Chemical Engineering High School Student Recruitment Program

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Tenth grade students are recruited for a five Saturday program to encourage them to enroll in chemical engineering. The Saturday program begins at 9am and ends at 3:30 pm with an initial snack and time for lunch.

The model for this program has the following format:

1. PowerPoint presentation about chemical engineering
2. Mini lecture related to the days activities
3. Hands-on Laboratory experience including data taking
4. Data analysis in the computer laboratory
5. Other related activity

Chemical engineering presentations include a general presentation and presentations on energy, the environment, bio-engineering, and materials.

Laboratory projects include
Exothermic and Endothermic Reactions
Electrochemical Reactions and Power
Polymers and slime balls
pH Acids and Bases
Water quality
Surface Tension

We used Calcium Chloride at different concentration to demonstrate an exothermic reaction and Ammonium Nitrate at different concentrations to demonstrate an endothermic reaction. Quantities were carefully measure using an accurate laboratory scale. Deionized water was used for the mixtures and the temperature of the mixture was measured. Graphs of temperature versus concentration were made in the computer laboratory using EXCEL as part of the data analysis. Appropriate safety procedures are discussed before each experiment. For the electrochemical experiment we use aluminum at the anode and a semi-permeable membrane at the cathode to allow air to interact with a catalyst. The electrolyte we used was NaOH at different aqueous concentrations. Multimeters were used to measure the voltage and the current. The data analysis included graphing a performance curve of voltage versus current.

For the polymers and slime ball experiments we used Elmers glue, water and Borax. The students had to carefully follow a procedure of measuring out the ingredients and carefully mixing them. Drying was accomplished with a paper towel. Measurements include indentation from drops of varying heights. Graphs of this data were generated for the analysis. A series of pH measurements of common household chemicals were determined using pH paper. Concentrations effects were determined by dilution with deionized water. Ammonia was used

as a base and diluted to get a range of pH's and tonic water, carbonic acid, was used as a base and diluted to get a range of pH's. The data was also graphed in the computer laboratory. For the water quality laboratory, students went to different buildings on the campus and took immediate grab sample from bathroom faucets and then let the water run for five minutes and obtained additional water samples. They returned to the laboratory and measured pH, total chlorine, iron, copper, hardness and total alkalinity. They also observed color and odor and turbidity or appearance of the samples. Two tests were run for each sample to show repeatability of the experimental measurements. Dissolved oxygen measurements were made for three different temperatures. The dissolved oxygen measurements were graphed as a function of temperature. A lively discussion occurred after looking at the results of different sample locations and comparing the initial grab sample to the five-minute sample.

One part of the surface tension experiments had pepper carefully placed on the surface of water in a small plastic glass. By adding dishwashing soap to the water the pepper sank. A second experiment involved making a small aluminum boat is driven across a surface of water by an expanding front of soap molecules. The speed of the boat was an open ended challenge for the students. The final experiment involved putting drops of water on pennies. An eyed dropper was used and by carefully placing the drops on a penny more than 200 drops could be used. An attempt was made to determine the angles the water formed on the surface of the penny.

An afternoon visit was made to a local farm that produces maple syrup. A brief discussion of the process and the effect of temperature on evaporation and the final product was given immediately before the visit. At the farm the students had a chance to collect samples and follow the distribution system from the trees. They then observed the evaporator and the measurements that tell the quality of the syrup.

In the data analysis the students use EXCEL for calculations and graphing. An example of other related activities includes the disassembly of a Zinc Carbon battery and assembly of a solar power generation experiment and a water drop. These additional projects usually have a mini-lecture associated with them. For example the Zinc Carbon battery disassembly lecture includes a discussion of anodes and the zinc case of a D cell, the carbon rod as a cathode, and electrolyte paste in between the anode and cathode as well as electron and ion flows.

Undergraduate mentors help with the laboratory experiments and other activities. They are invaluable in the laboratory for supervision and for safety. Socialization takes place while the students work on their projects and at snack time in the morning and at lunch. The undergraduate students are included in this socialization experience and act as role models for the high school students. Working with the high school teachers is important for assistance in recruiting. We also let the teachers know what projects are involved and encourage the students to show the teachers the results of their experiments.

This is a new program and has only been given once. While most of the experiments are related to chemistry, the lectures tie these to chemical engineering. Students are intensely active in the laboratory activities and the days are very busy and need to be well planned. The effectiveness of the program will be measured by enrollment in our department in two years. A student survey indicates a high interest in the program and students interest in majoring in engineering and the sciences. A general engineering recruitment program following a similar model has been run for the last three years and out of about 14 students in the first group three have enrolled in engineering and most of the others have enrolled in science programs. One is majoring in our pre med. program and one enrolled in pharmacy.

Appendix

The appendix gives some details of the activities of the project. Further details are available from Harry Knickle, knickle@egr.uri.edu

Appendix . Exothermic and Endothermic Reactions: Two cases:
Endothermic: NH_4NO_3, ammonium nitrate in water; heat is absorbed and temperature of solution decreases.
Exothermic: $CaCl_2$, calcium chloride in water; heat is given off and temperature of solution increases

In today's Lab you will measure the temperature change while varying the grams of each chemical.

Safety: Chemical safety goggles must be worn. Keep your bench top workspace neat and clean.

Procedure:

Ammonium Nitrate

1. Carefully pour 300 ml of room temperature distilled water into an empty and clean 400-mL beaker.
2. Measure the initial temperature of the water. for this trial (#1) and record on the data sheet provided.. Use a clean plastic spoon to gently stir the water. After 3 minutes measure the temperature of the water and record the temperature on the data sheet.
3. Rinse and clean the 400-mL beaker and the plastic spoon.
4. Again carefully pour 300 mL of room temperature distilled water into the clean 400-mL beaker.
5. Measure and record the starting temperature of the water for this trial (#2).
6. Use a laboratory digital scale to accurately measure 5 grams of ammonium nitrate into a small cup.
7. Carefully pour the chemical from the small cup into the water in the 400-mL beaker.
8. Use a clean plastic spoon to gently stir the mixture every 20 seconds, for a total of 3 minutes. After 3 minutes, measure the temperature of the solution and record the temperature for this trial on your data sheet.
9. Repeat Steps 3 - 8; this time, however, use 10 g or two level spoonfuls of chemical. Be sure to record the data for this amount of chemical (trial #3) in the data table.
10. Repeat Steps 3 • 8; this time, however, use 15 g or three level spoonfuls of chemical. Be sure to record the data for this amount of chemical (trial #4) in the data table.
11. Repeat Steps 3 - 8; this time, however, use 20 g or four level spoonfuls of chemical. Be sure .to record the data for this amount of chemical (trial #5) in the data table.
12. Repeat Steps 3 • 8; this time, however, use 25 g or five level spoonfuls of chemical. Be sure to record the data for this amount of chemical (trial #6) in the data table.

Now repeat the above this time using **Calcium Chloride**.

In the Computer Lab, graph your data using EXCEL.

Answer the questions:
Which chemical is exothermic? How does the temperature vary with increasing grams of the chemical?
Which chemical is endothermic? How does the temperature vary with increasing grams of the chemical?
Write a one page essay and describe today's Lab.

Appendix. Water quality
DISSOLVED OXYGEN TEST

PREPARING THE SAMPLE
We will use two plastic cups: one marked SAMPLE and the other marked TEST.
Collect the water samples as directed
Add water to the mark on sample plastic cup 1. Pour water slowly so there is no splash.
Add DO I pillow powder and DO II pillow powder (each one) to the sample plastic cup. Stir slowly with coffee stirrer until the powders dissolve totally
Let the sample stand for a while until the floc has settled halfway and the upper half layer is clear.
Stir again. Then let stand again until the upper half layer is clear.
Add DO III (one pillow) to the sample plastic cup., stir carefully to mix until the floc dissolves and a yellow color is present.

TEST
Pour the prepared sample to the mark on TEST plastic cup.
While gently swirling the sample, add PAO liquid dropwise, counting each drop, until the sample changes from yellow to colorless.
*The dropper must be held vertically.
1 drop = 1 mg / 1 DO

WATER QUALITY
VOCABULARY
DISSOLVED OXYGEN
Photosynthetic of plants adds all the oxygen to the environment that is necessary for all organisms, both aquatic and terrestrial to sustain life. The D.O. content of water depends on factors such as temperature, light, living and dead organisms, and other organic matter present. As the D.O. of fresh water bodies decreases, so do the organisms that can live in it. Low levels of D.O. ten to kill plant and fish life.
pH
The pH of water is very important. The pH scale runs from 0-14 with7 being neutral. Below 7the pH becomes acid; the closer to 1 the more acid. Above7 the pH is basic. Drinking water should always be near a pH of 7.
COLOR
The color of water may be caused by impurities such as high iron content making it brownish. Other impurities or microorganisms, such as algae, can add a greenish color to the water
ODOR
The odor of water can be caused by chemical or biological contamination. Badly polluted waters may have foul odors caused by the action of bacterial decay or "fishy" odors can be caused by some algae. Other odors may be associated with waters polluted by industrial wastes or chemicals added at the water treatment plant.
TURBIDITY
This is another method of estimating how much suspended matter is in water. It is usually measured with an instrument called a turbidimeter. Water can be checked for turbidity by its clearness or cloudiness. The degree of cloudiness may be described by visual determination.

Procedures

Collect and label water samples from various sources. Use a clean, preferably sterile or boiled container with a screw cap. Be sure samples are filled to the top so that there is no air above the sample.

1. TOTAL CHLORINE, IRON, COPPER, HARDNESS, TOTAL ALKALINITY

Carefully fill one of the empty screw cap vials with water from the sample taken. For each water sample use the test strip in the white bottles and test for each component.

2. pH TEST

Use the strip in the whit pH bottle.

pH 2-3	**Red-Orange**
pH 4	**Orange**
pH 5-6	**Orange Yellow**
pH 7	**Green-Yellow**
pH 8	**Green**
pH 9	**Green-Blue**
pH 9.5	**Blue-violet**
pH 10	**Violet**
pH 11-12	**Violet- Red**

3. COLOR AND ODOR

Observe the collected water sample and record the color. Use a colorimeter if one is available. Describe the odor, such as fishy, foul, fresh, etc.

4. TURBIDITY

Observe the appearance of the original water sample and record as clear, cloudy, particles in suspension, etc.

Appendix: Maple Syrup

The students work through the steps of the maple syrup process at a visit to a maple syrup farm.
Tapping the tree.
Collecting the sap.
Filtering the sap.
Putting the sap in the evaporator.
Measuring temperature.
Taking samples and performing grade determinations.
Eating pancakes with the syrup.
Rule of Thumb
It takes about four sugar maple trees three to six weeks during the Spring to yield the 40 gallons or more of sap needed to produce each gallon of maple syrup.

US Grade A Maple Syrup falls into three classes established by the US Government.

- Light Amber - is the lightest in color, has a mild maple flavor. Great for Ice Cream
- Medium Amber - is one grade darker in color with more maple flavor. Great for Pancakes
- Dark Amber – caramel taste and used for cooking

Appendix: Antacids
Neutralizing Ability of Stomach Antacids
Background

Do you ever eat too much and respond by popping an antacid? What does an antacid do to relieve discomfort? Cells in the stomach secrete hydrochloric acid at a concentration of about 0.155 M (pH normally between 2 and 3). The HCl secreted increases when food enters the stomach. When you eat or drink too much, your digestive system may generate too much acid and you develop a condition called “heartburn” or indigestion. Antacids are swallowed to neutralize the excess acid and return the pH to normal. You can find a number of different products in drugstores,. Information on the product labels help you decide which product to choose. Record on your data sheet the chemicals in 7 different antacids from the labels. What are the characteristics of these chemicals when taken as an antacid?

Goal

To compare the effectiveness of various antacid products in neutralizing stomach acid

Name of antacid Product 1	Chemical One	*Chemical Two*	*Label Comments*
Product 2			
Product 3			
Product 4			
Product 5			
Product 6			
Product 7			

CONCLUSIONS: *Based on your data, which antacid neutralizes acid most effectively? Which antacid would you choose to use? On what factors did you base your decision? What additional information might affect your choice of antacids?*

Appendix. Primary Batteries - Battery Disassembly
Carbon and Zinc D Cell Battery
REVERSE ENGINEERING

Requirements
D-cell battery. Use only a common carbon zinc cell. These may say "Heavy Duty."
Needle point pliers.
Multimeter to measure voltage.

Safety

The carbon zinc battery can be opened and studied without encountering toxic chemicals.

WARNING You must not use an alkaline cell that contains highly corrosive chemicals.

Be careful of sharp edges.

Measurement

FIRST: Use a multimeter to measure the voltage of the D cell.

Disassembly

Pry the D-cell battery open with the needle nose pliers,

The battery is a cylindrical metal case bent over at the ends.

Use the pliers to straighten the bends.

Push the innards out through the end you have opened.

Use the pliers to pry the bottom off the D cell battery.

The sides are folded over the bottom.

The top is the end from which the terminals stick out.

When you have folded back the bottom, push the battery stack out from the top.

Observation

The D-cell has a central carbon rod surrounded by a black paste inside a metal can.

Chemistry and Physics

Chemical reactions at both the central carbon rod and at the zinc metal lining of the steel case of the D-cell.

The net effect of these reactions is the removal of electrons from the carbon and the addition of electrons to the zinc.

To the outside world, the case of the battery thus becomes a source of electrons, negative. The central electrode becomes a sink of electrons, and therefore positive.

A source of electrons is called a Cathode.

A sink of electrons is an Anode.

In between is paste called the Electrolyte.

Vocabulary:

Case, terminals, carbon rod, electrolyte paste.

Date:

Names of Team Members:

Voltage Measurement:

Describe the components of the D cell battery.

Describe the inside of the D cell battery.

Appendix Diassembly of a Lawn Mower Engine

Internal combustion gasoline engines run on a mixture of gasoline and air. The ideal mixture is 14.7 parts of air to one part of gasoline (by weight.) Since gas weighs much more than air, we are talking about a whole lot of air and a tiny bit of gas. One part of gas that is completely vaporized into 14.7 parts of air drives the piston down making the drive shaft turn.

The students take apart a lawn mower engine and examine the combustion process, combustion chamber, valves, carburetor, cam and shaft.

Appendix: Surface Tension

Objective: Understand "Surface Tension"

Materials Needed: water, pennies, beakers, toothpicks, bowls, liquid soap, oil, dropper

Experiments
How many drops of water on a penny?
Float some toothpicks in water.
Pour a little oil on top of water – then add a few drops of soap. What happens?

VOCABULARY Water and its Hydrogen Bond
Hydrophilic: water attraction
Hydrophobic: water repulsion
Adhesion: water attracted to surface
Surfactant: Surfactant molecule attaches to both oil and water.

Appendix. A Chemical Polymer
Introduction to Polymers
White Glue Elmer's
A chemical with repeating molecules in varying lengths
Can be used for waterproofing, to make chewing gum, to make synthetic rubber
Experiment

- Ratios
- Proportions
- Mixing

Ingredients: Borax, Sodium borate, $Na_2B_4O_7$ $10H_2O$, Sodium tetraborate decahydrate. Found in Salt Lakes

- Safety: Do not take internally

If in eyes-rinse with water for 15 minutes
Materials for today: Tap Water, Elmer's all white glue, Borax
Making a Borax Solution

- Add 4 grams of Borax
- to 96 grams of water

Procedure

•1. Place 25 ml of Elmer’s glue in the plastic cup.
•2. Add 20 ml of tap water to the glue.
•3. Stir until the ingredients are thoroughly mixed.
•4. Add 5 ml of a 4% borax solution.
•5. Stir well.

What is Happening?

•A solid material will begin to collect on the stirrer.
•Remove the solid material and place it on a paper towel.
•Knead the material with your fingers.
•The material will be sticky for a minute or two.
•It will become more puttylike as the substance loses excess water.

Questions!

•Does the material stretch?
•Does it go back to its original shape after stretching?
•What happens when the material is pulled rapidly?
•What happens when it is pulled slowly?
•If you roll it into a ball, does it bounce?

Appendix. What is a Chemical Engineer?

The term "chemical engineer" reveals what makes the field different from the other branches of engineering. All engineers learn and use math, physics, and engineering science and engineering design to solve technical problems in a safe and economical way. But it is the chemical engineer that makes use of chemistry (and increasingly biological sciences) to solve problems.

"**10 Greatest Achievements of Chemical Engineering.**" (AIChE) Discussion

Splitting the atom and isolate isotopes
The Plastic Age:
The Human Reactor:
Wonder Drugs for the Masses:
Synthetic Fibers, a Sheep's Best Friend:
Liquefied Air, Yes it's Cool:
The Environment, We All Have to Live Here:
Food, "It's What's For Dinner":
Petrochemicals, "Black Gold, Texas Tea":
Running on Synthetic Rubber: