INDEPENDENT INQUIRY EXPERIMENTS

Introduction

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Purpose

- To give you added experience in the scientific method by involving you in the experimental design, as well as data collection and analysis you have previously experienced.

- To provide experience in presenting scientific research before a "peer" group, and defending your thesis by extemporaneous response to questions.

Background

Each of the suggested projects attached hereto will involve using the ***MicroLab*** interface to perform and analyze some aspect of marketplace products or some fundamental chemical relationship. OR, **if you decide to do a project of your own origin, the project will need to be approved by your instructor**. In either instance, you will need to decide what data to collect and how to report it. For this project, you will not be given detailed instructions as you were for the regular labs.

Format

You will need to decide how to accomplish the following:

1. Review each of the following experimental abstracts with your partner, then submit your project choice on a 3X5 card at least two (2) weeks before the experiment is scheduled to begin. First come first served on the choice of projects.
2. Follow the generalized protocol of what is commonly called the **Scientific Method**, which consists of five generally accepted steps as follows:
   a. Observation of some as yet unexplained phenomena
   b. Searching the literature and conducting preliminary experiments to obtain additional information.
   c. Formulating one or more hypotheses to explain the observation in terms of the literature of known information and the additional information gained through the preliminary experiments.
   d. Devising experiments to test the hypotheses in terms of the known facts.
   e. Accepting or rejecting the original hypotheses in light of the experiments undertaken.
3. You will then research the various aspects of the selected project, utilizing your textbook and other chemical sources. You might want to review the concepts contained in **Organizing the Research and It's Report**, obtained from the CD your instructor has, perform a **Research Design Analysis (RDA)** of your project, to determine an overall purpose for the project chosen, then to determine appropriate subpurposes that will divide the overall project into smaller

problems that lead to a solution of the problem. Lastly, you will need to design a set of experiments for each of these subpurposes that will provide the information necessary to solve the problem.

4. Formulate an **RDA** sheet after the format given in **Organizing the Research Report**, and complete the **Independent Projects Experiment Form** attached herewith, listing all of the information required there.

5. Bring both of these to a prelab conference with your instructor at least one (1) week before the date the experiments are to be carried out in the lab. If your instructor passes you on the RDA and the Experiment Form, you may then take the form to the storeroom to request the necessary equipment and supplies. **CAUTION: Please follow these instructions, or you may not be able to start your experiments on the day they are scheduled to begin.**

6. Determine how you will program the MicroLab to collect the necessary data in the computer.

7. Carry out the experiments to collect the necessary data. **NO UNAUTHORIZED EXPERIMENTS MAY B E CONDUCTED, UPON PENALTY OF AN "F"!**

8. Analyze the collected data in terms of the aspects requested in the brief set of instructions you will be given after you have chosen your project.

9. Write a report of all of your work, again following the format given in **Organizing the Research and Its Report**, which can be obtained from your instructor, and roughly sketched out below as well. **It is expected that you will have several references to published literature, e.g., textbooks, etc, in this written report!**

As part of this project you may be required to give a brief oral presentation to the whole lab class on your final results, with a possible time limit set by your instructor. You and your partner(s) must participate equally in this report, and you will be judged on how well you meet the time limit, and how equally each participates, as well as how you show your application of the scientific method to your problem. It is highly recommended that you practice this report several times before the presentation, which will be the last lab period of the semester. Two of the most common complaints about recent graduates are "Why can't they explain themselves verbally?", and, "Why can't they write a simple report?". These requirements are here to build a little practice with these skills into your science courses. **You are strongly encouraged to do a "Power Point" type of presentation, and to apply the principles discussed in "Organizing the Research and its Report" and "Giving Oral Reports," also available from your instructor.**

These projects will be worth more than a normal lab, as determined by your instructor, so it is worthwhile to put in extra preparation time.

REPORTS: The following sections should be included in your report for each of the subpurposes, then connecting them together as indicated in "**Organizing the Research and Its Report**." Grammar, spelling and neatness DO count! ! (Every word processing program has a spell checker these days, so USE IT!) **Each student must submit their own written report of their experiment.**

A. Purpose: This should be brief and in your own words, no more than two or three sentences.

B. Experimental Procedures, Measurements and Data: This must include a **BRIEF** discussion of what you did, and **ALL** the data that you used in calculations, discussion and conclusions. All data should be presented in tabular format, **NOT** descriptively in the body of the text. Spreadsheet graphs should be included here, numbered sequentially and referenced in your discussion. Your original observations made during the experiments should also be included here. If your ***MicroLab*** data table is more than 40 rows long, do **NOT** print it out for inclusion in your report, but summarize the important aspects of it graphically.

C. Data Analysis/Calculations: A sample of any of the calculations you did as you analyzed the data must be shown here. If a calculation was repeated several times the multiple results should be shown as a table, but the calculation only needs to be shown once. It is best to have a composite table with the raw data and the results all together.

D. Discussion/Conclusion: This section is important but need not be long. You should say what your results mean to you and mention any problems you had in carrying out the experiment. Whatever conclusion you arrive at, **MUST** be supported by **your** data, and you **MUST SHOW** how you arrived at your conclusion from your data! ! You should also discuss any discrepancies within the data, and any unusual observations.

