CSEO SCIENTIST IN THE CLASSROOM PARTNERSHIP

Rates of Chemical Reactions

Last Updated: July 2022

GOAL: To understand factors which affect the rates of chemical reactions - temperature, concentration of reacting substances in solutions, surface area (particle size) of solids in reactions with gases and liquids, and catalysts.

TN STATE STANDARDS: 5.PS1.3 Design a process to measure how different variables (temperature, particle size, stirring) affect the rate of dissolving solids into liquids

5.PS1.4 Evaluate the results of an experiment to determine whether the mixing of two or more substances result in a change of properties.

This lesson was adapted from Vanderbilt Student Volunteers for Science. Additional information about the lesson may be found at https://studentorg.vanderbilt.edu/vsvs/.

Lesson Outline

I. Background

Gives overview of experiment.

II. Effect of Temperature

Students observe how fast bubbles of carbon dioxide are produced when room-temperature water and ice water are added to effervescent tablets in dry cups. The bubbles are produced faster in the room-temperature water than in the lower temperature of ice water.

III. Effect of Concentration

Students observe the difference in how fast bubbles of carbon dioxide are produced when two different concentrations of vinegar are added to baking soda. The stronger solution produces bubbles at a faster rate.

IV. Effect of Surface Area – Demonstration.

Dust in a flame - Spray lycopodium powder into the flame of the tea candle. This produces a large flame because of the rapid burning of the lycopodium powder due to its small particle size and therefore its large surface area that is exposed to the oxygen in the air.

V. Effect of Surface Area – Experiment with Tablets.

Students observe how fast bubbles of carbon dioxide are produced when water is added to a whole tablet and a crushed tablet in dry cups. The bubbles are produced faster with the crushed tablet than with the whole tablet.

VI. Effect of Surface Area – Demonstration.

Dust Can Explosion

Spray lycopodium powder into a can with a lit tea candle. This causes the same rapid burning of the lycopodium powder you demonstrated in Part IV. The large volume of combustion gases (carbon dioxide and water vapor) causes the lid of the can to blow off.

VII. Effect of Catalysts

You demonstrate the use of manganese dioxide, MnO_2, as a catalyst for the rate of decomposition of hydrogen peroxide to water and oxygen by adding a small plastic scoop of MnO_2 to a clear jar containing hydrogen peroxide. Bubbles of a gas are produced, and when you insert a glowing splint, the splint bursts into flame, proving that the gas is oxygen. (Hydrogen bubbles would put the flame out). Point out to the students that the manganese dioxide still looks the same – catalysts are not changed to something else nor are they consumed in the reaction.

Add some H_2O_2 to a cup with a potato chunk in it. Catalase is a catalyst (enzyme) in potatoes. Leave the potato chunk with the teacher for the next day.

VIII. Review

Materials

1 container of ice
16 3.5 oz cups marked for 50 mL
34 10 oz. clear plastic cups
9 bottles of water (fill when you arrive at the school)
8 plates (Activities II, III, IV, V)
18 packets of 2 effervescent tablets (Kroger or Alka Seltzer)
8 pairs of scissors (Activity II, V)
2 100 mL graduated cylinders (clear) (for demonstration in III)
1 bottle of 100 mL of red food dye solution (for demonstration in III)
1 piece of copy paper (for holding behind the graduated cylinder demo in (III)
8 small ziploc bags (Activity V)
1 bottle of hydrogen peroxide
1 cup with a chunk of potato
34 Instruction Sheets (in sheet protectors)
32 Observation Sheets
8 ziploc bags containing: (for Activity III - Effect of Concentration)
- 2 10 oz. clear plastic cups (labeled 20%, 5%)
- 2 containers with 50 mL of 20% vinegar, 5% vinegar solutions
- 1 container of baking soda
- 1 spoon

1 demo bag containing:
- 1 clear 6-oz screw-cap jar one-third full of 1.5% hydrogen peroxide
- 1 small container of manganese dioxide
- 1 small plastic scoop
- 2 splints
- 1 box of matches

1 Coffee Can with Lid (lid is lined with piece of aluminum pie plate) containing: (for Activities IV and VI)
- 1 box of matches
- 1 vial of lycopodium "dust" powder"
- 1 pipette - jumbo size
- 1 tea light candle
- 1 piece of paper

1 trash bag
1 picture of dust explosion

I. Introduction

Write the following vocabulary words on the board:

rate **concentration** **chemical reaction** **catalyst** **surface area** **enzyme**

Share the following information with the students:

- A **chemical change or chemical reaction** occurs when two or more substances react to form new substances with different chemical properties.
- Evidence of a chemical reaction might be a color change, a gas given off, or the formation of a precipitate.

Ask students what they know about Alka Seltzer or effervescent tablets.

Include the following information in the discussion.

- Tell students that effervescent tablets are commonly referred to as Alka Seltzer tablets because these were the first effervescent tablets available.
- Effervescent tablets contain citric acid and sodium bicarbonate. When water is added, these ingredients dissolve and react with each other to produce carbon dioxide gas - this is a **chemical reaction** as evidenced by the production of a gas.
- The rate of the reaction can be measured by measuring the rate at which carbon dioxide is given off.

Share the following information with the students:

- The **rate** of a chemical reaction is how fast the reaction occurs.
- Many reactions occur so fast that you cannot measure how long it takes. Others take years or longer to occur.
- Factors that affect the rate of reaction include **temperature**, **concentration, surface area,** and **catalysts**.
- Tell students that the activities today will demonstrate how these factors influence the rate of a chemical reaction.

Note: Organize the class into **eight groups** and give each **group 2 instruction sheets**. Give **each student** an **observation sheet**. You will still need to guide the students while they are performing the experiment. Constantly check the groups to ensure they are doing the experiment correctly.

II. The Effect of Temperature on the Rate of a Reaction

Introduction:

Ask students: What happens to food that is left out in the open on a hot day or in a hot room?

melts, spoils, molds, gets hard, ripens, stays the same and other responses – depending on the food item

Ask students: Since some foods spoil in heat, what do we do to slow down the rate of food spoilage?

Include the following information in the discussion:

- We refrigerate or freeze foods to delay the rate of food spoilage.
- The lower the temperature, the slower the reaction. Conversely, the higher the temperature, the faster the reaction.
- We know that food left out on a hot summer day can spoil fairly quickly. By cooling the food, we slow the chemical reaction of spoilage.
- Since food spoilage is a chemical reaction, this example illustrates the effect of temperature on the rate of a chemical reaction.

Procedure:
Give each group the following:

- 1 plate
- 1 bottle of water
- 2 10 oz. cups
- 1 pair of scissors
- 1 packet of 2 effervescent tablets
- 1 3.5 oz cup filled with ice to the 50 mL line
- 1 3.5 oz cup marked with a 50 mL line
- 4 observation sheets

Have students do the following (these instructions are on their Instruction Sheet):

- Place the two 3.5 oz cups (one already contains ice) on a plate.
- Fill both cups to the 50 mL line with water. (The ice cup will not require much water to reach the mark.)
- Carefully cut open one end of the packet of effervescent tablets.
- Carefully remove the effervescent tablets from the packet.
- Add a whole tablet to each of the 10 oz clear **dry** cups.
- Place the two cups with the tablets on the plate.
- Make sure groups are ready by asking two students from each group to hold a 3.5 oz cup with water or ice water in a "ready" position over the **dry** cup containing a tabletTell all students to be ready to observe what happens when the tablets are added.
- Then someone says "1,2,3, Go" and on "Go" the students add all the water or ice from their cups to the tablets in the 10 oz cups at the exact same time from the exact same height.
- Observe what happens and write your observations on the observation sheet.

Note: Students should save the 3.5 oz measuring cups for part VI. Collect the used 10 oz cups. Dry ones need to be used in the next section.

Ask students: Was the reaction faster in the ice water or the water at room temperature?
Room temperature water, bubbles of carbon dioxide come off more slowly in ice water.

Discussion:
Ask students, *How does this illustrate the effect of temperature on the rate of reaction?*
The rate of bubbles coming off in ice water was slower so the lower the temperature the slower the reaction; and the higher the temperature the faster the reaction

Ask students: How do you think we could make the reaction occur even faster?
Heat the water to a higher temperature.

Ask students: Is the total amount of carbon dioxide given off in both the slow and fast reaction the same if you wait until the reaction is over?
Yes. It is important for students to realize that since we started with the same amount of substance, as represented by the whole tablet in both cases, we will get the same amount of carbon dioxide gas when water is added - whether the reaction is fast or slow. The ice water/tablet cup will continue to fizz long after the other one has stopped.

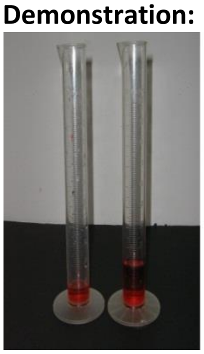
III. Effect of Concentration on the Rate of a Reaction

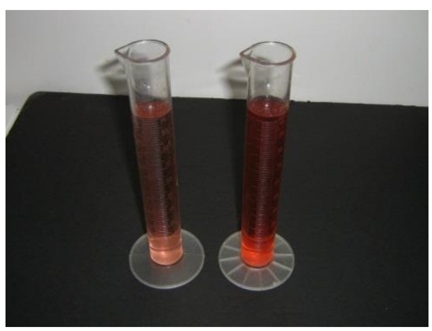
Materials for demonstration

2 100 mL graduated cylinders (clear)
1 bottle of 100 mL of red food dye solution
1 bottle of water
1 piece of copy paper

Share the following information with students:
The concentration of a solution refers to how much of a substance is dissolved in water.
A stronger (more concentrated) solution has more molecules of the reacting substance in water than a weaker (more dilute) solution does.

Demonstration:





Hold up the bottle of red dye and make sure class can see what you are doing.

- Take the bottle of red coloring solution and add 5 mL to one graduated cylinder and 20 mL to the other.
- Fill both graduated cylinders to 100 mL mark with water.
- Hold graduated cylinders up so students can see the difference in intensity of the red color. (Use the piece of white copy paper behind the cylinders to help students see the difference.) Tell students that the 5% and 20% vinegar solutions were prepared in a similar way.

Note: When discussing the effect of concentration, use "weak" and "strong", for the vinegar solutions which are labeled 5% and 20%, respectively. The reason for this is that you do not have time to explain concentration and percentage to students who don't understand this concept.

Ask students: have you ever mixed vinegar and baking soda? What happened?
Most students have done this and will remember that bubbles were formed.

Tell the students that they will be adding 2 different strengths of vinegar to baking soda. **Warn students that the reactions in the next experiment will be very fast and they must observe closely or they will miss the reaction.**

Give each group the following:
- 8 #1 ziploc bags containing:
- 2 10 oz clear plastic cups - labeled strong (20%) and weak (5%)
- 2 containers with 50 mL of strong (20%) vinegar, weak (5%) vinegar

container of baking soda, 1 spoon
(They should already have a plate and bottle of water per team)

- Place the vinegar solutions beside the matching cup. (strong (20%), weak (5%))
- Place a level spoon of baking soda in each cup.
- Make sure groups are ready by asking two students from each group to remove the top from a 5% or 20% vinegar container and hold it in a "ready" position over a cup of baking soda. The other students should observe closely to see the results.
- Then someone says "1,2,3, Go" and on "Go" the students should add **all** the vinegar solution from their containers to the cups of baking soda at the exact same time from the exact same height.
- Record the results.

Ask students to describe what happened.
Bubbles of carbon dioxide come off more slowly from the lower concentration of vinegar.

Ask, How does this illustrate the effect of concentration on the rate of reaction?
The rate of carbon dioxide bubble formation is slower for the weaker solution of vinegar. The stronger the solution, the more substance there is to react and the faster the reaction will occur.

Ask students: Which reaction was faster? *The strong vinegar should have given a faster reaction.*

Ask students: How does this illustrate the effect of concentration on the rate of reaction?
The stronger the solution, the more substance there is to react and the faster the reaction will occur.

IV. The Effect of Surface Area: Demonstration

- Ask students: What is surface area? *Students probably will not be familiar with the concept of surface area, so share the following information with them.*
- Surface area is the exposed surface of an object.
- Show students a flat piece of paper (in the coffee can) and ask students how much of the paper exposed to air. They should say all of it.
- Now crumple the paper into a small ball and ask students how much of the paper is exposed to the air. Make sure they understand that the crumpled paper has a smaller surface area than the flat paper.

Tell students that the next demonstration will illustrate the effect of surface area or particle size on the rate of a reaction.

Materials need for the Dust in a Flame Demonstration are in the Coffee Can which contains:

1	box of matches	1	vial of lycopodium "dust" powder
1	pipette (jumbo size)	1	tea light candle
1	aluminum pan		

- Show the students the lycopodium "dust" powder.
- Place a small pile of powder on the aluminum pan and attempt to light it with a match. (Depending on how long the match is held to the powder - it will either not burn or will burn enough to char a little.)
- Light the tea candle and place it on the aluminum pan.
- Load the pipette with a small amount of dust powder (enough to fill the tip). **Do not turn the pipette upside down**. There must be powder at the tip of the pipette for this to work.
- Hold the pipette so the tip is above the flame and squeeze the pipette bulb to release the lycopodium powder into the flame.
- There will be a flash of fire.

Ask students: Why was there a flash of fire?
More of the surface of the particles is exposed to the oxygen in the air when the particles are sprayed into the flame. This causes a flash of fire that indicates more rapid burning (combustion) of the lycopodium powder.

Explanation: When the powder is in a pile, it will not light. Oxygen cannot get inside the pile to react with enough particles of powder; it can only react with the particles on the outside of the pile. When the powder is suspended in the air, it has more surface area than when it was in a pile. This is because the particles are extremely small. When they are sprayed into the air near the flame, the particles are spread out so the oxygen in the air reaches more particles at the same instant – hence more particles are burning at the same time, and you see a big flash of flame. (Lycopodium powder is a dried-up moss. It is used for this type of demonstration because the powder has extremely small particles.)

V. The Effect of Surface Area on the Rate of a Reaction: Experiment

• Ask students to use what they learned about surface area in the last experiment to suggest ways to increase the surface area of the tablets to speed up the rate of the reaction.
You may have to guide this a little, but students should say that crushing the tablet will give a faster reaction because it has a larger surface area.

Give each group the following:

2	10 oz cups	1 packet of 2 effervescent tablets
1	small ziploc bag	

(Students should already have two 3.5 oz cups that they used in Section II, the bottle of water, a pair of scissors, and a plate.)

- Place the two 3.5 oz measuring cups on the plate.
- Fill the two cups to the mark using the bottle of water.
- Carefully cut open the packet of effervescent tablets and remove them from the packet.
- Place one whole tablet in the bottom of one of the **dry** 10 oz plastic cups.
- Place the other tablet in a small ziploc bag, seal the bag, and crush the tablet by tapping on the bag with the water bottle or the palm of their hand.
- Shake all of the crushed tablet into one bottom corner and cut the other bottom corner off.
- Then pour the crushed tablet through the bottom cut corner into the other **dry** 10 oz plastic cup.
- Ask students to observe the two tablets now and tell which tablet has more surface area.
  The crushed tablet - more of the inside surface of the tablet is now exposed.
- Make sure groups are ready by asking two students from each group to hold a cup of water in a "ready" position over either the cup with a whole tablet or the crushed tablet. Tell them they should be ready to pour all the contents into the cup on the count of 1,2,3, Go. (Make sure students realize the importance of making sure they add the contents at the same time and from the same height just above the cup containing the Alka Seltzer solid.)
- Then someone says "1,2,3, Go" and on "Go" the students should add all the water from their cups.
- Record the results.

Ask students: Which tablet had a faster reaction?
Bubbles of carbon dioxide come off more quickly from the crushed tablet than from the whole tablet.

Ask student: How does surface area affect the rate of a reaction?
A larger surface area will increase the rate of reaction.

VI. Dust Can Explosion: Demonstration

Caution: This experiment is loud and sometimes propels the lid of the coffee can in the air. Be sure the can is some distance away from the nearest students before you do this experiment!

- Show students the "dust can".
- Light the tea light candle and place it in the coffee can.
- Load the pipette with a small amount of dust powder (enough to fill the tip). DO NOT turn the pipette upside down. There must be powder at the tip of the pipette for this to work.
- Show the students the hole in the side of the can.
- Ask students to predict what will happen when you 'blow' the dust into the can.
- Holding the pipette at an angle (aiming down with about a 30° angle), place the pipette in the hole (make sure the pipette is snug).
- Place the lid on the can. **Do not do this until now – the flame will go out before you can get the powder into the can.**
- Squeeze firmly on the pipette and leave the pipette in the hole after squeezing.
- There will be a flash of fire, a loud explosion, and the lid will blow off the can.

Note: If the explosion does not happen on the first try, please try again. Some groups have to try this three or four times to achieve the desired results. The students love to see this more than once and it shows them that perseverance pays off.

Ask students: Why was the reaction quicker and bigger when the dust was blown around in the can rather than in an open flame?

Explanation: The dust can explosion is a dramatic illustration of the effect of surface area on the rate of reaction.   The chemical reaction is the same as any combustion reaction of any organic fuel - wood, coal, gasoline, natural gas.   The contents of these fuels are carbon compounds which combine with oxygen to give carbon dioxide and water vapor. If these gases are confined, an explosion will occur because the gases take up much more volume than the solid fuel. Some explosions are useful. For example, the internal combustion engine in a car works by small explosions set off by sparks from the spark plugs in each cylinder which drives the pistons. Other explosions can be disastrous - such as a flour mill explosion. The dust can explosion is a safe, small scale illustration of what happens in a flour mill explosion.

The dust can explosion illustrates why workers in grain elevators, saw mills, and flour mills have to be very careful about sparks. A spark can ignite burnable dust in the air to produce a large explosion.   **Show students the picture of a dust explosion in a rubber factory.**

VII. Effect of a Catalyst

Materials:

1 demo bag containing:

1 clear 6-oz screw-cap jar one-third full of 1.5% hydrogen peroxide
1 small container of manganese dioxide
1 chunk of potato in a cup
1 bottle of hydrogen peroxide
1 small plastic scoop
2 splints
1 box of matches
1 pair of tweezers

Ask students: What is a catalyst?
A catalyst is a substance that speeds up or slows down a chemical reaction but is not changed by the reaction.

Show the students the bottle of hydrogen peroxide.
Ask students what they know about hydrogen peroxide (H_2O_2).
Some students will know that hydrogen peroxide is often put on cuts and that it bubbles up. Someone might know that it is H_2O_2.
Include the following information in the discussion:

- Tell students that hydrogen peroxide (H_2O_2) will chemically decompose (break down) into oxygen gas (O_2) (yes, the glowing splint test will work!) and water (H_2O).
- Hydrogen peroxide is sold in brown bottles because it will decompose in the presence of light. Hydrogen peroxide bottles are dated because even in a brown bottle, hydrogen peroxide will decompose over time.
- Tell students that the decomposition of hydrogen peroxide will speed up if a catalyst is added to the hydrogen peroxide.

Demonstration of Manganese Dioxide as a Catalyst:

- Remove the clear jar containing hydrogen peroxide from the demo bag.
- Show the bottle to the students, telling them that it is a 1.5% solution of hydrogen peroxide.
- Unscrew the cap on the jar and set the cap down on a table and continue holding the jar while another person takes the small spoon and gets a level spoonful from the container of manganese dioxide.
- Light a splint with a match and shake it out until it is glowing without flaming.
- Tell students to watch what happens when the spoon of manganese dioxide is added to the jar. As soon as you see vigorous bubbling with what appears to be a gas coming from the bottle, insert the glowing splint into the top of the jar. Observe that it bursts into flame. Repeat the glowing splint test several times while bubbles of gas are being given off.
- As soon as bubbling ceases (about five minutes – you can wait until after students do the next part of the lesson), screw the cap back tightly on the jar and place it and the small plastic scoop back in the demo bag. Then put the demo bag back in the kit.

Ask students: What gas caused the glowing splint to burst into flame? *Oxygen. (Hydrogen bubbles would put the flame out).*
Point out to the students that the manganese dioxide still looks the same – catalysts are not changed to something else nor are they consumed during the reaction.

Demonstration of Catalase in a potato as a catalyst.
Add some H_2O_2 to the cup with the potato.
Bring the potato around to the students and ask what they observe. *There should be lots of bubbles around the potato but the potato itself does not change.*
Explanation: A catalyst speeds up a chemical reaction without being used up. The catalyst does this without undergoing permanent change itself, so it can act over and over again. Enzymes are biological catalysts. Enzymes speed up many of the chemical reactions that occur in our body all the time! Catalase is an enzyme made in potatoes. Catalase speeds up the decomposition of hydrogen peroxide. That's why bubbles form around the potato.
Another example of an enzyme at work is the breakdown of starches to simple sugars. The next time you are chewing a cracker, see if you can tell whether the initial salty taste turns to a sweet taste. The saliva in your mouth causes a chemical breakdown of the starch in the cracker as the cracker is chewed by the mouth. The enzyme amylase begins breaking down the starch in the cracker to individual sugar molecules so the cracker begins to taste sweet.

- Ask students if the potato will look different or the same tomorrow.
- Leave the potato chunk with the teacher and have the students check to see if their hypothesis is correct.

For Information Only: Many chemical reactions are slow because they involve several intermediate steps that are of high energy. A good analogy is the difference between driving over a mountain or driving through a tunnel in the mountain. It takes less time to drive through a tunnel than over the top of the mountain. The regular chemical reaction goes through an intermediate state of high energy like going over a mountain while the catalyst provides a new pathway of lower energy for the chemical reaction, similar to going through a tunnel in the mountain.

Enzymes bind their substrates (in this case H_2O_2) into a cavity before catalyzing a reaction. Once the substrate is in the cavity, binding between the enzyme and the substrate weaken substrate bonds, making it easier for new bonds to form. The best analogy is the Venus flytrap. This plant traps an insect by folding around it. The folding is triggered by the presence of the insect, just as the folding of the enzyme is triggered by the presence of the substrate. After the catalyzed reaction is complete, the enzyme opens up again to let the products leave and to prepare for the next substrate molecule. Your body has thousands of enzymes that catalyze reactions, including catalase in the blood that catalyzes the breakdown of hydrogen peroxide that is formed in some biological reactions and must be decomposed to avoid harmful effects on the body.

VIII. Review (Time Permitting)

Review the vocabulary words on the board. Then review the factors that affect the rate of

chemical reaction.
In each activity one of the factors that influences the rate of chemical reactions was varied while the others were held constant.

1. Ask students, What effect did temperature have on the rate of reactions?
   The lower the temperature, the slower the reaction. The higher the temperature, the faster the reaction.

2. In the second student activity, the concentration of vinegar was varied while the temperature was held constant
   Ask students, What effect did concentration have on the rate of the reaction?
   The higher the concentration, the faster the reaction occurred.

3. In the third student activity, the temperature of the water was constant, and the surface area was varied by using a whole tablet and a crushed tablet.
   Ask students, What effect did surface area have on the rate of the reaction?
   In this case, the crushed tablet reacted faster because of the higher surface area of the particles as compared to the whole tablet.

4. In the fourth student activity, the effect of a catalyst was studied at constant temperature, by adding the catalyst to the hydrogen peroxide.

Ask students, What effect did the catalysts have on the rate of decomposition of hydrogen peroxide?
   Both manganese dioxide and catalase in the potato caused the decomposition of hydrogen peroxide to be faster as indicated by the bubbles of gas given off when the catalyst was added

Be sure to leave the cup containing 3% hydrogen peroxide and a potato slice with the teacher so the students can look at it the next day to see whether the potato slice still looks the same.

Return of the Kit: It is important that **all** items be returned to the kit box. Be sure to collect all instruction sheets (in sheet protectors) and put them back in the kit box. **Be careful not to place wet objects in kit.**
Make sure the cap is on the demo bottle of hydrogen peroxide and put it back in the kit, not in the trash bag.

Lesson written by Dr. Melvin Joesten, Chemistry Department, Vanderbilt University
Pat Tellinghuisen, Coordinator of VSVS, Vanderbilt University
Susan Clendenen, Teacher Consultant, Vanderbilt University
Will Lindquester, Vanderbilt Undergraduate Student, 2012

Reference: Journal Editorial Staff, *J. Chem. Educ*. 1998, 75, p. 1120A

ANSWER SHEET
Rates of Reaction

Name ____

II. Effect of Temperature – Ice water vs. room temperature water

Which was faster? ____**Room Temperature**____ How can you tell? **Bubbles come off faster**

Which one finished before the other? __**Room Temperature**

How could we change the temperature to make the reaction occur even faster? **Heat the water to a higher temperature before adding the tablet. The higher the temperature, the faster the reaction will occur.**

III. Effect of Concentration – 5% vs. 20% vinegar

Which was faster? **20%**. How can you tell? **Bubbles come off faster**

V. Effect of Surface Area

1. Demonstration of lycopodium “dust” powder (dried-up moss)
Why was there a flash of fire when a pipette of lycopodium powder was sprayed across a burning match, but only some charring occurred when a burning match was held close to a pile of lycopodium powder?

More of the surface area of lycopodium powder was exposed to the oxygen in the air.

2. Which tablet reacts faster – crushed or whole? **The crushed tablet reacts faster**. Why? **The smaller particles in the crushed tablet expose more of the surface area to react with the water.**

3. Why was there an explosion when a pipette of lycopodium powder was sprayed into the coffee can with a lit tea candle?

The gases produced when the lycopodium powder burned built up enough pressure to blow off the lid.

4. What gases are produced when lycopodium powder is burned? **Carbon dioxide and water vapor (any organic material – lycopodium powder, wood, coal, gas – produce carbon dioxide and water gases when they burn.**

VI. Catalysts

What happens when manganese dioxide is added to hydrogen peroxide? **The solution foams vigorously, giving off bubbles of a gas.**

What gas is indicated by the glowing splint test**?** **Oxygen**

What happens when the potato slice is added to hydrogen peroxide? **Bubbles of gas can be seen.**

Do either manganese dioxide or the potato slice look like they’ve changed? **No**

OBSERVATION SHEET – Rates of Reaction

Name ________________________________

Vocabulary words: rate, concentration, chemical reaction, catalyst, surface area, enzyme

II. Effect of Temperature – Ice water vs. room temperature water

Which was faster? ______________ How can you tell? _________________________

Which one finished before the other? ____

How could we change the temperature to make the reaction occur even faster? ________

____

III. Effect of Concentration – 5% vs. 20% vinegar

Which was faster? _____________ How can you tell?_____________________________

____

IV. Effect of Surface Area

1. Demonstrations of lycopodium "dust" powder (dried-up moss)

Why was there a flash of fire when a pipette of lycopodium powder was sprayed across a burning match, but only some charring occurred when a burning match was held close to a pile of lycopodium powder?

____

2. Which tablet reacts faster – crushed or whole? ___________ Why? __________________

3. Why was there an explosion when a pipette of lycopodium powder was sprayed into the coffee can with a lit tea candle?

____

4. What gases are produced when lycopodium powder is burned?

____

IV. Catalysts

What happens when manganese dioxide is added to hydrogen peroxide? ________________

____

What gas is indicated by the glowing splint test**?** _________________

What happens when the potato slice is added to hydrogen peroxide? ___________________

Do either manganese dioxide or the potato slice look like they've changed? _____________