CITS INSTRUCTION BOOKLET

INTRODUCTION

DON'T READ WORD FOR WORD. THIS INTRODUCTION IS JUST AN OUTLINE. FEEL FREE TO CHOOSE YOUR OWN WORDS.

Say hello and that we are chemistry (and biology) majors at Valparaiso University. Introduce yourself individually, say what year you are, and what state you are from. Talk about chem club and explain that we are going to the fifth grade classes to do chem demos to show that chemistry and science in general is more than just what is written in a book. We want to show you the chemistry can be fun and exciting. (You had better be wearing your lab coats and goggles! Take a moment at some time to explain the importance of safety!)

Science studies the world around us. Biology looks at living things. Physics looks at topics such as energy and motion. Chemistry looks at matter; its properties and the changes in those properties when they undergo reactions to form new matter. Everything is made up of chemicals. Us, plants, clothing, the desks, pencils, paper, everything! Some chemicals are made by nature and others by people. Chemists created things such as nylon and nutrasweet. Chemists have also copied nature, creating many medicines such as penicillin and insulin. Without chemistry, we wouldn't have many of the things we have today. Chemistry also helps to keep the environment clean. Chemistry can make our lives better.

These demonstrations we have planned are to show some simple chemical principles. We hope you enjoy them and if you have questions, please raise your hand and ask.

HELPFUL HINTS and REMINDERS

BEFORE:

- -Everyone should have labcoats and goggles (or eyeglasses)!
- -Decide who will be performing which experiment(s).
- -Make sure everyone has practiced the experiment(s) they will be performing.
- -Read over the directions.
- -Make sure you have all the chemicals/equipment.
- -Remember: Plastic bag for waste, racquetball, banana or flower, liquid nitrogen, balloon, and extra paper towels.
- -When you have arrived at the school: go to the office and tell the secretary, "We are part of the Chemistry Club at Valparaiso University and we're here for the 5th grade chemistry demonstration. Where should we go?"
- -Find the lights (to turn off for the luminol expt.)
- -If the table is large enough, set up the expts in order.

DURING:

- -Encourage participation.
- -SMILE – this is supposed to be fun so HAVE FUN.
- -Pour the excess liquid nitrogen in the open dewar onto the floor IF no carpet and the kids are far enough away.

AFTER:

- -Take additional questions.
- -Thank teachers and kids for being a wonderful audience.
- -Use water from endothermic to clean up table.
- -Extra paper towels and plastic bag for trash
- -Wait to clean up hydrogen peroxide experiment until back at Neils.

AT NEILS:

- -Wash all glassware and throw away trash. This will help the next group immensely
- -THANK YOU for your help!

EXPERIMENT #1
METHANOL COMBUSTION, CANNON

Equipment/Materials

-Methanol
-Evaporating dish
-Matches
-"Cannon" – a 2 L pop bottle with 2 nails driven into opposite sides.
-Rubber stopper to fit the 2 L bottle
-Ringstand and clamp to hold the bottle
-Heavy books or other weights to hold down the ringstand
-Tesla coil

Presentation:

The experiments so far in this demonstration have shown chemical reactions, some of which produce light (luminol), changes in color (vanadium), or a gas (elephant toothpaste). Other reactions demonstrate thermodynamics, specifically the transfer of heat energy. In some instances, the reaction is endothermic. That means that the reaction absorbs heat. These next reactions are exothermic, which means they give off heat. They are combustion reactions, which are usually very exothermic.

Methyl alcohol is a liquid that burns very well. In fact, it is the fuel used in Indy 500 race cars! (Show how it burns by pouring a little into the evaporating dish and lighting it with a match.) In a combustion reaction, the fuel reacts with oxygen from the air to produce fire. Now, you can see that this methyl alcohol is giving off heat, but would this provide enough energy to drive a race car? For that, we have to make it burn much faster.

The reaction will go much faster if we mix alcohol vapor with air before we ignite it. That's what happens in the carburetor of a car. (Pour a little methanol into the bottle, put the stopper on, and shake it vigorously. Then clamp it to the ring stand.) How is the fuel in a car engine ignited? (spark plug) We'll use this device (the Tesla coil) to make a spark to light our fuel-air mixture.
Before proceeding, make sure:
1) The ring stand is secured with plenty of heavy books or weights.
2) The bottle is pointed in a safe direction – not anywhere near any people!
3) The angle of the bottle in the clamp is such that the stopper will not hit the ceiling or any lights.
Turn on the Tesla coil, touch the spark to a nail, and KA-BOOM!

Now that's the kind of energy that can drive a race car!

Note – In case they want you to do it again, you should probably decline. The bottle is now depleted in oxygen and filled with carbon dioxide, so there may not be enough oxygen left to fire again; also the heat given off tends to melt the plastic bottle, and two reactions too close together may be more than the bottle can take.

EXPERIMENT #2
OXIDATION STATE OF VANADIUM

Equipment/Materials

-1 L Florence flask (stoppered) with zinc amalgam in it (covered by water)
-Vanadium solution
-4 100 mL beakers

Presentation:

This demonstration is a colorful one. Some metals (especially transition metals – show on a periodic table if one is available) form very colorful compounds. You may be able to get the students to think of some. Possible examples are copper – blue or green compounds – or iron – orange compounds like rust. Usually different oxidation states of the metals (the ions that they form like +2 or +3) have different colors. For copper it's the +2 oxidation state that is blue or green, for iron it's the +3 oxidation state that is orange. Vanadium is an unusual metal because it has 4 different oxidation states and each one has a different color. In this demonstration we will show you the 4 oxidation states of vanadium and their colors. We will start with the +5 state and use a reducing agent to reduce it to +4, +3, and +2.

First, be sure to dump the water off of the zinc amalgam before adding the vanadium solution. Show the initial vanadium solution (+5, yellow) and pour some into a beaker. Then add vanadium solution to the Florence flask until it is about half full (or a little less). Begin shaking the flask so the students can see the color change. It will turn green very quickly, but that's not the color you're looking for. Continue until it's bright blue and stop. Pour some into a beaker and tell the students that this is the +4 oxidation state. (You might ask them what the green solution was.) Continue shaking the flask and the solution will turn green again, this time a darker green. When it's the right shade of green stop again and pour some into another beaker – this is +3. Continue shaking (the last one may require quite vigorous shaking) until it turns purple. This is +2. Pour some into the last beaker and note that it is not very stable and will go back to the green +3 state after a while. Finally, show all 4 solutions together – +5, yellow; +4, blue; +3, green; +2, purple. When finished, all the solutions can be poured back into the Florence flask and disposed of back at VU.

Note – This demo requires practice to determine at what shade of each color you need to stop and pour the solution into the beakers.

Preparation:

See "Chemical Demonstrations, Vol 1" by Summerlin and Ealy (pg. 140) for instructions to prepare the zinc amalgam and the vanadium solution. The zinc amalgam should be stored under water in a stoppered container.

EXPERIMENT #3
HYDROGEN PEROXIDE

Equipment/Materials

- -300 mL tall glass beaker
- -Plastic tub
- -100 mL graduated cylinder
- -30% H_2O_2 (make sure it's 30% and not 3%)
- -Dishwashing detergent
- -Solid KI
- -Scoopula
- -Cork rings

Presentation:

Before speaking – pour 30 mL of H_2O_2 into the beaker.

Write the reaction on the board: H_2O_2 (l) $\rightarrow$ H_2O (l) + 1/2 O_2 (g)

If you do not have a board, then just explain the reaction. This reaction shows that hydrogen peroxide breaks down into water and oxygen gas. However, this reaction is very slow. (Show the beaker of H_2O_2 and point out that it is not doing anything.) Sometimes reactions can be sped up by using a catalyst, so we're going to try adding a catalyst to see if we can make this reaction go faster. (Before you start the reaction, add a squirt of detergent into the beaker and tell the kids that this is used to make sure the reaction is working.) Place the beaker on some cork rings in a tub. Don't worry, the kids will be able to see the results even though it is in a tub. This prevents extremely obnoxious messes. Add a scoopful (1-2 grams) of KI to the beaker. Ask the kids what is in the soap bubbles. (The answer is oxygen.) If they happen to ask where the brown color came from, the answer is that it is iodine (I_2).

EXPERIMENT #4
LUMINOL

Equipment/Materials

- -2 250 mL Erlenmeyer flasks
- -400 mL beaker
- -Luminol solution
- -Dilute H_2O_2 solution (make sure it's the right H_2O_2 solution – see below)
- -Ring stand with funnel and tubing

Presentation:

Note where the lights are located in the room and have a fellow VU student be positioned there to turn them off. The next step works best if 2 students are doing the pouring, one for each solution.

Explain that this reaction gives off light. Pour equal amounts of the two solutions into separate Erlenmeyers, approximately 150 mL in each flask. Have the 400 mL beaker positioned under the tubing to catch the solutions. Turn off the lights and pour the solutions simultaneously down the funnel. (Be careful not to pour too fast and overflow the funnel.) The tubing should glow a brilliant blue color. Wait for the light to die away, and then turn the lights back on. Ask the kids if this reminds them of anything. You should be able to get them to say the reaction that occurs in fireflies and the glow sticks they use at Halloween.

Preparation:

H_2O_2 solution: Dilute 50 mL of 3% hydrogen peroxide to 1 L with distilled water.
Luminol: Dissolve 4.0 g of anhydrous Na_2CO_3 in 500 mL of distilled water. Add 0.2 g of luminol and stir to dissolve. Add 24.0 g of $NaHCO_3$, 0.4 g of $CuSO_4 \cdot 5\,H_2O$, and 0.5 g of $(NH_4)_2CO_3$ and stir until all the solid dissolves (the $(NH_4)_2CO_3$ is sometimes difficult to find in the stockroom).

EXPERIMENT #5
THE NON-BURNING DOLLAR

Equipment/Materials

- -50/50 % by volume solution of isopropanol and water
- -600ml beaker
- -Tongs
- -Matches
- -Dollar (or any denomination of choice)

Presentation:

Preface this experiment with a safety note that this should not be attempted at home!

Begin this experiment by asking their teacher for a dollar or any denomination of choice. (if he/she claims to have no money luckily a fellow chemistry demonstrator has a backup). Ask the children what they think would happen if they lit the dollar with a match. They will make suggestions along the line that it will "burn up." Ask them if they would like to see the teacher's dollar burn up (always a crowd pleaser). Place the dollar in a beaker with about 50 ml of the isopropanol/water solution until saturated, squeeze out the excess liquid (if the dollar drips solution after being set on fire the drips will also be on fire). Pick up the dollar with the tongs and have someone quickly light the dollar with a match. Hold the tongs away from your body, it may burn "cold" but you can still be burned. As the flame subsides use a quick jerk to put out the remaining flame. Look at the dollar – it was unharmed!

How did this happen? (Does your teacher use flame-proof money?) In the non-burning dollar, the liquid is an alcohol/water solution. The water in the solution absorbs enough of the heat of the alcohol fire to keep the dollar from catching fire – in effect the flame burns "cold."

EXPERIMENT #6
ENDOTHERMIC REACTION

Equipment/Materials:

- -30 g $Ba(OH)_2 \cdot 8\ H_2O$
- -10 g NH_4Cl
  (weigh these out in advance, and put them into 2 small jars with lids)
- -Stirring rod
- -Small wooden board
- -100 mL beaker
- -Squirt bottle of water

Presentation:

Explain that when chemical reactions occur, there is often a change in energy involved. Sometimes a reaction will release energy, like the combustion reactions, and sometimes it will absorb energy. This reaction is an example of one that needs to absorb energy from the outside in order for it to work. Explain the experiment that you are going to do. You will be mixing two solids together and they will be changing into a liquid. See if any of the kids can say that it takes energy to do this. You can use the example that it takes energy to change solid ice into liquid water.

Have the water ready. Add the two solid chemicals to the beaker and start stirring them together. Put a small puddle of water on the wooden board and quickly place the beaker on it before the water soaks into the board. (The temperature of the mixture drops from room temperature to about -25^{o} or -30^{o} C within 1 – 2 minutes, and the beaker should freeze to the board.) Don't stick your nose right over the reaction because ammonia fumes are given off.

Ask the kids if they notice a liquid forming. Ask them where the energy might be coming from. Some may say that it is from the stirring. Say that this is a good answer, but it takes much more energy for the reaction to occur than this. Remind them of the water under the beaker and then ask what might happen if energy is taken out of it…

By this time, hopefully the reaction will have worked and the water will have frozen. They might also notice frost forming on the beaker. Pick up the beaker, which should be stuck to the board, and hold it in front of the class. If the water didn't freeze, have someone come up and touch the beaker to see how cold it is.

Equation

$$Ba(OH)_2 \cdot 8\ H_2O\ (s) + 2\ NH_4Cl\ (s) \rightarrow BaCl_2 \cdot 2\ H_2O\ (s) + 2\ NH_3\ (aq) + 8\ H_2O\ (l)$$

EXPERIMENT #7
LIQUID NITROGEN

Equipment/Materials:

- -4 L Dewar filled with liquid nitrogen
- -Wide mouthed Dewar
- -Tongs (or insulated gloves)
- -Balloon (2, in case one breaks)
- -Racquetball
- -Banana or flower, etc.

Presentation:

Explain that liquid nitrogen is **very** cold. (It's temp is -196˚C.) The only danger with liquid nitrogen is that it is so cold that we have to take precautions when using it. The first experiment will involve the balloon. Blow up the balloon - not too much or it will not fit in the dewar. Ask what the kids think will happen when the balloon is put in the liquid nitrogen and why. When a gas becomes cold, it contracts, or gets smaller. (Hold the balloon in the liquid nitrogen with the tongs.) Ask the kids what they think will happen if the balloon became warmer. (Then hold the balloon in the air using the tongs and show that it expands.)

Next show the racquetball bouncing on the floor or table and then put it in the liquid nitrogen. You will have to hold it down with the tongs. While it is freezing (3-4 minutes), talk about elasticity. If something is elastic, it can change its shape easily. Then ask what the kids think will happen after the ball is frozen. Do they think it will bounce? Once the ball is frozen, drop/throw it at the floor (or drop on table if there is carpet.) Be sure to warn the kids not to touch the ball right away. Once the pieces have warned up, show that they bounce again.

You can do the same type of experiment with the banana or flower. You can explain that liquid nitrogen can also be used to freeze living things.

If the floor is tile and it is ok with the teacher, throw the extra nitrogen on the floor and amaze the kids. You can always do this after the last experiment is complete.

CLOSING

Ask the kids to please stay seated for a few minutes. Say we'd like to thank your teacher {the teacher's name} for allowing us to come here and visit you. You have been a wonderful audience. Remember that you can be a scientist when you get older if you put your mind to it. Anyone can be a chemist! It doesn't matter if you are a boy or a girl or if you like to play sports or you would like to play a musical instrument. Remember that science can be FUN! Do you have anymore questions?

Then you can take the time to pour the liq. nitrogen from the open dewar on the floor if you have not already done so. Then clean up and you are done!

PREPARATIONS PAGE

EXPERIMENT #1 – METHANOL COMBUSTION, CANNON

-Methanol

EXPERIMENT #2 – OXIDATION STATES OF VANADIUM

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-Banana or flower, etc.