E. References: Document any outside references you used in designing your experiment and preparing your report. You may use any book, journal or person as a reference. Failure to list references will have a severe effect on your grade.

SAFETY PRECAUTIONS

You will be responsible for determining all safety precautions for the special project you are conducting. If the MSDS sheets for what you need are not found in the laboratory, then you may request a copy of the appropriate sheets from the storeroom. **YOUR GROUP <u>MUST</u> REVIEW THESE SAFETY PRECAUTIONS, USING COPIES OF THE MSDS SHEETS, WITH THE INSTRUCTOR <u>BEFORE</u> YOU BEGIN ANY EXPERIMENTAL WORK.**

ERRORS

There are two general categories of errors that can affect the accuracy of experimental measurements, random errors and systematic errors. Random errors can come from mistakes, sloppy technique, lack of sensitivity in instruments or other sources. Regardless of source, random errors share the common characteristic of being unpredictable. If you occasionally misread a thermometer in a series of temperature measurements, there will be no discernable pattern in the magnitude or direction of the individual errors. Random errors are evaluated by taking repeated measurements and examining the variations among experimental values that, in principle, should all be the same. Errors that are truly random tend to cancel each other out when measurements are repeated many times and averaged. Statistical analysis is used in analyzing random errors in experimental measurements.

Systematic errors can arise from poor experimental design, from faulty or improperly calibrated instruments, from physical phenomena that effect experimental results in a way that cannot be directly measured or from other sources. Systematic errors result in biased measurements and they cannot be averaged out or evaluated statistically. If systematic errors are recognized and their sources can be identified and understood we can frequently "correct" measurements for systematic errors or eliminate the sources of such errors. We use measurements of known standards to identify and eliminate or correct for systematic errors. When you calibrate your laboratory temperature probes and pH electrodes, you use known standards to eliminate or minimize systematic errors in subsequent measurements with these instruments. If the temperature scale that is etched or painted on a thermometer is shifted from where it should be, measurements taken with that thermometer will be affected by systematic error. By using that thermometer to measure a known standard, e.g., the freezing point of pure water, we could recognize and quantify the systematic error and correct other temperature measurements by adding or subtracting the error.

INDIVIDUAL PROJECT DESCRIPTIONS

1. <u>Acid-Base Properties of Antacids:</u> You will titrate three different commercial antacids and compare their relative abilities to neutralize acid. The presence of aluminum in an antacid formulation poses some special problems in analysis, which you will look at but will not have to solve completely.

2. Acid-Base Properties of Buffered Aspirin: You will titrate three different brands of aspirin and buffered aspirin with both acid and base to determine their acidity and buffering capacity.

3. Acid-Base Properties of Some Common Household Products and Foods: You will test the pH of a number of common household products, and titrate liquid toilet bowl cleaners to determine their acid content.

4. Thermometric Determination of Ammonia in Household Cleaners: You will determine concentrations of ammonia in several household cleaners using two different methods to detect the endpoint of the reaction.

5. Determination of Phosphoric Acid Content in Colas: You will titrate two different colas to determine the content of phosphoric acid. This one requires some preparation because the carbonate has to be removed first.

6. Measuring Caloric Content of Snack Foods: You will "burn" a variety of snack foods to determine their "heat content" obtaining a measure of their caloric content.

7. Molar Enthalpies of Acid/Base Reactions: You will react three different acids with both NaOH and KOH to determine the molar enthalpies of reaction and compare them with the theoretical enthalpies obtained by thermodynamic calculations.

8. Molar Enthalpies of Solution: You will measure the amount of heat involved in the dissolution of three different salts and try to determine the origin of the energy changes.

9. Determination of a Mixture of Copper and Cobalt by Colorimetry: Using **the *MicroLab* Colorimeter Experiment**, you will obtain the visible spectra of a Cu^{2+} and Co^{3+} solutions, Choose the appropriate wavelengths for quantitative analysis of each compound, construct standard curves for each, then determine the concentration of an unknown containing both ions.

10. Identity of Group I Carbonate Samples: You will be given samples of Li_2CO_3, Na_2CO_3 and K_2CO_3 to identify by measuring CO_2 evolution by HCl addition. This has some interesting techniques.

11. Factors Affecting Freezing Point Depression in Water: You will explore the various factors which cause a decrease in the freezing point of water.

12. Penetrating Ability of Beta and Gamma Radiation: You will determine the penetrating ability of these radiations by stacking increasing numbers of cards, or aluminum or lead plates.

13. Colorimetric Determination of Phosphorous in Plant Food: You will determine the phosphorous content of three different plant foods by colorimetric analysis using a commercial analysis kit with the ***MicroLab* Colorimeter Experiment**.

14. Quantitative Determination of Vitamin C in Fruits and Vegetables: You will use N-bromosuccinimide as the titrant to analyze the vitamin C content of various fruits and vegetables.

15. Any other experiment that you are interested in exploring, as long as it meets the safety needs and is of interest to you in your further studies.