DEMONSTRATIONS TO ACCOMPANY
HIGH SCHOOL GENERAL CHEMISTRY COURSE

HONORS 499--HONORS SENIOR THESIS

by

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PHILOSOPHY OF EDUCATION

I believe that every student is an individual and that each has their own unique experiences to bring to a classroom. My students will be learning, not only from the text and lectures, but also from each other. Learning is a continuous process of life. When one stops learning, one ceases to be an active member of society. One of the goals of education is to initiate discovery and to encourage learning.

Each of us is born curious, and, through observation, we learn more about the world around us. Too often, children's questions are considered insignificant. In this case, learning becomes limited only to what is thought to be significant to others. My goal is to rekindle the childhood delight of discovery and the wonder of curiosity.

Science education needs to be continually updated. Students need to have every opportunity to learn more than just what the traditional texts and laboratories present. Instead, the students should have the opportunity to investigate new theories and gain hands on proof of scientific laws, provided this can be done within the safety procedures of guided study.

As a teacher, I see myself as the guide, directing students towards answers and yet still allowing them the opportunity for self-discovery. I strongly believe that all students have the ability to learn and that many even have the desire to learn. It is up to the educators to stimulate an environment that supports students' interests.

My classroom will be a place of active learning. Students will be free to offer opinions without fear of being incorrect. Even "wrong" answers have value in learning. Past experiences will not effect the success of students, rather students will realize that each individual has something valuable to contribute to the learning process of all. This way, education is an ongoing process despite the limitations of the text or classroom situation.

As a teacher, I will make up only part of each student's educational experience. Teachers need to work jointly with one another and our administrators. It is important that we remember we are there to help the students. As educators we need to be aware of the changes in the world so that we can best prepare students to be active members of society.

I also believe in the importance of sharing experiences with my students' families. For the most successful education, it is best to have parents involved. To accomplish this, communication is a must. I want my students and their guardians to feel that I am always available for conferences. I recognize there are some unfortunate students that have little support in their homes, but I also feel there are many parents that do not know what they can do to assist in their children's education. By opening communication, I will be
able to teach my lessons and parents can observe whether their children are having difficulty. I am open to listen to concerns and will do my best to cooperate on a solution.

Again, learning is a continuous process. In as much as my students will be learning from me, I believe that I shall also be learning from them. At varying levels, we will be gaining more information. By applying the information gathered throughout life, we gain more knowledge, knowledge that my students will realize can help them be successful in life.
PURPOSE STATEMENT:

Industry is continually changing. Because of this, the focal points of science education must change also to cover the important topics in technology. These changes make it increasingly difficult for textbook companies to produce an inexpensive curriculum which will cover all the new topics flexibly enough to sufficiently cover the background material required for science education. It is therefore important for science teachers to furnish material supplementary to the text which will cover more current topics.

The goal of this portfolio is to create a working folder from which I can draw ideas for my chemistry classroom. It may also contain ideas gathered for physics, general science, or other educational topic. Often curriculums will give a lab schedule to correspond with the text. In practice however, there is often not enough time for instructors to complete the necessary reading, lecture, discussion, and lab periods when school administration procedures (announcements, attendance, etc) cut into already small class periods.

I have collected a series of demonstrations and mini-labs which could be added to a normal class period or within a scheduled lab period which could correspond to the day’s lesson. These will come from materials gathered from various other educational texts and journals.

The portfolio is not a one time project. It is a collection from a variety of sources. The portfolio can continually change to express the needs of the educator. This collection can be amended as my experience grows to include more lesson plans and perhaps even some examples of students own invention. The portfolio represents the topics that I intend to cover as well as options to change focus depending upon students needs.
I. First Six Weeks

A. **Topic:** nature, chemistry, and you; activities of science
   1. **lab**
      a. check in
      b. use of all senses
   2. **demo**
      a. oscillating reactions
      b. effect of temperature on hydrates

B. **Topic:** measuring and calculating, activities of science
   1. **lab**
      a. measurement determination of mass, volume
      b. conservation of mass and energy
      c. density: a qualitative study
   2. **demo**
      a. distilling water
      b. physical and chemical changes

C. **Topic:** describing matter
   1. **lab**
      a. chemical and physical changes in matter
      b. specific heat of metals
      c. household substances and chemical change
   2. **demo**
      a. chemical changes
      b. mixtures and compounds
      c. buoyancy

D. **Topic:** chemical formulas and equations
   1. **lab**
      a. chemical formulas and oxidation numbers
      b. synthesis and composition of a compound
   2. **demo**
      a. moles of electrons

E. **Topic:** the mole and molar relationships
   1. **lab**
      a. the mole as a chemical unit
      b. quantitative determination of an empirical formula
   2. **demo**
      a. limiting and excess reagents

II. Second Six Weeks

A. **Topic:** chemical reactions
   1. **lab**
      a. qualitative study of a reaction
b. mole relationship in a chemical reaction

2. demo
   a. formation of precipitates

B. Topic: atomic structure
   1. lab
      a. flame tests
      b. spectrophotometer
   2. demo
      a. firefly reactions
      b. chemiluminescence

C. Topic: electron cloud and probability
   1. lab
      a. shapes of molecules and polyatomic ions
      b. locating an electron by analogy probability information
   2. demo

D. Topic: periodic table
   1. lab
      a. periodicity of physical, chemical, and atomic properties
      b. relationship between atomic number and radius of atom
   2. demo
      a. floating pennies

E. Topic: periodic elements
   1. lab
      a. grouping elements in families by similar electron patterns
      b. relationship between bond types and physical properties
      c. energy relationships of metallic ions
   2. demo
      a. properties and trends of alkali metals
      b. obtaining metallic iron from cereal

III. Third Six Weeks
A. Topic: chemical bonding
   1. lab
      a. conductivity and chemical bonding
      b. AV materials showing 3D bonding structures
      c. students assemble 3D molecules
   2. demo
      a. sugar digested by yeast

B. Topic: molecular structure
   1. lab
      a. shapes and polarities of covalent molecules
      b. properties of ionic and covalent compounds
2. demo
   a. light bulb in various solutions

C. Topic: polar molecules
1. lab
   a. introduction to chromatography
2. demo
   a. bending a stream of water
   b. mixing water and oil

D. Topic: kinetic theory
1. lab
   a. prediction reaction rates
   b. effect of temperature on volume and pressure of a gas
2. demo
   a. lessons with a fizz on reaction rates

IV. Fourth Six Weeks
A. Topic: solids
1. lab
   a. ion or atom arrangement in crystals
   b. determination of melting and freezing points
2. demo
   a. growing crystals
   b. silicate garden

B. Topic: liquids
1. lab
   a. energy changes during a phase change
   b. determining melting point of water
2. demo
   a. boiling water with ice
   b. water
   c. surface tension

C. Topic: gases
1. lab
   a. vapor pressure
   b. gas laws
   c. greenhouse* 
2. demo
   a. "thirsty bird"
   b. egg in the bottle

D. Topic: gases and the mole
1. lab
   a. ideal gas constant
   b. molar volume of a gas
   c. determination of a formula for an unknown compound
2. demo
a. pressure and volume relationships
b. osmosis

E. Topic: energy and disorder
1. lab
   a. entropy and enthalpy
   b. enthalpy of a chemical reaction
2. demo
   a. endothermic and exothermic reactions

V. Fifth Six Weeks
A. Topic: solutions
1. lab
   a. effect of temperature on solubility
   b. determination of a solution’s concentration
2. demo
   a. distilling water
   b. supersaturation and crystallization.

B. Topic: colligative and colloidal properties
1. lab
   a. molecular weight determination by boiling point and freezing point
2. demo
   a. mixtures and compounds

C. Topic: reaction rate and chemical equilibrium
1. lab
   a. reaction rates
   b. study of chemical equilibrium
   c. application of Le Chatelier’s principle
2. demo
   a. equilibrium and Le Chatlier’s principle
   b. reaction time with starch iodine clock reaction

VI. Sixth Six Weeks
A. Topic: acids, bases, and salts
1. lab
   a. qualitative analysis of net ionic reactions
   b. acid-base titrations and volumetric analysis
   c. water reactions with normal salts
2. demo
   a. indicators and pH
   b. buffers
   c. lesson with fizz acid/base and buffers
   d. salts and neutralization reactions

B. Topic: solutions of electrolytes
1. lab
   a. electro-chemical cells
b. hydronium ion concentration indicators

2. demo
   a. decomposing water by electrolysis

C. Topic: redox
   1. lab
      a. oxidation-reduction reactions
      b. qualitative titrations with redox reactions
   2. demo
      a. disappearing ink
      b. chemistry signs

D. Topic: electro-chemistry
   1. lab
      a. corrosion: an electro-chemical problem
   2. demo
      a. static electricity
      b. matter and electricity

E. Topic: nuclear chemistry
   1. lab
      a. natural radioactivity
   2. demo
      a. demonstrating half-life
**DEMONSTRATIONS**

**Effect of Temperature on a Hydrate**

Place 10 ml of 95% ethyl alcohol in a glass Petri dish. When it becomes room temperature, add a pinch of cobalt(II) chloride. Stir until it dissolves. The solution should be pink. If it is not pink dilute with a little distilled water until it becomes pink. Place dish on hot plate and warm until the solution turns blue. Remove from hot plate. As the solution cools it becomes pink again.

Cobalt(II) chloride is in the form of a hydrate. When the solution is heated, the blue anhydrous form is produced. As the solution is cooled, water in the solution recombines with the cobalt(II) chloride. The pink hydrate is again formed. 

\[
\text{Co(H}_2\text{O)}_6^{2+} + 4\text{Cl}^- \rightleftharpoons \text{CoCl}_4^{2-} + 6\text{H}_2\text{O(l)}
\]

This method is similar to that used in weather indicators. Strips of anhydrous cobalt(II) chloride paper turn pink in high humidity.

**Oscillating Reactions**

Perform this demonstration in a fume hood. Oscillating reactions are not always possible to explain as they are so complex. This one is believed to involve over 20 chemical species and have some 18 steps in its reaction mechanism. Exact amounts of chemicals are not important in this demonstration. Plastic spoons will give a good approximation of the necessary relative amounts.

Place a large beaker on a magnetic stirrer. Carefully add 900 ml of water and 50 ml of concentrated sulfuric acid. Dissolve 3 spoons (approximately 20 g) of malonic acid, 2 spoons (20 g) of KBrO₃, and 1/4 spoon (3 g) of MnSO₄. The solution fizzes and turns brown. Within a few seconds the oscillation begins. Some of the products from this reaction include CO₂, formic acid, HCOOH, and bromomalonic acid, BrCH(COOH)₂. The colorless and brown color solutions represent the different oxidation states of manganese.

**Yellow and Blue**

Prepare all of the necessary solutions. Solution A is prepared by adding 40 ml of 30% hydrogen peroxide to 100 ml of water. Solution B is prepared by adding 4.3 g KI0₃ and 0.5 ml of concentrated sulfuric acid to 100 ml of water while stirring. Solution C is made by preparing a paste of 0.15 g of soluble starch in hot water. While stirring, add this to 500 ml of hot water. Then add 7.8 g of malonic acid and 1.7 g of Mn(SO₄)₄·H₂O.

Put 100 ml of solution A in a 500 ml beaker on a magnetic stirrer. Stir on the slowest setting. Add 100 ml of solution B and 100 ml of solution C. Oscillations start in a few seconds. Again this is a complex reaction, but in the first steps of the reaction mechanism, oxygen gas an iodine are formed. The iodine reacts with the starch to produce the blue.
color. As iodine is used up in the other steps of the mechanism, the color fades to yellow and turns blue again as the concentration of iodine increases.

**Red and Blue**

Prepare all the necessary solutions before the demonstration. Solution A is prepared by dissolving 5 g of sodium bromate in 67 ml of distilled water. While stirring, slowly add 2 ml of concentrated sulfuric acid. Make solution B with 1 g of sodium bromide in 10 ml of distilled water. Solution C is made by dissolving 1 g of malonic acid in 10 ml of distilled water. Also prepare a 0.25 M solution of ferroin (phenanthroline ferrous sulfate).

Place 6 ml of solution A in a small beaker. Add 0.5 ml of solution B and 1.0 ml of solution C. Wait for the brown color to disappear and add 1.0 ml of ferroin. Add 1 drop of Photoflo or some other surface-active (or wetting) agent. Some of the steps in this reaction are known. Bromate reacts with malonic acid and produces bromomalonate. Bromate also reacts with red ferrous dye to produce blue ferric dye. Bromide and malonic acid react to form bromomalonate. Bromomalonate and the blue ferric dye react to form bromide. The bromide inhibits the reaction of red ferrous dye to blue dye, and a red color is produced.

**Distilling Water**

Mix 1/4 cup of water with 1 tsp sucrose. Make a second solution by mixing 1/4 cup of water with 1 tsp of sodium chloride. Mix the third solution with 1/4 cup warm water with 1 tsp of copper sulfate crystals. Note the appearance of all three solutions and then pour them together into a pyrex flask. Again note the appearance. Set up a simple distillation with the collection flask in an ice bath. Notice the appearance of the collected liquid. This is the distilled water. All the added impurities were left behind in the original flask because they evaporate at higher temperatures than does water.

**Physical and Chemical Changes**

Place 5 g crushed CuCl₂·2H₂O crystals in a 400 ml beaker. Add 100 ml of water. Don't stir. Observe and record observations. Stir solution and record new observations (physical). Drop a 4 cm² piece of aluminum foil into beaker. Observe the reaction (chemical).

**Physical and Chemical Changes**

After defining physical and chemical changes these demonstrations may be helpful for students to visualize the differences and perhaps rid themselves of some misconceptions. It is helpful to describe the physical properties of the materials to be demonstrated.

**Physical Changes:**

1. Heat a platinum wire in flame until it glows red hot.
Allow to cool. No change has occurred.
2. Break a piece of glass to show that its physical appearance has changed, but the properties remain the same.
3. Dissolve a tablespoon of sugar or salt in a glass of water. Allow a student to taste the solution to determine that the sugar or salt is still present. Evaporate the solution to show that the crystal can still be recovered. This is thus a chemical change but not physical.

**Chemical Changes:**
1. Oxidation of Copper. Clean a large piece of copper until it is free of oxide. Heat the metal in a flame until oxide crust has formed. Cool and compare before and after results. Compare with physical change of platinum.
2. Dehydrating sugar with sulfuric acid. Half fill a 50 ml beaker with granulated sugar. Place a thermometer in the center of the sugar. Add concentrated sulfuric acid to cover the sugar. Record the rise of temperature as the reaction progresses. The compound will expand during the reaction. The final product does not resemble the original solution. Test its solubility to further confirm chemical change.
3. Pharaoh's serpents: **Preform this demo in a fume hood!** Add 1g p-nitroacetanilide to 1-2 ml of concentrated sulfuric acid in a 50 ml beaker. During heating the mixture will melt and a vigorous reaction begins at about 200°C. Soon following, there is a mild explosion and a large, snake-like carbon mass emerges.

**Chemical Change**
1. Add a piece of baking powder or baking soda to 5 ml of clear vinegar or 1M acetic acid.
2. Cautiously add a few crystals of drain cleaner to 5 ml of water.
3. Repeat drain cleaner reaction with 5 ml of vinegar.
4. Pour 1M ammonium hydroxide into 3 beakers containing phenolphthalein, lead acetate, and copper sulfate.

**Difference Between Mixtures and Compounds**
Prepare a mixture of 9.6 g of sulfur and 16.5 g of iron filings. To half of this mixture, add 5 ml of carbon disulfide. Shake and filter off the carbon disulfide. Transfer solid to evaporating dish. Allow for evaporating time. Show that no change has taken place in the sulfur. Use a magnet to show that the iron can be removed from the mixture.

Take the remaining sulfur and iron mixture and place in pyrex test tube and heat until beginning of reaction. Withdraw from the flame. The reaction continues without additional heat. Remove the iron sulfide and test with magnet. It has lost a property from the original mixture. Try to dissolve the FeS in carbon disulfide to support that a new substance with new chemical properties has been formed.
BUOYANCY OF GASES, LIQUIDS, AND SOLIDS

This demonstration shows the change in density resulting from the buoyancy of gases. Fill a glass cylinder with a solution of salt water at such a density that a few moth balls placed in the solution will just sink. Place a few pieces of mossy zinc in the bottom of the cylinder and add just enough sulfuric acid so that bubbles of hydrogen gas begin to form. The hydrogen gas will attach themselves to the mothballs causing them to rise to the top. Upon reaching the top, the gas escapes and they will sink again in the solution.

If the mothballs tend to cling to the water surface, a small amount of detergent may be added. Also, baking powder in the water may be substituted for the zinc and sulfuric acid to produce carbon dioxide gas.

Moles of Electrons

The relationship between moles of electrons and oxidation number can be illustrated by using balloons to capture hydrogen gas generated during an oxidation-reduction reaction. The amount of H₂ produced from oxidation of sodium, magnesium, and aluminum is mole-dependent. The gas can easily be collected in balloons as the volume occupied by the collected gas is directly related to the moles of electrons transferred.

Put 150 ml of distilled water into one 250 ml flask and 150 ml of 6M HCl in each of two other same sized flasks. Put 0.23g sodium in a balloon and flatten it. Without dropping any of the metal into the flask, slip the neck of the balloon onto the water flask and secure it. Add 0.24 g magnesium to a different balloon and attach it to one of the HCl flasks as above. Repeat with 0.27 g of aluminum.

After all the flasks are prepared, tilt up the balloons and make sure all the metal enters the flask. Swirl to ensure all the metals react. Write out balanced equations for each reaction. Label the moles of hydrogen gas produced. Compare the size of the reaction balloons. Their volumes follow the predicted sizes from the experiment.

Limiting and Excess Reagents

This is a two day demonstration or it can be run as a lab. Day one: Obtain and label with name a 1 oz plastic cup. Record its mass. Mass a piece of zinc between 0.10 g and 0.50 g, record mass and place in plastic cup. Using a graduated pipet, add 5.0 ml of 1M HCl to the cup. Students should record all observations up to this point including a drawing of cup and contents with labels. Place cup in safe area until next lab period.

