Institutional Effectiveness Report

Name of Program/Department:	**Chemistry**
Year:	**2016-2017**
Name of Preparer:	**Pete Peterson** **(Department Chair and IE Coordinator)**

Program Mission Statement

The mission of the Chemistry Department is to offer a dynamic and inquiry based curriculum in chemistry that provides knowledge and skills needed for students to be successful in their professional and life-long endeavors. Accordingly, the department offers introductory, foundation, and in-depth chemistry courses that satisfy requirements in liberal arts, pre-professional programs, the basic chemistry degree, and the American Chemical Society approved degree. The department strongly encourages undergraduate research and networking within the scientific community.

Program Learning Outcomes (PLOs)

Graduates with a Chemistry degree from Francis Marion University will:

PLO #1 – Demonstrate that they have the chemical knowledge and skills needed that will allow them to communicate modern chemistry effectively in both oral and written form.

PLO #2 – Demonstrate that they can think critically to solve chemical problems.

PLO #3 – Demonstrate an understanding of core chemical concepts, methods and limits of scientific inquiry that will allow them to successfully solve complex problems in chemistry.

PLO #4 – Demonstrate that they can adequately apply their chemical knowledge.

PLO #5- Demonstrate that they can adequately use the scientific literature.

PLO #6 - Demonstrate an understanding of safe laboratory practices and procedures.

Executive Summary of Report

Presented in this report are the Chemistry Department's Mission, Program and Student Learning Outcomes, the assessment and results of each, and action items for academic year 2016-2017. Achievement of our senior Chemistry majors in chemical concept knowledge, critical thinking, communication skills, and chemical safety were assessed with Capstone writing assignments, the ACS *Diagnostic of Undergraduate Chemical Knowledge* (**DUCK**) Exam, a chemical term paper with an associated oral presentation, and a laboratory safety exam.

89% of students in the Chemistry Senior Capstone course performed at or above the pass threshold on the capstone writing assignments (Attachment III) that assess their understanding of key chemical concepts as measured by four (4) writing assignments administered over the course of the semester and measured by a departmentally developed rubric. Our goal was 80% for this (SLO # 1). Therefore, our target was achieved.

Students in the Chemistry 499 Senior Capstone course also demonstrated their understanding of chemical concepts by scoring at the 23.00 Percentile, on average on the ACS Diagnostic of Undergraduate Chemical Knowledge (DUCK) exam (SLO #2). One student, which represents 11.11% of the group, was at or above the target of the 50th Percentile. However, our target of the 50th Percentile for 80% of capstone students for SLO # 2 was not achieved.

Students in Chemistry 499 Senior Capstone, on average, performed at the 80.22% and 82.24% levels when demonstrating competency in presenting technical information via written (SLO #3) and oral communications (SLO #4), respectively. Our targets for SLO's # 3 was 80.00% and for SLO #4 was 80.00%. Therefore, our target was achieved for both.

All students passing Organic Chemistry 201, a course all chemistry majors must pass, demonstrated an understanding of laboratory safety procedures at the 70% level or above. Our goal for this SLO (# 5) was 70%. Therefore, our target was achieved.

To address concerns identified in the evaluation of data from this academic year (2016-2017), the Chemistry Department developed an action plan to be implemented during the 2017-2018 academic year. Even though the target was met for all SLO's with the exception of SLO #2, we will improve and extend our existing SLO strategies. With this goal in mind, the Chemistry Department will continue to develop an online SLO component of the Capstone course. The online component will serve as an early intervention tool that will allow chemistry majors to access rubrics (Attachments I and II), sample materials, and practice exams at any time during their course of study. This material will help them begin to develop critical skills well before they enroll in the senior capstone course. The availability of this material will be communicated to all chemistry majors through their advisors and the capstone instructor.

Student Learning Outcomes (SLOs)

SLO# 1.0: 80% of students in the Chemistry Senior Capstone course perform at or above the pass threshold on the capstone writing assignments (Attachment III) that assess their understanding of key chemical concepts.

SLO# 2.0: 80% of graduating Chemistry students will, on average, perform at the 50th percentile or above when demonstrating their understanding of integrated chemical concepts based on their performance on a nationally standardize chemistry exam.

SLO #3.0: Students in the Chemistry Senior Capstone course, on average, will perform at the 80% level or above when demonstrating competency in presenting technical information through written communication.

SLO #4.0: Students in the Chemistry Senior Capstone course, on average, will perform at the 80% level or above when demonstrating competency in presenting technical information through oral communication.

SLO #5.0: 100% of students enrolled in Chemistry 201 will demonstrate an Understanding of laboratory safety procedures at the 70% level or above.

Assessment Methods

SLO # 1.0: 80% of students in the Chemistry Senior Capstone course perform at or above the pass threshold on the capstone writing assignments (Attachment III) that assess their understanding of key chemical concepts as measured by four (4) writing assignments administered over the course of the semester and measured by a departmentally developed rubric.

Assessment Method SLO# 1.0: Four writing assignments (Attachment III) were administered throughout the course of the senor Chem 499 Capstone course during the spring of 2017. The assignments were graded on a pass/fail basis. A passing grade was assigned if the student presented adequate knowledge of the chemical concept tested. Otherwise, a grade of fail was assign.

SLO # 2.0: 80% of graduating Chemistry students will, on average, perform at the 50th percentile or above when demonstrating their understanding of integrated chemical concepts based on their performance on a nationally standardize chemistry exam.

Assessment Method SLO# 2.0: Graduating Chemistry students were administered the *Diagnostic of Undergraduate Chemical Knowledge* (**DUCK**) exam, a standardized exam that is produced by the American Chemical Society (ACS). The DUCK contains multiple choice questions that cover the core areas of chemistry - organic, inorganic, analytical, physical, and biochemistry. Students are presented with chemistry scenarios and are then asked to answer a series of questions relating to them.

SLO #3.0: Students in the Chemistry Senior Capstone course, on average, will perform at the 80% level or above when demonstrating competency in presenting technical information through written communication.

Assessment Method SLO# 3.0: To assess their written communications skills, each student in the Chemistry Senior Capstone course wrote a term paper based on a faculty approved technical chemistry topic the student selected. Each paper was graded by the Capstone instructor using a standard, department generated grading rubric (Attachment I) for scientific term papers, and the scores were averaged.

SLO #4.0: Students in the Chemistry Senior Capstone course, on average, will perform at the 80% level or above when demonstrating competency in presenting technical information through oral communication.

Assessment Method SLO# 4.0: To assess their oral communications skills, each student in the Chemistry Senior Capstone delivered an oral presentation on the same chemistry topic as their written topic, which is described in SLO 3.0. Each presentation was graded by all of the available chemistry instructors using a standard, department generated grading rubric (Attachment II) for scientific term papers.

SLO # 5.0: 100% of students enrolled in Chemistry 201 will demonstrate an understanding of laboratory safety procedures at the 70% level or above.

Assessment Method SLO# 5.0: All students enrolled in Organic Chemistry 201, a foundation course that is required for all chemistry majors, are taught a lab module on chemical safety during the first couple of weeks of the course. This is followed by their taking a comprehensive and cumulative lab safety exam that is produced and administered by the Chemistry Department. To remain in the course, a score of at least 70% on the safety exam is typically required.

Assessment Results

SLO# 1.0: 80% of students in the Chemistry Senior Capstone course would perform at or above the pass threshold on the capstone writing assignments (Attachment III) that assess their understanding of key chemical concepts as measured by four (4) writing assignments administered over the course of the semester and measured by a departmentally developed rubric.

Assessment Results for SLO# 1.0: 89% of students in the Chemistry Senior Capstone course performed at or above the pass threshold on the capstone writing assignments (Attachment III) that assess their understanding of key chemical concepts as measured by four (4) writing assignments administered over the course of the semester and measured by a departmentally developed rubric. Our target of 80% for SLO # 1 was therefore achieved, and it surpassed last year's results by 21%.

SLO# 2.0: 80% of graduating Chemistry students will, on average, perform at the 50th percentile or above when demonstrating their understanding of integrated chemical concepts based on their performance on a nationally standardize chemistry exam.

