1. **Day One Mineral Activity:** Your objective is to determine the amount of a given product that could be made from a lode of ore the size of this classroom.

Materials: ore sample, product, graduated cylinder, scale, tape measure, overflow can

Procedure:

1. At your lab table, you will find a sample of bauxite ore which is 34.6% aluminum.
2. Determine how many grams of bauxite can be extracted from a lode of ore the size of this classroom.
3. Determine how many grams of aluminum can be extracted from this lode.
4. On your lab table is an aluminum cupcake pan. Determine how many of these cupcake pans could be made from the aluminum extracted from the lode.

(Each lab table or lab group has a different product and/or different ore sample. For example, if they also have bauxite ore they may have an aluminum pop can as the product. If their ore is hematite, 69.9% iron or magnetite, 72.3% iron, their product might be a steel vice-grip, or an iron magnet. If their ore is chalcopyrite, 34.6% copper their product may be copper pipes or copper wire. If their ore is sphalerite, 72.3% zinc, their product may be galvanized supports.)

Word Puzzle: Rearrange the letters below to spell out the name of an element. Use the letters in the circles to find the mystery work; an activity that every family should engage in.

PRCEOP O_ _ _ _ O   CIZN _ _ _ O   XONYEG _ _ O _ O _   ALDE O O _ _

MYSTERY WORD _ _ _ _ _ _ _

2. **Blue Box Experiment:** You will be given a sealed box that contains one or more items. Your task is to determine the contents of the box without physically opening the box. All of the boxes contain items you should be familiar with or things you have at least heard of before.

Procedure:

1. Initial Observations: Without touching a box, list 10 things you know are not in the box. 1. 2. 3. 4. 5.
6. 7. 8. 9. 10.

2. Select a box and write down it's number here: __________

3. With out manipulating the box, what would be your best guess as to what is in the box.

4. Physical Characteristics: Without opening or crushing the box, determine the size and shape of the box contents. Make a sketch below of the possible shape(s) and include all dimensions with your sketch.

5. Conclusions: List the item(s) you think are in the box.

6. Exchange: When told to do so, trade boxes with another group and repeat steps 2 – 5. You may use the back of this sheet to record your information.

7. Sharing: When told to do so, select a member of your group to go to the board. Write down the number of the box you had first, make a sketch of the items in the box and show your dimensions. Write your conclusions.

3. **Metric Measurement Lab:** In this lab you will perform a number of measurements to become more familiar with the metric system.

Materials: meter stick, graduated cylinder, scale

Procedure: Go to the front table and pick up a tub of materials to be measured. For each part listed below, make the necessary measurements and conversions, showing your work in the space provided.

1. Measure the length of the lab room from north to south.
   a. L = ____________m = ____________cm
2. Find the volume of the wood block.
   a. V = __________ cm^3 = ____________ m^3
3. Use the graduated cylinder to find the volume of the liquid in the beaker.
   a. V = _________mL = _________ cm^3 = __________L
4. Use the graduated cylinder to find the volume of the irregular shaped object.
   a. V = _________mL = _________cm^3 = _________ L
5. Find the mass of the solid in the cup. (Do not pour the solid directly onto the balance pan.)
   a. M = _________g = ___________kg
6. Find the mass of the test tube.
   a. M = ________g = __________hg = __________mg
7. Find the area of the top of the tub of supplies.
   a. A = ________cm^2 = __________mm^2 = _________ m^2

4. **Finding Density Using a Graph:** Your task is to find the density of the 3 most common coins used in America, the penny, the nickel, and the quarter.

Materials: graduated cylinder, scale, bag of coins

Procedure: Go to the front lab table and pick up a zip-lock bag containing 5 pennies, 5 nickels, and 5 quarters. In the space below, write your laboratory procedure used to collect enough data to plot 5 data points for each type of coin. Plot your graphs. Explain how you used your graphs to determine the density of each coin. Turn in your graphs with your lab.

5. **How Does Dimensional Analysis Make "Cents"?** The following experiment will help you to develop a relationship between two parameters (measurable properties that interact in some way.) This recognition is one of the steps in the problem solving approach which is called dimensional analysis. It is the method you will use this year to solve many chemistry problems.

Materials: bag of pennies, ruler, scale, graduated cylinder

Procedure:

Part I: a. Remove the 12 pennies from the bag and stack them up in one pile on your lab table. Measure the height of the stack to the nearest 0.01 cm and record your measurement in the data table.

b. Remove 2 pennies from the stack and measure the height of the stack. Record.
c. Remove 2 more pennies from the stack and measure again.
d. Remove 2 more pennies from the stack and measure agin.

Part II: a. Find the mass of your 12 pennies to the nearest 0.01 g and record this mass in the data table.
b. Remove 2 pennies from the scale and record the new mass.
c. Remove 2 more pennies from the scale and record the new mass.
d. Remove 2 more pennies from the scale and record the new mass.

Part III: a. Add about 10 mL of water to the graduated cylinder and record the volume to the nearest 0.1 mL. Add 6 pennies to the graduated cylinder and read the new volume. Find the volume of the 6 pennies and record in the data table.
b. Add 2 more pennies to the graduated cylinder, read the new volume, find the volume of the 8 pennies and record in the data table.
c. Add 2 more pennies to the graduated cylinder and repeat step b.
d. Add 2 more pennies to the graduated cylinder and repeat step b.

Data Table:

Number of pennies	Height	Mass	Volume

1. For each number of pennies in the data table, calculate the ratio of height to number of pennies in cm/penny. Average your 4 values to find the average ratio.
2. For each number of pennies in the data table, calculate the ratio of mass to number of pennies in g/penny. Average your 4 values to find the average ratio.
3. For each number of pennies in the data table, calculate the ratio of volume to number of pennies in mL/penny. Average your 4 values to find the average ratio.

Problems: Using your average ratios, including their units, solve the following problems.
1. What would be the height of a stack of 36 pennies?
2. How many pennies would be in 1.3 kg of pennies?
3. How many pennies would be in a liter of pennies?
4. What volume would 497 g of pennies take up?
5. How many pennies would it take to reach the moon from the Earth if the distance is 4.0×10^8 m?

6. Can You Float An Egg?: You assignment is to find the density of a raw egg by floating the egg.
Materials: raw egg, beaker, stirring rod, beaker of sugar
Problem: What must the density of a solution of water and sugar be in order for the egg to float? How can you achieve that? Will the egg float near the bottom of the beaker, the top or middle of the solution? How will you determine the density once you get it to float?
Write your report in the space below. Include your objective, your procedure, your calculations and your summary and conclusion.

7.Household Substances and Chemical Change: In this investigation, you will perform experiments using common household products. You will indicate any evidence

of chemical change. You will classify household chemicals as pure substances or mixtures.
Materials: test tubes, spatulas, baking soda, baking powder, Alka-Seltzer, flour, vinegar, household ammonia

Procedure:

1. At the front table you will find a box of small test tubes. Take 4 to your lab table.
2. On the back of this lab sheet, write down the names of the household chemicals you will be using: baking soda, baking powder, Alka-Seltzer, and flour. Go the front lab table and read the label for each chemical and list it's ingredients below its name. Classify each as a pure substance or a mixture.
3. To each of your 4 test tubes, place a small amount of each of the chemicals listed in step 2.
4. At your lab table you will find a small bottle of distilled water. Add a few milliliter of water to each test tube and record your observation in an appropriate data table on the back of this sheet. Clean the 4 test tubes.
5. To each of your 4 test tubes, again place a small amount of each of the chemicals from step 2.
6. At your lab table you will find a small bottle of vinegar. Add a few milliliters of vinegar to each test tube and record your observations. Clean the 4 test tubes.
7. To each of your 4 test tubes, again place a small amount of each of the chemicals from step 2.
8. At your lab table you will find a small bottle of household ammonia. Add a few milliliters of household ammonia to each test tube and record your observations. Clean the 4 test tubes.
9. Write a summary of your findings, including similarities between tested chemicals and results observed.

8. Physical Properties Lab: In this lab you will exam different materials and list physical properties that you observe.
Materials: Chemicals A – F, magnifier, test tubes, iron ring, water

Procedure:

1. From the front lab table take a half file folder that is divided into sections, A, B, C, D, E, F. Next to the file folders are 6 beakers labeled A – F. Use the spatula in each beaker to place a sample of the chemical in the appropriate section on the file folder. Carefully carry the file folder with chemicals back to your lab table.
2. Observe the chemical state of each chemical and record.
3. Observe and record the color of each chemical.
4. Determine if the chemical has a crystalline structure or is a powder or non-crystalline. Record this under Shape.
5. Place a small sample of A in a test tube and add a few milliliters of water. Shake the test tube and see if the chemical is soluble (dissolves in water.) Repeat for the other chemical samples.

6. Use an iron ring to try and crush the remainder of each sample. This is a hardness test. Determine if the chemical structure is soft, hard, or medium hard.
7. When finished, dispose of your chemicals as instructed by your teacher at the start of the lab.

Data Table:

Chemical	State	Color	Shape	Soluble	Hardness

8. For more advanced students I also give them a sample of a mixture of iron filings, salt, and sand and have them separate the mixture into the appropriate parts, using a magnet, funnel, evaporating dish and Bunsen burner.

9. **Building Electron Structures:** Having talked about the Quantum Theory and the 4 quantum numbers it is time to see what the electron structure of the elements looks like.

Materials: Styrofoam rectangle, white topped pins, colored headed pins.

Procedure:
1. In the center of the Styrofoam rectangle is a circle representing the nucleus of the atom. The atomic number of the element tells how many protons are in this nucleus. The white topped pins are protons, so stick the appropriate number of protons into the nucleus.
2. Around the nucleus are the orbitals giving the probable location of the electrons. Electrons enter the lowest energy shells first. Remember around the 4^{th} shell you start to have overlapping of orbitals – the 4s orbitals fills before the 3d orbitals. For each proton you place in the nucleus you must add one electron, (colored pin) into the next available orbital.
3. As you build each atom, write it's chemical symbol and it's electron configuration in the space below and on the back of this sheet.
4. You are to build the atoms for the first 88 elements on the Periodic Table.

10. **Identification of Metals Using the Flame Test:** When metals are heated, their electrons absorb energy and jump to higher energy levels. When these excited electrons drop back down to lower energy levels, the excess energy is released as light. The color emitted depends upon the energy jump. Each element has a series of light lines emitted which acts as it's fingerprint. These are the spectral lines. For several metals, there are enough light of a particular color emitted, so that the metal can be identified by it's characteristic color. Your goal in this lab is to view the color emitted by certain metals and use your data to identify two of these metals labeled as unknowns.

Materials; Solutions of $NaNO_3$, KNO_3, $Ca(NO_2)_2$, $Sr(NO_3)_2$, $LiNO_3$, $Cu(NO_3)_2$, $Ba(NO_3)_2$, Bunsen burner, 8 test tubes, test tube rack, HCl as a cleaning agent, wire loop.

Procedure:

1. From the front table, pick up a test tube rack, 8 test tubes, and a wire loop.
2. Lay out a paper towel in front of the test tube rack and label the 8 test tubes, Na, K, Ca, Sr, Li, Cu, Ba and HCl.
3. Take your test tube rack to the front lab table and pour about ½ inch of the appropriate solution in the corresponding test tube. Carefully carry the test tube rack back to your lab table.
4. Light your Bunsen burner so you have a nice inner blue cone. You will test each solution by dipping the wire into the appropriate test tube and then hold the wire loop right at the tip of the inner blue cone.
5. The colored flame will last only for a very short time, so be alert and watch for the characteristic color of each metal ion. If you leave the wire loop in the flame it will always burn yellow after the liquid has burned off. Record your observed color in the data table.
6. Before going to the next solution you must clean the wire loop by dipping it into the HCl solution and burning off the liquid. Do this at least twice between each solution.
7. When you have finished your observations, come to me and I will give you 2 unknown solutions for you to identify. Be sure to record the number of your unknown in the data table, the color observed, and your identification of the metal ion.
8. When finished, pour all solutions down the drain and wash out all test tubes and put your equipment back on the front lab table.

Data Table:

Metal Ion (Na^+, K^+, etc)	Flame Color	
Unkonwn #_____		Metal Ion Identified________

11. **What is the Average Atomic Mass of Beanium and Pennium?**

Background: Nuclear chemists, performing basic research on dirty silverware and plates in local restaurants, recently discovered what is believed to be element 120. The researchers have named the element beanium, derived from the small vegetables which grow on climbing plants. It was this type of food residue that led researchers to ultimately discover the existence of the element.

Further research is needed and will be conducted in various high school science labs. The first task will be to determine the average atomic mass of this new element. This will be determined by studying the atomic mass for each isotope of the element, the relative abundance of the isotope and then calculating the average atomic mass. (Normally average atomic masses are expressed in atomic mass units, however researchers have asked us to express it in grams.) One unique property of beanium will make these experiments practical, the atoms are VERY LARGE, which will allow high school students to separate the different isotopes.

Materials: cup of beanium atoms, scale

Procedure: Part I:

1. Go to the front lab table and pick up a cup of beanium atoms.
2. Separate the isotopes of beanium into different piles.
3. Find the total number of atoms of each isotope and the total number of atoms. Calculate the percentage of abundance for each isotope by dividing the number of atoms of each isotope by the total number of atoms.
4. Find the total mass of each isotope in your sample and divide that mass by the total number of atoms of that isotope to find the average atomic mass for each isotope.
5. Determine the average atomic mass for the beanium element by using the following equation.

Average atomic mass = % isotope #1 x average mass #1 + % isotope #2 x average mass #2 ………….

Data Table:

Isotope #	Number of atoms	Total Mass	Average mass	% Abundance

Total number of atoms.

Part II: Pennium – Pennium has 2 isotopes, those dated before 1980 and those after 1980. Your task is to find the average atomic mass of Pennium.

Materials: bag of pennium atoms, scale

Procedure: Use the same procedure as in part I.

Data Table:

Isotope #	Number of atoms	Total mass	Average mass	% Abundance

Total number of atoms

12. **Mapping Atomic Structure: Drawing a Scale Model:** This is a ChemFax! Lab from Flinn Scientific. If you are not getting emails from Flinn I highly recommend you go to their web site and get on their list. They periodically send out labs that are very good.

Materials: basketball, city map, ruler, tape measure

13. **Determining the Size of a Nucleus You Cannot See:** Chemistry experiments are often designed to gather information about what cannot be directly observed. The purpose of this lab is to demonstrate how an experiment can provide information about something that cannot be seen. Your task will be to determine the diameter of a sphere without directly measuring it.

Materials: 7 spheres (golf balls or large marbles), meter stick, masking tape

Procedure:

1. Find a space on the floor where you can work. You may want to choose an area with a lab table as a backstop. Use masking tape to make a line exactly 60 cm long across the floor.
2. Place 6 spheres along the masking tape spacing them out so they are not touching each other.
3. Measure one meter in front of the masking tape and place the 7^{th} sphere at this point.
4. One person sit where the 7^{th} sphere is but facing away from the masking tape. With out looking roll the 7^{th} sphere toward the 6 spheres on the masking tape. One partner note if the incoming sphere hit one of the six or missed. If one sphere is hit, record a hit and replace the sphere, and return the 7^{th} sphere to the roller for another trial. Keep track of all hits and all misses. If a hit ball rolls to the side and hits another of the 6 on the masking tape, this still only counts as one hit.
5. Each person will roll the 7^{th} sphere without looking, 100 times. Record your data and the total data for your lab group in the data table.
6. Use the following equation to determine the diameter of the sphere in cm, using your own data and your group data.
   i. $$\text{Diameter} = \frac{\text{Width of field x \# of hits}}{\text{2 x \# of target spheres x \# of trials}}$$
7. When finished, post your data on the board and when all groups have posted their data, record those totals under class data.
8. Calculate the diameter of the ball using the class data.

Data Table: Exact length of masking tape: _________cm
Number of target spheres: _________

	Your Data	Group Data	Class Data
Total Number of Hits			
Total Number of Trials			

Your instructor will write the exact diameter of the spheres on the board. Write a summary of your findings, comparing the actual diameter to the calculate diameter for each set of data (yours, your group, the whole class). Also, speculate how your data might change if the size of each sphere was doubled or cut in half. How does this experiment relate to Rutherford's Gold Leaf Experiment and the work done by Hans Geiger and Ernest Marsden?

14. It's Time To React:
Procedure: For each step below, follow the given instructions and write down what you observed. What did you see that indicated a chemical reaction had occurred? Then write a balanced equation for the reaction and tell what type of reaction occurred (synthesis, decomposition, single replacement, double replacement, combustion).

1. Go to the front lab table and pick up a tray of materials. Take the butane lighter out of the tray and press down on the lever at the top to light it. The formula for butane is C_4H_{10}.
2. Take the birthday candle out of the tray and use the butane lighter to light the candle. For wax use the formula $C_{24}H_{50}$. Blow out the candle.
3. Take the watch glass from the tray and use the plastic spoon to place a small amount of baking soda onto the watch glass. Take the bottle of HCl and use the eye dropper to put a few drops of HCl onto the baking soda. For this reaction there will be 3 products formed.
4. Wash off the watch glass from part 3, be sure to dry it, then use the plastic spoon to put another small amount of baking soda onto the watch glass. Take the bottle of vinegar and the eye dropper with it to place a few drops of vinegar onto the baking soda. This reaction will also have 3 products.
5. Take the larger test tube from the tray and add approximately 3 cm of HCl to the test tube. Stand the test tube up in the beaker in the tray. Take the small piece of zinc from the zip lock bag and drop it into the HCl.
6. After the reaction has progress a few minutes, light the candle and bring the candle flame to the top of the test tube.
7. Carefully pour the liquid from the test tube down the drain, then tap the solid material onto a paper towel and throw it away. Do not let your hands touch the wet part of the paper towel.
8. Clean the test tube and watch glass, put everything back into your tray and put the tray on the front lab table.

15. **Mole Lab:** The chemist's way of counting atoms and molecules in the mole. One mole of any substance is equal to the average atomic mass for an element or average formula mass for a compound. This mass is called the molar mass. One mole of any substance contains Avogadro's number of particles, 6.022×10^{23} particles. In this lab you will count the number of atoms and molecules in cups containing either an element or a compound. If it is an element, you will have one answer, if it is a compound you will have 2 answers. **You must show all of your work.**

Procedure:

1. Pick up a tray of chemicals from the lab table in the front of the room.

2. Find the mass of the empty cup. Assume all of the cups have the same mass, so you can use this mass to find the mass of the chemical in each cup.
3. Record the chemical formula written on the cup. (The cups contain Al (nails), Cu (plumbing elbows), NaCl, $NaHCO_3$, $C_6H_{12}O_6$, H_2O, and other safe chemicals from the store room.)
4. Find the mass of cup and its contents. Find the mass of the chemical in the cup.
5. From the formula find the molar mass of the chemical in the cup.
6. Use the mass of the chemical and it's molar mass to find the number of moles of chemical in the cup.
7. Use Avogadro's number to find the number of atoms in the cup if the chemical is an element or the number of molecules in the cup if the chemical is a compound.
8. If the chemical is a compound, then find the number of atoms in the cup.
9. When finished put the cups back into the tray and place the tray on the front lab table.

Data Table: (I just number #1, leave a space, #2, leave a space, etc.)

16. **Mole Food Lab:** Your objective in this lab is to determine the amount of a food item that will provide you with one mole of sodium and the amount that will provide you with one mole of potassium. You will find the amount in grams for each and the amount in mL for each.

Materials: One cereal box, one can of vegetables, one can of fruit, one box of juice, one can of tomato juice. (I have also used yogurt as an item.)

Procedure: Analyze the serving data on each food container. You will need to know the amount of Na in each serving and the amount of K in each serving. You will need to know the mass in grams of one serving and the volume in mL of one serving. **Show all of your calculations in the space below.** When you are done with your calculations, there are questions that relate to your findings.

Helpful conversions: 1 cup = 236 mL Density of the juice drink = 1 g/mL
Density of the tomato juice = 1.007 g/mL

There are different brands of cereal and pears so write down which one you had.

Cereal ___________________ Pears _______________

Questions:
1. What food item will provide 1 mole of sodium with the least volume? What is that volume?
2. What food item will provide 1 mole of sodium with the least mass? What is that mass?
3. What food item will provide 1 mole of potassium with the least volume? What is that volume?

4. What food item will provide 1 mole of potassium with the least mass? What is that mass?
5. What food item will provide a minimum of 1 mole of both sodium and potassium with the least volume? What is that volume?
6. What food item will provide a minimum of 1 mole of both sodium and potassium with the least mass? What is that mass?

(As an addition to this lab, I cut off and copy a label from a multivitamin and assign each student an element and have them determine how many tablets it would take to get one mole of their element and if they took one tablet, how many atoms of their element would they consume.)

17. **Preparing Chemical Solutions:** In several of the labs you performed so far this year, many of the chemicals were label as 0.1 M or 3 M, etc. . Now you know what that the M stands for Molarity or moles/liter. Your task today is to make 3 solutions of a given molarity and showing all of your work in determining the procedure. Some of these solutions will be used by you in later labs and your results may be determined on how well you prepared the solution today. **Use distilled water to prepare all solutions.**

    Procedure:

    1. Go to the storage cupboard and get 3 400 mL beakers. Clean them thoroughly.
    2. Then come to the front desk and select one card with the solution to be prepared.
    3. In the space below, show all necessary calculations and explain how you will make the given solution.
    4. Go to the front lab table, get the bottle of chemical you are to prepare.
    5. Take the chemical to your lab table and prepare the solution.
    6. When finished, bring the beaker with your solution to me. I expect you to tell me exactly what solution is in the beaker.
    7. Return the chemical bottle to the front table. Select another card and repeat steps 3-6.
    8. Return the chemical bottle to the front table and select your 3rd card and repeat steps 3-6.

#1. What is to be prepared? ____________________________________

18. **The Effects of Pressure on a Confined Gas:** In this experiment, you will try to discover a relationship between the volume of a sample of trapped gas and the pressure exerted on the gas. The gas will be trapped in a hypodermic syringe as pictured below.

Materials: insulin syringe, rubber stopper, open ended can, ring stand and 2 iron rings, cardboard supports.

Caution: The syringe needles are very sharp and will cause injury if not handled properly. Always point the needle away from you and keep it inserted in the rubber stopper as much as possible.

Procedure:

1. You will find all of the equipment you need on your lab table. Set up the ring stand with the 2 iron rings as pictured below.
2. Carefully remove the needle from the rubber stopper, insert needle end of the syringe into the bottom cardboard support and insert the needle into the rubber stopper. This is a delicate set up, so one lab person should hold onto the syringe at all times and keep it vertical.
3. Pull the plunger all the way out of the syringe and then re-insert it. Sometimes these syringes have a tendency to stick, so be sure the plunger is free to move.
4. Find the mass of the empty open topped can. Add enough water to bring the mass up to 100 grams.
5. Insert the open topped can into the top cardboard support and rest it on top of the syringe plunger. Press down on the can to force the plunger down and then release the can and allow the plunger to settle into it position.
6. Read the volume from the bottom of the black plunger. Record the mass and the volume in the data table. Note: There will be no data point for zero grams.
7. If you have trouble with the plunger sticking, call me over to your table.
8. Using a graduated cylinder, add water to the can in 50 mL increments. After each addition, push the can down and release the can before making your volume reading. Record both mass and volume after each water addition. Remember the density of water is 1g/mL.
9. Continue to add water until you reach a mass of 500 – 550 grams.
10. Remove the water can and dump it out. Carefully remove the needle from the stopper, pull the syringe out of the cardboard support, re-place the needle into the rubber stopper.
11. You may leave the equipment on the lab table for the next class.
12. Plot a graph with volume on the x-axis and pressure (mass) on the y-axis.
13. Write a statement that relates pressure (mass) P and volume V.

Data Table:

Pressure (mass) g	Volume mL

19. **How Is The Volume Of A Gas Affected By Temperature?** In this experiment you will try to discover a relationship between the volume of a trapped gas and the temperature of the trapped gas.

Materials: Two pipets, (one with a larger neck and one with a smaller neck), ice water, beaker, hot plate, thermometer, ruler

Procedure:

1. Pick up the pipets, thermometer, beaker and ruler from the front table.
2. Fill the beaker 2/3 full of ice water from the thermos jug. Put the bulb end of the pipet with the larger neck into the ice water and hold it so the bulb part of the pipet stays below the water. Leave it there for 3 to 4 minutes.
3. Place a thermometer into the beaker of cold water and record the temperature right before you do the next step.
4. Take the smaller necked pipet to the front table and get a small amount of colored water into the neck of the pipet. Take it to your lab table and insert the smaller neck of the pipet into the larger neck of the cold pipet and squeeze out a small drop of colored water right above the bevel of the larger pipet. (See the diagram below.)
5. Quickly measure the distance from the end of the bevel to the end of the colored water drop and put the bulb of the pipet back into the water if you took it out. Record the temperature of the water and distance to the water drop in the data table.
6. Carefully set the beaker of water onto the hot plate and turn on the hot plate.
7. Every time the temperature of the water rises 6-8^{o}C, measure the distance from the bevel to the end of the water drop. Record the temperature of the water and distance in the data table.
8. Continue to collect data until you reach about 40^{o}C or the drop is about to leave the neck of the pipet.
9. Rinse out both pipets and return all your equipment to the proper place.
10. The millimeter the drop moves in the pipet neck is equivalent to 0.01 mL of volume. Convert your distances to volumes.
11. Convert the temperature reading to Kelvin.
12. Plot a graph with the volume on the x-axis and the Kelvin temperature on the y-axis.
13. Write a conclusion statement relating the volume of a gas to the Kelvin temperature.

Data Table:

Temperature	Kelvin Temperature	Distance	Volume

20. **Graham's Law Lab:** As you know Graham investigated the rate of diffusion of gases from an area of high concentration to an area of low concentration. Today you will measure and compare the rates of diffusion of HCl vapor and NH_3 vapor. (NH_3 is derived from ammonium hydroxide)

Procedure:

1. From the front lab table pick up a straw, 2 cotton swabs, a ruler, and a stop watch.
2. Lay the straw in the center groove of the ruler and take it along with the other materials to one of the hoods.
3. One person will dip the end of one cotton swab into the bottle of NH_4OH and another person will dip their cotton swab into the bottle of HCl. They will immediately insert the cotton swabs into opposite ends of the straw and the 3rd partner will start the stop watch.
4. Carefully carry the ruler back to your lab table and observe the straw. At the earliest formation of a white cloud inside the straw, stop the watch and mark the spot where the cloud first appeared.
5. Measure the distance the HCl vapor moved from the end of the swab to the white cloud position. Divide this distance by the time on the clock to get the velocity of the HCl vapor in the straw. $V = d/t$
6. Measure the distance the NH_3 vapor moved from the end of its swab to the white cloud position. Divide this distance by time on the clock to get the velocity of the NH_3 vapor in the straw. $V = d/t$
7. Divide the velocity of the NH_3 vapor by the velocity of the HCl vapor.
   $V(NH_3)/V(HCl)$ = ____________
8. According to Graham's Law the rate of NH_3/HCl = the square root of the molar mass of HCl/molar mass of NH_3. Calculate this square root.

   ____
9. Find the absolute error between your collected value and the theoretical value calculated above. Show your work. If your error is more than 10%, discuss reason for your larger error.

(Since some people do not like to mess with the smelly NH_3, I sometimes tell them I collected the following data using HCl and an unknown gas. I give them the picture below for the apparatus. Time: 34.6 seconds; distance HCl vapor traveled: 24.0 cm. distance unknown vapor traveled; 35.2 cm. Then using Graham's Law they calculate the molar mass of the unknown gas. Then as a question, I tell them the unknown gas is composed of nitrogen and hydrogen and they have to come up with the formula of the gas.)

21. **Model Building of Covalent Molecules:** Most of our learning is in two dimensions. You watch me write notes and draw figures on a two dimensional white board or overhead projector screen. We have been looking at Lewis dot structures in two dimensions. These models are good for under standing electron distribution and the concept of sharing electrons to reach a stable electron configuration. However, we live in a three dimensional world and these models do not portray what the molecule would look like in 3 dimensions, if we could see it. In this lab, you will try to put molecules together and get a 3 dimensional view of what the molecule looks like and then try to determine if the covalent bonds are polar or non-polar and if the bonds are polar, does the structure allow the molecule to be polar.

Materials: toothpicks, marshmallows (large marshmallows are carbon, nitrogen or oxygen and small marshmallows are hydrogen or halogens) (I actually have lab kits with connecting spheres of different colors for the elements but not everyone can afford the kits.)

Procedure: For each formula below, draw the Lewis dot structure for the compound. From the dot structure you can tell if the bonds are single covalent, double covalent, or triple covalent and if there are un-bonding pairs of electrons. Look at the diagrams below to help you put your models together.

2 atom molecules are always linear
3 atom molecules with two double bonds are linear
3 atom molecules with single bonds and un-sharing electrons are bent triatomic.
4 atom molecules with un-sharing electrons are pyramidal
4 atom molecules with no un-sharing electrons are trigonal planar.
5 atom molecules with no un-sharing electrons are tetrahedrals.

Once you have the molecular model made, then determine the electronegativity difference for each bond. Show your work. Determine if the molecule is polar or non-polar, remember the structure has to allow it to be polar.

Data Table:

Formula	Dot Structure	Shape	Electronegativity difference & Polarity
HBr			
H_2S			
PH_3			
CCl_4			
CS_2			
HCN			
CH_2Cl_2			

22. **Paper Chromatography:** Chromatography is a method of separating substances mixture. The method is often seen on crime shows on TV, but most often using a gas chromatograph. The word originates from the Greek word Chromos or color. Solutions that appear to be one color can often be separated into many colors by this method. In today's lab you will be using a polar molecule (water) to separate a mixture of colors in overhead pen dyes.

The difference in migration of the various dye colors is due to the intermolecular forces between the dye molecules and water molecules and the dye molecules and the paper molecules. The distance a color moves relative to the distance the water moves is called the R_f value. $R_f = D_s/D_f$ D_f is how far the water travels from the starting point on the paper strip and D_s is how far a particular color moves from the same starting line as measured to the end of the color mark.

A given pen color may have two or more color components so you will have to determine the R_f value for each color in the dye.

Procedure:

1. At the front table pick up well plate, ruler, 5 strips of chromatography paper and one of each colored pen, red, blue, green, black and yellow.
2. On each strip, use a pencil and mark a starting line 3 cm from one end.
3. In the middle of this pencil line make a dot of color using one overhead pen. Use one colored pen for each paper strip. (You may want to use a pencil and label each paper at the top with a letter or two so you keep the pen color straight.)
4. Put a small amount of distilled water in 5 of the wells.

5. Bend the paper strip one cm below the colored dot (pencil line) and set that end into one of the water wells. You do not want the dot to get into the well. Do the same with the other strips.
6. Keep the strips in the water for 20 minutes.
7. Remove the strips from the water and measure the distance from the pencil line to where the water ended. Record this as D_f.
8. Record the colors that you can see on the paper strip in the data table. Measure the distance from the pencil line to the end of each color noted. Do not try to distinguish between the different shades of the same color, for example pink and light red and dark red. Record this distance as D_s in the data table.
9. Calculate the R_f value for each color seen in each pen.

Data Table:

Pen Color	Ink Color	D_s	D_f	$R_f = D_s/D_f$

Questions:
1. Is there an ink color(s) that appears to be composed of a single color component? If so, what color of pen(s)?
2. Is there an ink color(s) that appears to be composed of 2 or more color components? If so, what color of pen(s)?
3. Which dye component of the inks appears to be most strongly attracted to the paper molecule?
4. Which dye component of the inks appears to be most strongly attracted to the water molecules?

23. **Specific Heat:** In this lab you will use the Law of Heat Exchange to determine the specific heat of 2 different metals.

Materials: Styrafoam calorimeter cup, beaker, Bunsen burner, thermometer, ring Stand, cold water

Procedure:
1. Set up the ring stand and ring. Fill the beaker 2/3 full of tap water and begin heating the water with the Bunsen burner.
2. Go to the front lab table and select two metal samples, Styrafoam calorimeter, and thermometer. Record the name of the metal in the data table.
3. Find and record the mass of the empty calorimeter. Find and record the mass of the metal sample.
4. Tie a piece of string around one metal sample and place it in the heating water. Use a separate piece of string for the other metal and place it in the heating water.
5. When the water has begun to boil, take the calorimeter to the front table and pour enough water into the calorimeter cup, to cover one of the metal samples. Find the mass of the calorimeter cup and water. Then find the mass of the cold water.
6. Find the temperature of the cold water and record. Then find the mass of the boiling water and record this as the initial temperature of the metal.
7. Quickly take one metal sample out of the boiling water and lower it into the cold water, place the top on the calorimeter, place the thermometer into the top and

carefully stir the metal in the water until the temperature levels off. Record this temperature as the final temperature of both the metal and the water.

8. Pour out the cold water, go to the front table and again put enough water into the calorimeter cup to cover the 2nd metal sample. Repeat steps 5-7 for the 2nd metal sample.

Show your work for the following steps.

9. Calculate the heat gained by the water in the calorimeter. (This equals the heat lost by the metal sample.)
10. Calculate the specific heat of the metal sample.
11. Use your textbook to find the accepted value for each metal and calculate your experimental error.

Data Table:

Kind of metal
Mass of metal
Mass of empty cup
Mass of cup and water
Mass of cold water
Temperature of cold water
Temperature of boiling water (metal)
Final temperature of cold water
Final temperature of metal
Temperature change of metal
Temperature change of cold water

Metal ___________ Heat gained by cold water:

Heat lost by metal:

Specific heat of metal:

Accepted value for specific heat: %Error:

Metal___________ Heat gained by cold water:

Heat lost by metal:

Specific heat of metal:

Accepted value for specific heat: %Error:

24. **Heat of Fusion of Ice:** Ice melts at 0^{o} C and turns into water at 0^{o}C, yet heat must continually be added for this to occur. In this lab you will determine the amount of heat needed to make the change from ice to water.

Materials: Styrafoam calorimeter, thermometer, water and ice.

Procedure:

1. Go to the front lab table and collect a calorimeter and thermometer and a small beaker of ice cubes. Find and record the mass of the empty calorimeter.
2. Go to the coffee pot in the front of the room and fill the calorimeter cup about 13 full of hot water. Find and record the mass of the cup and water. Then find the mass of the hot water in the cup.
3. Place the lid on the calorimeter, insert the thermometer into the hole on top, and take and record the temperature of the hot water.
4. Raise the lid enough so that 3 ice cubes can be dropped into the warm water. Lower the lid and carefully stir the ice cubes and water until all of the ice has melted.
5. Take the final temperature of the water and record. This will also be the final temperature of the water formed from the ice.
6. Find the mass of the cup now, and calculate the mass of the ice cubes added to the cup.
7. Use the Law of Heat Exchange to find the amount of heat needed to melt the ice.
8. Divide the amount of heat needed to melt the ice by the mass of the ice to determine the heat of fusion of the ice. Show your work when needed.
9. Empty the calorimeter and repeat steps 2-8.

Data Table:	Trial 1	Trial 2
Mass of empty cup		
Mass of cup and hot water		
Mass of hot water		
Initial temperature of hot water		
Final temperature of water and ice		
Temperature change of hot water		
Temperature change of water formed from ice		
Mass of cup, water, and ice		
Mass of ice		

Heat lost by hot water: $Q_1 = mc\Delta t$

Heat gained by water formed from ice:

$Q_2 = mc\Delta t$

Heat needed to melt the ice: $Q_1 - Q_2 =$ _______

Heat of fusion of ice: Heat needed to melt ice/mass of ice

$L_f = \Delta Q/m$

25. **Heat of Reaction:** Energy changes occur in all chemical changes due to the re-arrangement of chemical bonds. Reactions that release heat are exothermic and reactions that absorb heat are endothermic. In this lab you will measure the amount of heat liberated in 2 different chemical changes.

Materials: Styrofoam calorimeter, thermometer, beaker, sodium hydroxide, hydrochloric acid, zinc metal, test tube.

Part I: Procedure:

1. Go to the front lab table and pick up a Styrofoam calorimeter, thermometer and beaker.
2. Find and record the mass of the beaker. Go to the front table and use the spatula to place 8 pellets of NaOH into the beaker. Find and record the new mass of beaker and NaOH and the mass of the NaOH.
3. Find the mass of the empty calorimeter. Take the calorimeter to the front of the room and fill it 1/3 full of cold water. Find and record its new mass and find the mass of the water contained.
4. Record the temperature of the water in the calorimeter.
5. Add the NaOH pellets to the water, put the top on the calorimeter, insert the thermometer into the hole in the top and gently stir the water. Record the highest temperature reached by the water.
6. Calculate the heat gained by the water in this chemical change by using $Q = mc\Delta t$.
7. Calculate the joules/mole of heat released in this chemical change.

Data Table:

Mass of beaker
Mass of beaker and NaOH
Mass of NaOH
Moles of NaOH
Mass of calorimeter
Mass of calorimeter and water
Initial temperature of water
Final temperature of water
Temperature change of water
Heat change in chemical change
Joules/mole released by NaOH

Part II:

1. Empty the calorimeter cup. Again fill it about 1/3 full of cold water. Find the new mass of the calorimeter cup and the mass of the cold water.
2. Take the test tube and calorimeter cup to the front table and add 10 mL of HCl to the test tube and stand the test tube in the calorimeter cup. Place a few pieces of mossy zinc on a paper towel and take everything back to your lab table.
3. Measure the temperature of the cold water in the cup. Add mossy zinc to the HCl in the test tube, place the lid on the calorimeter and insert the thermometer into the top in such a way that it is in the water and not the test tube.
4. Stir the water and record the highest temperature reached in the water.
5. Calculate the heat gained by the water in this chemical change by using $Q = mc\Delta t$.

Data Table:

Mass of calorimeter
Mass of calorimeter and water

Mass of water
Initial temperature of the water
Final temperature of the water
Heat change in this chemical change

26. **pH of Household Items:** In class discussions you have seen that the pH of a solution tells you weather the solution is acidic, basic, or neutral. Indicators can be used to determine the pH of a solution. In this lab you will use an indicator called pH paper whose color changes can be used to determine the pH of a solution by matching the color of the paper to a colored pH scale.

Procedure:

1. At each lab table are containers of common household solutions. At the front lab table you will pick up a color code sheet, a cup of small pieces of pH paper, and a paper towel to lay the on.
2. As you rotate through the tables you will read the label on the bottle to see what the household substance is and then use the eye dropper to place a small drop of the solution on one of the pH papers.
3. Match the color of the pH paper to color code and record the pH below.
4. When you have determined the pH of each solution return the color code and cup of remaining pH strips to the front lab table. Throw the paper towel with the used strips away.
5. From the pH, record if the solution is acidic, basic, or neutral. Calculate the hydrogen ion concentration in the solution and the hydroxide ion concentration in the solution.

Data Table:

Solution	pH	Type of solution	$[H^+]$	$[OH^-]$

(Tap water, vinegar, pepsi, baking soda, windex, drain cleaner, coffee, milk, aspirin, tea, juice, baking powder, laundry detergent, toilet bowl cleaner, shampoo, alka seltzer or any household solution you choose.)

27. **Strong and Weak Electrolytes:** We have seen that strong acids and strong bases put a lot of ions in solution and are thus good conductors of electricity, while weak acids and weak bases put few ions in solution and are poor conductors of electricity. We can test the conductivity of a solution by using a diode conductivity tester. If the diode lights up brightly the solution contains a strong electrolyte and if the diode barely lights up, the solution contains a weak electrolyte. You will test all of the solutions from the pH of Household Items to determine if the solution is a strong or weak acid or base.
Materials: well plate, diode tester, small bottles of household solutions, beaker of distilled water, beaker of tap water.

Procedure:

1. Pour a small amount of one of the household liquids into one of the wells of the well plate. Pour a different liquid in each well.

2. Clean the wires of the diode tester in distilled water before placing the ends in the 1st well. Record your observations.
3. Before going to the 2nd well, clean the wires of the diode tester with tap water, then distilled water.
4. Clean the wires of the diode tester between each well.

Data Table:

Solution	Conductivity	Type of Electrolyte	Strong or Weak Acid or Base

28. **Titration of an Acid and a Base:** We have seen that when an acid solution and a basic solution are mixed tend to neutralize each other and form water. This neutralization process can be used to determine the concentration of an unknown acid by neutralizing it with a basic solution of known concentration. Likewise, the concentration of an unknown basic solution can be determined by neutralizing it with an acidic solution of known concentration. This laboratory process is known as titration. In this lab you will use a 0.4 M solution of NaOH to determine the concentration of an unknown HCl solution. Once you have determined the concentration of the HCl solution you will use it to determine the concentration of an unknown NaOH solution. As an indicator you will use phenolphthalein which is clear in an acid and pink in a base.

Procedure:

1. From the front lab table take an eye dropper, a graduated cylinder and a beaker. Add some distilled water to the beaker. Use the eyedropper to add exactly 10 mL of water to the graduated cylinder, counting the number of drops needed. Repeat 3 times and take an average of the number of drops. Produce a ratio to convert number of drops to mL.
2. Empty the beaker and dry it. Go to the front lab table and pick up a bottle of unknown HCl, a bottle of 0.4 M NaOH solution, and a bottle of phenolphthalein solution.
3. Use the eyedropper to add exactly 10 mL of 0.4 M NaOH solution to the beaker.
4. Add a drop or 2 of phenolphthalein to the beaker. The solution should turn pink or red.
5. Add drops of HCl solutions and carefully swirl the beaker to mix the solution. Count the number of drops of HCl added. Stop when the solution just turns clear. Record the number of drops used.
6. To be sure you have reached the neutralization point, one drop of base should turn the solution pink and one drop of acid should turn it back to clear.
7. Determine the volume of HCl needed by using your drops to mL ratio.
8. Find the concentration of the HCl solution using your titration equation:
    i. $V_b \times M_b \times \#OH^- = V_a \times M_a \times \#H^+$

Data Table:

Exact volume of NaOH

Drops of HCl
Volume of HCl
Molarity of HCl solution

9. Clean out the beaker. Repeat steps 3 – 8, replacing 0.4 M NaOH with the now known HCl solution. Pick up a bottle of unknown NaOH solution from the front lab table.

Data Table:

Exact volume of HCl
Drops of NaOH
Volume of NaOH
Molarity of NaOH solution

29. **Periodic Table:** In class, we have been looking at patterns and trends on the Periodic Table. We looked at trends in atomic radius, ion radius, ionization energy, electronegativity, and electron affinity. Earlier we looked at other properties of matter like the state of matter and properties of the states of matter.

Procedure: From the front table, you will pick up a packet of 40 cards containing information about the elements in series 2 through 6 on the Periodic Table. The elements will only be representative elements, those with s and p orbitals being filled. On each card you will find the following data.

1. Upper left hand corner is the elements state at room temperature.
2. Upper right hand corner is the elements electronegativity value.
3. Lower left hand corner is the elements melting point in degrees Celscius.
4. Lower right hand corner is the elements density in g/cm^3
5. In the middle is the symbol of the element or a Unknown #.

Your task is to arrange the known elements as they appear on the Periodic Table, then using the information on those cards and the information on the unknown element cards, place the unknown elements in the appropriate spaces and identify the unknown element in the chart below. Also provide your reasoning for your selection.
Data Table:

Unknown – is	Reasons for selection
1 -	
2 -	
3 -	
4 -	
5 -	
6 -	
7 –	
8 –	
9 –	
10 –	

30. Rates of Reaction: When alka-selzer is placed in water a fizzing reaction takes place. Alka-seltzer contains aspirin, citric acid, and sodium hydrogen carbonate. The sodium hydrogen carbonate in water decomposes forming carbon dioxide gas. In this lab you will measure the rate of the reaction by measuring the rate of change in the volume of a balloon.

Materials: Alka-seltzer tablets, 50 mL flask, balloon, stopwatch, thermometer, metric tape, graduated cylinder

Procedure;

5. Go to the front lab table to collected the needed materials. Measure out 30 mL of tap water and place it in the flask. Measure the temperature of the water.
6. Break one of the alka-seltzer tablets into 4 pieces and drop them into the balloon.
7. Stretch the top of the balloon over the mouth of the flask.
8. As you raise the balloon to allow the tablet pieces to drop into the flask, start the stop watch.
9. When the reaction ceases, stop the watch and quickly measure the circumference of the balloon. Record the time and circumference in a data table you created.
10. The volume of the balloon can be found by $V = 4/3\pi R^3$ where R = circumference/2π.
11. Find the rate of the reaction in terms of cm^3/s change in volume.
12. Empty the flask and clean. Go to the front table and measure out 30 mL of cold water and repeat steps 1-7.
13. Empty the flask and clean. Go to the front table and measure out 30 mL of hot water from the coffee maker and repeat steps 1-7.
14. In the space below, show your data table, your calculations and write a paragraph or 2 summarizing your results.

31. **Redox Reactions:** Substances that lose electrons during chemical reactions are said to be oxidized, the oxidation number increases. Substances that gain electrons during chemical reactions are said to be reduced, the oxidation number decreases. If one substance gains electrons, another substance must lose electrons, one cannot happen without the other. These types of reactions are called REDOX reactions.

Materials: matches, small bottles of $AgNO_3$, $Cu(NO_3)_2$, HCl, a few small pieces of mossy zinc, copper wire, shiny zinc, well plate, test tube.

Procedure:

1. For each reaction below, first write down your observations and what indicates that a chemical change has occurred.
2. Write a balanced Redox equation for this reaction, showing all of the steps we went over in class.

3. Identify what element has been oxidized and what element has been reduced.
4. All chemical solutions are in the small bottles on the front lab table.

Reaction #1: In a well of the well plate place 10 drops of $AgNO_3$. Add a small piece of copper wire. After 5 minutes, exam the copper wire.

1. Evidence of reaction:
2. Write a balanced redox equation for this reaction.
3. Element oxidized ____________
4. Element reduced _____________

Reaction #2: In a second well of the plate, place 10 drops of $Cu(NO_3)_2$ solution. Add a small piece of shiny zinc metal. After 5 minutes examine the zinc.

Reaction #3: Stand the test tube up in a beaker and add 5 mL of HCl solution. Then place a few small pieces of mossy zinc to the test tube.

Reaction #4: After 3 minutes, bring a lit match to the mouth of the test tube holding reaction #3.

32. **Half Life Lab:** Radioactive nuclei decay into more stable nuclei at a near constant rate. Every radioisotope has its own decay rate or half life. This half life value is often used in identifying unknown samples of radioactive materials. In this lab you will do simulation half life activity, then use data collected by high school physics class to determine the half life of a radioactive isotope of thorium.

Part I: Simulation

Take a box from the front lab table that contains 100 pennies. Turn all of the pennies heads up in the box. Record the 100 in data table under time period zero. Close the box and shake it several times, so the pennies will do several flips. Open the box and remove the pennies showing tails and count them as you remove them. In the data table, record the number of pennies remaining in the box. Close the box and shake again. Remove and count the pennies showing tails. Record the number of pennies left in the box. Repeat this procedure until there are no pennies left in the box. (There may be more or fewer columns in the data table needed.)

Replace the pennies in the box heads up and repeat the procedure, recording your data as trial 2. Replace the pennies in the box heads up and do trial 3. For each time period find the average value of pennies in the box.

Data Table:

Time Period	0	1	2	3	4	5	6	7	8	9	10
Trial 1											
Trial 2											
Trial 3											
Average											

Plot a graph of number of pennies left in the box (heads) vs the time period.

Questions:

1. What is the shape of the graph? What relationship is indicated by the graph?
2. Suppose each shake of the box represented 2 years, what percent of the pennies would be in the box after:

a. 8 years ________ b. 2 years _______ c. 4 years _______

3. Suppose each time period represented 5 days. How many days will it take to have

a. 50% left ______ b. 25% left _______ c. 12.5% left ______

Part II: Previous Data:

The following data was collected by a high school physics class using an isotope of thorium. A Geiger Counter was used to first count the background radiation. Then the radiation from the radioactive isotope was counted and the value recorded for every 30 second (0.5 minute) interval. The back ground count was subtracted from the radiation count for each time period.

Time	Counts	Time	Counts	Time	Counts	Time	Counts
0.5	263	4.5	120	8.0	75	11.5	30
1.0	251	5.0	111	8.5	52	12.0	25
1.5	242	5.5	81	9.0	31	12.5	25
2.0	211	6.0	94	9.5	42	13.0	31
2.5	196	6.5	76	10.0	60	13.5	22
3.0	176	7.0	72	10.5	27	14.0	20
3.5	165	7.5	64	11.0	38	14.5	25
4.0	159						

1. Plot a graph of the data with time on the x-axis and number of counts on the y-axis. When you have the points plotted draw in **a best fit line** (a smooth curve) through the points.
2. To determine the half life, select any count on the y-axis. From that point go horizontally over to the graph, then straight down vertically to the time line. Record this time as T_1. On the y-axis find the point that is ½ of your original selection. From that point, go horizontally over to the graph, then straight down vertically to the time line. Record this time as T_2. $T_2 - T_1$ should represent a half life.
3. Select a new starting point on the y-axis and repeat step 2 above.
4. Select a new starting point on the y-axis and repeat step 2 above.
5. You now have 3 values for the half life of the isotope, average these 3 values.

Trial 1 - $T_2 - T_1$ = ________ Trial 2 – $T_2 - T_1$ = _______ Trial 3 – $T_2 - T_1$ = _______

Average Isotope Half Life ______________