Day two: Observe cup and contents. Make another drawing and label. Discard liquid in sink, return zinc to solid container, and discard cup. Using the previously recorded volumes, molarity, and masses, determine the moles of zinc and HCl used in this reaction. Write the balanced equation for the reaction. Use the mole to mole ratio to determine which
reactant was in excess and which was the limiting reagent.

**Precipitate Formations**

Place 10 ml of SnCl₂ solution in a 150 ml beaker. Add rapidly 90 ml of HgCl₂ solution. Note the formation of the white precipitate. \( 2\text{Hg}^{2+}(aq) + \text{Sn}^{2+}(aq) + 2\text{Cl}^-(aq) = \text{HgCl}_2(s) + \text{Sn}^{4+} \) By contrast, place 10 ml of HgCl₂ in a different 150 ml beaker. Rapidly add 90 ml of SnCl₂ solution. Now, notice the formation of a black precipitate. \( \text{HgCl}_2(s) + \text{Sn}^{2+}(aq) = \text{Hg}(s) + \text{Sn}^{4+}(aq) + 2\text{Cl}^-(aq) \)

Special care must be taken with mercuric chloride and mercury are toxic. Wear disposable gloves and follow waste procedures carefully. Make sure that the SnCl₂ solutions is made fresh prior to the demonstration. The 0.1M SnCl₂ is made by dissolving 19 g of SnCl₂ per liter of water. The 0.1M HgCl₂ by 27.2 g HgCl₂ per liter of water. Add 2 drops of concentrated HCl to prevent formation of metal hydroxyl complexes.

Precipitates come in a large variety of colors. Place 200 ml of clear limewater in a beaker. Add a few drops of cobalt nitrate solution. The wine colored solution turns into a blue precipitate when it comes in contact with the limewater. \( \text{Co(NO}_3)_2(aq) + \text{Ca(OH}_2(aq) = \text{Ca}^{2+}(aq) + 2\text{NO}_3^-(aq) + \text{Co(OH)}_2(s) \). This demonstration projects well if done with Petri dishes on an overhead projector.

**Chemiluminescence--Firefly Reaction**

The firefly reaction is the laminal reaction. Like a firefly it gives off light without heat. Solution A is made by adding 100 ml of bleach (6.5% NaOCl) to an Erlenmeyer flask and dilution to the 1-L level. Stopper the flask. Solution B is made by adding 0.4 g Laminal into a second Erlenmeyer flask. Fill to 1-L mark with water and then add 4.0 g NaOH. Swirl to dissolve pellets and stopper.

To demonstrate reaction, dim the lights. Evenly pour from both flasks into a 2-L beaker. This demonstration not only illustrates chemiluminescence, but also photon emission and that not all reactions give off energy in the form of heat.

**Chemiluminescence**

Here is a list of dyes that can be used in this demonstration and the colors that they can produce: perylene, blue; tetracene, green; rebrune, yellow; isoviolanthrone, orange; violanthrone, red. Select the colors for demonstration (perhaps school colors or season representative). Prepare the necessary solutions: hydrogen peroxide solution, 30%; dichloromethane, CH₂Cl₂; oxalyl chloride. Make sure to wear gloves and to pour solutions in fume hood.

Add enough dichloromethane to be approximately 1" in the bottom of each large (at least 1 liter) round bottom flasks.
Add a pinhead sized pinch of selected to dye to flasks. Add 0.5 ml of oxalyl chloride to each flask. Have volunteers hold the flasks. Simultaneously add a dropper full of hydrogen peroxide to each flask. Stopper each flask, dim the lights and swirl the flasks.

When the hydrogen peroxide reacts with oxalyl chloride, the intermediate product is formed. This intermediate product will decompose to release energy. The released energy is transferred to the dye molecule and excites the electrons to a higher energy level. As the electrons return to ground state, visible light is emitted. The color of light emitted (wavelength) depends upon the chemical structure of the dye.

Floating Pennies

Obtain a post-1983 penny. Make several small notches around the edge of the penny using a triangular file. Place penny in 20 ml of 6M HCl in a 100 ml beaker. The next day the penny will be floating in the beaker.

This demonstration can be used to introduce the reaction of metals with acids. New pennies should be used because of their zinc core. Old pennies average 3.1 g each and 94% copper. The new pennies are 2.6 g each and contain only 2.4% copper. Make sure to expose the zinc core when making the notches. As the HCl reacts with the zinc producing hydrogen gas. It is the trapped hydrogen gas that causes the penny to float. An alternate demonstration would be to use new quarters. New quarters have a copper core which can be reacted with dilute nitric acid.

Properties and Trends of the Alkali Metal Family

This experiment is to be performed behind a safety shield. To each of three liter bottles, add 200 ml of water, one drop of detergent, and a few drops of phenolphthalein. To the first bottle add a small amount (the size of a split pea or smaller) of lithium and immediately cover the top with a glass plate. Repeat this experiment with same sized quantities of sodium and potassium. Compare the reactivity of these elements what is the periodic trend?

Separating Metallic Iron from Cereal

Find an iron-fortified cereal. Add water and stir. When cereal becomes soggy, metal stirring bar to cereal and stir with magnetic stirrer. After 20-30 minutes, remove the magnet and notice the dark slivers of iron covering the magnet.

These slivers are metallic iron which cannot be absorbed by humans. More useful Fe²⁺ and Fe³⁺ are produced when hydrochloric acid reacts in the stomach with the metallic iron. Cereals are fortified with metallic iron to protect against oxidation. Some chemicals (such as oxalate and tartrate) found naturally in vegetables will complex and prevent iron absorption.
**Sugar Digested by Yeast**

Put some R-glucose in a beaker and an equal amount of S-glucose in another beaker. Cover each sample with a blanket of yeast. Add water to each sample and watch. Although each sample of glucose has the same chemical formula they have different chemical structures. The yeast will only react with one of the structures.

**Light Bulb in Various Solutions**

Set up a conductivity apparatus. This consists of two terminals connected to a light bulb and a plug for connection to a 110 volt wall electrical outlet. Prepare the following solutions: distilled water, tap water, 1M NaCl, 0.1M NaCl, 1M sucrose (C12H22O11), 0.1M sucrose, 1M HCl, 0.1M HCl, glacial acetic acid (CH3COOH), and 0.1M acetic acid. Place about 20 ml of each solution into different 100 ml beakers.

To avoid electrical shock, be careful not to touch terminals of conductivity apparatus while it is pulled in. Lower the terminals into a beaker so that the solution covers the terminals. For each solution, the distance between terminals and the depth of coverage should be consistent. After apparatus is in place, plug into electrical outlet and observe the light bulb. A solution containing an electrolyte conducts electricity, connects the circuit, and lights the bulb. Strong electrolytes will give a bright light; weak electrolytes will give dim light; and nonelectrolytes will give no light at all. Be sure to disconnect the apparatus between each test and rinse terminals with distilled water before placing in new solution.

**Bending a Stream of Water**

Fill one buret with distilled water and another with nonpolar solvent (cyclohexane, trichlorotrifluoroethane, or any of the hydrocarbons). Charge a rubber or plastic rod by rubbing it with a piece of wool or fur. Alternately, charge a glass rod with silk or charge a comb by quickly stroking through your hair. Open the stopcock of the buret with water to allow a fine, unbroken stem to flow. Hold the charged rod near the stream and observe the attraction of the stream towards the rod. Repeat with the nonpolar liquid and observe that there is no attraction.

The water molecule is slightly negative at the oxygen atom and slightly positive at the hydrogens. The molecules are attracted to a charged object. The nonpolar solvent has no polarity for it to be attracted toward a charged object. The polarity of water accounts for its liquid state at room temperature, lower density as ice, ability to dissolve ions, and tendency to form ions, OH⁻ and H⁺.

**Kinetic Theory with alkalizing tablets**

The effervescent alkalizing tablets demonstrate one of
best commercial examples of reactions induced by the presence of water. The effervescent alkalizing tablets contain heat treated sodium bicarbonate, citric acid, and a salicylate analgesic. When sealed in their packets, no reaction can occur. Placed in water, however, a double displacement reaction takes place: 

\[ 2\text{NaHCO}_3(s) + \text{H}_2\text{C}_6\text{H}_5\text{O}_7(s) + \text{H}_2\text{O} = \text{C}_6\text{H}_5\text{O}_7\text{Na}_3(aq) + 4\text{H}_2\text{O}(l) + 3\text{CO}_2(g). \]

A property of this reaction is the idea of effervescence, the rapid release of gas from the solution.

**humidity dependant**

Expose a tablet to the open air for a week or so leaving a still-sealed tablet in the same location as a control. Leave these pairs of tablets in various locations of varying humidity. How does the amount of moisture in the air effect the dissolving time of the tablets? In separate beakers containing 150 ml of water, drop the air exposed and freshly opened tablets into the water. The tablets exposed to the air take longer to dissolve. This is especially true for those located in high humidity where those tablets may not dissolve at all.

