the stopper. This portion can be completed by you or have your students assemble this apparatus. A technique sheet, *How to Cut and Fire Polish Glass Tubing, Fit into Stopper, and Correctly Fit the Stopper into the Container Opening,* is available.

Fill the test tube 1/3 full of water and insert the stopper with the glass tubing into the test tube. Food coloring can make the levels easier to observe.



Have students first predict what will happen when the test tube is inverted with their hand wrapped around the test tube. Then have them invert the test tube and try it.



Background:

This is an excellent example of the confounding of variables, so that no simple controlled experiment is easily conducted. Instead students can concentrate on a descriptive explanation of what happens. This can be in terms of pressure and volume, but involves both a liquid and a gas. The particulate model explanations are also important, and how the particles exert pressure and occupy volume.

When air molecules are heated, they move faster, exerting a higher pressure. When water is heated, it expands very slightly. Thus, the heat transferred from the hand to the test tube of liquid water and air (with some water vapor molecules) increases the kinetic energy of both the liquid water and the gas.

But the particles of liquid just vibrate at a greater rate and expand only slightly, while the gas molecules move faster and exert greater pressure against the water, pushing it rapidly out the tube.

Students initially predict that the water will just run down the tube due to gravity. They should be led to evidence that this is not correct. Others may predict that it will not run down the tube at all because of the capillary action of water and this, too, should be tested. As they hold the test tube upside down, they will see the water move down the tube in a pumping action. Some may think that they are pumping water down the tube by pressing on the sides of the test tube! The next step is to move students toward a reasonable explanation of the phenomena and designing an experiment to test their hypothesis.

The air particles will expand to a greater volume than an equal number of water particles due to the differences between the gaseous and liquid phase. Thermal energy from the hand increases the kinetic energy of the air (and water vapor). The particles of air and water vapor moving at greater speeds increases pressure. The increased pressure forces water out of the tube. Both the air and water particles absorb some energy from the hand. Since the air is expanding more than the water, the water is forced to move into the tube.

Cooling of the hand with ice and then holding the test tube causes a reduction of kinetic energy of the air and water vapor molecules and a consequent reduction in the pressure of the air cavity in the test tube. As a result, water and air bubbles move upward into the test tube through the glass tubing.

Further Variations:

Use probing questions with students for possible explanations for what they observe. What is the most important substance associated with their observations - air or water? Students can repeat these observations and vary the temperature of their hand by holding ice or rubbing their hands together.

Students can design their own experiment and attempt to hold the volume of the air constant while changing the amount of water. Then they could reverse the situation and hold the volume of water constant while varying the amount of air (One way to accomplish this feat is to use different sizes of test tubes).

Adapted by L. Crow (BaylorCollege of Medicine, Houston) from:
Iowa Physics Task Force, *Physics Resources and Instructional Strategies for Motivating Students* (R. D. Unruh and T. M. Cooney, Eds.). Cedar Falls: Iowa Academy of Science, 1993.

alternative/extension activity for Event 1

Teacher Sheet

Science as Inquiry

Balloon and Bottle

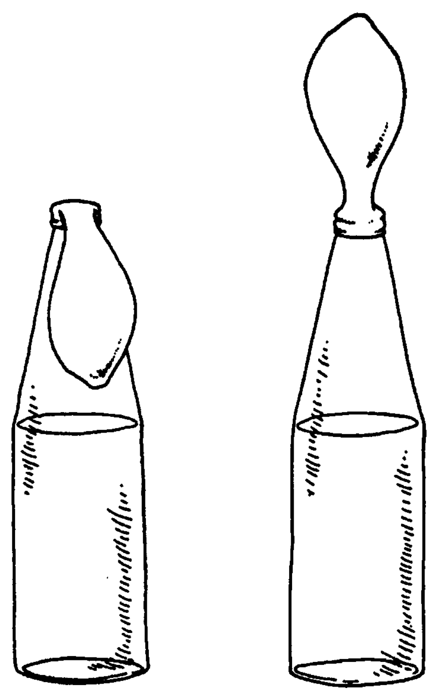
How does temperature affect volume?

Materials:

1 large volume balloon
1 glass soda bottle or flask
freezer

Procedure:

Students first place a soda bottle in the freezer for at least 15 minutes. They remove it and immediately place a large volume balloon over the mouth of the bottle. This could also be done with a flask.



After a short period of time, students observe the bottle and balloon.

Background:

When the bottle is placed in the freezer, the air in the bottle cools, lowering the pressure inside the bottle, thereby drawing air into the bottle from the freezer. Out of the freezer, the cold air inside the bottle warms, increasing the pressure and expands. If the balloon is large enough and has been flattened so that no air is in it when attached to the bottle, it will partially fill, but will not begin to inflate. In this way, the air in the balloon and bottle will reach room temperature at one atmosphere of pressure, assuming that the pressure has been held constant.

Students will therefore observe that the original volume of cold air has expanded under constant pressure, but higher temperature to occupy a larger volume. The expanding air moves into the balloon where it is confined.

Further Variations:

Have students return the bottle with the balloon still attached to the freezer for about 15 minutes. Then they remove the bottle with the balloon attached and make additional observations over some period of time.

A nice variation is to flatten the balloon, put it on a bottle containing air at room temperature, and then put it in a freezer for about 15 minutes. The balloon will be pushed into the bottle by the pressure difference created, as the air in the bottle cools.

Adapted by L. Crow (Baylor College of Medicine, Houston) from:
Van Cleave, Janice. *Teaching the Fun of Physics*. New York: Prentice-Hall, 1985.

alternative/extension activity for Event 1

Teacher Sheet

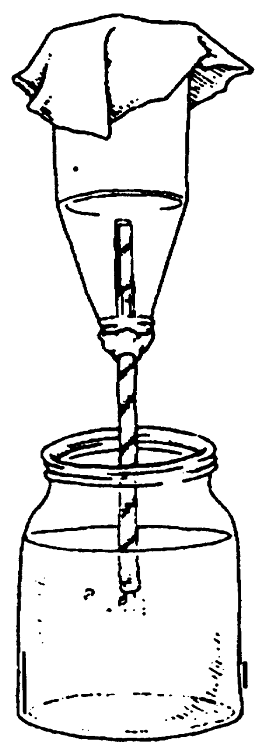
Science as Inquiry

Fountain Machine

How does temperature affect volume and pressure?

Materials:

1 wide mouth jar or beaker
1 glass soda bottle or flask
1 straw or glass tubing
clay or one-hole stopper
water
food coloring
ring stand and ring or clamp



Procedure:

Have students place one end of a straw (or glass tubing) into the mouth of a clean dry glass soda bottle (or flask). Students secure the straw and seal the opening by using a small amount of clay.

Next have them fill a quart bottle (or beaker) three fourths full of water. If they add food coloring, the movement of water will be easier to see. Have students turn the bottle over so that the free end of the straw is in the jar of colored water. A ring stand with a ring or clamp can be used to stabilize the bottle. Otherwise students can hold the bottle in place. Be sure the end of the straw is at least one inch below the water's surface. See drawing.

Finally have students place a hot, wet rag on the top of the inverted bottle and then quickly use a very cold, wet rag (take a wet rag from the freezer, but do not let it freeze).

Background:

The warm, wet rag causes the air in the bottle to become heated. As a result it expands and moves down the straw, forming gas bubbles in the water. The volume and pressure both are constant, but the amount of gas (number of molecules) decreases. thus this is a case where the temperature increase is affected by a decrease in number of molecules, with pressure and volume being held constant.

When a cold rag is placed on the bottle, the colored water from the jar moves up the straw and into the soda bottle. The air in the bottle has cooled and contracted due to a cooling effect. The contraction causes the air pressure inside the bottle to be less than that pushing down on the surface of the colored water. The water moves up the straw in response to these pressure differences, decreasing the volume of air inside the bottle. Thus, this experiment involves a decrease in both volume and pressure, but with the amount of gas being held constant.

Further Variations:

Students could vary the temperature to test the sensitivity of this apparatus.

Adapted by L. Crow (Baylor College of Medicine, Houston) from:
Van Cleave, Janice. *Teaching the Fun of Physics*. New York: Prentice-Hall, 1985.

alternative/extension activity for Event 1

Teacher Sheet

Science as Inquiry

A Reacting Bottle

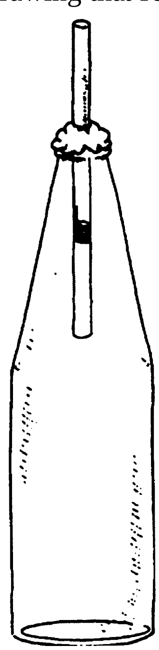
How does temperature affect volume?

Materials:

1 straw or glass tubing
clay or one-hole stopper
1 glass soda bottle or flask
water
food coloring
small container to mix water and food coloring

Procedure:

Students will wrap modeling clay around the middle of a drinking straw. They then fill a small container with water and add enough food coloring to make the water a dark color. Blue works well. Next have them dip one end of the straw in the water; then have them place their index finger over the open end of the straw. They then lift the straw which has captured about 2 cm of water in its lower end, while continuing to hold their finger over the end of the straw. They insert the free end into a soda bottle and seal it in place with clay. (Before they remove their finger from the end, they must push the clay around the opening of bottle and seal it.) See drawing that follows.



Instruct them to place their hands around the bottom of the bottle and make observations.

Background:

Heat from one's hands increases the temperature inside the bottle. The air in the bottle is heated. As the air is heated, molecules move faster. But instead of the pressure increasing, the molecules lift the column of water, and the volume increases. Thus, the temperature increase produces a small increase in volume at constant pressure. The expanding air pushes the colored water column upward in the straw. This apparatus could be called a gas expansion thermometer. The colored water column trapped in the straw responds to changes in air pressure in the bottle.

If students cool the bottle with ice or cold water, the colored column of water will move down the straw. The air cools inside the bottle, reducing the internal gas volume. The trapped column of colored water therefore moved down the straw, decreasing the volume of gas.

Further Variations:

Have students cool the bottle with ice or by running cool water over the bottle.

Adapted by L. Crow (Baylor College of Medicine, Houston) from:
Van Cleave, Janice. *Teaching the Fun of Physics*. New York: Prentice-Hall, 1985.

alternative/extension activity for Event 1

Teacher Sheet

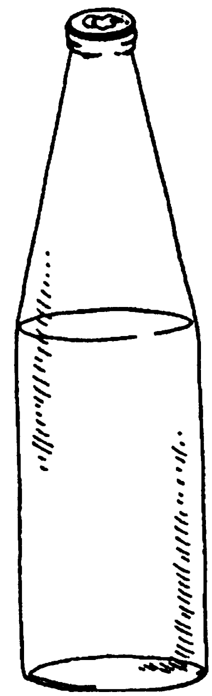
Science as Inquiry

Coin Tricks

How does temperature affect pressure?

Materials:

1 soda bottle
freezer
1 dime
water



Procedure:

Have students place a soda bottle in the freezer for at least 15 minutes. Next they should remove the bottle from the freezer, and immediately cover the mouth with a wet dime. Be sure the dime and bottle have no chips. To obtain a better seal, have them drip some water along the edge of the dime

Background:

Students will observe that the dime will begin to make a popping sound, as it rises up on one side and falls back into place. This popping will continue.

As the bottle is cooled in the freezer, the air particles slow down and as a result exert less pressure than the air pressure outside the bottle. More air, therefore, moves from the outside to the inside of the bottle. Once the bottle is outside the freezer, the cold air inside the bottle starts to heat up and the gas molecules increases their velocity thereby increasing the inside pressure. This air pushes up with enough pressure to lift the dime on one edge. Each time as small quantities of this air escapes, the dime rises and falls back down again.

Further Variations:

Have students place their hands around the bottom of the bottle as soon as it is removed from the freezer and a dime placed on the mouth and observe what happens.

Adapted by L. Crow (Baylor College of Medicine, Houston) from:
Van Cleave, Janice. *Teaching the Fun of Physics*. New York: Prentice-Hall, 1985.

alternative/extension activity for Event 1

Teacher Sheet

Science as Inquiry

The Hot Can Trick

How does the pressure change as the number of molecules of a gas changes?

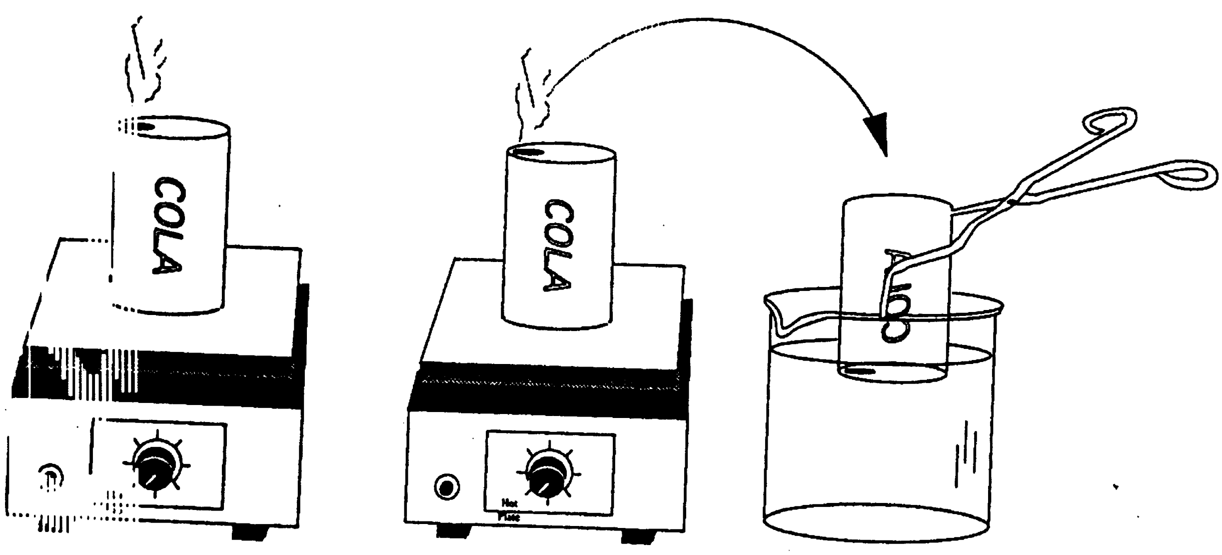
Materials:

large beaker (1000 mL) or bucket
aluminum soft drink can
water
hot plate
tongs

Procedure:

Students pour water into an empty aluminum soft drink can to a depth of about 1 cm. This can with the water is placed on a hot plate until the water begins to boil. Caution them not to let the water boil away. As soon as the water begins to boil, have them remove the can from the hot plate and place it in an upright position on the table top. Ask them to note what they observe.

Next students repeat the process. But they first fill a large beaker or bucket with cold water. And this time they will invert the can and submerge the can into the bucket of water.



Background:

When the water inside the can boils it changes into steam and displaces the air that was originally in the can. If the can is cooled and sealed, this steam condenses to liquid water, but it occupies about 1000 times less space. As a result the number of gas molecules in the can has suddenly been reduced from a very large number to almost zero. The gas pressure inside the can therefore drops to almost zero.

Since the air pressure outside the can remains approximately the same, and the inside pressure drops so dramatically, the can collapses. The water in the beaker or bucket does not enter the can quickly enough to equalize the pressure due to the inertia of the water. The can reacts to the pressure so quickly, it collapses before any significant amount of water can enter it.

In this experiment, the can is open and the water is boiling inside. Just placing it on the table will create no changes. However, when it is inverted and placed upside down in a buck/beaker of water, it rapidly collapses.

Further Variations:

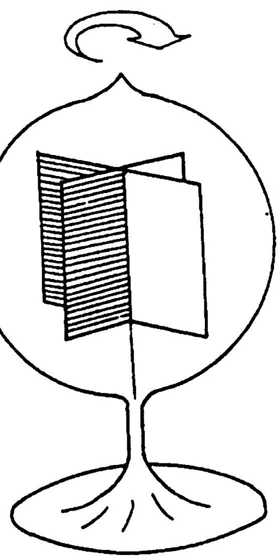
Use cans that have a cap and can be tightly sealed. Boil the water in the can and quickly cap it.

