SCHOLARSHIPS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (S-STEM)

CHEM 285

(DIRECTED STUDY)

SUMMER 2015

General Course Information

Start Date: 6/15/2015 End Date: 7/24/2015
Class Days/Times: Fridays 9:35 am – 11:40 am + Lab Hours
Sites/Rooms: MSA 403 and MSA 405 Teaching Format: Integrated Lecture/Lab

Open Lab Hours: M-Th 1:00 pm – 3:00 pm. Check-in and Check-out hours will be documented

Credit Hours: 2.0

Instructor: Dr. Abraha Bahta **Office:** MSB 231/233 **E-mail:** bahtaa@wlac.edu

There is ***no required Textbook***. Reading materials pertaining to the topics that would be covered will be made available or links will be provided for materials available on the web.

Course description:

The course will involve hands-on activities in the laboratory on selective topics in chemistry. Various analytical methodologies (both wet chemistry and instrumentation) are utilized for scientific investigations. The emphasis shall be on the chemistry of the environment; the areas to be covered include air and water pollution, as well as environmental issues such as the ozone layer, climate change, and acid rain.

Recording and Reporting Results:

- A **laboratory notebook** for this course will be provided to you at no cost. It is a bound notebook, and starting on the 4th sheet, the pages should be numbered consecutively for easy reference. The notebook is a day-to-day record of your activities in the laboratory.
- There is no formal examination for this course, but you will be required to:

- submit your laboratory notebook on July 26, 2015
- You shall produce written Laboratory reports for every project undertaken

Course Objectives:

Develop and employ basic scientific knowledge in research.

Develop specific capabilities working outside the classroom.

Employ methodologies (wet and instrumental) to carry out projects related to chemistry.

Besides chemistry, you would be learning:

- How to learn
- Listening and oral communication
- Competence in reading, writing and computation
- Adaptability based on creative thinking and problem solving
- Group effectiveness characterized by interpersonal skills and teamwork

Institutional SLOs:

1 .Critical Thinking: Analyze problems by differentiating fact from opinions, using evidence, and using sound reasoning to specify multiple solutions and their consequences.

2. Quantitative Reasoning: Identify, analyze, and solve problems that are quantitative in nature.

3. Technical Competence: Utilize the appropriate technology effectively for informational, academic, personal, and professional needs.

Course SLO

1. Discuss and examine topics not normally offered as a formal class in chemistry.

2. Demonstrate a degree of competency via readings, discussions, and/or experimentation in the area of chemistry in which the course is offered.

3. Research the appropriate journals to write professionally in the topic(s) of interest.

4. Master the instrumentation and laboratory skills required for the subject level.

Program SLOs:

- Utilize an appropriate and effective scientific methodology to analyze chemical and physical processes in the work place and in everyday living.
- Explain and analyze the chemical world –as chemistry is the basic science with connections to many careers.
- Research and interpret scientific literature.
- Student lab notebooks that summarize background research/observations leading to hypothesis development are submitted.
- Students are expected to present, justify and record in lab notebooks their choice of methods and rationale for instructor review.

Laboratory Safety on the Web: Dow Chemical has introduced video library of *'**Best Practices**'*. It includes a comprehensive set of training videos and additional resources. They are available at ***safety.dow.com***. This website incorporates 30 professionally produced videos. Please make frequent visits to this site.

THE PROJECTS

I. Extension of the Global Chemistry Experiment: "Water: A Chemical Solution"

II. Absorption Spectrum of Metallic ions: Co^{2+},

III. Chemical Kinetics of a Clock Reaction

IV. A 10-minute presentation on July 24, the last Friday of Summer Session, from your choice of a selection of stories from the six online Topical News Channels cited in C&EN's weekly magazine (will issue separate listing for your selection)

I. "Water: A Chemical Solution"

Introduction

Throughout history, the quality and quantity of water available to humans have been vital factors in determining our well-being. Whole civilizations have disappeared because of water shortages resulting from changes in climate. Droughts in Africa during the 1980's as well as in the past few years have had catastrophic crop failures and starvation. In California, the Governor has declared that our State is suffering from epic drought and the National Oceanic and Atmospheric Administration projects the drought to get worse. Around the world millions of people lack access to clean drinking water resulting from human pollution as well as climate change and it up to a new generation of scientists to fix this problem.

Waterborne diseases, such as cholera, and typhoid, have killed and continue to kill millions, particularly in less-developed countries in which a high percentage of diseases are waterborne. However, even in the United States a great deal of our watersheds of become contaminated due to industrial pollution. Problems with water-supply quantity and quality are becoming more serious, largely due to population growth, contamination of drinking water by improperly discarding hazardous waste, and poisoning of wildlife by water pollutants. A United Nations report (1997) warns of a global shortage of water.

In 2011, the Global Water Experiment (GWE) was initiated by the International Union of Pure and Applied Chemistry (IUPAC) and of the United Nations Educational, Scientific and Cultural Organization (UNESCO). The experiments were designed to further student's knowledge and appreciation for chemistry while working on key issues such as water quality and purification. The data gathered from around the world provides scientists with crucial data which is needed to meet the Millennium Development Goal of improving access to safe drinking water before 2015. It is decided that the STEM scholars at West Los Angeles College (WLAC) will also conduct these experiments along with two other water related experiments to understand how we may test a watershed for its health. The GWE experiments were conducted using the procedures and guidelines put forth by the GWE whereas the other two experiments have strict guidelines that must be followed.

Distribution of Water

The total amount of water on Earth is about 1.4 billion cubic kilometers (1.4×10^9 km^3). 97.5 % of this water is found in the ocean. Only 2.5% of the world's water is fresh and of that fresh water 70% of it is contained in the solid state as ice, snowpack, glaciers, permafrost and the polar ice caps. 29.7% of the planet's fresh water is found in underground aquifers. Surface water is found in lakes, streams and reservoirs and accounts for .3% of all the fresh water.

The importance of water cannot be overemphasized! It boils at 100^{o}C and freezes at 0^{o}C, and at room temperature (25), water is a colorless, tasteless, odorless liquid. Water is essential to life on Earth. One of water's unique characteristics is that it is an excellent solvent for a variety of chemical materials (acids, bases, and salts), in that it transports nutrients and waste products, making biological processes possible in aqueous medium. Furthermore, water molecules absorb heat allow us to enjoy the climate that we do on the blue planet. This is the reason why it is typically cooler by the ocean in the summer and warmer by the ocean in the winter. However, most of the world's water is highly contaminated by human activity. Thus, the role chemistry plays in issues of water quality and purification is significant as we are realizing that fresh water is a limited resource it is with this backdrop that we carried out the following experiments:

Following protocols established by the GWE, the students must measure:

- the pH, Salinity and Conductivity of water samples from local natural resources and compare them with data gathered by students from across the globe.
- Alkalinity of a Water resource.
- The following background were given to them:

Background to the pH Activity

pH measurements is one of the most common tests performed on water. This is due to the fact that pH of a body of water is an indication of the quality of that water, both for aquatic systems living in the water as well as for human consumption.

All creatures can only tolerate a certain level of acidity and therefore function within a particular pH range. For example, if the ocean becomes too acidic than the marine life which use calcium carbonate for their exoskeletons will die due to the reaction between these molecules.

Humans can only drink water that is in specific pH range. We know that the pH of water is greatly affected by many external factors---dumping chemicals by individuals or industries, pollutants such as sulfur dioxide from automobiles and coal power station emissions produce acid rain that can drastically reduce the pH of streams and rivers---- acidic water can interact with metals and other chemicals that can contaminate our water resources. Thus, pH is a critical factor when monitoring the health of a body of water.

Background to the Salty Waters Activity

Water acts as an excellent solvent for a variety of chemical materials (acids, bases, and salts), leading to the formation of aqueous solutions of different composition and therefore waters of various qualities. The water in the Pacific ocean is roughly 3% salt whereas most fresh water bodies are less than 1% salt. Most organisms will die by desiccation via osmosis if the water becomes too saturated with salt. Although marine animals have evolved in a salty environment, the mechanisms which they use to get rid of excess salt will not be able to function in an extremely salty environment.

Background to the Measurement of Conductivity of Aqueous Solutions

The conductivities of solutions will allow you to distinguish between strong electrolytes, weak electrolytes and nonelectrolytes. The magnitude of the conductance depends on the concentration of the ions and on their type. Pure H_2O does not have a conductive charge and therefore the conductivity of it cannot be measured. However, all water sources found in nature have minerals and salts dissolved within them. Therefore, one can test the concentration of ions by checking the conductivity of the water.

Background to the Alkalinity of a Water resource

The ability of water to accept protons is called alkalinity. Two levels of alkalinity in a water sample are to be addressed depending on sample source. Alkalinity is important in water treatment and in the chemistry and biology of natural waters. The source of alkalinity is primarily from water passing over (surface water) or through (underground aquifers) limestone (calcium carbonate) deposits. The alkalinity of the water is a good indication of how well the water can absorb acid without becoming acidic itself. This is very important as human activity have acidified our oceans and watersheds. Thus, the alkalinity of water must be known to make a determination of the quantities of chemicals to be added in treating the water.

Background to the determination of $NaClO^-$ in Bleach

Sodium hypochlorite is the active ingredient in commercially purchase bleaches. This is an exercise to experimentally determine the % of bleach and compare with the chlorox values in the original bottle. The EPA put forth a standard range on what the concentration of sodium hypochlorite should be in bleach. This standard is from 6-8 percent of the overall solution. The reason behind this standard is due to the fact that many people around the world use bleach as a disinfectant. Therefore, if the bleach is too dilute it will not be strong enough to kill microbes. However, if the bleach is too concentrated this could have the opposite effect and kill the person consuming the water. You are encouraged to write to US EPA about the controversial protocol that was published by the Agency on use of bleach as disinfectant.

II. Spectrophotometric Determination of the Absorbance of metallic solutions

Handouts for this project to be distributed in class.

III. Chemical Kinetics of a Clock Reaction Project

In this investigation, the experiments involve the study of the rate properties of the reaction between iodide ion, and hydrogen peroxide under acidic conditions (1).

$$3I^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow I_3^-(aq) + 2H_2O(1) \quad (1)$$

The kinetics of the reaction: $H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$ is studied by the introduction of a small and fixed amount of $S_2O_3^{2-}$(aq)and starch indicator. The thiosulfate is used to interact with the I_2 product, thus, creating a clock reaction that parallels with the time elapsed (color change) to produce a necessary amount of I_2. By using different mixtures of the reactants and measuring the time that would take for each solution to turn blue, the dependence of the reaction rate with respect to each reactant concentration (order) is measured. The temperature dependence of the reaction rate is also investigated and the activation energy for the reaction system determined.

The study of chemical reaction rates and the mechanism pathways by which reactants are converted to products is the field of chemistry known as chemical kinetics. Reaction rates measure the change in concentration of a reactant (or product) per unit time. Often a change in a physical property, such as color, is one of the ways to monitor the change in reactant concentrations takes a simple form known as the rate law:

$$\text{Rate} = k[A]^x[B]^y[C]^z$$

Where k is the rate constant and x, y, and z are the orders of the reaction with respect to each reactant. The overall order is the sum of x, y and z. Typically, x, y and z are whole numbers. The rate law parameters k, x, y and z must be determined experimentally. The effect of temperature on the rate of the reaction will also be determined. The relationship between temperature T (Kelvin units) and the rate constant is given by the Arrhenius equation:

$$K = Ae^{Ea/RT}$$

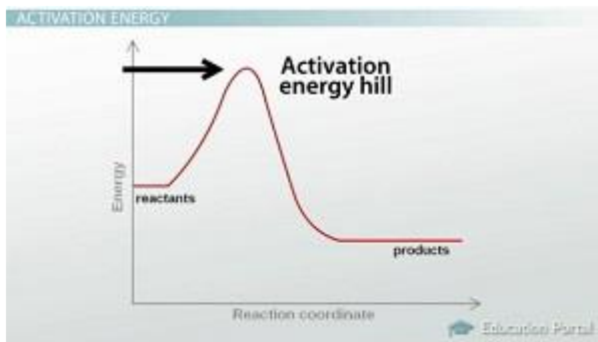
A = frequency factor

e = natural logarithm

E_a= activation energy

R = universal gas constant = 8.314 J/mol.K

By measuring the rate constant of a chemical reaction at different temperatures, we can calculate the activation energy for the reaction system.



The activation energy is important to know because it tells us how much energy a reaction requires in order to occur. A certain amount of energy must be provided, or a reaction will not make it over the activation energy barrier.

Typically, concentrations are expressed in units of molarity (M) and the rate constant has the units that yield rate in units of molarity per unit time; activation energy is expressed in Joules per mol per Kelvin.

The Investigation:

Determine the rate law as well as the activation energy and the pre-exponential factor for the reaction between hydrogen peroxide and iodide in an acidic environment.

When hydrogen peroxide is added to a solution of iodide (in acidic medium), the iodide ions are slowly oxidized according to the equation:

$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$ .... (1) [main reaction]

The rate law for this reaction should include the concentrations of iodide, hydrogen ion and hydrogen peroxide:

$$Rate = k[H_2O_2]^x[I^-]^y[H^+]^z$$

Monitoring the rate of the reaction:

Part 1. Determination of the rate law

Because reaction (1) has no visible sign of compeletion, eg color change, we employ a secondary reaction that involves color change. We do this by adding a small and known amount of thiosulfate. The thiosulfate does not react with any of the reactants to any degree of significance; however it does react very rapidly with the iodine (I_2) produced in reaction (1) according to the equation:

$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$ ....(2) [*monitor reaction*]

As the iodine produced by reaction (1) forms, it is instantaneously consumed by the thiosulfate ion. When the small quantity thiosulfate in the reaction mixture is consumed, iodine molecules will accumulate and form in intense blue colored complex with the starch, according to the equation:

Starch solution + $I_2(aq) \rightarrow$ blue complex ....(3) [*indicator reaction*]

By noting the time required for the appearance of the starch-iodine complex, after mixing the reactants, the rate of the reaction can be established. In this experiment the rate is expressed as the rate of formation of iodine (2) in units of mol L^{-1} s^{-1}.

The concentration of thiosulfate ion used to measure the reaction rate is very small compared to the initial concentrations of the reactants. Therefore, we can assume that the concentrations of the reactants remain essentially constant during the reaction time period.

Thus, at the start of the reaction, zero moles of I_2 are present. At the instant the blue color appears, a stoichiometric amount of iodine has formed and reacted. To calculate the moles of I_2 that reacted with the thiosulfate, the following stoichiometric calculation is performed:

moles I_2 reacted = moles $S_2O_3^{2-}$(1 mol I_2/2 mol $S_2O_3^{2-}$)

The change in concentration of I_2 is obtained by dividing the moles of iodine reacted by the total volume of the reaction mixture in units of liters. By dividing this value by the time it took for the blue color to appear, we measure and record the rate of every kinetic run

Experimental part 1: determining the values of x, y, z and k from the rate law, at 25 degrees Celsius.

Experimental:

Each chemist took chemicals from the stock room, and prepared their own potassium iodide solution to be used in the experiment. Five trials were carried out by each student. The rate was measured by observing the change in color of the solution in the reaction vessel from clear to dark blue. The rate was determined by dividing the change in concentration of peroxide, which was $2.0\times 10^{-3}M$ divided by the time it took for the solution to change to blue.

Table 1.1 contains the tabulated rates. From this table of data the values for the orders with respect to each reactant were determined using Equation 1. These results are found in the results section of this paper. The k values are calculated using Equation 2, and are tabulated in.

Part Two: determination of activation energy and frequency factor from the Arrhenius equation.

Carry out four reactions at different temperatures, the rates of these reactions are recorded and the k values determined. Equation 3 is used to determine the activation energy, and Equation 4 is used to determine the value of the frequency factor. From the tabulated data the values of –ln(k) vs. 1/Temperature are graphed, and the slope of the line of best fit is used to calculate the activation energy as the slope of this line is equal to Ea/RT. Graph Two shows the graph of-ln(k) vs. 1/Temperature using the group data.

EQUIPMENT NEEDS OF THESE PROJECTS

pH meter to test pH

Evaporating Dish for Salinity

Conductivity; conductivity meter

Spec -20 for Absorption

Burets and pipets for volumetric and titration measurements