**temperature and reaction rate**

Set up series of beakers containing 50 ml of water in a wide temperature range from ice water to hot water. The tablets will react quicker in the hot water. This is because the increase in temperature increases the molecular motion and lowers the activation energy.

**surface area and reaction rate**

Grind up on tablet into a fine powder. Add it to a beaker containing 150 ml of water at room temperature. Record the reaction time. Grind a second tablet into the consistency of coarse sand. Add to another beaker of water and record reaction time. Repeat process with 3 more tablets of increasingly bigger sized pieces and finally with a whole tablet. The smaller the pieces and greater surface area increase the reaction rate.

**concentration and reaction rate**

Place 150 ml of water in each of 5 200 ml beakers. To the second beaker add 10 g table salt, 25 g to the third, 40 g to the forth, and 55 g to the fifth. The increased amount of salt lowers the reaction time of effervescent alkaline tablets to dissolve. Can the salt completely inhibit the dissolving of the tablets?

**Growing Crystals**

In a shallow pan, mix 1 cup sodium silicate with 4 cups of warm water. Randomly sprinkle one or two of each of the following types of crystals throughout the pan: cobalt chloride, copper sulfate, manganous sulfate, lead nitrate,
ferrous sulfate. Do not disturb pan until crystals are done growing. Then siphon off the sodium silicate solution and replace with clear water.

Silicate Garden

When metal salts are added to a silicate solution, insoluble silicates are formed. When these salts are placed in the sodium silicate solution, a semipermeable membrane is formed around the salt. Because the concentration of ions is greater inside the membrane, water enters the membrane to dilute the concentrated solution. This effect is called osmosis. Osmosis causes the membrane to break. It breaks upward because the pressure of the water on the sides of the crystal is greater than that on the top. This process is repeated as a new membrane forms, and an upward growth of the crystal garden results.

Each type of crystal has each own color: iron(III) chloride, brown; cupric chloride, bright green; cobaltous nitrate, dark blue; manganous nitrate, white; and zinc sulfate, white. Placing sand in the bottom of the tray or bowl will prevent the crystals from sticking to the bottom.

Boiling Water with Ice

This dramatic demonstration can be useful for showing the relationship between pressure, temperature, and boiling point of a liquid. A Franklin flask is required, or some viable substitution. A Franklin flask is a round bottom flask with concave bottom. Place water in the flask. Heat until vigorously boiling. Boil until all the air in the flask has been replaced with water vapor and steam.

Remove from the heat source and immediately stopper. If detailed study and critical pressure studies are to be made use a well sealed rubber stopper with thermometer. Invert flask and place securely in a ring stand. Place ice onto concave area or top of inverted flask. The water in the flask boils because the ice lowers the temperature in the flask. The lowered temperature lowers the pressure of the flask and the water boils.

Water

Fill a baby food jar to the rim with water and tightly screw on lid. Wrap jar with cellophane tape. Place jar in beaker or some other container and put in freezer. Remove beaker and jar the next day. The jar broke because of water’s property to expand when it freezes. Most liquids contract on freezing. Repeat experiment with some other liquids that do not contain water.

Measure the amount that the water expands. Put 50 ml of water into a 100 ml graduated cylinder. Place cylinder in freezer. After water has frozen, remove and note the final volume. Calculate percentage of expansion.

Fill a baby food jar with dried beans or peas. Add water
to fill jar to brim. Tightly cap jar and place in beaker or empty can. The next day the jar is broken. The water rehydrates the dried beans and causes them to expand, breaking the jar.

**Surface Tension**

Sprinkle baby powder on water in a dish. Touch a soapy toothpick to the powder. The surface tension weakens at that point and you see the powdered water suddenly pulled away in all directions by the stronger surface tension elsewhere.

Tie the ends of a 6" silk thread to form a loop. Place the loop in water. Touch a soapy toothpick to the center of loop. The surface tension is weakened inside the loop and the greater surface tension outside pulls the thread into a circle.

Obtain a small piece of cork. Place it in a glass of water. Cork likes to float at the highest level of water. Because the water has a concave surface, the cork moves to the edge of the glass where the water is higher. Slowly fill the glass to beyond the top. This will create a convex surface. In convex surfaces, the highest point is at the center and this is where the cork will float.

**"Thirsty Bird" and Gas Properties**

The drinking bird can be used as more than just a fun object to watch. Principles of gas properties can explain these actions. Inside the bird there is a tube which runs the length of the body and is connected to the beak. Evaporation of water from the cloth covering the beak cools the gas in that end of the tube, causing greater pressure in the bulb at the tail end of the bird. This pressure drives the entrapped liquid past the balance point, making the bird drink. Upon drinking, the head is cooled and the entrapped liquid again flows to the bottom bulb.

This visual aid is a useful way to link to link kinetics of gas properties to energy transformation. Alternately, the birds drink could become a solution with ethanol or some other liquid.

**Egg in a Bottle**

Find a 1-qt bottle with neck and mouth small enough that an egg placed on the mouth will not fall in. Fill the bottle with hot water and empty. Fill again with near boiling water and allow it to sit for a few minutes before emptying. Immediately after emptying, place a previously peeled hard boiled egg on the mouth of the bottle with the small end pointed downward. In a few seconds the egg will be pushed into the bottle. To remove the egg, turn the bottle upside down, allowing the egg to plug the neck. Blow onto the mouth of the bottle and the egg will be pushed out.

When the hot water was in the bottle it cause the air inside the bottle to also be heated. When the egg plugged the
mouth, the inside air was isolated from the eternal air. As the bottle cools, the air inside the bottle cools as well, decreasing the internal air pressure. The greater pressure outside pushes the egg into the bottle. When one blows in the mouth of the inverted bottle to remove the egg, the external pressure immediately outside the bottle is decreased. The greater pressure inside the bottle pushes the egg back out.

**Pressure and Volume Relationships**

Place a large marshmallow on the platform of a vacuum pump. Seal the container and turn on the pump. As the pressure inside decreases, the size of the marshmallow increases. This happens because there are large amounts of air trapped inside the carbohydrate structures of the marshmallow. As the pump reduces the amount of air outside the marshmallow the pressure of the air inside it causes it to expand.

This demonstration helps with understanding of Boyle’s law \( P_1V_1 = P_2V_2 \). If a vacuum pump is not available, place the marshmallow in a side-arm suction flask connected to a water aspirator. Balloons are also good to demonstrate relative air pressure. Placing the marshmallow in hot cocoa and observing its increase in size (before it is dissolved) will demonstrate the temperature relation to volume.

**Osmosis**

Place a raw egg in a 250 ml beaker. Fill the beaker with vinegar and cover the beaker with plastic wrap. Punch a few holes in the wrap. In a couple of days the egg shell has been completely dissolved. The remaining parts of the egg has swollen considerably. Carefully pour off the solution and examine the egg. Its membrane is firm enough to be carefully held in ones hand. Dilute clear syrup (50:50) and place the enlarged egg in beaker containing the syrup solution. In another couple of days observe again. The egg has shrunk in size smaller than the original egg.

This demonstration shows osmosis, the movement of water across a semipermeable membrane from an area of lower to higher solute concentration. When the egg was first placed in vinegar, the acetic acid reacted with the calcium carbonate in the egg shell.

\[ 2H^+(aq) + CaCO_3(aq) \rightarrow CO_2(g) + H_2O(l) + Ca^{2+}(aq) \]

A very high concentration of protein (mostly albumin) exists in eggs. The water entered the egg attempting to dilute this and make the solute concentration equal on both sides of the membrane. The water entering the egg causes it to get larger. The reverse happened when the egg was placed in the syrup solution. The higher solute concentration was on the outside of the egg in the form of glucose. The water left the egg (crossed the membrane) to dilute the more concentrated solution. The same type of osmotic situation happens in cells to move small nutrient molecules and water into cells and to
remove waste products. This is how pickles are made from cucumbers.

**Endothermic and Exothermic**

**Endothermic**
Put 20 g barium hydroxide crystals \([\text{Ba(OH)}_2cdot 8\text{H}_2\text{O}]\) in a 50 ml beaker. Add 10 g ammonium thiocyanate (or 7 g ammonium chloride or 10 g ammonium nitrate). Stir with a wood splint. Place the beaker on small wooden block with a puddle of water between beaker and board. Wait a few minutes and pick up beaker. The board is frozen to the beaker. This demonstration is a good way to introduce endothermic and exothermic reactions. It also shows that heats of reaction are not necessarily in the presence of a solution. Heat + \(\text{Ba(OH)}_2*8\text{H}_2\text{O} (s) + 2\text{NH}_4\text{SCN} (s) = \text{Ba(SCN)}_2 (s) + 2\text{NH}_3 (g) + 10\text{H}_2\text{O} (l)\).

**Exothermic**

Note and record temperature of 100 ml of water in a beaker. Quickly add 10-15 g calcium chloride. Note the increase in temperature. The temperature should increase about 12°C. The exothermic heat of solution for calcium chloride is 117 calories per 100 ml of water. \(\text{CaCl}_2 (s) + \text{H}_2\text{O} (l) = \text{Ca}^{2+}(\text{aq}) + \text{heat}\). For more accurate recording of temperature change, use styrofoam cups. Destroy cups following demonstration.

**Distilling Water**
Mix 1/4 cup of water with 1 tsp sucrose. Make a second solution by mixing 1/4 cup of water with 1 tsp of sodium chloride. Mix the third solution with 1/4 cup warm water with 1 tsp of copper sulfate crystals. Note the appearance of all three solutions and then pour them together into a pyrex flask. Again note the appearance. Set up a simple distillation with the collection flask in an ice bath. Notice the appearance of the collected liquid. This is the distilled water. All the added impurities were left behind in the original flask because they evaporate at higher temperatures than does water.

**Supersaturation and Crystallization**

Place 50 g of sodium acetate trihydrate in a small flask. Add 5 ml of water and slowly warm the flask. Swirl while heating to dissolve all of the solid. Wash down any solid on neck or sides of flask with a small amount of water. Remove flask from heat, wrap it in aluminum foil, and cool to room temperature.

To perform demonstration, place a few crystals of sodium acetate on clean area of work bench. Slowly drip the sodium acetate solution on top of the crystals. Crystallization begins from the original crystals and tall columns of crystals form.

An alternate method would be to heat sodium acetate trihydrate in a flask on a hot plate until it completely
liquefies, melted not boiled. Rinse the neck of the flask for any extra crystals. Turn off heat, stopper the flask, and cool to room temperature. When it has cooled, carefully remove stopper and add one sodium acetate trihydrate crystal to generate crystal formation.

Both of these methods allow for multiple repetitions of demonstrations by just melting down the solid crystals again. The first method allows the variety of controlling the amount and relative shape of the structure by added the supersaturated solution to the crystal. It is also more difficult as bumping the flask can cause crystallization within the flask.

**Difference Between Mixtures and Compounds**

Prepare a mixture of 9.6 g of sulfur and 16.5 g of iron filings. To half of this mixture, add 5 ml of carbon disulfide. Shake and filter off the carbon disulfide. Transfer solid to evaporating dish. Allow for evaporating time. Show that no change has taken place in the sulfur. Use a magnet to show that the iron can be removed from the mixture.

Take the remaining sulfur and iron mixture and place in pyrex test tube and heat until beginning of reaction. Withdraw from the flame. The reaction continues without additional heat. Remove the iron sulfide and test with a magnet. It has lost a property from the original mixture. Try to dissolve the FeS in carbon disulfide to support that a new substance with new chemical properties has been formed.

**Equilibrium and LeChatelier’s Principle**

For better visibility of the reaction, place the demonstration in a Petri dish on an overhead projector and reflect onto a screen, or it can be performed in a standard beaker. Cover the bottom of the Petri dish with KSCN solution (0.19 G KSCN per liter). Note the ions in the solution are K⁺ and SCN⁻. Add 2-3 drops of Fe(NO₃)₃ solution (8 g Fe(NO₃)₃·9H₂O per 100 ml water). Note the addition of ions Fe³⁺ and NO₃⁻. The color change indicates the formation of a new species. Fe³⁺(aq) + SCN⁻(aq) ⇌ reversible FeSCN²⁺(aq).

Add a small crystal of KSCN. This will cause formation of a darker color from FeSCN²⁺(aq). This represents a shift in the equilibrium to the right. Add a drop of Fe(NO₃)₃ solution. This intensifies the color change signifying an additional shift to the right. A shift to the left can by facilitated by removing some of the Fe³⁺ by reacting it with some Na₂HPO₄ to produce a colorless complex.

An alternate to this reaction would be CoCl₂ + H₂O ⇌ Co(H₂O)₆²⁺ which equilibrium is heat dependent. Place 10 ml of 95% ethyl alcohol in a glass Petri dish. When it becomes room temperature, add a pinch of cobalt(II)chloride. Stir until it dissolves. The solution should be pink. If it is not pink dilute with a little distilled water until it becomes pink.
Place dish on hot plate and warm until the solution turns blue. Remove from hot plate. As the solution cools it becomes pink again.

Cobalt(II) chloride is in the form of a hydrate. When the solution is heated, the blue anhydrous form is produced. As the solution is cooled, water in the solution recombines with the cobalt(II) chloride. The pink hydrate is again formed. \[ \text{Co(H}_2\text{O)}_6^{2+} + 4\text{Cl}^- \rightleftharpoons \text{CoCl}_4^{2-} + 6\text{H}_2\text{O(l)} \].

Reaction Time using Starch-Iodine Clock Reaction

Add 0.2 g of soluble starch to 100 ml of boiling water. Heat and stir, but do not boil for 3-4 minutes. Dilute to 800 ml. Add 30 ml of concentrated acetic acid, CH\(_3\)COOH; 4.1 g of sodium acetate, NaO\(_2\)CCH\(_3\); 50.0 g potassium iodide, KI; 4.7 g sodium thiosulfate, Na\(_2\)S\(_2\)O\(_3\). After solution cools, dilute to 1.0 liters.

Add 100 ml of this solution to a beaker. Pour 100 ml of 3% hydrogen peroxide solution into another beaker. Mix the two solutions by pouring them back and forth twice. Note the time required for the sudden appearance of a deep blue color. Repeat, using solutions warmed to different temperatures and again with solutions cooled. Notice the warm solution the shorter the reaction time and the cooler the solution the longer the reaction time. Repeat with dilute solutions of hydrogen peroxide. This increases the reaction time. This demonstration is useful for discussions on reaction rates and what factors affect them.

Indicators and pH

Place 10 glass cylinders in pairs. Fill all 3/4 full of water. To each pair add one of the following indicators: thymolphthalein, phenolphthalein, phenol red, bromthynol blue, and methyl red. To a thymolphthalein cylinder add enough NH\(_3\) to produce the deep blue indicator color. Add the same amount to the nine other cylinders. Drop lumps of dry ice into one cylinder of each pair, leaving the remaining cylinders as comparisons. As the CO\(_2\) dissolves, the pH changes and the indicators change colors. The pH in the methyl red cylinders does not drop enough for a complete color change, but HCl added dropwise will complete the change.

Buffers

Prepare a pH buffer solution by dissolving 7.0 g of potassium acid phosphate, K\(_2\)H\(_2\)PO\(_4\) in 295 ml of 0.1M KOH and diluting to 1 L. Place 100 ml of the buffered solution in a beaker. Place 100 ml of distilled water into another beaker. Add 5-8 drops of phenolphthalein indicator to each beaker. Add 0.1M sodium hydroxide solution, drop wise to each beaker. Record the number of drops required to obtain a permanent pink color for each beaker. Obtain fresh 100 ml proportions of water and buffer solution and add the same number of drops of methyl orange indicator solution to each beaker. Add 0.1M
hydrochloric acid dropwise until a red color is seen. Compare number of drops of base and acid needed to change pH of the water and the buffer solution. From the results attempt to have students define buffer action.

A buffer solution resists change in pH when either a base or an acid is added. A buffer solution consists of a weak acid and the anion that is its conjugate base. Essentially, buffers contain a base to react with added acid and an acid to react with added base. The phosphate buffer can react with acids or bases like this: $\text{HPO}_4^{2-}(aq) + \text{H}^+(aq) = \text{H}_2\text{PO}_4^-(aq)$ and $\text{H}_2\text{PO}_4^-(aq) + \text{OH}^-(aq) = \text{HPO}_4^{2-}(aq) + \text{H}_2\text{O}(l)$. This demonstration could use a variety of buffered solutions (such as acetate-acetic acid) and different indicators (brom cresol green to get blue or brom cresol blue to get yellow).

**neutralizing-acid/base reactions**

This is designed to demonstrate how antacids work. Place 150 ml of water in a beaker and add 10 drops of brom cresol green-methyl red indicator (prepared by dissolving 0.1 g brom cresol green and 0.07 g methyl red in 100 ml of ethanol). Add 2-5 ml of household white vinegar (7% acetic acid). The solution turns pink, indicating an acidic condition. Now add one alkalizing tablet to container. Observe the color change. The reaction alters the pH of the solution from acidic to neutral or slightly basic as indicated by the blue color formed from the indicator.

**alkalizing tablets as buffers**

The sodium citrate produced by the reaction of an alkalizing tablet with water is a powerful buffer. Prepare the sodium cerate solution by adding one alkalizing tablet to 150 ml of water in a 250 ml flask. Seal the container, shake vigorously, venting frequently, to disperse the carbon dioxide as much as possible. Add 10 drops of brom cresol green-methyl red indicator. Using 25 ml portions of this citrate solution, titrate dropwise with weak (0.2N) sulfuric acid or hydrochloric acid solution to the pink endpoint. Count and record the number of drops necessary to turn acidic. Add 10 drops of the indicator to 150 ml of distilled water. Using 25 ml portions of the water solution, repeat the same drop titration method used on the citrate solution. Distilled water has virtually no buffering capacity.

**buffering effect on distilled water**

Using a pH meter, measure and record the pH of 150 ml of distilled water. Crush an alkalizing tablet to a fine powder. Add a tiny pinch of powder to the water. Stir until the powder has dissolved. Measure and record the new pH. Add increasingly larger amounts of powdered tablet until it is used up, dissolving, taking, and recording the pH with each addition. Only a small amount of tablet was needed to initially change the pH of the distilled water. Once the
solution had been buffered with the citrate, additional amounts do not substantially change the pH. This is a property of buffered systems.

**Salts and Neutralization Reactions**

Prepare exactly 0.1 normal solutions of sodium hydroxide and hydrochloric acid. Mix precisely 20 ml of each of these solutions. Test pH both before and after mixing. Upon reaction completion, feel the bottom of the flask to demonstrate heat of neutralization. Evaporate solution to dryness. Collect the NaCl crystals.

**Decomposing Water by Electrolysis**

**Materials:**
- Copper wire—2 pieces 12" long and 2 pieces 4" long; 2 dry cells; sodium chloride; 2 strips of aluminum foil—1/2" x 3"; 2 test tubes; and wide mouthed beaker.

**Set up:**
Attach one strip of aluminum foil to one end of 12" copper wire. Connect the free end of wire to the central terminal of one dry cell. To the outside terminal of that cell attach one end of a 4" wire. Attach the other end to the central terminal of the second cell. To the outside terminal of this second cell, connect one end of the second 12" wire. To the other end of this wire connect the second strip of aluminum foil.

Fill the beaker with water. So that it will conduct electricity, add a teaspoon of sodium chloride. Place the aluminum strips in beaker inverted upward. Cover each strip with a test tube that is half filled with water. Allow the cell to react for approximately an hour.

**Results:**
Gas bubbles begin to collect on the foil strips. This gas is collected at the tops of each test tube and pushes the water out. The amount of gas present in one test tube is twice the amount of the gas present in the other. Chemical tests can be performed on the gases to determine their identity. Here, light a wood splint and then extinguish the flame. While the tip is still glowing and while still holding the test tube in an inverted position, place splint inside the test tube.

In the test tube containing the smaller amount of gas, the splint will burst into a bright white flame. This combustion demonstrates the gas's identity to be oxygen. The tube containing the larger amount of gas produced a high-pitched "pop" sound that can identify the compound as hydrogen. The relative volumes of hydrogen and oxygen can be represented by the formula for water: \( \text{H}_2\text{O} \).

The set up for this experiment can be reassembled in a solution of just water (without sodium chloride) to show that the salt is necessary for the conductance of electricity.
Disappearing Ink

This blue liquid can be squirted on almost any clothing, leaving a blue "ink" spot that will gradually fade, and eventually disappear. To make the ink, place 50 ml of 95% ethyl alcohol in a beaker. Add a few drops of thymolphthalein indicator solution. Add just enough 1M NaOH solution, dropwise, to produce a deep blue color in the solution. Put solution in small squirt bottle. Perhaps make yourself the first "victim."

The sodium hydroxide reacts with carbon dioxide in the air to form sodium carbonate, which is less basic than the sodium hydroxide. The less basic sodium carbonate causes the indicator to change from blue to colorless. The colorless pH is below pH 9.3 and the blue range is above pH 10.5. The alcohol evaporates and leaves only the colorless residue. $2\text{NaOH(aq)} + \text{CO}_2(\text{g}) = \text{Na}_2\text{CO}_3(\text{aq}) + \text{H}_2\text{O(1)}$. The produced compound is actually washing soda.

Chemistry Signs

Using 5% potassium ferrocyanide solution (5 g $K_4\text{Fe(CN)}_6$ in 95 g $H_2O$) to make blue letters or 5% potassium thiocyanate (KSCN) solution for red letters paint solution onto chromatography paper or filter paper that has been wet and dried. Allow solutions to dry on the signs. Spray with solution of 1 g $\text{FeCl}_3$ in 100 ml of 0.1M $\text{HCl}$ to bring out the colors. If the signs have been made in advance, keep them in a dry place. For a variation, after writing the first message, paint a second message with 1% phenolphthalein solution over one of the other messages. Spray the paper with 1% NaOH. The second message will appear red. If you then spray with $\text{FeCl}_3$, the red color of the phenolphthalein work will disappear and the first/bottom message will appear.

Static Electricity

Most static electricity experiments are best performed in the winter when there is less humidity. Touch the end of a fluorescent tube or small neon bulb to a charged balloon in a dark room. The balloon is charged by rubbing with a piece of nylon, wool, or fur. When the balloon comes in contact with the bulb, sparks carrying electric current will light the bulb.

Matter and Electricity

Charge an electroscope by rubbing a rubber rod with fur. Bring the rod near the electroscope. Watch the electroscope. Suspend and ebonite rod from a ring stand so that it can swing freely. Charge another ebonite rod with the fur and ring it towards the suspended one. The rod will swing away from its like charged component. Repeat, this time using a glass rod and silk. This time they attract.
Understanding Half-Life

This is a non-chemical lab, but may have the tendency to become noisy. It can be modified to a quieter, group participation, mini-lab. The purpose is to help students understand the concept of half-life by demonstrating similar situations. Students will place 200 pennies in a box with a lid. Shake the box for 5 seconds and remove the lid. Find, remove, and count all pennies that are head sides up. Replace the lid and shake for another 5 seconds. Again, find, remove, and count all pennies that are heads up. Repeat until there are none or only 1 penny remaining. Record the total time in seconds and number remaining for each trial. By plotting the remaining pennies versus time spent (or number of shakes) it can be determined that one shake is the half-life for the pennies in this exercise. This experiment provides a visual graph representation which can be applied to real world, yet it was created in minutes, not lifetimes.
Additional Demonstrations

Weisbruch:

Boiling Point Changes with Pressure

Fill a 1 liter round bottom flask approximately 1/3 full with water. Fit a two hole stopper to the top containing a thermometer and a glass tube bent at a right angle. Connect the glass tube to a water vacuum with rubber tubing. Turn on the water suction and then heat water until boiling. Note the temperature at which the water boils. Disconnect the flask from the suction and heat again, this time the water boils at a higher temperature, close to the 100°C at which standard pressure water boils.

Spontaneous Combustion

1. Combustion of wood in KClo₃. Place enough KClo₃ in a large test tube to cover the bottom of the tube to a depth of about one inch. Gently heat until the salt has melted. Standing back, drop a wood splint into the melted salt. The splint will ignite.
2. Oxidation of Bleaching Powder. Place a teaspoon of bleaching powder on ceramic plate or tile. Put a small crater in center of pile. Place a few drops of glycerine in the depression. A vigorous reaction will follow and the glycerine will ignite.

Acids and Bases

1. Indicators—Using both red and blue litmus paper, test for acid or base of small portions of hydrochloric acid, acetic acid, sodium hydroxide, and ammonium hydroxide. Place 10 ml of each acid and base in small separate test tubes and add a drop of phenolphthalein to each. Note the color in acids and in bases. Repeat the indicator test for methyl orange and again note color for acids and bases.
2. Test for alkali—common bases. Use small shavings from a bar of soap or laundry detergent and dissolve in 50% alcohol solution. Add a drop of phenolphthalein solution to determine if alkali is present. Test can be repeated for ammonia, toothpowder, borax, sodium carbonate, and vinegar.
3. Chemical Properties. In each of three test tubes, place a small amount of mossy zinc. To one add a dilute solution of HCl, the second a solution of acetic acid and the third a solution of NaOH. Notice that both the acids and bases have hydrogen which can be released in a gaseous form when reacting with the metal. It may become necessary to assist reactions with heat. Tin or magnesium may also be used in this experiment.

Dutton:

Chemical Pop Gun

Tightly wrap cloth tape around a large test tube (to keep it from breaking. Add 10-15 ml of vinegar to the tube. Wrap
7-8 g sodium carbonate in a small piece of tissue (to delay reaction). Place tissue in test tube and quickly cork the test tube. Make sure to hold at arms length, pointed away from students.

The acetic acid and the carbonate react to form carbon dioxide gas. The production of gas in a confined space builds pressure until it exerts enough to pop the cork from the tube.

\[
\text{Na}_2\text{CO}_3(s) + 2\text{CH}_3\text{COOH}(aq) = 2\text{NaCH}_3\text{COO}(aq) + \text{H}_2\text{CO}_3(aq) \\
\text{H}_2\text{CO}_3(aq) = \text{H}_2\text{O}(l) + \text{CO}_2(g)
\]

This demonstration can be used primarily to show the relation between gas pressure and volume. It also is an example of action of an acid on a base, the production of gas from a chemical reaction, and a double decomposition reaction.

"Lemonade Reaction"

This is a multiple step reaction which produces various chemical reactions until the final step produces a yellow solution. Five small beakers are prepared with their own chemical substance. Dissolve 30 g of ferric chloride (FeCl\(_3\)·6H\(_2\)O) in 100 ml of water. Place 15 drops of this solution in beaker 1. Dissolve 22 g ammonium thiocyanate (NH\(_4\)SCN) in 100 ml of water. Two drops of this solution go into beaker 2. Place 10 drops of this into beaker 3. Prepare a saturated solution of tannic acid (C\(_8\)H\(_{52}\)O\(_{16}\)). Add 12 drops to beaker 4. Prepare a saturated solution of oxalic acid and add 10 ml to beaker 5.

Fill a larger beaker with water. Pour some water into beaker 1. The solution turns a pale yellow. It is not dark enough so pour beaker 1 back into large beaker. Pour from the large beaker into beaker 2. This produces an orange color so pour it back. Pour from the large beaker into number 3. Remember this is the same solution as beaker 2. This time the solution is red. Pour solution back into large beaker. Pour from large beaker into beaker 4. A black color is produced. Pour back the solution. Pour into beaker 5. This looks like "lemonade." Pour beaker 5 back into large beaker. The dark solution of the large beaker also turns yellow.

Dilute FeCl\(_3\)·6H\(_2\)O is light yellow. Fe\(^{3+}\)(aq) + SCN\(^-\)(aq) = Fe(SCN)\(^{2+}\) (red). Fe\(^{3+}\)(aq) + tannic acid = Fe(III)tannate(aq) (black). 2Fe\(^{3+}\)(aq) + 3C\(_2\)O\(_4\)\(^2-\)(aq) = Fe\(_2\)(C\(_2\)O\(_4\))\(_3\)(aq) (yellow). In the final step, excess oxalate reacts with all of the Fe\(^{3+}\) in the beaker to form yellow iron(III) oxalate.

Patriotic Colors

This is an alternate method to achieve similar results. Prepare 1M ammonium hydroxide solution. Add the following to their corresponding beakers: 1) 5 drops of phenolphthalein, 2) 5-10 drops of saturated lead nitrate solution (30 g Pb(NO\(_3\))\(_2\) in 100 ml water, and 3) 5-10 drops of saturated copper sulfate solution (15 g CuSO\(_4\) in 100 ml water). Add ammonium hydroxide solution from flask to produce red, white, and blue. Use care
when disposing of lead nitrate solution.

This is an explanation of the reactions in order of there beaker numbers. Ammonium hydroxide reacted with the indicator in beaker 1 to give a red color. In beaker 2 a double displacement (metathesis) reaction occurs and lead hydroxide (white) precipitates. \( \text{Pb(NO}_3\text{)}_2(\text{aq}) + 2\text{NH}_4\text{OH}(\text{aq}) = \text{Pb(OH)}_2(\text{s}) + 2\text{NH}_4\text{NO}_3(\text{aq}) \). A blue complex ion forms in beaker 3 with copper and ammonium ion. \( \text{Cu}^{2+}(\text{aq}) + 4\text{NH}_4\text{OH}(\text{aq}) = [\text{Cu(NH}_3\text{)}_4]\text{(OH)}_2(\text{aq}) \).

**Traffic Light Reaction**

Mix 3 g dextrose (glucose) and 5 g NaOH in 250 ml of water. Place 50 ml of this solution in a 250 ml flask. Add 5-10 ml of indigo carmine indicator solution (1.0%). This will make the solution in the flask a pale yellow. Stopper the flask and gently swirl and the solution turns red. Give the flask a quick shake and the solution turns green.

The indicator is reduced by alkaline dextrose, producing the yellow color. When the solution was swirled, the indicator was oxidized and produced a red color. Shaking the flask oxidizes the solution even more yielding a green color. After sitting for a period of time, the indicator is reduced again and the original yellow color appears.

**Blue Bottle Reaction**

This reaction is similar to the traffic light reaction. In a flask add 8 g of KOH to 30 ml of water. Cool the solution and add 10 g of glucose (dextrose). Add a few drops of methylene blue indicator solution (or a small amount of solid indicator—no larger than the head of a match). Stopper the flask. Shake the flask and the solution turns blue. After settling for a few seconds, the solution turns clear again. The process can be repeated 10-15 times with the same solution although venting the flask periodically may be necessary.

Students should understand that gas + liquid = blue color and that blue color + x = colorless. The actual process is the reduction of methylene blue by an alkaline dextrose solution. Shaking causes the solution to be reoxidized. This is a four step process. \( \text{O}_2(\text{g}) + \text{O}_2(\text{dissolved}) ; \text{methylene blue (colorless)} + \text{dissolved O}_2 = \text{methylene blue (blue)} ; \text{glucose + OH}^- = \text{glucoside} ; \text{glucoside + methylene blue (blue) = methylene blue (colorless) + OH}^- \).

**Beating Heart**

A small portion of mercury is placed on a watch glass and covered with solution. When an iron wire touches it, the mercury pulsates in rhythm, like a beating heart. Perform procedure in a fume hood. Carefully rinse and store mercury after experiment.

Put clean reagent-grade mercury in center of watch glass which has been place in Petri dish to catch any accidental
spills so that it is no more than 3/4" in diameter. Just cover this mercury pool with dilute (less than 1M) sulfuric acid. Secure a wire of iron wire to watch glass with piece of putty so that it barely touches the mercury. Carefully drop hydrogen peroxide (6%, drugstore dilutions) on top of the mercury. The mercury will start to pulsate in different patterns: a small to large sphere, an equilateral triangle, or a four-lobed shape. Beats can be adjusted for maximum effect by adding drops of hydrogen peroxide and adjusting the wire.

**Brass Pennies**

Copper pennies can undergo chemical reactions which will change its surface material and color. In this reaction copper pennies will appear silver and, through a second step, establish a gold color. This is not actual gold, of course, but a brass alloy.

Place 5 g zinc dust in an evaporating dish. Cover the zinc and fill dish 1/3 full with 6M NaOH. Heat on hot plate until solution is near boiling. Place a cleaned penny (pre-1980) in the mixture using tongs. In 3-4 minutes when silver coating is complete, remove penny. Carefully rinse penny to remove zinc particles. Blot (do not rub) penny dry. Using tongs, place penny on hot plate and watch in turn gold. Remove, rinse, and dry. To dispose of the zinc-NaOH solution rinse with water and add solid to 200 ml of 1M sulfuric acid before flushing down the drain.

The penny turned silver color from the plating of copper with zinc when the zinc reacted with the sodium hydroxide to form sodium zincate, \([\text{Zn(OH)}_3\text{(H}_2\text{O)}]^{\text{Na}^+}\). The second reaction forms a brass alloy (60-82% Cu and 18-40% Zn). This is what gives the penny its gold color. Heat is the cause of fusion between zinc and copper.

**Chemical Sunset**

Cover the top of an overhead projector with a piece of cardboard which has a hole the size of Petri dish in the center. Place Petri dish in this hole. Make 0.03M sodium thiosulfate pentahydrate solution, \(\text{Na}_2\text{S}_2\text{O}_3\cdot5\text{H}_2\text{O}\) (5 g per liter of water). Add enough of this solution to cover bottom of dish. Add 5 ml concentrated HCl and stir solution.

In 25-30 seconds the formation of colloidal sulfur will appear scattering light to produce the different colors. HCl reacts with the sodium thiosulfate to produce thiosulfuric acid. The thiosulfuric acid decomposes immediately to produce sulfurous acid and sulfur in a colloidal suspension. \(2\text{H}^+(\text{aq}) + \text{S}_2\text{O}_3^{2-}(\text{aq}) = \text{H}_2\text{S}_2\text{O}_3 = \text{H}_2\text{SO}_3 + \text{colloidal sulfur}\). As the amount of colloidal sulfur increases, more light is blocked and the various colors are produced. This experiment can also be performed in a glass beaker using a beam of light from a slide projector.
**Slime and Hydrogen Bonding**

Prepare the necessary solutions. Polyvinyl alcohol is a 4% solution. Add 4 g to 100 ml of hot water. Heat to 70°C until the solution clears. Be careful not to boil. Sodium borate (sodium tetraborate) is a 4% solution also. Add 4 g of sodium borate, Na₂B₄O₇*10H₂O to 100 ml of water.

Measure 50 ml of polyvinyl alcohol solution into small beaker and observe its qualities. Measure 7-8 ml of sodium tetraborate solution into another beaker. Observe its qualities. Add 1 drop of food coloring to sodium tetraborate solution to make visibility of final product easier. Pour the sodium tetra borate into the poly(vinyl alcohol) solution while stirring vigorously with a wooden stick. Examine the properties of the cross-linked polymer.

This polymer is non toxic. Allow students to handle it. How far will it flow from your hand. The non-newtonian fluid can be shaped, will flow, but will shear if twisted. The flowing is endothermic. If pressed onto a design written with magic markers, the slime will pick up the image.

Vinyl alcohol does not exist. Polyvinyl alcohol is made by first forming polyvinyl acetate from vinyl acetate. This is followed by hydrolysis to form the alcohol. The borate forms a complex structure called tetraborate, B₄O₇(OH)₄²⁻, that links the polyvinyl alcohol polymer strands together by hydrogen bonds. The cross-linking can be compared with the hydrogen bonding that links proteins into specific structures.

**Hydrogen Bonding in Liquids**

In separate 300 ml beakers, place 100 ml of each of the following liquids: glycerin, 18M H₂SO₄, glycol, water, ethanol, ether, and benzene. Swirl each beaker equally and note the time it takes for the vortex to disappear. This difference in viscosities is based primarily on the intensity of hydrogen bonding. This idea can be further supported by mixing equal molal solutions of CHCl₃ and (C₂H₅)₂O. This solution is more viscous than either of the pure substances because of the hydrogen bond formation.

**Patriotic Color Reactions**

Prepare the following solutions: FeCl₃ solution, 16 g FeCl₃ per liter of distilled water; K₃Fe(CN)₆ solution, .36 g K₃Fe(CN)₆ per liter of distilled water, AgNO₃ solution, 1.7 g AgNO₃ per liter of distilled water, and NH₄CNS solution, .15 g NH₄CNS per liter of distilled water. Place 250 ml of each of the last three solutions in separate 600 ml beakers. then add 5-10 ml of ferric chloride solution to each beaker.

**Colored Clock Reaction**

Prepare three solutions: A is made with 20 g sodium metabisulfite, 3 g sodium sulfite anhydrous, and water to make 1 liter. B is 90 ml formalin solution (37%) diluted to 1 liter. C is phenolphthalein indicator (made by 10 g
phenol thalein in 500 ml 95% ethyl alcohol and enough water for 1 liter solution).

Place 150 ml of distilled water in a 400 ml beaker and add 50 ml of solution A and 1 ml indicator. Start a stop watch and stir thoroughly upon the addition of 50 ml solution B. Time the appearance of the color. Repeat reaction again using 200 ml of water and on 25 ml of solutions A and B. Compare reaction time.

The reactions for this demo are 1) HCHO + HSO₃⁻ → CH₂OSO₃⁻ 2) H₂O + HCHO + SO₃²⁻ → CH₂OSO₃⁻ + OH⁻ and 3) OH⁻ + HSO₃²⁻ + H₂O. Reactions 1 and 2 are rate determining steps. Try reaction with different indicators for different color changes. Using a universal indicator will result in a series of colors. Reaction time is shortened by a change in temperature. A 10°C raise will double the reaction rate.

**Kinetic Molecular Theory and the Movement of Molecules and Ions**

Assemble 3 beakers in a row each containing the same amount of water, but at different temperatures (cold, room temperature, and near boiling). Carefully add one drop of ink or dye to the center of each water surface. Observe how long it takes for the color to diffuse completely in each beaker. Other liquids can also be used to compare solutions.

**Density, Buoyancy, Non-Miscibility**

Add a small portion of mercury (optional) with portions of dichloethy ether, water, and light oil to a tall hydrometer jar which can be tightly sealed. Drop in cork, oak wood, ebony, a coin, and a piece of gold or platinum. Tightly close the container. Contents can be thoroughly mixed and will return to their correct positions upon standing. This sealed container may be kept indefinitely.

**Spontaneous Combustion--Acetylene**

Perform this demonstration in fume hood. Generate chlorine gas by placing a few milliliters of 5% sodium hypochlorite solution (or household chlorine bleach) in a large beaker and adding a little 6.0M HCl. Cover the beaker with a watch glass. After a few seconds to insure chlorine gas has been produced, add a few lumps of calcium carbide to beaker without displacing watch glass too far or for too long. The calcium carbide reacts to release acetylene which combines spontaneously with the chlorine gas to produce visible light and heat.

**Indicator Action**

Place 300 ml of 95% ethanol in an Erlenmeyer flask. Add several drops of Alkali Blue indicator to turn solution bright red. If the solution is not red, add drops of very dilute base until red just appears. Have a student blow across the flask. Swirl the flask and note color change. This
demonstrates that indicators can be relatively sensitive and that human breath contains enough carbon dioxide to affect the pH (by adding acid) of the solution.

Tyndall's Effect--Artificial Sunset

Fill a glass tank with water. Arrange demonstration so that the tank is one foot from the screen (or any smooth whit surface) and the projector is one foot from the tank. Turn on project and focus so that the light will pass through the water, forming a sharp focused spot on the screen.

Add a few drops of milk. Just enough so that one can see the beam of light visible throughout the length of the tank. Observe the projected spot on the screen and add more milk gradually. Note the color changes. View the beam through a piece of Polaroid from an angle perpendicular to the path of the beam. Note that the beam is almost completely polarized. Now place the Polaroid between the projector and tank. Rotate and note that the beam will disappear in certain planes of polarized incident light. Compare colors seen in the tank’s beam and in the screen’s spot to the colors of a clear sky, cloudy sky, and a sky during a sunset.

Hughes:

Polymers--Gluep

Put 45 ml of white glue into a 250 ml beaker, add 3 drops of food coloring, and stir. In a separate beaker and 45 ml of water to 30 ml of 4% borax (Na₂B₄O₇·H₂O) and stir. Add this to the glue and again stir the mixture. The physical properties elasticity, viscosity, compressibility, etc. vary with the quantities of glue, borax, and water. For hard polymers use 15 ml of water to 30 ml of borax while 30 ml of water and 20 ml of borax will yield a more flexible mixture.

Reaction Rates

Prepare each graduated cylinder as follow: Cylinder 1 is 1 L with 150 ml of 3% H₂O₂, 10 ml dish soap, 10 drops of food coloring, and 40 ml of cool saturated KI solution; cylinder 2 is 2 L with 75 ml of 30% H₂O₂, 20 ml dish soap, 15 drops of food coloring, and 10 g of KI crystals; and cylinder 3 is a 2 L cylinder with 75 ml of 50% H₂O₂, 20 ml of dish soap, 15 drops of food coloring, and 40 ml of hot saturated KI solution.

Wait until all the cylinders are prepared and then add the correct amount of KI for each example.
Acid Rain

Increased environmental concern has lead many students to question how such environmental problems (ozone depletion, acid rain, etc.) happen. For perhaps by understanding the cause, further damage can be limit and the situation may even be remedied. In this lab, students will set up and observe a small scale aerosol trail similar to the large scale acid rain which is an increasing environmental concern.

This experiment should be performed in a fume hood in groups small enough that each individual will be able to observe the gas reactions. Add 2 drops of 6M NH₃ to the bottom of a dry 100 ml graduated cylinder. On a glass plate add half a drop of 6M HCl. Carefully invert plate to rest on top of graduated cylinder so that the drop of HCl is situated over the cylinder opening. Observe the descent of the aerosol trail over the next few minutes.

Students should observe aerosol particles forming at the surface of the hanging drop of HCl. As the stream of these particles fall, the particles interact with another forming rings that accelerate and fall through each other. The fine particles will accumulate at the bottom of the cylinder appearing as a haze. The rings are formed when the rising haze meets the falling aerosol particles.

This lab is useful in that it will provides visible, microscale learning about environmental issues. It can also clear up some faulty conceptions about acid rain. The lab demonstrated that acid deposition does not necessarily have to be part of some other form of precipitation.

AIDS Awareness Activity

Introduction:
As part of an AIDS awareness discussion, this lab will allow students the opportunity for students to understand how AIDS can spread exponentially. It can also provide further science skills as to use of indicators, graphing skills, and ability to research more information.

Supplies:
Clear plastic cups (8 ounce)--one per student
Eye dropper or plastic pipette bulb--one per teacher
Phenolphthalein--enough for a squirt (5-10 drops) per cup
Base Solution*: NaOH, KOH, or other mixed 200 ml of concentrated base per 3-4 liters of solution.

Procedures:
Before class, fill two cups half full with the base solution. These represent the infected carriers. Fill the
remaining cups with water. Pass out cups to students randomly or allow them to choose cups.

Allow students to move around the room and exchange fluids with three other individuals that they trust. To exchange fluids, the liquid of one cup is poured completely into another and then half of the fluid is transferred back. After the exchanges have taken place, give each student and HIV test using the indicator.

Ask the students to remember who their partners had been. By comparing results of other infected and non infected students, see if they can determine at which exchange they became infected. Allow students the opportunity to graph the rate of infection.

Perhaps classes can be combined and the experiment repeated to see how the spread of AIDS has the same trend even in larger populations. Another twist to add to the demonstration would be to allow students the opportunity to "just say no." How many will give into the peer pressure of the rest of the participating class.

Conclusions:
This experimentation can be fun, yet it also represents a serious topic. It is important to follow the presentation with a list of some basic information. A health coordinator may be helpful. Facts about the disease should be available and time allotted for students questions. Most importantly, students should understand that although the activity was fun and the students will most likely tease the "infected" person, having HIV or AIDS is not a joke but a serious, DEADLY condition.

An alternate way to perform lab is to use a strong base and a very weak acid (vinegar) instead of water. This will avoid accidental infection from environmental situations.

Greenhouse--Energy Absorbance of Different Gasses

Students should work in small groups. Each group will be given 3 large Zip-Loc bags, a marking pencil, and 3 thermometers. One bag should be filled with air, another with methane gas from lab, and the third with a piece of dry ice. The bags should be labeled appropriately.

The bags can be lain on white pieces of paper in sunlight outside or near a window. Thermometers should be placed underneath center of bags so that readings can be taken without moving them. These temperature readings should be taken every minute for 12 minutes. At end of experiment, release the gases outdoors.

Students should plot temperature versus time for all three gases on the same plot. Correct results should yield carbon dioxide temperature rose most slowly, showing that it absorbed the most energy from the sunlight.
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