Chemistry on a budget

Green and effective labs on a Dime
By Annette Sebuyira
Guilderland High School
November 8th 2017.
A little Bit About Me

• Annette Sebuyira
• High School Chemistry Teacher At Guilderland High School.
• I teach Advanced Placement (AP) Chemistry, Regents Chemistry
• Lead Teacher with Beyond Benign Green Chemistry Institute
• Enjoy Finding new ways to use greener, sustainable labs that I can use for both levels of Chemistry.
Non-profit organization founded in 2007 by Dr. John Warner and Dr. Amy Cannon, located north of Boston (Wilmington, MA).

**Mission:**
 Beyond Benign’s mission is to equip educators, scientists, and citizens with the tools to teach and practice green chemistry to achieve a sustainable society.

**Vision:**
 Beyond Benign envisions a world where scientists and citizens enter the workforce with the skills to design and choose greener, sustainable technologies that spur the innovation economy.

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BB Programs

K-12 Curriculum & Training
- Open-access curriculum
- Lead Teacher program
- Teacher training institutes/workshops
- On-line course

Community Engagement
- College Student Outreach Fellows
- On-site field trips
- Outreach experiences and events
- Open-access activity plans

Green Chemistry Commitment
- Green Chemistry Education webinar series
- GC resources for higher education
- Toxicology in the chemistry curriculum

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K-12: Core Philosophies

✓ Teachers teaching teachers
✓ Classroom tested teaching materials
✓ Classroom support
✓ Hands-on, inquiry-based activities
✓ Science for all in an interdisciplinary format
✓ Open Access education materials
✓ Industry partnerships
✓ Neutrality

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What Is Green Chemistry

- Green Chemistry inherently minimizes the impacts of science on the environment.
- It is a sustainable approach to chemistry.
- The relationship between Green Chemistry and the environment provides a uniquely positive, solutions-based starting point for encouraging younger students, who are greatly interested in the environment, to consider the positive contributions they can make in any scientific field.
What we Know so far

• Green Chemistry fits into the NYS curriculum
• Green Chemistry is aligned with the NGSS
• Safety in the Lab is of utmost importance
• Household products can be used as a non-hazardous alternative
• Household products are affordable.
• Hence the sub title: LABS ON A DIME
Which Household products to Use

• They must have Low Hazard
• They must be widely available
• They cannot be “Brand Specific”
• They must be inexpensive
• They must be easily disposed of (ie. down the drain or into the trash)
• They must have easily legible labels (with the active ingredients listed and quantified)
Green Stock room

Common household products
Common Household Acids and Bases
Must Haves

Vinegar
Ammonia
Hydrogen peroxide
Baking Soda
Aspirin
# Some Common Antacids

Useful for Titrations  
PpH tests  
Neutralization reactions  
Product rating

<table>
<thead>
<tr>
<th>Commercial Name</th>
<th>Acid-Neutralizing Agents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alka-Seltzer®</td>
<td>NaHCO₃</td>
</tr>
<tr>
<td>Amphojel®</td>
<td>Al(OH)₃</td>
</tr>
<tr>
<td>Di-Gel®</td>
<td>Mg(OH)₂ and CaCO₃</td>
</tr>
<tr>
<td>Milk of Magnesia</td>
<td>Mg(OH)₂</td>
</tr>
<tr>
<td>Maalox®</td>
<td>Mg(OH)₂ and Al(OH)₃</td>
</tr>
<tr>
<td>Mylanta®</td>
<td>Mg(OH)₂ and Al(OH)₃</td>
</tr>
<tr>
<td>Rolaid®</td>
<td>NaAl(OH)₂CO₃</td>
</tr>
<tr>
<td>Tums®</td>
<td>CaCO₃</td>
</tr>
</tbody>
</table>
Non Specific Brands
The Reaction of Alka Seltzer and Vinegar

- The Alka Seltzer Box indicates that there is 1916mg of sodium Bicarbonate.
- The Vinegar bottle indicates that there is 5.00% Acetic Acid in a solution of vinegar.
- A reaction between a measured amount of Vinegar and a known Mass of an Alka Seltzer tablet can be used to cover various concepts.
  1. Neutralization reactions
  2. Law of Conservation of Mass
  3. Limiting reactants
  4. Stoichiometric ratios.
  5. %NaHCO$_3$ in Alka Seltzer
Chemical or Physical Reaction

**Teacher Background Information:**
This lab replaces traditional reactions involving chemicals such as cupric chloride, 6M hydrochloric acid, potassium hydroxide, and copper sulfate. Students will understand the difference in chemical reactions vs. physical reactions using all green materials.

This lab is designed to be done very early in the year. Students will have minimal lab experience. The goal is to use observations of different types of reactions to discover common threads, ultimately leading to conclusions regarding evidence of chemical reactions. Students will ultimately learn the difference between chemical and physical changes. The goal of the lab is to dispel common misconceptions; i.e. boiling water is not a chemical reaction
Set Up
# Materials

Calcium chloride, CaCl₂  
Sodium bicarbonate, NaHCO₃  
Phenol red or universal indicator  
Scoops  
zip-lock baggies  
deionized water

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Health Hazards</th>
<th>Physical Hazards</th>
<th>Environmental Hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Chloride</td>
<td>Listed as a skin, eye, ingestion, and inhalation irritant. HMIS - 2</td>
<td>None listed</td>
<td>LC 50 100 mg/L 96 hours in fish</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Phenol Red</td>
<td>Chronic toxicity to lungs and mucus membranes. Listed as a skin, eye, ingestion, and inhalation irritant. HMIS - 2</td>
<td>May be combustible at high temperature.</td>
<td>Not available</td>
</tr>
</tbody>
</table>
Mixing Observations

I. OBSERVATIONS OF EACH SUBSTANCE –
Create a data table to for these observations.

Describe the properties of each substance you will be using during the experiment

II. MIXING OBSERVATIONS - Create a data table to for these observations.
Put on lab goggles and gloves.
Mix 2 scoops of calcium chloride and 1 scoop of sodium bicarbonate in a zip-lock bag. Shake and list your observations.
In a small beaker, mix 10 mL of water with indicator [5 drops of phenol red or 5 drops of universal indicator]. Record your observations.
Now pour the liquid mixture into the zip-lock bag containing the two solids. Squeeze out as much air as possible from the zip-lock bag and seal it. Make complete and detailed observations.
III. Did you need all four chemicals to see the changes in step 3 from above?

At your lab table, design a series of experiments to determine specifically which combinations of substances are responsible for each of the observed changes. You will need to include your procedure in the write-up.
Vitamin C Reactions

- Lemon – Le chatelier’s lab
- Vegetable oil in density columns
- Thickness of an oil drop
Vitamin C Clock Reaction: Integrated Rate Laws

• A clock reaction is demonstrated with common household items. Two clear, colorless solutions are mixed together. Upon mixing the solution remains clear for a period of time and then suddenly turns dark purple-blue.

| Solution A                  | 5ml 0.1M Ascorbic acid solution  
|                            | 5mL 2% tincture of Iodine  
|                            | 30ml DI water |
| Solution B                  | 15 L 3% H₂O₂  
|                            | 3ml 1% starch solution  
|                            | 30ml DI water |

Discussion
Tincture of Iodine contains 0.08M Iodine and 0.16M Sodium Iodide in solution of ethanol and water.
Hydrogen Peroxide slowly oxidizes the Iodide in acidic solution to Iodine. Once the iodine is formed vitamin C rapidly reduces it to regenerate Iodide ion.
Reaction

• \( \text{H}_2\text{O}_2(\text{aq}) + 2\text{I}^- (\text{aq}) + 2\text{H}^+ (\text{aq}) \rightarrow \text{I}_2(\text{aq}) + 4\text{H}_2\text{O}(\text{l}) \)  
  \hspace{1cm} \text{(1)}

• \( \text{C}_6\text{H}_8\text{O}_6(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{I}_2(\text{aq}) \rightarrow \text{C}_6\text{H}_6\text{O}_6(\text{aq}) + 2\text{H}_3\text{O}^+ (\text{aq}) + 2\text{I}^- (\text{aq}) \)  
  \hspace{1cm} \text{(2)}

• Vitamin C is also being oxidized by Hydrogen Peroxide to a Lactone which spontaneously decomposes.

• When vitamin C has been consumed \( \text{I}_2 \) accumulates, reacts with \( \text{I}^- \) to form \( \text{I}_3^- \) ion, which reacts with the starch to form the \( \text{I}_5^- \) - starch complex with the blue-black color.
Variation

• Temperature
• Heat the solution to show the effect of temperature on the rate of reaction
• Concentration
• Use lower concentrations of reactants to show effect of concentration on rate.
• Safety: aprons and goggles
• Disposal: Solutions can go down the drain with water
• Hazards: Low
Mixture Separation
Example of results
Starch Iodine Complex

Iodine + Starch $\leftrightarrow$ Starch-Iodine complex
Brown Colorless $\rightarrow$ Blue Black

Have Students determine whether the Reaction is Exothermic or Endothermic
Black Tea solution

With Ammonia  Control  With Vinegar

Tea ↔ Tea + H⁺ Complex
Factors affecting Rates of reactions

Alka Seltzer, Water, Food Coloring

Ground up Alka Seltzer

Whole Tabs

Surface Area
Electrolytes

Pure water, $\text{H}_2\text{O}(l)$

*does not conduct electricity*

Sucrose solution, $\text{C}_{12}\text{H}_{22}\text{O}_{11}(aq)$

*Nonelectrolyte*

*does not conduct electricity*

Sodium chloride solution, $\text{NaCl}(aq)$

*Electrolyte*

*conducts electricity*
Possible labs that can be done on a dime in the High school lab program

- **Sample traditional Lab list**
  - Lab Safety
  - Procedures
  - Investigating a chemical reaction
  - Rates of reactions
  - Clock Reaction
  - Le Chatelier’s Principle
  - Properties of Acids and bases
  - Saponification
  - Redox Reactions
  - Ionic reactions
  - Solubility curves

- **Greener (adjusted) Labs**
  - Green Chemistry Principals
  - Precipitation
  - Black Berry Solar cells
  - All screwed up
  - PLA recycling
  - Wood Ash Titration
  - Freezing Point Depression
  - Le Chatelier’s Principle
  - Empirical Formula
  - Solubility Curves
  - Rates of reactions
All labs can be found at
http://www.beyondbenign.org/cur-high-school/

Any Question?
Want more green chemistry?

Summer 2018 – Online courses for HS teachers (Intro to GC & Advanced GC)
Flinn & Beyond Benign kits [http://ow.ly/Qbod30f0T99](http://ow.ly/Qbod30f0T99)

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