2019

SCIENCE DEMO WORKSHOP FOR HOUSTON EDUCATORS

fluorine 9	uranium 92	nitrogen 7	tungsten 74	iodine 53	thorium 90
F	**U**	**N**	**W**	**I**	**Th**
18.998	238.03	14.007	183.84	126.90	232.04

CHEMISTRY

Rice University Chapter

www.ricefunwithchem.com
@ricefunwithchem
ricefunwithchem@gmail.com

Disclaimer

This document contains instructions on how to perform the chemistry demonstrations used by Fun with Chemistry at Rice University for K-12 student education. To ensure the safety of yourself and others when performing the demonstrations, be sure to wear appropriate personal protective equipment including safety goggles, gloves, and laboratory coats. Be sure to read the relevant safety data sheets for each chemical to understand the risks and precautions. Perform the demonstrations in rooms or fume hoods with sufficient ventilation and air flow and be mindful of proper chemical waste disposal procedures. If you choose to do these demonstrations on your own, there are potential risks for which you are solely responsible. We hope all the demonstrations go well in the classroom and feel free to contact us with any questions.

Terms from Learning Objectives

Physical Change: The form of matter is altered but the chemical composition of a substance is not changed. This process can be reversible since no chemical bonds are broken. Processes representing physical changes include changes to state of matter, size or shape, and appearance. For example, as ice melts on a hot summer day it first becomes a liquid and then a gas. The chemical composition does not change as it is always H_2O, but the state of matter varies depending on the temperature.

Chemical Change: A chemical reaction occurs to change the identity of a substance. This process is typically irreversible as the atoms are rearranged to create a new substance (i.e. chemical bonds are broken and new ones are formed). Indications that a chemical change took place are the production of light, heat, sound, or odor. For example, baking a cake takes many individual ingredients. Once combined and heated, a new substance is formed from which the individual ingredients cannot be removed.

State of Matter Change: Phase changes between solid, liquid, and gas. For example, boiling water turns a liquid into a gas.

> Sublimation: A phase transition directly from a solid to a gas without entering the liquid phase. For example, solid dry ice sublimes in air to form gaseous carbon dioxide.

Endothermic: When energy in the form of heat is absorbed by a substance from its surroundings. This creates an observable decrease in temperature. For example, dissolving table salt (NaCl) in water requires energy to separate the ions and is an endothermic process.

Exothermic: When energy in the form of heat or light is released from a chemical reaction. More energy is required to make the new chemical bonds than to break the old ones. For example, burning wood in air to create a flame emitting light and heat is an exothermic reaction.

Decomposition Reaction: A chemical reaction where one substance is broken down into two or more new substances. Chemical bonds are broken and new ones are formed. The individual elements do not change and matter is conserved, but the arrangement of the elements is different. For example, hydrogen peroxide (H_2O_2) can decompose into water (H_2O) and oxygen (O_2).

Combustion Reaction: A type of chemical reaction in which a substance (fuel source with carbon atoms) reacts with oxygen in the air to produce carbon dioxide (CO_2), water (H_2O), and heat/light. This reaction is exothermic. For example, the carbon in coal reacts with oxygen in the air when heated to produce carbon dioxide gas and more heat energy.

Catalyst: A substance that can speed up the rate at which a chemical reaction occurs. The catalyst lowers the amount of required energy so a chemical reaction can take place more easily. The catalyst itself is not changed, it is present at the beginning and end of a reaction, and can be reused. For example, enzymes in yeast act as a catalyst to speed up the decomposition of hydrogen peroxide in the elephant toothpaste experiment to make the foam rise from the container quickly.

Polymer: Large molecules made up of repeating units of small molecules. The individual units that make up polymers are called monomers. When crosslinking polymers, individual polymer chains are bound through covalent bonds. These cross-linked polymers are more rigid and exhibit different physical properties. For example, alginate polymers are cross-linked between calcium cations and become structured enough to pick up.

Ion: An atom or molecule with a net charge due to the gain or loss of electrons

Cation: A positively charged ion resulting from loss of electrons (example: Na^+)

Anion: A negatively charged ion resulting from gain of electrons (example: Cl^-)

pH scale: The measure of the acidic or basic properties of a water-soluble substance. This can also be defined as the measure of the concentration of hydrogen (H^+) ions in a solution where high concentrations indicate a low pH. The scale ranges from 1-14. Water has a pH equal to 7, which is the midpoint of the range and considered neutral.

Acid: A chemical species with a pH less than 7. Acids can donate a proton in a chemical reaction.

Base: A chemical species with a pH greater than 7. Bases forms hydroxide (OH^-) ions when dissolved in water.

Surface Tension: Surface tension is a result of the forces between molecules in a liquid. Different liquids have stronger or weaker forces between the molecules and exhibit different values for surface tension. For example, the spherical shape of water that comes out a dropper is a result of its high surface tension.

1. Dry Ice Experiments

Learning Objectives by Age Range:

- Elementary School:
    - **Balloon Inflating**: The solid dry ice sublimes to gaseous carbon dioxide (CO_2). This is an example of a physical change and state of matter change. When the balloon is put into the warm water, the higher temperature promotes the solid to gas transition (sublimation) and the balloon inflates faster.
    - **Dry Ice + Candles**: Carbon dioxide is heavier than air and settles inside the glass container to put out the flame that requires oxygen.
    - **Dry Ice Bubbles**: The gas from the carbon dioxide sublimation is trapped in the soap to form bubbles. This experiment is an example of a physical change.
    - **Freezing Flowers**: The temperature of dry ice is -78.5 °C or -109.3 °F.
- Middle/High School:
    - **Dry Ice + Candles**: The ignited candle is an example of a combustion reaction. When the candle is engulfed in carbon dioxide, the reaction stops because no oxygen gas (O_2) is present.
    - **Freezing Flowers**: An energy transfer in the form of heat occurs between the solid dry ice and the liquid ethanol. The ethanol transfers heat energy to the dry ice and loses energy itself to become cold. When flowers are placed in the cold solution, another energy transfer occurs to freeze the water molecules in the flowers making them more rigid and brittle.

	Classroom Friendly: **Balloon Inflating**
Supplies	o Party balloons o Dry ice (available at grocery stores) o Glass container with warm water (bowl or baking dish)
Procedure	1. Place a few small pieces of dry ice inside the balloon and tie it closed 2. Place the balloon in the container of warm water 3. Watch the balloon inflate!
Extra Tips	o Experiment with different water temperatures to evaluate the effect on the speed and size of balloon inflation

	Classroom Friendly: **Dry Ice + Candles**
Supplies	o Candles o Lighter o Dry ice o Glass container (pitcher, beaker)
Procedure	1. Light candles 2. Place pieces of dry ice in the glass container 3. Pour the gaseous carbon dioxide over the candles to put out the flame
Extra Tips	o Place candles at various heights inside a high-walled container such as a fish tank. Place pieces of dry ice inside a bowl of water in the fish tank. Watch the candles go out as the CO_2 fills the container from bottom to top

	Classroom Friendly: **Dry Ice Bubbles (2 Ways)**	
Supplies	○ 2 L soda bottle with hole drilled in the cap ○ Plastic tubing ○ Funnel ○ Dry ice ○ Glass dish ○ Water ○ Dish soap	○ Cylindrical plastic container ○ Dry ice ○ Water ○ Dish soap ○ Paper towels
Procedure	1. Fill the soda bottle halfway with water and add small pieces of dry ice 2. Attach one end of the plastic tubing to the funnel and place the other end inside the hole in the soda bottle cap 3. Add dish soap and water to the glass dish 4. Place the funnel into the soapy liquid for a few seconds and lift up 5. Bubbles will form out of the funnel as the CO_2 sublimes	1. Fill the cylindrical container ¾ high with water 2. Add large chunks of dry ice 3. Soak the paper towels in soapy water 4. Wet the rim of the container with a soaked paper towel 5. Stretch the paper towel across the diameter of the container and pull your hands slowly along the rim 6. Watch the bubble form!
Extra Tips	○ Place your hands in the soapy water mixture to be able to hold the bubbles	○ Add food coloring into the water for added fun

	Classroom Friendly: **Freezing Flowers**
Supplies	○ Dry ice ○ Ethanol (available on Amazon) ○ Flowers ○ Insulated container
Procedure	1. Add ethanol and pieces of dry ice into the insulated container 2. Holding the stem, place the flower into the liquid 3. Hold until the petals become brittle (30 seconds to a minute) 4. Hit the flower against a hard surface (floor or table)!
Extra Tips	○ Can use high proof (>100) commercial alcohols such as vodka ○ Freeze other items to smash (fruits, rubber ducks, racquetballs, etc.)

2. pH + dry ice indicators

Learning Objectives by Age Range:

- Elementary School:
  - The dry ice (solid CO_2) undergoes a physical change in air to become a gas in a process known as sublimation. The pH scale is used to measure if a liquid is an acid or a base. An indicator tells us when there is a change in pH by changing color. In the experiment, the solutions start off as basic and turn colors as the solution turns more acidic.
- Middle/High School:
  - The carbon dioxide from the dry ice reacts with water to create carbonic acid (H_2CO_3), which is an example of a chemical change. With the addition of a base (sodium hydroxide), the solutions begins at a high pH. The carbonic acid releases protons (H^+ ions) to neutralize the alkaline solution. With a high concentration of protons, the solution becomes acidic. The molecules in the indicator respond to changes in pH by changing color.

	Classroom Friendly

Supplies	o Glass graduated cylinder
	o Dry ice (available at grocery stores)
	o Indicators:
	    o Universal indicator solution (available on Amazon)
	    o Phenolphthalein solution (available on Amazon)
	    o Bromothymol blue solution (available on Amazon)
	    o Litmus solution (available from most chemical suppliers)
	o 1 M NaOH solution in water (solid sodium hydroxide available on Amazon and from chemical suppliers)

Procedure	1. Fill graduated cylinder halfway with water 2. Add 1 M NaOH (2 mL) 3. Add indicator of choice (2 mL) 4. Drop in small pieces of dry ice 5. Watch sublimation and color change!

Extra Tips	o Indicator color changes:
	    o Universal indicator: purple to blue to green to yellow
	    o Phenolphthalein: red to pink to clear
	    o Bromothymol blue: blue to green to yellow
	    o Litmus: blue to purple to red
	o Vary the ratio of universal indicator to NaOH to see differences in the rate of color change
	o Other aqueous alkaline solutions can be used (ex. KOH)

3. Baking Soda + Vinegar Balloons

Learning Objectives by Age Range:

- Elementary School
  - The baking soda and vinegar react to form water (H_2O) and carbon dioxide (CO_2) gas. The gas gets trapped inside the balloons to inflate them and is an example of a chemical change.
- Middle/High School:
  - Baking soda is sodium bicarbonate (a base) and vinegar is acetic acid. The acid and base react to form water at a neutral pH. When the amount of baking soda is varied, the amount of generated CO_2 changes and the balloons inflate to different sizes. This explains the concept of limiting reagents in chemical reactions.

	Classroom Friendly
Supplies	o Baking soda (available at grocery stores) o Vinegar (available at grocery stores) or 10% aqueous acetic acid solution o Party balloons o Container with a narrow opening (Erlenmeyer flask, soda bottle)
Procedure	1. Measure out different amounts of baking soda and put into each balloon. We usually use 1 gram, 5 grams, and 10 grams 2. Pour vinegar into the container. The amount varies depending on the size of the container. We use a volume that is approximately 1/3 the size of the container 3. Stretch the balloon over the opening of the container and flip upside down to pour in the baking soda 4. Watch the balloons inflate!
Extra Tips	o Hold the edges of the balloon around the container to make sure it is secure

4. Oscillating Clock

Learning Objectives by Age Range:

- Elementary School: This reaction is an example of a chemical change. As a generalized explanation, chemicals A and B can react to form a new substance called chemical C. Chemical C can then react with another chemical in the solution called chemical D to regenerate chemicals A and B. The reaction goes around in a circle like a clock.
- Middle/High School:
    - This process can be broken down into two main reactions that can alternate between different pathways. The product of one reaction is the reagent in the next reaction. The color changes between yellow or blue based on which reaction pathway is occurring. The yellow color results from a high concentration of iodine (I_2), which is consumed as the solution becomes clearer. The blue color is a result of I_2 and I^- binding to starch.

	Lab Version
Supplies	○ Potassium iodate ○ Concentrated sulfuric acid ○ Vitex starch ○ Manganese sulfate monohydrate ○ Malonic acid ○ 30% hydrogen peroxide ○ Water ○ Glass container (Erlenmeyer flask, beaker)
Procedure	1. Solution A: Dissolve 21.5 grams of potassium iodate in 500 mL of deionized water. Add 2.25 mL of concentration sulfuric acid 2. Solution B: Dissolved 2 grams of Vitex starch, 7.8 grams of malonic acid, 1.7 grams of manganese sulfate monohydrate in 500 mL of deionized water 3. Solution C: Dilute 200 mL of 30% hydrogen peroxide with 300 mL of deionized water 4. Pour solutions into the glass container in the order of A, B, then C 5. Watch the colors change back and forth between yellow and blue for 5-8 minutes!
Extra Tips	○ Stir Solution A to ensure all the potassium iodate is dissolved ○ Neutralize the iodine in the reaction with 10 grams of sodium thiosulfate for disposal down the drain. Quenching the reaction is exothermic so do this in a chemical fume hood

5. Elephant toothpaste

Learning Objectives by Age Range:

- Elementary:
    - A reaction is occurring where hydrogen peroxide (H_2O_2) decomposes into water (H_2O) and oxygen gas (O_2). The oxygen gas gets trapped inside the soap to form bubbles. This is an example of a chemical change. The reaction gives off energy in the form of heat that can be seen as steam rising from the foam.
- Middle/High School:
    - The reaction is a decomposition reaction of H_2O_2 that utilizes a catalyst (yeast or potassium iodide). In yeast, an enzyme called catalase reacts to speed up the decomposition process. This is an example of an exothermic reaction.

<table>
<tr><th></th><th>Classroom Friendly</th><th>Lab Version</th></tr>
<tr><td>Supplies</td><td>o 6-12% hydrogen peroxide (available on Amazon or at beauty supply stores as hair developer)
o Dish soap
o Nutritional yeast packet completely dissolved in warm water
o Food coloring
o Container (graduated cylinder, beaker, soda bottle)</td><td>o 30% hydrogen peroxide (laboratory grade)
o Dish soap
o Potassium iodide dissolved in water
o Food coloring
o Container (Erlenmeyer flask, beaker)</td></tr>
<tr><td>Procedure</td><td colspan="2">1. Add hydrogen peroxide (100 mL), dish soap (10 mL), and food coloring (few drops) to the container
2. Add catalyst solution
- KI (10 g) dissolved in water (5 mL)
- A yeast packet dissolved in warm water (20 mL)</td></tr>
<tr><td>Extra Tips</td><td colspan="2">o Boiling water may destroy the catalytic ability of the yeast so make sure the water is not too hot
o A saturated solution of KI in water works best (dissolve in the minimum amount of water)
o Cover surface with a tarp to make cleanup easy
o Carve out watermelon or pumpkin faces to make the foam come out of the mouths (vomiting elephant toothpaste)
o Pour stripes of food coloring down the side of the container to give a toothpaste appearance
o The experiment can be scaled up to a large size by using 100 g of KI and 250 mL of 30% hydrogen peroxide</td></tr>
</table>

6. Genie in a Bottle

Learning Objectives by Age Range:

- Elementary:
  - A reaction is occurring where hydrogen peroxide (H_2O_2) decomposes into water (H_2O) and oxygen gas (O_2). Water vapor and oxygen gas flow out of the container and can be visualized as steam. This is an example of a chemical change. Heat is released during the reaction and the container is warm.
- Middle/High School:
  - The reaction is a decomposition reaction of H_2O_2 that utilizes a catalyst (solid manganese oxide). The catalyst speeds up the decomposition to emit the oxygen gas.

	Lab Version
Supplies	○ 30% hydrogen peroxide ○ 125 mL Erlenmeyer flask ○ Manganese (II) oxide ○ Spatula
Procedure	○ Add 50 mL of 30% hydrogen peroxide to the Erlenmeyer flask ○ Add a small amount (the tip of spatula) of manganese oxide ○ Watch the steam evolve!
Extra Tips	○ Perform the reaction in well-ventilated area

7. Whoosh Bottles

Learning Objectives by Age Range:

- Elementary School: A fuel source is converted into carbon dioxide (CO_2) and water (H_2O) using heat energy. This reaction is an example of a chemical change.
- Middle/High School:
  - A combustion reaction occurs when the carbon-based fuel source (alcohol solution) is heated via a flame source and reacts with oxygen gas in the air to form water and carbon dioxide. This is an example of a chemical change and an exothermic reaction. The "whoosh" noise is from release of the carbon dioxide gas quickly out of the water jug. Methanol has one carbon atom, ethanol has 2 carbon atoms, and isopropanol has 3 carbon atoms. As the number of carbon atoms increases, the amount of energy produced from the combustion reaction increases to make the flame brighter. To create colors, a metal salts can be added to the alcohol fuel sources. Heat energy is absorbed by the metals and excites their electrons to higher energy states. As the electrons relax down to the ground state energy, a photon of light in the visible region is released at a distinct wavelength.

	Lab Version

Supplies	o Empty, dry 5-gallon water jugs
	o Fuel sources (laboratory grade):
	    o Methanol
	    o Ethanol
	    o Isopropyl alcohol
	o Metal additives:
	    o Boric acid
	    o Strontium nitrate
	o Flame torch or match

Procedure	1. Completely coat the inside of the water jug with 40 mL of any alcohol fuel source 2. Hold the handle of the jug and bring the flame source to the spout pointing the jug away from you
Extra Tips	o Dissolve 0.4 grams of a metal additive into the alcohol fuel source before the experiment. Boric acid will turn the flame green and strontium nitrate will turn the flame red. o Rinse each jug with isopropyl alcohol and let dry overnight before reuse

8. Edible Gummy worms

Learning Objectives by Age Range:

- Elementary:
    - Sodium alginate comes from brown seaweed and kelp. Sodium atoms originally bind to the alginate molecules but exchange for calcium atoms in the experiment to create a new polymer. This polymer has different physical and chemical properties that can be observed visually. The new bonds are stronger so the gel can be picked up and eaten if food grade sodium alginate and calcium chloride are used. This is an example of a chemical change.
- Middle/High School:
    - Mixing sodium alginate and calcium chloride forms cross-linked polymers. Sodium is a +1 cation that can only bind to a single -1 alginate anion and creates a viscous liquid. Calcium is a +2 cation that can bind to 2 alginate anions to create a strong polymer that is insoluble in the salt solution.

	Classroom Friendly
Supplies	o Food grade calcium chloride (available on Amazon from Modernist Pantry) o Food grade sodium alginate (available on Amazon from Modernist Pantry) o Kool Aid flavor packets (available at grocery stores or from Amazon) o Container (glass baking dish, paper cups) o Plastic squeeze bottle
Procedure	1. Dissolve calcium chloride in water to make a 2% by weight solution 2. Dissolve sodium alginate in water to make a 4% by weight solution 3. Add Kool Aid flavor to sodium alginate solution and place in squeeze bottle 4. Add calcium chloride solution to container 5. Squeeze sodium alginate solution into calcium chloride solution 6. Eat or play with gummy worms!
Extra Tips	o Heat the sodium alginate solution on a stove or hot plate to dissolve o Rinse the gummy worms in fresh water before eating to remove the salty taste

9. Bouncing Bubbles

Learning Objectives by Age Range:

- Middle/High School:
    - A typical soap bubble pops because dirt or oil on your fingers interferes with the forces between the molecules on the surface of the liquid. The glycerin or Karo syrup creates a thicker film around the outside of the bubble to increase the surface tension. Using a wool glove prevents contaminants on your hand and decreases the likelihood of popping the bubbles. Therefore, the bubbles can bounce!

	Classroom Friendly
Supplies	○ Bubble wand ○ Wool gloves ○ Water ○ Dish soap ○ Glycerin (available on Amazon or from chemical suppliers) or Karo syrup (available at grocery stores) ○ Glass dish or cup
Procedure	1. Mix together 1 cup of water, 2 tablespoons with dish soap, and 1 tablespoon of glycerin or Karo syrup 2. Use a bubble wand to blow bubbles 3. Wear the wool gloves to watch the bubbles bounce!
Extra Tips	○ Leave the bubble solution to sit overnight before use ○ Use distilled water for the bubble solution since it has less contaminants

10. Cabbage pH indicator

Learning Objectives by Age Range:

- Middle/High School:
    - A chemical called flavin in cabbage acts as an indicator to show pH changes through color changes. The pH of miscellaneous household items can be measured as the color of the juice changes in response to changes in hydrogen ion concentration.

	Classroom Friendly
Supplies	○ 2 cups of chopped red cabbage ○ Miscellaneous Household items (examples: white vinegar, lemon juice, shampoo, baking soda) ○ Large glass container ○ Boiling water ○ Strainer ○ Small glass containers (beakers, cups)
Procedure	1. Place the cabbage into the large glass container, cover with boiling water, and let sit at least 10 minutes 2. Use a strainer to remove the solid cabbage pieces 3. Pour 50 mL of liquid from the cabbage into each small glass container 4. Add various household items to each container until a color change is observed

Extra Tips	○ Use a blender to extract the cabbage indicator into the boiling water
	○ Observed colors based on pH
	    ○ pH 2 = red
	    ○ pH 4 = purple
	    ○ pH 6 = violet
	    ○ pH 8 = blue
	    ○ pH 10 = green
	    ○ pH 12 = yellow

11. Strawberry DNA

Learning Objectives by Age Range:

- Middle/High School:
    - Strawberries are octoploid, which means they contain 8 copies of their DNA in each cell. Salt is sodium chloride which has a +1 sodium cation and a -1 chloride anion. The sodium ions and the soap break chemical bonds and allow DNA to be released from inside the cells of the strawberry. The DNA is soluble in the water. Once the isopropanol is added, the DNA is no longer soluble and visibly rises to the top as string-like fibers.

	Classroom Friendly
Supplies	o Rubbing or isopropyl alcohol (available at grocery stores) o Salt o Water o Dishwashing liquid o Small bowl o Wire strainer or funnel with cheesecloth o Strawberries o Ziploc bags o Small glass container (cup, beaker)
Procedure	1. Chill the rubbing alcohol in the freezer 2. Mix salt (¼ teaspoon), water (90 mL), and dishwashing liquid (10 mL) in a small bowl to use as the extraction liquid 3. Place 1 strawberry (without the stem) into the Ziploc bag, pour in the extraction liquid, and remove all the air before sealing 4. Mash the strawberry with your hands until no large pieces remain 5. Pour the strawberry pulp into the strainer over the glass container 6. Add chilled isopropyl alcohol (5 mL) to the strawberry solution in the glass container 7. Use tweezers to remove the white top layer that is the DNA!
Extra Tips	o Use a spoon to press the strawberry pulp into the strainer to get more of the mixture through