Adapted by L. Crow (Baylor College of Medicine, Houston) from:
Cunningham, James, and Herr, Norman, *Hands-On Physics Activities*. New York: Center for Applied Research in Education, 1994.

Science as Inquiry

Radiometer

How does reflected and absorbed light energy produce pressures on the absorber or reflector surface in the presence of a small amount of gas?



Materials:

radiometer
light source (overhead projector turned on its side, sunlight, lamp)
black cloth (12-inch square)

Procedure:

Have students place the radiometer in a bright light and observe what happens under different conditions of light. Ask them to explain in terms of heat, particles (or molecules), and pressure what they observe.

Background:

The vanes of a radiometer have a shiny mirrored side and a black side. The glass chamber that surrounds these vanes has been evacuated so that there are very few molecules remaining and very little pressure inside the chamber. This low pressure allows for a greater difference between energy transferred between the shiny side and the darker side of the vane. The effect of an increase in energy of the gas molecules compared to the number of molecules present is enhanced.

As the radiometer is exposed to bright light, gas particles on the black side of the vane gain energy upon collision with the vane. Thus they are made hotter. Since the gas particles bounce off at a greater velocity than before, this change in momentum imparts a reaction force to the vane, causing it to move away. The pressure, therefore, increases on the black side. The vanes begin to rotate with the black sides moving away from the bright light source. Note that this is opposite to the directions one would expect if it were radiation pressure. Radiation bouncing off the shiny side would impart twice the force to the shiny side than to the black side that absorbs radiation.

Further Variations:

Students could vary the experiment by moving the light source to see what effect this varying distance and position has on the outcome.

Adapted by L. Crow (Baylor College of Medicine, Houston) from:
Ehrlich, Robert, *Turning the World Inside Out.* Princeton: Princeton University Press, 1990.

Science in Personal
and Social Perspectives

Hot Air

Item:

Explain how the use of hot air balloons compares to using airplanes, as it relates to pollutants and other social perspectives.

Possible student answers:

The hot air ballon produces few pollutants. The fuel it burns is relatively clean and it does not use a great deal. Airplane fuel is relatively dirty, and the engine is very inefficient. The airplane also creates noise pollution, while the balloon only produces intermittent noise and has to be very low before it can be heard. The problem is the airplane travels at a greater speed and socially may be preferable for business or other travel plans. Economically, ballons are much cheaper to produce. Safety factors based on percentages would probably favor the plane, with one danger of the balloon being that the energy source is exposed.

Science and Technology

Hot Air

Item:

Airships (hydrogen or helium filled fixed-volume balloons called dirigibles) were once proposed as a good way to carrry freight and passengers from one coast of the U.S. to the other. However, the route used had to avoid mountain ranges. Hence many of the first uses of airships occurred across oceans, which are flatter than land.

Explain why the dirigible needed to avoid mountains but worked well for trips over the ocean.

Explain how using airships compares to using airplanes, as related to possible pollutants, convenience, and other social perspectives.

Possible student answers:

Because atmospheric pressure is reduced as the altitude increases, the balloon has less lifting power at higher altitudes and so cannot carry a big payload if it has to go over mountains. It could stay at or near sea level over the ocean for maximum lifting power. The dirigible produces few pollutants since “lift” is obtained by bouyancy, not by burning fuel. The fuel is only needed for horizontal transport, which is sedate and so uses little fuel in a low-power engine. Airplane fuel is relatively dirty and the engine is very inefficient. The airplane also creates noise pollution, while the balloon only produces intermittent noise and has to be very low before it can be heard.

The airplane travels at a greater speed and socially may be preferable for business or other travel plans.

Science and Technology

Car Tire Pressures

Item:

You measure the pressure of the air in your automobile tires early in the morning and find it to be 32 psi. After driving around town most of the day, you stop at a gas station and measure the pressure again and it now reads 34 psi. Which of the following statements correctly explains why the pressure may build up in a tire on a hot day?

A. As the temperature increases, more molecules are produced.
B. The volume of the tire decreases as the temperature increases.
C. As the temperature increases, the molecules expand and occupy more space.
D. As the temperature increases, the molecules move faster.

Justification:

Explain your answer in terms of kinetic energy.

Answer:

The correct choice is D. The average kinetic energy is proportional to the temperature. As the temperature increases, the average kinetic energy increases. Therefore, the molecules are moving faster and hitting the sides of the tire faster and more often. This will cause an increase in pressure. Therefore, the answer is D.

Science and Technology

Bread Dough

Item:

Bread dough rises when it is baked in an oven. This is because bubbles of carbon dioxide gas within the dough expand. The volume of these gas bubbles is NOT dependent on the:

A. mass of the CO_2 molecules
B. temperature of the CO_2 molecules
C. velocity of the CO_2 molecules
D. kinetic energy of the CO_2 molecules

Justification:

Explain what causes the bubbles of carbon dioxide gas to expand when the bread is baked.

Answer:

Choice A is correct. Kinetic energy is proportional to the temperature. Kinetic energy is thought of as energy in motion. It is described by the equation $KE = 1/2\ mv^2$ where v represents velocity. Since mass, m, is constant throughout the baking process,the volume of the gas bubbles is not dependent on it.

History and Nature of Science

Guy-Lussac

Item:

When Guy-Lussac investigated how the volume of a gas increased as its temperature increased, he used NO thermometers. The results were:

A. accurate because he kept the temperature fixed, so he didn't need to measure it.
B. accurate because comparisons at two different fixed temperatures (ice water and boiling water) were all that were needed.
C. inaccurate; later workers had to repeat everything using thermometers because his conclusions turned out to be wrong.
D. inaccurate because he couldn't control the temperature precisely enough.

Justification:

From what you know about gas laws and behavior, suggest if and how Guy-Lussac's experiment should be changed if it were done today.

Answers:

B. Guy-Lussac used ice water and hot water to see the "relative" changes in the amount of gas produced. The proportions would be relative and change by the same ratio each time, no matter what the gas (ideally). The idea of proportion wasn't based on a Celsius or Fahrenheit or Kelvin insertion of numbers.

Possible misconceptions:

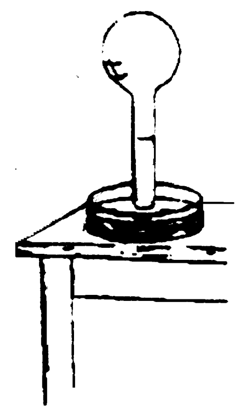
That temperature is a numerical concept, rather than a science concept. That a design without a thermometer would not work, so that the design would include some other temperature measuring device (even if it didn't exist). Early scientists were always "inaccurate" because they didn't have fancy equipment.

History and Nature
of Science

Guy-Lussac

Item:

Galileo is credited with using the first thermometer which
This thermometer, when calibrated at sea level, will give r
accurate temperature readings for an air temperature. When
up onto a hilltop 1000 meters high:



A. The thermometer will still give correct readings of the
air temperature.
B. The thermometer will be completely inaccurate unless
gas is in the bulb.
C. The thermometer will read too high because the atmos
pressure will be lower.
D. The thermometer will read too low because the atmosp
pressure will be lower.

Justification:

List and explain different factors that would affect the accuracy of Galileo's thermometer.

Answers:

C. The liquid will be depressed further down the tube by a fixed pressure of gas in the bulb, thus indicating that the gas is hotter than it would be at sea level.

Factors that could affect accuracy besides the changes in atmospheric pressure include:

· change in volume because of the change in liquid level

· expansion of the liquid

· vapor pressure of the liquid (not very significant if water)

· change in the bulb volume due to glass expansion/contraction

· nonideality of the gas (only significant at T near the boiling temperature)

Science as Inquiry/
History and Nature
of Science

Guy-Lussac

Item:

When Guy-Lussac discovered how the volume of a gas increased as its temperature increased, he used NO thermometers.

Propose a way to show how temperature changes could create volume changes in a certain proportion without using a thermometer to measure temperature.

Possible student answers:

Guy-Lussac used ice water and hot water to see the “relative” changes in the amount of gas produced. By adding more ice or more hot water, he could measure the relative changes in volume of a gas (like air). As the heat increased, he could tell that the volume of the gas would increase. As the heat decreased, he could tell that the volume of the gas would decrease. The proportions would be relative also. If he added twice as much ice, he would see a halving of the gas volume. The idea of proportion wasn’t based on a Celsius or Fahrenheit insertion of numbers.

Possible misconceptions:

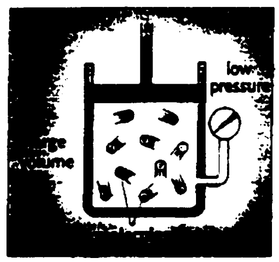
That an increase in temperature would cause a decrease in volume and vice versa. That a design without a thermometer would not work, so that the design would include some other temperature measuring device (even if it didn’t exist).

History and Nature
of Science

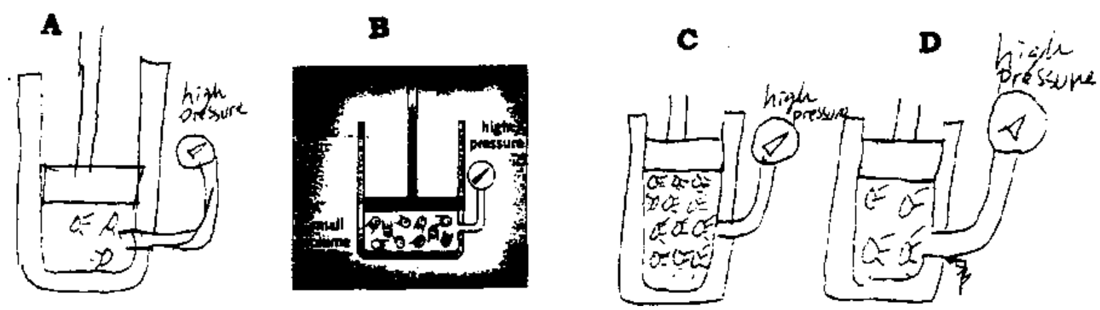
Gas Molecules

Item:

In an automobile engine, fuel and air molecules are drawn in to the cylinder at low pressures. The following picture represents the molecules of a gas in the cylinder at low pressure.



When the engine turns, the piston is forced in, and the gas is at high pressure. Which of the following diagrams represents the molecular arrangement at high pressure?



Justification:

Explain what the diagram you chose represents about the speed and distribution of the molecules.

Answer:

B. As the pressure increases the volume decreases and the molecules stay at the same speed as they move closer together (isothermal situation). Collisions increase. The other answers show situations that are contrary to the relationship that should be expressed.

Misconceptions:

Many students misunderstand what happens when you increase the pressure. They think that as the molecules are put under more pressure, they will expand and “push" out from each other.

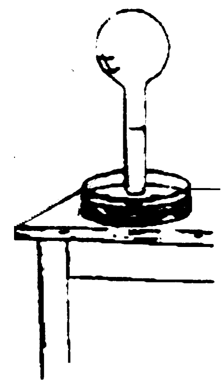
Science as Inquiry
History and Nature
of Science

Galileo

Item:

Galileo is credited with using the first thermometer which l
Explain carefuily how this works, using modern understandin
molecules behave in a gas and in a liquid.

Would it give a linear scale like a modern thermometer if it
calibrated (degree marks at equal distances on the indicating t
why not?



Possible student answers:

Hotter air molecules collide more rapidly and so exert more
the liquid surface disturbing the balance of the air pressure on
of the liquid. The height of the liquid in the column shifts to b
pressure.

Since the ideal gas law suggests P is a linear function of pressure (Charles' law), provided that the diameter of the tube is small compared to the volume of the flask so that the volume of gas is essentially constant, then the thermometer will have a linear scale.