Assessment Results for SLO# 2.0: On average, graduating FMU chemistry majors scored at the 23.00 Percentile mark on the DUCK exam for the 2016-2017 academic year, surpassing the 16.43 Percentile level achieved for the previous 2015-2016 academic year by 7.71%. Five out of the nine students enrolled in the 2016-2017 capstone course exceeded the 2015-2016 mark. One student out of the 9 (11.11%) scored at or above the 50^{th} Percentile. Our target for 80.00% of the students at or above the 50th Percentile for SLO # 2.0 was therefore not achieved.

SLO #3.0: Students in the Chemistry Senior Capstone course, on average, will perform at the 80% level or above when demonstrating competency in presenting technical information through written communication in the form of a chemistry term paper.

Assessment Results for SLO# 3.0: Students in 499 Chemistry Senior Capstone, on average, performed at the 80.22% level on their chemistry term paper as graded by the Chemistry 499 Capstone instructor using a standard scientific term paper rubric (Attachment I). Our target for SLO # 3 was 80.00%. Therefore, our target was achieved.

SLO #4.0: Students in the Chemistry Senior Capstone course, on average, will perform at the 80% level or above when demonstrating competency in presenting technical information through oral communication.

Assessment Results for SLO# 4.0: Students in 499 Chemistry Senior Capstone, on average, performed at the 82.24% level on their chemistry oral presentation as graded by the chemistry faculty using a standard scientific, department generated rubric. Our target for SLO # 3 was 80.00%. Therefore, our target was achieved.

SLO #5.0: 100% of students enrolled in Chemistry 201 will demonstrate an Understanding of laboratory safety procedures at the 70% level or above.

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Assessment Results for SLO# 5.0: 100% of students enrolled in Chemistry 201 demonstrated an Understanding of laboratory safety procedures at the 70% level or above as measured by a cumulative exam on laboratory safety. Our target for SLO # 4 was 70% for all students in the course. Therefore, our target was achieved.

Action Items

SLO# 1.0: 89% of students in the Chemistry Senior Capstone course performed at or above the pass threshold on the capstone writing assignments (Attachment III) that assess their understanding of key chemical concepts as measured by four (4) writing assignments administered over the course of the semester and measured by a departmentally developed rubric. Our target of 80% for SLO # 1 was therefore achieved, and it surpassed last year's results by 21%.

Action Items for SLO#1.0: Even though the target was met, the Department decided to explore ways to improve student outcomes for SLO#1.0. We will continue to infuse more inquiry based learning into the curriculum and to better communicate high expectations to students.

SLO# 2.0: Graduating students demonstrated their understanding of Chemical concepts by scoring at the 23rd Percentile, on average on the ACS Diagnostic of Undergraduate Chemical Knowledge (DUCK) exam. Our target was for the 50th Percentile for SLO # 2. Therefore, our target was not achieved.

Action Items for SLO#2.0: To help improve upon their scores for SLO 2.0, the Department will continue to build upon the online component of the Capstone course it had started in 2016-2017. Items that will be added are practice exams with DUCK type problems, more sample writing assignments, and term paper and presentation rubrics, sample term papers and PowerPoint Presentations will also be added. This material will be made available to all chemistry majors, and they will be asked to begin preparing for the DUCK during their sophomore and junior years by studying the posted material. In addition, upper level chemistry majors will be encouraged to invest in a chemistry study guide such as the one published by the American Chemical Society (ACS).

SLO #3.0: Students in 499 Chemistry Senior Capstone, on average, performed at the 80.22% level when demonstrating competency in presenting technical information via written communication as measured by the capstone instructor with input from all department faculty members using a standard rubric (Attachment I). Our target for SLO # 3 was 80%. Therefore, our target was achieved.

Action Items for SLO#3.0: Even though the target was met, the Department decided to explore ways to improve student outcomes for SLO#3.0. To better prepare students for doing chemistry term papers, all students taking upper level chemistry courses will have access to the department's term paper rubric and they will be encouraged to use it when writing similar papers in their chemistry courses. We will also provide students with several different ways that they can choose their term

paper/oral presentation topic, and put more emphasis on strategies they can us in searching the scientific literature to get reliable sources.

SLO #4.0: Students in 499 Chemistry Senior Capstone, on average, performed at the 82.24% level when demonstrating competency in presenting technical information via oral communication as measured by departmental faculty members using a standard rubric (Attachment II). Our target for SLO # 4 was 80%. Therefore, our target was achieved.

Action Items for SLO#4.0: Even though the target was met, the Department decided to explore ways to improve student outcomes for SLO#4.0. To better prepare students for doing oral presentations, all students taking upper level chemistry courses will have access to the department's chemistry oral presentation rubric and they will be encouraged to use it when writing similar papers in their chemistry courses. We will also provide students with several different ways that they can choose their term paper/oral presentation topic, and put more emphasis on strategies they can us in searching the scientific literature to get reliable sources.

SLO #5.0: 100% of students enrolled in Chemistry 201 demonstrated an Understanding of laboratory safety procedures at the 70% level or above as measured by a cumulative exam on laboratory safety. Our target for SLO # 5 was 70%. Therefore, our target was achieved.

Action Items for SLO#5.0: Even though the target was met, the Department decided to explore ways to improve student outcomes for SLO#5.0. As the department has done for many years, part of all prelab sessions before students enter the lab will be devoted to lab safety and procedures. We will further improve upon our delivery of lab safety and procedures to students.

Appendix

I. **Chemistry Term Paper Rubric**
II. **Oral Presentation Rubric**
III. **Capstone Writing Assignments**

Attachment I

Chemistry 499 Capstone Course 2017

Chemistry Term Paper Rubric

Student's Name _____ Faculty Reviewer _____

	Category	Scoring Criteria	Score Range	Reviewer's Score
1	**Abstract**	(a) Main points are briefly presented, (b) keywords accurately describe information in report, (c) abstract is less than 200 words long	**0-5** 5 being the highest	
2	**Introduction**	(a) effectively communicates the purpose and importance of the research topic in the context of chemistry, (b) supplies and demonstrates understanding and proper use of needed information and terms, (e) lays out the framework for the rest of the paper	**0-15** 15 being the highest	
3	**Body**	(a) shows command of topic, (b) chemistry content is sufficient (c) describes experimental procedures and results and makes valid interpretation of results, (d) contains accurate information, (e) draws on multiple areas, (f) content backed up by multiple, refereed, and credible sources	**0-25** 25 being the highest	
4	**Conclusion**	(a) Communicates a logical conclusion that follows from the body, (b) summarizes and evaluates the major points, strengths and possible weaknesses of the research, (c) discusses further research needed in the area	**0-20** 20 being the highest	
5	**References and Appendices**	(a) Cite at least six references from at least three different peer review journals, (b) references are complete and numbered, (c) references follow acceptable format (see ACS Style Guide or the reference style of one of the journals cited, (d) supplementary materials are located at the back of report, (e) sources of information including graphics are appropriately cited and referenced	**0-10** 10 being the highest	
6	**Appearance and Format**	(a) makes effective use of headings and subheadings, (b) pages are numbered and bound in a folder, (c) uses appropriate font sizes, the height of the letters must not be smaller than 10 point type density, including characters and spaces, must be no more than 15 characters per 2.5 cm, for proportional spacing, the average for any representative section of text must not exceed 15 characters per 2.5 Cm, (d) no more than 6 lines of type within in a vertical space of 2.5 cm, left and right margins are justified and must be at least 2.5 cm	**0-5** 5 being the highest	
7	**Writing Style and Grammar**	(a) writing is coherent, clear, concise, engaging, and gets point across (b) no sentence fragments, comma splices, or fused sentences, (c) no errors in punctuation , spelling, and/or in the placement of words, (d) makes good use of strong nouns and action verbs	**0-10** 10 being the highest	
8	**Other Relevant Factors**	(a) Title is sufficiently narrowed down and reflects the content of the paper (b) shows some understanding of other relevant areas outside of chemistry, (c) engaging, (d) good choice of topic, (e) new and interesting ideas	**0-10** 10 being the highest	
9	**Faculty Comments and Recommendations for Rubric Improvements**		**100 Pts maximum**	**Reviewer's Total Score** _____

Attachment II

Chemistry 499 Capstone Course 2017

Chemistry Research Oral Presentation Rubric

Student's Name _____ Faculty Reviewer _____

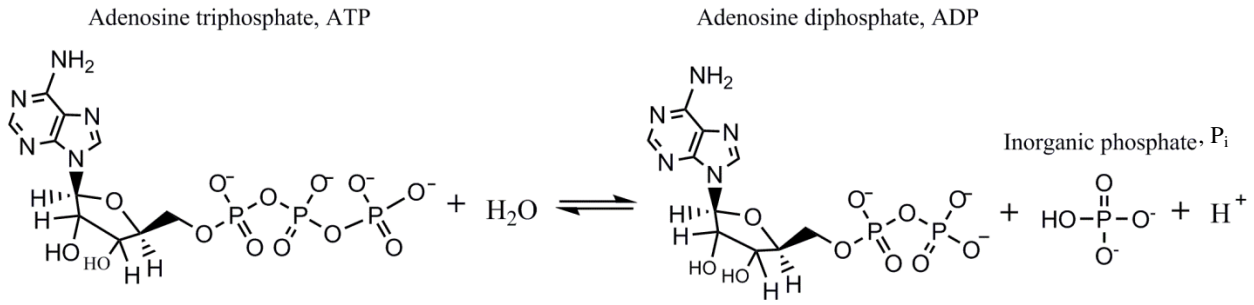
	Category	Scoring Criteria	Score Range	Reviewer's Score
1	**Introduction**	(a) Good opening statement, (b) effectively communicates the purpose and importance of the talk and research in the context of chemistry, (c) supplies and demonstrates understanding of background information, (d) lays out the framework for the rest of talk	**0-10** 10 being the highest	
2	**Chemistry Content**	(a) Describes experimental procedures and results relating to chemistry, (b) contains accurate information, (c) draws on multiple areas, (d) good use and explanation of visual aids (e.g., data charts, illustrations, and drawings), (e) content backed up by multiple, refereed, and credible sources	**0-30** 30 being the highest	
3	**Knowledge of Topic**	(a) Understands basic chemical terms and principles relevant to the research for the level of senior chemistry majors, (b) evaluates the research (e.g., strong and weak points) at the level of senior chemistry majors, (c) answers questions adequately without a distractive use of notes, internet, or other persons	**0-30** 30 being the highest	
4	**Conclusion**	(a) Communicates a logical conclusion, (b) summarizes the major points, strengths and possible weaknesses of the research, (c) discusses further research needed in the area	**0-10** 10 being the highest	
5	**Delivery**	(a) Speaks clearly and presentation does not seem to be read from a scripted text, (b) well organized, (c) effective and smooth transitions, (d) dresses appropriately, (e) good body language, (f) delivers presentation adequately and generally not reading from prepared notes (g) does not go to internet to answer questions from the audience, (h) presentation done within the 15 minute (not counting Q&A's) allotted time	**0-10** 10 being the highest	
6	**Other Relevant Factors**	(a) Adequately understands other relevant areas outside of chemistry, (b) engaging; (c) creativity; (d) topic choice; (e) new and interesting ideas; (f) answers questions adequately without the use of note cards, internet, or other persons	**0-10** 10 being the highest	
7	**Faculty Comments and Recommendations for Rubric Improvements**		**100 Pts maximum**	**Reviewer's Total Score** _____

Attachment III

Chemistry Capstone Writing Assignment 1 **Due Date: By 5:00 pm on 31/Jan/17**

Name_____

The hydrolysis of adenosine triphosphate (ATP) to yield adenosine diphosphate (ADP) plus an inorganic phosphate (HPO_4^{2-} or p_i) is a crucial biochemical reaction:



$$ATP^{4-} + H_2O \rightleftharpoons ADP^{3-} + HPO_4^{2-} + H^+ \qquad \Delta G^{o'} = -30.5\ kJ/mol$$

Write a short paper of about 250 words or less that discusses both the importance of this reaction and addresses the following topics:

(a) Describe the basic structural components of ATP, and tell why the reaction above is classified as a hydrolysis?

(b) The value of $\Delta G^{o'}$ is -30.5 kJ/mol. Determine and then justify whether or not the reaction is spontaneous under standard state conditions at 25°C.

(c) The standard enthalpy change (ΔH^o) for the ATP hydrolysis reaction above is -16.7 kJ/mol at 25°C. Determine the corresponding value for ΔS^o, and decide if this value makes sense based on the number of reactants and products species given in the ATP-to-ADP hydrolysis reaction above? Justify your response.

(d) ATP is a major energy transporter for many biochemical reactions in the cell to make nonspontaneous reactions spontaneous. Describe how ATP performs this task, and give a specific example of this.

(e) ADP must constantly be converted back to ADP to meet the steady energy requirements of cells. Give a very brief and general overview of where the energy comes from to convert ADP back to ATP?

Your paper will be graded on the degree to which it addresses the points above, on basic grammar and punctuation, and on its organization and structure. You are free to order the topics in any way to produce an effective, well written paper. You may also discuss additional topics for continuity and support.

Capstone Writing Assignment 2 **Due Date: By 5:00 pm on 21/Feb/17**

Name_____

For the compound with the molecular formula C_5 H_{10} O, determine its structure from its corresponding proton nmr spectrum, ^{13}C nmr spectrum, IR spectrum, and its mass spectrum, all of which are given below. Draw your structure using a molecular drawing software program such as ChemDraw or Accelrys Draw. The latter is installed on all 3rd floor computers and you may also install it on your personal computers. Just ask Dr. Gray for instructions. For each of the spectra, provide a reasonable explanation below on what specific piece of information it provided to allow you to ascertain the structure.

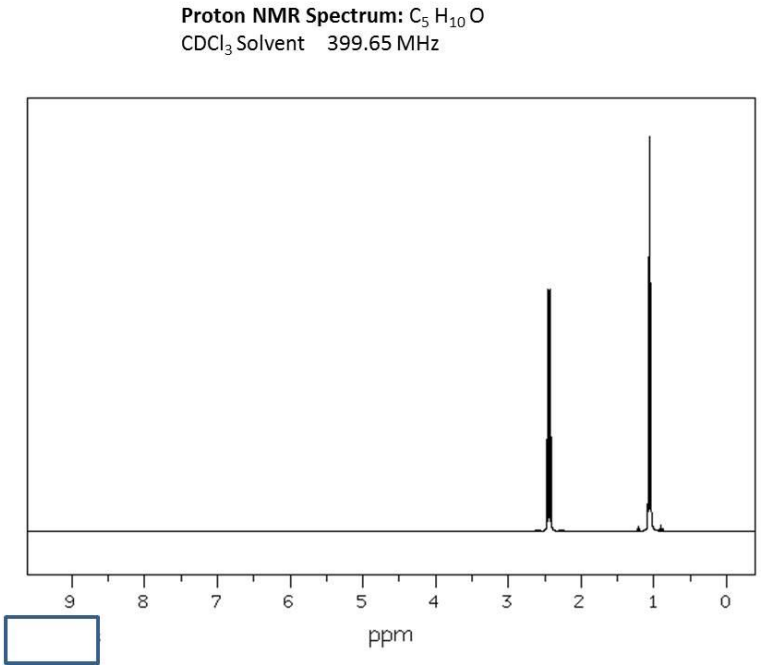
Structure of C_5 H_{10} O:

Proton NMR spectrum:

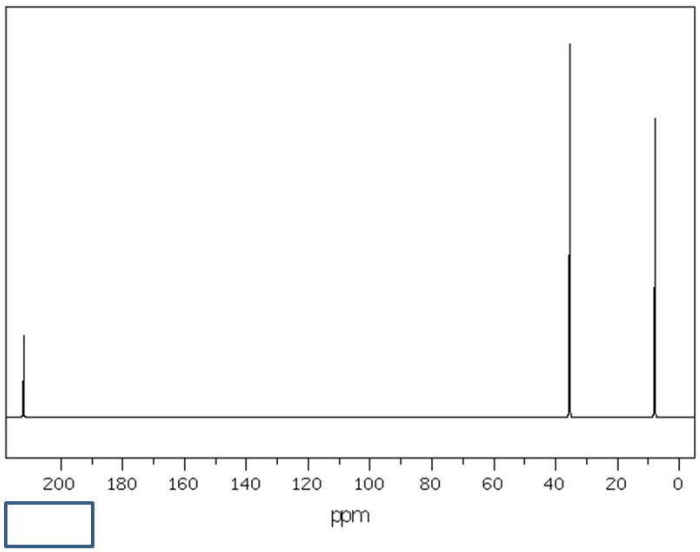
^{13}C NMR spectrum:

IR Spectrum:

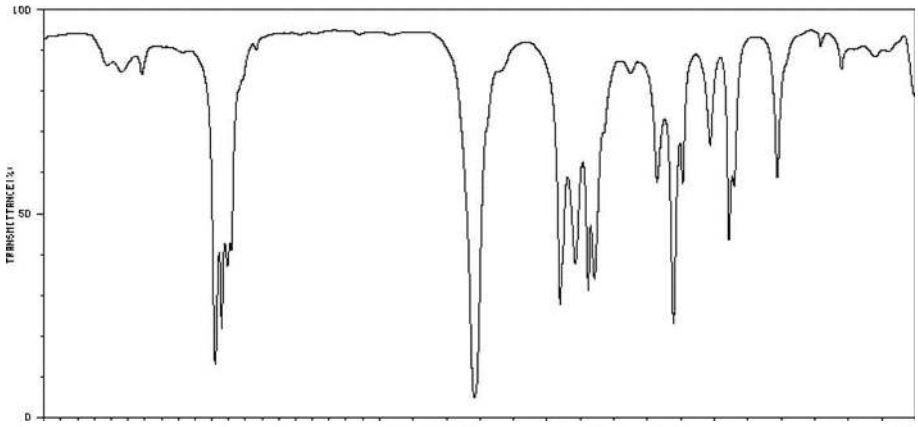
Mass Spectrum:



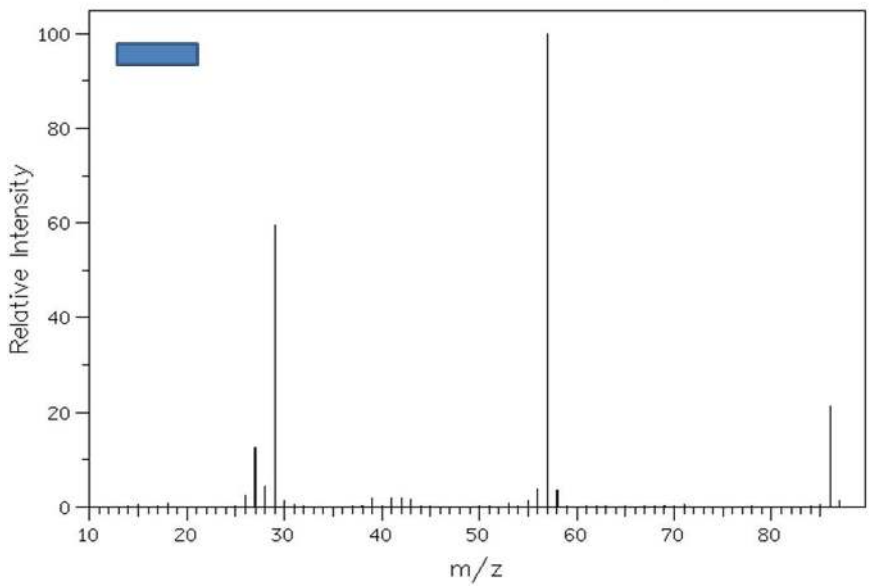
^{13}C NMR Spectrum: $C_5H_{10}O$
$CDCl_3$ Solvent 15.09 MHz



Infrared Spectrum : $C_5H_{10}O$
Liquid Film



Mass Spectrum: C5 H10 O (Mass of molecular ion: 86)



Chemistry Capstone Writing Assignment 3 **Due Date: By 5:00 pm on 21/March/17**

Name_____

For the coordination compounds $K_3[Fe(CN)_6]$ and $[Fe(H_2O)_6](NO_3)_3$: (a) Make a line-dash-wedge drawing of $K_3[Fe(CN)_6]$ and $[Fe(H_2O)_6](NO_3)_3$. Both have octahedral geometries. (b) Construct a d orbital splitting diagram with d electrons shown for each. (c) Which of the two complexes is expected to be paramagnetic? (d) Which complex is expected to absorb light at the shorter wavelength? Justify your choice for each.

Capstone Writing Assignment 4 **Due Date: By 5:00 pm on 31/Mar/17**

Name_____

Title: Production of Table Salt from the Reaction of Baking Soda with Hydrochloric Acid

Lab Setup:

A lab experiment was performed to produce table salt (sodium chloride, NaCl) by reacting a quantity of baking soda (sodium bicarbonate, $NaHCO_3$) with a stoichiometric amount of hydrochloric acid (HCl) according to the reaction:

$NaHCO_3$ (s) + HCl (aq) → NaCl (s) + CO_2 (g) + H_2O (l)

The experiment begins by weighing a clean, dry, empty test tube. The baking soda was then placed in the test tube and the mass of the tube plus the baking soda was determined. Stoichiometric amounts of hydrochloric acid was then slowly and carefully added to the tube, whereupon the reaction occurred to completion as described above, until all the baking soda reacts.

The resulting solution was then carefully heated to dryness, leaving behind only the table salt, a white solid. The test tube with the table salt product were allowed to cool to room temperature and then weighed again. The mass of the table salt produced was then determined by subtraction.

Circle the correct answer for the questions below and give a brief justification for your answer directly below it. Use additional sheets for the justification if needed.

1. If the baking soda was unknowingly added to a wet test tube and then weighed, the calculated mass of table salt at the end of the experiment in comparison to the mass calculated using the dry test tube would be

(a) too high (b) too low (c) the same (d) equal to the excess water

Justification:

2. The formula NaCl tells us that there is

(a) 1 gram of sodium per 1 gram of chlorine. (b) 1 atom of sodium per 1 atom of chlorine.

(c) 1 mole of sodium per 1 gram of chlorine. (d) 1 atom of sodium per 1 mol of chlorine.

Justification:

3. When the procedure is carried out correctly using stoichiometric amounts of baking soda and hydrochloric acid, the mass of table salt formed is less than the mass of the baking soda reacted. Why is this?

(a) The mass of sodium in the table salt is less than the mass of sodium in the baking soda.
(b) The mass of chlorine in the table salt is less than the mass of bicarbonate in the baking soda.
(c) The mass of bicarbonate in the baking soda is less than the mass of chlorine in the table salt.
(d) Much of the baking soda is lost due to splashing.

Justification:

4. After the conversion of baking soda to table salt is complete, and the tube and sodium chloride is weighed, a student then adds more hydrochloric acid to the table salt in the tube, again heated to dryness, and then weighs the tube and its contents a second time. The mass of the tube and its contents should be _____ .

(a) the same as its mass before adding more hydrochloric acid.
(b) more than its mass before adding more hydrochloric acid.
(c) less than its mass before adding more hydrochloric acid.
(d) the same as the mass of the hydrochloric acid added.

Justification:

5. A student wishes to prove that the conversion of baking soda to table salt is complete. Which of the following observations would most likely indicate that the conversion was completed?

(a) The solid remaining in the test tube was white.
(b) The solid remaining in the test tube gives a positive test for chloride ion.
(c) Addition of HCl to the solid remaining in the test tube yields no evolution of gas
(d) Litmus paper shows that the white solid is basic.

Justification:

6. Student A uses twice as much HCl in the procedure as student B. Which of the following statements is true?

(a) Both students will obtain the same amount of NaCl.
(b) Student A will obtain twice as much NaCl.
(c) Student A will obtain $NaCl_2$.
(d) Student A's reaction will not work, and the solid remaining in the test tube will be baking soda.

Justification: