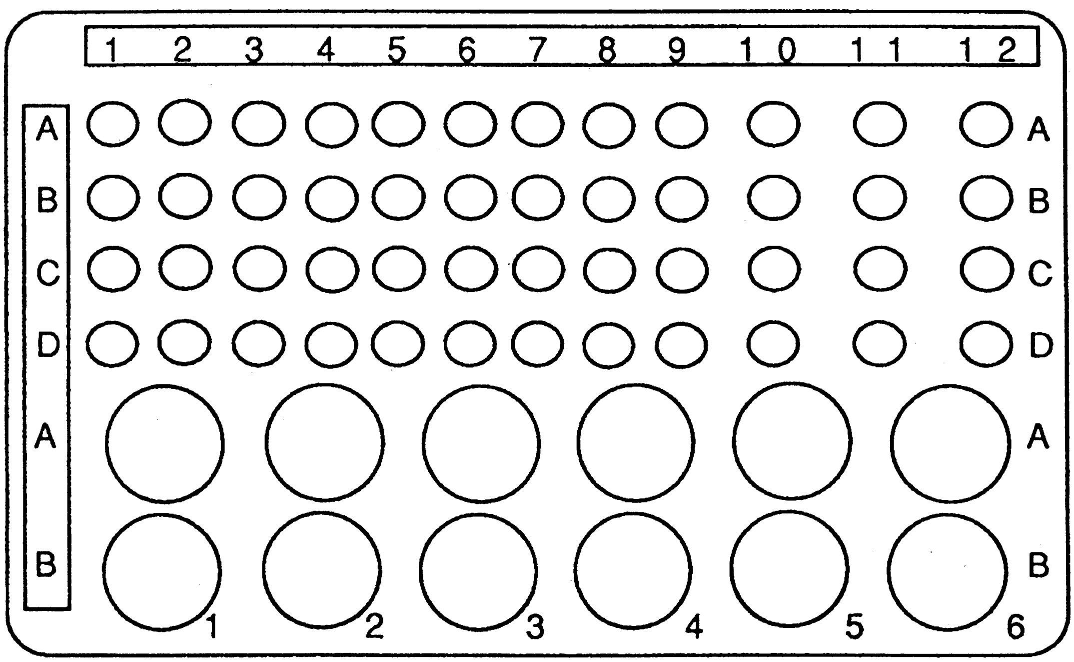
ITEM #2860
AGES 10 AND UP

WARNING:

THIS SET CONTAINS CHEMICALS & APPARATUS THAT MAY BE HARMFUL IF MISUSED. READ CAUTIONS ON INDIVIDUAL CONTAINERS CAREFULLY. NOT TO BE USED BY CHILDREN EXCEPT UNDER ADULT SUPERVISION.

SMITHSONIAN®

MicroChemistry XM 5000



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MicroChemistry XM 5000

INDEX

GROUP 1 INTRODUCTION

Introduction

MICROCHEMISTRY XM-5000 Revision II

A WORD TO PARENTS

This laboratory manual is prepared with one main concern:

SAFETY!

In recent years the ecological and health sciences have stated that exposure to certain chemicals, either in work, school, or at home, can cause serious health problems. Yet young scientists need the "hands on" experience, the thrill of experimentation, and the satisfaction of discovery which is possible only through labs.

The MicroChemistry approach has been adopted by high schools and colleges throughout the United States. The use of small amounts of chemicals to investigate the workings of chemistry in no way lessens the excitement of experimentation. Yet, this approach reduces the possibility of exposure of the experimenter to harm from chemicals necessary for the experiment itself.

This is not to say that ALL CHEMICALS and CHEMICAL PROCESSES in the MicroChemistry approach are absolutely safe.

ALL CHEMICALS AND PROCEDURES HAVE A POTENTIAL TO CAUSE HARM.

MicroChemistry lessens that possibility by reducing, considerably, the amount of materials used. By using plasticware, minimal amounts of glassware, by eliminatng the use of fire or burners and restricting the use of heat, an additional safety factor is provided. MicroChemistry equipment is safe and easy to use.

From the scientific viewpoint, for the first time in **ANY** chemistry set, young experimenters will be able to tell HOW MUCH of a substance reacts or is present rather than only looking at general properties.

Some of the experiments in this manual are:

QUALITATIVE

This means that if a test is done you will, for example, be able to tell if starch is present in a food.

Some of the experiments in this manual are:

QUANTITATIVE

This means that young chemists will be able to tell, for example, HOW MUCH starch there is in a sample of food.

Prior to the MicroChemistry approach, QUANTITATIVE experiments by young scientists were not possible.

Even though MicroChemistry is safer than the chemistry which requires more material, it is important to realize that you are STILL handling some potentially harmful materials.

The safest way to handle ANY chemical is to treat it as if it were

THE MOST DEADLY POISON

Follow these simple rules to insure that your interest in chemistry will not be stopped by an injury or sickness caused by mishandling your experiment.

Safety Rules

1) *NEVER* ALLOW A CHILD TO EAT ANY CHEMICAL OR THE PRODUCTS OF THEIR EXPERIMENT!

   NEVER ALLOW THEM TO EAT FOOD WHEN YOU ARE EXPERIMENTING. DO NOT ALLOW ANY LIQUID TO BE DRUNK WHILE EXPERIMENTATION IS BEING CONDUCTED.

2) CAUTION A CHILD NEVER TO HANDLE A CHEMICAL WITH THEIR BARE HANDS. USE A SCOOP OR FOLLOW DIRECTIONS FOR MAKING A PLASTIC SCOOP TO MEASURE OUT SOLID CHEMICALS.

3) LIQUID CHEMICALS ARE ALWAYS DISPENSED WITH A SPECIAL PIPETTE. USE ONLY DROPS OF CHEMICAL FROM THIS PIPETTE. DO NOT USE THIS PIPETTE OR ANY OTHER EQUIPMENT IN THIS SET FOR OTHER PURPOSES!

4) *ALWAYS* WORK WITH GOGGLES.

5) CHILDREN SHOULD WORK UNDER THE SUPERVISION OF AN ADULT AT ALL TIMES.

6) IF THERE IS A SPILL OF ANY CHEMICAL, THE AREA SHOULD BE CLEANED THOROUGHLY.

7) WASTE CHEMICALS FROM EXPERIMENTS AND MATERIALS USED TO CLEAN AN AREA OF SPILL OR ACCIDENT SHOULD BE DISPOSED OF IN AN ENVIRONMENTALLY SAFE MANNER.

8) **IT IS IMPORTANT TO COVER CLOTHING WITH A PROTECTIVE LAYER OF CLOTH, PLASTIC OR RUBBER. YOU SHOULD OBTAIN AN APRON (LIKE A WORKSHOP APRON) AND WEAR IT WHILE YOU WORK WITH YOUR CHEMISTRY SET. A PROTECTIVE PIECE OF PLASTIC SHEET SHOULD BE USED UNDER YOUR WORK AREA TO PROTECT THE SURFACE YOU ARE WORKING ON.**

While it is fitting that your child learns some ideas and principles about chemistry while experimenting with his/her new set, it is important that he/she have FUN while exploring and discovering! Throughout this Laboratory Manual, questions have been provided to help the experimenter "HOME IN" on the principles of chemistry. Some answers are given right in the experiment, while other answers can be found in the Appendix at the end of the Laboratory Manual.

It is hoped that by providing interesting questions along with the experiments, the young chemist will develop a basic knowledge of chemistry along with the workings of chemistry.

GROUP 2 — A WORD TO THE "CHEMIST"

A Word to The "Chemist"

You live in an **EXCITING** world.

It is a world full of the latest in **TECHNOLOGY** (the use of scientific knowhow in every day life) and invention. Many of the things in today's world were never considered to be possible a few years ago. The advancements in technology could only be possible by advancement in the basic sciences. For example, scientists found that by treating silicon wafers with certain chemicals that the electrical conducting ability of the silicon wafers was changed in certain ways. This discovery opened up a whole world of "electronic micro chips" which helped in the development of computers and other electronic devices.

Your chemistry set is an excellent starting point to advance your skills as a scientist.

The world of science is a world of questions.

While you are working on your experiments in this manual, a series of questions will help you understand the hows and whys of what you are seeing. The answers to some questions will be given right after the questions in the experiments. The answers to other questions will be given in the Appendix section at the end of the Laboratory Manual.

The world of SCIENCE is the world of OBSERVATION. Scientific Observation means that the experimenter looks for and writes down (records) all the changes which happen that can be seen, and records how much (QUANTITATIVE) these changes can be measured.

Everything that scientists do depends on their ability to make careful observations and measurements about their experiences. We call these experiences **EXPERIMENTS**. An experiment is a carefully controlled set of situations which allows a scientist to see what effects a change in a single **VARIABLE** will have on the rest of the experiment. A variable is a single part of the experiment.

Suppose, for example, we were experimenting with plants and the effects of a change of things important to a plant.

We would start with two sets of plants. The two sets of plants have to be identical to each other. They must be of the same species, size, age, etc. One set would be a **CONTROL**, or standard. The control set would be compared with an **EXPERIMENTAL** group. The control plants would be treated in a normal manner. An experimental set of plants would have the same treatment as the control, EXCEPT FOR ONE PART. This is the **VARIABLE**. In our experiment, let's select temperature as the variable.

In the experiment, the control and the experimental plants would have the identical soil, receive the same amount of water, and have the same lighting. The temperature surrounding the experimental plants, however, would be different than the control plants. By making careful observations, the scientist would be able to see what effect temperature has on the growth of plants. He could do this by comparing the experimental plants to the control plants.

In this laboratory manual you will always be asked to compare an EXPERIMENTAL to a CONTROL.

SAFETY

No matter what the experiment, equipment, or procedure, one thing should be the first to think about:

SAFETY

Follow these simple rules to insure that your interest in chemistry will not be stopped by an injury or sickness caused by mishandling your experiment.

SAFETY RULES

1) *NEVER* EAT ANY CHEMICAL OR THE PRODUCTS OF YOUR EXPERIMENT!

   NEVER EAT FOOD WHEN YOU ARE EXPERIMENTING.

   DO NOT DRINK ANY LIQUID WHILE YOU ARE EXPERIMENTING.

2) *NEVER* HANDLE A CHEMICAL WITH YOUR BARE HANDS. USE A CHEMICAL SCOOP. FOLLOW DIRECTIONS ON PAGE 4 FOR MAKING A PLASTIC SCOOP TO MEASURE OUT SOLID CHEMICALS.

3) DISPENSE LIQUID CHEMICALS WITH CARE. USE ONLY DROPS OF CHEMICAL FROM A SPECIAL MEDICINE DROPPER CALLED A PIPETTE. THESE PLASTIC PIPETTES ARE PROVIDED IN YOUR CHEMISTRY SET.

4) USE CHEMISTRY SET EQUIPMENT FOR EXPERIMENTS IN YOUR CHEMISTRY LAB MANUAL ONLY.

5) *ALWAYS* WORK WITH GOGGLES, IN PLACE, OVER YOUR EYES.

SAFETY RULES (continued)

6) YOU SHOULD WORK UNDER THE SUPERVISION OF AN ADULT AT ALL TIMES.

7) IF THERE IS A SPILL OF ANY CHEMICAL, THE AREA SHOULD BE CLEANED THOROUGHLY. MATERIALS USED TO CLEAN THE AREA SHOULD BE DISPOSED OF IN A SAFE MANNER.

8) IT IS IMPORTANT TO COVER YOUR WORK AREA WITH A PROTECTIVE NEWSPAPER, LAYER OF CLOTH OR PLASTIC.

9) DISPOSE OF USED CHEMICALS IN A MANNER WHICH IS ENVIRONMENTALLY SAFE. TALK TO YOUR PARENTS OR SCHOOL SCIENCE TEACHER ABOUT THE BEST WAY TO DISPOSE OF CHEMICALS.

GROUP 3 THE MICROCHEMISTRY SYSTEM

The MicroChemistry System

Your chemistry set is different!

It uses the latest methods in experimental chemistry. These methods were developed to make chemistry a safer science. The MicroChemistry System uses smaller amounts of chemicals than other chemistry sets. The hazards of glass have been minimized by the use of plastic labware. If a chemical reaction must be heated, hot water will provide the needed heat. Open flames or burners are **NEVER** used in MicroChemistry.

By using MicroChemistry you will be able to do more experiments, get better results in a shorter amount of time and have a safer environment in which to work. Your work in the laboratory will be more efficient. That means you will be able to have more time to explore chemistry and have more fun doing it!

You will need the following materials to complete this series of experiments.

SECTION 1 - PREPARATION OF LABORATORY EQUIPMENT

LIST OF MATERIALS

- ❑ Microplate (from your chemistry set)
- ❑ Three plastic pipettes (from your chemistry set)
- ❑ Small piece of cotton (obtain at grocery or drugstore)
- ❑ Pair of scissors (from home)
- ❑ Measuring cup (from your chemistry set)
- ❑ Distilled water (from grocery)
- ❑ Rubbing alcohol or isopropyl alcohol (from grocery or drugstore)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

The Basics

MicroChemistry uses two basic tools. The MICROPLATE and the PIPETTE.

THE MICROPLATE

The first is a plastic tray called a microplate. This tray is very sturdy. The tray has shallow wells arranged in order of rows (running across) and columns (running up and down). These wells are used instead of test tubes, flasks and beakers. See Figure #1.

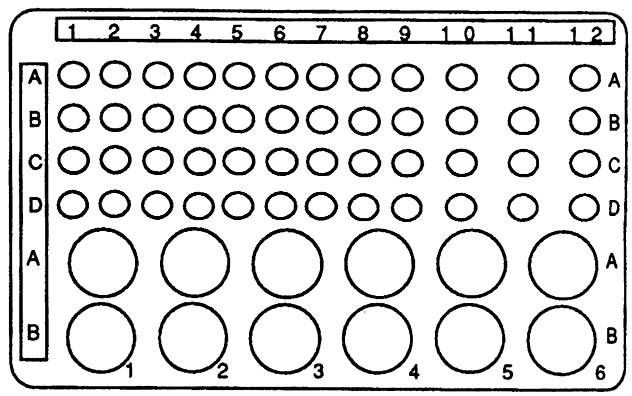

Figure #1

The tray is divided into two parts. Each has a series of rows and columns. This makes the microplate very orderly. It also makes a series of chemical reactions easy to compare to a control. Changes in color, or any other changes in a reaction can be easily seen when compared to the control.

There are 48 "small wells" or depressions in the MICROPLATE. These are numbered as columns #1 through #12. These are also lettered as rows A, B, C, D. During testing of reactions, you can identify individual reaction "wells" by using the row and column. For example, "Small well A-7 or Small well C-10".

There are 12 "large wells" or depressions in the MICROPLATE. These large wells are located directly down from the small well section. The large wells are numbered as columns 1, 2, 3, 4, 5, 6. These column numbers for the large wells appear at the base of the MICROPLATE near the bottom edge. The deep wells are lettered as rows A and B. You can identify individual large wells by the same method you identified the small wells, for example, "Large well A-6 or Large well B-2".

THE PLASTIC PIPETTE (medicine dropper)

MicroChemistry uses a plastic pipette, see Figure #2. The pipette is made of POLYETHYLENE. This form of plastic is soft and is very DUCTILE (flexible).

Examine one of the PIPETTES provided in your chemistry set. You will observe that is has an enlarged area called a BULB, a long tubelike section called a STEM.

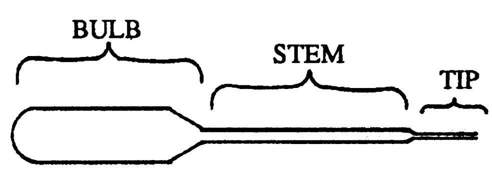

Figure #2

(RV695)

You may wish to form a microtip on some of your pipettes. This can be done by pulling the tubelike portion of the microtip until it stretches into a thinner diameter and then cutting the lower portion off with scissors, allowing only the very thin tip to be the end of the stem.

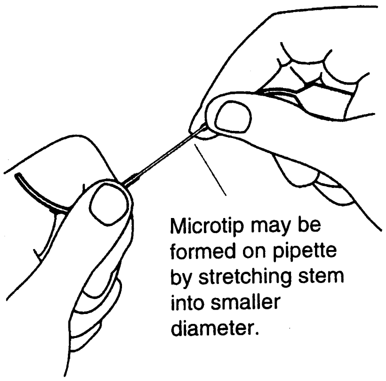

Figure #2A

The plastic PIPETTE will be used to dispense drops of chemical liquids to the microplate wells where your chemical reactions will take place. The use of the PIPETTE is just the same as the use of a conventional medicine dropper or eye dropper. When the tip is placed below the surface of a liquid and the bulb squeezed BETWEEN THUMB AND FOREFINGER, and then released, the PIPETTE will draw up liquid into the bulb. The pipette can then be used to deliver drops of liquid or chemicals to your MICROPLATE wells.

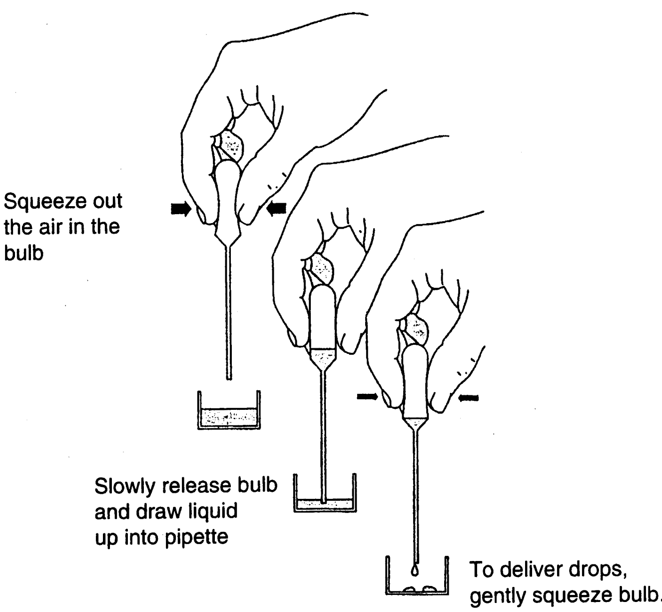

Figure #2B

The pipette can be used over again by simply rinsing the stem and bulb between chemicals. Water and chemical solutions do not "stick" to the plastic inside the pipette the way they might if the pipette was made of glass or rubber. The plastic surface of the pipette is NON-WETTING. This means that all the contents of the pipette can be dispensed with none of the chemical left behind.

The chemicals in your chemistry set will most often be in SOLUTION. This means that the chemical has been DISSOLVED in water. Solutions of chemicals react faster and more evenly than if the chemical were in the powdered or solid form. In fact, many of the experiments which will be done in this manual would not be possible if the chemicals were not in solution.

Making a Chemical Scoop

When it is necessary for you to use a solid in an experiment, the chemical solid can be transferred by the use of a CHEMICAL SCOOP. We can very easily make a CHEMICAL SCOOP out of another pipette.

1) Hold a plastic pipette by the stem.
2) With scissors, cut through both sides of the pipette at an angle. See Figure #3 for a picture of the procedure.

The cut pipette makes an excellent chemical scoop for any solids which will be used in the rest of the experiments in the laboratory manual.

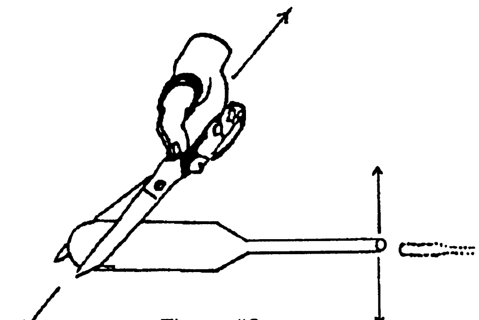

Figure #3

Making a Filter Funnel

We can make a filter funnel from another pipette.

1) Hold a plastic pipette by the stem.
2) With scissors, cut through the entire pipette straight across the bulb of the pipette.
3) Place a small piece of cotton from a cotton swab or cotton ball in the bottom of bulb. See Figure #4 for a picture of the procedure.

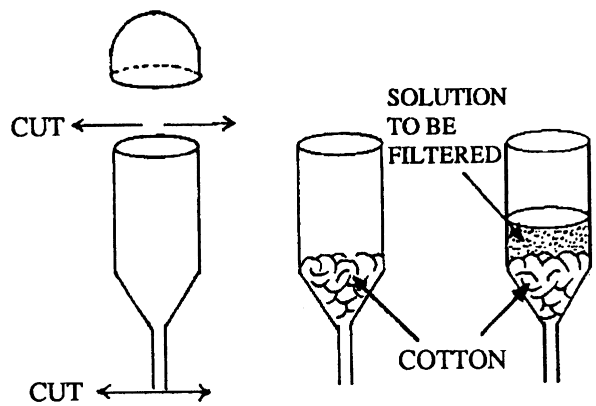

Figure #4

Delicate filtering of liquids into test tubes or into wells of the MICROPLATE can be accomplished using the microfunnel. Figure #4B shows how a funnel stand is made from a small piece of folded card stock.

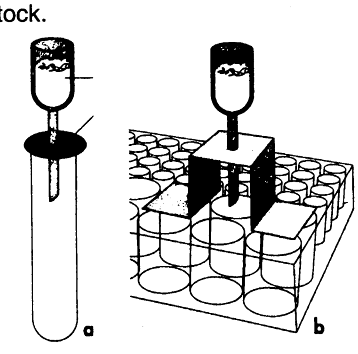

Figure #4A & 4B

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A Measuring Cup

Often solid material will be required in your experimentation. In order to weigh out correct amounts of solid materials, you will need to use the plastic measuring cup. See Figure #5.

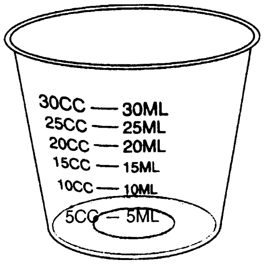

Figure #5 - Plastic Measuring Cup

These measuring cups are provided in your chemistry set and are printed on their sides with different lines and measurements. There are measures in teaspoons, and also in fluid ounces. There are measures in cubic centimeters (cc) and in milliliters (ml).

These measuring cups will also be used for weighing solids on your chemical balance or scales. The measuring cups are used for holding solids while weighing so that you do not get chemicals on the "pans" of your chemical weighing scales.

Always keep the plastic measuring cups clean and dry before using them on your weighing scales.

PREPARING THE CHEMICAL VIALS

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

All of the chemical vials in your chemistry set which will produce the chemical solutions you will use are made in a special way.

Look at one of the plastic vials (small plastic bottles). Notice that each has a screw-on, screw-off cap. The cap is a safety cap. To get it off, simply push down on the plastic cap and unscrew the cap. If you turn the cap clockwise it gets tighter. If you turn the cap counter-clockwise it comes off.

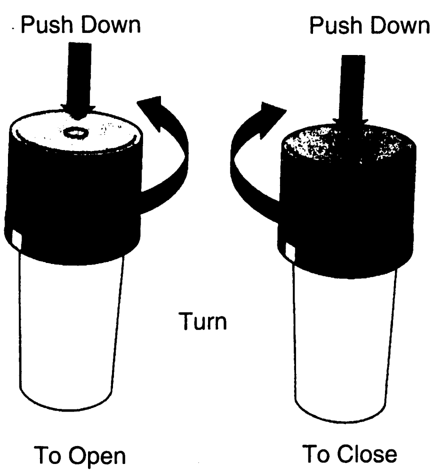

Figure #6

Under the cap and affixed to the top of the vial is the vial sealing disk. Look closely at the sealing disk. You will observe that there is a small "H" shaped cut in the top of the seal. This is the "H" septum sealing disk.

The "H" cut in the seal is a special opening for the stem and tip of your pipette. Try pushing the tip end of your pipette through the "H" cut in the seal. Notice how it opens to allow the pipette to enter the chemical vial. Notice how it closes back up after you take the pipette out.

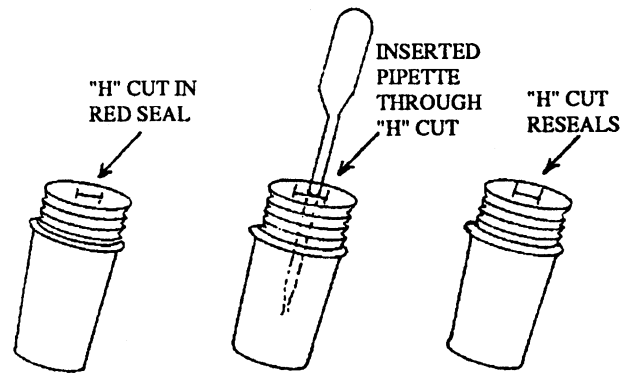

Figure #7

You may have to use a pencil or ball point pen's point to initially open and widen the "H" cuts in the seals so that your pipette can easily be inserted into the vials.

Each chemical vial contains a few small plastic "mixing beads" which themselves do not dissolve. The "chemical" in each vial is either on small strips of special paper or as solids in precisely measured amounts. The "mixing beads" help the chemicals dissolve.

When a solvent is added to the vial, the chemicals dissolve upon shaking the vial, and forms the chemical solution which you will use in your experiments.

The chemical's name is printed on the label on the exterior of each vial.

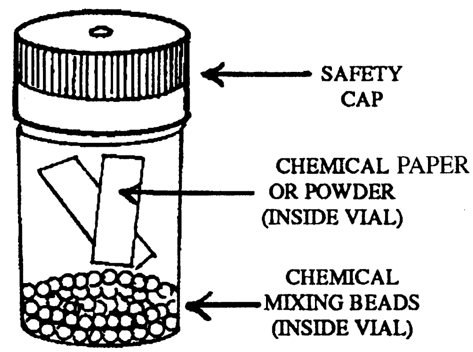

Figure #7A

ADDING SOLVENT TO THE VIALS

IMPORTANT

READ THESE DIRECTIONS BEFORE ADDING ANY LIQUID TO YOUR CHEMICALS!

You are now ready to activate your chemical vials with either water or alcohol. Be sure to follow the directions exactly so that you will put the correct liquid into the correct chemical vial.

You will need to gather the following materials to complete this procedure:

- ❑ All of the GREEN TOP chemical vials from your Chemistry set (put aside in one group)
- ❑ All of the YELLOW TOP chemical vial(s) from your Chemistry set (put aside in one group)
- ❑ All of the BLUE TOP chemical vials from your Chemistry set (put aside in one group)
- ❑ All of the plastic seal top envelopes with wires or other material (put aside in one group)
- ❑ Two plastic pipettes (medicine droppers) from your set
- ❑ One plastic measuring cup (measuring cup with measurement marks on it) from your set
- ❑ Sharp pointed pencil or ball point pen
- ❑ Alcohol - either isopropyl alcohol (rubbing alcohol) or ethyl alcohol. (Obtain from your local pharmacy or grocery store)
- ❑ Distilled water (Obtain from your local supermarket or pharmacy)

NOTE: Some vials and inside inner tops may be sealed with clear tape for added protection. Remove the tape on the inner top and puncture "H" with pencil point and proceed with the instructions below.

STEP 1 - Using the point of a pencil or ball point pen, poke through the plastic inner seal of all the chemical vials which have the small "H" cut on the inner seals. This will allow you to insert the pipette into these vials and will make it easier to fill and use later. Make sure you put the safety screw-on cap back onto each vial after you puncture the seal.

STEP 2 - Find the plastic measuring cup in your set. You will see it is marked with various measurements. Using the "ML" measurement scale ("ML" stands of milliliter), fill the cup to the 5 ML mark with distilled water.
Using your plastic pipettes, and your measuring cup with distilled water in it, draw up (suck up into the pipette) 5 ML (five milliliters) of DISTILLED WATER. Now push the tip of the pipette through the inner seals with the "H" cut on them and squeeze out 5 ML of distilled water into only the vials with the **BLUE** tops. ADD THE DISTILLED WATER ONLY TO THE VIALS WHICH HAVE BLUE TOPS AND BLUE COLORED SEALS! These vials which will get the 5 ML of distilled water are listed below:

Methylene Blue (#47)	Sodium Silicate (#18)	Biuret Reagent (#59)
Ferrous Sulfate (#44)	Copper Sulfate (#11)	Fehling's Solution (#62)
Potassium Iodide (#49)	Cobalt Chloride (#8)	Magnesium Sulfate (#64)
Citric Acid (#42)	Sodium Sulfate (#53)	Sodium Carbonate (#67)
Calcium Nitrate (#41)	Aluminum Ammonium Sulfate (#57)	
Calcium Hydroxide (#40)	Ammonium Chloride (#58)	

STEP 3 - You are now ready to fill some of the other vials with alcohol. You may use Isopropyl (rubbing) alcohol or Ethyl alcohol. Obtain the alcohol from the local pharmacy or grocery store. Using the same technique as you did in STEP 2, place 5 ML (five milliliters) of alcohol into the measuring cup. Then using your pipette, suck up the 5 ML of alcohol into a pipette and then insert the pipette into ONLY the following vials. PUT THE ALCOHOL ONLY INTO THE VIALS WHICH HAVE YELLOW COLORED CAPS AND YELLOW COLORED SEALS:

Phenolphthalein (#65)	Universal Indicator (#70)

STEP 4 - DO NOT ADD ANYTHING TO the following green capped vials:

Zinc Powder (#71)	Borax Powder (#50)
Iron Filings (#14)	Sodium Carbonate Powder (#67A)

NOTE: Sodium Carbonate powder (#67A) has an inner seal and is also taped over with cellophane tape for added protection for the chemical. When using this chemical, remove inner seal and tape covering, remove necessary amount of chemical with your chemical scoop, then replace top and seal.

STEP 5 - DO NOT ADD ANYTHING TO the following plastic envelopes:

Marble Chips (#33)	Iron Wire (#63)	Aluminum Wire (#38)
Copper Wire (#61)	Zinc Wire (#54)	

NOTE: Iron Wire used in this set is pure and will rust. Rust will not affect your experiments. Just wipe off as much rust as possible with a clean paper towel and sand the iron wire with a small piece of sandpaper if needed. The wire does have a light coating of oil to reduce rusting.

STEP 6 - Now replace all of the caps back on to the vials which they came off of. Screw the caps on securely. Make sure you ALWAYS put the SAME cap back on the SAME vial it came off of each time you use a chemical. Finally, place all of the vials and all of the plastic envelopes back into the proper place in your chemistry set.

Review of Terms

MICROPLATE - A plastic plate containing a series of small and large wells in which chemicals are tested and reactions observed. The wells are arranged in numbered columns and lettered rows.

PLASTIC PIPETTE - A plastic one-piece dropper. The micro-tip end of the pipette is used to deliver small droplets of liquids for reactions in the microplate.

FILTER FUNNEL - An altered pipette which contains cotton as the filter element.

CHEMICAL SCOOP - A pipette which has had its bulb end cut off and is used as a chemical spoon to deliver solid chemicals.

(RV695)

SECTION 2 - PROPERTIES OF THE MICROCHEMISTRY SYSTEM

Are you ready to do your first experiment?

It is a good thing to know the properties of your equipment BEFORE YOU USE THEM.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Plastic cup
- ❑ Water
- ❑ Methylene Blue Dye Solution
- ❑ Plastic pipette
- ❑ Microplate
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place your microplate on a white piece of paper.

2) Fill a small plastic cup about 1/2 full of water.

3) Add two drops of methylene blue dye to the water in the cup. Be sure to use your MICROTIP pipette for this experiment.

4) Return the blue dye which you have not used back to its original container.

5) Stir the water with the stem of the pipette.

6) Draw up some of the water/dye mixture into the MICROTIP pipette.

7) Place 7 or 8 drops of the water/dye mixture into small wells A-1, A-2, A-3, A-12, B-12, C-12. See Figure #8.

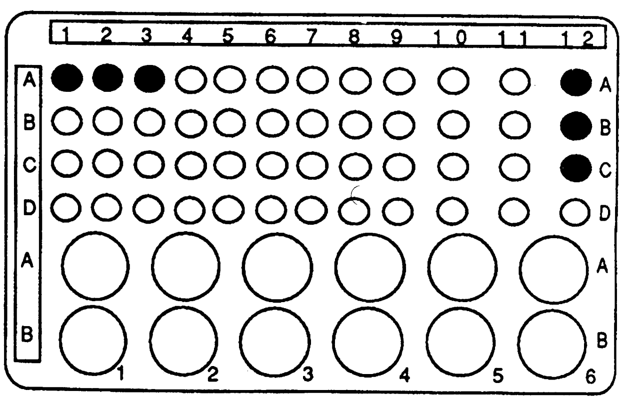

Figure #8

8) Look at the color of the wells with the drops of the coloring. Turn the plate and look at the drops from the side of the plate.

9) Hold the plate up to a light source. Observe the color of the wells through the bottom of the plate.

10) Finally, turn the plate upside down over the white paper. Does anything unexpected happen?

Normally, you would expect the solution to fall out of the wells. This does not happen because the solution holds onto itself and the surface of the plastic well by SURFACE TENSION. Surface tension is the force which binds water to itself and the surface of the container in which it is stored. The surface tension of the water (a force) is greater than gravity (another force). So the water stays in the plate.

11) Now place some of the blue dye/water mixture in three of the LARGE WELLS. Large well B-1, A-3 and B-6. Use more liquid since the large wells can hold more liquid.

12) Look at the color of the large wells with the drops of coloring. Turn the plate and look at the drops from the side of the plate.

PERFORM THE NEXT STEP #13 OVER THE SINK!
DO NOT TRY THIS UPSIDE DOWN OVER YOUR HEAD!

13) Carry the microplate CAREFULLY to the sink. Turn the microplate upside down over the sink. What happened?

14) Now wash the microplate out with water, being careful to clean and rinse all of the wells of the water/dye mixture.

The water/dye mixture acts differently in the large wells than it did in the small wells. Why?
Answer: Water in the large wells has greater mass and a larger surface area. The water in the large wells falls out of the wells. The surface tension of the water is not great enough to keep the water in the large wells.

SECTION 3 - HOW TO DESTROY SURFACE TENSION

How to Destroy Surface Tension

Surface tension, as you have learned, is the property of a liquid's surface to form a thin layer of particles or molecules at the surface of the liquid which pull on one another so that a "surface layer" is formed. This tends to "hold in" the liquid below. On water, for instance, the surface tension is strong enough to support the weigh tof small insects which live on the surface of the water in ponds and lakes. You can see how surface tension forms such a layer by carefully "floating" a needle on the top surface of a container of water.

There are chemicals which will "destroy" or lessen the effect of surface tension. Just think how difficult it would be to wash yourself or other things if the surface tension of the water was so strong that it would not penetrate dirt or cloth or whatever you are trying to wash!

In this experiment we will "destroy" or lessen the effect of surface tension by the use of something that makes water more wet. A dishwashing soap has the property of a "wetting agent," or in other words, it will make water wetter!

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Plastic cup (from your chemistry set)
- ❑ Methylene Blue Dye Solution (from your chemistry set)
- ❑ Liquid dishwashing soap (obtain from grocery or kitchen)
- ❑ Microplate (from your chemistry set)
- ❑ Goggles

(RV695)

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) If you have any methylene blue dye solution left in your cup from the last experiment, you may use it here. If not, mix a little more methylene blue dye solution with water in the plastic cup. (see Section 2, steps 2 and 3).

2) Add one drop of dishwashing soap to the methylene blue/ water mixture. Stir and mix thoroughly.

3) Draw up some of the water/dye/soap mixture into the MICROTIP pipette.

4) Place 7 or 8 drops of the water/dye/soap mixture into small wells of the microplate. Use the same wells as before: A-1, A-2, A-3, A-12, B-12 and C-12.

5) Look at the color of the wells with the mixture in them. Turn the plate and look at the wells from the side of the microplate.

6) Finally, carry the microplate CAREFULLY to the sink. Turn the microplate upside down over the sink.

7) What happens? What does the dishwashing soap do to the water? Why is this property of detergent valuable?

Answer: Dishwashing soap destroys the surface tension of water. The water falls out of the wells. The "wetting" power of the detergent is what makes it a valuable cleaning agent.

Extension:
Try this same experiment using a drop of hair shampoo.
Try this same experiment using dishwasher "Jet Dry™" liquid.
Try this same experiment using a drop of liquid hand soap.

SECTION 4 - ALCOHOL AND SURFACE TENSION

Other chemicals besides soap products have the property of destroying or lessening surface tension. This experiment explores these chemicals.

WARNING: Ethyl alcohol, isopropyl alcohol and rubbing alcohol are flammable liquids. Keep these liquids and their vapors away from any open flame. Use these chemicals only in a well-ventilated area.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Plastic cup
- ❑ Water
- ❑ Methylene Blue Dye Solution
- ❑ Isopropyl "rubbing alcohol," or ethyl alcohol (from the drugstore)
- ❑ Plastic pipette
- ❑ Microplate
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Throw away the water/dye/detergent mixture from the previous experiment.

2) Rinse the plastic cup and add 40 drops of water to the cup.

3) Add a few drops of methylene blue dye solution as you did previously.

4) Add 20 drops of ethyl or isopropyl alcohol to the water in the plastic cup.

5) Repeat steps 6, 7, 8, 9 and 10 from Section 2 Experiment. How is the result similar to either Section 2 or Section 3?

SECTION 5 - A VISIBLE ILLUSTRATION OF SURFACE TENSION

As in many experiments in chemistry, even though changes go on at the atomic or molecular level, we often cannot see the effects with our eyes. Sometimes we need to use something we CAN see to show us things we cannot see. In this experiment we are using fine powders, which we can see, to help us observe the changes taking place with the surface tension layer of a liquid.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Microplate
- ❑ Ethyl or isopropyl alcohol (obtain from drugstore)
- ❑ Water
- ❑ Liquid dishwashing detergent
- ❑ Plastic pipette
- ❑ Baby powder, talcum powder or flour
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Fill two large wells of the microplate with water. Use large wells A-1 and B-1.

2) Fill two other wells with ethyl or isopropyl alcohol. Use large wells A-3 and B-3.

3) Dust the surface of each of the four wells with baby powder, talcum powder or flour.

4) Add 1 drop of dishwashing detergent to one well with alcohol (A-3) and one well with water (A-1).

5) Describe the result. What caused the change?

Notes: ____

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GROUP 4 MIXTURES

Mixtures

TERMS TO KNOW

CHROMATOGRAPH (paper) - A strip of paper which contains separated parts of a dissolved mixture.

CHROMATOPRAPHY (paper) - A process of separating dissolved material.

DISSOLVE - To change form from a solid phase into an aqueous (or liquid) phase. Dissolving always requires two substances.

FILTRATION - The process of separating out from a liquid the solid material which is not soluable in that liquid.

HOMOGENEOUS - Mixed evenly throughout. Example: Milk is a homogeneous mixture; it is just as concentrated at the top, middle, or bottom of a glass.

MATTER - Anything which takes up space and has mass (weight).

MISCIBLE - One liquid which is able to dissolve in another liquid. Example: Alcohol will dissolve in water. Alcohol is said to be miscible in water.

MIXTURE - A combination of two or more pure substances which can be separated by a non-chemical process. Physical means (see below) can be used to separate the substances in a mixture.

PHYSICAL MEANS - Methods of treating material so that only size, shape or physical state (liquid, gas or solid) are changed. Example: Stirring, turning water to steam, freezing a liquid, or dissolving.

SOLUBLE - Able to be dissolved.

SOLUTE - The substance which dissolves in a solution.

SOLUTION - A mixture of two or more pure substances. In a solution one pure substance is DISSOLVED in another pure substance, HOMOGENEOUSLY. Example: Salt can be dissolved in water. The salt water has the same concentration throughout. The salt water solution is homogeneous.

SOLVENT - The substance which dissolves another to form a solution. Example: In a salt and water solution, water is the solvent. Salt is the solute.

PHYSICAL MIXTURES

Un-Mixing Mixtures and Compounds

Compounds and elements can be combined by physical means to form **MIXTURES AND SOLUTIONS**. Mixtures and solutions can be separated by **PHYSICAL MEANS**.

Mixtures can be classified into several groups. A mixture of sand and sugar is a **mixture of two solids**. A mixture of sand and water is a **mixture of a solid and a liquid**. A mixture of sand and water is NOT a solution since the sand does NOT DISSOLVE in the water. After stirring the sand and water mixture, the sand will settle to the bottom. A sand and water mixture is NOT a homogeneous mixture.

A mixture of a solid which dissolves in a liquid, or two liquids which dissolve in each other evenly (MISCIBLE), is a special kind of mixture called a **SOLUTION**. Solutions are mixtures of a **SOLVENT** and a **SOLUTE**. Solutions are always **homogeneous**.

You will recall, that oxygen, nitrogen, and helium are different gasses. When two or more gasses are mixed together they **ALWAYS** form a solution.

Let's make and separate some **MIXTURES** using physical means.

SECTION 1 - SOLID/SOLID MIXTURE

In this experiment we examine the simplest of mixtures, the "SOLID/SOLID MIXTURE", which is how many things in our everyday lives are combined. An example would be the mixing of flour, salt, spices, and baking soda in a baking recipe. It is often difficult or impossible to separate a solid/solid mixture because the particles are so small or have so closely mixed. The following experiment uses small solid particles which we CAN separate because of their unique properties.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Table salt
- ❑ Zinc powder
- ❑ Chemical scoop
- ❑ Pipette
- ❑ Water
- ❑ Filter funnel
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place one scoop of zinc powder with one scoop of table salt (sodium chloride, NaCl) in a plastic cup. (If you are unsure of how to make a chemical scoop, see Figure #3.)
2) Stir the two solids together and mix thoroughly. This is a mixture. Can you separate the two solids?
3) Add three full pipettes of tap water to the mixture of solids in the cup.
4) Stir the water/zinc/salt mixture. Which solid dissolved? This is another mixture.
5) Slowly pour the salt/zinc/water mixture through the filter funnel. If the liquid does not come through the filter funnel immediately, tap the top of the filter funnel with your finger to shake loose air bubbles which might prevent liquid flow. Catch the FILTRATE, the liquid coming through the filter, in another plastic cup. (If you are unsure of how to make a chemical scoop, see Figure #3.)
6) Which solid remains in the filter funnel? What remains in the liquid?
7) Leave the remaining solution in the plastic cup. Let the solution remain in the cup until the liquid EVAPORATES (changes into a vapor or gas). Observe what remains after the water evaporates. Using a magnifying glass compare the residue (what is left over) with a sample of the original zinc granules and original table salt you used.

The experiment above shows how the individual properties of solids can be used to aid in the separation of solids from a mixture.

How could a mixture of salt and pepper be separated?

SECTION 2 - SOLID/LIQUID MIXTURE

Another example of a common mixing of substances uses a liquid and a solid... but it is still a MIXTURE... and, like the solid/solid mixture, can be separated. Neither the solid/solid mixture nor the solid/liquid mixture is CHEMICALLY combined ... and therefore we can separate the things we have mixed back to their original form. Take note of HOW we do this separation.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Zinc powder
- ❑ Chemical scoop
- ❑ Water
- ❑ Filter funnel
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place one scoop of zinc powder into a plastic cup and add three full pipettes of water to the zinc powder. Stir these together.
2) Can you separate this liquid from this solid?
3) Slowly pour the zinc/water mixture through the filter funnel. Catch the FILTRATE from the funnel in another plastic cup.
4) What material remains in the filter funnel?

What does the SOLID/LIQUID mixture have to be like so that you can separate them by filtration?

SECTION 3 - SOLID/LIQUID MIXTURE

One of the most fascinating areas of chemistry is the study of CHROMATOGRAPHY. In this experiment we use the tools and methods of chromatography to separate a solid/liquid mixture (in this case, ink - a solid dissolved in a liquid). Think how many other ways you could use chromatography as a tool or method to separate things that you thought before was impossible!

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Ethyl or isopropyl alcohol (obtain from grocery store or pharmacy)
- ❑ Water
- ❑ Pipettes (2)
- ❑ Filter paper (from your chemistry set)
- ❑ Pair of scissors
- ❑ Pencil
- ❑ Ink marker pens with small points, use different color markers in this experiment
- ❑ Plastic sandwich bag
- ❑ Metric ruler
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

WARNING: ETHYL AND ISOPROPYL ALCOHOL ARE HAZARDOUS. THESE LIQUIDS AND THEIR VAPORS ARE HIGHLY FLAMMABLE. DO NOT USE NEAR A FLAME. USE WITH ADEQUATE VENTILATION.

When solid substances are dissolved in a liquid (this is the most common form of solution) they can be separated by the process called CHROMATOGRAPHY. There are several forms of chromatography. We will be using paper chromatography to illustrate the process.

1) Place 1/2 pipette of water in a large well in the microplate.
2) Add 1/2 pipette of ethyl alcohol to the same well.
3) Mix thoroughly by drawing up all the liquid into the bulb of the pipette and squeeze the bulb to return the liquid to the well.
4) From the large sheet of filter paper supplied in your chemistry set, and using your metric ruler and pencil, carefully mark a strip of filter paper which is 1/2 inch (about 12 mm) wide by 4 inches (about 100 mm) long.
5) Make a PENCIL line across the width of the paper about 1/2 inch (12 mm) from one end of the paper. See Figure #10.
6) Make a black ink blot on the middle of the pencil line.

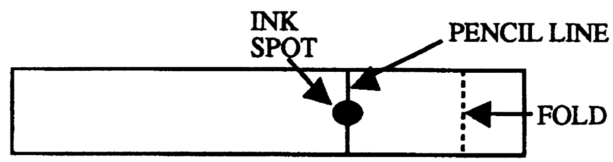

Figure #10

7) Using one of the small point ink marker pens, make a black ink dot in the middle of the pencil line.
8) Allow the ink dot to dry and again dot the marker on the same spot. Allow to dry. Repeat this several times until you have a small ink blot which has a lot of ink in it.
9) You now have what is called an UNDEVELOPED CHROMATOGRAPH.
10) Fold the paper above the end of the strip, but BELOW the pencil line.
11) Insert the ink stained, folded end on the paper strip into the alcohol/water mixture in the large well of the Microplate. DO NOT ALLOW THE INK OR PENCIL LINE TO COME IN CONTACT WITH THE SOLVENT SOLUTION IN THE WELL. (See Figure #10A)

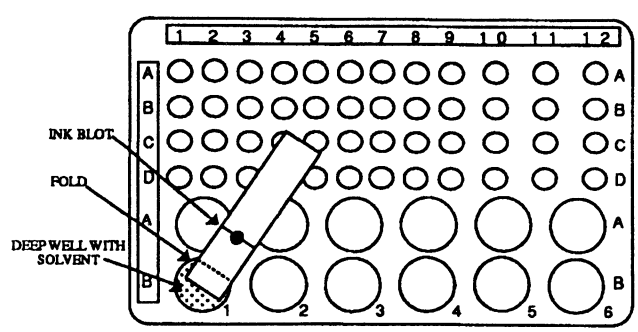

Figure #10A

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12) You will see the solvent (alcohol and water solution) "creep" up the paper from the well. Allow this solvent to move up and through the strip of paper. Soon it will pass the ink blot and continue on toward the other end of the strip.

13) Carefully place the microplate and the chromatograph strip into the plastic sandwich bag and allow the process to continue.

14) When the solvent reaches the end of the paper strip away from the blot remove the DEVELOPED CHROMATOGRAPH from the Microplate. Allow the paper to dry.

15) Observe what happened to the ink blot. What do you see as a result of the solvent going through and <u>past</u> the ink blot? Do you see any colored lines or bands from the ink blot?

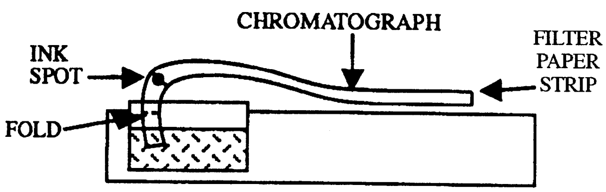

Figure #10B

SECTION 4 - SEPARATION OF COLORS

Color chromatography, a method of separating colors which are mixed, is a simple yet effective way of separating things which before was extremely difficult. This experiment is fun and very "colorful"! Think of other things which have color that you could separate into its individual colors by use of this method!

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Rubbing Alcohol (isopropyl alcohol) (obtain from grocery store or pharmacy)
- ❑ Water
- ❑ Pipettes (2)
- ❑ Filter paper (from your chemistry set)
- ❑ Pair of scissors
- ❑ Pencil
- ❑ Ink marker pens with small points, use different color markers in this experiment
- ❑ Plastic sandwich bag
- ❑ Metric ruler
- ❑ Goggles

<u>BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!</u>

1) Place 1/2 pipette of water in each of the 6 large wells of your Microplate.

2) Place 1/2 pipette of isopropyl alcohol into each of the wells where you have already placed the water.

3) Mix thoroughly by drawing up all of the liquid into the bulb of the pipette and squeezing the bulb to return the liquid to the well.

4) From your large piece of filter paper, mark and cut 6 strips as before.

5) Mark the pencil line across each filter paper strip as before.

6) Using 6 different colored markers, place a different color marker ink on each of the strips right in the middle of the pencil line as shown before.

7) Allow the different colored blots to dry on their individual paper strips.

8) Fold each paper strip above the ends of the strip but BELOW the pencil lines.

9) Insert the ink stained/folded end of each strip in its OWN well of solvent. Make sure the papers do not touch each other. Gently lay the strips up across the Microplate pointing toward the small wells. DO NOT ALLOW THE INK OR PENCIL LINE TO COME IN CONTACT WITH THE SOLVENT SOLUTION IN THE WELLS.

10) Carefully place the Microplate and all of the strips inside of the plastic sandwich bag and allow the "creep" of solution to go to the ends of the paper.

11) When the solvent reaches the end of the paper strip away from the blots, remove your developed chromatographs from the Microplate and allow the paper to dry.

12) Put the dried sheets along-side each other.

13) Are there any of the strips that look similar? Are there any similarities among any of the colors? How do you know?

SECTION 4A - MORE COLOR SEPARATION

Repeat the same experiment as in SECTION 4 but this time, instead of color markers, try using ball point pens of different colored ink. Try using "water soluble" markers. Try using "permanent" markers. Observe the different dyes used in the marker and pen inks.

Notes: ____

SECTION 5 - LIQUID/LIQUID MIXTURES

One of the most difficult mixtures to separate is the mixture of liquids because the individual particles of the liquids intermingle and mix so completely...even though they do not combine chemically. It is often very difficult to remove the pollutant benzene, or other liquid toxins from our drinking water. This is one of the biggest jobs of the water company which supplies our fresh drinking water... to remove the "bad" liquids from our liquid water. Even with the liquid/liquid mixture below, an easy separation for us in the laboratory, it is difficult and expensive on a large scale. Can you think of a disaster on the coast of Alaska involving a liquid/liquid mixture?

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Vegetable oil (obtain from your kitchen)
- ❑ Water
- ❑ Pipettes (2)
- ❑ Plastic cup
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 pipette of vegetable oil in a plastic cup.
2) Add 1/2 pipette of water to the oil.
3) Mix thoroughly by drawing up all the liquid into the bulb of the pipette and return the liquid to the plastic cup.
4) While the oil/water are still mixed, draw the mixture into a pipette.
5) Place a test tube into one of the large wells of your Microplate.
6) Place the pipette TIP DOWNWARD in the test tube.
7) Allow the pipette to stand for 5 minutes with the stem facing down.

Oil and water are NOT MISCIBLE. The water will settle out of the mixture. The oil will float on top of the water. When no further changes are noted in the water/oil mixture, continue with step 8.

8) Squeeze the pipette slowly and drain the water layer into a plastic cup.
9) The oil remains in the pipette and the water has been drained into the plastic cup.

SECTION 6 - SOLID/SOLID MIXTURE II

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Zinc powder (Zn)
- ❑ Iron filings (Fe)
- ❑ Plastic cup
- ❑ Magnet
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place one scoop of zinc powder (Zn) and one scoop of iron filings (Fe) in a plastic cup.
2) Mix the two solids until the mixture is uniform.
3) Can you separate the two solids? (Both zinc and iron filings are NOT soluble in water.)
4) Draw a magnet through the mixture. What happens? Which solid responds to the force of a magnet? Which does not?

SOLID MIXTURES AND LIQUID MIXTURES CAN BE SEPARATED BY TAKING ADVANTAGE OF THEIR DIFFERENT PROPERTIES.

Notes: ____________________

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GROUP 5 CHEMICAL MODELS CHEMICAL REACTIONS

Chemical Models and Chemical Reactions

TERMS TO KNOW

ATOM - The smallest particle of an element.

CHEMICAL MEANS - Methods of treating material which separate pure substances into new compounds or elements.

COMPOUND - A chemical combination of two or more elements. A compound has different properties from the elements which make it up. Compounds cannot be separated into their elements by physical means.

ELECTRODE - A wire which is placed in an electrolyte and through which an electrical charge flows.

ELECTROLYTE - A solution which conducts an electric current.

ELECTRON - The particle outside the nucleus of an atom which carries a negative (—) charge.

ELEMENT - A substance which contains only ONE KIND of atom. Example: iron, sulfur or carbon are each ELEMENTS.

EQUATION - A statement showing the way chemicals combine or break up. An equation shows how reactants become products in a chemical reaction.

ION - An atom or a group of atoms which are NOT electrically neutral. Ions will either be POSITIVE charged or NEGATIVE charged.

METAL - A chemical element which tends to lose electrons in a chemical reaction. Example: Sodium Metal (Na) will give off one electron per atom during a chemical reaction. Sodium metal atom will then become a sodium metal ion ($Na+$).

MODEL - A representation of something else.

NON-METAL - A chemical element which tends to gain electrons. Example: A Chlorine atom will accept an electron to become a Chlorine Ion (Cl^-).

PERIODIC TABLE - A list of the different elements and some of their properties.

PRODUCT - A substance which is produced in a chemical reaction.

PROTON - The particle in the nucleus center of an atom which carries a positive (+) charge.

REACTANT - A substance which combines with another in a chemical reaction.

REACTION - The chemical combination or change of two or more elements or compounds.

STOICHIOMETRY - The combining ratios of chemicals in a chemical reaction.

It is important to know how chemicals react before you experiment. An explanation of the workings of chemical reactions means that a **MODEL** should be used. Models are used because the atoms and molecules which make a chemical reaction are far too small to be seen even with the most powerful microscope.

A MODEL is an imitation of the real thing. Models are useful in trying to understand how things work. Scientists often use models to explain unseen forces. We use models to make an idea easier to understand.

The advantage of a model is in its ease of use. For example, it is certainly easier to show someone a MODEL of a plane, rather than a full size one.

A MODEL airplane is an imitation. A model plane is not a real plane. It is a smaller representation of a real plane. It can be used to imitate the workings of a real plane. A model can help to picture something real but unseen or unfamiliar.

In the same manner, models of chemicals can be used to scale down, represent or MODEL the functioning of *REAL* chemicals.

When chemicals combine they are said to **REACT**. Reactions can be of several types involving few or many chemicals. By using cut-out model ions you can see how different chemicals can combine to form the many compounds which chemists find so interesting.

In addition to the paper cut-out atoms and ions, your chemistry set contains three-dimensional (3-D) models of atoms. These models give a 3-D view of the structure of some of the chemical compounds which you will use in your set.

It is interesting to see if you can build both the paper model and the 3-D model of molecules for comparison. The paper model is useful only to show how many ions combine with others to form compounds. The method of telling how many IONS of one chemical reacts with how many ions of another is called **STOICHIOMETRY** (sto 'key ah ma tree). The 3-D models give you a better picture of what chemists think these molecules would look like if we could see them. The 3-D models still can show the stoichiometry of a reaction.

Experiments with Model Elements and Ions

An **ELEMENT** is a chemical which has only one kind of atom. These atoms are neutral in charge.

An **ION** is an atom or group of atoms which is NOT electrically neutral. Some ions are positive in charge. Other ions are negative in charge.

Chemists experiment with ELEMENTS and IONS.

Atoms, though very small, are made up of parts. These parts make the atom what it is. Atoms are the basic building blocks of ALL CHEMICALS.

In order to talk about the atom, scientists have devised a MODEL of what an atom looks like. This model is called the PLANETARY or BOHR model of the atom. The model is named after a scientist, Niels Bohr, who came up with the idea. Further, based on the reactions of atoms, they have an idea (MODEL) of what the molecules of chemical compounds look like.

The nucleus is the center of the atom and has almost all the WEIGHT or MASS of the atom. Each element has a DIFFERENT NUMBER of positive charges in the center of the atom. These charges are called PROTONS. The number of positive charges in the center of the atom is called the ATOMIC NUMBER. Each element has a distinct atomic number.

The positive particles or protons, along with neutral particles, called NEUTRONS, make up the NUCLEUS of an atom. See Figure #11.

The atom also contains negative charges, called ELECTRONS, which are located at different distances from the nucleus in ORBITS or ENERGY LEVELS.

The number of electrons in an element is the same as the number of protons in the same element. The number of electrons (-) must equal the number of protons (+) in a neutral atom. The electrons are NOT located in the nucleus.

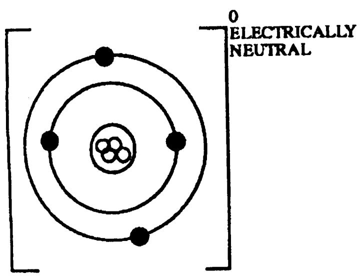

Figure #11

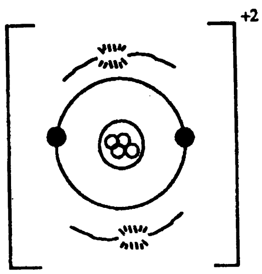

Figure #12

If the number of electrons DOES NOT EQUAL the number of protons, the atom has a charge. What is a charged atom called? See Figure #12. Figure #12 is an example of a positively charged ion.

Even though the electrons are located at a distance from the nucleus, ELECTRONS MAKE CHEMICAL REACTIONS HAPPEN.

Chemists have organized all the known atoms into an organized list they call the PERIODIC TABLE. See Table #1 found at the end of your manual.

Each ELEMENT has only the same type of atoms. By organizing the known atoms, or elements into a table, chemists have been able to predict the properties of many other elements and the chemical compounds they form. The most important organization of all elements is the division of the elements into two general classes.

The two general classes of elements are:

Metals and Non-Metals

Metals tend to GIVE UP or release electrons. Non-metals tend to GAIN or take on electrons.

The paper and plastic models of atoms have been organized into these two groups.

SECTION 1 - PAPER CHEMISTRY LAB 1

Most of the time chemists never actually SEE the atoms and molecules which make up the chemical reactions they study and experiment with.

What we, as chemists, can "see" in our mind's eye, are the representations, or MODELS, of atoms and molecules!

You are urged to complete this experiment fully because each of the models you will see and study, will represent for you the "picture" of unseen atoms and molecules and how these very small building blocks of our world combine and form new substances!

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Paper ions and atoms (pink and blue sheet of cardboard ions from your chemistry set)
- ❑ Pair of scissors
- ❑ 3-D plastic models (from your chemistry set)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Cut out or separate all the paper atoms which are metals.

Notice that the metal atoms have little triangles on one side. These triangles represent (are MODELS of) the electrons which metals lose when they form compounds. Each ELEMENT has a SYMBOL. A SYMBOL is like a special initial or name (model) which is written instead of using the whole word for the element.

The SYMBOL is used by chemists as a shorthand way of talking about chemical elements or chemical ions.

For example, sodium is a metal element. Sodium has a SYMBOL. The symbol for sodium is Na. The Na stands for the original name for sodium which was NATRIUM. The symbol Na is still used today. Sodium acts alone as a chemical element. Many of the elements on the Periodic Table have symbols taken from their original names in Greek or Latin. Iron was originally called ferrum. The symbol for iron is Fe. Gold was called aurum. The symbol for gold is Au.

Usually, the symbol for the element is the first letter or first two letters in its English name. Oxygen's symbol is O, hydrogen's is H, nitrogen's is N, helium's is He, etc.

2) Cut out or separate all the paper atoms which are non-metals.

Notice that the non-metal atoms have little notches on one side. These notches represent (are MODELS of) the sites which non-metals use when they form compounds.

There is a set of 3-D models of the elements in your chemistry set. These models give you another way of seeing how chemicals combine. The plastic models are also color coded. (See Table #2 on page 15.)

3) Chlorine is a non-metal. The symbol for an atom of chlorine is Cl. Chlorine exists in nature as a gas made of two atoms joined together. Chlorine is DIATOMIC (die' ah tom ik). This means two atoms of a particular element joined together to form a molecule.

4) Select two paper atoms of chlorine.

5) Slide the two atoms together in such a way that the side tab and notch of one chlorine fill the side notch and tab of the other. See Figure #12A.

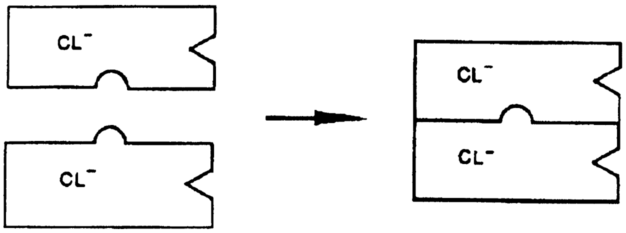

Figure #12A

This is a MODEL of a MOLECULE OF CHLORINE. A chlorine molecule would have the symbol Cl_2.

6) Using your plastic molecule models now make a 3-D model of chlorine. Use the following color code to identify the different atoms. See Figure #13.

TABLE #2
Color code for plastic molecule models

COLOR	Number of Arms	Atom this represents
Black	4 arms	Carbon
White	1 arm	Hydrogen
Red	2 arms	Oxygen
Green	1 arm	Chlorine, Fluorine
Gray	1 arm	Sodium, potassium
Orange	2 arms	Iron +2
Orange	3 arms	Iron +3
Silver	3 arms	Aluminum
Yellow	4 & 6 arms	Sulfur
Blue	4 arms	Nitrogen

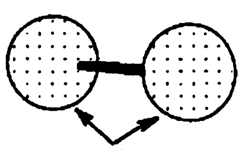

Figure #13

7) Select a sodium metal atom and a chlorine non-metal molecule from your supply.

8) Slide the sodium metal atom's triangles into the notch in the chlorine atom.

9) Once the sodium metal has been placed into contact with the chlorine, the side tie to the other chlorine is broken. Pull away the combined chlorine with the attached sodium from the uncombined chlorine.

What do you think happens to the uncombined chlorine atom?

The combination of sodium, a metal, with chlorine, a non-metal, has formed a new substance, a compound. This compound is sodium chloride. The FORMULA (model) for sodium chloride is NaCl.

10) Make a 3-D model of sodium chloride. Use the color code given in Table #2 to identify the different atoms. See Figure #14.

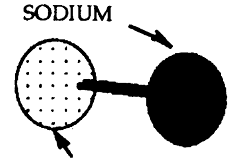

Figure #14

Sodium metal is a silvery substance. It is an active element which will react violently with water. Chlorine is a green-yellow gas. Chlorine was used in war as a poison. Sodium chloride is a substance which is essential to life. Sodium chloride is also known as table salt. We use table salt to season our food. Sodium chloride is a simple compound which has the properties of neither sodium nor chlorine.

THE REACTION OF TWO OR MORE SUBSTANCES PRODUCES A NEW SET OF SUBSTANCES WHICH ARE DIFFERENT THAN THE ORIGINAL CHEMICALS.

Two or more elements can react with each other to form a new chemical called a **COMPOUND**.

The process of forming a compound from the elements is called **SYNTHESIS** (sin' the sis).

SECTION 2 - PAPER CHEMISTRY LAB II

Iron is a metal. Iron can combine with many non-metals. The most common compound formed by iron is iron oxide. The oxide of iron is known as RUST.

Some elements, you may remember, are diatomic. Oxygen is diatomic like chlorine. Iron is not diatomic.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Paper models of Iron +2 and Cl -1
- ❑ 3-D models of the atoms of Iron +2 and Cl -1
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Select four paper iron atoms.

2) Make three oxygen molecules (that's six atoms, combined to form three molecules).

3) Rearrange the atoms to form two molecules or iron oxide, or rust. Rust has the formula Fe_2O_3.

4) Try to make a 3-D model of iron oxide. How do the atoms arrange themselves? Does the paper model show this? See Figure #15.

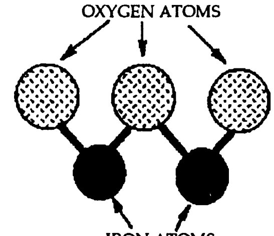

Figure #15
This is another synthesis reaction.

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SECTION 3 - SYNTHESIS

Synthesis is one of the most important and interesting areas of chemistry. You, as a chemist, are putting together, perhaps for the FIRST TIME EVER, chemicals which have never been put together before!

Even though the reactions you are doing are "known"... you will be making "brand new" chemicals and compounds which were not present in the materials you are working with before you started your experiment!

As a good chemist, you must observe closely and you must record or write down your results. The chart and tables are provided for your NEW data!

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Sodium chloride solution
- ❑ Calcium nitrate solution
- ❑ Ferrous sulfate solution
- ❑ Cobalt chloride solution
- ❑ Ammonium chloride solution
- ❑ Microplate
- ❑ Plastic pipettes (6)
- ❑ Short (1 cm) lengths of iron wire (from your chemistry set)
- ❑ Water
- ❑ Small test tube
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Using your MICROTIP pipette, place ten drops of sodium chloride solution to one of the small wells in the microplate. Rinse the plastic pipette. Place ten drops of calcium nitrate solution in another small well. Repeat this process with ferrous sulfate, cobalt chloride and ammonium chloride solution. Be sure to rinse the pipette between each chemical solution.

2) Add four drops of water to each solution.

3) Place fourteen microdrops of water in an adjacent well. See Figure #15A.

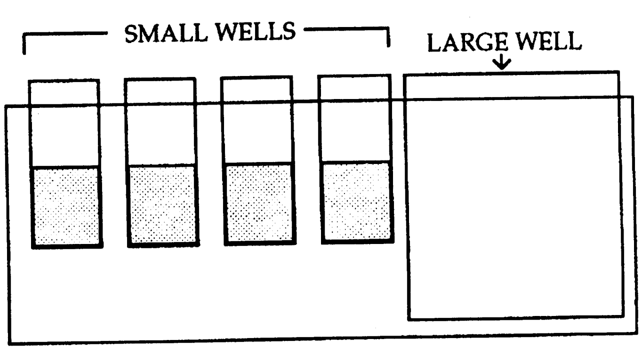

Figure #15A

4) Place 1 cm length of iron wire in each of the wells containing a solution.

5) Place another 1 cm length of iron wire in an adjoining empty well. This is a control.

6) Fill a small test tube with water.

7) Place a 1 cm length of iron wire in the test tube so that the wire is totally UNDER the water's surface.

8) Stand the small test tube in a large well in the microplate. See Figure #16.

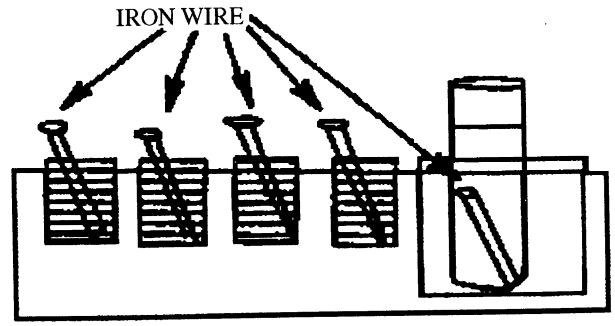

Figure #16

9) Let all the iron wires remain, undisturbed, for two days.

10) Observe the iron wire over the next two days.

11) How did the iron wire change? Where have you seen this color before? What chemical do you think has formed from the iron wire?

12) Which wire showed the most change? Which wire showed no sign of change? What other chemical is necessary for iron wire to change the way it did?

SECTION 3A - SYNTHESIS

In this experiment you will go even further in making "new materials". The main tasks of the chemist are (1) experimenting, (2) observing, and (3) recording the results so that the synthesis of new materials and new substances can be proven and done again by another chemist in another lab! If a friend also has a chemistry set, compare data and results with your friend as you each do the same experiment separately!

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Sodium chloride solution
- ❑ Calcium nitrate solution
- ❑ Ferrous sulfate solution
- ❑ Cobalt chloride solution
- ❑ Ammonium chloride solution
- ❑ Microplate
- ❑ Plastic pipettes (6)
- ❑ Copper wire lengths (1 cm) from your chemistry set
- ❑ Aluminum wire lengths (1 cm) from your chemistry set

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- ❑ Water
- ❑ Small test tube
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

NOTE: Copper wire is copper colored (like a new penny) and will NOT be attracted by a magnet. Aluminum wire will seem very light in weight and will be shiny silver in color. Aluminum wire will NOT be attracted by a magnet.

1) Using your microtip pipette, place ten drops of sodium chloride solution in small wells A-1 and A-12. Rinse the pipette. Place ten drops of sodium chloride solution in small wells A-1 and A-12. Rinse the pipette. Place ten drops of calcium nitrate solution in small well B-1 and B-12. Repeat this process placing ferrous sulfate solution in C-1 and C-12, cobalt chloride in small wells D-1 and D-12, ammonium chloride in D-3 and D-10. Be sure to rinse the pipette between each chemical solution.

2) Add four drops of water to each solution.

3) Place fourteen drops of water in small wells D-4 and D-9. See Figure #16B.

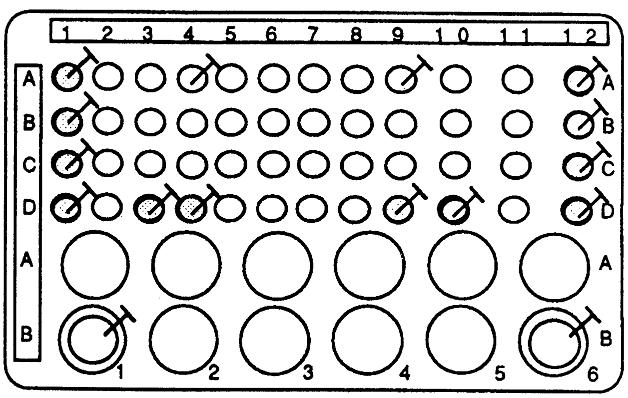

Figure #16B

4) Place 1 cm length of copper wire in small wells A-1, B-1, C-1, D-1, D-3 and D-4.

5) Place 1 cm length of aluminum wire in small wells A-12, B-12, C-12, D-12, D-9 and D-10.

6) Place 1 cm length of copper wire in empty small well A-4. Place 1 cm length of aluminum wire in small empty well A-9. These are control wells.

7) Fill two small test tubes with water.

8) Place 1 cm length of copper wire in one test tube so that the wire is completely under water's surface. Stand this test tube in large well B-1.

9) Let the wire remain undisturbed for two days.

10) Observe the wire for the next two days.

11) Did the wire change?

12) Comparing reactions of the iron wire from Section 3 and the aluminum and copper wire from Section 3A, which wire showed change? Which wire showed no change? What can you predict about the use of copper and aluminum wire instead of iron wire? Record your results on Data Table #3.

DATA TABLE #3

CHEMICALS USED	IRON NAILS	COPPER NAILS	ALUMINUM NAILS
SODIUM CHLORIDE			
CALCIUM NITRATE			
FERROUS SULFATE			
COLBALT CHLORIDE			
AMMONIUM CHLORIDE			
WATER			
WATER (SUBMERSED)			

SECTION 4 - PAPER CHEMISTRY LAB III

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Paper models of atoms
- ❑ 3-D models of atoms

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

Now that you have seen the way chemicals can combine to form a new substance, let's take the same chemical apart. The compound, sodium chloride can be separated into the original elements by adding the correct amount of energy. The process of making a compound return to the elements from which it was formed is called **DECOMPOSITION** (dee' kom po zi shun) or **ANALYSIS** (an al' lee sis).

1) Join one sodium atom to one chlorine atom to form a sodium chloride molecule. Make two paper molecules of sodium chloride. This is the process of SYNTHESIS.

2) DECOMPOSE the two molecules of sodium chloride by breaking the two chlorine atoms away from the sodium atoms.

3) The two atoms of chlorine combine with each other to form a MOLECULE of chlorine. This molecule of chlorine has the symbol Cl_2.

4) Each of the two atoms of sodium remain individual atoms of sodium.

5) The compound sodium chloride has been DECOMPOSED into the elements sodium and chlorine.

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SECTION 4A - USING MOLECULAR MODELS

Repeat the building of the molecules listed in Section 4 by using the 3-D molecular models provided in your chemistry set. Use the color code found in SECTION 1:6 to identify the different atoms.

SECTION 4B - USING MOLECULAR MODELS II

Look at the labels on the vials of chemicals provided in your chemistry set. There is listed on each label the name of the chemical as well as the FORMULA of the chemical compound which that name represents.

Write down on the chart below the name of the chemical compound, and next to it, the chemical FORMULA of that compound. The chart has started a few entries for you. Now you complete the rest.

DATA TABLE #4

Chemical Name on label of vial	Chemical Formula of the compund
CALCIUM NITRATE	$Ca(NO_3)_2$
SODIUM SILICATE	$Na_2SiO_3{\cdot}5\ H_2O$
SODIUM CARBONATE	Na_2CO_3

After you have listed all of the names and formulas, and using your paper models, construct as many of the compounds as you can with the paper models. This will let you think of the "making" (COMPOSITION) of chemical compounds in the same way chemists think of them.

Now try to put together your plastic 3-D models of these same chemical compounds which you were able to put together your paper models. Use the proper color code for different elements of your compounds as shown in SECTION 1:6.

SOME FORMULAS may be too long or complex to do with your models, so don't worry if you don't get all of them. You should, however, be careful with most of the chemicals.

At right are included some examples of simple and complex molecular models.

As you do the various experiments in this set, try building models of the reactions. This will help you to understand what is happening in each reaction. For example, reacting hydrogen with oxygen will result in the formation of water. The reaction looks like this:

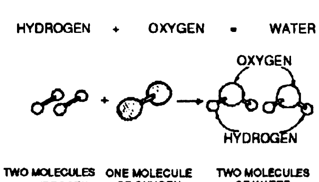
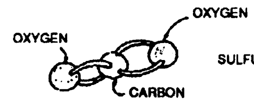


Figure 16-n

You might look around your house for things like styrofoam balls, modeling clay, toothpicks, pipe cleaners, and straws. These make excellent materials for building larger molecular models. Gum drop candies and toothpicks make great molecular models!



CARBON DIOXIDE MOLECULE

Figure 16-b

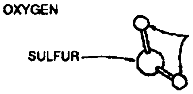
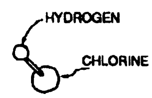
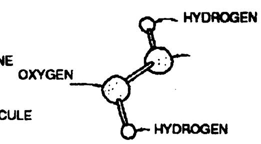


Figure 16-c



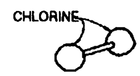
HYDROGEN CHLORIDE MOLECULE

Figure 16-d



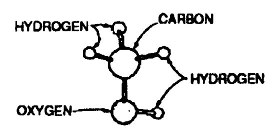
HYDROGEN PEROXIDE MOLECULE

Figure 16-e



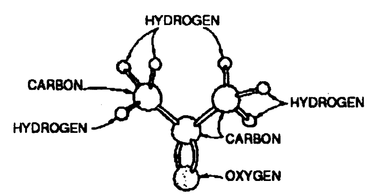
CHLORINE MOLECULE

Figure 16-f



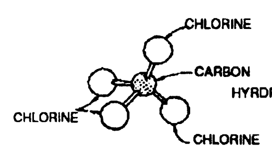
METHANOL MOLECULE

Figure 16-g



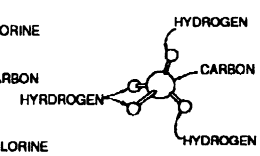
ACETONE MOLECULE

Figure 16-h



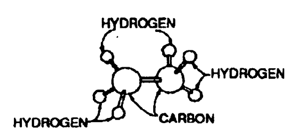
CARBON TETRACHLORIDE MOLECULE

Figure 16-i



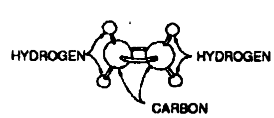
METHANE MOLECULE

Figure 16-j



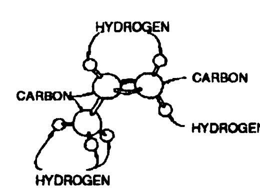
ETHANE MOLECULE

Figure 16-k



ETHYLENE MOLECULE

Figure 16-l



PROPYLENE MOLECULE

Figure 16-m

SECTION 5 - DECOMPOSITION OF WATER, A CHEMICAL CHANGE

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Plastic pipette
- ❑ 9-volt battery
- ❑ 9-volt battery clip
- ❑ Microplate
- ❑ A strip of filter paper and scissors
- ❑ Vinegar (acetic acid) - obtain from your kitchen
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/4 pipette full of vinegar in a small plastic cup.

2) Add 3 pipettes of tap water to the vinegar and stir with the pipette by drawing the solution up into the pipette and then squirting it back in the cup. Do this several times to insure a good mixing of the vinegar (acetic acid) and water.

3) Place one pipette of the water-vinegar solution in wash of three large wells of your microplate. Use wells B-1, B-2 and B-3. Two adjoining wells are for the experiment. The third well is a control.

4) Cut a piece of filter paper 6 mm x 60 mm. Wet the entire strip of filter paper with vinegar solution.

5) Place one end of the filter paper in large well B-1 and the other end of the filter paper strip in large well B-2.

6) Connect a battery clip to a 9-V battery.

7) Place the red coated wire (+ charge) in one of the wells containing the paper and the black wire (- charge) in the well containing the other end of the paper. See Figure #17.

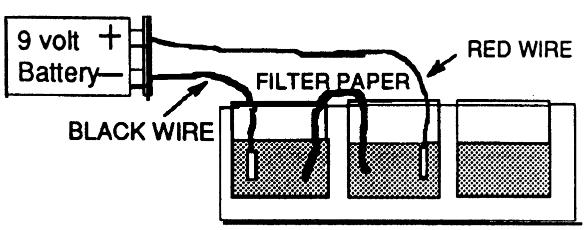


Figure #17

8) Observe the bubbling from each of the wells.

9) What charge is on the oxygen ion? (See your paper ion collection for the answer, if necessary).

10) What charge is on the hydrogen ion? (See your paper ion collection for the answer, if necessary).

11) If unlike charges attract each other, what possible gaseous elements are being given off at the positive charged wire?

12) What gaseous products are given off at the negative charged wire?

13) You are decomposing water (H_20) into its two basic elements. These two basic elements are oxygen and hydrogen.

14) Since hydrogen and oxygen are both gaseous at normal conditions, you should see bubbles forming at the wires, and bubbles moving up the wires to the surface of the liquid.

15) Since hydrogen IONS are positive (H^+) these will be attracted to the NEGATIVE wire (negative electrode). Since the oxygen (0^-) ions are negative, they will be attracted to the POSITIVE wire (positive electrode).

16) The acetic acid (vinegar) was used only to make the water conduct electricity better. The vinegar helped the water be an ELECTROLYTE.

17) Look closely at the positive electrode and at the negative electrode. Which electrode seems to be producing more bubbles than the other?

18) Since water is made up of <u>two</u> hydrogens for every <u>one</u> oxygen (H_20), there will be twice as much hydrogen gas produced as oxygen gas.

19) More bubbles will be produced at the negative electrode (where hydrogen gas is produced) than at the positive electrode (where oxygen is produced).

20) The wet filter paper between the wells not only conducts electricity between the wells but it also lets any ions go back and forth to get to the electrode to which they are attracted.

SECTION 6 - PAPER CHEMISTRY IV

Again, you get to use models to let you "see" and understand something that is happening on the atomic and molecular level which you cannot actually see with your eye. Remember the "way" in which the hydrogen and oxygen go together and come apart. This is an important reaction to know about.

Hydrogen and oxygen only go together in a very certain way to make water molecules. Water only decomposes in a very certain way to produce hydrogen gas and oxygen gas. Can you see the simple mathematical way that this happens?

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Paper models of hydrogen
- ❑ Paper models of oxygen
- ❑ 3-D models of hydrogen
- ❑ 3-D models of oxygen
- ❑ One red pencil
- ❑ One black pencil

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Build two paper models of water (H_20).

2) Place two pencils down on the table top. These two pencils represent the red and black wires in the water electrolyte.

3) Break the molecules of water up to form hydrogen gas at the negative wire (negative electrode). Remember hydrogen is diatomic gas (H_2).

4) Break the molecules of water up to form oxygen gas at the positive wire (positive electrode). Remember oxygen is diatomic gas (0_2).

5) Now can you see why twice as many bubbles are formed at the electrode where hydrogen gas is produced?

SECTION 6A - USING 3-D MODELS

Repeat the building of the molecules listed above by using the 3-D molecular models provided in your chemistry set. Use the color code found in SECTION 1:6 to identify the different atoms.

CHEMICAL COMPOUNDS AND CHEMICAL SEPARATIONS

Isolation of Elements from Compounds

Compounds are **NOT** mixtures. A mixture can be separated by physical means. Examples of physical means include: boiling, condensing, melting, thawing, etc. The substances in a mixture keep their own physical properties. Compounds can only be separated into elements by CHEMICAL MEANS. A compound is a chemically **DIFFERENT SUBSTANCE** from the reactants which formed it.

THE SEPARATION OF ELEMENTS FROM THEIR COMPOUNDS ALWAYS REQUIRES THE USE OF ENERGY FROM SOME OUTSIDE SOURCE.

Elements can be isolated or separated from compounds by using electrical, chemical or heat energy. The compound containing the element to be isolated must receive enough energy to allow the splitting of the compound into elements. For the experiments below, attention will be focused on the isolation of a single element by the use of electrical energy.

SECTION 7 - ELECTRICAL SEPARATION OF ELEMENTS FROM A COMPOUND

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Solution of potassium iodide
- ❑ Plastic pipette
- ❑ Microplate
- ❑ 9-volt battery
- ❑ 9-volt battery clip
- ❑ Filter paper strip (See Section 5)
- ❑ Microplate
- ❑ A circle of filter paper
- ❑ Small amount of corn starch (obtain from kitchen)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 pipette of potassium iodide (KI) solution in each of 3 large wells of the microplate. Use wells A-1, A-2 and A-3. Remember large well A-3 is a control.

2) Cut a piece of filter paper 6 mm x 60 mm with scissors. Wet the strip of filter paper with potassium iodide solution.

3) Place one end of the filter paper in one well A-1 and the other end in the other well A-2. Both wells contain solution of Potassium Iodide.

4) Connect a 9-volt battery to a battery clip.

5) Place the red wire from the battery clip into one well with the paper connector and the black from the battery clip into the well which is connected to the other end of the paper. See Figure #17.

6) Wait about 5 minutes for the reaction to take place. What do you observe in each well?

7) What do you think is produced at each electrode connected to the battery? What element is produced at the red (+) electrode? What element is produced at the black (-) electrode?

8) Cut a round piece of filter paper about 2 inches in diameter. Wet the filter paper with tap water and rub the corn starch onto the wet piece of round filter paper.

9) Cut the round starch rubbed filter paper circle in four parts. (Like four slices of pie).

10) Place one slice of the round filter paper in small well A-1, place another slice of the round starch filter paper in small well B-1.

11) Remove some of the liquid from the well with the (-) electrode. Place a few drops of the liquid in two small wells. Place a piece of filter paper into one well. The appearance of a black stain is a positive test for iodine.

12) Using another pipette, remove some liquid from the well with the (+) electrode. Place a few drops of the liquid in two small wells. Add a piece of paper to one well. The appearance of a black complex on the paper is a positive test for iodine.

    Which electrode produced the iodine? How do you know?

13) Remove all the liquid from the (+) electrode well. LABEL THE PIPETTE CONTAINING THE LIQUID "IODINE SOLUTION." SAVE THIS PIPETTE FOR FURTHER EXPERIMENTS.

14) Remove all the liquid from the (-) electrode well. Label the pipette containing the liquid "*POTASSIUM HYDROXIDE SOLUTION.*" SAVE THIS PIPETTE FOR FURTHER EXPERIMENTS.

SECTION 8 - ANOTHER ELECTRICAL SEPARATION

Again you are able to separate a compound by using a small amount of electrical energy. And again you can see if the separation has taken place by using an "individual," or in other words, something that will let your eye "see" a reaction which otherwise you could not see!

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Sodium sulfate solution
- ❑ Universal indicator
- ❑ Plastic pipette
- ❑ Microplate
- ❑ 9-volt battery
- ❑ 9-volt battery clip
- ❑ Filter paper strip (See Section 5)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 pipette of sodium sulfate (Na_2SO_4) solution in each of 3 wells of the microplate. Be sure that the wells selected are next to each other for comparison. (Remember the third well is the control!).

2) Place one drop of universal indicator in each of the wells.

3) Cut a piece of filter paper 6 mm x 60 mm with scissors. Wet the strip of filter paper with sodium sulfate solution.

4) Place one end of the filter paper in one well and place the other end of the paper in an adjoining well which contains the sodium sulfate solution.

5) Connect a 9-volt battery to a battery clip.

6) Place the red wire from the battery clip into one well with the paper connector and the black wire from the battery clip into the well which is connected to the other end of the paper connector.

7) Wait for about 3 minutes for the reaction to take place. What do you observe in each well?

8) What do you think is produced at each electrode connected to the battery? What element is produced at the red (+) electrode? What element is produced at the black (-) electrode?

SECTION 9 - ELECTROLYSIS OF FERROUS SULFATE

The secret in understanding this experiment and the unseen reactions taking place at the molecular level is in the positive and negative charge at the ends of the wire (electrodes) which are in different wells. Also remember that when compounds dissolve in water the molecules break up into positive charged and negative charged ions (in this case Fe++ and S04--). The negative electrodes attract the positive chemical ions. The positive electrodes attract the negative chemical ions.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ☐ Ferrous sulfate solution
- ☐ Plastic pipette
- ☐ Microplate
- ☐ 9-volt battery
- ☐ 9-volt battery clip
- ☐ Paper strip (See Section 5)
- ☐ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 pipette of ferrous sulfate solution in each of 3 large wells of the microplate. Use large wells A-1, A-2 and A-3. Be sure that the wells selected are next to each other for comparison. (Remember the third well is the control.)

2) Place one drop of universal indicator in each of the wells.

3) Cut a piece of filter paper 6 mm x 60 mm with scissors. Wet the strip of filter paper with ferrous sulfate solution.

4) Place one end of the filter paper in one large well A-1 and place the other end of the paper in an adjoining large well A-2 which also contains the ferrous sulfate solution.

5) Connect a 9-volt battery to a battery clip.

6) Place the red wire from the battery clip into one well with the paper connector and the black wire from the battery clip into the well which is connected to the other end of the paper connector.

7) Wait for about 3 minutes for the reaction to take place. What do you observe in each well?

8) What do you think is produced at each electrode connected to the battery? What is produced at the red (+) electrode? What is produced at the black (-) electrode?

SECTION 10 - A CHEMICAL SEPARATION

Sometimes to make a separation of a compound happen, chemists do not need to rely on an outside electrical force, such as a battery, but can depend on the "activity" of different metals to do the job for us. In this experiment we depend on the different "activity" of zinc and copper metals to help us in separating the copper sulfate molecule.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ☐ Copper sulfate solution
- ☐ Plastic pipette
- ☐ Microplate
- ☐ Zinc wire
- ☐ Copper wire
- ☐ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 pipette of copper sulfate solution into each of 3 large wells in the microplate.

2) Cut a piece of zinc wire (provided in your chemistry set) with scissors or wire cutter. Cut the piece about 1 inch long. Place this wire into one of the large wells where you have added the copper sulfate solution.

3) Cut a piece of copper wire (provided in your chemistry set) with scissors or wire cutter. Cut the piece about 1 inch long. Place this wire into the other large well where you have added the copper sulfate solution.

4) Do not add any metal wire to the last well. This is the control well. What is the purpose of the control well? See Figure #18.

5) Allow the wire to remain in the wells for at least ten minutes. Observe any change in the wells. Which well changes? Why does the other well NOT change? Leave the wire in solution for 3-4 hours. What changes do you notice?

What happened to the zinc wire? What happened to the copper solution? Compare the experimental solution to the control solution.

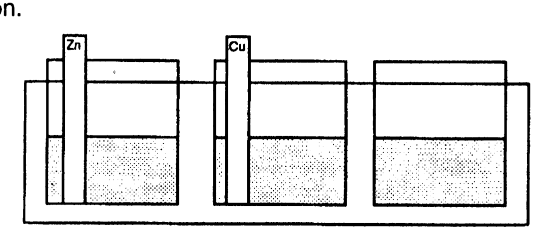


Figure #18

(RV695)

Conservation of Matter

In any chemical reaction, the mass of the reacting chemicals **ALWAYS** equals the mass of the chemicals produced. No matter is ever lost in chemical reaction. The chemicals may change, but the total amount of material remains the same. This is called the **Law of Conservation of Matter.**

You have a sensitive detector of the amount of matter. It is a **CHEMICAL BALANCE**. The balance will allow you to detect any change in mass in a chemical reaction.

Terms to Know

CHEMICAL BALANCE - A device which measures the mass of a substance.

CHEMICAL REACTION - A change in the nature of two or more substances which undergo a chemical change.

LAW OF CONSERVATION OF MATTER - The law which states that the total amount of matter in a system is constant.

MASS - Anything that takes up space and has weight.

SECTION 1A - YOUR LABORATORY BALANCE

PRELIMINARY - ASSEMBLY AND TESTING OF THE LABORATORY BALANCE

A laboratory balance is a device to measure mass. Your chemistry set includes an EQUAL ARM laboratory balance which is not yet assembled. There is also a set of metric masses (weights) which consist of a number of marked plastic disks. Each weight disk has a small extension column on it. These columns are the "handles" which you should use to pick up the weight disks. Each weight disk has embossed on it the relative metric mass (weight) which it represents (weighs).

Also included is a "U" shaped yellow plastic device called a "rider". The rider will go on the top of the balance arm of your balance. See Figure #18A.

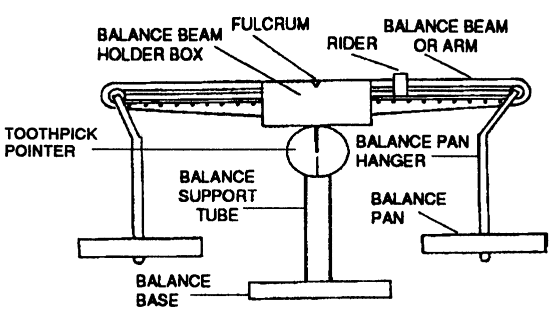


Figure #18A

You will need the following materials to assemble your laboratory balance:

LIST OF MATERIALS

- ❑ Balance base (blue plastic base with depressions in it for storing your metric masses (weights)
- ❑ Balance support tube (white plastic tube about 10 cm long)
- ❑ Balance beam holder (blue plastic box with open top and slotted sides)
- ❑ Balance BEAM or ARM (white plastic part about 20 cm long with holes on each end of the arm, a fulcrum in the middle, and a round extended disk down under the fulcrum)
- ❑ Two PAN HANGERS (white plastic rods shaped like question marks)
- ❑ Two BALANCE PANS (white plastic dish shaped items with "U" shaped holders molded to their underside)
- ❑ A wooden toothpick (obtain from outside source)
- ❑ A fine tip permanent marker (SHARPIE® brand made by Sanford works well since it will write on plastic and won't rub off)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) First, place the white tube (balance support tube) into the blue base by gently pushing tube over the "X" shaped projection of the base.

2) Place the balance beam holder (blue box with one open side and slots) into the other end of the white tube. Fit tube over the "X" shaped projection of the underside of the blue box.

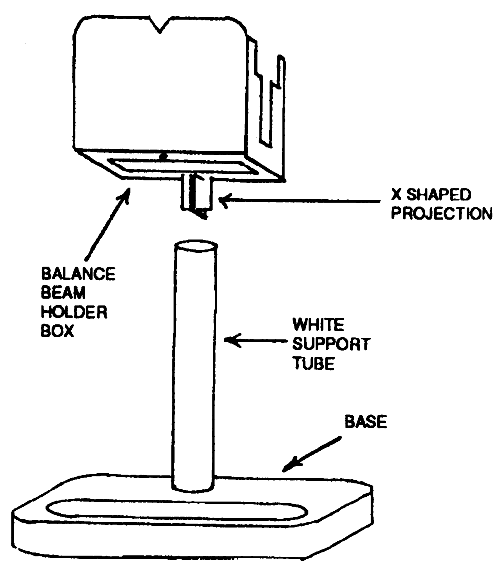


Figure #18B

3) Make sure as you look down through the slot in the balance beam holder you see the rectangular depressions in the balance base. At this time you should also see a small round hole in the center or the front edge of this slot. Gently place a toothpick up into this hole from the lower side. The toothpick will extend downward about 1/2 the way to the base of the round disk face.

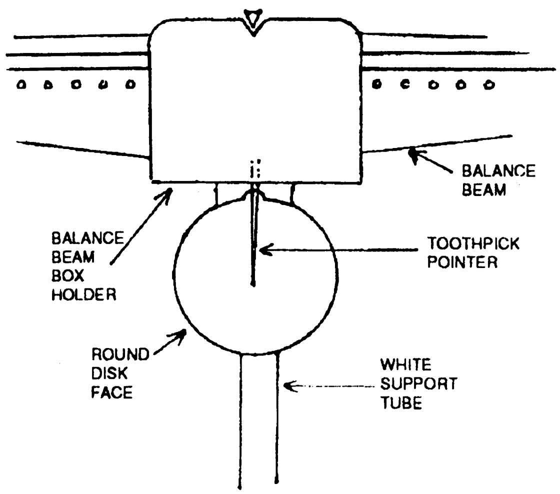


Figure #18C

4) Set aside assembly for a moment.

5) Pick up a balance PAN (one of the round dishes made of white plastic) and notice that on the underside of the dish part there is a small "U" shaped slot. Pick up one of the white plastic PAN HANGERS. These look like a question mark (?). There is an "L" shaped hook on one end and a small round tip on the other end. Carefully slide the "U" shaped slot of the balance pan over the end of the pan hanger with the small round tip. The small round tip will be facing down away from the bottom of the "U" slot. Do this same procedure for the other pan and other pan hanger.

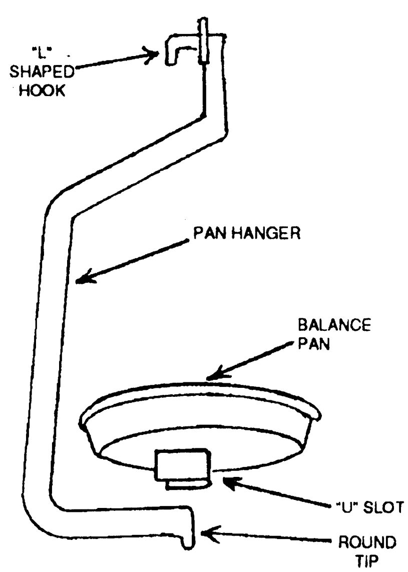


Figure #18D

6) You are now ready to insert the pan hanger hooks into the holes on each end of the balance BEAM or ARM. Hold the balance beam with the round white disk part downward and the long arm with the holes in the ends horizontally. Place the hooks of the pan hangers through the holes on each end of the arm. The little round collars on the hooks will stop the hook from going too far through the holes. The little round collars should be on the same side of the balance arm as the little dots (raised projections) which go all along the front side of the balance arm.

7) Now gently place the balance beam or arm assembly down into the balance beam holder box. Note that the big white disk neatly inserts through the slot in the base of the box. The little triangular projections of the balance are dropped into the small triangular notches of the holder box. This is called the FULCRUM.

8) Gently press one end of the arm downward. You will see the balance beam and the fulcrum work just like a see-saw. You will also see the white disk which projects through the bottom of the holder box move from side to side.

9) Look very closely at the white disk protruding down through the holder box. At the bottom of the face of this disk you will see a small circle with a line through it molded on the plastic. Using your permanent marker, make a black straight line about 1 cm long right on top of the line which goes through this circle. This will be your ZERO or Balance Line.

10) When the balance is "balanced," or equal weight is in both pans, the toothpick indicator will be exactly in line with your zero line.

ADJUSTING YOUR LABORATORY BALANCE

You will now make the final adjustments to your laboratory balance and make sure it operates properly.

1) Place your balance on a level surface. Always use your balance on a level surface which is flat and steady.

2) Make sure the pan hangers move freely in the holes of the balance arm.

3) Make sure the fulcrum works freely and allows the arm to see-saw up and down. You are ready to balance the arm.

4) Observe the balance after it has come to a complete rest (stops moving). Is one of the pans lower than the other? Is the toothpick NOT pointing at the zero line? Put a small dot of ink from your marker on the top of the balance arm or beam which is the highest.

5) Now remove the beam (arm) assembly from the base assembly.

6) Gently insert the yellow plastic "U" shaped rider over the top of the balance arm on the side where you put the ink dot. Notice that the rider slides back and forth in a groove, front and back. Make sure that the rider is in the groove, front and back.

7) Slide the yellow plastic rider in the groove (it will move easily when in place).

8) Place the balance arm assembly back into the beam holder box. Now move the yellow rider either to the left or to the right until the two pans are of equal height. The toothpick pointer and the zero line should be right over one another. You may have to try several different positions of the yellow rider until you can achieve this zero balance.

9) When the pans have stopped going up and down, and the beam and the pointer are "at rest" (still), your balance will have been adjusted to a zero start. At this time again take your marker and place a dot on the yellow rider and a corresponding dot on the white plastic arm just below the yellow rider, so that each time you use your balance, you can have a quick start-up measure of where the rider should be on the balance arm slide.

10) Always keep your balance CLEAN and free from chemicals and dirt since these will make your weighing inaccurate. Always use your measuring cups to weigh things in. Use of the plastic measuring cups will keep chemicals from harming the white plastic balance pans and will keep your weighing accurate.

USING YOUR LABORATORY BALANCE

1) Place a plastic measuring cup on each balance pan. After balance comes to rest, the cups should weigh the same. If not, adjust the rider slightly to make the zero point line up with the toothpick pointer.

2) Look at all of your plastic weight disks. You should have three each, 5.0 gram weights; five smaller 1.0 gram weights; two 0.5 gram weights, and finally five very small 0.1 gram weights. All of your weights when weighed together would weigh 21.5 grams.

3) Place all five of the 1.0 gram weights in one pan of the balance and one 5 gram weight in the other pan of the balance. These two pans should have equal weights in them, and your balance should be balanced.

4) Try next to balance five of the 0.1 gram weights on one pan and one of the 0.5 weights on the other pan. These should balance.

5) Try various combinations of weight mass disks until you are familiar with their various values and how to obtain various weight (mass) values.

6) You may wish to add sources of weights to your set provided. You may use anything which you know or can find the true weight of. For example, coins are an excellent mass weight source. Make sure you mark the various coins you use with your marker after you have determined how much each might weigh. Below is a general guide as to the weights of various coins:

   a new U.S. penny weighs 2.7 grams
   a new U.S. nickel weighs 5.0 grams
   a new U.S. dime weighs 2.3 grams
   a new U.S. quarter weighs 5.8 grams

7) Different coins have different weights. Ask your science teacher at school if he or she will weigh your penny, nickel, dime and quarter for you. Mark the weights on the coins with your marker. Use these coins for weights with your laboratory balance.

8) Another source of weights is by the use of a known weight of water. The following scale is true of water at 4° centigrade, although room temperature water will work for you with this balance.

   1 ml of water weighs 1 gram (20 drops of water is one milliliter)
   5 ml of water weighs 5 grams
   10 ml of water weighs 10 grams
   15 ml of water weighs 15 grams, and so on.

9) Try balancing out 100 drops of water in one of the measuring cups with your weights and a penny in the other measuring cup. How many weights does it take with one penny to weigh out (zero out) with 100 drops of water?

SECTION 1 - CONSERVATION OF MATTER IN SOLUTIONS

Just because a solid dissolves in a liquid (like salt dissolving in water), and we see the salt "go away"... or dissolve, it doesn't mean that the salt has disappeared... the salt is still there...we just cannot see it!

In "Conservation of Matter in Solutions" we see how although a substance seems to "go away", it is indeed still there, and if we wish, as chemists, to "bring back" the substance, we can do so!

You will discover that in dissolving or in chemical reactions, chemists don't "destroy" chemicals...we just change them into different forms or substances... the original amount of stuff (basic building blocks) are still present in the original amounts... but after the change, they are just in a different or changed form. We can demonstrate this by weighing all of the materials BEFORE and AFTER the experiment!

Your best weighing skills come to play in this experiment!

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Pipette
- ❑ Plastic measuring cups
- ❑ Table salt (sodium chloride) obtained from your kitchen
- ❑ Water
- ❑ Laboratory balance
- ❑ Weights
- ❑ Chemical scoop
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place the plastic measuring cup on one pan of your balance.

2) Add weights to the other pan of your laboratory balance until balance "zeros out" (balances).

3) Count how many grams the plastic measuring cup weighs. Do this by adding together all of the small and large weights which you will have added to the other pan of the balance.

4) Remember the values (weights) of your weighing disks. Also remember that a penny weighs about 2.7 grams, a nickel weighs about 5.0 grams, a dime weighs about 2.3 grams, and a quarter weighs about 5.8 grams.

5) Write down the mass of the plastic measuring cup in the Data Table at the end of the experiment.

6) Place 1/2 scoop of table salt (sodium chloride) in the plastic measuring cup. Now add more weights to balance out the measuring cup AND salt.

7) Write down the mass (weight) of the measuring cup AND the salt in the Data Table below.

8) Add two pipettes of water to the measuring cup containing the salt. Dissolve the salt completely in the water.

9) Balance the balance again. Count the weights. Write down the mass of the measuring cup, water and dissolved salt.

10) Where did the solid material go? What happened to the mass of the solid?

Data Table for SECTIONS 1 AND 1A		
1) Mass of measuring cup	____	g
2) Mass of cup and sodium chloride	____	g
3) Mass of sodium chloride	____	g
4) Mass of cup, sodium chloride and water (after dissolving)	____	g
5) Mass of cup and sodium chloride (after evaporation)	____	g

SECTION 1A - EVAPORATION OF A SOLUTION

11) Set the measuring cup aside. Allow the water to evaporate. This usually takes several days.

12) When the water has evaporated, take the mass of the measuring cup and its contents again. Note the mass in the Data Table above.

13) Are the masses in Number 2 of the Data Table, and Number 5 of the Data Table the same? Does the mass of the set up in Number 5 of the Data Table match any other mass?

SECTION 1B - CONSERVATION OF MATTER II

Perform Section 1 and Section 1A again, but this time instead of using table salt use sodium bicarbonate (baking soda). Be sure to use baking SODA and NOT baking powder. You should be able to obtain the sodium bicarbonate from your kitchen. If you do not have any, baking soda can be obtained from any grocery.

Use all of the same procedures 1-11. Make yourself another data table like Table #1 on a separate piece of paper. Record all of the masses of the different steps as indicated.

The answers to the questions are similar to the answers given for Step 11 in SECTION 1A. The only difference is that you have used another chemical salt (sodium bicarbonate) instead of sodium chloride. Do you find that the results are similar?

SECTION 2 - REACTION OF CALCIUM NITRATE AND SODIUM SULFATE SOLUTIONS

The "CONSERVATION OF MATTER" principle again comes into play in this experiment and even though we have an obvious chemical reaction, and we make new compounds which were not present at the start of the experiment, we have NOT created something from nothing! We have used the components of our starting chemicals and recombined them into new chemicals... all of the "stuff" is still there! It is just combined in a different way! We have "CONSERVED" matter.

If you are very careful in your weighing techniques and the use of your laboratory balance, you can demonstrate the "Law of Conservation of Matter"!

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Sodium sulfate solution (from your chemistry set)
- ❑ Calcium nitrate solution (from your chemistry set)
- ❑ Microplate
- ❑ Plastic pipettes (2)
- ❑ Laboratory balance
- ❑ Balance weights
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 pipette of calcium nitrate solution in one of the large wells in the plate. Use large well A-1.

2) Fill another pipette with a solution of sodium sulfate.

3) Place the pipette containing sodium sulfate, with the tip up, in an adjoining well in the plate.

4) Place the plate, solution, and filled pipette on the balance. See Figure #18E

5) Record the total mass of the materials in #1 of the Data Table.

6) Once the mass has been balanced and recorded, add the sodium sulfate solution to the calcium nitrate solution.

7) Is there any reaction? How do you know?

8) Place the plastic pipette back in the well of the plate.

9) Does the mass of the plate and its contents change?

10) What are the products of this reaction?

Data Table for SECTION 2	
1) Mass of plastic ware, plastic pipette, and solutions (before reaction)	____ g
2) Mass of plastic ware, plastic pipette, and solutions (after reaction)	____ g
3) Mass difference	____ g

SECTION 3 - REACTIONS OF CALCIUM NITRATE AND SODIUM CARBONATE SOLUTIONS

In this experiment, you can again demonstrate that even though a chemical reaction has taken place, and new compounds were produced, the total amount of "matter" is still present. You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Sodium carbonate solution (from your chemistry set)
- ❑ Calcium nitrate solution (from your chemistry set)
- ❑ Microplate
- ❑ Plastic pipettes (2)
- ❑ Laboratory balance
- ❑ Balance weights
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 pipette of calcium nitrate solution in one of the large wells in the plate. Use large well A-1.
2) Fill another pipette with a solution of sodium carbonate.
3) Place the pipette containing sodium sulfate, with the tip up, in an adjoining well in the plate.
4) Place the plate, solution, and filled pipette on the balance. See Figure #18E.
5) Record the total mass of the materials in line #1 of the Data Table.
6) Once the mass has been balanced and recorded, add the sodium sulfate solution to the calcium nitrate solution.
7) Is there any reaction? How do you know?
8) Place the plastic pipette back in the well of the plate.
9) Does the mass of the plate and its contents change?
10) What are the products of this reaction? Has the total mass of the reactants changed when the products were formed?

Data Table for SECTION 3	
1) Mass of plastic ware, plastic pipette, and solutions (before reaction)	____ g
2) Mass of plastic ware, plastic pipette, and solutions (after reaction)	____ g
3) Mass difference	____ g

SECTION 4 - A REACTION OF SODIUM HYDROGEN CARBONATE AND CITRIC ACID

What would happen in an experiment if one of the products of the reaction "left the scene of the reaction"? For instance, in this experiment, if a gas is produced, and escapes to the air in the room, will you be able to show that what you have left in the microplate weighs less than when you started the experiment. If you could catch and weigh the gas that was produced, it is likely that the weight of all the reactants before the experiment would weigh the same as the products after the experiment. Again, "Conservation of Matter"!

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Sodium hydrogen carbonate (same as sodium bicarbonate/baking soda; obtain from your kitchen or grocery)
- ❑ Citric acid solution (from your chemistry set)
- ❑ Microplate
- ❑ Plastic pipettes (2)
- ❑ Laboratory balance
- ❑ Balance weights
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place the microplate on the balance.
2) Place 1/2 plastic pipette scoop of solid sodium hydrogen carbonate in one of the large wells in the plate.
3) Fill a plastic pipette with a solution of citric acid.
4) Place the pipette, with the tip up, in an adjoining well in the plate.
5) Place the plastic ware, pipette and solid on your balance. See Figure #18E.

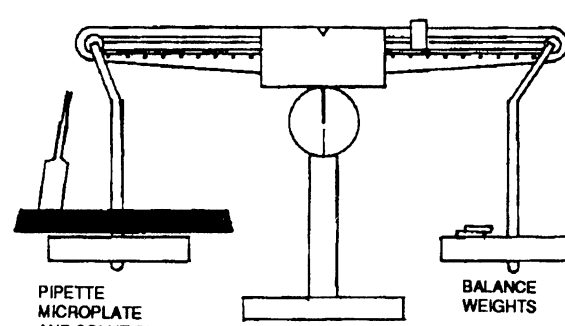


Figure #18E

6) Record the total mass of the materials in the Data Table below.

7) Once the total mass has been written down, add the citric acid solution SLOWLY to the solid sodium hydrogen carbonate.

8) Note the reaction. What is the gas produced in this reaction? How could you test for this gas?

9) Place the plastic pipette back in the well in the plate.

10) Place the plate back on the balance and record the mass in the Data Table below. Did the mass of the plate and its contents change?

11) What are the products of this reaction?

Data Table for SECTION 4		
1) Mass of plastic ware, plastic pipette, solution and solid (before reaction)	———	g
2) Mass of plastic ware, plastic pipette, solution and solid (after reaction)	———	g
3) Mass difference	———	g

SECTION 5 - A REACTION OF SODIUM CARBONATE AND CITRIC ACID

How can a chemist calculate "how much" gas has been produced in a reaction, even though the gas has escaped into the room air? In this experiment, if your weighing skills are good, you can actually determine how much (quantitative) gas has been produced by this reaction.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Sodium carbonate solid (from your chemistry set)
- ❑ Citric acid solution (from your chemistry set)
- ❑ Microplate
- ❑ Plastic pipettes (2)
- ❑ Laboratory balance
- ❑ Balance weights
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place the microplate on the balance.

2) Place 1/2 plastic pipette scoop of solid sodium carbonate in one of the large wells in the plate.

3) Fill a plastic pipette with a solution of citric acid.

4) Place the pipette, with the tip up, in an adjoining well in the plate.

5) Place the plastic ware, pipette and solid on your balance. See Figure #18E.

6) Record the total mass of the materials in the Data Table below.

7) Once the total mass has been written down, add the citric acid solution SLOWLY to the solid sodium carbonate.

8) Note the reaction. What is the gas produced in this reaction? How could you test for this gas?

9) Place the plastic pipette back in the well in the plate.

10) Place the plate back on the balance and record the mass in the Data Table below. Did the mass of the plate and its contents change?

11) What are the products of this reaction?

Data Table for SECTION 5		
1) Mass of plastic ware, plastic pipette, solution and solid (before reaction)	———	g
2) Mass of plastic ware, plastic pipette, solution and solid (after reaction)	———	g
3) Mass difference	———	g

SECTION 6 - A REACTION OF CALCIUM CARBONATE AND ACETIC ACID

We keep breaking molecules apart and recombining them. Sometimes when we produce a new compound, it does not stay in solution as we have observed. It turns to a gas and escapes. Sometimes the new compound is not soluble and falls to the bottom of our reaction vessel as a solid. In this experiment, we again produce a gas, this time using a different reactant. Can you see how putting together an acid and a carbonate produces a gas each time?

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Calcium carbonate solid (marble chips: from your chemistry set)
- ❑ Vinegar (a solution of acetic acid: obtain from your kitchen)
- ❑ Microplate
- ❑ Plastic pipettes (2)
- ❑ Laboratory balance
- ❑ Balance weights
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place the microplate on the balance.

2) Place 1/2 plastic pipette scoop of solid calcium carbonate in one of the large wells in the plate.

3) Fill a plastic pipette with a solution of acetic acid.

4) Place the pipette, with the tip up, in an adjoining well in the plate.

5) Place the plastic ware, pipette and solid on your balance. See Figure #18E.

6) Record the total mass of the materials in the Data Table below.

7) Once the total mass has been written down, add the citric acid solution SLOWLY to the solid calcium carbonate.

8) Note the reaction. What is the gas produced in this reaction? How could you test for this gas?

9) Place the plastic pipette back in the well in the plate.

10) Place the plate back on the balance and record the mass in the Data Table below. Did the mass of the plate and its contents change?

11) What are the products of this reaction?

Data Table for SECTION 6	
1) Mass of plastic ware, plastic pipette, solution and solid (before reaction)	____ g
2) Mass of plastic ware, plastic pipette, solution and solid (after reaction)	____ g
3) Mass difference	____ g

SECTION 7 - A COMMERCIAL CONSERVATION SYSTEM

Sometimes we may cause a chemical reaction to happen when the result produces something other than a new solid or liquid or gas. Sometimes we can produce light or heat. Light and heat are classed as energy. We can produce energy from a reaction! Even though we can feel or see some types of energy... they do not have mass that we can measure with our laboratory balance...even when the amount seems to be great! This next experiment will surprise you!

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ 9-volt battery
- ❑ 9-volt battery clip
- ❑ Photographic flash cube or flash bulb (obtain from outside source)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Obtain a flash bulb or "flash cube."

2) Record the mass of the flash bulb in the Data Table below. Write this value on the unused bulb.

3) Attach your 9-volt battery clip to the 9-volt battery.

4) Touch one end of the battery clip wire to one of the terminals of the bulb. What happens?

5) Touch both ends of the battery clip to the terminals of the bulb. What happens?

6) Record the mass of the used bulb. Has there been a change in mass?

7) What was produced in this reaction? Did the product have mass? How do you know this?

Data Table for SECTION 7	
1) Mass of flash bulb or cube (before the flash)	____ g
2) Mass of flash bulb or cube (after the flash)	____ g
3) Mass difference	____ g

SECTION 8 - THE MASS OF A CLOSED CHEMICAL SYSTEM

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ 9-volt battery
- ❑ Fine point permanent market (Sanford SHARPIE brand)
- ❑ Laboratory balance
- ❑ Balance weights
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

A battery is a closed chemical system. During a battery's useful life, chemical reactions (see the chapter on electrochemistry) produce a flow of electricity. The total mass of the chemicals involved in producing the flow of electricity is not lost. The chemicals are sealed in the battery.

While you are experimenting with your chemistry set, you will need some battery power. The battery you use will "die" once you have used it for a while. You can check on the CONSERVATION OF MATTER using this battery.

1) Mark a 9-volt battery with an "x" using a permanent marker.

2) Take the mass of the 9-volt battery.

3) Write the mass of the cell on the side of the battery.

Use the battery for the remainder of its life. When the battery is no longer working, take the mass again. Compare the first mass with the mass after use.

Has the mass of the battery changed? Did the battery give you electrical energy for nothing? What changed inside the battery?

The States or Phases of Matter

All matter, anything that takes up space and has weight, can be classified into four PHASES or STATES. The phases or states of matter are:

Solid
Liquid
Gas
Plasma

The most common phase of matter is the PLASMA state. Most of the matter in the universe is in the plasma state. The plasma state is the state of matter where electrons, and the centers of atoms, the nuclei, are separated from one another. A plasma state is a "soup" of charges. Plasma, while the most common of all the states of matter, exists only at very high temperatures. The temperatures needed for a plasma exists only inside stars. While plasma IS the most common state of matter for the universe, it is **NOT** a common state on earth.

The remaining three states of matter: solid, liquid and gaseous, are the phases which we see.

TERMS TO KNOW

SOLID - These are rigid substances which have a definite volume and definite shape. A CRYSTAL is an example of a solid.

LIQUID - These substances have a definite volume, but can flow and take the shape of the container in which they are placed.

GAS - This is the phase of matter which has neither a definite shape or definite volume. Gases take the shape of the container and expand or contract with changes in temperature and pressure.

THE ONLY DIFFERENCE BETWEEN A SOLID, LIQUID OR GASEOUS STATE OF A PARTICULAR PURE SUBSTANCE IS THE TEMPERATURE AND PRESSURE OF THE SURROUNDINGS OF THE SUBSTANCE.

An example of this chemistry fact can be quite startling!

Think about the gaseous element oxygen. Oxygen at room temperature (25°C) and normal pressure (sea level pressure) is in the gaseous phase. It is oxygen, in the gaseous state which keeps us alive. If the temperature and the pressure around oxygen is lowered, the gas first becomes a liquid then becomes a solid!

Can you think of a situation where oxygen or any other gas is more useful as a liquid? (Hint: What does NASA use in the boosters of large rockets to burn the fuel?) Can you think of a situation when a gas is useful as a solid? (Hint: What keeps ice cream very cold in a portable freezer?)

Phase Changes of a Pure Substance

Let's investigate the process of phase change in a common substance. Our phase change investigation will be limited to the changes within the solid, liquid and gaseous phases of a common pure substance, water.

SECTION 1 - PRE-LAB - PREPARING AN ACCURATE THERMOMETER

Measuring the temperature of chemical reactions is important because it often tells the chemist whether a reaction is taking place and how much of the reaction is taking place. This can be indicated by a change in temperature from the start of the reaction to the end of the reaction. The temperature may sometimes go up (an EXOTHERMIC reaction), or the temperature may go down (an ENDOTHERMIC reaction).

You will check the accuracy of a thermometer...or a device for measuring temperature, in the following experiment. Although the thermometer in your chemistry set is already calibrated, you can test the accuracy of your thermometer by performing the following experiment.

The calibrations on your thermometer are the lines and numbers inscribed on the tube of the thermometer to read the "temperature" of the material you are testing.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Thermometer
- ❑ Fine line permanent marker (Sanford SHARPIE® brand)
- ❑ Transparent Scotch® brand tape or similar tape (not in your set)
- ❑ Metric/English ruler (from your chemistry set)
- ❑ Plastic measuring cup (from your chemistry set)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) First crush some ice as explained in the next section (SECTION 1).

2) Add about one and a half pipettes full of tap water to the crushed ice in the measuring cup. Stir the ice/water mixture.

3) Place the thermometer bulb in the ice/water mixture. Notice how the red liquid column goes down toward the bulb. Stir the thermometer around in the ice/water liquid.

4) After about five minutes, the red liquid inside of the thermometer tube will not go down any more. This is your "zero" or starting point for the calibration of your thermometer. QUICKLY dry the tube of the thermometer and place a dot of ink from your permanent marker on the dry glass of the thermometer. The dot will be right where the red liquid column ends (about 3/4" up the tube).

5) Pick up your Metric/English ruler. Look at the English side of the ruler. Near one end is a small "0", and at the other end is a small "6". This side of the ruler measures six inches.

Look at the small, medium and long lines molded into the plastic. The distance between the small lines is 1/16th of an inch.

6) Using your marker, put a small dot opposite the very last line of the ruler. (This is the line right under the "0" on the ruler.)

7) Using your transparent tape, tape the thermometer to the UNDERSIDE of your clear plastic ruler. Tape the thermometer with the red bulb protruding past the end of the ruler. The two dots (one on the ruler and one on the thermometer) should line up exactly.

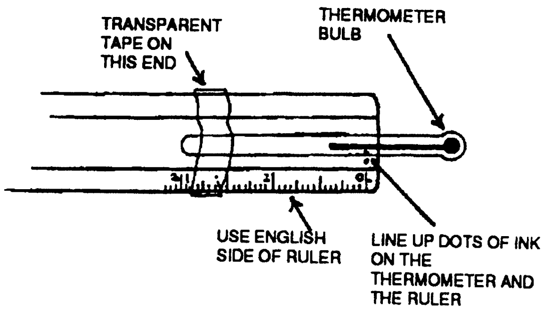


Figure #19

8) Using your marker, carefully put a line partway across the center part of your ruler and at the end of that line put "O'C." (standing for zero degrees Centrigrade, also called zero degrees Celsius).

9) This starting line of O'C. is what your thermometer registered when it was at the freezing/melting point of water (when the ice/water mixture was its coldest).

10) Now mark 10'C. at the 1/4" line, 20'C. at the 1/2" line, 30'C. at the 3/4" line, 40'C. at the 1" line, and 50'C. at the 1 1/4" line. Mark these temperatures on the clear center part of your ruler.

11) Every line on the ruler next to the thermometer represents two and one half degrees of temperature. Example: If the red liquid of the thermometer was just opposite the third line up from the bottom, the temperature you would be measuring would be at 7.5'C. (or 7 and one half degrees C.)

You are now ready to use your calibrated thermometer. Try to keep water off of the transparent tape, but if your thermometer does get loose from the tape, just re-tape the thermometer to the back of the ruler, being sure to line up your original two starting dots of "zero degrees C."

SECTION 1 - PHASE CHANGE IN A COMMON SUBSTANCE

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Ice
- ❑ Newspaper
- ❑ Hammer or other heavy object to crush ice
- ❑ Microplate
- ❑ Calibrated thermometer (from previous SECTION 1 - PRE-LAB)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Wrap an ice cube in several layers of newspaper. Crush the cube with a hammer.

2) Collect two small samples (enough to fill two large wells of the microplate) of ice (one is a control). Place the samples in two wells in the microplate. See Figure #19A.

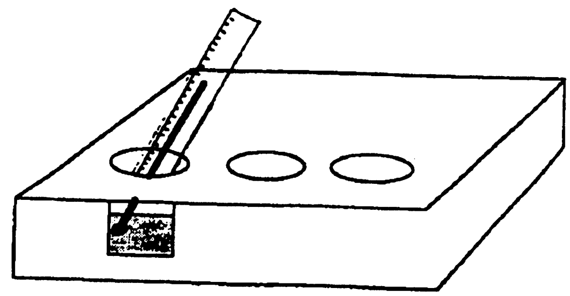


Figure #19A

3) What is the temperature of both ice samples?

4) Describe what happens to the ice as it is heated by the air around it. Take temperature readings of the sample every minute for at least ten minutes or until the ice has completely melted. Record your results in the Data Table below.

5) How do you know that the change of phase from solid to liquid is complete?

6) Compare the temperature of the two samples of ice as the experiment continues. Do each of the samples change at the same rate? Why or why not?

Data Table	
Time	**Temperature**
Minute 1	________ degrees C.
Minute 2	________ degrees C.
Minute 3	________ degrees C.
Minute 4	________ degrees C.
Minute 5	________ degrees C.
Minute 6	________ degrees C.
Minute 7	________ degrees C.
Minute 8	________ degrees C.
Minute 9	________ degrees C.
Minute 10	________ degrees C.

SECTION 2 - COOLING OF WATER SOLUTIONS

Sometimes adding a substance to a liquid (here we are using water as the liquid) will change the amount of cooling or heating which solutions experience. An example of this is the "Anti-Freeze" which is added to the cooling system water in a car engine. The "Anti-Freeze" additive is really an alcohol which extends the range of cooling of water as well as the range of boiling of the water. The coolant in the car's radiator will not freeze at its usual 0' Celsius but rather, will freeze only at very low temperatures. The "Anti-Freeze" also keeps the radiator coolant from boiling at 100' C. and keeps it from boiling away until very high temperatures occur. Adding salts to water will demonstrate this same property of changing a liquid's cooling rate as the following experiments show.

You will need the following materials to complete this experiment:
LIST OF MATERIALS

- ❑ Ice
- ❑ Calibrated thermometer
- ❑ Microplate
- ❑ Table salt (sodium chloride)
- ❑ Laboratory scoop
- ❑ Water
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place one pipette full of water in each of two large wells in the microplate. Use large wells A-3 and B-3.
2) Add 1/4 scoop of table salt to the water in large well A-3 and dissolve completely.
3) Immerse a thermometer in the table salt solution and add a scoop of ice to both of the wells containing liquid.
4) Take temperature readings every minute as the air heats the salt solution and the water. Record your data in the table below.
5) Does the salted water heat up at the same rate as the pure water?
6) What happens to the salt solution as it evaporates? (This may take several days.)

Data Table of SALT WATER vs. PLAIN WATER

Time	Plain Water Temperature	Salt Water Temperature
Minute 1	________ deg. C.	________ deg. C.
Minute 2	________ deg. C.	________ deg. C.
Minute 3	________ deg. C.	________ deg. C.
Minute 4	________ deg. C.	________ deg. C.
Minute 5	________ deg. C.	________ deg. C.
Minute 6	________ deg. C.	________ deg. C.
Minute 7	________ deg. C.	________ deg. C.
Minute 8	________ deg. C.	________ deg. C.
Minute 9	________ deg. C.	________ deg. C.
Minute 10	________ deg. C.	________ deg. C.

SECTION 3 - COOLING OF A SUGAR SOLUTION

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Ice
- ❑ Calibrated thermometer
- ❑ Microplate
- ❑ Table sugar
- ❑ Scoop
- ❑ Water
- ❑ Plastic pipette
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place one pipette full of water in each of two large wells in the microplate. Use large wells A-5 and B-5.
2) Add 1/4 scoop of table sugar to the water in large well A-5 and dissolve completely.
3) Immerse a thermometer in the table sugar solution and add a scoop of ice to both of the wells containing liquid.
4) Take temperature readings every minute as the air heats the sugar solution and the water. Record your data in the table below.
5) Does the sugar water heat up at the same rate as the pure water?
6) What happens to the sugar solution as it evaporates? (This may take several days.)

Are your results the same as the results with the pure water? What happened to the solutions when the liquid evaporated? What happened with tap water?

Data Table of SUGAR WATER vs. PLAIN WATER

Time	Plain Water Temperature	Sugar Water Temperature
Minute 1	________ deg. C.	________ deg. C.
Minute 2	________ deg. C.	________ deg. C.
Minute 3	________ deg. C.	________ deg. C.
Minute 4	________ deg. C.	________ deg. C.
Minute 5	________ deg. C.	________ deg. C.
Minute 6	________ deg. C.	________ deg. C.
Minute 7	________ deg. C.	________ deg. C.
Minute 8	________ deg. C.	________ deg. C.
Minute 9	________ deg. C.	________ deg. C.
Minute 10	________ deg. C.	________ deg. C.

SECTION 4 - COOLING OF ISOPROPYL ALCOHOL SOLUTION

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Ice
- ❑ Calibrated thermometer
- ❑ Microplate
- ❑ Isopropyl alcohol (rubbing alcohol)
- ❑ Water
- ❑ Scoop
- ❑ Plastic pipette
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place one pipette full of water in each of two large wells in the microplate. Use large wells A-6 and B-6.

2) Add 1/2 pipette of isopropyl alcohol to the water in well A-6 and dissolve completely.

3) Immerse a thermometer in the isopropyl alcohol solution and add a scoop of ice to both of the wells containing liquid.

4) Take temperature readings every minute as the air heats the alcohol solution and the water. Record your data in the table below.

5) Does the alcohol water solution heat up at the same rate as the pure water? (This may take several days.)

6) What happens to the alcohol solution as it evaporates? (This may take several days.)

7) Are the results the same as the results with the pure water?

Data Table of ALCOHOL SOLUTION vs. PLAIN WATER

Time	Plain Water Temperature	Alcohol Solution Temperature
Minute 1	________ deg. C.	________ deg. C.
Minute 2	________ deg. C.	________ deg. C.
Minute 3	________ deg. C.	________ deg. C.
Minute 4	________ deg. C.	________ deg. C.
Minute 5	________ deg. C.	________ deg. C.
Minute 6	________ deg. C.	________ deg. C.
Minute 7	________ deg. C.	________ deg. C.
Minute 8	________ deg. C.	________ deg. C.
Minute 9	________ deg. C.	________ deg. C.
Minute 10	________ deg. C.	________ deg. C.

GROUP 8 — EXPERIMENTS WITH SOLIDS

Experiments with Solids

The purest form of a solid substance is a **CRYSTAL.** A crystal of solid contains only molecules of a single pure substance. When crystals form, the structure of the crystal prevents most other materials from entering the crystal. Sometimes water is included in a crystal. A diamond is a crystal of carbon. A diamond is the purest form of the elemental substance carbon.

If you know someone who has a diamond (a wedding or engagement ring usually has one in it) observe the crystal with your magnifying glass. Crystals are usually a very pretty sight.

TERMS TO KNOW

CRYSTAL- The purest form of a solid. A crystal contains one kind of molecule.

EVAPORATION - The process by which liquids become gaseous. When a liquid changes into a gas, it evaporates.

MOLECULE - The smallest particle of a pure substance which still has the characteristics of that substance.

PRECIPITATION - The process of solid coming out of solution.

SATURATED - A solution which can hold no more solute.

SOLUTE - A substance dissolved in a solvent.

We will make crystals in two ways: the *evaporation method* and the *seed crystal method.*

SECTION 1 - THE EVAPORATION METHOD

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Solid table salt (sodium chloride)
- ❑ Plastic scoop
- ❑ Plastic weighing scoop
- ❑ Plastic pipette
- ❑ Test tube with cap
- ❑ Microplate
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

Sodium chloride is a chemical compound which forms crystals shaped like tiny cubes. Each side of the structure of the pure substance is equal in length to every other side. Observe some crystals of sodium chloride with your magnifying glass from a shaker of salt in your kitchen. Some of the crystals may not look like cubes, but most should be. Table salt is not a pure substance. Table salt is a mixture of solids. There have been other chemicals called additives mixed in with the salt. One additive, potassium iodide, provides iodine, a necessary nutrient. Another additive, called sodium silicate, is added to improve the physical property of flowing of the salt from the container or salt shaker.

1) Place a scoop of table salt into one of the large wells of your microplate.

2) Add a pipette full of water to the salt crystals.

3) Mix the salt and water until the crystals completely dissolve.

4) Continue to add salt to the water until the solution can hold no more solid. This solution is said to be SATURATED.

5) Place about 1/2 of the salt water solution in a plastic weighing dish. Save the other 1/2 of the solution in a stoppered test tube for use in SECTION 2.

6) Allow the water in the microplate to evaporate. What happens to the salt when the water evaporates?

7) Observe the "recrystallized" salt with your hand lens. How do they compare with the original salt crystals?

SECTION 1A - GROWING CRYSTALS

You have seen by the previous experiment how a salt dissolved in water can be "gotten back" or returned to the solid form as small water crystals. Many other of the substances in your chemistry set are also chemical salts which are able to be re-crystallized by evaporation. Remember some WILL make crystals and some WILL NOT.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Solutions of all the compounds in your chemistry set
- ❑ Rinse water (tap water)
- ❑ Plastic measuring cup
- ❑ Plastic pipette
- ❑ Microplate
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Turn your microplate upside down. You should be able to see the outline of the wells showing through the bottom of the plate.

2) Using the round raised bottoms of the LARGE wells as individual test platforms, place 5 drops of each solution from your chemistry set on the microplate. Only one solution per test platform round bottom of each large well. You will have to repeat this process twice since there are only 12 large well bottoms and 16 solutions.

3) BE SURE to rinse your pipette in the rinse water in the plastic.

4) Allow the microplate to remain undisturbed for a few days or until the water evaporates.

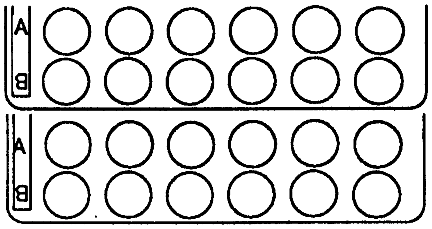


Figure #19B

5) Observe the crystals of each chemical compound with your magnifying glass. Are they all the same? Do they all have the same color?

SECTION 2 - SEED CRYSTAL METHOD

Putting a seed crystal in a saturated solution is much like "giving a pattern" to the solution which contains dissolved salt. It allows the dissolved salt to have a "seed" around which to form more crystals of the same or similar geometry. Some crystals form very slowly, and some form quite rapidly. Remember: be patient and let the crystals form slowly and undisturbed.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Solid table salt (sodium chloride)
- ❑ Solution of table salt from SECTION 1
- ❑ Magnifying glass
- ❑ Plastic wrap
- ❑ Microplate
- ❑ Tweezers
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) From a sample of the solid table salt (sodium chloride) and using a magnifying glass and your tweezers, select as perfect a salt crystal as you can. The single salt crystal will be like a small cube.

2) Pipette or pour some of the solution in a large well of your microplate. You may want to fill up the well to near its top with the saturated salt solution from SECTION 1.

3) Carefully place one crystal of solid salt into the large well with the saturated salt solution.

4) Allow this solution to stand, covered with plastic wrap, undisturbed overnight. What happens to the single crystal? Do the crystals from the evaporated solution appear to be the same as the crystal from the seeded solution?

5) What are the advantages and disadvantages to each method of crystallization?

SECTION 3 - WATCHING "SPEED CRYSTALS"

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Isopropyl alcohol (rubbing alcohol) (obtain from your local drugstore)
- ❑ Aspirin tablet
- ❑ Magnifying glass
- ❑ Plastic pipette
- ❑ Microplate
- ❑ Glass slide
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

If a solid is dissolved in a liquid which EVAPORATES quickly, crystals of the solid form in a very short time.

Acetyl salicylic acid, the active ingredient in aspirin, dissolves in alcohol. Most of an aspirin is NOT acetyl salicylic acid. Most of an aspirin is starch. An aspirin tablet is another mixture of solids. Starch is not soluble in alcohol. If an aspirin tablet is placed in alcohol, the starch settles out and the acetyl salicylic acid dissolves. If the alcohol is drawn off and the alcohol evaporates, the acetyl salicylic acid recrystallizes. The process of crystallization occurs quite rapidly.

WARNING: Ethyl and isopropyl alcohol are flammable liquids. Do not use near an open flame. Ethyl and isopropyl alcohol and their vapors are hazardous. Use only with adequate ventilation.

1) Dissolve an aspirin in 1/2 plastic pipette of alcohol in a large well of the microplate. Be sure to break up any large pieces of aspirin.

2) Mix thoroughly by drawing up the liquid into the pipette and returning the liquid to the well.

3) Allow the solid starch time to settle. Save the starch solid in the well for SECTION 4.

4) When the starch has settled, draw off all the liquid portion from the well.

5) Place a few drops of alcohol/aspirin on a plastic slide (provided in your chemistry set).

6) Observe the drops with a hand lens.

7) What do you notice happening? Where did the crystals come from? Do they look like any crystals from Section 1 or 1A?

SECTION 4 - TEST FOR STARCH IN ASPIRIN

You have been able to separate the acetyl salicylic acid (aspirin) from the starch filler in the previous experiment. You should have been able to see the aspirin crystals as well. In the following experiment, you need to perform a test on the other ingredient in aspirin... the starch. The well known "iodine test for starch" is used in this experiment. You will put the starch/water liquid on a piece of filter paper and then add the iodine test solution which you made previously, to the filter paper.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Small square of filter paper (about 2" x 2" sq.)
- ❑ Iodine solution which you saved from electrolysis experiment in GROUP 5, SECTION 7, STEP 10
- ❑ Plastic pipette
- ❑ Microplate with the starch of the aspirin
- ❑ Water
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Add about 1/4 pipette of water to the large well containing the white solid (precipitate) remaining from the aspirin experiment in SECTION 3.

2) Draw up into the pipette the water and the solid white substance.

3) Squirt the water/solid substance onto your square of filter paper.

4) Wash out your pipette with water.

5) Add a few drops of "IODINE SOLUTION" which you made in the electrolysis of potassium iodide experiment in GROUP 5, SECTION 7, STEP 10. The appearance of a black color on the paper when iodine is added to a sample is a way of telling that starch is present.

6) Does starch form a crystal? Does it form a crystal when it combines with iodine?

SECTION 5 - WHAT ARE CRYSTALS?

You probably think the answer to this question is simple. Right? Diamonds are crystals. Salt in the salt shaker is composed of crystals. Sugar cubes are made of crystals.

As a matter of fact, now might be a good time to take a closer look at table salt and at sugar crystals. Using your magnifying glass, notice that even though they are the same color, the individual crystals of salt and the crystals of sugar have different shapes.

Table salt looks like little cubes. Sugar crystals look like little hexagonal rods.

Different kinds of materials have crystals of different shapes.

These shapes are divided into seven categories called SYSTEMS.

The seven CRYSTAL SYSTEMS have the following names. Listed across from each CRYSTAL SYSTEM are some examples of chemicals, gemstones and minerals which fall into each category.

The reason CRYSTALS form at all is the result of the shape of the individual atoms or molecules which make up a particular crystal and also the electrical attraction between certain atoms or molecules. CRYSTALS result because the atoms or molecules which pack together closely, one by one, and keep on packing tightly together, repeat the pattern of packing. When enough (millions) of atoms or molecules pack together in this repeating pattern, we can see a crystal with a magnifying glass or with our naked eye.

CRYSTAL SYSTEM	EXAMPLES OF CHEMICALS AND MINERALS IN SYSTEM
MONOCLINIC	Iron Sulfate ($FeSo_4 \bullet 7H_2O$) Arsenic Sulfide (AsS) Gypsum ($CaSO_4$) Talc ($Mg_2Si_3O_8$)
ISOMETRIC or CUBIC	Iron Metal Crystals (Fe) Copper Metal Crystals (Cu) Salt ($NaCl$) Potassium Chloride (KCl) Diamond (C) Fluorite (CaF_2)
HEXAGONAL	Cadmium Sulfide (CdS) Ice (solid H_2O) Calcite ($CaCO_3$) Soda Niter ($NaNO_3$) Antimony Crystals (Sb) Zinc Sulfide (ZnS)
TETRAGONAL	Zircon Gemstone Manganese Dioxide (MnO_2) Tin Metal (Sn) Rutile Mineral (TiO_2)
ORTHORHOMBIC	Lead Sulfate ($PbSO_4$) Calcium Sulfate ($CaSO_4$) Sulfur (S) Barium Sulfate ($BaSO_4$) Topaz Gemstone
RHOMBOHEDRAL	Bismuth Metal Crystals (Bi) Calcium Carbonate ($CaCO_3$) Cinnabar Crystals (HgS) Nickel Sulfide (NiS)
TRICLINIC	Turquoise Gemstone Crystals Copper Sulfate Crystals ($CuSO_4 \bullet 5H_2O$) Copper Oxide Crystals (CuO)

In your chemistry set are provided models of the different crystal system shapes. These seven crystal system shapes are already cut out and the creases (folding lines) are already pressed into the cardboard. We shall now build these CRYSTAL SYSTEM MODELS.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Fine point permanent marker (SHARPIE® made by Sanford)
- ❑ Plastic ruler
- ❑ Seven cardboard crystal model shapes
- ❑ Transparent cellophane tape
- ❑ Goggles

<u>BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!</u>

1) Find the seven pre-cut and pre-creased cardboard CRYSTAL MODEL shapes in your chemistry set.

2) Compare the seven flat cardboard shapes with the drawings of the finished models below.

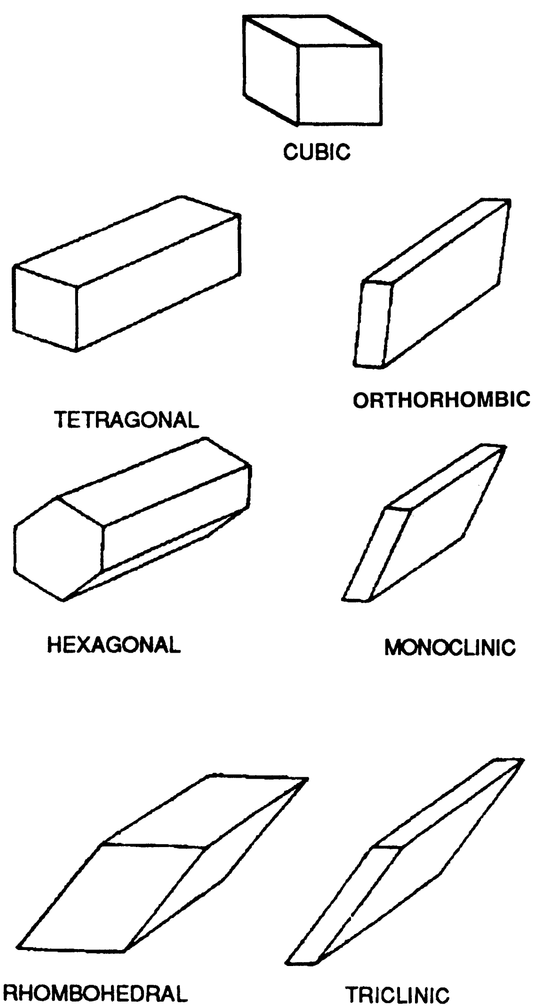


Figure #19C

3) Carefully re-fold your CRYSTAL MODELS one by one along the pre-creased lines. Assemble the models neatly, and tape the shapes together, being sure to tuck under the flaps so that they do not show on the finished model. See Figure #19D below. This is how to put together the CUBIC or ISOMETRIC shaped crystal model.

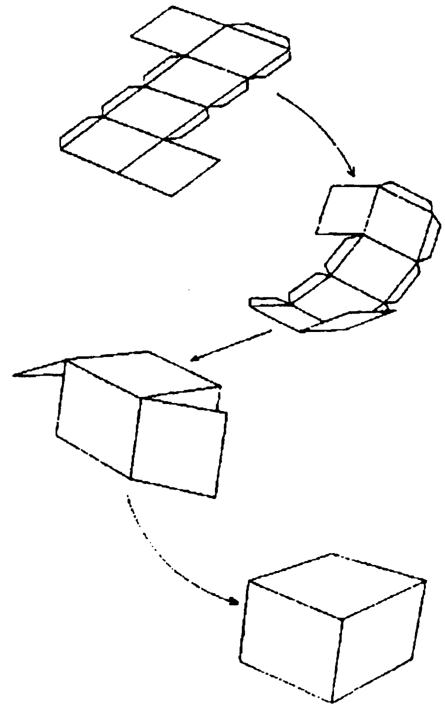


Figure #19D

4) Hold the shapes together with transparent cellophane tape or model cement.

5) Finish all seven CRYSTAL SHAPES.

6) With your fine tip permanent marker, carefully mark the name of each shape on the base of each model crystal. Compare your name with the previous drawings printed at left.

GROUP 9 | THE GASEOUS PHASE OF MATTER

The Gaseous Phase of Matter

Gas molecules are free to move about. They are not limited by other molecules. Since gas molecules are farther apart from each other than molecules in the solid state or the liquid state, gas molecules fill the shape of their container. Gases change their volume with temperature changes and pressure changes. Since most gases are colorless, odorless and tasteless, we tend to forget that:

A GAS IS MATTER.

Sometimes it is easy to forget that a gas is a form of matter. For us the most common gas is air. Air is not a single gas. It is a MIXTURE of gases. Is there any way to separate the gases in air?

Most of air is nitrogen. An important part of air is oxygen. Without oxygen, life on earth would be impossible. Can you think of any other gases in the air which are important? Can you think of other gases which are important?

Gases are not easily packed in your chemistry set. Some of the gases which we will use in experiments will be made from the chemicals in the set. Gases which we will use for our experiments will be made by chemical reactions.

TERMS TO KNOW

CATALYST - A catalyst is a chemical which either speeds up or slows down a reaction without being used up in the reaction.

DECOMPOSES - Breaks up into parts.

INVERSELY RELATED - If one variable goes up in value, another goes down. Inverses are opposites.

PRECIPITATE - A solid which does not dissolve in a solution.

Physical Properties of Gases

An example of this chemistry fact can be quite startling!

Gases respond to changes in the temperature and the pressure which surround them. A gas changes its volume when the temperature and/or the pressure on the gas changes. When scientists talk about gases, they are always careful to note the temperature and the pressure surrounding the gas.

SECTION 1 - THE EFFECT OF PRESSURE ON THE VOLUME OF A GAS

Did you ever try to squeeze a balloon without bursting it? Did you wonder what was happening to the air inside the balloon as you squeezed? Scientists have very carefully measured this experiment with all types of gases and have found interesting things which happen to gases (like air) when they are "squeezed" or put under pressure. Squeezed and expanded gases in the cylinder of an automobile engine is what makes the engine run. Scientists who fill up large helium weather balloons do NOT fill them up all the way because the helium expands as the balloon goes higher and higher. If the balloons were filled full at ground level, it would burst at higher altitudes where the atmospheric pressure is less and the helium gas volume becomes so much greater.

The following experiment lets you test for the effect of pressure on the volume of a gas. The blue solution is used in this experiment so that you can "see" the change in the volume of the gas you are testing. When you add weight (books) on top of the bulb, you are exerting force (pressure) on the gas to "reduce" its volume... just like squeezing a balloon.

Gases expand and contract with changes in the pressure of their surroundings. Gases expand when the pressure decreases. They contract when the pressure surrounding them increases. Gas volume and pressure are INVERSELY related.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Metric ruler
- ❑ A new plastic pipette
- ❑ Methylene blue solution (from your chemistry set)
- ❑ Plastic measuring cup
- ❑ Water
- ❑ Several heavy books
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 2 drops of methylene blue dye in a small plastic cup. Fill the cup about 1/2 full with water.

2) Fill ONLY the bulb of a plastic pipette with methylene blue solution. See Figure #20. After it is filled, DO NOT SQUEEZE the bulb, but hold the pipette tube and bulb as shown in Figure #20.

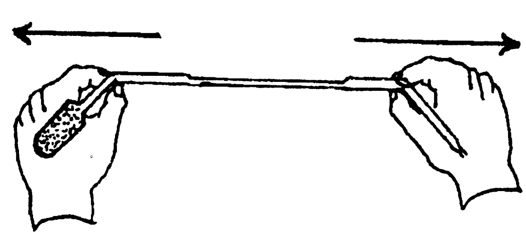


Figure #20

3) Grasp the pipette stem in one hand and the end of the pipette stem in the other. Pull until the pipette tube stretches very thin. Tie a knot in the stretched part of the pipette tube. See Figure #20A.

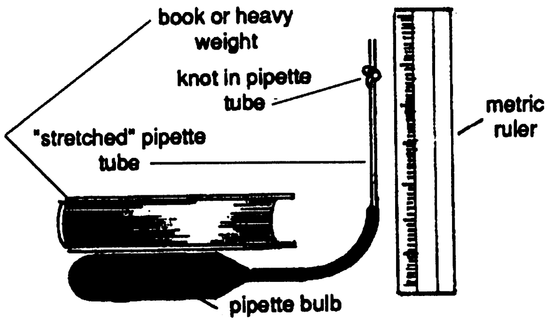


Figure #20A

4) Accurately measure the length of the trapped air column in the stem of the pipette using your metric ruler. See Figure #20A.

5) Place a book on top of the bulb of the pipette.

6) Measure the length of trapped air in the column with the book in place. What happened to the length of the column?

7) Continue to stack books on top of the bulb of the pipette. Measure the length of the column after each book has been added.

8) What statement can you make about the way pressure effects the volume of a gas?

SECTION 2 - THE EFFECT OF TEMPERATURE ON A VOLUME OF GAS

Temperature also will "change the volume of a gas." This is why, for instance, the tires on a car need to be inflated with a little more air than normal in very cold weather, and why you should let a little air out of the tires in very hot weather or on a long trip on hot highway surfaces.

In this experiment we will cool a gas (air) and watch as the volume of a gas changes (is reduced). Again we use the methylene blue dye solution just to be able to "see" the gas volume as it changes.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Methylene blue dye solution (from your chemistry set)
- ❑ A new plastic pipette
- ❑ Crushed ice
- ❑ Microplate
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

Gases expand and contract with changes in temperature. The expansion or contraction of a gas varies DIRECTLY with the temperature of a gas.

1) Start with a new pipette.

2) Fill a large well of the microplate with water. Add a few drops of methylene blue dye solution. The dye will allow you to observe the level of water in the stem of the pipette.

3) Place the bulb of the plastic pipette in a plastic cup.

4) Direct the stem of the pipette into the water in the well of the microplate. Hold the stem of the pipette below the water line by using some tape to secure the stem to the plate. See Figure #21.

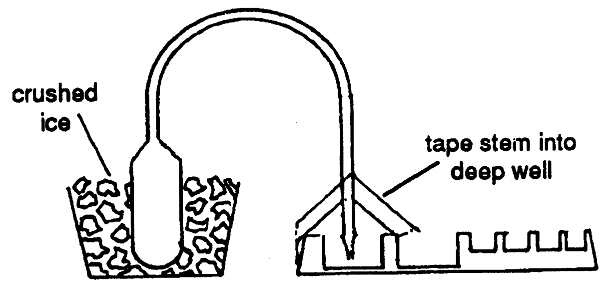


Figure #21

5) Place an ice cube or some crushed ice into a plastic cup with the pipette.

6) What happens to the water/methylene blue solution level in the stem? As the temperature of the air in the bulb decreased, what happened to the volume of the air? How do you know?

7) Remove the pipette from contact with the ice. Allow the air in the pipette to come to room temperature. What happens to volume of air as the bulb warms?

8) When the trapped air has returned to room temperature, pour some warm water into the plastic cup.

9) Place the bulb of the plastic pipette in contact with the warm water, by pouring warm water into the plastic measuring cup.

10) What happened to the level of water in the stem of the pipette as the bulb of air is warmed? What happens to a gas if the temperature of the gas increases?

SECTION 3 - GAS DIFFUSION

Of all states of matter, gases have the greatest ability to move from place to place and the greatest freedom of movement. The ability of gases to move through other gases is called DIFFUSION. The lighter the gas (the smaller the molecule), the faster its molecules can move.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Microplate
- ❑ Vinegar (from kitchen or grocery store)
- ❑ Household Ammonia (from kitchen or grocery store)
- ❑ Universal Indicator Solution (from your chemistry set)
- ❑ Plastic pipette
- ❑ Plastic sandwich bag
- ❑ Water
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Select one row of small wells in your microplate.
2) Place 10 drops of water in each well in the row, EXCEPT for the first and last well in the row.
3) Add one drop of Universal Indicator to each well containing water in the row.
4) Place 10 drops of vinegar in one of the empty wells.
5) Place 10 drops of ammonia in the other empty well.
6) **QUICKLY** place the microplate in a plastic sandwich bag.
7) What happens to the Universal Indicator? A change in color is due to the diffusion of vinegar and ammonia. A blue color indicates ammonia; a red color indicate vinegar.
8) Which diffused faster? Which is lighter?

SECTION 3A - GAS DIFFUSION II

Repeat the previous SECTION 3 in exactly the same way, but this time instead of using vinegar (acetic acid) try using lemon juice (citric acid).

SECTION 4 - PREPARATION OF OXYGEN

Hydrogen peroxide (H_2O_2) is a common household antiseptic which can be found as a 3% solution in many drug or grocery stores. Hydrogen peroxide can be DECOMPOSED into water the oxygen. The compound has a formula similar to water (H_2O).

The extra oxygen in peroxide can be freed by the reaction of hydrogen peroxide with a CATALYST. The reaction looks like this:

$$\text{hydrogen peroxide} \xrightarrow{\textbf{(steel wool)}} \text{water and oxygen}$$

The steel wool is the catalyst for the reaction. It is written above the arrow for the equation.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Fine steel wool (obtain from hardware store or grocery) DO NOT use the steel wool with soap embedded in it!
- ❑ Hydrogen peroxide (3%) (obtain from drugstore or grocery)
- ❑ Methylene blue solution
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Water
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Cut the round end of a pipette off with scissors. (If you have already made a filer funnel out of a pipette, you may use that.)
2) Pack steel wool into the bulb of the pipette so that it will not fall out the open end you just cut. Make sure the steel wool is close to the cut end but not sticking OUT of the open end you have cut.
3) With another pipette, add one pipette full of water to a large well of your microplate. Add 1 drop of methylene blue solution to the water in this large well.
4) Rinse out the pipette you have used with the water and the methylene blue solution.
5) Now place 1/2 pipette full of hydrogen peroxide solution into another large well.
6) Take the cut pipette with the steel wool and place the cut end into the well containing the hydrogen peroxide. Hold the pipette with the steel wool downward all the way to the bottom of the well of hydrogen peroxide. Hold the cut end of the pipette tightly against the bottom of the well containing hydrogen peroxide.
7) Oxygen gas will now be produced by the action of the catalyst (steel wool) and the hydrogen peroxide. The oxygen gas will go up the tube of the pipette.
8) Direct the stem of the pipette into the methylene blue solution. See Figure #22.

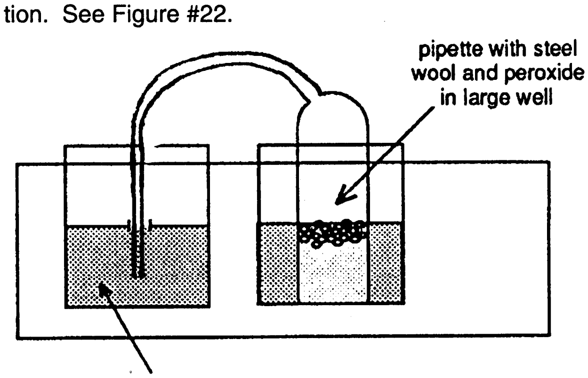


Figure #22

9) Observe the color of the methylene blue solution as the hydrogen peroxide decomposes. What happens? What gas is formed?

SECTION 5 - DOES AIR CONTAIN OXYGEN?

You probably have already heard that air contains oxygen. Oxygen is a gas which we breathe and which sustains life. How can we measure whether air actually does contain oxygen? By using methylene blue dye solution, we can measure for the presence of oxygen. Methylene blue dye solution will change color if it is in contact with oxygen. We can use this change of color to test for the presence of oxygen.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ A new plastic pipette
- ❑ Methylene blue solution
- ❑ Microplate
- ❑ Water
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 pipette of water in a large well in the microplate.
2) Add one drop of methylene blue to the water in the well.
3) Direct the stem of a plastic pipette into the methylene blue solution.
4) Squeeze the air out of the plastic pipette into the water containing the methylene blue solution.
5) Withdraw the tube from the methylene blue solution.
6) Allow the bulb to expand and fill with air.
7) Repeat the bubbling of air into the well as often as necessary until a color change is noted. Be sure to remove the tube from the well before allowing the bulb to return to the full position.
8) What happens to the methylene blue solution?

SECTION 6 - NATURAL OXYGEN PRODUCTION: THE ACTION OF ENZYMES

Oxygen is produced all the time by natural processes. The enzymes in the cells in liver will cause oxygen to be produced. Natural enzymes in raw potato will cause oxygen to be produced. In this experiment see if you can use the enzymes to release the oxygen from the hydrogen peroxide.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Hydrogen peroxide (3%) (obtain from drugstore or grocery)
- ❑ Raw liver or raw potato (obtain from your kitchen)
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Water
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place a small piece of raw liver or crushed potato in a large well in the microplate.
2) Add a pipette full of hydrogen peroxide to the liver or potato.
3) What gas is produced? How could you identify this gas?

SECTION 7 - METHYLENE BLUE AS AN INDICATOR

Using the materials listed above, and methylene blue, repeat the experiment.

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Add a pipette of hydrogen peroxide to two other large wells in the microplate.
2) Add a few drops of methylene blue to the hydrogen peroxide in both wells.
3) Place a small piece of liver or crushed potato in ONE of the wells.

SECTION 8 - PLANTS AND OXYGEN

Plants naturally produce oxygen when they are exposed to light. Plants take carbon dioxide from the atmosphere and produce oxygen. The next time you have FRESH spinach or a FRESH leafy green vegetable for dinner, save a few leaves of the vegetable for this experiment. You can use a plant leaf or a blade of grass instead of fresh spinach.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Source of sunlight or bright light
- ❑ Scissors
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Plastic measuring cup
- ❑ Grass or plant leaf
- ❑ Methylene blue solution
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

CUTTING LEAVES SHOULD BE DONE WITH YOUR PARENTS' ASSISTANCE

1) Place 1/2 pipette of water into two large wells in the microplate.
2) Add one drop of methylene blue to each of the wells containing the water.

(RV695)

3) Cut a small sample (about 1 g) of plant leaf into small pieces with scissors. Use a plastic cup to collect the pieces.

4) Using a chemical scoop, transfer the cut leaf to one of the wells in the microplate containing the methylene blue solution.

5) Place the plate in the sunlight or under a light for a few minutes.

6) What happens?

SECTION 9 - TESTING A GAS FOR CARBON DIOXIDE

A test for the presence of carbon dioxide in a gas is to bubble the gas into a saturated solution of calcium hydroxide. (Saturated calcium hydroxide solution is also known as lime water.)

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Calcium hydroxide solution (from your chemistry set)
- ❑ Scissors
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

NOTE:
To obtain lime water (saturated calcium hydroxide solution) you may have to see your pharmacist at your local drugstore, or use the calcium hydroxide solution from your chemistry set.

1) Cut a plastic pipette as shown in Figure #23. Use the cut-off stem as the blow straw. Save the bulb portion for another experiment.

SAVE THIS STEM FOR USE IN OTHER EXPERIMENTS

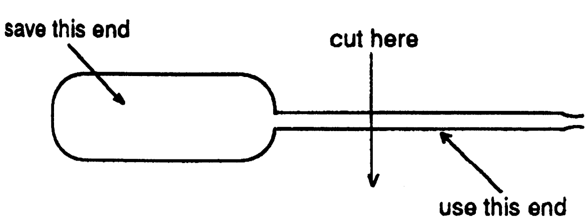


Figure #23

2) Fill another pipette with calcium hydroxide solution (lime water).

3) Place 1/2 the calcium hydroxide solution in one large well of the microplate. Place the other 1/2 of the solution in an adjoining well.

4) Place the large end of the plastic straw into your mouth. Direct a stream of breath gently into the solution.

5) Watch the solution carefully. A **PRECIPITATE** should form. A precipitate is a solid which is formed when a reaction occurs in solution. A precipitate formed in this experiment is an indication that carbon dioxide is in your exhaled breath. How could you tell if air has carbon dioxide?

6) The reaction for this precipitation is:

calcium hydroxide + carbon dioxide ⟶ **calcium carbonate** + water

$Ca(OH)_2 + CO_2$ **$CaCO_3$** $+ H_2O$

SECTION 10 - PREPARATION OF CARBON DIOXIDE

Carbon dioxide gas is produced when compounds containing carbonate react with acids. Carbon dioxide is also produced by living things.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Calcium hydroxide solution (lime water)
- ❑ Scissors
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Cellophane tape
- ❑ Sodium bicarbonate (baking soda from your kitchen)
- ❑ Vinegar (from your kitchen)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Cut a plastic pipette with scissors as indicated in Figure #24.

2) Place a 1/4 scoop of sodium bicarbonate in the pipette through the slit you have just formed.

3) Cover the slit with a piece of transparent tape or electrical tape.

SAVE THIS PIPETTE FOR USE IN OTHER EXPERIMENTS

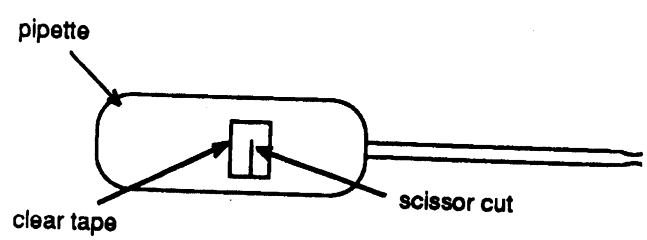


Figure #24

4) With another pipette, fill a large well of the microplate with calcium hydroxide solution.

5) With another clean pipette, fill an adjoining well with vinegar.

(RV695)

6) **QUICKLY** draw up some vinegar into the pipette with the sodium bicarbonate.

7) Direct the stem of the pipette into the calcium hydroxide solution.

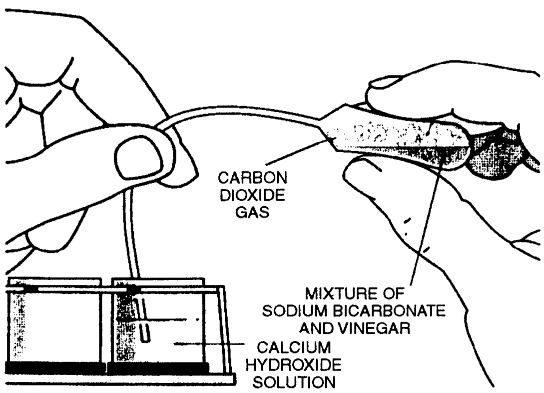


Figure #24A

8) Stand the plastic pipette combination in the microplate next to the well containing the calcium hydroxide solution, allowing the pipette end to bubble CO_2 gas into the clacium hydroxide solution.

9) What compound is generated by this reaction?

calcium hydroxide + carbon dioxide $\longrightarrow$???? + H_2O

10) What happens to the calcium hydroxide solution when the gas generated bubbles through the solution?

11) Where have you seen this reaction of calcium hydroxide before?

SECTION 11 - A REACTION WHICH PRODUCES CARBON DIOXIDE

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Baking soda solution (Sodium bicarbonate solution)
- ❑ Plastic pipette
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Citric acid solution
- ❑ Water
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

Make your own sodium bicarbonate (baking soda) solution by placing 1/4 scoop of baking soda (obtain from your kitchen or grocery) in your plastic measuring cup and adding a pipette of water. Stir this mixture until all baking soda has dissolved.

1) Place 20 drops of sodium bicarbonate solution in a large well of the microplate.

2) Add 1/2 pipette of water to the well.

3) Add 1/2 pipette of citric acid to the well.

4) Watch what happens as acid is added to the sodium bicarbonate.

5) How could you tell that the gas produced is carbon dioxide?

SECTION 12 - PRODUCING CARBON DIOXIDE IN ANOTHER WAY

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Alka Seltzer®
- ❑ Scissors
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Cellophane tape
- ❑ Vinegar
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Clean, rinse and dry the pipette you prepared in SECTION 10, Figure #24A.

2) Break off a piece of Alka Seltzer® which will fit into the pipette.

3) Repeat the procedure of SECTION 10, Parts 3-11.

What gas was produced by this reaction? How do you know?

What chemicals do you think caused the production of this gas?

SECTION 13 - THE PRODUCTION OF AMMONIA

Ammonia (NH_3) is a gaseous compound which, in water solution is found in the household preparation called "household ammonia." Ammonia and its solutions have a piercing odor. Ammonia is also commonly found in a medicinal preparation called smelling salts. Ammonia is important for use as a fertilizer. Ammonia is often a product of protein decay.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Ammonium chloride solution (from your chemistry set)
- ❑ Calcium hydroxide solution (from your chemistry set)
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Filter paper
- ❑ Universal Indicator solution
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 of a pipette of ammonium chloride solution into a well of your microplate.

2) Moisten a small (1 inch x 1 inch) piece of filter paper with Universal Indicator solution.

3) Add 1/2 plastic pipette of calcium hydroxide solution to the well containing ammonium chloride.

4) Hold the moistened filter paper over the well containing the mixture of ammonium chloride and calcium hydroxide.

5) What is the result? What gas caused the color change, if any?

   A color change with universal indicator indicates the presence of ammonia vapor. Remember that ammonia is a base!

SECTION 14 - NEUTRALIZATION OF GASES

Sometimes gases may be "acidic"... like the pollution gases in the atmosphere which dissolve in rainwater to cause "acid rain." Sometimes gases are "basic" or alkaline. And, as you might expect, the acid gases and the base gases can be mixed to neutralize one another. In the following experiment you will see how some gases are acidic by the way gases will change the color of a special "Universal Indicator" test paper. The test paper will change color to show not only if an acid is present but the color change can also give you an idea of "how strong" the acid is.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Microplate
- ❑ Plastic pipette
- ❑ Universal Indicator solution on a small piece of filter paper
- ❑ Vinegar
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 pipette of household vinegar in a well.

2) Place the filter paper which was made in SECTION 13, Part 4 over the well with the vinegar.

3) Allow the paper to stay above the well for a few minutes.

4) What happens to the color of the paper? Which side of the paper turns color first?

5) Add household ammonia to the well drop by drop. Mix after each addition. Cover with the paper again after each addition.

   What do you think happened to the ammonia?

   What gas do you think caused the change in the filter paper?

   What would happen if you mixed the household vinegar with a mixture of ammonium chloride and calcium hydroxide?

SECTION 15 - REACTION OF AMMONIUM CHLORIDE AND CALCIUM HYDROXIDE

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Ammonium chloride solution (from your chemistry set)
- ❑ Calcium hydroxide solution (from your chemistry set)
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Filter paper
- ❑ Universal indicator solution
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 of a pipette of ammonium chloride solution into a well of your microplate.

2) Moisten a piece of filter paper with Universal Indicator solution.

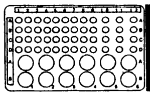
3) Add 1/2 of a pipette of calcium hydroxide solution to the well containing ammonium chloride.

4) Place 1/2 pipette of household vinegar in the same well. What is the name of the acid in household vinegar?

5) Mix the two solutions together. Wait a few moments for the two liquids to react together.

6) Allow the paper to stay above the well for a few minutes.

7) What happens to the paper? What is the compound formed when the acid reacts with the ammonia? How do you know that a reaction occurred?



GROUP 10 EXPERIMENTS WITH SOLUTIONS

Experiments with Solutions

TERMS TO KNOW

AQUEOUS - A water solution.

ANION - A negatively charged ion. Example: Cl-

CATION - A positively charged ion. Example: Na+

CONDUCTIVITY - The ability to allow electricity to flow through a substance.

CONDUCTOR - A solid or solution which allows electric current to flow through it.

DISSOLVE - To become part of a solution.

ELECTROLYTE - A solution which conducts an electric current.

ELECTRODE - A wire in an electrolyte which carries an electrical charge.

HOMOGENEOUS - The same throughout.

ION - A positively charged or negatively charged atom or group of atoms.

NONELECTROLYTE - A solution which does not conduct an electric current.

PRECIPITATE - A solid which does not dissolve in water.

Solutions are mixtures. Solutions are most often a mixture of a solid dissolved in a liquid or a liquid dissolved in another liquid.

The material which DOES the dissolving is called the SOLVENT. The material which is DISSOLVED is called the SOLUTE. In solutions, the most plentiful material in the mixture is called the solvent, while the material dissolved is the solute.

A solution is a special kind of mixture because a solution contains the same amount of solute throughout the solvent. Since a solute is evenly distributed throughout the solvent, a solution is often referred to as a HOMOGENEOUS mixture. A mixture (solution) of sugar dissolved in water is an example of a homogeneous mixture or a solution.

A) Can you think of a solution of a solid dissolved in solid? **(These solutions are called ALLOYS.)**

B) Can you think of a solution of a gas dissolved in a gas? Which gas is the solvent, which is the solute? **(Air is such a solution.)**

SECTION 1 - AN ELECTROLYTE DETECTOR

An electrolyte detector is easily made. The detector will allow you to determine if a solution conducts an electric current. You will be able to find out if a solution is an electrolyte or a non-electrolyte.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ LED (light emitting diode)
- ❑ 9-volt battery
- ❑ 9-volt battery clip
- ❑ 1-K ohm resistor
- ❑ Alligator clips (2)
- ❑ Insulated wire
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) From your chemistry set, obtain the LED (light emitting diode), 1-K ohm resistor, battery clip, and alligator clips. From the store, obtain a 9-volt battery.

2) Attach the battery clip to the battery.

3) The LED has two wires, one of which is longer than the other. Attach the LONG wire of the LED to the positive (red) wire of the battery clip. To connect them, carefully twist the bare metal end of the wires together.

4) Attach one of the resistor wire ends to the negative (black) wire of the battery clip. Connect these two wires by carefully twisting the bare ends of the metal wires together.

5) Next, take your two wires which have the alligator clips on their ends. Carefully strip the insulation from the other ends of the wire. Only strip about one half inch of insulation off each of their ends.

6) Connect one of the pieces of wire to the end of the resistor with an alligator clip. The free end of the wire is one **ELECTRODE.**

7) Connect the other piece of wire to the end of the LED with an alligator clip. The free end of the wire is the other **ELECTRODE.**

8) See Figure #25 for a picture of the completed Electrolyte Detector.

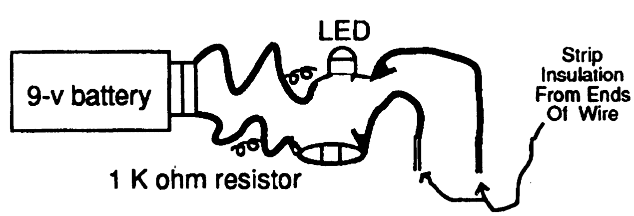


Figure #25

(RV695)

The chemicals most used in your chemistry set are solutions in which a solid or liquid chemical is dissolved in water. Solutions of chemicals dissolved in water are called **AQUEOUS SOLUTIONS**.

Some aqueous or water solutions conduct electricity. These are called **ELECTROLYTES.** Other solutions DO NOT conduct electricity. These solutions are called **NON-ELECTROLYTES.**

The ability of a water solution of dissolved chemical to conduct or not conduct electricity tells something about the way the chemical itself is held together in a molecule.

SECTION 2 - ELECTROLYTES AND NON-ELECTROLYTES

It is important to know whether a solution is an electrolyte or not. Usually, electrolyte solutions are made of a chemical salt which is dissolved in water. These WILL conduct small or large amounts of electrical current. The "Electrolyte Detector" which you made will allow you to determine if a solution is conducting even a small amount of electrical current...the detector will even tell you if a solid will conduct an electrical current.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Solutions of all the chemicals in the chemistry set
- ❑ Water
- ❑ Microplate
- ❑ Electrolyte Detector (made in SECTION 1)
- ❑ Pipette
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Using a pipette, place 7 drops of EACH CHEMICAL SOLUTION IN YOUR CHEMISTRY SET SEPARATELY in the small wells in the microplate. Rinse the pipette with clean water between each chemical which your pipette touches. Use small wells A-1 through A-12, and B-1 through B-4.

2) Place a pipette of water in one of the large wells in your microplate. This well is used to rinse off the electrodes between each test.

3) Place 7 drops of water in one of the small wells in the microplate. Use well B-12.

4) Place the two electrodes in the well containing 7 drops of water. Does pure water conduct? Remember, tap water is NOT pure water. If your parents have DISTILLED WATER, try the experiment again using distilled water. Distilled water is used in electric steam irons. Why?

5) Place the two electrodes in each of the solutions and rate them according to the ability to conduct electricity. Be sure not to let the two electrodes touch each other while they are in the solution. (The glow of the LED is a good indication of the solution being an ELECTROLYTE. The more the LED glows, the better the electrolyte.)

6) As you do your experiment, group the ELECTROLYTES together. Group the NON-ELECTROLYTES together. Make a Data Table on a separate sheet of paper similar to the Data Table shown, with Electrolytes separated from Non-electrolytes.

DATA TABLE #1

Data Table for Conductivity	
Substance	Conductor/Non Conductor
Cobalt Chloride Solution	
Copper Sulfate Solution	
Sodium Silicate Solution	
Calcium Hydroxide Solution	
Calcium Nitrate Solution	
Citric Acid Solution	
Ferrous Sulfate Solution	
Potassium Iodide Solution	
Sodium Sulfate Solution	
Aluminum Ammonium Sulfate Solution	
Ammonium Chloride Solution	
Magnesium Sulfate Solution	
Sodium Carbonate Solution	
Phenolphthalein Solution	
Universal Indicator Solution	

7) What is common about the non-electrolytes? What is true about electrolytes?

8) Test some common household solutions to see if they are electrolytes or non-electrolytes. For example, test household bleach, ammonia, detergent, milk, etc. Use small wells D-1 through D-12 for these tests.

9) Try testing some samples of food for conductivity. **DO NOT EAT THE FOOD AFTER YOU HAVE TESTED IT!**

SECTION 3 - ANOTHER USE FOR THE ELECTROLYTE DETECTOR

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Electrolyte Detector
- ❑ Household solids (see list below)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

Your electrolyte detector will tell you if a solid is a **CONDUCTOR.** Place the two electrodes from the tester on a piece of copper wire from your chemistry set. What happens? Try this test on a copper penny.

Test several solids in your home to see if they are conductors.

Some solids to test:
A tissue, a pencil (try the "lead" in the pencil; it isn't really lead), a teaspoon, toothbrush, window, pen, wooden or plastic ruler, etc.

List all the conductors. What was common about all the conductors?

List all the non-conductors. What was common about all the non-conductors?

Enter all tests you make into the Data Table you prepared in Section 2.

SECTION 4 - REACTIONS OF SOLUTIONS

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Solutions of the chemicals listed below in Table #2
  Two Groups: Group 1 Chemicals and Group 2 Chemicals)
- ❑ Electrolyte Detector
- ❑ Microplate
- ❑ Plastic pipettes
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

Chemical compounds when dissolved in a water solution often break up into charged particles called IONS. The presence of these charged particles or IONS, allow the solution to conduct electricity. The experiment above showed which compounds contain ions. Ions react with each other in solution.

Cations react with anions to form new compounds. As in any chemical reaction, when two chemicals react, the reaction sometimes produces products which have totally different properties from the beginning compounds.

1) Divide the chemical compounds which have been made into solutions into two groups of chemicals as shown in Table #1.

TABLE #2

Group 1	Group 2
Copper Sulfate Ferrous Sulfate Calcium Nitrate Magnesium Sulfate	Potassium Iodide Sodium Chloride Sodium Sulfate Sodium Bicarbonate Sodium Carbonate Ammonium Chloride

2) Remembering how you used the ELECTROLYTE DETECTOR from Section 2, write a small "e" for electrolyte after each chemical you tested. Also write a small "n" for non-electrolyte after the chemicals which you tested which were non-electrolyte.

3) Remember which of the chemicals in Table #2 are Electrolytes.

4) Place 4 drops of copper sulfate solution in each well in the first ROW of small wells across the microplate. See Figure #26.

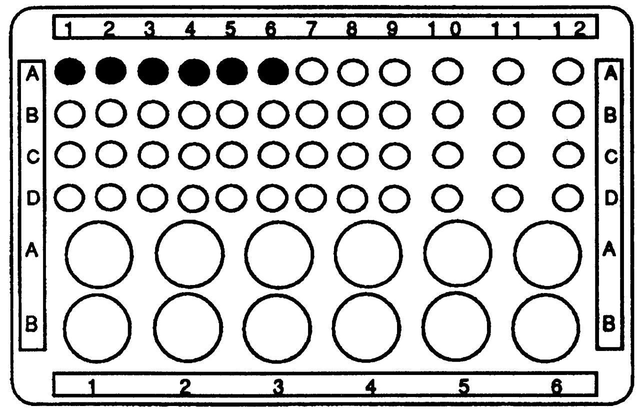


Figure #26

5) Place 4 drops of ferrous sulfate solution in the second row of small wells across the microplate.

6) Continue to put 4 drops of each chemical solution in Group 1 chemicals in an individual ROW of wells across the microplate. See Figure #26.

7) Add 4 drops of potassium iodide solution (Group 2 chemicals) to each of the wells in the first COLUMN of the microplate. See Figure #27.

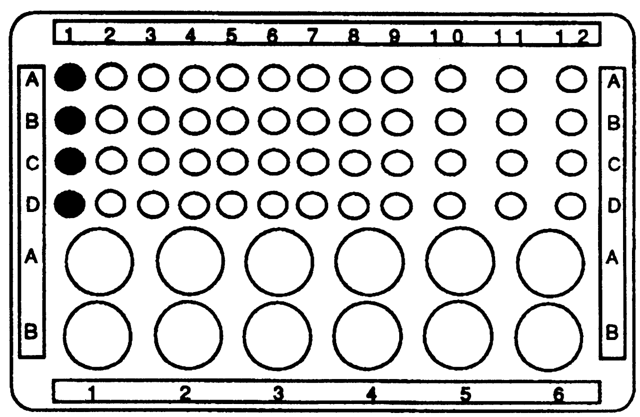


Figure #27

8) Continue to put 4 drops of each chemical solution in Group 2 chemicals in an individual COLUMN of wells.

9) Which combination of chemicals gave a chemical reaction? How do you know that a chemical reaction has taken place? **DO NOT DISCARD THIS MICROPLATE OF REACTIONS!**

10) Prepare a chart which records all of these reactions similar to Table #3 - REACTION RECORDING TABLE.

11) Record each reaction (or non-reaction) in the blank spaces in your table.

Table #3 - REACTION RECORDING TABLE

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
ROW 1	Copper Sulfate + Potassium Iodine	Copper Sulfate + Sodium Chloride	Copper Sulfate + Sodium Sulfate	Copper Sulfate + Sodium Bicarbonate	Copper Sulfate + Sodium Carbonate	Copper Sulfate + Ammonium Chloride
ROW 2	Ferrous Sulfate + Potassium Iodine	Ferrous Sulfate + Sodium Chloride	Ferrous Sulfate + Sodium Sulfate	Ferrous Sulfate + Sodium Bicarbonate	Ferrous Sulfate + Sodium Carbonate	Ferrous Sulfate + Ammonium Chloride
ROW 3	Calcium Nitrate + Potassium Iodine	Calcium Nitrate + Sodium Chloride	Calcium Nitrate + Sodium Sulfate	Calcium Nitrate + Sodium Bicarbonate	Calcium Nitrate + Sodium Carbonate	Calcium Nitrate + Ammonium Chloride
ROW 4	Magnesium Sulfate + Potassium Iodine	Magnesium Sulfate + Sodium Chloride	Magnesium Sulfate + Sodium Sulfate	Magnesium Sulfate + Sodium Bicarbonate	Magnesium Sulfate + Sodium Carbonate	Magnesium Sulfate + Ammonium Chloride

SECTION 5 - TESTING THE PRODUCTS OF A REACTION

Even though you have already tested solutions and solids in the previous experiments, now you can test the PRODUCTS of a reaction with your electrolyte detector. Remember: in this experiment you are testing to see whether the PRODUCTS of a chemical reaction will behave differently than the chemicals which were used to form them. Observe carefully, and you may want to test some of the products after you have dried them out to see if the dry powder products react differently than the "wet" products.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Microplate with the completed reactions from SECTION 4
- ❑ Electrolyte Detector made in SECTION 1
- ❑ Water
- ❑ Plastic pipettes
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Allow all the reactions to finish. (Wait about 15 minutes for the reactions to settle out.)

2) Place the tip of a MICROTIP pipette just below the liquid level in a well. Remove the **LIQUID ONLY** from each of the wells where a reaction has occurred. DO NOT DISCARD THESE SOLUTIONS! Place each solution removed in another unused well on the right side of your microplate. Example: solution from A-1 should be put in well A-7, and so on. Rinse the pipette with water between each chemical solution. The liquids which you are saving in microwells A, B, C, D-7-12 will be used in SECTION 6 experiments.

3) Add 10 drops of rinse water (tap water) to each of the wells which showed a chemical reaction and allow the precipitate to settle to the bottom of the well.

4) Remove and discard the rinse water which is above the precipitate in the well.

5) Add 8 drops of fresh water to each of the wells where a reaction has occurred.

6) Test the solution of the products in each of the wells where a reaction has occurred with the ELECTROLYTE DETECTOR.

7) Is there any difference between the products and the reactants which formed them? What do you think happened to give the results you have noticed?

8) Which combination of chemicals produced a reaction? Which chemical product is a PRECIPITATE? Which chemical product is a gas?

SECTION 6 - TESTING THE REMAINING SOLUTION OF A CHEMICAL REACTION

Just as you tested the precipitates (the wet and dry products of a chemical reaction), you now need to test the solutions which were formed in the chemical reactions. Many of these solutions carry dissolved in them the salts from a chemical reaction. Your electrolyte detector will show the ones which conduct electrical current, in other words, the solutions which have dissolved salts and which are ELECTROLYTES!

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ☐ Microplate with the solutions from SECTION 4 (wells A, B, C, D - 8-12)
- ☐ Electrolyte Detector
- ☐ Water
- ☐ Plastic pipettes
- ☐ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

Test the solutions saved from SECTION 5 in the small wells A, B, C, D - 8 - 12, for conductivity using the ELECTROLYTE DETECTOR.

Prepare another table like Table #3 and record which solutions conduct electricity (these are ELECTROLYTES).

GROUP 11 | ACID AND BASE SOLUTIONS

Acid and Base Solutions

Acids and bases are two types of chemicals which you have contact with every day. Common acids can be found in many man-made and natural products. Acids which you may have seen include ascorbic acid (vitamin C), acetic acid (vinegar), auto battery acid (sulfuric acid), tea (tannic acid), and sour milk and yogurt (lactic acid).

Bases are also quite common. Milk of magnesia (magnesium hydroxide), lye (sodium hydroxide) and household ammonia (ammonium hydroxide) are some common bases.

ACIDS AND BASES ARE WATER SOLUTIONS.

TERMS TO KNOW

ACID - A chemical which ionizes in water to form H^+ ions.

ACIDIC - A solution which has a pH less than 7.

ALKALINE - A solution which has a pH greater than 7.

BASE - A chemical that ionizes in water to form OH^- ions.

EXTRACT - To use a solvent to isolate an individual chemical from a source.

INDICATOR - A chemical which turns color at a particular pH.

ION - A charged atom or group of atoms.

IONIZATION - The breaking apart of a molecule into parts which have a positive (+) or negative (-) charge.

NEUTRAL - Neither acid nor base.

pH SCALE - A scale which tells the relative amount of acid or base in a solution.

SALT - The chemical which results when an acid reacts with a base.

Water (H_2O) contains two different chemical parts. These parts are called IONS. The hydrogen ion (H^+) which has a positive charge and the hydroxide ion (OH^-) which has a negative charge. Acids add extra H^+ ions to water, bases add extra OH- ions to water.

In pure water the amount of H^+ ion *exactly equals* the amount of OH^- ion.

When any chemical is added to water the balance of H^+ and OH^- in the solution changes. For example, when sulfuric acid is added to water to make a solution for a car battery, the amount of H^+ increases while the amount of OH^- decreases.

This solution is said to be **ACIDIC.**

When calcium oxide, unslaked lime, (CaO) is added to water to form slaked lime, the amount of OH^- increases while the amount of H+ decreases. This solution is said to be **BASIC** or **ALKALINE**.

Almost **ALL** solutions are either ACIDIC or ALKALINE. Very few solutions are **NEUTRAL**.

Scientists measure the amount of acidity or alkalinity by using a special scale called the **pH SCALE**. The pH scale rates solutions from 1 to 14 based on the amount of H^+ or OH^- ion in the solution. A solution which has a rating of between 1 to 6 is considered **ACIDIC** (1 is the highest amount of acid, 6 is the least). A solution which is rated 8 to 14 is ALKALINE or **BASIC** (a solution which has a 14 pH has the highest amount of base, while 8 is the least basic). A solution which is exactly 7 is **NEUTRAL**.

The chart below may help you to understand this important scale.

pH (1 - 2 - 3 - 4 - 5 - 6) 7 (8 - 9 - 10 - 11 - 12 - 13 - 14)

← STRONGER ACID		neutral	STRONGER BASE →	
STRONGEST *ACID*	WEAKEST *ACID*		WEAKEST *BASE*	STRONGEST *BASE*

SECTION 1 - THE pH SCALE AND INDICATORS

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Household vinegar (acetic acid) obtain from kitchen or grocery
- ❑ Household ammonia (ammonium hydroxide solution) obtain from kitchen or grocery
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Water
- ❑ Universal indicator solution (from your chemistry set)
- ❑ Phenophthalein solution (from your chemistry set)
- ❑ Transparent tape
- ❑ Set of colored pencils
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

This experiment will show you the characteristics of both the pH scale and the way INDICATORS work.

Use a microtip pipette for these experiments.

1) Place 9 drops of water in each of the small wells A-3 and A-10 in the microplate.

2) Place 10 drops of vinegar (acetic acid) in well A-2.

3) Take one drop out from small well A-2 and drop it into the water in small well A-3.

   You have just made the acid in small well A-3 ten times LESS THAN the acid solution in small well A-2. Why? See Figure #28.

4) Take one drop out of small well A-3 and mix it with the water in small well A-4.

5) Repeat the above process with well 5 and 6. **DO NOT ADD ANYTHING TO WELL 7.** Why?

   (Hint: small well A-7 will be used as neutral or just plain water which is neutral pH.)

6) Place 10 drops of household ammonia (ammonium hydroxide) in small well A-11.

7) Take one drop out of small well A-11 and add it to the water in small well A-10.

   You have just made the base in small well A-10 ten times LESS THAN (weaker than) the basic solution in small well A-11. Why?

8) Take one drop out of small well A-10 and mix it with the water in small well A-9.

9) Take one drop out of small well A-9 and mix it with the water in small well A-8.

10) **DO NOT ADD ANYTHING TO SMALL WELL A-7.** Why?

11) Add one drop of Universal Indicator to all the wells. What happens in each of the wells?

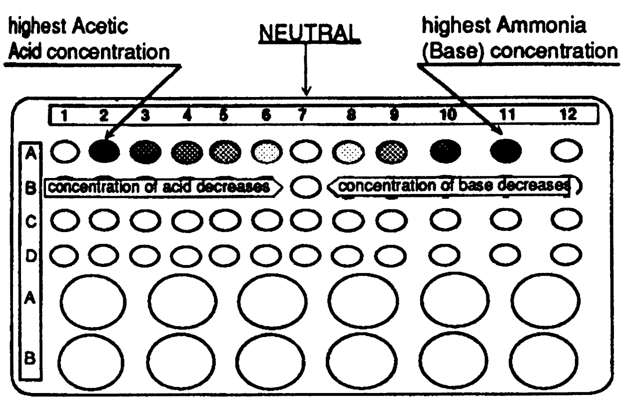
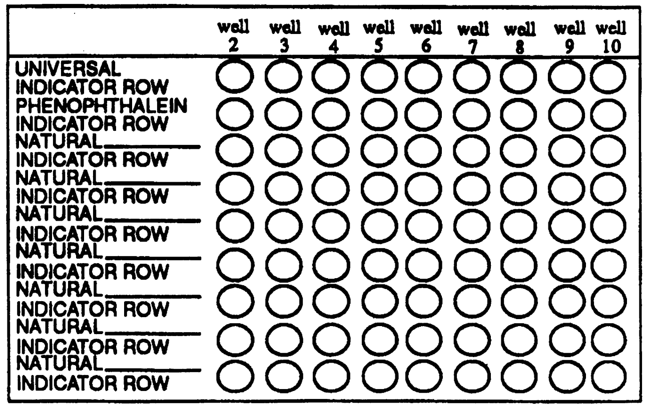


Figure #28

12) On RECORD CHART 28-A, using your colored pencils, fill in the colors which the Universal Indicator solution changed to in each of the small wells A-2 through A-11. Mark this row (A-2 through A-10) the Universal Indicator Row.



RECORD CHART 28-A

SECTION 1A - DILUTION OF ACID

In this experiment you will see how to dilute an acid, more and more, and to show how the dilution can be seen by the use of an "indicator." The indicator used in this experiment is Phenophthalein which will change color in a basic solution and NOT in an acid solution. You will need the color change information to compare with acid and base experiments later.

Use a microtip pipette for these experiments.

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 9 drops of water in small wells B-3 and B-10 in the microplate.

2) Place 10 drops of vinegar (acetic acid) in small well B-2.

3) Take one drop out of small well B-2 and mix it with the water in small well B-3. You have just made the acid in small well B-3 ten times LESS THAN small well B-2 by a factor of 10. Why? See Figure #28.

4) Take one drop out of small well B-3 and mix it with the water in small well B-4.

5) Repeat the above process with small wells B-5 and B-6. **DO NOT DO ANYTHING TO WELL 7.** Why?

6) Place 10 drops of household ammonia (ammonium hydroxide) in small well B-11.

7) Take one drop out of small well B-11 and mix it with the water in small well B-10. You have just made the base in small well B-10, ten times LESS THAN small well B-11. Why?

8) Take one drop out of small well B-10 and mix it with the water in small well B-9.

9) Tkae one drop out of small well B-9 and mix it with the water in small well B-8.

10) **DO NOT ADD ANYTHING TO SMALL WELL B-7.** Why?

11) Add one drop of phenophthalein solution (another indicator) to each of the wells in this row.

Compare the results of your experiments. How is phenophthalein different from Universal Indicator?

12) On RECORD CHART 28-A, using your colored pencils, fill in the colors which the phenophthalein Indicator Solution changed to in each of the small wells B-2 through B-11. Mark this row on your RECORD CHART 28-A (B-2 through B-10) Phenophthalein Indicator Row.

DO NOT DISCARD YOUR INDICATORS!!

You can save the Universal Indicator and phenophthalein for use as **CONTROLS** for experiments you will do later. Seal the indicators in their wells by covering the wells with a piece of transparent tape. Cover each row of wells with a long, single piece of tape. Run your finger over each well to seal the contents in the well.

SECTION 2 - NATURAL INDICATORS

One of the most fascinating discoveries is that many plants also have natural "indicators" included in the flowers, leaves or stems of the plant. We can use these as indicators for our acid and base change experiments.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Flower petals (obtain from plant flowers with colored petals)
- ❑ Plant fruit skin (example: cherries, blueberries, etc.)
- ❑ Red cabbage leaves (obtain from your grocery)
- ❑ Large test tube with cap
- ❑ Household tea (from tea bag)
- ❑ Isopropyl alcohol (rubbing alcohol) (obtain from drugstore or grocery)
- ❑ Microplate
- ❑ Household vinegar (acetic acid)
- ❑ Household ammonia (ammonium hydroxide)
- ❑ Plastic pipette
- ❑ Plastic soda straw
- ❑ Scissors
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

WARNING: Ethyl or isopropyl alcohol and their vapors are highly flammable. Do not use alcohol in the presence of an open flame. Use alcohol in an area with good ventilation.

Some naturally occurring chemicals are indicators. They must be separated from natural sources in order to see them work. We will **EXTRACT** the natural indicators with ethyl alcohol or with isopropyl alcohol (rubbing alcohol).

Almost all plant colors (pigments) are indicators. Use the skin, rind, or petal of a plant. The indicator will be in the colored or tinted part of the plant. Green leaves contain **CHLOROPHYLL**. Chlorophyll is not an indicator. The petals of flowers, even white flowers, contain indicators. The following is a list of plant sources of indicators. Red cabbage, cherry skins, tea, blueberry skins, blackberry skins or flower petals are good sources of natural indicators.

TO EXTRACT THE INDICATOR, FOLLOW THESE DIRECTIONS: Be sure to use a microtip pipette for this experiment.

DO NOT MIX SKINS OR FLOWERS!
BE SURE TO EXTRACT EACH PLANT OR FLOWER INDIVIDUALLY

1) Place a 5-6 gram sample of the plant or flower into a test tube.

2) Add 1/2 pipette of ethyl or isopropyl alcohol. Mix well. Crush the petals with a plastic soda straw to squeeze alcohol throughout the sample.

3) Allow the plant material to stay in the alcohol for at least 5 minutes.

4) Pour off the liquid into a large well of the microplate.

5) Save this liquid as your "natural indicator solution" in further experiments. If you wish, you may also save the indicator in same plastic pipette which you used for extracting or drawing up the indicator solution out of the test tube. Be sure to label your plastic pipette, which indicator it holds.

SECTION 3 - NATURAL INDICATORS

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Flower petals, plant skin, or red cabbage extraction (from previous experiment)
- ❑ Large test tube
- ❑ Isopropyl alcohol (rubbing alcohol)
- ❑ Microplate
- ❑ Household vinegar (acetic acid)
- ❑ Household ammonia (ammonium hydroxide)
- ❑ Plastic pipette
- ❑ Colored pencils
- ❑ Water
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Repeat SECTION 1 Steps 1-9 in another row of small wells (Rows C and D).

2) Add 6-8 drops of your indicator to each of the wells in the row.

3) Record the color change on RECORD CHART 28-A by coloring in the correct well circles with your colored pencils.

Put the correct name at the end of the row you are recording as to what indicator you used and the colors indicated.

Note: You may have to repeatedly clean out the wells in rows C and D and re-use them after each recording and experiment with different indicators. Try to find as many colored "natural indicators" possible. Always record the color changes on RECORD CHART 28-A.

SECTION 4 - OTHER NATURAL INDICATORS

Repeat the procedure in SECTION 3 until you have tested all of your natural indicators.

What can you tell about all the indicators?

What is similar or different about each of the indicators?

BE SURE TO RECORD, on RECORD CHART 28-A with your colored pencils, all of the color changes observed from the testing of your natural indicators.

SECTION 5 - TESTING FOR ACIDS AND BASES

Now by using the tests and the color changes which you recorded in previous experiments which told you the color changes occurring at specific acid or base concentrations, you can now test for the acid and base changes and concentrations with some unknown solutions. Again compare any color changes with what you already recorded from previous experiments and color changes.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Microplate of indicators from SECTION 1 (small rows A & B)
- ❑ Household soap solution (example: Dial® liquid soap or dishwashing liquid soap)
- ❑ Shampoo solutions
- ❑ Liquid laundry detergent
- ❑ Pet shampoo
- ❑ Vinegar
- ❑ Clear soda (sparkling water)
- ❑ Toothpaste
- ❑ Milk
- ❑ Lemon juice
- ❑ Grapefruit juice
- ❑ Universal Indicator solution
- ❑ Plastic pipettes
- ❑ Colored pencil set
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

As stated above, many of the products which are in your home are acids and bases. You can test home products for acid, base or neutral pH in the following way.

1) Place a small sample of each of the liquids mentioned in the materials list separately in large wells of your microplate.
2) Add some water to each large well containing your samples.
3) Add a few drops of Universal Indicator to each of the large wells containing samples.
4) Compare the colors of the wells with samples to the control wells with Universal Indicator you prepared in SECTION 1. Record the solutions you test on RECORD CHART 28-B. Use your colored pencils to show changes.

Which products are acids? Which are bases? Were any of the materials you tested neutral?

SOLUTIONS TESTED	COLOR BEFORE UNIVERSAL INDICATOR ADDED	COLOR AFTER UNIVERSAL INDICATOR ADDED
Shampoo		
Dishwashing detergent		
Laundry detergent		
Pet Shampoo		
Vinegar		
Clear Soda		
Toothpaste		
Milk		
Lemon juice		
Grapefruit juice		
Rain water		
Other Material Tested		
Other Material Tested		
Other Material Tested		
Other Material Tested		
Other Material Tested		
Other Material Tested		

RECORD CHART 28-B

SECTION 6 - TESTING RAIN WATER FOR pH VALUE

Rain water is not pure water. As rain falls from the sky, it picks up particles and chemicals. The particles may be pieces of dust, dirt or smoke. The chemicals may be gases which have been released from a factory or home. In any case, rain water may absorb this material and change the pH of rain water.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Microplate of indicators from SECTION 1
- ❑ Rain water
- ❑ Plastic cup
- ❑ Plastic pipette
- ❑ Universal Indicator solution
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Obtain a sample of rain water in a plastic cup.

2) Transfer ten drops of the rain water to each of 4 small wells in the microplate.

3) Add a drop of Universal Indicator to ONE of the wells with rain water.

4) Add phenophthalein indicator to the next well.

5) Finally, test some of your natural indicators with your rain sample.

6) Compare the color of the indicator in the rain sample well with the control Universal Indicator wells you prepared in SECTION 1.

7) Compare the color of the indicator in the phenophthalein control with the rain sample and phenophthalein.

8) Finally, compare the "natural indicators" and rain sample with the colors noted in SECTION 2.

Which indicator was the best for telling the pH of rain water? Which indicator would be the worst?

What would you expect the pH of rain to be? Are your results different than what you expected?

Extend the spaces on your RECORD CHART 28-B to include the rainwater sample you tested. Color in any changes noticed.

SECTION 7 - TESTING THE pH OF OTHER CHEMICALS

Now that you know that an INDICATOR such as Universal Indicator Solution or Phenophthalein Solution may be used to tell the chemist if a solution is an acid or base, it is time to determine the acidity and basicity of the other chemicals in your chemistry set.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Microplate of indicators from SECTION 1 (with indicator colors in small well rows A and B)
- ❑ Plastic pipette
- ❑ Water
- ❑ Colored pencil set
- ❑ Calcium nitrate solution (from your chemistry set)
- ❑ Ferrous sulfate solution (from your chemistry set)
- ❑ Cobalt chloride solution (from your chemistry set)
- ❑ Ammonium chloride solution (from your chemistry set)
- ❑ Potassium iodide solution (from your chemistry set)
- ❑ Sodium sulfate solution (from your chemistry set)
- ❑ Copper sulfate solution (from your chemistry set)
- ❑ Sodium carbonate solution (from your chemistry set)
- ❑ Citric acid solution (from your chemistry set)
- ❑ Sodium silicate solution (from your chemistry set)
- ❑ Calcium hydroxide solution (from your chemistry set)
- ❑ Aluminum ammonium sulfate solution (from your chemistry set)
- ❑ Magnesium sulfate solution (from your chemistry set)
- ❑ Universal Indicator solution (as an indicator)
- ❑ Phenophthalein solution (as an indicator)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Using the small well rows C-1 through C-12 and D-1 through D-12, place 9 drops of water into each small well in row C and row D of your microplate.

2) Place 9 drops of water in large well A-1 and large well B-1.

3) Pipette one drop of each solution listed above in small wells C-1 through C-12 and large well A-1. Again do the same for small wells D-1 through D-12 and large well B-1. DO NOT use the phenophthalein or Universal Indicator yet.

4) Pipette one drop of Universal Indicator solution to small wells C-1 through C-12 and large well A-1.

5) Pipette one drop of phenophthalein indicator to each of the small wells D-1 through D-12 and to large well B-1.

6) Observe any color change in all of the wells tested. (A piece of white paper under your microplate may help show the colors.)

7) Using your colored pencil set, record any color change on RECORD CHART 28-C.

8) Some of your chemical solutions will show no change. Some will be acids. Some will be bases. With a black pen, put an "A" by the ones which show an acid color present. Put a "B" by the ones which show a base present. Put an "N" (neutral) by the ones which appear to have no change.

SOLUTIONS TESTED	UNIVERSAL INDICATOR SOLUTION TEST	PHENOPHTHALEIN INDICATOR SOLUTION TEST
MAGNESIUM SULFATE SOLUTION		
ALUMINUM AMMONIUM SULFATE SOLUTION		
CALCIUM HYDROXIDE SOLUTION		
SODIUM SILICATE SOLUTION		
CITRIC ACID SOLUTION		
SODIUM CARBONATE SOLUTION		
COPPER SULFATE SOLUTION		
SODIUM SULFATE SOLUTION		
POTASSIUM IODIDE SOLUTION		
AMMONIUM CHLORIDE SOLUTION		
COBALT CHLORIDE SOLUTION		
FERROUS SULFATE SOLUTION		
CALCIUM NITRATE SOLUTION		

RECORD CHART 28-C

GROUP 12 TITRATION: A QUANTITATIVE METHOD

Titration: A Quantitative Method

Using your chemistry set, you have been able to test many different materials to see if they were **ACIDIC** or **BASIC**. Chemists sometimes want to know HOW MUCH acid or base is in a substance. While pH tells the general amount of H^+ in a solution, a more exacting method used to determine the amount of acid or base is the process called **TITRATION.**

Titration is the oldest method of **QUANTIFYING** in chemistry. By comparing a standard solution (a control) to an unknown solution, we can determine the exact amount of acid or base in solution. This is the process of titration.

Titration is a very common scientific procedure. Perhaps you have seen advertisements which say something like... "our product contains 47 times as much as Brand X." This statement is based on comparisons made by using titration.

TERMS TO KNOW

ACID - A chemical which ionizes in water to form H^+ ions.

ACIDIC - A solution which has a pH less than 7.

ALKALINE - A solution which has a pH greater than 7.

BASE - A chemical that ionizes in water to form OH^- ions.

NEUTRALIZATION - The reaction of H^+ ions with another ion to form water. <u>A BASE NEUTRALIZES AN ACID TO FORM WATER</u>.

QUANTIFYING - Telling <u>how much</u> there is.

SALT - The chemical produced when an acid and a base react.

TITRATION - A process of determining the amount of acid or base in a sample.

<u>SECTION 1 - PREPARATION OF A STANDARD BASE SOLUTION</u>

It is important to always have a "standard" solution which can be used to compare other solutions which you are testing. This comparison of a "known" (standard) to an "unknown" (thing to be tested) is what TITRATION is all about. With a standard base solution you can test acids. With a standard acid solution you can test bases.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Sodium bicarbonate solid (baking soda) obtain from kitchen or grocery
- ❑ Test tube, small
- ❑ Water
- ❑ Electrolyte detector (from the <u>GROUP 10 - SOLUTIONS</u> SECTION)
- ❑ 9-volt battery
- ❑ Plastic scoop
- ❑ Plastic wrap (Saran® wrap or other plastic wrap)
- ❑ Transparent cellophane tape
- ❑ Fine point marker (Sharpie® brand by Sanford or one like it)
- ❑ Goggles

<u>BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!</u>

Sodium bicarbonate is a base. In water, **sodium bicarbonate** breaks up into **sodium ions** and **hydrogen carbonate ions.**

$$NaHCO_{3(S)} \longrightarrow Na^+_{(aq)} + HCO^-_{3(aq)}$$

1) Place 1/2 scoop of sodium bicarbonate solid in a small test tube.

2) Add three pipettes of water to the solid in the tube.

3) Stir the solid in the liquid until the solid totally dissolves.

4) Cover the tube with a piece of plastic wrap and label the tube "Control Base" with cellophane tape and your fine point marker.

5) Place 7 drops of sodium bicarbonate solution which you made in a small well of the microplate. What would you use to see if it conducts electricity?

   Does a solution of sodium bicarbonate conduct electricity?

   What test will show if sodium bicarbonate is a base?

   What other bases do you know?

   What other compounds in your chemistry set are bases? (Refer to GROUP 11 - SECTION 7.)

<u>SECTION 2 - TESTING VINEGAR SOLUTIONS</u>

It may be a surprise that not ALL vinegars which are sold have the same acid concentration. Many times the makers of the vinegar will put on their label how much acid (the concentration of acetic acid) is in their product.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Household vinegar (white vinegar)
- ❑ Plastic pipette
- ❑ Control base (prepared previously in SECTION 1)
- ❑ Microplate
- ❑ Universal Indicator Solution
- ❑ Toothpick
- ❑ Electrolyte detector (from the <u>GROUP 10 - SOLUTIONS</u> SECTION)
- ❑ 9-volt battery
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

Acids react with bases. The reaction of an acid with a base produces a SALT and water. Common salt, sodium chloride (NaCl), is the salt resulting from a reaction between sodium hydroxide (NaOH) and hydrogen chloride (HCl). The reaction which produces sodium chloride is:

$$\underset{\text{(base)}}{NaOH} + \underset{\text{(acid)}}{HCl} \longrightarrow \underset{\text{(a salt)}}{NaCl} + \underset{\text{(water)}}{H_2O}$$

Household (salad) vinegar is acidic. The acid in vinegar is acetic acid (CH_3COOH). Acetic acid dissolves in water and ionizes like this:

Acetic acid ionizes to produce a **hydrogen ion** and an **acetate ion.**

$$CH_3COOH_{(aq)} \longrightarrow H^+_{(aq)} + CH_3COO^-_{(aq)}$$

1) Place 7 drops of vinegar in a small well of the microplate. Does vinegar conduct electricity? What would you use to check for conductivity?

2) Test a solution of household vinegar to see if it is an acid. What would you use to test it?

   When acetic acid (vinegar) reacts with sodium bicarbonate, a salt, water and a gas is formed. The reaction is given below:

   Vinegar reacts with sodium bicarbonate to produce sodium acetate, water and ???????.

$$\underset{\text{(vinegar)}}{CH_3COOH} + \underset{\text{(sodium bicarbonate)}}{NaHCO_3} \longrightarrow \underset{(\quad)}{CH_3COONa} + \underset{(\quad)}{H_2O} + \underset{(\quad)}{????}$$

What is the name of the salt produced in this reaction? Look at the SECTION ON NAMING COMPOUNDS to check the name of the salt. What gas is produced in this reaction? Look at the SECTION ON GASES to check your guess.

If you use your CONTROL BASE to titrate household vinegar, you can determine how much acid is in commercial vinegar preparations.

SECTION 3 - HOW MUCH ACETIC ACID IS IN VINEGAR?

Some household vinegars measure out to have a 3% solution of acetic acid in them. Other vinegars, like Heinz® Distilled White Vinegar, measure out to have 5% acetic acid in them.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ☐ Two plastic pipettes
- ☐ Toothpick
- ☐ Water
- ☐ Control base (prepared in SECTION 1)
- ☐ Your color chart for Universal Indicator and vinegar (GROUP 11 - SECTION 1, 1A)
- ☐ Universal Indicator solution
- ☐ Microplate
- ☐ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

A standard 5% solution of acetic acid is a solution of household white distilled vinegar!

1) Using a microtip pipette, place 10 drops of one individual brand of acetic acid in a large well of the microplate.

2) Add 10 drops of water to the acetic acid solution.

3) Fill another microtip pipette with CONTROL BASE prepared in SECTION 1.

4) Add 2 drops of Universal Indicator to the acid solution in the large well. What is the pH of the acid? (Consult the chart you colored in.)

   Be sure to COUNT THE NUMBER OF DROPS OF BASE USED in the next step (5).

5) Using a toothpick to constantly stir, add the standard base to the acid solution. See Figure #29.

6) When the acid solution has been neutralized, (how will you know?) enter the number of drops of base used in the Data Table below. Determine the % acetic acid in vinegar.

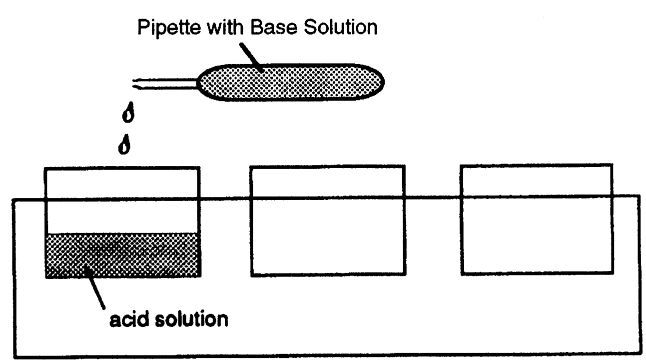


Figure #29

DATA TABLE

A) Number of drops of base (for 5% acetic acid)		______ drops
B) Number of drops of base (for another vinegar sample)		______ drops
C) % acetic acid in vinegar sample. (B divided by A)	=	______ %

SECTION 4 - COMPARING DIFFERENT BRANDS OF VINEGAR

Try to collect samples of as many DIFFERENT brands of vinegar, both white vinegar and amber colored vinegar, Apple Cider Vinegar, Tarragon Vinegar, and yes, even vinegar made from pineapple juice! You should try to get as many DIFFERENT brand makes of vinegar as you can. Ask neighbors and relatives for samples of their vinegar and be sure to record the name and type of the vinegar collected.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Samples of vinegar (as many as possible)
- ❑ Control base (prepared in SECTION 1)
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Your color chart for universal indicator and vinegar (GROUP 11 - SECTION 1, 1A)
- ❑ Universal Indicator solution
- ❑ Toothpick
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Using your pipette, place 10 drops of each brand or type of vinegar in a large well of the microplate. Start with large well A-1, and continue putting 10 drops of EACH DIFFERENT kind of vinegar in each different large well. Keep track of which type of vinegar is in which large well.
2) Add 10 drops of water to each large well which contains different types of vinegar.
3) Fill another pipette with CONTROL BASE prepared in SECTION 1.
4) Add 2 drops of Universal Indicator solution to each of the large wells where you are testing the different vinegars.
5) Using your pipette with the CONTROL BASE, add the Control Base, drop by drop, to the vinegar test wells. BE SURE TO COUNT THE DROPS OF BASE USED IN EACH LARGE WELL.
6) Use the toothpick to constantly stir as you add the STANDARD (CONTROL BASE) solution. See Figure #29.
7) When the acid (vinegar) solution has been neutralized, enter the number of drops of base used in the data table provided below. Determine the % acid of each of the different types of vinegar tested.

Test different brands of vinegar to determine which vinegar has the most acid.

What other household products do you think have acid?

If the substance is a base, how would you find out HOW MUCH BASE is present?

Percentage of Acetic Acid in Different Vinegars - DATA TABLE

TYPE/BRAND OF VINEGAR TESTED	COLUMN A No. of Drops of Base for 5% Acetic Acid (Heinz® Distilled White Vinegar)	COLUMN B No. of Drops of Base for this brand/type of vinegar	% ACID IN THIS BRAND/ TYPE OF VINEGAR (Column B divided by A)
White Vinegar	drops	drops	%
Amber Vinegar	drops	drops	%
Apple Cider Vinegar	drops	drops	%
Pineapple Vinegar	drops	drops	%
Tarragon Vinegar	drops	drops	%
Brand ______________ Vinegar	drops	drops	%
Brand ______________ Vinegar	drops	drops	%
Brand ______________ Vinegar	drops	drops	%
Brand ______________ Vinegar	drops	drops	%
Brand ______________ Vinegar	drops	drops	%

SECTION 5 - HOW MUCH BASE IS IN ANTACID TABLETS

Antacid tablets are sources of mild base. These tablets are used to settle upset (sour or acid) stomachs. Why should the base used to settle upset stomachs be a mild base? A mild base does not dissolve completely in a water solution. A solution of household vinegar is about 5% acetic acid. This acid can be used as a standard (control) for the determination of the amount of base in a solution of antacid tablets.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Vinegar
- ❑ Antacid tablets (as many different brands as you want to sample)
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Toothpick
- ❑ Universal Indicator solution
- ❑ Metal tablespoon
- ❑ Metal teaspoon
- ❑ Small test tube
- ❑ Chemical balance
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Using the large tablespoon as a base, place the antacid tablet into the large tablespoon. Take the smaller teaspoon and use the teaspoon to crush the antacid tablet into powder in the large tablespoon by putting your thumb into the curved inside of the teaspoon. See Figure #29A. Be sure not to lose any of the particles of the antacid tablet.

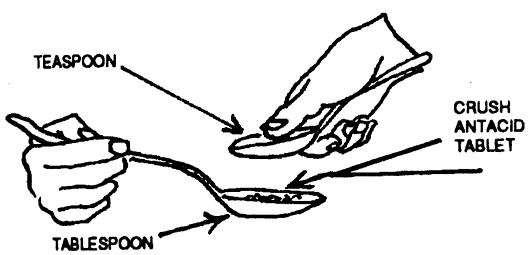


Figure #29A

2) Weigh the crushed antacid tablet on your laboratory balance and enter the weight in the data table provided below.

3) Dissolve an antacid tablet in a large plastic cup.

4) Transfer 10 drops of antacid tablet solution to a large well in the microplate.

5) Transfer the remaining solution in the large test tube for storage.

6) Using a microtip pipette, add 10 drops of water to the large well containing the antacid solution.

7) Fill another microtip pipette with **STANDARD ACID SOLUTION** (Heinz® White Distilled Vinegar).

8) Add 2 drops of Universal Indicator to the acid solution in the large well. What is the pH of the solution?

   Be sure to COUNT THE NUMBER OF DROPS OF ACID USED in the next steps below.

9) Using a toothpick to constantly stir, add the standard acid solution to the well with the antacid solution. See Figure #29.

10) When the antacid solution has been neutralized, (how will you know?) enter the number of drops of acid used in the Data Table below.

ANTACID NEUTRALIZATION TABLE

Antacid Tablet #1			
A)	Mass of antacid tabled used	________	g
B)	Number of drops of vinegar used	________	dr
Antacid Tablet #2			
A)	Mass of antacid tablet used	________	g
B)	Number of drops of vinegar used	________	dr
Antacid Tablet #3			
A)	Mass of antacid tablet used	________	g
B)	Number of drops of vinegar used	________	dr

SECTION 6 - DIFFERENT BRANDS OF ANTACID

Test different brands of antacid (Rolaids®, Tums®, etc.) to determine which antacid has the most soluble base.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Samples of different brands of antacid (example: Rolaids® or Tums®)
- ❑ Two plastic measuring cups
- ❑ Water
- ❑ Toothpick
- ❑ Plastic pipette
- ❑ White paper
- ❑ Tablespoon and teaspoon for crushing tablets
- ❑ Color chart from GROUP 11, SECTION 1
- ❑ Universal Indicator solution
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Obtain as many sample tablets of different brands of antacid as you can. Ask friends or relatives for one or two tablets for you to test.

2) Place one tablet of each brand to be tested in each of your plastic measuring cups. You may want to crush the tablet into smaller pieces just as you did in the previous experiment.

3) Add enough water with your pipette to EACH measuring cup to bring the level of the water AND the antacid tablet in the water up to the 20 ml or 20 cc mark on the side of the cup.

4) Stir each sample with a toothpick and then allow the cups to sit undisturbed for 30 minutes.

5) Carefully draw up some of the liquid from the top of the measuring cup into your pipette.

6) Place 20 drops of each sample into separate large wells of the microplate. Use large wells B-1, B-2, B-3, etc.

7) Note on a piece of paper which brand of antacid is in large well B-1, which is in large well B-2, etc. Wash out your pipette with water between samples.

8) Using your pipette, place 3 drops of Universal Indicator solution into each well containing the samples.

9) Stir each well with the toothpick and observe the color change.

10) Compare the color change of the Universal Indicator solution with the comparison color chart you prepared in GROUP 11, SECTION 1.

11) Which sample showed the stronger base? The sample which showed the stronger base will be the brand which has the most soluble base. In other words, the more soluble base will go into the water solution more easily and produce more base for use as an antacid.

12) Record your results at right on the Antacid Solubility Comparison Chart.

What other household products do you think have base? Look at the results of your experiments in the part of this lab book on pH.

ANTACID SOLUBILITY COMPARISON CHART

	Color of Universal Indicator compared with chart from Group 11, Section 1		
Antacid Tablet #1 brand ________			
Antacid Tablet #2 brand ________			
Antacid Tablet #3 brand ________			
Antacid Tablet #4 brand ________			
Antacid Tablet #5 brand ________			
Antacid Tablet #6 brand ________			
Antacid Tablet #7 brand ________			
Antacid Tablet #8 brand ________			
	LOW concentration of base thus less soluble base in tablet	MEDIUM concentration of base thus medium soluble base in tablet	HIGH concentration of base thus high soluble base in tablet

GROUP 13 ELECTROCHEMISTRY

Electrochemistry

When you turn on a portable radio, TV remote control or any other device which uses electrical energy away from a wall socket, you are using chemical energy provided by batteries. **BATTERIES** are simple machines. A battery is a simple machine because a machine changes one form of energy into another. Batteries change chemical energy into electrical energy. Electrical energy is carried by electrons in motion.

A battery is composed of **CELLS**. A cell contains two metals and an electrolyte. One metal in the battery GIVES UP electrons, the other metal TAKES ON electrons. If the flow of electrons goes through a wire, the electrons can do work! This is the way a cell provides electrical power. **TWO DIFFERENT METALS**, in an **ELECTROLYTE** form a cell. A battery is a series of cells linked together.

TERMS TO KNOW

ACTIVITY SERIES - A list of elements in order of their ability to give up or take on electrons.

BATTERY - A series of cells connected together.

BOND - A force which holds molecules together.

CELL - A chemical device composed of two different metals in an electrolyte. Cells convert chemical energy into electrical energy.

CHEMICAL ENERGY - Energy stored in the bonds of chemicals.

COMPASS - A device for the detection of magnetic fields.

CORROSION - The chemical combination of a metal with another chemical usually resulting in the destruction of the metal.

ELECTRICAL ENERGY - The energy carried by electrons in motion.

ELECTRODE - A piece of metal surrounded by an electrolyte.

ELECTROLYTE - A solution which conducts electricity.

GALVANOMETER - A device which detects the flow of electrons or electricity.

TERMINAL - The part of a battery which provides or draws electrons.

BUILDING YOUR COMPASS/ ELECTRON FLOW DETECTOR

In your next section (SECTION 1) you will use a compass which is wired in a certain way to detect the flow of electrons through a wire. You must first assemble your COMPASS - ELECTRON FLOW DETECTOR from the materials provided in your chemistry set. First, find the plastic bag in your chemistry set containing the parts for your compass.

SECTION 1 - DETECTING

The following experiment shows you how to build a detector or instrument for detecting the "flow of electrons" through a wire. This flow of electrons happens when an electrical current is produced in a chemical reaction and by using the instrument that you will make, you can actually see evidence of the electrons produced in your chemical reaction. The electron detector is a compass device which changes the "deflection," or movement of the compass needle, when electrons flow in a series of loops of wire near the compass.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ☐ Compass unit (from your chemistry set) which contains the plastic base, compass face, thumbtack, compass needle, and cardboard back plate with the notches cut into its ends
- ☐ Transparent cellophane tape
- ☐ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Lay all of the materials out in front of you and look them over carefully. The thumbtack is stuck into the top of the plastic case so it won't get lost during shipping. Take the thumbtack out of where it has been stuck, and lay it with your other parts in front of you.

2) You should have the following parts ready:
Thumbtack
Black plastic case with a round depression in its center
Compass needle, one end of which is dyed blue
Compass face, or round cardboard disc with N, E, S and W printed on it
Cardboard backplate which goes on the underside of your compass.

3) Place the cardboard disc (compass face) into the round depression of the plastic base. You want the North or N letter of the compass face to point toward the end of the rectangular case. See Figure #29B.

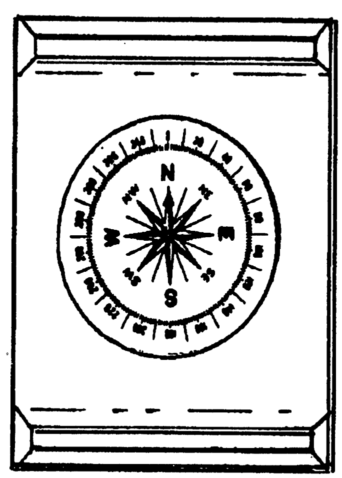


Figure #29B

4) If you wish, you may tape the compass face into its round depression with a loop of transparent cellophane tape just to secure it from turning in the round depression. See Figure #29C

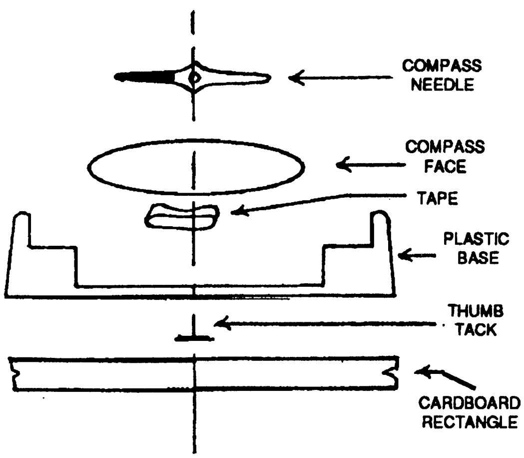


Figure #29C

5) Press thumbtack up through the bottom of the black plastic base and up through the very center of the compass face so that the sharp point of the tack comes out right in the center of the 8-pointed star of the compass face.

6) Tape a small length of plastic cellophane tape over the head of the thumbtack underneath so that the tack doesn't fall out. See Figure #29C.

7) Gently sit the compass needle with its one end dyed blue onto the sharp, pointed end of the thumbtack.

8) You will notice that the compass needle will move freely on top of the thumbtack and the needle will eventually become still and point to magnetic North.

9) Make sure that neither of the points of the compass needle scrape on the cardboard compass face.

10) You may turn the whole compass unit so that the blue end of the compass needle and the "N" printed on the compass face line up. This particular orientation of the compass unit will tell you which way is North (N), or South (S), or East (E), or West (W). You can even read off the "degrees" of the compass, like 90° for EAST, or 180° for SOUTH or 270° for WEST, or, finally, Zero, or 360° for NORTH.

11) The white piece of cardboard with the notches on each end is the base of your compass. You should tape the cardboard onto the underside of the compass plastic frame. Tape if to the long sides of the plastic base. This will give your compass assembly more rigidity. See Figure #29C.

SECTION 1A - DETECTING THE FLOW OF ELECTRONS

When electrons flow through a wire, a magnetic field is formed. We can detect the flow of electrons through a wire by detecting the magnetic field which is formed.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ☐ Compass assembly
- ☐ D-Cell battery
- ☐ Permanent fine tip marker
- ☐ Insulated wire (the clear lacquer on the outside of the wire acts as insulation)
- ☐ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Locate the magnetic compass packed in your chemistry set, which you built in the previous section.

2) Measure out about 2 ft. (60 cm.) of #24 insulated copper wire.

3) Strip the insulation away from about 1" (2.5 cm.) of each end of a wire. Label one end of the wire negative (-) and the other end of the wire positive (+). Use your transparent tape to label the ends of the wire. (The wire is insulated with clear lacquer. This coat of lacquer is what you "strip" away at the ends of the wire.)

4) Wrap the wire around the compass as shown in Figure #30. BE SURE TO HAVE THE COMPASS NEEDLE AT AN ANGLE WITH THE WRAPPED WIRE.

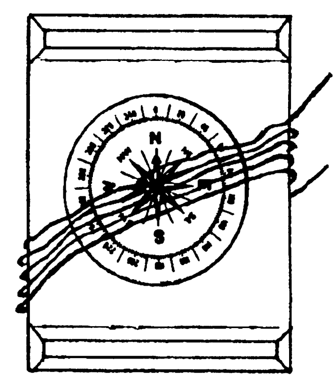


Figure #30

5) Lay the compass and wire on a flat surface. Be sure that the needle can move freely.

6) Touch the ends of the wire to the ends of a "D" cell. (The best method for using your electron flow detector is to just touch the wire ends to whatever you are testing. An "on-off-on-off" technique is best. When you touch wire for "on," quickly look for movement of compass needle. Then take wire "off" and observe compass needle return to normal direction.)

7) What happens to the compass needle? Which way did the needle move?

8) Detach one wire going to the "D" cell. What happens to the needle? Which direction did the needle move? Note the movement of the needle on a piece of paper. <u>BE SURE TO NOTE BOTH THE MOVEMENT AND THE WIRE ATTACHMENT</u>.

9) Touch the wires to the OPPOSITE ENDS of the "D" cell.

10) What happens to the needle? <u>NOTE THE NEEDLE MOVEMENT AND THE WIRE ATTACHMENT</u>.

This device is called a GALVANOMETER. It detects the flow of electricity through wires. It also tells the DIRECTION of the flow of electrons! How?

DO NOT DISASSEMBLE THIS DEVICE!! IT WILL BE USED IN THE FOLLOWING SERIES OF EXPERIMENTS.

<u>SECTION 2 - A SIMPLE CELL</u>

The first electrical cell ever made was the voltaic cell. It was first made by the Italian scientist Alessandro Volta. We can perform a similar experiment which Volta did back in the 18th century.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ☐ Compass galvanometer (ELECTRON FLOW DETECTOR) which you made in SECTION 1
- ☐ A nickel
- ☐ A penny
- ☐ Cleanser or scouring powder, or fine sandpaper
- ☐ Insulated wire
- ☐ Paper towel or tissue like Kleenex®
- ☐ Salt water (sodium chloride solution) Prepare your own sodium chloride solution by mixing 1/2 teaspoon of table salt with 10 ml. of water. Stir until all salt is dissolved.
- ☐ Goggles

<u>BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!</u>

1) Clean a penny and a nickel with scouring powder or sandpaper. These are the two different metals.

2) Attach an alligator clip and wire to the penny. Attach the other alligator clip and wire to the nickel.

3) Place a piece of folded paper towel between the two coins. See Figure #31.

4) Attach the wires to the galvanometer you built in SECTION 1.

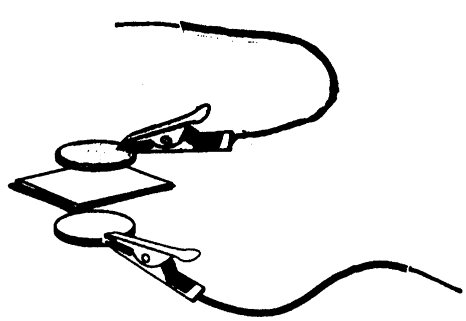


Figure #31

5) Wet the paper towel with a solution of sodium chloride (salt water). Sodium chloride solution is the electrolyte. (Remember to use the "off-on-off" technique for testing this "electrolytic cell").

6) What happens to the galvanometer? Which way did the needle move? Which metal do you think is giving up the electrons? Which is taking the electrons?

<u>ELECTRONS ALWAYS FLOW FROM NEGATIVE TO POSITIVE!</u>

7) Disassemble your cell. Rinse off the coins. Discard the paper towel.

<u>SECTION 3 - A SIMPLE BATTERY</u>

You can make a simple battery by connecting several cells together. A battery is a series of cells.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ☐ Compass galvanometer (from SECTION 1)
- ☐ 5 nickels
- ☐ 5 pennies
- ☐ Cleanser or scouring powder, or fine sandpaper
- ☐ Insulated wire
- ☐ Paper towel or tissue like Kleenex®
- ☐ Sodium chloride solution (salt water)
- ☐ Goggles

<u>BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!</u>

1) Clean the pennies and nickels with scouring powder or sandpaper.

2) Attach a copper wire to one penny and one nickel with alligator clips. These will be the TERMINAL ELECTRODES.

3) Place a piece of folded paper towel, alternating between pennies and nickels. See Figure #32. Make sure that the coins with the wires are located at the ends of the stack.

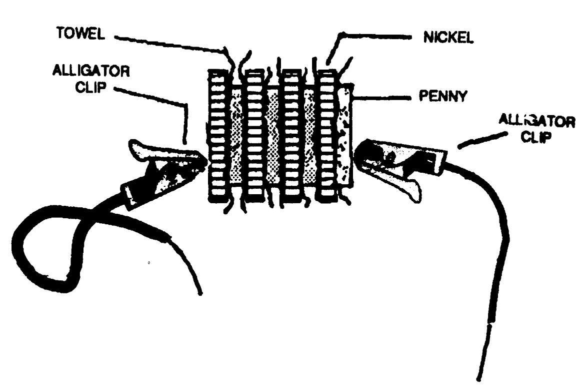


Figure #32

(RV695)

4) Attach the wires to the galvanometer you built in SECTION 1.

5) Wet all the pieces of paper towel with a solution of sodium chloride (salt water).

6) Test this electrolytic cell by touching the wires in an "off-on-off-on" method. Watch the needle on your galvanometer move back and forth.

7) What happens to the needle of the galvanometer? Which direction does the needle move? Which metal gives up electrons? Which metal receives them? Which electrode was the NEGATIVE ELECTRODE? Which electrode was the POSITIVE ELECTRODE?

SECTION 4 - ANOTHER BATTERY

You can make a simple battery by connecting several cells together. A battery is a series of cells.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Compass galvanometer (ELECTRON FLOW DETECTOR) which you made in SECTION 1
- ❑ 10 nickels
- ❑ 10 pennies
- ❑ Cleanser or scouring powder, or fine sandpaper
- ❑ Insulated wire with alligator clips
- ❑ Paper towel or tissue like Kleenex®
- ❑ Sodium chloride solution (salt water). Prepare your own sodium chloride solution by mixing 1/2 teaspoon table salt with 10 ml. of water. Stir until all salt is dissolved.
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Clean the coins with scouring powder or sandpaper.

2) Attach a copper wire to one of each kind of coin with alligator clips. These will be the **TERMINAL ELECTRODES**. See Figure #32.

3) Place a piece of folded paper towel, alternating between pennies and nickels. See Figure #32. Make sure that the alligator clips touch the coins at each end of the stack.

4) Attach the wires to the galvanometer you built in SECTION 1.

5) Wet all the pieces of paper towel with a solution of sodium chloride.

6) What happens to the needle of the galvanometer? Which direction does the needle move? Which metal gives up electrons? Which metal receives them? Which electrode was the NEGATIVE ELECTRODE? Which electrode was the POSITIVE ELECTRODE? How do you know?

SECTION 5 - ACTIVITY OF METALS

There are several different kinds of cells, but they all have one thing in common. Each cell converts STORED CHEMICAL ENERGY into ELECTRICAL ENERGY.

As you may have guessed by now, chemists have a good idea which metals on the Periodic Chart are best for cells or batteries. Their ideas about activity are based on experiments. The experiment below is an example of how these activities were determined.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Compass galvanometer from SECTION 1
- ❑ Ferrous sulfate solution
- ❑ Iron nail or a 3 cm. length of iron wire from your chemistry set
- ❑ Aluminum ammonium sulfate solution
- ❑ Aluminum nail or a 3 cm. length of aluminum wire from your chemistry set
- ❑ Copper sulfate solution
- ❑ Sodium chloride solution (salt water)
- ❑ Insulated wire
- ❑ Copper nail or a 3 cm. length of copper wire from your chemistry set
- ❑ Filter paper (from your chemistry set)
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Ruler
- ❑ Pencil
- ❑ Scissors
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 pipette full of ferrous sulfate solution in large well B-1. Rinse the pipette with rinse (tap) water.

2) Place 1/2 pipette full of Aluminum ammonium sulfate solution in large well B-2. Rinse the pipette with rinse (tap) water.

3) Place 1/2 pipette full of copper sulfate solution in large well B-3. Rinse the pipette with rinse (tap) water.

4) Place a piece of metal wire or nail in each well which has the same ion in solution. Put the iron nail or wire in the ferrous sulfate solution (large well B-1). Put the piece of Aluminum wire or nail in the Aluminum ammonium sulfate solution (large well B-2). Put the piece of copper wire or nail in the copper sulfate solution (large well B-3).

5) Mark the filter paper with ruler and pencil to the shape shown in Figure #33. Each leg of the filter paper should be 1 cm apart. See Figure #34. Fold the filter paper on the dotted line.

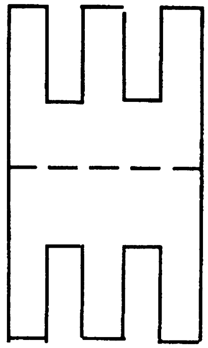


Figure #33

6) Soak the filter paper with sodium chloride solution. Make your own sodium chloride solution by adding some table salt to water in your plastic measuring cup and dissolving it thoroughly.

7) Insert the filter paper cut out into the three wells containing the three different solutions. See Figure #34.

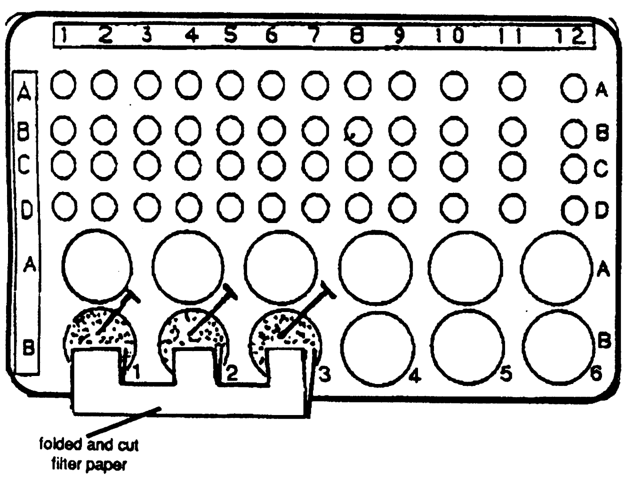


Figure #34

8) Touch the ends of the galvanometer to two metals in the solutions.

9) Repeat the process of testing with each combination of metals. Which metal pair gave the greatest movement of the compass needle? Which metal pair gave the least movement of the compass needle? Which pair of metals would make the best battery or cell?

10) Which metal of the three is the most active? How do you know? Which metal is the least active?

11) What would be a good use for metals which are not very active?

12) Compare your results of the metals you tested with the Activity Chart above.

ACTIVITY CHART

ACTIVITY SERIES -
METALS WHICH WILL TEND TO LOSE ELECTRONS

MOST ACTIVE METALS (Those which lose electrons most easily)	K	Potassium Metal
	Ba	Barium Metal
	Ca	Calcium Metal
	Na	Sodium Metal
	Mg	Magnesium Metal
	Al	Aluminum Metal
	Zn	Zinc Metal
	Cr	Chromium Metal
	Fe	Iron Metal
	Co	Cobalt Metal
Hydrogen sometimes acts like a metal by giving off an electron. Hydrogen is shown here in the ACTIVITY SERIES.	Ni	Nickel Metal
	Sn	Tin Metal
	Pb	Lead Metal
	H	HYDROGEN---
	Cu	Copper Metal
LEAST ACTIVE METAL (Those which DO NOT lose electrons very easily)	Ag	Silver Metal
	Pt	Platinum Metal
	Au	Gold Metal

SECTION 6 - OTHER ELECTROCHEMICAL REACTIONS

The most common form of electrochemistry of metals does not occur in a battery. Metals give up electrons to non-metals and other metals in chemical reactions. One of the most common electrochemical reactions is the process of **CORROSION**.

In a previous section you experimented with iron wire or nails which were placed in salt solutions. These salt solutions helped the process of corrosion. Some processes help PREVENT corrosion.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Fifteen (15) small iron nails or 3 cm lengths of iron wire
- ❑ Piece of fine sandpaper
- ❑ Model paint or fingernail polish
- ❑ Sodium chloride solution
- ❑ Ferrous sulfate solution
- ❑ Citric acid solution
- ❑ Sodium carbonate solution
- ❑ Tap water
- ❑ Zinc wire (from your chemistry set)
- ❑ Microplate
- ❑ Plastic wrap
- ❑ Plastic Pipette
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Obtain 15 small iron nails (check with magnet to see that they are iron). Make sure the 15 nails are the same size. Sand the iron nails with fine sandpaper to remove any oxidation or coating. You may also use 3 cm. lengths of iron wire from your chemistry set.

2) Paint the "point half" of 5 nails or wire with oil paint, nail polish or model paint. Allow the coating time to dry.

3) Cut 5 lengths of zinc wire (from your chemistry set) into lengths of 3 cm. each. Wrap each of the five nails with zinc wire. See Figure #35.

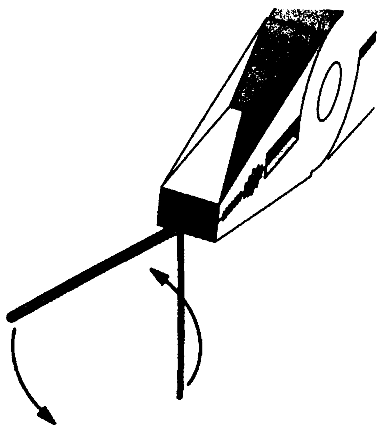


Figure #35

4) Place the 5 pointed nails in the first five small wells of Row 1 in the microplate. The painted nails will be in small wells A-1, A-2, A-3, A-4 and A-5. See Figure #36.

5) Place the 5 nails wrapped with zinc wire in the first five small wells of Row B in the microplate. The zinc wire wrapped nails will be in small wells B-1, B-2, B-3, B-4 and B-5. See Figure #36.

6) Place the 5 other nails in the next row of small wells in the microplate. Use small wells C-1, C-2, C-3, C-4 and C-5. See Figure #36.

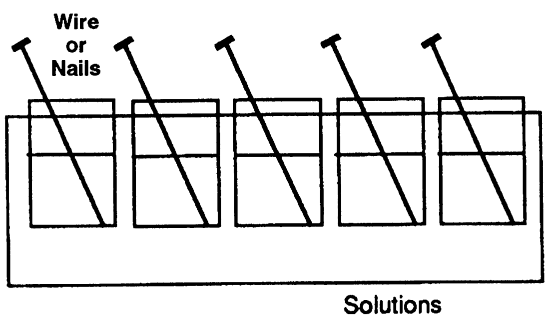


Figure #36

7) Add 7 drops of each of the following solutions in the microplate column as directed.

COLUMN	CHEMICAL SOLUTION	WELLS USED
1	Sodium Chloride	A-1, B-1, C-1
2	Ferrous Sulfate	A-2, B-2, C-2
3	Citric Acid	A-3, B-3, C-3
4	Sodium Carbonate	A-4, B-4, C-4
5	Tap Water	A-5, B-5, C-5

8) Cover the microplate with a piece of plastic wrap. Leave the nails in the solutions in a safe place overnight.

Which nails did you expect to be protected? Why?

Look up the word GALVANIZED in your dictionary. Which metal is associated with GALVANIZED steel?

SECTION 7 - CORROSION OF DIFFERENT METALS

Different metals often corrode when they come in contact with each other. This is a problem if the two different metals are used in ships or boats where salt water is present or sometimes in plumbing systems in houses where water or steam makes contact with both metals. Sometimes to prevent this corrosion problem, one of the metals is coated to protect it. Sometimes non-corrosive metals must be used in certain applications...such as stainless steel or platinum which do not tend to corrode.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Fifteen (15) small copper nails OR 15 lengths of copper wire cut into 3 cm. lengths
- ❑ Piece of fine sandpaper
- ❑ Model paint or fingernail polish
- ❑ Sodium chloride solution
- ❑ Ferrous sulfate solution
- ❑ Citric acid solution
- ❑ Sodium carbonate solution
- ❑ Tap water
- ❑ Zinc wire cut into 3 cm. lengths (from your chemistry set)
- ❑ Microplate
- ❑ Plastic wrap
- ❑ Plastic Pipette
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

Repeat the experiment in SECTION 6 using aluminum or copper nails instead of common iron nails.

SECTION 8 - A CORROSION PAIR

In this experiment you can actually see the change occur, just overnight, when two different metals are in close contact with one another in a salt solution. By use of an indicator we can see if a change has occurred in the solution, and also if a change has occurred to the different metals.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ An iron nail (or a 3 cm. length of iron wire)
- ❑ An aluminum nail (or a 3 cm. length of aluminum wire)
- ❑ Sodium chloride solution. (Prepare your own sodium chloride solution by mixing 1/2 teaspoon of table salt with 10 ml. of water. Stir until all salt is dissolved.)
- ❑ Universal Indicator solution
- ❑ Wire with alligator clips
- ❑ Microplate
- ❑ Plastic pipette
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Fill a plastic pipette with sodium chloride solution. Place 1/2 pipette full of sodium chloride solution in each of two large wells in the microplate.

2) Add a few drops of Universal Indicator to both wells with the sodium chloride solution.

3) Join an aluminum nail or wire and a common iron nail or iron wire at their ends with an alligator clip.

4) Place the joined nails or wire in one of the wells with the sodium chloride solution.

5) Leave the nails in the solution overnight.

What happens to each of the nails?

What happens to the Universal Indicator?

Is there evidence of corrosion?

GROUP 14 ORGANIC CHEMISTRY

Organic Chemistry

Organic chemistry is the chemistry of the carbon atom. At one time, the study of organic chemicals was limited to the chemicals found in living things. That was because carbon was thought to be found only in living things or things which were once alive. Living things are not the only source of carbon compounds.

Organic chemicals touch your life in many ways every day. Some organic compounds include:

> Vitamins, plastics, rubber, detergents, clothing, inks, paints, heating oil and natural gas, film, audio and video tapes, medicines, perfumes, cosmetics, fertilizers, food products and adhesives.

Organic chemistry has undergone remarkable growth as a science separate from inorganic chemistry since the 1940s. The growth of the organic branch of chemistry was influenced by the needs of this country during World War II. The production of artificial rubber and nylon and the use of plastics are three examples of "new" products of the 1940s which owe their development to an increased interest in organic chemistry.

TERMS TO KNOW

MONOMER - A single unit of a polymer.

ORGANIC CHEMICAL - A chemical compound which contains carbon.

PLASTIC - A substance which is made of an organic polymer.

POLYMER - A chemical compound which is formed from many single units called monomers. Polymer actually means "having many pieces."

SECTION 1 - A MODEL OF A POLYMER

It is important in the study of organic chemistry for chemists to be able to visualize what the molecules they are working with "look like" if they could see them close up. In order to do this, chemists, and you as well, will make "models" of organic molecules in order to see how the molecules and atoms which make up the molecules attach to one another or are arranged. Keep in mind the models which you will build.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ 3-D molecular model set (from your chemistry set)
- ❑ Paper clips
- ❑ Plastic garbage bag
- ❑ Scissors
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Build a model of ethylene with your 3-D molecular model set provided. Use Carbon atoms as the main links in the molecule, with Hydrogen atoms coming off from the carbon atoms. See Figure #37.

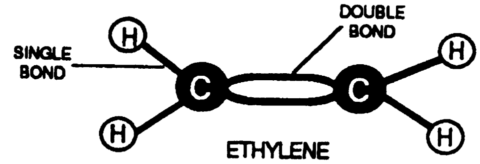
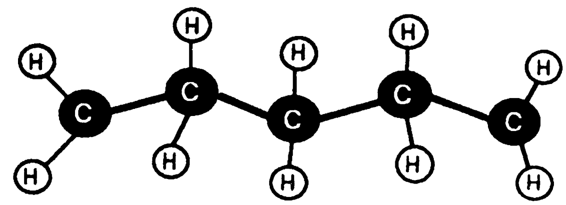


Figure #37

2) To make POLY-ethylene, the double bonds between the carbon atoms must be broken, and onto their broken ends will go more and more carbon atoms. Each new carbon atom will also carry the two Hydrogen atoms as "baggage." See Figure #37A.



POLYETHYLENE
Figure #37A

3) Obtain a box of paper clips. Each clip can represent a molecule of ethylene.

4) Link one end of a paper clip to another. Repeat this process for about 30 clips. See Figure #38.

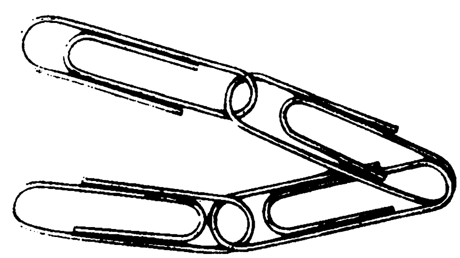


Figure #38

5) You have just made a model of POLY-ethylene. Polyethylene is a **POLYMER** of ethylene molecules.

6) Cut out a piece of plastic garbage bag about 5 cm by 5 cm (2 inches x 2 inches). Make sure that the plastic bag is a single layer plastic bag.

7) Hold the piece of plastic bag up to the light.

8) What do you see?

9) Hold the piece of bag firmly in both hands. Pull the piece apart, slowly. If the piece of bag tears, repeat with another piece.

10) Repeat the process again. This time cut the bag at right angles to the previous piece. What happens?

11) What did you notice happening when you pulled in one direction that you did not see when you pulled in the other direction?

SECTION 2 - A NATURAL ADHESIVE

Organic chemistry has given us many new chemical products which we take for granted. You have probably used "white glue" or "paper cement" for gluing things together. The glue or "adhesive" which you will make in this experiment is an early type of "white glue" and is made from natural substances.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Milk
- ❑ Vinegar
- ❑ Microplate
- ❑ Chemical scoop
- ❑ Paper towel
- ❑ Plastic pipette
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

Adhesives are organic compounds which cause one object or part of an object to stick or adhere to another. Long before organic chemists gave us epoxies or super glues, natural organic adhesives were available.

1) Place 1/2 pipette full of milk into a large well in the microplate.
2) Add vinegar drop by drop to the milk until a solid is formed. The solid part of the milk is called CASEIN (curds) or milk protein. The liquid part is called WHEY.
3) Allow the solid to settle to the bottom of the well.
4) Draw off the liquid whey from the solid precipitate.
5) Using a chemical scoop, remove the solid from the well.
6) Place the solid on some paper towels or tissues to absorb the excess liquid.
7) Take two pieces of paper and try to glue them together using the solid scooped out of the well. Be sure to spread the glue evenly. Press the paper together firmly and allow to dry overnight.
8) Try to separate the two pieces of paper after the glue dries.

SECTION 3 - A CURIOUS PLASTIC-LIKE MATERIAL

The following experiment is not a chemical reaction, but is a "physical reaction" which happens between the very fine and dust-like particles which make up the material called "cornstarch." These small starch granules or particles do not just pack together, but under the right conditions actually "slide" against one another. The following experiment will let you experiment with the properties of a material whose very small particles are moving in ways that particles usually do not move. This microscopic movement will produce interesting properties affecting the whole substance. Remember that cornstarch is a natural organic substance.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Large plastic coffee cup
- ❑ Cornstarch (obtain from your kitchen or grocery store)
- ❑ Spoon
- ❑ Water
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/2 cup of cornstarch in a large plastic cup.
2) Add about 1/4 cup of water. Mix thoroughly with a spoon.
3) Investigate the properties of this curious plastic-like material.
4) Try to poke your finger into the material.
5) Try to splash the material by tapping the surface of the liquid.
6) What happens when you attempt to pour the material?

SECTION 4 - CURIOUS PLASTIC II

In this experiment the properties of the white glue are drastically changed. Reactions which occur to organic chemicals are interesting, important and often quite unusual.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Polyvinyl acetate adhesive (Elmer's Glue®)
- ❑ Borax powder (sodium tetraborate) obtain at your grocery or from your chemistry set
- ❑ Two clear plastic drinking cups (disposable type). DO NOT USE FOAM CUPS
- ❑ Spoon, to use as stirrer
- ❑ Plastic measuring cup (from your chemistry set)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place about 3 oz. (90 ml.) of adhesvie into a clear plastic, disposable cup.
2) Mix about 0.5 oz. (12 g.) of borax with 2 oz. (50 ml.) of water in the other clear plastic disposable cup. Dissolve completely.
3) Mix the contents of the first cup with the contents of the second cup.
4) How does the liquid behave now? Compare the physical properties of the changed glue with the normal glue.

SECTION 5 - AN UNUSUAL PLACE FOR A POLYMER

Just as we have caused a polymer to happen (Polymerization) in the previous experiment...(remember the paper clips you hooked to each other) ... we caused this polymerization to happen by adding Borax. In the following experiment we will see polymerization occur by addition of other chemicals to the cornstarch. Also we will see how raising the temperature helps the reactions to take place. Many organic chemical reactions need small amounts of heat to make them work.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Plastic chemical scoop
- ❑ Cornstarch (like Argo® brand) from your kitchen or grocery
- ❑ Vinegar
- ❑ Copper sulfate solution
- ❑ Citric acid solution
- ❑ Sodium carbonate solution
- ❑ Hot water (from tap)
- ❑ Shallow metal pan (like an oven baking pan)
- ❑ Toothpick
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place 1/4 of a chemical scoop of cornstarch in each of two large wells in the microplate.

2) Place 1/2 pipette of vinegar in ONE of the wells with the starch. Place 1/2 pipette of tap water in the OTHER well with the starch.

3) Mix both wells completely with a toothpick. Leave the plate undisturbed overnight.

4) Remove 10 drops of liquid from the well with the vinegar and cornstarch and place this into another unused large well. Remove 10 drops of the liquid from the well with the water and cornstarch and place this amount into another EMPTY large well.

5) Place 5 drops of copper sulfate, 2 drops of citric acid, and 4 drops of sodium carbonate solution in each of the two wells of liquid you have removed above.

6) Float the microplate on the surface of a pan of hot water (hot tap water will be hot enough).

Compare the results of the test.

What caused the difference in results?

GROUP 15 | BIOCHEMICAL REACTIONS

Biochemical Reactions

Animals and plants are living things. Living things contain many chemicals. Chemical reactions are going on continuously within their CELLS. Living may be thought of as a very complicated chemical reaction. Chemicals come into and leave living things. The way in which animals and plants use chemicals to keep life going is called **BIOCHEMISTRY**.

Living things, from the simplest to the most complex, need food, water and oxygen. As living things go through the life process, they produce chemicals in the form of waste, water and carbon dioxide. While each plant and animal's way of using chemicals is different from the other, there are some chemicals which are used by all forms of life. Let's call these chemicals:

LIFE CHEMICALS

Water is the most important of all the LIFE CHEMICALS. More than 85% of living things is water. All living functions and all biochemical reactions happen in an **AQUEOUS** solution. Almost all of the other chemicals found in living things

CONTAIN CARBON.

LIFE CHEMICALS can be placed into three main groups:

PROTEINS, CARBOHYDRATES AND FATS

TERMS TO KNOW

AQUEOUS - Dissolved in water.

BALANCED DIET - A variety of food from each of the major food groups.

FEHLING'S SOLUTION - A reagent used to test for sugar.

BIOCHEMICAL - A chemical which is normally found in a living thing.

BIOCHEMISTRY - The study of the chemistry of living things.

"BIURET" SOLUTION - A reagent used to test for protein.

CARBOHYDRATES - Starches and sugars are carbohydrates.

CELL - The basic unit of living things. All animals and plants are made up of cells.

DIGESTION - The process of breaking down large food molecules into smaller ones.

ENZYME - A chemical which makes a reaction occur faster.

FATS - Chemicals which are the storage units for chemical energy in the cell.

PROTEINS - Chemicals which are used in the building and repair of cells.

REAGENT - A chemical which tests for another. Reagents usually turn color when a specific chemical is present.

TRANSLUCENT - Allowing light to pass through to a limited degree.

SECTION 1 - TESTS FOR WATER

You can make your own "test paper" in the following experiment. The test paper you will make is called COBALT CHLORIDE PAPER. You will use this test paper for further experiments.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Filter paper (from your chemistry set)
- ❑ Cobalt chloride solution (from your chemistry set)
- ❑ Scissors
- ❑ Microplate
- ❑ Test tube with stopper
- ❑ Plastic pipette
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Invert your microplate.
2) Place a piece of filter paper or paper toweling on the back of the plate.
3) Drip a solution of cobalt chloride onto the paper until the paper is just moistened with the solution.
4) Allow the filter paper to dry in the sun or place in a warm area to speed the drying.
5) When the paper is dry (it should turn blue), cut the paper into strips about 1" (25 mm.) by 1/4" (6 mm.).
6) Place the strips into an airtight can or test tube with a stopper. A discarded plastic film can is ideal!
7) Label the container "cobalt paper".

SECTION 2 - SAMPLE PREPARATION AND TESTING

Although this is an experiment to test for water being present in different substances, the cobalt chloride test paper can also be used to detect humidity. You have probably seen "weather detectors" use cobalt paper just like you have made.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Test paper (prepared in SECTION 1)
- ❑ Potato
- ❑ Water
- ❑ Microplate
- ❑ Other sample foods like lettuce, corn, cereal, etc.
- ❑ Teaspoon
- ❑ Disposable plastic cups
- ❑ Plastic pipette
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Place a small piece of potato on a hard, flat surface.

2) Grind up the potato into a pulp with a teaspoon.

3) Transfer the mashed raw potato into a large well in the microplate.

4) Rinse and DRY all your equipment.

Repeat SECTION 2, Parts 1-4 with pieces of meat, bread, and vegetables keeping each food in separate wells.

5) Place 1/2 pipette of water in another well.

6) Touch a piece of cobalt test paper prepared in SECTION 1 to each sample of mashed food.

7) Touch a piece of cobalt test paper to the sample of water.

What color did the test paper turn when the foods were touched?

What color did the test paper turn when the water (control) was touched?

Did any food seem to have MORE water than another? How did you know? Why are some foods "watery"?

8) Discard the test foods. Rinse and DRY the microplate.

Try this experiment with other foods.

SECTION 3 - TESTS FOR LIFE CHEMICALS

It is important to be able to test for the chemicals which are always present where life is present or has been present. Our space program tested for "life chemicals" which may or may not have been present on the Moon, as well as on the planet Mars.

Scientists often can test geological samples to see whether life was present and left certain chemicals behind when the rock was formed. In this experiment you will be able to test for organic life chemicals with certain testing solutions called REAGENTS.

You will need the following materials to complete this experiment:

LIST OF MATERIALS
- ❑ Warm water (from your sink or faucet will work)
- ❑ Microplate
- ❑ Sample foods (use the same foods as in SECTION 2)
- ❑ Shallow pan (to use as warm water bath)
- ❑ Disposable plastic cups
- ❑ Biuret Reagent
- ❑ Fehling's Solution "Reagent"
- ❑ Brown wrapping paper (for fat test)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

All living things need energy. Plants get their energy from the sun. Animals cannot get their energy from the sun the way plants do. Animals, including man, need food to make energy. Food contains "life chemicals" which we use for energy and repair of our bodies.

All animals need carbohydrates for energy and proteins for repair of body cells. Other foods needed are vitamins and minerals. While less important than sugars and proteins, minerals and vitamins provide cells the chemicals they need to stay alive.

A diet which contains all the chemicals vital to life is called a **BALANCED DIET**.

Food contains the chemicals which are needed by cells. Before food can be used by living things, it must first be broken down into individual molecules. Food must be **DIGESTED**.

In the experiment below you will test for the presence of life chemicals in food.

Here is a table (Table #2) of some foods and the "life chemical" which is provided by the food when it is digested. The chart also shows the testing chemical or **REAGENT** used to tell if a chemical is present in the food.

TABLE #2

Food	Life Chemical	Digested Product	Reagent for Test
Meat	Protein	Amino acids	Biuret solution
Fish	Protein	Amino acids	Biuret solution
Cheese	Protein	Amino acids	Biuret solution
Bread	Carbohydrate	Sugar	Fehling's solution
Pasta	Carbohydrate	Sugar	Fehling's solution
Candy	Carbohydrate	Sugar	Fehling's solution
Butter	Fat	Fatty acids	Brown paper
Oil	Fat	Fatty acids	Brown paper

1) Place a small sample of <u>each</u> of the foods listed in Table #2 SEPARATELY (don't mix them) on a hard, flat surface and crush the sample with a teaspoon as you did in SECTION 2. Transfer the pulps to individual plastic cups.

2) Add a pipette of WARM water to each of the cups with crushed food samples. It is not necessary to heat the water above the temperature of that provided from a hot water faucet.

3) Mix each food sample in its individual cup with the warm water. Then let the solid particles settle to the bottom of the mixture.

4) Using your pipette, transfer the WATER ONLY from your first food sample to small wells A-1, B-1 and C-1. Do the same with your second food sample and put in small wells A-2, B-2 and C-2. Repeat with the third food sample, placing the water only from the cup to small wells A-3, B-3 and C-3, and so on, until all of the food samples (the water from them) are represented in the microplate.

5) Place a pipette of WATER ONLY in the last set of small wells at the end of your test samples. This will be a control.

6) You will be using two REAGENTS in this section. The REAGENTS are Fehling's Solution and Biuret Reagent. These two reagents are provided in your chemistry set, or you may choose to make your own. (See Appendix B at the back of your manual if you wish to make your own.) You will also need some brown paper (like paper from a lunch bag or grocery bag).

7) Prepare the Fehling's Solution in large well B-1, or use the prepared Fehling's Solution provided in your chemistry set.

8) Prepare the Biuret Solution in large well B-6, or use the prepared Biuret Solution provided in your chemistry set.

9) Using your pipette, add 3 drops of Fehling's Solution to each of the small well food sample water in small wells Row B.

10) Using your pipette, add 3 drops of Biuret Solution to each of the small well food sample water in small wells Row B.

11) Cut a small piece of brown paper into strips each measuring 1 cm. by 4 cm. Place a small piece of this brown paper in each of the small wells in small well Row C, which contains the food sample waters. Remove the paper and allow it to dry.

12) Fill a pan or shallow baking tray about half full with hot tap water.

13) Float the microplate on the hot water. Allow the reagents to react with the food extract.

A color change in wells containing the Biuret or Fehling's reagent and a food proves the presence of protein or sugar.

No color change means that particular "life chemical" is NOT present. If the brown paper remains translucent, fat is present in the sample.

14) Thoroughly clean your microplate with soap and water. You will need your Fehling's Solution reagent for further tests.

<u>SECTION 4 - THE WORK OF ENZYMES</u>

Enzyme Chemistry

Enzymes are chemicals produced by living things which make chemical reactions happen faster. They are CATALYSTS. All living things need these special chemicals to make life possible. Some enzymes are found only in the digestive system. Some are found only inside cells. In any case, individual enzymes make individual reactions happen faster. You saw the workings of a catalyst when you did the experiments on the production of oxygen. See The Gaseous Phase of Matter, SECTION #7.

What was produced in that experiment? What chemical was involved in the reaction?

Your saliva contains another enzyme which is very important in the process of digestion. It is called <u>AMYLASE</u>. This next experiment shows the action of amylase on the "life chemical" called starch.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Water cracker or bread (obtain from kitchen or grocery)
- ❑ Water
- ❑ Shallow pan (for water bath)
- ❑ Microplate
- ❑ Fehling's Solution Reagent (see Appendix B at end of this manual, or use the prepared Fehling's Solution provided in your chemistry set)
- ❑ Plastic pipette
- ❑ Goggles

<u>BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!</u>

1) Break a water cracker into quarters. If a cracker is not available, a piece of bread about the same size will do nicely. The cracker or bread is the source of starch.

2) Break up one of the pieces of bread or water cracker into very small pieces and place them into a large well of the microplate.

3) Add a pipette of water to the food sample.

4) Chew another quarter of the cracker very well. DO NOT SWALLOW THE CRACKER.

5) Put the chewed up cracker into another well of the microplate. Add 20 drops of water to this well.

6) Place 1/2 pipette of water into the next large well in the microplate.

7) Fill a pan or shallow baking tray about half full with hot tap water.

8) Float the microplate on the hot water.

9) After a minute, remove 5 drops of the saliva/cracker mixture and place the mixture in a small well of the microplate. Remove 5 drops of the water/cracker mixture and place the mixture in a well next to the first sample. Remove 5 drops of water and place the water next to the second sample.

10) Continue to take samples of saliva/cracker, water/cracker mixture and water at one minute intervals for 5 minutes.

11) Place 5 drops of Fehling's Solution in each of the small wells containing a sample.

12) Allow the reagent to react with the mixtures for 5 minutes.

13) Compare the colors of the reagent/ENZYME/cracker mixture to the reagent/WATER/cracker mixture.

14) What is the result? What happened to the cracker? Compare the color change of the reagent in this experiment with the color change of the Fehling's reagent in SECTION 4.

15) What happened to the pure water? What was the function of the pure water/reagent mixture?

SECTION 5 - STOPPING THE ACTION OF ENZYMES (ACID)

The enzymes from the saliva in your mouth start to break down certain foods as soon as you start to chew. In this experiment we will use an acid to halt the beginning action of this enzyme. The enzyme works best in a slightly basic (alkaline) solution. When the solution is changed to slightly acidic, the enzyme stops its action.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Water cracker or bread (obtain from kitchen or grocery)
- ❑ Fehling's Solution
- ❑ Water
- ❑ Microplate
- ❑ Shallow pan (for water bath)
- ❑ Plastic pipette
- ❑ Vinegar
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Break a water cracker into quarters. If a cracker is not available, a piece of bread about the same size will do nicely. The cracker or bread is the source of starch.

2) Break up one of the pieces of bread or water cracker into very small pieces and place them into a large well of the microplate.

3) Add a pipette of water to the food sample.

4) Chew another quarter of the cracker very well. DO NOT SWALLOW THE CRACKER.

5) Put the chewed up cracker into another well of the microplate. Add 20 drops of VINEGAR to this well.

6) Place 1/2 pipette of water into the next large well in the microplate.

7) Fill a pan or shallow baking tray about half full with hot tap water.

8) Float the microplate on the hot water.

9) After a minute, remove 5 drops of the saliva/cracker/vinegar mixture and place the mixture in a small well of the microplate. Remove 5 drops of the water/cracker mixture and place the mixture in a well next to the first sample. Remove 5 drops of water and place the water next to the second sample.

10) Continue to take samples of saliva/cracker/vinegar, water/cracker mixture and water at one minute intervals for 5 minutes.

11) Place 5 drops of Fehling's Solution in each of the small wells containing a sample.

12) Allow the reagent to react with the mixtures for 5 minutes.

13) Compare the colors of the reagent/ENZYME/cracker/vinegar mixture to the reagent/WATER/cracker mixture.

14) What is the result? What happened to the cracker? Compare the color change of the reagent in this experiment with the color change of the Fehling's reagent in SECTION 4.

SECTION 6 - STOPPING THE ACTION OF ENZYMES (BASE)

The same enzyme which was helping to digest the starch in the cracker in the previous experiment can also have the action of the enzyme halted by the presence of a basic salt which produces a more basic solution than the enzyme needs to work.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Water cracker or bread (obtain from kitchen or grocery)
- ❑ Fehling's Solution Reagent
- ❑ Water
- ❑ Microplate
- ❑ Shallow pan (for water bath)
- ❑ Plastic pipette
- ❑ Sodium carbonate solution (from your chemistry set)
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Break a water cracker into quarters. If a cracker is not available, a piece of bread about the same size will do nicely. The cracker or bread is the source of starch.

2) Break up one of the pieces of bread or water cracker into very small pieces and place them into a large well of the microplate.

3) Add a pipette of water to the food sample.

4) Chew another quarter of the cracker very well. DO NOT SWALLOW THE CRACKER.

5) Put the chewed up cracker into another well of the microplate. Add 20 drops of SODIUM CARBONATE SOLUTION to this well.

6) Place 1/2 pipette of water into the next large well in the microplate.

7) Fill a pan or shallow baking tray about half full with hot tap water.

8) Float the microplate on the hot water.

9) After a minute, remove 5 drops of the saliva/cracker/sodium carbonate mixture and place the mixture in a small well of the microplate. Remove 5 drops of the water/cracker mixture and place the mixture in a well next to the first sample. Remove 5 drops of water and place the water next to the second sample.

10) Continue to take samples of saliva/cracker/sodium carbonate solution, water/cracker mixture and water at one minute intervals for 5 minutes.

11) Place 5 drops of Fehling's Solution in each of the small wells containing a sample. Mix well.

12) Allow the reagent to react with the mixtures for 5 minutes.

13) Compare the colors of the reagent/ENZYME/cracker/sodium carbonate mixture to the reagent/WATER/cracker mixture.

14) What is the result? What happened to the cracker? Compare the color change of the reagent in this experiment with the color change of the Fehling's reagent in SECTION 4.

SECTION 7 - STOPPING THE ACTION OF ENZYMES WITH HEAVY METALS

Not only acids and bases can slow down or stop the action of enzymes, but some metals will also stop enzyme action. Many organic enzymes are prevented from doing their action by the addition of metals and metallic salts. Many times these salts are used as preserving agents to keep enzymes from changing organic materials which we do not want acted upon by enzymes.

You will need the following materials to complete this experiment:

LIST OF MATERIALS

- ❑ Water cracker or bread
- ❑ Fehling's Solution
- ❑ Water
- ❑ Microplate
- ❑ Shallow pan (for water bath)
- ❑ Plastic pipette
- ❑ Ferrous sulfate solution
- ❑ Goggles

BE SURE TO WEAR GOGGLES WHEN DOING EXPERIMENTS IN THIS CHEMISTRY SET!

1) Break a water cracker into quarters. If a cracker is not available, a piece of bread about the same size will do nicely. The cracker or bread is the source of starch.

2) Break up one of the pieces of bread or water cracker into very small pieces and place them into a large well of the microplate.

3) Add a pipette of water to the food sample.

4) Chew another quarter of the cracker very well. DO NOT SWALLOW THE CRACKER.

5) Put the chewed up cracker into another well of the microplate. Add 20 drops of FERROUS SULFATE SOLUTION to this well.

6) Place 1/2 pipette of water into the next large well in the microplate.

7) Fill a pan or shallow baking tray about half full with hot tap water.

8) Float the microplate on the hot water.

9) After a minute, remove 5 drops of the saliva/cracker/ferrous sulfate mixture and place the mixture in a small well of the microplate. Remove 5 drops of the water/cracker mixture and place the mixture in a well next to the first sample. Remove 5 drops of water and place the water next to the second sample.

10) Continue to take samples of saliva/cracker/ferrous sulfate solution, water/cracker mixture and water at one minute intervals for 5 minutes.

11) Place 5 drops of Fehling's Solution in each of the small wells containing a sample. Mix well.

12) Allow the reagent to react with the mixtures for 5 minutes.

13) Compare the colors of the reagent/ENZYME/cracker/ferrous sulfate mixture to the reagent/WATER/cracker mixture.

14) What is the result? What happened to the cracker? Compare the color change of the reagent in this experiment with the color change of the Fehling's reagent in SECTION 4.

What do the results of SECTIONS 6, 7 and 8 reveal about the conditions of an enzyme's work? Where do digestive enzymes work best? Why?

APPENDIX A

Answers to Experiment Questions

Group 3 - BASICS

SECTION 2

10) The liquid which has been added to the well remains in the well. The force of cohesion of water (surface tension) and adhesion to the plastic is greater than the force of gravity.

Water in the large wells has greater mass and a larger surface area. The water in the large wells falls out of the wells. The surface tension of the water is not great enough to keep the water in the wells.

SECTION 3

7) Dish detergent destroys the surface tension of water. The water falls out of the wells. The "wetting" power of detergent is what makes detergent a valuable cleaning agent.

SECTION 4

5) The water once again falls out of the wells. Alcohol also destroys the surface tension of water. The results of this part are similar to SECTION 2.

SECTION 5

5) The baby powder or flour coated the surface of the water. When the detergent was added the surface tension of the water was destroyed and the powder or flour was forced toward the walls of the well. The flour or powder sunk to the bottom of the well.

Group 4 - MIXTURES

SECTION 1

2) The mixture of zinc and salt must be separated by inspection. For even a small amount of zinc/salt mixture, the process is almost impossible.

4) The salt in the mixture is dissolved. The zinc is not soluble in water.

6) Since the zinc did not dissolve, the zinc remains in the filter funnel. A mixture or solution of salt and water is the liquid part which comes through the filter.

7) Salt and pepper can be separated by the same process as above. Salt will dissolve in the water, pepper will not dissolve. Pepper can be filtered out while the salt can be recovered by evaporation of the water.

SECTION 2

2) In order for filtration to work as a method of separating a mixture of a liquid and a solid, the solid material cannot be soluble in water.

SECTION 3

15) The ink blot is drawn up the filter paper and is separated into its different colors. What appeared to be a single color is really a mixture of colors. The process of chromatography separates the components or parts of the mixture of dyes in the ink.

SECTION 4

13) When other inks are separated, the individual dyes in the inks often are the same. A mixture of dyes which are orange and green, for example, will often have the same dye for yellow in each. This yellow dye will "develop out" of the chromatograph in approximately the same position or location on the chromatograph from sample to sample.

SECTION 6

3) Since both iron and sand are not soluble in water, the sand and iron cannot be separted on the basis of water solubility.

4) The iron can be separated from the sand by using another difference in physical characteristics between the two substances. A magnet will attract the iron while the sand remains unaffected.

Group 5 - MODELS

A charged atom is called an ion.

SECTION 1

6) A 3-D model is better than a paper or 2-D model since the 3-D model gives a clearer, more useful picture of what the actual molecule is believed to look like. The 3-D model lets you look at the structure of the molecule.

SECTION 2

4) The combination of iron and oxygen requires that the iron and oxygen form an alternating structure of oxygen-iron-oxygen-iron-oxygen. The paper model may show this but the 3-D model is more informative.

SECTION 3

11) The nails which were covered with solution show greater rusting than nails which were only covered with water. The nails tend to be rusty ABOVE the line of the solution. The red-brown color of the nail is due to the formation of iron oxide or rust.

12) The nail which shows the most change is the nail which is in a salt solution. In order for nails to change into rust, the iron must be able to react with oxygen in the water or oxygen in the air.

SECTION 3A

11) The nails which were covered with solution show greater change than the nails which were only covered with water.

12) Copper and aluminum nails are resistant to chemical change. A discoloration shows which chemicals tend to change copper and aluminum.

SECTION 5

9) The oxygen ion has a negative (-) charge.

10) The hydrogen ion has a positive (+) charge.

11) The possible products formed at the positive wire of the battery are: gaseous hydrogen and gaseous oxygen. The gas released is gaseous oxygen.

12) The positive electrode is producing oxygen gas. Hydrogen gas is being produced at the negative electrode.

17) The formula for water gives us the clue. H_2O tells us that a molecule of water has two hydrogen atoms for every one oxygen. When we decompose water, two times as much hydrogen is produced than oxygen. This is why twice as many bubbles of hydrogen come out of the solution at the cathode as do oxygen bubbles come out of the solution at the anode.

SECTION 7

6) The electrolysis of aqueous potassium iodine produces elemental iodine (I_2) at the positive electrode. Hydrogen is produced at the negative electrode.

7) Iodine is produced at the red electrode. Hydrogen is produced at the black electrode.

11) & 12)
The positive electrode produced the iodine which tests positive with starch or paper as the indicator. A black color indicates iodine.

SECTION 8

7) & 8)
The Universal Indicator turns two different colors in the two wells. The positive electrode well produces oxygen gas (which is soluble) and an orange or red color is seen when the indicator is present. The negative electrode produces hydrogen and is colored blue.

SECTION 9

7) & 8)
The Universal Indicator turns two different colors in the two wells. The positive electrode well produces oxygen gas (which is soluble) and an orange or red color is seen when the indicator is present. The negative electrode produces hydrogen and is colored blue.

SECTION 10

1) The last or control well is left alone to show the original color of the copper sulfate solution before the reaction has occurred.

2) & 3)
The copper solution did not change in the control or copper wire well. The well which contained the zinc wire faded when the zinc was left in the solution.

4) & 5)
As the zinc wire reacted with the copper ion in solution, the zinc metal in the wire became zinc ion and dissolved into the solution. Zinc in aqueous solution is colorless. The copper wire in the copper solution showed no change.

Group 6 - CONSERVATION OF MATTER

SECTION 1

8) The mass of the sodium chloride, weighing cup and water remain constant. The dissolving of the sodium chloride has no effect on the mass of the sodium chloride. The solid material, or sodium chloride, went into the aqueous phase. The mass of the sodium chloride is unaffected.

SECTION 1A

3) The masses of sodium chloride remain constant throughout the experiment. The water of the solution evaporates. The mass of the salt remains constant.

SECTION 2

7) & 9)
Calcium nitrate and sodium sulfate react together to form a white solid called calcium sulfate. Sodium nitrate remains in solution. You know that a reaction has occurred because the two clear solutions of calcium nitrate and sodium sulfate form a white solid when mixed together.

SECTION 3

7), 9) & 10)
Sodium carbonate reacts with calcium nitrate to form sodium nitrate, which remains in solution and calcium carbonate which forms a white precipitate. The total mass of the products does not differ from the total mass of the reactants.

SECTION 4

8) One of the products of the reaction between citric acid and sodium hydrogen carbonate is carbon dioxide gas.

10) The mass of the plate and contents changed because of the loss of carbon dioxide to the atmosphere.

11) The products of the reaction of citric acid and sodium bicarbonate are sodium citrate, a salt, water and carbon dioxide.

SECTION 5

8) One of the products of the reaction between citric acid and sodium carbonate is carbon dioxide gas.

10) The mass of the plate and contents changed because of the loss of carbon dioxide to the atmosphere.

11) The products of the reaction of citric acid and sodium carbonate are sodium citrate, a salt, water and carbon dioxide.

SECTION 6

8) One of the products of the reaction between citric acid and calcium carbonate is carbon dioxide gas.

10) The mass of the plate and contents changed because of the loss of carbon dioxide to the atmosphere.

11) The products of the reaction of citric acid and calcium carbonate are calcium citrate, a salt, water and carbon dioxide.

SECTION 7

4) & 5)
When the wires of the battery touch the flash bulb, the flash bulb goes off. The bulb releases light energy.

6) The weight of the flash bulb does not change. The bulb is a sealed system. The products of combustion of the metal and oxygen in the bulb are sealed in the bulb preventing the loss of mass to the environment.

7) The flash bulb contains a metal which burns very quickly producing a bright white light. The chemical produced in this reaction is the oxide of the metal. The product's mass must equal the mass of the reactants since the bulb did not lose or gain weight.

SECTION 8

3) The mass of the battery remains unchanged after use. The chemical compounds responsible for the flow of electricity from one end of the battery to the other remain sealed inside the battery. There is no loss of chemical outside the battery. There have been chemical changes in the battery but the total mass of the reactants inside the battery is exactly equal to the mass of the products produced when the battery functions.

Group 7 - THE STATES OF MATTER

Oxygen would be most useful as a liquid when a large volume of oxygen must be stored. The space program uses tons of liquid oxygen (LOX) in rockets. The liquid oxygen provides oxygen for combustion of rocket fuel in space. Hospitals usually have a liquid oxygen tank outside the building. The liquid oxygen is evaporated and the gas is piped into the building to provide oxygen for patients. There is no practical use for solid oxygen. Solid oxygen would take up even less space than an equal weight of liquid oxygen.

SECTION 1

2) Ice has a temperature of 0°C or 32°F in both samples.

4) As the ice is heated, it changes phase and melts into liquid water. After the ice has melted, the temperature of the liquid water continues to increase.

5) You will know the ice has completely melted when the liquid water starts to go up in temperature. As long as ice remains in the well, the temperature of the ice/water mixture will not increase above 0°C.

6) The ice in the unheated well will remain at 0° C for most of the experiment. The heated ice/water will increase in temperature.

SECTION 2

5) The salted water will heat at a different rate from the pure water.

SECTION 3

The sugar and salt solutions do not cool at the same rate. When room temperature was reached again, the solution remained as a solution. Solid material (sugar and salt) remained in as dissolved solids.

SECTION 4

The alcohol/water solution did not cool at the same rate as water alone. When room temperature was reached again, the solution still remains a solution. After evaporation of the alcohol and the water, both materials turned to gaseous substances and went into the air as gaseous alcohol and gaseous water (water vapor).

Group 8 - SOLIDS

SECTION 1

6) When the water evaporates, salt is left behind. The crystals of salt left behind are larger and easier to study with the hand lens.

7) The recrystallized salt crystals should be larger and more even.

SECTION 1A

5) Each substance forms a unique crystal. The crystal form of a compound is the purest form of the compound. The shape of the crystal gives a hint to the shape of the molecule of that substance. The physical characteristics of each substance's crystal is determined by the structure of the substance's molecule.

SECTION 2

4) A single crystal added to a saturated solution of a substance causes the "seed" crystal to form a larger crystal. The crystals from the seeded solution are identical to those formed by other means.

5) The seed crystal method is more precise since no outside energy source is used to promote crystallization. The addition of energy could change the shape of the crystal. The evaporation method uses extra energy to form crystals. This energy could alter the shape of the natural crystal.

SECTION 3

7) As the ethyl alcohol evaporates, the crystals of aspirin start to form. The crystals form because the liquid in which they were dissolved has evaporated leaving the solid in the mixture. The crystals of aspirin are flat while the crystals of salt are three dimensional.

SECTION 4

6) Starch does not normally form a crystal. It is a compound which is said to be amorphous, or without shape.

Group 9 - THE GASEOUS PHASE OF MATTER

SECTION 1

8) As the pressure on the gas is increased, the volume of the gas trapped in the column decreases. Pressure and volume are INVERSELY related. The higher the pressure, the smaller the volume.

SECTION 2

6) As the gas in the bulb of the pipette is decreased, the volume of the gas decreases. We know that the volume decreases because the liquid level goes up into the pipette. The volume of a gas is DIRECTLY related to the temperature of the gas.

10) As the air in the bulb is warmed, the volume of the gas increases. The air which is heated expands and is forced out into the well of water. As the temperature on the gas is increased, the volume of the gas increases.

SECTION 3

7) As the ammonia vapors leave the well, the universal indicator changes from green to blue. As the vinegar vapors leave the well, the universal indicator changes from green to orange or red.

8) The ammonia vapor travels faster than the vinegar vapor. The ammonia molecule is smaller and travels faster than the vinegar (acetic acid) molecule.

SECTION 4

9) As the hydrogen peroxide is decomposed, oxygen gas is generated. As the oxygen gas bubbles through the methylene blue solution the methylene blue is decolorized.

SECTION 5

8) As air goes into the methylene blue solution, a small amount of oxygen in the air causes the methylene blue to decolor in the same way as in SECTION 4, part 9. Oxygen gas is the only gas which decolorizes methylene blue.

SECTION 6

3) Liver and potato contain the natural catalyst catalase which aids in the decomposition of hydrogen peroxide to water and oxygen. The gas, oxygen, can be identified by oxygen's ability to decolorize methylene blue.

SECTION 8

6) When the leaf is exposed to light, photosynthesis occurs. Photosynthesis produces oxygen as one of its products. The oxygen decolorizes the methylene blue solution.

SECTION 9

5) The carbon dioxide reacts with the calcium hydroxide solution to form calcium carbonate, a white precipitate. The formation of a white precipitate when a gas is bubbled through calcium hydroxide solution proves the presence of carbon dioxide.

SECTION 10

9) The reaction of the calcium carbonate with an acid produces carbon dioxide gas.

10) Calcium hydroxide reacts with carbon dioxide to produce a white precipitate of calcium carbonate.

11) The precipitation reaction has been the method of testing for carbon dioxide in SECTION 9 and also this section.

SECTION 11

5) The reaction of an acid with sodium hydrogen carbonate produces carbon dioxide. Precipitation of calcium hydroxide solution is a good test for the presence of carbon dioxide.

SECTION 12

3) Alka-Seltzer® is a solid mixture of an acid and a carbonate. When the Alka-Seltzer® dissolves, the acid and the carbonate produces carbon dioxide. The reaction of this gas with calcium hydroxide would show the gas to be carbon dioxide.

SECTiON 13

5) The reaction of ammonium chloride with calcium hydroxide will produce ammonia gas. The ammonia gas dissolves in the moistened filter paper and causes the universal indicator to change color.

SECTION 14

4) & 5)
The filter paper which had been soaked in Universal Indicator will change color as the ammonia is reacted with the vapors of vinegar.

6) The vinegar will eventually tint the universal indicator back to green and finally to orange or red. The side of the paper closest to the vinegar vapors will change color first.

The reaction of household vinegar (acid) with calcium hydroxide (a base) and ammonium chloride would produce a solution which would cause the Universal Indicator to return to its green color.

SECTION 15

7) The Universal Indicator paper would show that the reaction would produce a basic gas, ammonia. You would know a reaction occurred by the change in the color of the paper.

Group 10 - EXPERIMENTS WITH SOLUTIONS

PRE-LAB:

1) Any metallic alloy is an example of a solid solution. Stainless steel, carbon steel, gold jewelry, etc., is a solid solution.

2) Air is a good example of a solution of a gas in a gas. In the case of air, nitrogen is the solvent since it is in greater amount in the air.

SECTION 2

4) Pure water is not an elecrolyte. Tap water is not pure water. Try to detect conduction with distilled water. There should be little or no conductivity. Tap water contains some salts and chemicals added to prevent bacterial contamination.

7) Non-electrolytes are solutions of either compounds which have carbon in the molecule or are precipitates. Electrolytes are solutions of inorganic compounds which dissolve and ionize in water to form charged particles.

SECTION 3

Conductors conduct electricity. Non-conductors do not conduct electricity.

SECTION 4

3) Electrolytes cause the indicator to glow while non-electrolytes do not cause the indicator to show conductivity.

9) The combinations of chemicals which produce a precipitate or gas gives an indication that a chemical reaction has taken place.

SECTION 5

7) & 8)
The reactants would be electrolytes since their solutions showed conduction with the conductivity tester. One of the products of the reaction is a precipitate. Precipitates do not dissolve or ionize in water. If no ionization takes place, a solution of a chemical does not show conductivity.

Group 11 - ACID AND BASE SOLUTIONS

SECTION 1

3) By diluting the acid by a factor of 10, the amount of acid per unit volume is decreased by an equal amount.

7) By diluting the base by a factor of 10, the amount of acid per unit volume is decreased by an equal amount.

10) The universal indicator will turn different colors dependent on the amount of acid or base in the solution in each well.

11) Phenophthalein is different than Universal Indicator since it has only one change of color. Phenophthalein is a single chemical indicator. Universal Indicator is a mixture of several indicators.

SECTION 4

All indicators show a change in color at a particular concentration of acid or base.

Each indicator changes color at only one concentration of acid or base. Often, a single chemical indicators may be found in more than one source.

SECTION 5

4) You will be able to tell if each product is acid or base by the color of the universal indicator. It is very unusual to find a product which is neutral.

SECTION 6

8) An indicator which turns color near the range of pure water would be most useful. Ask your teacher about the normal pH of rain.

Group 12 - TITRATION: A QUANTITATIVE METHOD

SECTION 1

5) A solution of sodium bicarbonate conducts electricity because sodium bicarbonate ionizes in water. If a drop of Universal Indicator is added to sodium bicarbonate, the indicator turns blue to indicate the presence of a base. Sodium hydroxide, ammonium hydroxide, calcium hydroxide and potassium carbonate are common bases. Individual tests with Universal Indicator will show which of the salt solutions in the chemistry set are bases.

SECTION 2

2) Sodium acetate is the name of the salt formed when sodium bicarbonate reacts with acetic acid. The gas formed is carbon dioxide.

SECTION 4

4) Household products which test positive with universal indicator are acids. Common acids are citrus juices, vinegar and soda water. The amount of base in a substance can be determined by the process of titration.

SECTION 5

8) The pH of a solution will vary with the substance being tested. The pH can be estimated by comparing the color in the test solution with the indicator with the standard colors of the indicator as determined in the previous series of experiments.

SECTION 6

Bases commonly found in the home are milk of magnesia, household ammonia, and milk.

Group 13 - ELECTROCHEMISTRY

SECTION 1

7) The compass needle moves to the left or to the right. The movement indicates that a current is flowing through the wire from one end of the battery to the other.

10) When the connections are reversed, the needle moves in the opposite direction. As electrons move through a wire they create a magnetic field which affects the compass.

SECTION 2

6) The needle of the galvanometer moves in response to a flow of electrons. By comparing the movement noted in this experiment to the movement in the previous experiment, the direction of electron flow can be determined in SECTION 3.

   Electrons flow from the NEGATIVE TERMINAL of the battery or cell to the POSITIVE TERMINAL of the battery or cell.

SECTION 5

10) The activitiy of a metal pair can be determined by the size of the movement of the compass needle. The greater the swing of the needle, the more active the metal pair.

11) Inactive metals are useful in applications where a resistance to corrosion is important. Inactive metals would have a longer useful life than active metals.

SECTION 6

7) The metals which were not coated would be expected to corrode. Metal which was wrapped in zinc wire did not corrode because the more active zinc metal corroded before the metal with which the zinc was in contact. The zinc functioned as a SACRIFICIAL METAL.

SECTION 8

5) The metals corroded in the expected manner. Changes in the solutions would also be noted due to a change in the pH of the solution as indicated by the change in the Universal Indicator color change. Evidence of corrosion would be seen on the nail similar to previous experiments on the activity of metals.

Group 14 - ORGANIC CHEMISTRY

SECTION 1

8) You should be able to see the fibers of polyethylene running in one direction or another. The fibers will appear as fine lines running parallel to each other in the piece of plastic.

10) In one direction the plastic will stretch to about 5 or 6 times the initial length. In the other direction the stretch will not be as pronounced.

11) In one direction the fibers will run perpendicular to the direction of stretch, in the other test the fibers will be parallel to the stretch. The greatest stretch will occur in the sample where the fibers are perpendicular to the stretch.

SECTION 3

6) The "liquid" does not pour as expected. The material seems to stick together as a blob.

SECTION 4

4) The glue now behaves as if it were a gel instead of a liquid. The sodium tetraborate solution makes the organic compound in the glue recombine in a different polymer structure. This change in structure alters the physical properties of the substance.

Group 15 - BIOCHEMISTRY

SECTION 2

7) The cobalt test paper changes from blue to pink. Testing the water turns the test paper pink. Foods which are plants are more watery than other forms of food.

SECTION 4

PRE-LAB:

Oxygen was produced in the chemical reaction in the gaseous phase of matter. The chemicals involved in these reactions are hydrogen peroxide and catalase. Other nonbiological chemicals which produce oxygen are hydrogen peroxide and manganese dioxide. The manganese dioxide was the catalyst for the decomposition of hydrogen peroxide.

SECTION 4

14) The cracker is digested by the saliva. The starch in the cracker is changed by the enzymes in the saliva into sugars.

There was no reaction between the cracker and water.

SECTION 5

14) When vinegar is used instead of water, the enzyme is destroyed and the reaction does not occur.

SECTION 6

14) When sodium carbonate is used in the reaction, the enzyme is destroyed and the reaction between the enzyme and the cracker does not occur.

SECTION 7

14) Using iron in the reaction causes the enzyme to be denatured. The denatured enzyme cannot help decompose the cracker. Enzymes must have specific conditions to function properly. Enzymes can function only in certain areas of the digestive system. Water does not contain enzymes to react with the cracker. The water/cracker combination is the control for this reaction.

APPENDIX B

FEHLING'S SOLUTION

Place 10 drops of citric acid solution into a large well. Add 5 drops of sodium carbonate solution. Mix into this solution 20 drops of copper sulfate solution. Mix well.

BIURET SOLUTION

Place 10 drops of potassium hydroxide solution (saved from Group 5, Section 5, Direction 7) into a large well of the microplate. Add 20 drops of copper sulfate solution. Mix well.

APPENDIX C

A NOTE TO ADULTS AND PARENTS

You have wisely chosen to purchase the NSI XM 5000 chemistry set. With this set, you have started your child on the path of learning about SCIENCE and the wonders found in the world of chemistry, biology and physics. But remember also, too little knowledge can be a dangerous thing. Real scientists use powerful tools, substances which can be poisons and may cause harm if misused or misapplied. Because of this, the WARNINGS on this set are REAL. They apply to the materials WHEN USED IN LARGER QUANTITIES! BUT, that is not the case here! HERE'S WHY! The amounts are deliberately made small and dilute. They are less LIKELY to cause harm because of the limited quantity and form. BUT, we still want **YOU AND YOUR CHILD** to READ, HEED AND UNDERSTAND the instructions given you in the set. In this way, we trust that POWERFUL chemicals may be SAFELY USED, in many fun experiments. Remember, too, if you have any questions about CHEMICAL HEALTH AND SAFETY contact your local physician or Poison Control Center, or Natural Science Industries.

VIAL NUMBER	SIZE OF VIAL OR CONTAINER	NAME OF CONTENTS (CHEMICAL NAME)	CHEMICAL FORMULA	WARNING ON LABEL	FIRST AID
#8	6 ml	COBALT CHLORIDE	$CoC1_2 \bullet 6H_2O$	**POISON DANGER** READ SIDE PANEL BEFORE USING. CAUSES EYE, SKIN, AND MUCOUS MEMBRANE IRRITATION. HARMFUL IF INHALED OR ABSORBED THROUGH SKIN. MAY BE FATAL IF SWALLOWED.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN FREELY WITH WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, IMMEDIATELY GIVE WATER AND INDUCE VOMITING. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#11	6 ml	COPPER SULFATE	$CuSO_4 \bullet 5H_2O$	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES SKIN, MUCOUS MEMBRANE AND SEVERE EYE IRRITATION. HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN FREELY WITH WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, IMMEDIATELY GIVE WATER AND INDUCE VOMITING. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#18	6 ml	SODIUM SILICATE	$Na_2SiO_3 \bullet 5H_2O$	**DANGER** READ SIDE PANEL BEFORE USING. CAUSES SKIN, MUCOUS MEMBRANE AND SEVERE EYE IRRITATION. HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN FREELY WITH WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, GIVE LARGE QUANTITIES OF WATER OR MILK. **DO NOT INDUCE VOMITING. IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#40	6 ml	CALCIUM HYDROXIDE	$Ca(OH)_2$	**DANGER** READ SIDE PANEL BEFORE USING. CAUSES BURNS, ESPECIALLY ON WET SKIN - CORROSIVE, HARMFUL IF SWALLOWED OR ABSORBED THROUGH SKIN. MAY BE FATAL IF INHALED.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN FREELY WITH WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, WASH OUT MOUTH WITH WATER. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#41	6 ml	CALCIUM NITRATE	$Ca(NO_3)_2 \bullet H_2O$	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES EYE, SKIN, AND MUCOUS MEMBRANE IRRITATION. MAY BE HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN FREELY WITH WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS,WASH OUT MOUTH WITH WATER. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#42	6 ml	CITRIC ACID	$C_6H_8O_7 \bullet H_2O$	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES EYE AND SKIN IRRITATION.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND LARGE AMOUNTS OF WATER • IF INHALED, GET TO FRESH AIR **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#44	6 ml	FERROUS SULFATE	$FeSO_4 \bullet 7H_2O$	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES EYE, SKIN, AND MUCOUS MEMBRANE IRRITATION. MAY BE HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN FREELY WITH WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, IMMEDIATELY GIVE WATER AND INDUCE VOMITING. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#47	6 ml	METHYLENE BLUE	$C_{16}H_{18}C1N_3S \bullet 3H_2O$	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES EYE AND SKIN IRRITATION. HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND LARGE AMOUNTS OF WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, WASH OUT MOUTH WITH WATER. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**

VIAL NUMBER	SIZE OF VIAL OR CONTAINER	NAME OF CONTENTS (CHEMICAL NAME)	CHEMICAL FORMULA	WARNING ON LABEL	FIRST AID
#49	6 ml	POTASSIUM IODIDE	KI	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES EYE, SKIN, AND MUCOUS MEMBRANE IRRITATION. HARMFUL IF INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN FREELY WITH WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, IMMEDIATELY GIVE WATER AND INDUCE VOMITING. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#53	6 ml	SODIUM SULFATE	$Na_2SO_4 \cdot 10H_2O$	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES EYE AND SKIN IRRITATION. MAY BE HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND LARGE AMOUNTS OF WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED GET MEDICAL HELP IMMEDIATELY. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#57	6 ml	ALUMINUM AMMONIUM SULFATE	$A1NH_4(SO_4)_2 \cdot 12H_2O$	**DANGER** READ SIDE PANEL BEFORE USING. CAUSES BURNS - CORROSIVE. HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN FREELY WITH WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, GIVE WATER AND GET MEDICAL HELP. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#58	6 ml	AMMONIUM CHLORIDE	NH_4C1	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES SKIN, MUCOUS MEMBRANE AND SEVERE EYE IRRITATION. MAY BE HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND LARGE AMOUNTS OF WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, WASH OUT MOUTH WITH WATER. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#59	6 ml	BIURET REAGENT (dry paper/ dry powder) Contains: SODIUM CARBONATE AND COPPER SULFATE	$CuSO_4$ on paper strip Sodium CarbonatePowder Na_2CO_3	**DANGER** READ SIDE PANEL BEFORE USING. CAUSES BURNS - CORROSIVE. HARMFUL IF SWALLOWED OR ABSORBED THROUGH SKIN. MAY BE FATAL IF INHALED.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN FREELY WITH WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, IMMEDIATELY GIVE WATER AND GET MEDICAL HELP. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#62	6 ml	FEHLING'S SOLUTION Contains: SODIUM CARBONATE, SODIUM CITRATE AND COPPER SULFATE	$CuSO_4$ on paper strip Na_2CO_3 powder $C_6H_5Na_3O_7 \cdot 2H_2O$	**DANGER** READ SIDE PANEL BEFORE USING. CAUSES BURNS - CORROSIVE. HARMFUL IF SWALLOWED OR ABSORBED THROUGH SKIN. MAY BE FATAL IF INHALED.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND LARGE AMOUNTS OF WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, IMMEDIATELY GIVE WATER AND GET MEDICAL HELP. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#64	6 ml	MAGNESIUM SULFATE	$MgSO_4 \cdot 7H_2O$	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES IRRITATION. MAY BE HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND LARGE AMOUNTS OF WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, WASH OUT MOUTH WITH WATER. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#65	6 ml	PHENOLPHTHALEIN	$C_{20}H_{14}O_4$	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES EYE, SKIN AND MUCOUS MEMBRANE IRRITATION. MAY BE HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN WITH WATER, THEN WASH THOROUGHLY WITH SOAP AND WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, GIVE WATER AND GET MEDICAL HELP IMMEDIATELY. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#67	6 ml	SODIUM CARBONATE	$Na_2CO_3 \cdot 10H_2O$	**DANGER** READ SIDE PANEL BEFORE USING. CAUSES BURNS - CORROSIVE. HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND LARGE AMOUNTS OF WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, IMMEDIATELY GIVE WATER AND GET MEDICAL HELP. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**

VIAL NUMBER	SIZE OF VIAL OR CONTAINER	NAME OF CONTENTS (CHEMICAL NAME)	CHEMICAL FORMULA	WARNING ON LABEL	FIRST AID
#70	6 ml	UNIVERSAL INDICATOR on paper strips	Methyl Red-$C_{15}H_{15}N_3O_2$ Phenolphthalein Bromthymol Blue Thymol Blue Methyl Yellow	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES EYE AND SKIN IRRITATION. HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN FREELY WITH WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, WASH OUT MOUTH WITH WATER. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#50	6 ml	BORAX POWDER	$Na_2B_4O_7•10H_2O$	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES EYE IRRITATION. HARMFUL IF SWALLOWED OR INHALED.	**FIRST AID:** • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, GIVE WATER AND INDUCE VOMITING. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#67A	6 ml	SODIUM CARBONATE POWDER	$Na_2CO_3•10H_2O$	**DANGER** READ SIDE PANEL BEFORE USING. CAUSES BURNS - CORROSIVE. HARMFUL IF SWALLOWED OR ABSORBED THROUGH SKIN. MAY BE FATAL IF INHALED.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND LARGE AMOUNTS OF WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, IMMEDIATELY GIVE WATER AND GET MEDICAL HELP. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#14	poly-bag	IRON FILINGS	Fe	**CAUTION** READ SIDE PANEL BEFORE USING.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN FREELY WITH WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, IMMEDIATLEY INDUCE VOMITING. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#71	poly-bag	ZINC POWDER	Zn	**DANGER** READ SIDE PANEL BEFORE USING - FLAMMABLE SOLID. KEEP AWAY FROM WATER, HEAT AND ACIDS. CAUSES EYE AND SKIN IRRITATION. MAY BE HARMFUL IF SWALLOWED OR ABSORBED THROUGH SKIN. MAY BE FATAL IF INHALED.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY FLUSH SKIN FREELY WITH WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, IMMEDIATELY INDUCE VOMITING. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#33	poly-bag	MARBLE CHIPS	$CaCO_3$	**WARNING** READ SIDE PANEL BEFORE USING. CAUSES EYE AND SKIN IRRITATION. MAY BE HARMFUL IF SWALLOWED.	**FIRST AID:** • IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH EYES FREELY WITH WATER • IN CASE OF SKIN CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND LARGE AMOUNTS OF WATER • IF INHALED, GET TO FRESH AIR • IF SWALLOWED AND PERSON IS CONSCIOUS, IMMEDIATELY GIVE WATER. **IN ALL CASES, CONTACT A POISON CONTROL CENTER AND/ OR SEEK MEDICAL ATTENTION. KEEP OUT OF REACH OF CHILDREN.**
#63	poly-bag	IRON WIRE	Fe	**CAUTION**	**KEEP OUT OF REACH OF CHILDREN.**
#54	poly-bag	ZINC WIRE	Zn	**CAUTION**	**KEEP OUT OF REACH OF CHILDREN.**
#38	poly-bag	ALUMINUM WIRE	Al	**CAUTION**	**KEEP OUT OF REACH OF CHILDREN.**
#61	poly-bag	COPPER WIRE	Cu	**CAUTION**	**KEEP OUT OF REACH OF CHILDREN.**

Periodic Table of the Elements

(based on $^{12}_{6}C$ = 12.0000)

14	Atomic number
Si	Symbol
Silicon	Name
28.086	Atomic mass
$3s^23p^2$	Valence electron configuration

TRANSITION METALS

Period	1* 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B
1	1 **H** Hydrogen 1.008 $1s^1$								
2	3 **Li** Lithium 6.941 $2s^1$	4 **Be** Beryllium 9.012 $2s^2$							
3	11 **Na** Sodium 22.990 $3s^1$	12 **Mg** Magnesium 24.305 $3s^2$							
4	19 **K** Potassium 39.098 $4s^1$	20 **Ca** Calcium 40.078 $4s^2$	21 **Sc** Scandium 44.956 $4s^23d^1$	22 **Ti** Titanium 47.88 $4s^23d^2$	23 **V** Vanadium 50.942 $4s^23d^3$	24 **Cr** Chromium 51.996 $4s^13d^5$	25 **Mn** Manganese 54.938 $4s^23d^5$	26 **Fe** Iron 55.847 $4s^23d^6$	27 **Co** Cobalt 58.933 $4s^23d^7$
5	37 **Rb** Rubidium 85.468 $5s^1$	38 **Sr** Strontium 87.62 $5s^2$	39 **Y** Yttrium 88.906 $5s^24d^1$	40 **Zr** Zirconium 91.224 $5s^24d^2$	41 **Nb** Niobium 92.906 $5s^14d^4$	42 **Mo** Molybdenum 95.94 $5s^14d^5$	43 **Tc** Technetium (98) $5s^24d^5$	44 **Ru** Ruthenium 101.07 $5s^14d^7$	45 **Rh** Rhodium 102.906 $5s^14d^8$
6	55 **Cs** Cesium 132.905 $6s^1$	56 **Ba** Barium 137.327 $6s^2$	57 **La** Lanthanum 138.906 $6s^25d^1$	72 **Hf** Hafnium 178.49 $6s^25d^2$	73 **Ta** Tantalum 180.948 $6s^25d^3$	74 **W** Tungsten 183.85 $6s^25d^4$	75 **Re** Rhenium 186.207 $6s^25d^5$	76 **Os** Osmium 190.2 $6s^25d^6$	77 **Ir** Iridium 192.22 $6s^25d^7$
7	87 **Fr** Francium (223) $7s^1$	88 **Ra** Radium (226.025) $7s^2$	89 **Ac** Actinium 227.028 $7s^26d^1$	104† **Rf** Rutherfordium (261) $7s^26d^2$	105† **Ha** Hahnium (262) $7s^26d^3$	106† **Sg** Seaborgium (263) $7s^26d^4$	107† **Ns** Neilsbohrium (262) $7s^26d^5$	108† **Hs** Hassium (265) $7s^26d^6$	109 **Mt** Meitnerium (266) $7s^26d^7$

INNER TRANSITION METALS

Lanthanide series

58 **Ce** Cerium 140.115 $6s^24f^15d^1$	59 **Pr** Praseodymium 140.908 $6s^24f^3$	60 **Nd** Neodymium 144.24 $6s^24f^4$	61 **Pm** Promethium (145) $6s^24f^5$	62 **Sm** Samarium 150.36 $6s^24f^6$
90 **Th** Thorium 232.038 $7s^26d^2$	91 **Pa** Protactinium 231.036 $7s^25f^26d^1$	92 **U** Uranium 238.029 $7s^25f^36d^1$	93 **Np** Neptunium 237.048 $7s^25f^46d^1$	94 **Pu** Plutonium (244) $7s^25f^6$

Actinide series

An atomic mass given in parentheses is the mass number of the isotope of longest half-life for that element.

**The 1–18 group designation has been recommended by the International Union of Pure and Applied Chemistry (IUPAC) but is not widely used. We refer to the standard U.S. notation for group numbers (1A–8A and 1B–8B).*

†ACS-endorsed names; IUPAC names for 104–108 are dubnium (Db), joliotium (Jl), rutherfordium (Rf), bohrium (Bh), and hahnium (Hn), respectively.