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# A Collection of Laboratory Activities

## Introduction

The activities included in this collection are the result of the authors' participation in Partnership for the Advancement of Chemical Technology (PACT) short courses. PACT is an industrial/ academic collaborative that is committed to creating a well-educated, chemistry-based technical workforce. In 1994, the National Science Foundation awarded PACT the first Model Project award through its Advanced Technological Education initiative (DUE-9454518).

Each of the activities in this collection (with the exception of a couple of unique contributions) is organized into three sections: introduction, student handouts, and instructor notes. As with any laboratory activity, we recommend that instructors perform the activities themselves before they involve their students. Summaries of the activities in this collection are provided below. The computer file names correspond with the activity numbers shown.

## 01 Polyacrylamide Slab Gel Electrophoresis of Proteins

**by Hassan Ahmad, University of Texas-Pan American, Edinburg, TX**

Electrophoresis involves the transport of charged molecules through a solvent in an electrical field. Many practical laboratory techniques have been developed to apply the principles of electrophoresis. Polyacrylamide gel electrophoresis (PAGE) is a powerful analytical technique used by biochemists and molecular and cell biologists to characterize and assay the purity of various biological macromolecules. The method is based on the principle that macromolecules can be separated according to their unique size and charge when placed in a gel matrix under an electrical field. In this experiment, the student will become familiar with one of the more popular versions; *the sodium dodecyl sulfate (SDS) PAGE.*

## 02 The Aspirin Shelf-Life Scenario

**by Gene Crabill, East Central High School, St. Leon, IN**

This quantitative exercise is designed to give students experience using the Spec-20 in determining species concentration. It also allows the students to determine if salicylic acid is present in commercial aspirin and the amount that may be present as the aspirin decomposes. In the lab, students determine the proper wavelength to use in checking for salicylic acid concentration. They also create a known concentration curve for the colored complex. The students also develop a long-term testing program involving the type of packaging material used for the aspirin and the possible environmental storage procedures the consumer may use and their effect on the shelf-life of the aspirin.

## 03 Laboratory Ventilation and Risk Assessment Exercise

**by John Cullen, Monroe Community College, Rochester, NY**

Students are presented with a scenario that requires them to decide if it is safe to do an experiment in which certain amounts of volatile organic solvents are vaporized in a particular laboratory room. They need to find the TLV data for the solvents under consideration from the MSDS (Material Safety Data Sheets) for the compounds which can be retrieved on the Internet.

They will also need to measure the volume of a laboratory room and the ventilation rate of the fume hoods in the laboratory.

## 04 Laboratory Safety Orientation

**by Mike Garlick, Delta College, University Center, MI**

As a laboratory manager, one of this author's primary concerns is safety training of his student employees, many of whom are pursuing careers in chemistry or chemical technology. It is very important to instill the proper safety habits and knowledge that will be required in professional laboratories. Nothing can replace hands-on or individual training, but time restrictions have led the author to require that the employees go through a web-based self-study course prior to active employment in the laboratory work area. The information presented here is the text that can be accessed at http://www.delta.edu/~slime/pact.html via the internet.

## 05 Color Me Analytical

**by John George, Bluffton High School, Bluffton, OH**

This lab is an introduction to colorimetry on two levels. First, the students learn how to physically manipulate the colorimeters (it should be noted that this lab presumes the students will already be familiar with the PCs and Vernier™ software). Secondly, the students start on a pathway of discovery to one of the most important principles in analytical chemistry: Beer's Law. The lab is inquiry-based, designed to be completed by the student one page at a time (i.e., students must check their answers for each page with the teacher before they receive the next page). The lab is designed for students to work cooperatively in teams of 3–4.

