Off the Shelf Chemistry
Laboratory Experiments

by Robert Farber
### Table of Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intro</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Where to Buy Chemicals</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>Chapter 1: Introduction to Alchemy</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Chapter 2: Water, Water Everywhere Different</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Chapter 3: A Slippery, Slimy Substance</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>Chapter 4: What is the POP in Popcorn?</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Chapter 5: Hard Rock Candy</td>
<td>29</td>
</tr>
<tr>
<td>6</td>
<td>Chapter 6: Heat and Seek</td>
<td>35</td>
</tr>
<tr>
<td>7</td>
<td>Chapter 7: Hot and Cold Reactions</td>
<td>38</td>
</tr>
<tr>
<td>8</td>
<td>Chapter 8: Are We Saturated Yet?</td>
<td>41</td>
</tr>
<tr>
<td>9</td>
<td>Chapter 9: Cleaning Up Your Act</td>
<td>45</td>
</tr>
<tr>
<td>10</td>
<td>Chapter 10: The SOLUTION to SOLUBILITY is the SOLVENT</td>
<td>48</td>
</tr>
<tr>
<td>11</td>
<td>Chapter 11: Out Spot, Darn Spot</td>
<td>52</td>
</tr>
<tr>
<td>12</td>
<td>Chapter 12: Can the METTLE of the METAL be Improved?</td>
<td>57</td>
</tr>
<tr>
<td>13</td>
<td>Chapter 13: Blowing Up Balloons, Chemically</td>
<td>61</td>
</tr>
<tr>
<td>14</td>
<td>Chapter 14: Creepy Metals</td>
<td>66</td>
</tr>
<tr>
<td>15</td>
<td>Chapter 15: Antacids</td>
<td>69</td>
</tr>
<tr>
<td>16</td>
<td>Chapter 16: Chemistry Clicks Your Bic</td>
<td>73</td>
</tr>
<tr>
<td>17</td>
<td>Chapter 17: Electric Gel Cell</td>
<td>77</td>
</tr>
<tr>
<td>18</td>
<td>Chapter 18: Viscosity is a Virtue</td>
<td>84</td>
</tr>
</tbody>
</table>

**Special note about the author and reproduction of this manual:** Robert Farber teaches Chemistry at Central High School in Philadelphia, PA, and was a participant in Serendip's Brain and Behavior Institute in 2002. He has informally collaborated with Ingrid Waldron, professor of Biology at the University of Pennsylvania, (see also: Hands-On Activities for Teaching Biology ...) over the years. He encourages other teachers to copy and modify these labs for use in their teaching, and Serendip is pleased to make these activities available to a wider audience.
OBJECTIVES

1. The student will learn that chemicals are not something just found in laboratories. Our physical environment is composed of chemicals. Our bodies are composed of chemicals. Understanding the principles of chemistry helps us better understand our world.

2. The student will learn to read and understand the ingredient labels on consumer products. In doing this the student will become a more sophisticated consumer.

3. The student will be able to use both English and SI systems of weights and measures to conduct experiments and to compare different brands of similar products.

4. The student will learn the importance of making and recording accurate observations.

5. The student will learn that in science, language is very important. Terms must be carefully defined in order for scientists to communicate with each other. The student will learn the difference between operational definitions and conceptual definitions.

6. The student will develop an appreciation of the chemistry that is used in our everyday lives.

GENERAL PROCEDURES

This chemistry lab manual is designed to use consumer products for student chemistry experiments. The students should be required to shop for many of the reagents. They will need to carefully read the labels of the products. They will develop greater understanding with experience. As they develop the good habit of reading the fine print on the ingredients portion of the label, they will be more confident of their ability to make informed intelligent choices.

Safety: All standard chemistry lab safety procedures must be strictly followed. The instructor must carefully check the labels on all the products used in the labs. The formula of a product and the chemicals used in a product can be changed by the manufacturer at any time.

Obtaining the Chemicals: Here is a list of where the chemicals for the experiments may be purchased. All of the reagents for these experiments may be purchased in supermarkets, drugstores, paint stores, etc., except chemical indicator solutions.

No Lab Tables Required: These experiments are especially suited to schools that have intensive scheduling. The experiments are designed to use a minimum of laboratory equipment so that they may be carried out on tables in a standard classroom if necessary.
This allows the students to do hands on lab work without being in the chemistry lab. The emphasis is inquiry. The students must do more thinking and will not be able to look up answers to complete the laboratory reports. This makes these experiments more challenging than they may appear at first glance.

**Background Information:** As in any scientific endeavor, the first step is to gather information about the subject. Before each experiment, the students need to have information relevant to the lab topic. The PRE LAB DISCUSSION provides some background information. The teacher may wish to provide additional information or the students may look up additional relevant information.

**Language Skill Building:** Clear precise communication is a key to good science. Scientists must be able to communicate their findings in unambiguous language. This often means that the common words are defined as used in this report so that the reader knows exactly what the scientist means when he reads the term. The teacher may wish to discuss the term significant as it is found in many scientific studies. It is usually defined using a statistical test in a scientific study but it shows up in advertising without any definition. Scientific writing is designed to have only one interpretation while poetry will invoke many different meanings, depending on the reader's personal experiences.

Students often tell the teacher that they "know" something but can't put it into words. Developing language skills is a large part of science, and students must be taught how to better use their language to communicate their ideas. The first step is to have students clearly define the terms that they are using. In many experiments, the students need to develop operational definitions for terms that are needed to describe critical aspects of the experiment.

**Scientific Thinking:** The students must develop confidence in their own THINKING ability. Great science does not depend on expensive complex equipment but on the clear thinking of the experimenter. The experiments in this manual serve only as entertainment if students do not do the follow-up THINKING SCIENTIFICALY. Teachers should insist that students think before they write and that they express their thoughts clearly.
# Where to Purchase Chemicals for Experiments

## OVER THE COUNTER CHEMICALS

<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>Type of Store</th>
<th>Type of Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetic acid</td>
<td>supermarket</td>
<td>vinegar</td>
</tr>
<tr>
<td>acetone</td>
<td>drug store</td>
<td>fingernail polish remover</td>
</tr>
<tr>
<td></td>
<td>paint store</td>
<td>solvent</td>
</tr>
<tr>
<td>alcohol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ethanol</td>
<td>hardware/paint</td>
<td>denatured alcohol</td>
</tr>
<tr>
<td></td>
<td></td>
<td>paint thinner</td>
</tr>
<tr>
<td>isoproponal</td>
<td>drugstore</td>
<td>rubbing alcohol</td>
</tr>
<tr>
<td></td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>methanol</td>
<td>hardware/paint</td>
<td>paint thinner</td>
</tr>
<tr>
<td></td>
<td>auto supply</td>
<td>gas line antifreeze</td>
</tr>
<tr>
<td>antacid tablets</td>
<td>drugstore</td>
<td></td>
</tr>
<tr>
<td></td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>aluminum</td>
<td>hardware</td>
<td>wire, siding nails, flashing</td>
</tr>
<tr>
<td></td>
<td>craft store</td>
<td></td>
</tr>
<tr>
<td>bobby pins</td>
<td>drugstore</td>
<td>metal not plastic</td>
</tr>
<tr>
<td>butane lighter</td>
<td>supermarket/drugstore</td>
<td></td>
</tr>
<tr>
<td>citric acid</td>
<td>supermarket</td>
<td>gator aid, tang, crystal light</td>
</tr>
<tr>
<td>copper</td>
<td>hardware</td>
<td>wire</td>
</tr>
<tr>
<td></td>
<td>craft store</td>
<td>strips</td>
</tr>
<tr>
<td>cornstarch</td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>corn syrup</td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>cream of tartar</td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>dishwashing liquid</td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>gelatin dessert</td>
<td>supermarket</td>
<td>jell-o, royal etc [citric flavors]</td>
</tr>
<tr>
<td>glycerin</td>
<td>drugstore</td>
<td></td>
</tr>
<tr>
<td>guar gum</td>
<td>health food store</td>
<td></td>
</tr>
<tr>
<td>hydrochloric acid</td>
<td>commercial</td>
<td>muriatic acid</td>
</tr>
<tr>
<td></td>
<td>company</td>
<td></td>
</tr>
<tr>
<td>Iodine [tincture of]</td>
<td>drugstore</td>
<td></td>
</tr>
<tr>
<td>iron</td>
<td>hardware</td>
<td>nails, wire</td>
</tr>
<tr>
<td>lead</td>
<td>craft store</td>
<td>strips</td>
</tr>
<tr>
<td></td>
<td>sporting goods</td>
<td>sinkers</td>
</tr>
<tr>
<td>Item</td>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------</td>
<td></td>
</tr>
<tr>
<td>lighter fluid</td>
<td>drugstore</td>
<td></td>
</tr>
<tr>
<td>magnesium</td>
<td>bicycle repair shop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>camping supply</td>
<td></td>
</tr>
<tr>
<td>oxalic acid</td>
<td>commercial cleaning supply</td>
<td></td>
</tr>
<tr>
<td></td>
<td>auto supply</td>
<td></td>
</tr>
<tr>
<td>oils</td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>paradichlorobenzene</td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>pH indicator strips</td>
<td>pet supply</td>
<td></td>
</tr>
<tr>
<td>plaster of paris</td>
<td>hardware</td>
<td></td>
</tr>
<tr>
<td>popcorn</td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>powdered sugar</td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>sodium bicarbonate</td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>sodium borate</td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>sodium hydroxide</td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>sodium thiosulfate</td>
<td>photography store</td>
<td></td>
</tr>
<tr>
<td>sugar</td>
<td>supermarket</td>
<td></td>
</tr>
<tr>
<td>toluene</td>
<td>hardware</td>
<td></td>
</tr>
<tr>
<td>waterless hand cleaner</td>
<td>auto supply</td>
<td></td>
</tr>
<tr>
<td>white glue</td>
<td>craft store</td>
<td></td>
</tr>
<tr>
<td>xylene</td>
<td>paint store</td>
<td></td>
</tr>
<tr>
<td>zinc</td>
<td>hardware</td>
<td></td>
</tr>
<tr>
<td></td>
<td>hot dipped galvanized nails</td>
<td></td>
</tr>
</tbody>
</table>

**Indicators that the school will need to purchase:**

Congo red, phenolphthalein, lead nitrate
INTRODUCTION TO ALCHEMY

PRE LAB DISCUSSION

Alchemy preceded modern chemistry. It began in Egypt, Persia, and Mesopotamia. There are records of alchemists in Alexandria around 300 BC. From there it spread to India, China and to Europe. Alchemists made many important discoveries and developed equipment and procedures that we still use today. They contributed to metallurgy, dyeing, glass making, and medicine. Their work advanced our knowledge of the physical world.

In the Middle Ages, court alchemists worked to transmute base metals into gold to provide wealth for their sponsors. They often conducted their experiments in secret and kept their records using symbols to represent chemical ingredients. As a result of this, alchemy is often thought of as mysticism, magic, or fraud.

OBJECTIVES: Like the alchemists, our objective is to make gold from base metals.

CHEMICALS/EQUIPMENT: Bunsen burner, tongs, evaporating dish or beaker, ring, ring stand, penny, drain cleaner [lye-NaOH or KOH], hot dipped galvanized nails [zinc], water

PART I
First attempt at Transmutation

PROCEDURE:

1. Place the drain cleaner in a beaker or evaporating dish to a depth of about one inch.

2. Add several hot dipped galvanized nails.
3. Using tongs, add several clean pennies. Do not allow the pennies to overlap each other. [pennies can be cleaned using salt & vinegar]

4. Heat gently until the liquid is almost boiling. Maintain this temperature for several minutes. Do not boil unless this is being conducted under a fume hood.

5. Using tongs, remove the pennies and rinse thoroughly to remove all traces of the drain cleaner.

6. Examine the pennies and record your observations.

Observations........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................

PART II
Transmutation: Try, try again

PROCEDURE:
1. Hold a silver penny from Part I by the edges with tongs. Place it just above the flame of a Bunsen burner. Remove it from the heat immediately when it changes color.

2. Allow the coin to cool and record your observations.
THINKING SCIENTIFICALLY

Hypothesis: [circle one]  
A base metal was transmuted to gold.

Gold cannot be produced by this method

Gathering data & library research

1. What are some of the physical properties of gold?
   color _____________ hardness _____________ melting point _____________
   density _____________ solubility _____________
   heat conductivity _____________ electrical conductivity _____________
   Other unique properties______________________________________________

2. What are the chemical properties of gold?
   valance _________ reactivity ___________ atomic number _____
   atomic mass _____
   REACTION with:
   Oxygen

   Acids

   Bases

3. What metal or metals are used to make pennies?
   ___________________ ___________________

4. What is an alloy?
5. List at least two common alloys and tell their composition.
Alloy name ___________ composition ___________________________

_________________                     ____________________________

Conclusions
Write an essay to defend your choice of hypothesis. You will combine the information about the known properties of gold, pennies, and alloys with your experimental observations to support your hypothesis.

You may suggest further experiments that you could or would like to do to prove your hypothesis. Do not conduct any experiments without the prior approval of your teacher.

Extra
Read and report on some famous alchemists. The names of a few are provided below.

Jabir ibn Hayyan            Arnold of Villanova
Rhaes                   Geber
Ko Hung                  Paracelsus
Sun Po                   Bottger
Hermes Trismegistus      Hennig Brand
WATER, WATER EVERYWHERE DIFFERENT

PRE LAB DISCUSSION
This lab will help us compare the properties of water samples from different sources. The impurities in water may affect its taste or usefulness in specific chemical processes. We will use various techniques to measure these impurities.

Water that tastes good is not the same for everyone. What tastes good depends on the palette of the taster. To some extent, taste is learned. This is why some of us prefer Coke, some like Pepsi, and others always buy Frank’s Cola.

Conductivity
Pure water does not conduct electricity. However, the water in our world is seldom pure. Water is often called the “universal solvent” because many elements and compounds can dissolve in it. Take, for example, rainwater. Rain dissolves both gases and suspended solids as it falls to the ground, leading to such extremes as “acid rain” in highly polluted atmospheres.

Electrical conductivity is a measure of the total amount of dissolved ions in the water. This does not indicate specific elements or compounds, which are dissolved in the water, but rather the total amount of dissolved ions. Water from the same source may show different amounts of conductivity in different seasons or with different weather conditions. For instance, the conductivity of water in the winter changes when there has been a lot of salt applied to the roads to melt ice and snow.

We will use a simple conductivity device. A clear electric light will allow us to compare the relative conductivity of the water samples. If we wanted to be more exact we could use a multimeter to measure the exact conductivity in ohms of resistance.
pH
This is a measure of the amount of acidity or alkalinity of the water. This can be measured with either a battery operated pH meter or by using the pH test paper. Neutral water will have a pH of 7. Water that is below 7 is acidic and water that is above 7 is alkaline.

Carbonates
Water that has traveled under ground or over limestone dissolves some carbonates (CO$_3$). Usually this is calcium carbonate. Water that is high in carbonates usually does not have a low pH. This is because any acids that may have been present in the water have reacted with the limestone. This water will often leave a white residue when it evaporates. Dilute hydrochloric acid will react with solid carbonates producing bubbles.

To test for carbonates in solution, a saturated solution of lead nitrate will be used. The reaction between the carbonate and the lead nitrate produces insoluble lead carbonate. The amount of cloudiness indicates the amount of carbonate in the water. This white substance will slowly settle to the bottom of the test tube.

Hardness (total)
Water is called *hard* when it contains a lot of dissolved minerals. These minerals can include calcium, chlorides and sulfates. This type of water makes it difficult to produce suds of lather and leaves a "ring-around-the tub" residue. Many of the laundry products on the market today include a water softener compound in the detergent to prevent a gray color remaining on washed clothes.

There is a simple test for hardness. Just add a drop of soap solution to 5 ml sample of water and shake for 15 seconds. Then measure the height of suds on the sample. In order for this test to be accurate, each sample must be shaken with the same energy. Testing labs use shaking machines to do this, but we will have to rely upon our own shaking skills.

Total Dissolved Solids
The total amount of solids can be determined by evaporating a measured amount of water and observing the amount of residue.

OBJECTIVES: To determine the differences between the samples of water obtained by the class.
CHEMICALS/EQUIPMENT: At least 5 samples of water including distilled water, rainwater, pond or stream water, pH paper or meter, conductivity tester, lead nitrate solution, soap solution\(^1\), test tubes, stoppers, watch glass, beaker, ring stand, ring, screen, Bunsen burner.

PROCEDURE:

1. Using the conductivity apparatus, test each water sample and rate the samples from the most conductive \([1]\) to the least conductive \([5]\). Record this rating in the data chart.

2. Determine the pH of each sample and record the pH in the data chart.

3. Place 10 ml of each sample in separate, labeled test tubes. Add 2 ml of saturated lead nitrate solution. Rate the samples from the most lead carbonate produced \([1]\) to the clearest \([5]\). Record this information on the data chart under carbonates or \(\text{CO}_3\).

4. Place 5 ml of each sample in separate labeled test tubes. Add one drop of soap solution to each sample. Shake each sample 15 seconds and measure the height of the suds immediately. Record the height of the suds in the data chart.

5. Place a beaker \(3/4\) full of tap water above a Bunsen burner using a ring stand, ring, and screen. Then put a watch glass on top of a beaker and fill the watch glass with one of the water samples. Boil the water in the beaker and allow the steam to evaporate the water in the watch glass. Be careful not to allow the beaker to boil to dryness. Repeat this for each water sample. Then compare the amount of residue on the watch glasses and rate the water samples from the most \([1]\) to the least \([5]\) amount of dissolved solids.

---

\(^1\) Soap solution can be made using any hand soap dissolved in water. Shampoos and some dishwashing liquids may be designed to foam too well to use in this lab.
**DATA CHART**

<table>
<thead>
<tr>
<th>Sample source</th>
<th>Electrical conductivity</th>
<th>PH [acid/base]</th>
<th>Carbonates CO₃</th>
<th>Hardness</th>
<th>Total Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**THINKING SCIENTIFICALLY**

1. Chemists and pharmacists use distilled water when making solutions. Why do they use this type of water rather than tap water?

2. Many women wash their hair in rainwater or "soft water" when it is available. Why would they prefer this water for their hair?
3. If you showered in salt water, could you clean yourself well? Why or why not?

4. Using the information from the data sheet, what effect do you imagine the dissolved chemicals have on the taste of the waters? [DO NOT taste samples from non-approved drinking water sources]

**EXTRA**
1. Take a survey of students using a questionnaire and determine what type of water they prefer for drinking.

2. Set up a water taste test with drinking water from several sources. Number the water so that the subjects do not know the sources of water. Then select students at random to sample the waters and rate the taste as excellent, good, OK, or poor. [Make sure that the water is safe to drink, e.g. no stream or pond water.]

3. Compare the data collected in the two questions above. Use charts and graphs to present the comparisons. What conclusions can be drawn from this data?
A SLIPPERY SLIMY SUBSTANCE

PRE LAB DISCUSSION

Scientists must use exact language to communicate their observations and ideas to other scientists. Many words have different meanings to different people. To avoid miscommunication, scientists often include definitions of the words they use to describe their ideas and observations. For example, there will be phrases in the report such as "for the purpose of this report _______ will mean..."

Many words have both a conceptual and an operational definition. A conceptual definition is an abstract idea that may not be measured or observed. An operational definition is a series of observations and measurements that will determine the existence of something.

In the laboratory you observe chemical and physical phenomena and need to communicate your findings clearly to others. You need to define terms operationally. In this lab, if you cannot define the states of matter in operational terms, you cannot communicate or defend your ideas and opinion.

OBJECTIVE: To make and study an unusual polymer

Materials/equipment: Beaker, stirring rod, ring, wire screen, ring stand, Bunsen burner, saturated solution of sodium tetraborate [Borax], Guar gum, food coloring,

[Guar gum can be purchased in most health supplement stores & borax is a natural laundry product]

PROCEDURE:

1. Add 100 ml of water to your beaker. You may use water colored with food coloring for a more colorful experiment.
2. Add 0.7 grams of guar gum to the water.

3. Heat the water while stirring gently to dissolve the guar gum.

4. When the guar gum is completely dissolved, add 7 ml of saturated sodium borate solution. Stir *just* once or twice to mix the two liquids.

5. Allow the newly formed polymer to cool to room temperature. Then pour it out on your table. Move it around and pick it up with your hands.

6. Make and record as many observations as possible.

THINKING SCIENTIFICALLY
Before a scientist uses a term, the scientist must be sure of the meaning of the term. If the term may have slightly different meanings in a different context or to different people, the scientist will define the term for the purpose of this experiment. In this case, you must provide an *operational* definition of the terms *solid* and *liquid*.

What are the properties that define a *solid*?

What are the properties that define a *liquid*?

Conclusion- Is SLIME a solid or a liquid?
Defending your Conclusion—Write an essay combining your observations with your definitions to support your conclusion. You may attach it to this report.

THE UNIQUE PROPERTIES OF SLIME

Materials/equipment: Plastic wrap, marker pen, meter stick, timer [watch]

Background
Rheology is the study of the flow and deformation of matter. When dealing with solids, the study of rheology tests the property known as elasticity. When dealing with fluids, rheology tests the property known as viscosity.

VISCOITY

Viscosity is defined as the internal resistance to flow shown by a liquid. One way viscosity is measured is to drop a metal ball through a column of liquid and measure the time that it takes to fall through the liquid. However, we will not do this. Measuring the rate of flow of a specific amount of a liquid between two points is less accurate but will suffice at this time because everyone’s SLIME is not exactly the same.

Procedure
1. Draw a circle using a small beaker, coin, etc on a plastic sheet [plastic wrap]

2. Draw a larger concentric circle around the first circle using a larger circular object.

3. Roll a ball of SLIME of a size to almost fill the center circle and place it in the center of the smaller circle [determining its mass provides a more accurate experiment].

4. Begin timing the flow of the SLIME when it flows to touch the inner circle and record how long it takes to reach the outer circle. [If the SLIME stops flowing, your circles are too big]
5. Measure the distance between the two circles and calculate the rate of flow of your SLIME in centimeters per minute.

**DATA**

Mass of SLIME used [optional] 

1. Time to flow from inner to outer circle. 

2. Distance between the circles 

3. Rate of flow [cm/min] 

**ELASTICITY, ELONGATION, & TENSILE STRENGTH**

Tensile strength of a solid substance is its strength under tension. It is the force needed to pull a substance apart.

Elasticity allows a solid to regain its original shape and size after it has been stretched. When the force applied to an elastic substance reaches a certain strength, the substance loses its elasticity and may break. This force is called the elastic limit.

**Procedure**

1. Place a meter stick on the table.

2. Take 20 grams of slime and roll it into a sausage shape about 2 cm [inch] in diameter.

3. One student will hold the SLIME between two fingers and a thumb. Start at the edge of the yardstick and stretch the SLIME at a uniform rate across the table. The other student will count seconds per cm that the SLIME is stretched.

4. Record the length of the SLIME when it snapped.
5. Repeat this several times and average the results. Try to maintain the same speed each time.

<table>
<thead>
<tr>
<th>Data</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>ave</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Seconds per cm stretched.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. centimeters stretched</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
WHAT is the POP in POPCORN?

PRE LAB DISCUSSION

The corn grown for use as popcorn has to have a high moisture content and a tough seed coat. It is usually packaged and shipped in airtight containers. Bags of microwave popcorn are individually sealed in airtight packages.

During this experiment it is crucial that the popcorn is popped in the exact same way in each of the three parts, using the exact same amount of heat energy. If a microwave is available, it should be used. However, if a microwave is not available, students should use Bunsen burners and be sure to heat the corn for the same amount of time in each of the three parts of this experiment.

OBJECTIVE: To determine what causes some corn kernels to POP when heated.

CHEMICALS/EQUIPMENT: balance, Bunsen burner, flask, two hole stopper, ring, ring stand, screen, sharp probe, popcorn, cooking oil (not needed if a microwave is used), pan and oven or hot plate

PROCEDURE:

PART I

1. Determine the mass of 40 kernels of popcorn. Record.

2. Calculate the average mass of one kernel of popcorn.

3. Place the popcorn in a flask with a few drops of cooking oil. Stopper the flask with a two hole stopper.
4. Heat the flask and pop the corn, shaking it and being careful not to burn the corn.

5. Determine the number of popped kernels.

6. Determine the mass of the popped kernels.

7. Calculate the average mass of the popped kernels.

8. Calculate the percentage of kernels that popped.

PART II

1. Using a sharp probe, bore a small hole into each of 20 kernels of popcorn.

2. Place the corn in a flask, add a few drops of cooking oil, and stopper the flask with a two hole stopper.

3. Heat the flask to pop the corn, shaking it and being careful not to burn the corn.

4. Determine the number of kernels that popped.

5. Calculate the percentage of kernels that popped.

PART III

1. Place 40 kernels of popcorn in a pan and place in a warm oven [below 200º F] or on a warm hot plate for 40 minutes.

2. Place the popcorn in a flask with a few drops of oil and stopper the flask with a two hole stopper.

3. Heat the flask to pop the corn, while shaking it and being careful not to burn the corn.

4. Determine the number of kernels that popped.
5. Calculate the percentage of the kernels that popped.

DATA & CALCULATIONS

1. Mass of 40 kernels of popcorn.................................

2. Calculated mass of one kernels of popcorn.................

3. Number of kernels that popped.............................

4. Calculated mass of one popped kernel.....................

5. Percentage of kernels popped in part I ..................

6. Number of kernels popped in part II......................

7. Percentage of kernels popped in part II..................

8. Number of kernels popped in part III....................

9. Percentage of kernels popped in part III.................

THINKING SCIENTIFICALLY

1. Why is popcorn usually sold in tightly sealed containers?

2. What caused the loss of mass when the kernels popped?

3. Why were the kernels with a hole in them less likely to pop?

4. Why were the kernels less likely to pop after they had been heated for 40 minutes?
HARD ROCK Candy

PRE LAB DISCUSSION

This is an experiment in controlling crystal growth. Rock candy, like most candy, is made primarily from sugar. The candy can be anything from large single crystals to an amorphous solid. In this experiment the students will produce each end of this spectrum.

Making fudge is an excellent follow-up to this experiment. The key to making good fudge is controlling crystal growth in a supersaturated solution. Most fudge recipes use both chemical and mechanical means to reduce the size of the sugar crystals in order to have a creamy texture. It is difficult to make fudge in most classrooms, however. An analysis of fudge recipes will extend the appreciation of how chemical principles are used in candy making. Students may wish to make fudge at home and have the class evaluate their results.

This experiment will take several days to complete.

PART I

OBJECTIVE: To make sugar crystal rock candy.

CHEMICALS/ EQUIPMENT: cane sugar, 250 ml beaker, Bunsen burner, ring, screen, ring stand, string, glass rod, weight [a nail will do]

PROCEDURE:

1. Boil 125 ml of water in a very clean beaker. Turn off the burner.

2. Add sugar until no more sugar will dissolve. Be sure that all the crystals have dissolved. It may be necessary to re-heat the solution.

3. Tie a weight on a piece of string. Suspend the string in the supersaturated sugar solution using a glass rod or pencil to support it.

4. Place the beaker where it will not be disturbed for a few days. Make and record daily observations of crystal growth.

PART II
OBJECTIVE: To make amorphous rock candy.

CHEMICALS/EQUIPMENT: cane sugar, corn syrup, candy thermometer, non-stick spray [Pam] or solid shorting [Crisco], large beaker, stirring rod or spoon, aluminum foil, *optional* wooden splints, food coloring, flavoring such as mint, orange, lemon etc.

PROCEDURE:

1. Place 1/2 cup of sugar, 1/8 cup of corn syrup, and 1/8 cup of water into the beaker and stir.

2. Heat the beaker while stirring gently to prevent burning. Continue heating until the mixture boils. Record the temperature at which it begins to boil. Observe and record any changes in the clarity of the liquid.

3. Continue to gently boil the solution 285°F. Then turn off the burner and allow it to cool.

4. Prepare aluminum foil molds for your candy or lollipops. Lightly grease the foil molds so that the candy will not stick to the foil. Position wooden splints in the mold to make lollipops.

5 *optional* When the solution has cooled to about 200°F stir in one drop of food coloring and a drop of flavoring.

6. Pour the solution into the molds. Allow the solution to cool to room temperature without being disturbed. Make and record the observations of the resulting solid.

**PART III**

OBJECTIVE: To determine the effect of "seeding" at various temperatures on sugar crystal growth.

CHEMICALS/ EQUIPMENT: cane sugar, beaker, Bunsen burner, ring, screen, ring stand, stirring rod or spoon, candy thermometer, 4 evaporating dishes
PROCEDURE:
1. Place 25 ml of water and 50 grams of sugar in the beaker.

2. Heat gently while stirring until the sugar has dissolved.

3. Continue heating until the mixture boils and reaches a temperature of approximately 240°F

4. Using beaker tongs, pour equal amounts of the hot liquid into four evaporating dishes. *BE VERY CAREFUL NOT TO GET ANY OF THIS HOT STICKY LIQUID ON YOUR SKIN.*

5. Using a strong stirring rod or spoon, beat one portion of this now.

6. Beat another portion when it reaches 160°F.

7. Beat the third portion when it reaches 140°F.

8. Beat the last portion when it reaches 100°F.

9. Examine each portion to determine crystal size using a low power microscope or magnifying glass. Record your observations.

10. Feel each portion to determine which has the smoothest texture. Record your observations.

**PART IV**

OBJECTIVE: To determine the effect of chemical additives on the growth of sugar crystals.

CHEMICALS/EQUIPMENT: cane sugar, corn syrup, cream of tartar, glycerin, vinegar, beakers, Bunsen burner, Candy thermometer, ring, screen, ring stand, stirring rod or spoon.

PROCEDURE: *The teacher should divide the class into 5 groups, a control group and a group for each of the 4 additives*
1. Place 25 ml of water and 50 grams of cane sugar into a beaker.

2. Add the following according to your group assignment:
   - control group..............add nothing
   - group one..................add 0.1 gram of cream of tartar
   - group two..................add 4 ml of vinegar
   - group three..............add 10 ml of corn syrup
   - group four..............add 3 ml of glycerin

3. Heat the mixture gently while stirring until it reaches a temperature of 240°F.

4. Allow the solution to cool to 140°F and then beat it with a spoon or stirring rod.

5. Using a microscope or magnifying glass, observe the crystal size of each of the five portions.

6. Touching the sugar, determine the texture of the sugar.

---------------------------------------------

OBSERVATIONS
PART I

Day one observations

Day two observation

Day three observations

Day four observation

Day five observations
PART II
Observations of the clarity or crystal structure of the candy

PART III
Crystal size and texture of:
Portion I [beating at high temperature]
Portion II [beating at 160 °F]
Portion III [beating at 140 °F]
Portion IV [beating at 100° F]
PART IV

Crystal size and texture of:

Control

With cream of tartar

With vinegar

With corn syrup

With glycerin

THINKING SCIENTIFICALLY

Cooking and candy making are often described as an "art". Many famous chefs have secret recipes. Other times recipes become "family secrets" that are passed from mother to daughter. These recipes were often developed over years by trial and error. The cooks often do not know why certain ingredients are used or why something must be stirred only at a certain temperature.

Large-scale commercial food preparation is not an art. It is a science. The company has a sound reason for each ingredient used and cooking times and temperatures are computer controlled.

Write an essay comparing the methods of the alchemists and the modern chemists, chefs using secret recipes, and to the methods of the modern commercial food industry.
HARD ROCK Candy

PRE LAB DISCUSSION

This is an experiment in controlling crystal growth. Rock candy, like most candy, is made primarily from sugar. The candy can be anything from large single crystals to an amorphic solid. In this experiment the students will produce each end of this spectrum.

Making fudge is an excellent follow-up to this experiment. The key to making good fudge is controlling crystal growth in a supersaturated solution. Most fudge recipes use both chemical and mechanical means to reduce the size of the sugar crystals in order to have a creamy texture. It is difficult to make fudge in most classrooms, however. An analysis of fudge recipes will extend the appreciation of how chemical principles are used in candy making. Students may wish to make fudge at home and have the class evaluate their results.

This experiment will take several days to complete.

PART I

OBJECTIVE: To make sugar crystal rock candy.

CHEMICALS/ EQUIPMENT: cane sugar, 250 ml beaker, Bunsen burner, ring, screen, ring stand, string, glass rod, weight [a nail will do]

PROCEDURE:

1. Boil 125 ml of water in a very clean beaker. Turn off the burner.

2. Add sugar until no more sugar will dissolve. Be sure that all the crystals have dissolved. It may be necessary to re-heat the solution.

3. Tie a weight on a piece of string. Suspend the string in the supersaturated sugar solution using a glass rod or pencil to support it.

4. Place the beaker where it will not be disturbed for a few days. Make and record daily observations of crystal growth.

PART II
OBJECTIVE: To make amorphous rock candy.

CHEMICALS/EQUIPMENT: cane sugar, corn syrup, candy thermometer, non-stick spray [Pam] or solid shorting [Crisco], large beaker, stirring rod or spoon, aluminum foil, optional wooden splints, food coloring, flavoring such as mint, orange, lemon etc.

PROCEDURE:

1. Place 1/2 cup of sugar, 1/8 cup of corn syrup, and 1/8 cup of water into the beaker and stir.

2. Heat the beaker while stirring gently to prevent burning. Continue heating until the mixture boils. Record the temperature at which it begins to boil. Observe and record any changes in the clarity of the liquid.

3. Continue to gently boil the solution 285°F. Then turn off the burner and allow it to cool.

4. Prepare aluminum foil molds for your candy or lollipops. Lightly grease the foil molds so that the candy will not stick to the foil. Position wooden splints in the mold to make lollipops.

5 optional When the solution has cooled to about 200°F stir in one drop of food coloring and a drop of flavoring.

6. Pour the solution into the molds. Allow the solution to cool to room temperature without being disturbed. Make and record the observations of the resulting solid.

PART III

OBJECTIVE: To determine the effect of "seeding" at various temperatures on sugar crystal growth.

CHEMICALS/ EQUIPMENT: cane sugar, beaker, Bunsen burner, ring, screen, ring stand, stirring rod or spoon, candy thermometer, 4 evaporating dishes
PROCEDURE:
1. Place 25 ml of water and 50 grams of sugar in the beaker.
2. Heat gently while stirring until the sugar has dissolved.
3. Continue heating until the mixture boils and reaches a temperature of approximately 240° F
4. Using beaker tongs, pour equal amounts of the hot liquid into four evaporating dishes. *BE VERY CAREFUL NOT TO GET ANY OF THIS HOT STICKY LIQUID ON YOUR SKIN.*
5. Using a strong stirring rod or spoon, beat one portion of this now.
6. Beat another portion when it reaches 160° F.
7. Beat the third portion when it reaches 140° F.
8. Beat the last portion when it reaches 100° F.
9. Examine each portion to determine crystal size using a low power microscope or magnifying glass. Record your observations.
10. Feel each portion to determine which has the smoothest texture. Record your observations.

PART IV

OBJECTIVE: To determine the effect of chemical additives on the growth of sugar crystals.

CHEMICALS/EQUIPMENT: cane sugar, corn syrup, cream of tartar, glycerin, vinegar, beakers, Bunsen burner, Candy thermometer, ring, screen, ring stand, stirring rod or spoon.

PROCEDURE: [*The teacher should divide the class into 5 groups, a control group and a group for each of the 4 additives*]
1. Place 25 ml of water and 50 grams of cane sugar into a beaker.

2. Add the following according to your group assignment:
   - control group: add nothing
   - group one: add 0.1 gram of cream of tartar
   - group two: add 4 ml of vinegar
   - group three: add 10 ml of corn syrup
   - group four: add 3 ml of glycerin

3. Heat the mixture gently while stirring until it reaches a temperature of 240°F.

4. Allow the solution to cool to 140°F and then beat it with a spoon or stirring rod.

5. Using a microscope or magnifying glass, observe the crystal size of each of the five portions.

6. Touching the sugar, determine the texture of the sugar.

--

**OBSERVATIONS**

**PART I**

Day one observations

Day two observation

Day three observations

Day four observation

Day five observations
PART II

Observations of the clarity or crystal structure of the candy

PART III

Crystal size and texture of:

Portion I [beating at high temperature]

Portion II [beating at 160 ° F]

Portion III [beating at 140 ° F]

Portion IV [beating at 100° F]
PART IV

Crystal size and texture of:

Control

With cream of tartar

With vinegar

With corn syrup

With glycerin

THINKING SCIENTIFICALLY

Cooking and candy making are often described as an "art". Many famous chefs have secret recipes. Other times recipes become "family secrets" that are passed from mother to daughter. These recipes were often developed over years by trial and error. The cooks often do not know why certain ingredients are used or why something must be stirred only at a certain temperature.

Large-scale commercial food preparation is not an art. It is a science. The company has a sound reason for each ingredient used and cooking times and temperatures are computer controlled.

Write an essay comparing the methods of the alchemists and the modern chemists, chefs using secret recipes, and to the methods of the modern commercial food industry.
HEAT--Hide & Seek

PRE-LAB DISCUSSION

Some textbooks use the term *latent* to describe the energy evolved in the change of state of a pure substance. The term latent means "hidden". Heat energy is usually measured in calories. A kilocalorie is one thousand calories and is often written as simply Calorie [with a capital C] to describe the energy value of foods. The amount of energy needed to raise the temperature of one gram of water one degree Celsius is a calorie.

A thermometer actually measures the average speed of the motion of the atoms and molecules. It does not account for the freedom of motion of the particles. It normally takes more energy for the particles to increase the randomness of their motion [higher entropy].

OBJECTIVE: To learn the difference between heat and temperature.

CHEMICALS/EQUIPMENT: Moth crystals [either paradichlorobenzene (preferred) or naphtha], 150 mm test tube, 400 ml beaker, Bunsen burner, test tube clamp, ring, screen, ring stand, thermometer.

PART I

PROCEDURE:

1. Fill the beaker 3/4 full of water and place it on the ring and screen with the Bunsen burner under it.

2. Place 20-25 grams of moth crystals in the test tube and clamp the tube so that the bottom half of the tube is in the water. Put the thermometer into the moth crystals.

3. In your lab notebook, set up a full sheet of paper with the following three columns: 1. Observation Number 2. Temperature 3. Observations of paradichlorobenzene
4. Heat the water to boiling. Continue heating until the moth flakes form a clear liquid that is the same temperature as the boiling water. Record this temperature for observation number "1".

5. Turn off the burner and remove the test tube from the water. Clamp it on the ring stand on the opposite side from the beaker of water. Record the temperature and observations of the paradichlorobenzene every two minutes until the substance cools to below 30° Celsius.

PART II

PROCEDURE:

1. Heat the beaker of water to boiling again.

2. Set up another page in your notebook with the same three columns.

3. Record the temperature of the moth crystals. Record this temperature for observation # "1".

4. Turn off the burner and allow the water to cool for 2 minutes.

5. Clamp the test tube so that the bottom half of the tube is in the hot water. Make and record observations and temperature every 20 seconds until the temperature reaches 75° Celsius.

DATA AND OBSERVATIONS

1. Set up a graph with the temperature on the vertical axis and the observation numbers on the horizontal axis. Graph the points for Part I and connect them with a smooth line.

2. Make another graph for the data from Part II.
THINKING SCIENTIFICALLY

1. Describe the differences between the two graphs.

2. Describe the similarities between the two graphs.

3. At the point on both graphs where the temperature did not change for several observations, what was happening to the material in the test tube?

4. Give an operational definition of calorie.

5. Give an operational definition of temperature.

6. Give an operational definition of "heat of crystallization."

7. There was a period of time when the temperature was about 52°C and remained constant for several observation time periods although heat was going into or out of the material. Review the observations of the paradichlorobenzene and the operational definitions above. Write a paragraph or more explaining how the heat content of the material could be changing while the temperature did not change.

POST LAB DISCUSSION

This lab experience highlights the importance of clear, concise operational definitions. Conceptual definitions of heat and temperature would not permit a clear explanation of the observations made in this lab.

If we could take the operational definition of temperature to an even more precise level, we could make some very interesting mathematical projections. If we could actually measure the speed of the molecules at each temperature, then we could calculate the reduction in speed for each degree change. We could plot a graph of the reduction in speed per change in temperature until "zero" speed is reached. This point is called "absolute zero". Logic will tell us that it is not possible to go slower that "stop". If something is moving any direction, it has a speed. It is not possible to have a negative speed. [you may need to review the difference between speed and velocity] It is also not possible to have a temperature below "absolute zero" which is -273°C Celsius.
HOT & COLD REACTIONS

PRE LAB DISCUSSION:
Chemistry is the study of matter, energy, and change. This experiment will focus on energy. Chemical reactions can be endothermic or exothermic. The chemist not only needs to know whether a reaction takes in energy or gives off energy but also needs to know exactly how great the energy change will be per mole of reactant. The chemist can better control the reaction by limiting the total amount of reactants and by regulating the flow of energy into or out of the reaction vessel. For example, chemical engineers often design elaborate cooling systems for commercial size reacting vessels.

Heat energy is measured in a unit called calories. A calorie is the amount of heat needed to raise one gram of water one degree Celsius. The energy value of food is measured in kilocalories. Nutritionists use the word Calorie with a capital C instead of using the term kilocalorie.

CHEMICALS/EQUIPMENT: Sodium hydrogen carbonate [baking soda], zinc [granular or shavings], acetic acid[vinegar], 1M hydrochloric acid, sodium hydroxide [lye]. graduated cylinder, balance, thermometer, Styrofoam cup

PROCEDURE

PART I
1. Place 100 ml of acetic acid in a large Styrofoam cup, and determine and record its temperature.

2. Weigh out 2 grams of sodium hydrogen carbonate.

3. Place the sodium hydrogen carbonate in the Styrofoam cup and determine and record the temperature of the system immediately after the reaction is completed.
PART II

CAUTION- use a scoopula to handle sodium hydroxide pellets

1. Place 100 ml of water in the foam cup and determine and record its temperature.

2. Weigh out 2 grams of sodium hydroxide.

3. Place the sodium hydroxide in the foam cup and stir gently. When all of the pellets have dissolved, determine and record the temperature.

PART III

1. Place 100 ml of 1 M hydrochloric acid in the foam cup and determine and record its temperature.

2. Weigh out 2 grams of sodium hydroxide.

3. Place the sodium hydroxide in the cup and stir gently. When the reaction is completed, determine and record the temperature.

PART IV

1. Place 100 ml of 1 M hydrochloric acid in the form cup and determine and record its temperature.

2. Weigh out 0.5 grams of granular zinc.

3. Place the zinc in the foam cup and when the reaction is complete, determine and record the temperature.
### DATA and CALCULATIONS

<table>
<thead>
<tr>
<th>ml of water or solution</th>
<th>initial temp</th>
<th>final temp</th>
<th>temp change</th>
<th>calories</th>
<th>moles of reactant</th>
<th>calories per mole</th>
</tr>
</thead>
<tbody>
<tr>
<td>part I</td>
<td>100 ml</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>part II</td>
<td>100 ml</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part III</td>
<td>100 ml</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part IV</td>
<td>100 ml</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### THINKING SCIENTIFICALLY

1. Which parts of the experiment were exothermic reactions and which parts were endothermic?

2. It has been said that endothermic reactions are inherently safer than exothermic reactions. Write a paragraph to explain why this is so.

3. Two reactions can give off the same amount of heat energy but one reaction may be far more explosive than the other. Write a paragraph or more to explain what other things a chemist should know about a reaction in order to devise a safe procedure.
ARE WE SATURATED YET?

PRE LAB DISCUSSION

A solution is made up of two parts: the solvent and the solute. In this experiment, water will be the solvent and sodium thiosulfate [photography fixer] will be the solute. A true solution is optically clear. If there are undissolved particles, the solution will be cloudy. Do not confuse color with clarity. A true solution can have color. Scientists use an electrical apparatus that shines a narrow beam of light through a solution and measures the light that is scattered in other directions by the undissolved particles. This indicates the amount, if any, of undissolved particles. Before starting the procedure, write an operational definition of:

- unsaturated solution
- saturated solution
- supersaturated solution

Air is a gaseous solution. It has water vapor dissolved in it. [An understanding of the factors that influence the saturation point of water vapor dissolved in the air is important in predicting weather.] Likewise the energy changes related to vaporization and condensation are major factors in both weather and climate.

A review of a map of the United States and the results of HEAT-HIDE & SEEK will be helpful in thinking about the observations made of these solutions.

OBJECTIVE: To make and observe the properties of unsaturated, saturated, and supersaturated solutions.
CHEMICALS/EQUIPMENT: Sodium hyposulfite [also known as hypo or fixer], Test tubes (large), graduated cylinder, balance, beaker, test tube holders, Bunsen burner

PROCEDURE:

1. Place 2 ml of water in a test tube and add 1 gram of hypo crystals. Shake the tube to dissolve the crystals. [Do not shake any tube for more than five minutes]

2. Place 2 ml of water in a test tube and add 2 grams of hypo crystals. Shake the tube to dissolve the crystals.

3. Place 2 ml of water in a test tube and add 3 grams of hypo crystals. Shake the tube to dissolve the crystals.

4. Place 2 ml of water in a test tube and add 4 grams of hypo crystals. Shake the tube to dissolve the crystals.

5. Continue adding one gram more of hypo crystals until a saturated solution is produced.

6. Place 2 ml of water in a test tube and add 30 grams of hypo crystals. Gently heat this mixture until it boils and forms a clear solution. Then place this test tube in a beaker of cold water or in a test tube rack until it nearly room temperature. Make and record observations of this tube.

7. When the tube has cooled to room temperature, place one crystal of hypo in the tube. Make and record observations of this tube. Use your hand to detect any temperature changes.

--------------------------------------------------------------------------------------------

OBSERVATIONS

The following test tubes were unsaturated:

The amount of hypo needed to produce a saturated solution with 2 ml of water was ________________grams.
Did the temperature of the test tubes rise, fall or remain the same as the hypo dissolved? ____________________________________________

Procedure number 6 produced a _________________ solution.

When a "seed" crystal is placed in a supersaturated solution, the result is _______________________________________________________

What energy change was observed when a "seed" is added to a supersaturated solution?

What is the proper term for this energy change? __________________

__________________________________________________________________________________________

THINKING SCIENTIFICALLY

1. Why are saturation points for various solutes always stated at a given temperature?

2. In the United States, air masses generally move from west to east. As moist air masses rise over the Rocky Mountains, air cools 10° C for every kilometer it rises. What will happen as moist air rises to the top of the Rocky Mountains?

3. The temperature of air will increase 10° C as it descends downward. If moist air that is 24° C rises to the top of the mountains and then descends down the other side of the mountain as dry air, will it be the same temperature when it reaches the leeward base of the mountain?

Using the knowledge gained in this experiment, explain your answer.
4. What factors of elevation, prevailing winds, and topography make Death Valley the hottest and driest area of the United States?

5. On a hot, humid summer day, why is it likely to rain and/or thunderstorm in the late afternoon or early evening?
CLEANING UP YOUR ACT

PRE-LAB DISCUSSION

All soap is made from fats and alkaline solutions. There are many kinds of fats, both animal and vegetable. Animal fats are usually solid at room temperature, but many vegetable fats are liquid at room temperature. Liquid cooking oils are made from vegetable fats extracted from corn, peanuts, olives, soybeans, and many other plants. When it comes to making soap, however, all different types of fats (anything from lard to exotic tropical plant oils) can be used!

Basic (alkaline) solutions all contain a metal and a hydroxide ion. The most common bases are those produced by the reaction of a group I metal plus water. These are highly water-soluble and can be used to make very strong solutions. Lye and drain cleaner are the most common alkali compounds used in every day life.

Up until the early 1900's, many people made their own soap from household waste products. They used the solid animal fats that were left over from cooking and a potash solution from wood ashes.

Making soap was a long and arduous process. First the fat had to be rendered, that is melted and filtered to remove any non-fat solids. Then the potash solution was added to the hot fat. Since water and oil do not mix, this mixture had to be continuously stirred and heated sufficiently to keep the fat melted. Slowly a chemical reaction called soaponfication would take place between the fat and the hydroxide which resulted in a liquid soap. When the fat and water no longer separated, the mixture was allowed to cool. At this point salt [sodium chloride] was added to separate the soap from the excess water. The soap came to the top, was skimmed off, and placed in wooden molds to cure. It was often aged many months to allow the reaction between the fat and hydroxide to run to completion. Poorly make soap could contain excess alkali and could dry and chap people's skin. Today laundry soaps such as "Fels Napha" soap are much like the home made soaps made by early Americans.
Today soap is made in basically the same way, but we can use a few tricks of chemistry to accelerate the process. We will start with a liquid vegetable fat [cooking or salad oil] and use alcohol to speed the process of mixing oil and a water-based solution of sodium hydroxide.

LAB OBJECTIVE: To make a useable soap.

CHEMICALS/EQUIPMENT: Ring, ring stand, screen, Bunsen burner, stirring rod, beaker, fat [cooking oil, linseed oil, shortening], ethyl alcohol, 6M sodium hydroxide solution [lye], saturated salt solution.

PROCEDURE.
1. Place 10 ml of cooking oil, linseed oil, or melted vegetable shortening in the beaker

2. Add 10 ml of alcohol to the beaker

3. Add 5 ml of sodium hydroxide solution to the beaker

4. Heat *GENTLY* with constant stirring. If flame is too high, the alcohol vapors will ignite, followed by the cooking oil.

5. Continue heating until you can see no more oil droplets on the surface. The mixture froths easily. If this happens, stir the foam to break up the bubbles so that it does not overflow. The heating process usually takes about 10 minutes.

6. Allow the mixture to cool. The substance will be semi-solid.

7. After the mixture has cooled, add 20 ml of hot water to the beaker and stir to dissolve the substance.

8. Now add 25 ml of salt solution. Do not stir. If it does not seem to mix, swirl it gently once or twice.

9. Let the beaker stand for 5 minutes. The soap should float to the surface.
10. Skim the curds of soap from the top of the liquid and place on a paper towel. Press and form this into a block of soap.

OBSERVATIONS
You may make observations now or allow the soap to dry and harden overnight and then make observations.

Does it smell like any soap that you may have used in the past?

______________________________________________________________

Wash your hands with a small piece of your soap. Does it lather?

______________________________________________________________

Does it clean your hands as well as your regular soap? Explain.

______________________________________________________________

Now rinse your hands thoroughly just in case your soap contains any unreacted lye.

THINKING SCIENTIFICALLY

1. What could you add to your soap formula to make soap that would look and smell like the soaps that you buy in the stores?

2. Do you think that the type of fat used will make a difference in the produce? Why or why not?

3. Go to the store and read the ingredients label on the soaps. List the type of fat used in several different brands of soaps and/or shampoos.
The SOLUTION to SOLUBILITY is the SOLVENT.

PRE-LAB DISCUSSION
Before beginning this lab, it is important to understand the terms solution, solvent, and solute. A solution is a homogeneous, liquid mixture of two or more substances. A solvent is the dissolving agent, e.g. water. A solute is a substance that is dissolved in a solution.

Water is a polar molecule. It has a positive and a negative side. It will dissolve IONIC COMPOUNDS. It will also dissolve some MOLECULAR COMPOUNDS that have covalent polar bonds.

Xylene [(CH₃)₂C₆H₄], toluene [C₇H₈] and oils are non-polar molecules. They will dissolve MOLECULAR COMPOUNDS that have non-polar covalent bonds.

Methanol [CH₃OH], ethanol [C₂H₅OH] and proponal [C₃H₇OH] are the most common form of alcohols. Their ability to dissolve common substances varies somewhat but they can often show "intermediate" polarity.

OBJECTIVES: To determine the solubility of three general types of common solvents.

CHEMICALS/EQUIPMENT: small test tubes, test tube rack, electrical conductivity tester, alcohol, distilled water, xylene or toluene [found in hardware or paint store], salt crystals, sugar crystals, paradichlorobenzene or naphalene crystals [moth flakes].

PART I

Procedure:
1) Place ½ inch of each solvent in separate test tubes. Label the test
so that you know which solvent is in each tube.

2) Test each solvent for electrical conductivity. If any of these pure solvents show conductivity, you have contamination.

3) Place a moth crystal in each tube and swirl gently to determine if the crystal will dissolve. Record your results.

4) Then test each tube for electrical conductivity. Remember to clean the electrical contacts between the three tests. Record your results.

5) Repeat steps 1-5 using salt as the solute.

6) Repeat steps 1-5 using sugar as the solute.

PART II

Procedure

1) Place 1/2 inch of water in each of two small test tubes.

2) Place an equal volume of alcohol in the first tube and mix. Does it dissolve? Record your observations

3) Place an equal volume of xylene or toluene in the second tube and mix. Record your observations

4) Place a 1/2 inch of alcohol in a test tube and add an equal amount of xylene or toluene and mix. Does it dissolve? Record your observations.
### Part I
#### DATA: Solubility

<table>
<thead>
<tr>
<th></th>
<th>moth crystal</th>
<th>salt crystal</th>
<th>sugar crystal</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>alcohol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>xylene/toluene</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Part II
#### DATA: conductivity

<table>
<thead>
<tr>
<th></th>
<th>moth crystal</th>
<th>salt crystal</th>
<th>sugar crystal</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>alcohol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>xylene/toluene</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Part III
#### DATA: solvent-solvent solubility

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>water-alcohol</td>
<td></td>
</tr>
<tr>
<td>water-xylene</td>
<td></td>
</tr>
<tr>
<td>alcohol-xylene</td>
<td></td>
</tr>
</tbody>
</table>
Thinking Scientifically

1. If you were painting using an oil-based paint, what common liquids could you use to remove paint from your hands? [hint: don't overlook liquids in the kitchen]

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

2. Why are alcohols used in window washing products?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

Extra

When clothes are dry-cleaned does this mean that they are not placed in a liquid?

Visit your local dry cleaning store and find out how clothes are dry-cleaned and what chemicals are used in the cleaning process.

The term Hydraulics means moved by water. We use hydraulic brakes to stop our cars and hydraulic jacks to lift heavy objects. The hydraulic systems that we use today do not use water. What properties of today's hydraulic fluid make it superior to water for use in these systems?

Why is oil or grease placed in pans before cooking or baking foods? [Hint: are foods usually water or oil systems?]
OUT SPOT, DARN SPOT

PRE LAB DISCUSSION

We usually don't think about doing laundry as a scientific endeavor. Most people would be amazed at the number of chemists involved in developing better chemicals to clean clothes. Every year new fabrics, dyes, sizing chemicals, wrinkle resistant chemicals, etc. are developed, so the cleaning agents need to be constantly altered to be compatible and effective with the other changes in the clothing industry.

Cleaning clothes is applied solubility chemistry. We try to dissolve dirt, oil, etc. out of our clothes, but we do not want to remove any of the bright colorful dyes and anti-wrinkle agents or damage the fabric.

Spot removal is the most difficult part of clothes cleaning. To be successful in removing a spot or stain we must approach the problem as a scientist. The first and most important step is to try to determine what caused the spot or stain.

Knowing the type of stain allows us to narrow the list of solvents that will effectively dissolve and thus remove the spot. Remember that there are two basic types of solvents, polar [water] and non polar [oil].

For water-soluble stains, soaps and detergents increase the solubility of water. Dish washing liquid is especially good since it contains ingredients designed to break up oil.

There are many types of oils that may be used to dissolve non polar stains. These include paint thinner, waterless hand cleaner, cooking oil, kerosene, and lighter fluid. Waterless hand cleaner works well because it can be worked into the fabric and is designed to be removed with warm water.
There are stains that are not readily soluble in either type of solvent [i.e. rust]. This type of stain may be removed by oxidation or reduction of the substance that caused the spot. These procedures should be the "last resort" since they may react with the dye or even the fabric. It is best to test the reactive agents on an inconspicuous area of the garment before attempting to remove the spot.

It is important to remove spots before normal laundering. **Heating and drying** may make a stain almost impossible to remove. The fresher the stain, the easier it is to remove. When possible, it is best to try to remove a stain before it dries. One trick used for oil stains is to put some white shortening on the stain immediately to prevent the oil from drying. Sometimes the oil will dissolve in the shortening and then the shortening [and stain] can be removed by dish washing liquid and warm water.

Once a stain has been dissolved, the next step is to remove the solvent-stain mixture from the fabric. With a water-soluble stain, the next step is obvious, just rinse with a large amount of water.

In the case of a nonpolar solvent-stain mixture, there can be more of a problem. Sometimes a heavy oil and stain mixture must be removed by using a lighter oil, and then the light oil can be removed by soap and warm water.

Another method that is very useful in removing the solvent-stain mixture is to use capillary action to move the mixture into another material. This method is often used in carpet cleaning where rinsing out the solvent-stain mixture is not practical. Carpet cleaners use foam or insoluble powder for the other material. The solvent stain mixture travels by capillary action to the surface of foam or powder where the liquid evaporates leaving the stain on the upper surface. When the surface is covered with a powder such as cornstarch, the stain is in the powder rather than the rug. The powder, dirt, and stains are then picked up by a vacuum cleaner.

The same process can be done by using an absorbent paper towel or cornstarch on a stained piece of clothing. The solvent-stain mixture will travel into the cover material. Often, more solvent may be needed and the procedure repeated several times to completely remove a spot. This works
most effectively with solvents that evaporate quickly such as alcohol, acetone, and lighter fluid.

Bleaches cause a chemical change in the substance, which caused the stain. Bleaches are oxidizing agents. Substances such as sodium bisulfite and oxalic acid are reducing agents. Both oxidizing and reducing agents also react with the dyes in the cloth. They should not be used on anything except white colors. In a more concentrated form, they may also damage the fabric of the garment. There are also several other chemicals that may be used to remove stains.

The chart below is meant to give guidance for trying to remove some common spots.

<table>
<thead>
<tr>
<th>Stain</th>
<th>Treatment Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood</td>
<td>If wet, rinse with lukewarm water. If dry, soak in ammonia solution, then treat with dilute [2-5%] oxalic acid [found is auto radiator cleaner and in bar tenders cleanser]</td>
</tr>
<tr>
<td>Coffee</td>
<td>Wash in concentrated salt water</td>
</tr>
<tr>
<td>Grass</td>
<td>Fresh stains may be removed using alcohol; older stains try sodium perborate solution [drug store]. On white clothing, bleach followed by sodium thiosulfate solution.</td>
</tr>
<tr>
<td>Ink</td>
<td>Dissolve in alcohol or acetone [dissolves acetate fabrics] and cover solvent-stain solution with cornstarch or paper towel. Usually needs to be repeated several times.</td>
</tr>
<tr>
<td>Iodine</td>
<td>Chemically react with a solution of sodium hyposulfite [hypo or photographer's fixer]</td>
</tr>
<tr>
<td>Rust</td>
<td>Try citric acid [Tang, Gator Aid, or Crystal Light drink powder] or 5% oxalic acid with 5% glycerin.</td>
</tr>
</tbody>
</table>
CHEMICALS/EQUIPMENT:

Students are to bring in fabric with a variety of stains and the teacher will provide fabric stained with iodine, rust, and unknown spots.

The chemicals listed below may not all be needed and other organic solvents may be included by the instructor based on availability:

acetone, alcohol, ammonia water, bleach [sodium hypochlorite and/or hydrogen peroxide], citric acid, corn starch, glycerin, baby oil or lighter fluid, oxalic acid, sodium bisulfite, sodium thiosulfate, waterless hand cleaner.

PROCEDURE:

This laboratory exercise is different in that students will not be given a set procedure to follow to remove a spot. Instead they will need to use the information above to develop a procedure to remove a spot. The students will do a complete written report for each type of spot that they attempted to remove.

RESULTS AND CONCLUSION

Each student will be assigned to remove a number of spots. The student will write a report on EACH spot. The report will include the following:

1. The type of stain on the fabric
2. The procedure used to attempt to remove the spot.
3. The rationale behind choosing this procedure.
4. The success of the procedure.
5. If the procedure was not successful, then parts 2, 3, & 4 will be repeated

The fabric will be attached to the report to show the final success.

THINKING SCIENTIFICALLY

1. List the things in your kitchen that could be used for spot removal.
2. List the things in your bathroom that could be used for spot removal.

3. List the things in your workshop, garage, or basement storage area that may be used for spot removal.

4. Record the ingredients from the label in several commercial spot removers and tell why these chemicals are included in the solution or mixture.
CAN the METTLE of METAL be IMPROVED?

PRE-LAB DISCUSSION:
Metals are used for many different purposes. Two hundred years ago, the town blacksmith produced nails, hammers, wheel rims, knives, and horseshoes from the same basic metal. In some applications, a metal must be able to bend easily without breaking, whereas in other cases the metal must resist bending. Today metallurgists can produce these results by using different metals, alloying metals, and by heat treating metals. The substitution of a different metal or using a special alloy is often costly. Therefore heat treatment of a common metal is often the most cost efficient method of producing a metal that has the properties required in a specific application. Most metals respond to heat treatment, but the treatment temperatures are unique for different metals.

Students may be assigned only one or two of the metals if the lab is being done in only one day.

OBJECTIVE: To determine the effects of annealing, quenching, and tempering on metals.

CHEMICALS/EQUIPMENT: Bunsen burner, tongs, beaker, bobby pins, hair clip, single strand steel wire

PROCEDURE:

CONTROL

1. Straighten a bobby pin and determine the number of bends to break it in two. Record this on the data chart. Repeat this two more times.

ANNEALING

1. Heat a bobby pin to red hot by holding it over the flame with the tongs. It must remain red hot for thirty seconds. Then gradually lift it straight up until it is about a foot out of the flame. Let the sample cool
gradually in the air for about three minutes. This process of strong heating and slow cooling is called annealing.

2. After it has cooled, bend it back and forth until it breaks and record the number of bends that it takes to break the metal.

3. Repeat this for two more times.

**QUenchING**

1. Take a piece of bobby pin and heat it to redness. When it is red hot, immediately place it in a beaker of water. This process of strong heating and quick cooling is called quenching.

2. Bend the pin and record the number of bends needed to break the pin.

3. Repeat this two more times.

**TEMPERING**

1. Heat a pin to red hot and keep it in the flame for another thirty seconds. Then place it in a beaker of water. Reheat the pin until it glows with a *dull redness* and remove it gradually from the flame as you did in the annealing process. This process of strong heating, quick cooling, strong heating and then slow cooling is called tempering.

2. Bend the pin and determine the number of bends needed to break the pin.

3. Repeat the process two more times.

Repeat this procedure for the other metals available.
### DATA
NUMBER OF BENDS TO BREAK

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>UNTREATED</th>
<th>ANNEALED</th>
<th>QUENCHING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>average</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**THINKING SCIENTIFICALLY**

1. What are the effects of annealing?

2. What are the effects of quenching?

3. What are the effects of tempering?

4. What type of treatment would be used in making a scalpel blade?

5. What type of treatment would be used in metal used for making wire?

6. What type of treatment was used in making spring clips?
7. What type of treatment produces the hardest metal? [Hint: To answer this question correctly, you must first define the word "hard" in operational terms.]

8. What type of treatment produces the strongest metal? [Hint. To answer this question correctly, you must first define the word "strong" in operational terms.]

EXTRA
9. Using the library or Internet, find the heat treatment temperatures for other common metals such as aluminum.

10. Explain the meaning of the following statement:

"A MAN IS LIKE STEEL,
WHEN HE LOSES HIS TEMPER,
HE IS WORTHLESS."
BLOWING UP BALLOONS, chemically

PRE LAB DISCUSSION:

Today we will be using a closed system. A closed system does not permit matter to enter or exit the apparatus. Lavoisier's classic 12-day experiment, which lead to the discovery of oxygen and an understanding of burning, was conducted in a closed system.

The system we will be using is closed to matter, but it is not closed to energy. If the system becomes warmer, energy is being released by the reaction. This is called an exothermic reaction. If the system becomes cooler, energy is being used by the reaction. This is called an endothermic reaction. Most laboratory thermometers will not fit inside a closed flask, but the students can determine temperature changes by just touching the bottom of the flask before and after the reaction.

Sometimes chemists use an experimental apparatus which is designed to be closed to the transmission of energy. This type of apparatus permits the chemist to determine exactly how much energy change there is in a specific chemical reaction.

If time is limited, the class may be divided into two groups, with one group assigned to do the reaction with zinc\(^1\) and hydrochloric acid\(^2\) and the other group with sodium bicarbonate and acetic acid [vinegar].

OBJECTIVES: To determine what observable factors are changed in a chemical reaction and what factors remain constant.

CHEMICALS/EQUIPMENT: 250 ml flask, balloon, balance, acetic acid\(^3\), hydrochloric acid, sodium bicarbonate, zinc

---

\(^1\) Zinc can be obtained by melting pennies over a Bunsen burner. The penny has a copper coat over a zinc core. Pennies can be cut into small pieces with shears for this lab. The small amount of copper will make no difference in the final outcome.

\(^2\) Hydrochloric acid is sold as "muriatic acid " by commercial cleaning supply companies. It may be as strong as 12 M. It must be diluted to 3 M for this lab.
PROCEDURE:

**PART I**
1. Place 50 ml hydrochloric acid in the 250 ml flask and determine the combined mass of the flask and acid.

2. Place 8 grams of Zn in the balloon and determine the combined mass of the balloon and the reagent.

3. Place the balloon on to the mouth of the flask without dropping the contents of the balloon into the flask. Determine the total mass of the system at this point. BEFORE doing anything else, think about and answer question number 1. You may wish to check the weights again.

4. Hold the balloon up so that the reagents in the balloon fall into the flask. Carefully observe the reaction and carefully and fully record all your observations [temperature, colors, changes in the reagents, volume of the substances, etc.].

5. After the reaction has reached completion, determine the total mass of the system. DO NOT OPEN THE SYSTEM. The balloon and gases produced by the reaction must be weighed.

**PART II**
1. Place 50 ml of acetic acid in a 250 ml flask and determine the combined mass of the flask and acid.

2. Place 15 grams of sodium bicarbonate in a balloon and determine the combined mass of the balloon and reagent.

3. Place the balloon on to the mouth of the flask without dropping the contents of the balloon into the flask. Determine the total mass of the system at this point. BEFORE doing anything else, think about and answer question number 1. You may wish to check the weights again.

---

3Food coloring may be added to the acids. This helps avoid the problem of students using the wrong acid and may result in reactions that have interesting color changes.
4. Hold the balloon up so that the reagents in the balloon fall into the flask. Carefully observe the reaction and carefully and fully record all your observations [temperature, colors, changes in the reagents, volume the substances etc].

5. After the reaction has reached completion, determine the total mass of the system. DO NOT OPEN THE SYSTEM. The balloon and gases produced by the reaction must be weighed.

DATA

PART I

1. Mass of flask and HCl..........................................................

2. Mass of balloon and zinc......................................................

3. total................................

4. Mass of flask, acid, balloon & zinc before the reaction..............

5. Mass of apparatus and chemicals after the reaction....................

Changes observed in the system as it reacted

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

PART II

1. Mass of flask and acid...........................................................

2. Mass of balloon and NaHCO₃....................................................

3. total..........................

4. Mass of flask, acid, balloon & chemicals before the reaction.........
5. Mass of apparatus and chemicals after the reaction..........................

Changes observed in the system as it reacted

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

THINKING SCIENTIFICALLY

1. Is the total mass of the chemical system (3) equal to the sum of the mass of (1) flask and acid plus (2) the mass of the balloon and reagents?

Why or why not?

2. Is there any significant difference in the mass of the system after the reactants have formed the products?

Why or why not?

3. Did the zinc and hydrochloric acid system take in energy [endothermic] or give off energy [exothermic] to the environment?

How did you determine this?

4. Did the sodium bicarbonate and acetic acid system take in energy [endothermic] or give off energy [exothermic] to the environment?
How did you determine this?

5. In each part, which had a greater volume, the reactants or the products?
   How do you know this?

5. Did the color of the liquid change? ________
   If so, tell what color it was before, during, and after the reaction.

6. Did the color of the solids change? ________
   If so, tell the color before and after the reaction.

7. Did the texture, shape or form of the solids change? ________
   If so, describe how they looked before and after the reaction.

8. What is the "law of the conservation of matter"?

9. How does the "law of the conservation of matter" apply in this experiment?
5. Measure and record the distance between the tapes every 24 hours for several days.

<table>
<thead>
<tr>
<th>METAL</th>
<th>START</th>
<th>DAY 1</th>
<th>DAY 2</th>
<th>DAY 3</th>
<th>CREEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>12 in</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Cu</td>
<td>12 in</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>Fe</td>
<td>12 in</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

Set up a graph with days on the horizontal axis and creep on the vertical axis. Use a different color for each of the three metals.

THINKING SCIENTIFICALLY

1. Which wire showed the greatest creep?

2. Which wire do you think will break first?

3. Using the graph predict how long it will take until the bricks or block held by the aluminum, copper, and iron wires to reach the floor assuming that the wire does not break first.
   - Al
   - Cu
   - Fe

4. Do you think that the amount of creep per day will increase, decrease, or be constant over a long period of time? Explain your answer using the graph.
5. Over time, wires strung between two posts or poles begin to sag. Why?

6. Of the three metals tested, copper is the best conductor of electricity. Utility companies build huge towers to support high voltage transmission lines that may carry electric across several states. What kind of wire is used in these interstate electrical grids and why?

7. What type of wire is used by the electric company to bring electricity into your neighborhood and why?

8. Write out a procedure that you think that can be completed safely in your classroom to test the tensile strength of each type of wire.

EXTRA

9. Repeat this lab procedure using only one of the three metals but this time use three different amounts of bricks. Determine how creep rate varies with weight.
PRE LAB DISCUSSION

Among the properties of all metals are malleability and ductility. These properties make metals very useful to us. Metals can be reshaped or drawn into wire. But these same properties sometimes limit the useful life of a metal product.

The tensile strength of a material is the amount of weight that it will support without breaking. When a metal supports a weight over a period of time it will elongate. This is called creep.

This experiment will take several days to complete. It is open ended and the procedure should be altered to allow for availability of space, time, and materials.

OBJECTIVE: To determine the tensile strength and creep in three common metals.

CHEMICALS/EQUIPMENT: aluminum, copper, and iron wire of the same diameter [gauge], bricks or small cement blocks, 2x4 lumber, chairs.

PROCEDURE:

1. Attach one of the wires to two or more bricks or to a cement block. Repeat this for each of the metals being tested, using the same number of bricks or size of block for each wire.

2. Attach the 2x4 lumber across the backs of two chairs that are several feet apart.

3. Attach the wires to the 2 x 4 so that the bricks or block is suspended exactly two feet from the lumber.

4. Place a tape on each wire exactly 6 inches from the top. Then place another tape exactly 12 inches below the first tape.
ANTACIDS

PRE LAB DISCUSSION

The stomach produces hydrochloric acid to begin the chemical breakdown [digestion] of the food that you eat. Although this acid is quite strong, (about 2 M), the stomach has a thick mucus lining that protects the stomach tissue itself from being digested by the acid. When the stomach is too full or when you have swallowed air, the acid will be forced up out of the stomach into the unprotected esophagus. The acid will react with the unprotected tissue and cause a burning sensation commonly known as "heart burn".

There are a number of over-the-counter medications called "antacids". These are not chemical bases. If they were bases and you used them regularly or took them in large doses, they would raise the pH of your blood. This condition, called alkalosis, would result in kidney damage. The brands of antacids sold in the drug store contain insoluble compounds that acids will react with, resulting in the acid being consumed in the reaction. The most common ingredient used is calcium carbonate [CaCO₃], also known as limestone. This limestone is ground to a powder, mixed with a starch paste, and formed into a tablet. Often flavoring and coloring is added to make the tablet more attractive. Other tablets contain insoluble hydroxides that will react with hydrochloric acid.

There are also newer types of antacids that are taken before eating. These consist of a hormone [chemical messenger] that reduces the amount of acid produced by the stomach. This is not the type of antacid that we will evaluate in this lab.

OBJECTIVE

To determine the amount of acid neutralized by each brand of antacid tablet.
CHEMICALS/EQUIPMENT:
Beaker [100 or 250 ml] Buret¹, ring stand, test tube clamp, stirring rod, mortar & pestle, 0.5 M hydrochloric acid, congo red indicator², several brands of antacid tablets such as TUMS, ROLAIDS, MAALOX etc. [white colored tablets are better in this lab]

PROCEDURE
1. Record the names and amounts of the active ingredients contained in each brand of antacid. This information is found on the container.

2. The instructor will have already clamped the buret to the ring stand. Put some water in the buret and make sure that it does not leak. Then, practice dripping the water into a beaker. Then drain all of the water out of the buret.

3. Fill the buret with hydrochloric acid to the "zero" line.

4. Crush one antacid tablet using a DRY mortar and pestle.

5. Place the crushed tablet in a clean beaker and add about 50 ml of distilled water. Then add 3-4 drops of congo red indicator.

6. Place the beaker under the buret. The acid should be added drop wise and stirred until the color changes to blue. Since the antacid is not water soluble, the first blue color is not necessary the end point of this titration.

7. Continue stirring until the blue color remains for five minutes after the last drop of acid was added. This is the end point.

8. Record the amount of acid used by this tablet.

9. Repeat this procedure for each brand of antacid tablet.

¹If burets are not available, the students can use a dropping pipette. The students can count the number of drops needed to reach the end point. This can be just as accurate as the when a buret is used.
²CONGO RED indicator solution must be purchased from a scientific supply company.
**DATA**

<table>
<thead>
<tr>
<th>BRAND TESTED</th>
<th>INGREDIENTS</th>
<th>ML of HCl reacted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**THINKING SCIENTIFICALLY**

1. Did the tablets dissolve in water?

2. Why was it necessary to stir for five minutes in order to be sure that the end point had been obtained?

3. Based on this lab and your knowledge, which brand of tablet would you recommend? Write an essay to explain your reasons for this recommendation.

Rx
CHEMISTRY CLICKS
YOUR BIC

PRE-LAB DISCUSSION

A mole of any pure gas at STP has a volume of 22.4 liters. The weight of that gas in grams is equal to the molecular mass of the gas in atomic mass units.

If the volume, mass, temperature and pressure of a gas is known, then using the combined gas law, its volume can be mathematically converted to a volume at STP. Then, the mass of 22.4 liters can be determined. Thus its molecular mass can been determined experimentally.

When gas is collected by water displacement, Dalton's law of partial pressures can be used to factor out the water vapor.

OBJECTIVE: To experimentally determine the molecular mass of butane.

CHEMICALS/EQUIPMENT: butane lighter, balance, 250-300 ml flask, china marker or water proof marker, graduated cylinder, trough [bucket, dishpan etc], thermometer glass plate.

PROCEDURE:

1. Place exactly 200 ml of water in the flask. Using the marker, draw a highly visible line at the 200 ml water line.

2. Determine and record the exact mass of the butane lighter [estimate to the 100th of a gram].

3. Fill the trough or other large container with water.

4. Fill the flask completely with water and using your hand or a glass plate, invert it into the trough without permitting any air bubbles in it.
5. Make sure that the lighter is turned to its highest gas flow. Hold the butane lighter under the mouth of the flask, press the release lever, being careful that all of the gas flows into the flask. Hold the flask so that the 200 ml mark is exactly even with the water level in the trough. Fill the flask to the 200 ml mark that you made on the flask.

6. Determine and record the temperature of the water in the trough and the barometric pressure of the lab.

7. Thoroughly dry the butane lighter and determine and record its exact mass.

---

**DATA**

Initial mass of lighter ..............................................................

Final mass of lighter ...................................................................

Mass of butane collected ............................................................

volume of butane collected ...................................................... 200 ml

Temperature ................................................................................ C

................................................................................................. K

lab pressure ..............................................................................

water vapor pressure at this temperature ..............................

partial pressure of butane ......................................................

---

Table of water vapor pressures at normal lab temperatures

<table>
<thead>
<tr>
<th>temperature (C)</th>
<th>pressure [torrs]</th>
<th>temperature (C)</th>
<th>pressure [torrs]</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>14.5</td>
<td>23</td>
<td>21.0</td>
</tr>
<tr>
<td>18</td>
<td>15.5</td>
<td>24</td>
<td>22.4</td>
</tr>
<tr>
<td>19</td>
<td>16.5</td>
<td>25</td>
<td>23.7</td>
</tr>
<tr>
<td>20</td>
<td>17.5</td>
<td>26</td>
<td>25.2</td>
</tr>
<tr>
<td>21</td>
<td>18.6</td>
<td>27</td>
<td>26.7</td>
</tr>
<tr>
<td>22</td>
<td>19.8</td>
<td>28</td>
<td>28.3</td>
</tr>
</tbody>
</table>

---

**CALCULATIONS:**
1. Using Dalton's law of partial pressures, enter the pressure of water vapor that corresponds to the lab temperature in the data table. Then subtract this from the lab pressure to find the partial pressure of butane gas.

2. Convert the lab temperature from Celsius to Kelvin.

3. Using the combined gas law formula, calculate the volume of butane at STP. Record your answer.

\[
\frac{\text{volume of butane}}{\text{lab temp (K)}} = \frac{\text{volume at STP}}{760 \text{ torrs}} = \frac{\text{volume at STP}}{273^\circ \text{ K}}
\]

4. Determine what mass of this gas would produce 22,400 ml at STP. Record your answer.

\[
\frac{\text{mass of butane}}{\text{volume of butane @ STP}} = \frac{22,400 \text{ ml}}{}
\]

5. Butane has the formula C\textsubscript{4}H\textsubscript{10}. Calculate its molecular mass from this formula. Record your answer.

6. Calculate your percentage of error.

THINKING SCIENTIFICALLY

1. What could you have done to have more accurate results?

2. Write a balanced equation for the reaction of butane with oxygen.
3. How much butane is contained in a new lighter? [read the label]

4. If all the butane in the lighter is reacted with air:
   A. What volume of air would be needed for this reaction? [Hint-air is only 1/5 oxygen]

   B. What would be the total volume of the gases produced by this reaction? [Hint-H$_2$O and CO$_2$ are the gases produced]
PRE LAB DISCUSSION

An electric current is a flow of electrons. In electric cells [commonly called "batteries"] electrons move from the cathode to the anode in a redox reaction. The modern operational definition of oxidation is the loss of electrons. Oxidation takes place at the anode [+]. The modern operational definition of reduction is the gain of electrons. Reduction occurs at the cathode [-].

Voltage is the electrical PRESSURE that is causing the electrons to flow. It is commonly called electro motive force [EMF]. Amperage is the NUMBER of electrons that move past a given point per second. Electric energy is measured in Watts, which is defined as voltage X amperage. A 9-volt battery has more electrical pressure than a "D" cell, but it does not have as much amperage.

A series circuit is when the anode of one cell is connected to the cathode of the next cell. This adds the voltage of the first cell to that of the second cell. Most common electrical cells [such as "D" cells] are 1.5 volts. If the cover is removed from a 9-volt battery, one will discover that it is made up of six AAA cells connected in a series. Each AAA cell produces 1.5 volts, which is added to next cell, which is added to the next cell etc. The combined pressure of the six 1.5 volt cells is 9 volts.

Electrical cells can produce direct current [D.C.], that is, a current of electrons that flows only in one direction. The electricity that is used in our homes is alternating current [A.C.], in which the flow of electrons reverses 60 times per second. Thomas Edison was an advocate of direct current and wanted to build electric supply systems based on this type of electric current. Nikola Tesla and George Westinghouse were advocates of A.C. electrical systems. The conflict between these great scientists is very interesting technological history.

---

1 A battery is a grouping or series of individual units. The term "battery" is correct when applied to the 9-volt unit of 6 individual units. The term "cell" is the correct term to describe a "D" cell although the term battery is often incorrectly applied to them.
Electricity can be produced in a number of ways. The electricity that powers our homes is produced by induction. This is done by moving a metal conductor through a strong magnetic field using mechanical energy. Electrons are displaced by the force of the field. Photovoltaic cells use light energy to displace electrons. In this laboratory we are using chemical energy to displace electrons. Two metals will react in an ionic solution. This reaction will occur when an electrical circuit provides a way for the electrons to move from one metal to the other.

Each partition of the egg carton can be made to function as an electrical cell. If the students want to increase the electrical voltage, the cells must be connected in series. The metals used for the cell determine the voltage of the cell. To increase the amperage of a cell, the students must increase the amount of reactive surface of the metals or connect the cells in parallel circuits.

Students should be aware of the importance of cleaning all metal surfaces with sand paper or emery cloth to insure good electrical conductivity. Students will need to connect alligator clips to bell wire in order to connect the electrical cells in a series or to motors, lights, and galvanometers.

OBJECTIVE: To make functional electrical cells and determine the relative strength of each type of cell.

CHEMICALS/EQUIPMENT: Styrofoam egg carton, Gelatin desert such as Jell-O [lemon, lime or orange flavored], copper [pennies, tubing or strips], aluminum [nails or strips of can and foil], magnesium, iron [nails], lead [weights, wall anchors, strips], zinc [hot dipped galvanized nails], bell wire, alligator clips, galvanometer or 1.5 volt DC motors and plastic coffee stirrers. filter paper, phenolphthalein solution

PROCEDURE:

1. Make the Jell-O with only 1/2 half of the water that is normally used in the directions on the box.

2. Fill the individual partitions of an Styrofoam egg carton with the
Jell-O and allow it to gel.

3. Attach alligator clips to both ends of four pieces of bell wire.

4. If you are using 1.5 volt electric motors, poke a hole in the center of a plastic coffee stirrer and place it on the shaft of the motor.

5. Make the following cells and test them by connecting them to the galvanometer or the electric motor. If there is no reaction, then make a second cell and connect it in series to the first. Then connect it to the motor or galvanometer. For each type of cell, rate its voltage relative to the other cells. If two or more cells in series were needed to obtain a measurable voltage, divide the reaction by the number of cells used in the series.

   Cu---Zn cell
   Al --Cu cell
   Fe--Zn cell
   Cu--Mg cell
   Pb--Al cell
   Pb--Mg cell

6. For each of the cells above that you were able to make, record the reading on the galvanometer or the relative speed of the electric motor. You need to be able to rate the cells from the highest voltage to the lowest voltage.
<table>
<thead>
<tr>
<th>CELL</th>
<th>GALVANOMETER READING</th>
<th>OR</th>
<th>RELATIVE SPEED OF MOTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu--Zn</td>
<td>________</td>
<td></td>
<td>________</td>
</tr>
<tr>
<td>Cu--Al</td>
<td>________</td>
<td></td>
<td>________</td>
</tr>
<tr>
<td>Fe--Zn</td>
<td>________</td>
<td></td>
<td>________</td>
</tr>
<tr>
<td>Cu--Mg</td>
<td>________</td>
<td></td>
<td>________</td>
</tr>
<tr>
<td>Pb--Al</td>
<td>________</td>
<td></td>
<td>________</td>
</tr>
<tr>
<td>Pb--Mg</td>
<td>________</td>
<td></td>
<td>________</td>
</tr>
</tbody>
</table>

PART II
(optional)

OBJECTIVE: To make a paper galvanometer.

PROCEDURE:

1. Saturate a piece of filter paper in a solution of concentrated salt water and phenolphthalein.

2. Attach opposite sides of the filter paper to one of the working electrical cells using the alligator clips. Observe for several minutes until there is a definite color change at one clip.

3. Reverse the position of the alligator clips and observe for several minutes until color changes are seen at both clips.
PART III
THE TEN-CENT BATTERY

OBJECTIVE: To make a voltaic pile.

PROCEDURE:

1. Place a small piece of aluminum foil on the table, then place a small piece of filter paper saturated with salt water on the foil. Now place a penny on the filter paper.

2. Cover the penny with another piece of filter paper soaked with salt water.

3. Repeat this procedure until you have a stack of ten pennies and aluminum foil, separated by moist salty filter paper.

4. Attach wire to the bottom piece of aluminum foil and another wire to the top penny. Now test this Voltaic pile with the motor or galvanometer.

THINKING SCIENTIFICALLY

1. List the cells in the relative strength beginning with the cell that produced the highest voltage.

2. Determine which metal was the anode and which metal was the cathode in each of the cells tested.
3. Using a table of reduction potentials, calculate the theoretical voltage for each of the experimental cells.

4. Compare the relative strength of the theoretical voltages to the relative strength of the experiment cells. Are they the same or not? How can you explain any differences?

5. This experiment specified the flavors of gelatin to be used. What would have happened if cherry or strawberry gelatin were used instead? Why?

6. How many cells were in the Voltaic pile? Theoretically, what voltage could this battery of cells produce?

7. What is the same about a "D" cell and a "AAA" cell?

8. What is difference between a "D" cell and a "AAA" cell?
9. Phenolphthalein turns pink in a basic solution. Did the anode or the cathode side of the filter paper turn pink?

10. Write the two half reactions for the electrolysis of NaCl.

11. Write an equation for the reaction of metallic sodium with water.
VISCOSITY IS A VIRTUE

PRE-LAB DISCUSSION

The machines upon which our technology depends will not operate without lubricants. Engines are made of metal parts, which move against each other, creating friction and wear. Lubricants function to keep the metal parts from actually touching each other. A thin layer of oil, grease, or other lubricant must be placed between the moving parts to prevent them from actually touching. The lubricant must be placed between the parts before they are forced together, and must have enough viscosity so as not to be squeezed out from between the parts before the pressure between the metal parts is relieved. The higher the viscosity, the slower the lubricant will move and the better it will adhere to the metal parts. Therefore, once a lubricant is placed between moving parts, the higher the viscosity, the more it will protect moving parts.

But the problem is more complicated. Machines move at speeds that allow only milliseconds to place the lubricant between the moving parts. The lubricant must be thin enough to get an adequate amount of lubricant between the parts when they are not being forced together. Understanding viscosity is further complicated by the fact that the viscosity of most fluids decreases as temperature increases. Machines operate over a wide range of temperatures, so a lubricant which protects moving parts at room temperature will not do the job at 200° F.

The Society of American Engineers determines the viscosity of motor oils by measuring the time it takes a weight to drop through a standard distance of oil. A weight will fall more slowly through a high viscosity oil than it will through an oil of low viscosity. All lubricating oils have a viscosity rating on the container. Most automobile engines require an oil that has 30 weight S.A.E rating.
In very cold climates, a thinner oil may be used in the wintertime and in very hot areas, a thicker oil may be used in summer. Oil chemistry has advanced from just refining oils to specific viscosities, to adding chemical agents, which control viscosity over a range of temperatures. Now motor oils have viscosity ratings such as 10w-30w. This means that the oil acts like a thin oil at cold temperatures but at higher temperature gives the protection of a 30-wt. oil.

Heat will cause the long molecules of an oil to break into small molecules. This will change a thick oil to a thin oil. Oxygen will react with oil to create heavier particles which become "sludge" that may clog oil lines or narrow channels that oil must move through to provide lubrication.

In this investigation, you will compare the viscosity of three different grades of motor oils. You will compare their viscosity at three different temperatures and then you will test a multigrade oil at the same three temperatures. Finally you will test a sample of used motor oil. You will need to find the oil change sticker [usually inside of a car door]. From this you will determine the brand and grade of the oil. By comparing the mileage on the car’s odometer and the mileage on the oil service sticker, you will be able to determine the number of miles driven using this oil.

OBJECTIVES:
To compare the viscosity of motor oil at different temperatures; compare the viscosity’s of several grades of motor oil; and to compare the viscosity of new and used motor oil.

EQUIPMENT/CHEMICALS
Glass beads, large test tubes, test tube clamp, ring stand, 250 or larger beakers, hot plate/Bunsen burner, ice, at least 3 grades of motor oil, one sample of multi-grade motor oil, sample[s] of used motor oil, watch or timer with second hand. [optional-microscope]

PROCEDURE

PART I

COMPARING MOTOR OILS AT ROOM TEMPERATURE

1. Complete at least 3 trials on each oil sample and record all results in the data table.
Clamp a large test to a ring stand. Fill it almost to the top with a sample of motor oil.

2. Mark the level of oil in the test tube. Each time the test is repeated, the test tube must be filled to this line with oil.

3. Use a timer with a second hand. Drop a glass bead in the test tube and record the seconds it takes to drop to the bottom.

4. When the test of this oil is completed, pour the oil through a wire screen and into a beaker. Remove the glass beads from the screen and set them aside on a paper towel.

5. Repeat steps 1-4 for all of the motor oil provided for this investigation.

PART II

COMPARING MOTOR OILS AT NEAR FREEZING TEMPERATURES

1. Place the test tube of oil in a beaker of ice and water. Stir the oil very carefully with a thermometer until the oil is about 3°C. Record the lowest temperature of the oil.

1a. [Alternative method] refrigerate the oil samples overnight. Record the temperature of the oil at the beginning of each test.

2. Repeat Part I steps 1 through 5 and record the results of the trials in the data table.

PART III

COMPARING MOTOR OILS AT NEAR BOILING TEMPERATURES

1. Place the test tube with the oil sample to be tested in a beaker of boiling water. Caution. Use a hot plate or turn off the Bunsen burner before placing the oil sample in the boiling water. Never allow an oil sample to come even close to a flame.

2. Repeat Part I steps 1 through 5 and record the results of the trials in the data table.
<table>
<thead>
<tr>
<th>Type of oil</th>
<th>Seconds at 3°C</th>
<th>Seconds at room temperature</th>
<th>Seconds at near 100°C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ave</td>
<td>Ave</td>
<td>Ave</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Questions**

1. Describe the appearance and odor of the used motor oil. If possible, examine a thin film of used oil under a microscope.
2. How does the viscosity of the used oil compare to the same grade of virgin oil?
3. What factors may have caused the changes in appearance, odor, and viscosity of the used motor oil?
4. Does the used oil protect the moving metal parts in as well as fresh oil? Why or why not?

**THINKING SCIENTIFICALLY**

1. Why is it important for the life of a machine to change the oil regularly?
2. Why do some experts recommend than an engine is allowed to warm up a few minutes before driving a car in very cold weather?
3. It has been said that most of engine wear occurs in starting the engine. Explain how this may be true based on your knowledge of motor oil and its functions.
4. You are buying a used car and find two similar cars with about the same mileage on the odometer. A salesman who traveled over a large area drove one. An office worker who drove in the city to
work and did other local driving drove the other. Which car would you buy based on your knowledge of oil and engine wear? Explain your choice.