## 06 Investigating Plant Pigments: A Guided Inquiry Laboratory Experiment

**by Mary Graff, Amarillo College, Amarillo, TX**

This experiment includes traditional methods of laboratory instruction as well as guided inquiry. The first part of the experiment teaches basic laboratory techniques of column chromatography, including the packing of a column, sample application, elution methods, and variations of these techniques. This portion is presented in a routine method of directed work to be sure the students understand the basic premise of column chromatography. After the students have successfully completed Part I of the experiment, the method switches to discovery or guided inquiry. In Part II, the students will design an experiment to separate the components of a pre-prepared leaf extract. The students will be provided with a variety of packing materials, different solvents, and the necessary equipment. Four questions in Part II will prepare the students for the task of actually writing the procedure for this experiment. The questions include identifying the variables in the experiment, determining how to test the variables, testing the variables, and finally writing the experiment. Part III has been included to extend the experiment to detection and identification of the components separated in Part II. Depending on the equipment available to your students, this can be as basic as using the Spec 20, or as complex as FTIR and GC-MS. Part IV gives the entire class an opportunity to collaboratively write and test a procedure after completing the first three parts of the experiment.

## 07 Investigating a Sewage Lagoon

**by Jane King, West Virginia University-Parkersburg, Parkersburg, WV**

Sewage lagoon systems for treatment of wastewater, also called total containment ponds, are becoming an attractive, cost-effective alternative for single residences and small communities. A sewage lagoon system in a residential or small institutional setting usually consists of two ponds and a wetland area. Sewage is pumped into the first pond, where settling and some decomposition take place. Water flows through a pipe into a second pond where further

decomposition takes place. It then flows into a wetlands area. In very wet weather, the wetlands area discharges into a creek. Using kits such as those produced by Hach, CHEMets, and LaMotte, students can investigate various analytes such as dissolved oxygen, phosphates, ammonia, and nitrates. In addition, they can investigate conditions such as temperature and pH. By comparing differences among the three areas of the system and/or changes in the system over time, students can assess the condition, progression, and effectiveness of the system.

## 08 Spectroscopy as a Tool for Forensic Chemists

**by Diane Krone, Northern Highlands Regional High School, Allendale, NJ**

This hands-on unit will introduce students to atomic emission and absorption spectra. Chemistry students will "fingerprint" some elements and identify them in some common sources. They will then create spreadsheets to relate the Bohr model of the atom to the observed spectral lines of the hydrogen atom. Raman spectra are used to solve a forensic case study. Finally, students will examine a commercial application of photochemistry called the cyanotype process. This unit will strengthen the students' organizational and analytical thinking skills through the creation of spreadsheets and will involve the students in some practical applications of quantum chemistry.

## 09 Investigating the Relationship between the Mass of a Liquid and its Volume

**by Ken Lyle, St. John's School, Houston, TX**

Students fill a buret with one of five liquids, note the initial volume, and mass an empty beaker. They then deliver a portion of the liquid into the beaker, note the buret reading, and mass the beaker with the liquid. This process is repeated nine more times, adding the liquid to that which is already in the beaker. Students share data for all five liquids. Using a spreadsheet program, the students enter the data for each liquid, plot a graph of mass vs. volume for each liquid, and obtain the slope, y-intercept, and $R^2$ regression value for each line. The students then draw conclusions, answer questions, and form hypotheses based on the data and spreadsheet analysis.

## 10 Introduction to the Chemistry Lab: Safety Comes First

**by Sharyl Majorski, Central Michigan University, Mount Pleasant, MI**

One of the most important things that a chemistry instructor can teach students is how to handle themselves in a safe manner and how to react when and if an emergency should occur. Many students find learning a lot easier when they are actually obtaining the information on their own and through demonstrations rather than having someone simply tell them what they should and should not do. Discovery-based learning is an effective tool in educating safety. A safety unit was developed such that students will learn not only how to use the various safety devices in the laboratory, but also how to research the chemicals they will be working with prior to lab. Demonstrations prior to lab will further help students visualize the importance of safety.

## 11 Chromatographic Separation of Methylene Blue and Fluorescein

**by Phil McBride, Eastern Arizona College, Thatcher, AZ**

This lab has been modified from a common cookbook lab on column chromatography to be more of an inquiry-based lab on both thin-layer and column chromatography. The goal of the lab is to help students explore the roles of the stationary and mobile phases in chromatography. The students begin with a TLC lab in which they change the mobile phase and record the effects. They then do the same experiment using a column. The stationary phase is alumina (column) instead of silica gel (TLC). The students witness a reverse of the order in which the components are eluted. They must arrive at a hypothesis on why this happens. They are then given a real-life scenario problem in which they must figure out a method to separate methylene blue from

fluorescein with fluorescein being eluted first. They must choose the correct stationary phase and mobile phase to obtain the desired separation.

## 12 Using Bottled Water as a Problem Solving Exercise in Chemical Identification

**by Rusty Myers, Alaska Pacific University, Anchorage, AK**

In this exercise, students are divided into groups of two or three. The groups are given four unidentified bottled waters in unmarked containers and the chemical characteristics taken from the labels on the bottled waters. The students must devise and carry out a plan to match the water in the unmarked containers with the appropriate labels. This lab is appropriate after a discussion on water quality so that students have a basic knowledge of hardness, alkalinity, pH, metals, and nutrients found in unprocessed water. A typed proposal outlining the methods, chemicals, equipment, and instruments needed for analysis, with references, must be approved by the instructor before students analyze the samples. Students are coached on the appropriate methods without dictating exact procedures.

## 13 Chromatography Is a Gas: Inquiry-Based Introduction to Gas Chromatography

**by Cynthia Peck, Delta College, University Center, MI**

This chromatography exercise was designed to introduce students to the theory of chromatographic separation of mixtures and packed column chromatography. The students will become familiar with basic operation of the gas chromatograph and explore the relationship between temperature and retention time of individual components in a mixture. A section on instrument trouble-shooting may be included as an additional optional activity.

## 14 Experimenting with Copper(II) Solutions

**by Patricia Schroeder, Johnson County Community College, Overland Park, KS**

This experiment helps students determine that the relative concentration of copper ions in water can be determined by a color comparison. Students make a copper(II) sulfate solution of a given concentration. Students dilute their initial solutions until their solutions are colorless. Students work in groups of 3–4, comparing solutions to discover any relationship between color and concentration. A portion of each solution will be mixed with concentrated ammonia solution, forming a dark blue copper-ammonia complex. Students decide if the complex can be used to find the useful concentration of copper ions in a swimming pool water sample.

## 15 A Search for Automated Plastics Recycling Separation

**by Paul Schumm, Ayersville High School, Defiance, OH**

Recycling efforts of recent years have been hampered by the high cost of manually separating the materials. This is particularly true of plastics. Students will be challenged to investigate the physical and chemical properties of plastics and use these properties to design a system that could be used to separate them. First-year chemistry students were steered in the direction of using density for separation. They were directed to use information gathered from handbooks and the Internet to prepare a series of solutions with different densities which could be used to separate the plastics. A flow chart was developed to describe and outline this process. Second-year chemistry students were given the problem during a study of infrared spectroscopy. During discussion they were directed to search for absorption peaks unique to each plastic. Again a flow chart was used to summarize the process design. Third-year chemistry students with some limited experience in chemical instrumentation were given the problem as an independent study.

## 16 Separation Science Lab: An Inquiry-Based Lab

**by Kim Segar, Normandale Community College, Bloomington, MN and Karen Sanchez, Florida Community College, Jacksonville, FL**

In this inquiry-based experiment the students are put in the role of a method development chemist. The scenario they are given is that a train wreck has occurred which resulted in a chemical spill. They are told that the spill mixture consists of three substances: a proprietary chemical called CARBOSE (simply sodium chloride), naphthalene, and sand from the dry Florida riverbed where the accident took place. The students work in teams of 2–3 and the team's task is to design a method to separate the three components of the mixture in the most efficient, cost-effective manner possible. In addition, their method must allow them to recover the CARBOSE in the solid form. The lab is divided into three parts and should be spread out over two lab periods to allow students time to collect data and reflect on questions.

## 17 Determining the Accuracy of Selected Laboratory Glassware

**by Duane Sell, William Rainey Harper College, Palatine, IL**

Students determine the accuracy of several pieces of laboratory volumetric glassware while learning to use pipettes and bulbs, burets, and top-loading balances. Through their calculations they experience the relationships between mass, volume, and density and determine the actual volumes contained by the various pieces of glassware. Students will need to determine the density of water based on the temperature of the water they use for this experiment. The ultimate goal is to have students recognize what pieces of glassware to use to obtain the best accuracy and when they should use this glassware. This experiment is a good introduction to the chemistry laboratory and some of the glassware that is commonly used.

## 18 Gas Chromatography: Introduction and Application

**by Patricia Sharp, Libertyville High School, Libertyville, IL**

This laboratory exercise introduces students to gas chromatography using a discovery-based approach. The student is presented with a scenario/industrial application where their job is to verify that the company's mouthwash contains a specific percentage of ethanol. They must discover that ethanol can be detected by gas chromatography and that peak height can be related to percentage of ethanol. This requires preparation of standard ethanol solutions. A batch of mouthwash is then suspected of isopropyl alcohol contamination and the student must develop a method to determine whether there is contamination. The technique of indirect determination by a standard addition method is introduced here.

## 19 Analysis of the Sugars in Soft Drinks

**by Marie Sherman, Ursuline Academy, St. Louis, MO**

Why analyze the sugars in soft drinks? "Sugar" is a loosely used term, which can mean many distinctly different chemicals. Labels on soft drink cans and bottles are a good example of this murky terminology—"high fructose corn syrup and/or sugar."

## 20 Introduction to the Mole

**by Golda Steiner, Park Ridge High School, Park Ridge, NJ**

This unit uses a discovery-based method to introduce the mole concept without relying on students' strong background. The lessons contain activities with candy that lead students to develop the rules for mole-item, item-mole, mole-mass, and mass-mole "conversions." Experiences that engage different types of learners are utilized to reinforce the concepts. The unit provides students with opportunities to make the connection between the mole concept and

familiar counting units, such as a dozen, and apply the concept of the mole to measuring out a given quantity of a substance.

## 21 Factors Affecting the Nitrogen Cycle in a Freshwater Aquarium

**by Don Storer, Southern State Community College, Hillsboro, OH**

In this experiment, each student is assigned the task of designing an experiment to evaluate the effects of various treatments on the nitrogen cycle in a freshwater aquarium. The students are required to maintain a laboratory notebook of all work, measure the key analytes of the bio-system at periodic intervals, analyze and interpret data through appropriate tables and graphs, and write a formal report at the end of the term. The students set up the experiment using small goldfish bowls and incorporate some treatment, for example, a freshwater plant. This arrangement might have a bowl with fish only, one with a plant only, one with fish plus plant, and one with neither plant nor fish. A variety of techniques for analyzing for nitrate and ammonia are included depending on the time available and level of sophistication desired. Since nitrite is typically not observed in this experiment, a technique for its determination is not included.

## 22 DNA on a Stick

**by Charlotte St. Romain, Carencro High School, Lafayette, LA**

What is the chemical basis of life? What kind of chemical is DNA? The first step in the genetic manipulations involved in biotechnology is the isolation of DNA. This project describes one method of chromosomal DNA isolation with minimum breaks. There are several basic steps in DNA extraction. The cell must first be lysed (broken open) to release the nucleus. The nucleus must also be opened to release the DNA. At this point the DNA must be protected from enzymes that will degrade it, causing shearing. Once the DNA is released, it must then be precipitated in alcohol.

## 23 A Five-Module, Discovery-Based Unit to Teach Separation Science in a High School Chemistry Class

**by Dick Trent, Elk Grove High School, Elk Grove Village, IL**

There are several methods of separating and identifying compounds. These techniques range from the simple paper chromatography to thin-layer chromatography (TLC) to gas chromatography to distillation to high performance liquid chromatography (HPLC) to the newest super critical fluid chromatography. A scientist would choose a separation technique based on the substances to be separated and the desired quantitative accuracy. Coupled with the separation must be a detection technique to observe and identify the separated fractions. These detection techniques range from visual colorimetric identification to spectrophotometric identification to mass spectrophotometric identification. The choice of detection technique depends on the separation technique.

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