Institutional Effectiveness Report

Name of Program/Department:	**Department of Chemistry**
Year:	**2020-2021**
Name of Preparer:	**Pete Peterson, Chair**

Program Mission Statement

The mission of the chemistry department is to provide 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 natural sciences requirements for General Education, pre-professional programs, the basic chemistry degree, or the American Chemical Society approved chemistry degree program. The department strongly encourages students to engage in undergraduate research, service, and networking within the scientific community.

Program Learning Outcomes (PLOs)

Senior chemistry majors at Francis Marion University will be characterized by the following qualities or attitudes:

Direct Assessments:

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

PLO #2 – Chemistry majors will demonstrate that they can apply critical thinking skills in chemistry.

PLO #3 – Chemistry majors will demonstrate an understanding of core concepts, methods and limits of scientific inquiry that will allow them to successfully solve integrated problems in chemistry.

PLO #4 – Chemistry majors will demonstrate that they can adequately apply their knowledge of chemistry.

PLO #5 – Chemistry majors will demonstrate that they can adequately use the scientific literature.

PLO #6 – Chemistry majors will demonstrate an understanding of safe laboratory skills and procedures for laboratory experiments that they perform.

PLO #7 – Chemistry majors will have accrued over the period of their undergraduate studies, an overall favorable view of the Department of Chemistry's quality of instruction, advising, and facilities.

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 the academic year 2021-2022. Achievement and attitudes of our senior chemistry majors on their chemistry concept knowledge and critical thinking skills, and on communication skills were assessed with (1) writing assignments, (2) the standardized American Chemical Society (ACS) *Diagnostic of Undergraduate Chemical Knowledge* (**DUCK**) Exam, (3) an oral presentation, (4) a written chemistry term paper, (5) a chemical safety exam, and (6) an exit questionnaire and interview.

The knowledge and skills assessments were carried out in our senior Chemistry Capstone course (Chem 499), while lab safety skills assessment was` carried out in our Organic Chemistry 201 (Chem 201) course.

The four senior students enrolled in our Spring 2021 Chemistry 499 Senior Capstone course performed at a 64.00% pass rate on six capstone writing assignments that assessed their understanding of key chemical concepts SLO (# 1). The 64.00% fell below our target goal of 80.00% for SLO # 1, and it was 4.00 % below the percentage recorded in the spring of 2019, the last time this SLO was assessed.

Students in the Chemistry 499 Senior Capstone course scored on average at the 32-percentile level with a range of 20-42 percentile. This average is a 10th percentile increase above the last time this standard was measured in the spring of 2019. The 32nd percentile is slightly above the mean national percentile of 31.37 (Std error = 3.70%), but was also well below the Department's very optimistic goal for the 50th Percentile for SLO # 2.

Students in Chemistry 499 Senior Capstone, on average, performed at the 81.00% average level when demonstrating competency in presenting technical information through their written communication skills on a chemistry topic of their choosing that was approved by the chemistry faculty (SLO # 3). Our goal for SLO # 3 was 80.00%. Therefore, our target was achieved for two out of the four students turning in a copy of their term paper.

Students taking the Chemistry 499 Senior Capstone, on average, performed at the 76.80% level when demonstrating competency in presenting technical information through their oral communication skills on the same chemistry topic in SLO # 3 that they choose and that was approved by the chemistry faculty (# 4). Our goal for SLO # 4 was 80.00%. Therefore, our target was not achieved.

All students (100%) enrolled in Chemistry 201 demonstrated an adequate level of knowledge of laboratory safety procedures and practices at or above the 70% level (SLO # 5). Our goal for SLO # 5 was 70%. Therefore, our target was achieved.

Although no Gen Ed Assessment Exam (SLO #7) was administered due to Covid-19 course changes, the Department's SLO #7 (Gen Ed Assessment Goal 5) was assessed through SLO #2. The results for SLO's #2 show that Gen Ed Assessment Goal 5 was achieved.

The assessment of students' attitudes about the Department of Chemistry shows overwhelming satisfaction that the Department of Chemistry's program is at or above the level considered to be favorable.

Student Learning Outcomes (SLOs)

SLO# 1.0: Students in the Chemistry Senior Capstone course, on average, will perform at or above the 80.00% level, on a pass/fail basis, on capstone writing assignments that assess their understanding of key chemical concepts.

SLO# 2.0: 80% of graduating Chemistry students will, on average, perform at or above the 50^{th} percentile on 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 or above the 80.00% level on their ability to present technical information through written communication.

SLO #4.0: Students in the Chemistry Senior Capstone course, on average, will perform at or above the 80.00% level on their ability to present technical information through oral communication.

SLO #5.0: 100% of students enrolled in Chemistry 201 will demonstrate at least an adequate level of 70.00% on their understanding of laboratory safety procedures.

SLO #6.0: 95% of chemistry majors will have accrued over the period of their undergraduate studies, an overall favorable view of the Department of Chemistry's program, instruction, and facilities.

SLO #7.0: 75% of students will demonstrate proficiency in Gen Ed Goal 5 by scoring a raw score of at least 40% on the American Chemical Society (ACS) Diagnostic of Undergraduate Chemical Knowledge (DUCK) exam.

Assessment Methods

SLO# 1.0: Students in the Chemistry Senior Capstone course, on average, will perform at or above the 80.00% level, on a pass/fail basis, on capstone writing assignments that assess their understanding of key chemical concepts.

Assessment Method for SLO# 1.0: Six writing assignments were administered to the four students enrolled in the chemistry capstone course (Chem 499) for the spring of 2021 semester. The assignments were graded on a pass/fail basis. A passing (P) grade was assigned if the student presented sufficient knowledge of the basic chemical concepts tested as determined by capstone course instructor. Otherwise, a grade of fail (F) was assigned. If the assignment was not turned in, then a NTI (Not Turned In) was assigned. NTI is used for record keeping, but for grading purposes, it was treated just like a Fail (F).

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

Assessment Method for SLO# 2.0: Four senior chemistry majors enrolled in the chemistry capstone course (Chem 499) were administered the *Diagnostic of Undergraduate Chemical Knowledge* (**DUCK**) exam (see Appendix 2 for Description) near the end of the spring 2021 semester. The DUCK is a standardized exam produced by the American Chemical Society (ACS) designed to assess basic chemistry knowledge for a senior undergraduate student.

SLO #3.0: Students in the Chemistry Senior Capstone course, on average, will perform at or above the 80.00% level on their ability to present technical information through written communication

Assessment Method for SLO# 3.0: To assess their written communications skills, eight students enrolled in the Chemistry Senior Capstone course wrote a term paper near the end of the spring semester of 2021, based on a technical chemistry topic they select and then was faculty approved. Each paper was graded by the capstone instructor using a standard, department generated grading rubric for scientific term papers.

SLO #4.0: Students in the Chemistry Senior Capstone course, on average, will perform at or above the 80.00% level on their ability to present technical information through oral communication

Assessment Method for SLO# 4.0: To assess their oral communications skills, eight students enrolled in the Chemistry Senior Capstone course delivered an oral presentation near the end of the spring of 2021 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 for scientific term papers. The student's score was an average of all faculty scores.

SLO #5.0: 100% of students enrolled in Chemistry 201 will demonstrate at least an adequate level of 70.00% on their understanding of laboratory safety procedures.

Assessment Method for SLO# 5.0: All of the students enrolled in Organic Chemistry 201, a foundation course that is prerequisite to taking any higher-level chemistry course, were presented a lab module on chemical safety during the first two weeks of the course at the beginning of the fall 2020 semester. This was followed by their taking a comprehensive and cumulative lab safety exam that is produced and administered by the Organic Chemistry Department faculty. As students must score at least 70% on this safety exam to

remain in this required course and thus major in chemistry, 100% of chemistry majors will have completed this outcome before they become senior chemistry students.

SLO #6: 95% of chemistry majors will have accrued over the period of their undergraduate studies, an overall favorable view of the Department of Chemistry's quality of instruction, programs, and facilities.

Assessment Method for SLO# 6.0: To help access the quality of its instruction, advising, and facilities, the Department of Chemistry administers an associated questionnaire and also an exit interview (Appendix 2) to its senior chemistry majors enrolled in the senior capstone course.

SLO #7.0: 75% of students will demonstrate proficiency in Gen Ed Goal 5 by scoring a raw score of at least 40% on the American Chemical Society (ACS) Diagnostic of Undergraduate Chemical Knowledge (DUCK) exam.

Assessment Method for SLO# 7.0: 75% of students taking the ACS DUCK exam will demonstrate proficiency in Gen Ed Goal 5 by scoring a raw percentage score of at least 40% on the exam.

Assessment Results

SLO# 1.0: Students in the Chemistry Senior Capstone course, on average, will perform at the 80% level, on a pass/fail basis or above, on capstone writing assignments that assess their understanding of key chemical concepts.

Assessment Results for SLO# 1.0: Students in 499 Chemistry Senior Capstone on average, performed at a 68.00% average for the 2020-2021 academic year for SLO # 1. Since our target was 80%, the pass rate of 68.00% for SLO # 1 was not achieved.

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. The exam, which is the ACS (American Chemical Society) Diagnostic of Undergraduate Chemical Knowledge (DUCK) exam, consisted of several chemistry scenarios testing integrated chemical concepts, each of which was followed by several multiple choice questions based on it. There are a total of 60 questions in all.

Assessment Results for SLO# 2.0: Senior FMU chemistry majors scored an average at the 32.00 percentile with a range of 22.00-42.00 percentile for the 4 students enrolled in the senior capstone course. Since no student reached the 50th percentile for SLO # 2.0 our target goal of 80.00% at the 50 percentile was not reached. However, the 32.00 percentile is significantly better than the 22.00 percentile reached in the spring of 2019, the last time the DUCK exam was administered for IE purposes.

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: Two students enrolled in Spring 2021 Chem 499 Senior Capstone, on average, performed at the 81.00% level % level on their chemistry term paper as graded by the Chemistry 499 Capstone instructor using a standard scientific term paper rubric. Our target for SLO # 3 was 80.00%.

Therefore, our target was achieved for these two students, but two students failed to turn in a term paper. These two students were not counted in the 81.00% reported.

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 76.80 % level on their chemistry oral presentation as graded by the chemistry faculty using a standard scientific, department-generated rubric. Our target for SLO # 4 was 80.00%. Therefore, our target was not achieved.

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

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 based on a comprehensive and cumulative lab safety exam that was produced and administered by the Chemistry Department. Respective lab instructors graded the lab safety exams. Our target for SLO # 5 was 100.00%. Therefore, our target was achieved.

PLO #7 – Chemistry majors will have accrued over the period of their undergraduate studies, an overall favorable view of the Department of Chemistry's quality of instruction, programs, and facilities.

Assessment Results for SLO # 6.0: To help access the quality of its instruction, advising, and facilities, the Department of Chemistry administers a questionnaire as well as an exit interview to its senior chemistry majors enrolled in the senior capstone course. The questionnaire is grouped into questions pertaining to the quality of its programs, resources, and instructions. The Exit Interview gets a face-to-face sense of our program with any and all issues on the table. All of the student responses from the questionnaire and the exit interview were viewed as favorable, with several constructive comments on how to make our program better.

Gen Ed Assessment (SLO 7)

SLO #7.0: 75% of students will demonstrate proficiency in Gen Ed Goal 5 by scoring a raw score of at least 40% on the American Chemical Society (ACS) Diagnostic of Undergraduate Chemical Knowledge (DUCK) exam.

Because of Covid-19 class restructuring, we replaced our normal Gen Ed assessment exam that is usually administered to our General Chemistry students, with the DUCK exam score, as described above, that is administered to only capstone students for the 2020-2021 Academic Year. The 40% threshold on the DUCK is valid for Gen Ed evaluation based on comparison between scores on our normal Gen Ed and DUCK exams from previous years.

Assessment Results for SLO # 7.0: The scores from the DUCK exam for the four capstone students clearly show that our Gen Ed goal was met for #5, with all the students answering correctly at least 40% (24 out of 60) of the questions on this nationally standardized exam.

Action Items

To better prepare students for the high level critical thinking problems given on exams like the DUCK (SLO 2) and what they will confront at the next phase of their professional careers, the following action items will be implemented:

1. All chemistry instructors will be given a quick reference guide to Bloom's Taxonomy and they will be encouraged to continue with creating such higher order problems in their courses.

2. We will continue to modify and create new, modern, and more relevant lab experiments, particularly in the general and organic chemistry labs, to be used in place of older lab experiments. This will also aid in recruiting more chemistry majors early on. That such efforts will aid in recruitment of chemistry majors was alluded to by students during their Exit Interview, since the new lab experiments are expected generate more enthusiasm and excitement about chemistry that some of the older experiments do not conjure up.

Pertaining to students' attitudes about the Department of Chemistry that based on the Department Exit interview and questionnaire, the overwhelming majority of the responses that the four students enrolled in the Chemistry 499 Capstone course felt that the Department of Chemistry's instruction, programs, and facilities are adequate.

Based on these Department Exit Interview and Questionnaire given to capstone students this spring 2021 as well as in previous assessments, the major concerns below were identified by them:

1. There is a need, as what was also mentioned by students in past years, to change the math requirement for chemistry majors to make it more flexible. In particular, students believe that the current required Math 203 is of little importance for the basic chemistry major, and that it should be eliminated or replaced by a more flexible option so that they may choose among several math course options.

2. There is a need to make the last semester for senior students who take the senior capstone course less compressed and more spread out over a longer period of time.

3. There is a need for classrooms to be more comfortable and conducive to learning with respect to climate control. The classrooms are often too hot.

4. There is too much homework for chemistry majors compared to other majors.

Other action items that will need to be address are the following:

The Department of Chemistry will address matters associated with program improvements as described in this IE Report, as well as others. We will continue to review and modify our current action plan from previous IE and IE feedback reports, and these will be incorporated in upcoming years.

Department efforts will be dedicated toward improving our program, our PLO's, SLO's, and our Gen Ed Assessment, and they will be discussed and decided upon on a regular basis, particularly at our department's regular meetings.

Appendices

Appx I. 2020-2021 IE Knowledge/Skills Instruments Measured and Student Scores

Appx II. DUCK Exam Information

Appx III. Capstone Writing Assignments 1-6

Appx IV. Chemistry Term Paper Rubric

Appx V. Chemistry Oral Presentation Rubric

Appx VI. Exit Questionnaire

Appx VII. Exit Interview Questions

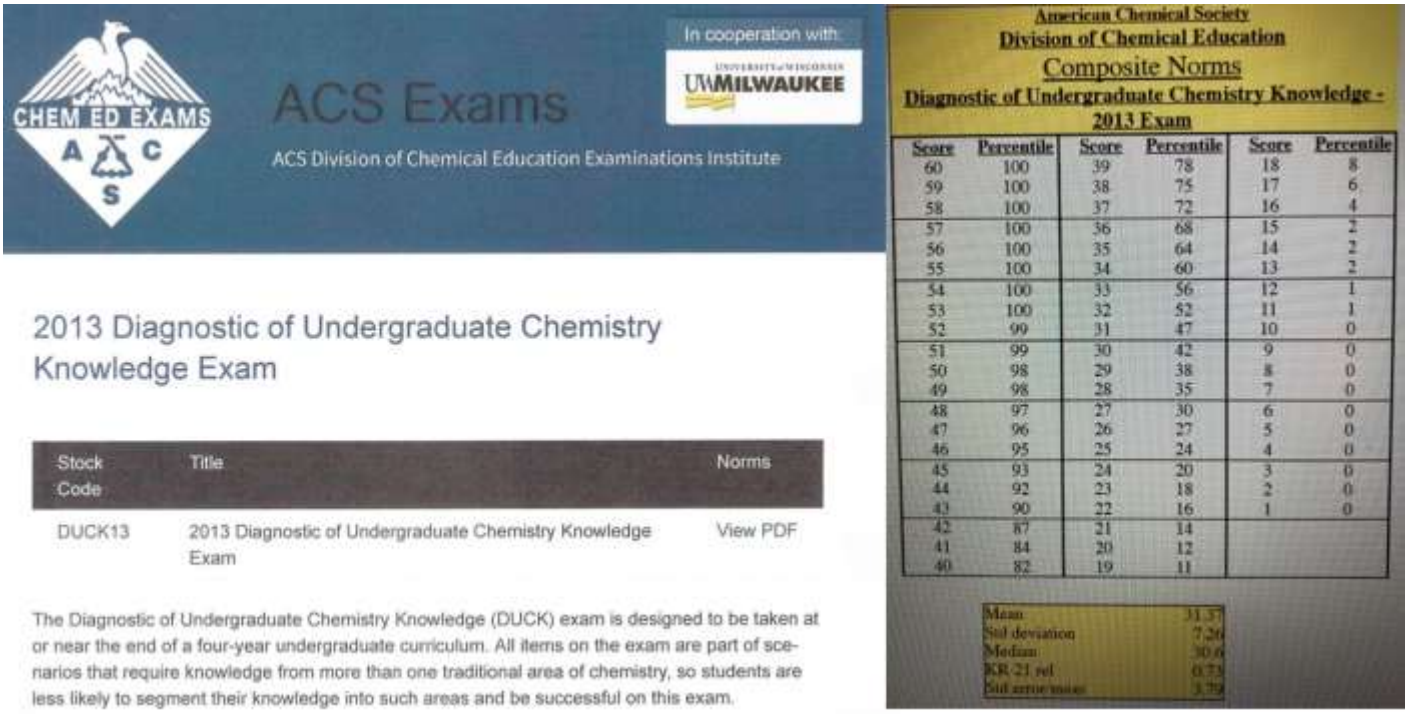
Appendix VIII. Gen Ed Goals 2020-2021

Appendix I: 2020-2021 IE Knowledge/Skills Instruments Measured and Student Scores

Department of Chemistry
2020-2021 IE Knowledge/Skills Instruments Measured and Student Scores

	Lab Safety (P/F)*	Writing Assignments (W1-W6) P = Pass, F = Fail, NTI = Not Turned In						Talk Avge Score (%)	Term Paper (%)	2013 Duck Exam (# Right out of 60 Questions)	2013 Duck Exam (% Correct out of 60 Questions)	2013 DUCK Exam National Percentiles
		W1	W2	W3	W4	W5	W6					
Student 1	P	P	NTI	NTI	NTI	NTI	NTI	80.30	60.00	29	48.33%	38
Student 2	P	P	P	NTI	P	P	P	87.30	81.00	26	43.33%	27
Student 3	P	P	NTI	NTI	NTI	NTI	NTI	76.80	NTI	24	40.00%	20
Student 4	P	P	P	P	P	P	P	79.80	81.00	30	50.00%	42

Appendix II. DUCK Exam Information



In cooperation with: UWMILWAUKEE

ACS Exams

ACS Division of Chemical Education Examinations Institute

2013 Diagnostic of Undergraduate Chemistry Knowledge Exam

Stock Code	Title	Norms
DUCK13	2013 Diagnostic of Undergraduate Chemistry Knowledge Exam	View PDF

The Diagnostic of Undergraduate Chemistry Knowledge (DUCK) exam is designed to be taken at or near the end of a four-year undergraduate curriculum. All items on the exam are part of scenarios that require knowledge from more than one traditional area of chemistry, so students are less likely to segment their knowledge into such areas and be successful on this exam.

American Chemical Society
Division of Chemical Education
Composite Norms
Diagnostic of Undergraduate Chemistry Knowledge - 2013 Exam

Score	Percentile	Score	Percentile	Score	Percentile
60	100	39	78	18	8
59	100	38	75	17	6
58	100	37	72	16	4
57	100	36	68	15	2
56	100	35	64	14	2
55	100	34	60	13	2
54	100	33	56	12	1
53	100	32	52	11	1
52	99	31	47	10	0
51	99	30	42	9	0
50	98	29	38	8	0
49	98	28	35	7	0
48	97	27	30	6	0
47	96	26	27	5	0
46	95	25	24	4	0
45	93	24	20	3	0
44	92	23	18	2	0
43	90	22	16	1	0
42	87	21	14		
41	84	20	12		
40	82	19	11		

Mean	31.37
Std deviation	7.26
Median	30.6
KR-21 rel	0.73
Std error meas	3.79

Appendix III: Capstone Writing Assignments 1-6

Capstone Writing Assignment 1

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:

Capstone Writing Assignment 2

Name_____

For the compound with the molecular formula $C_5 H_{10} O$, determine the correct structure from its corresponding proton nmr spectrum, C-13 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 and attach it to this report. 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.

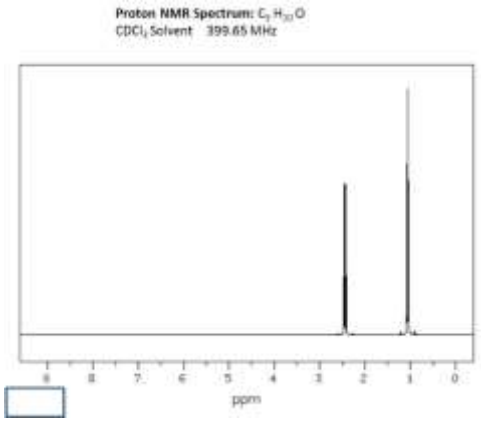
Correct structure of $C_5 H_{10} O$ (Draw by hand here):

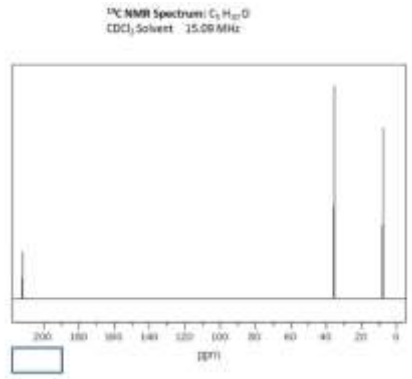
Proton NMR spectrum:

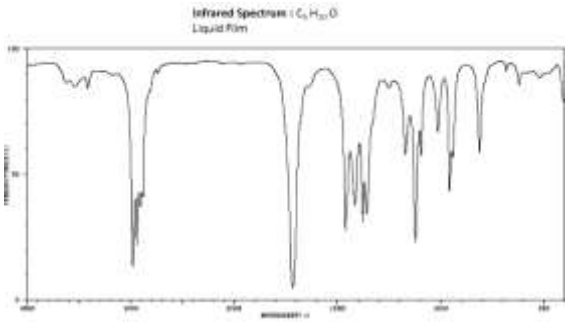
^{13}C NMR spectrum:

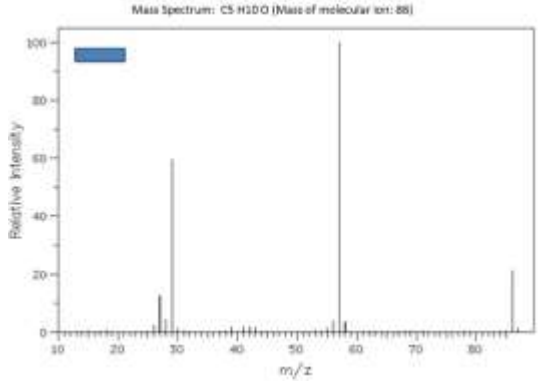
IR Spectrum:

Mass Spectrum:





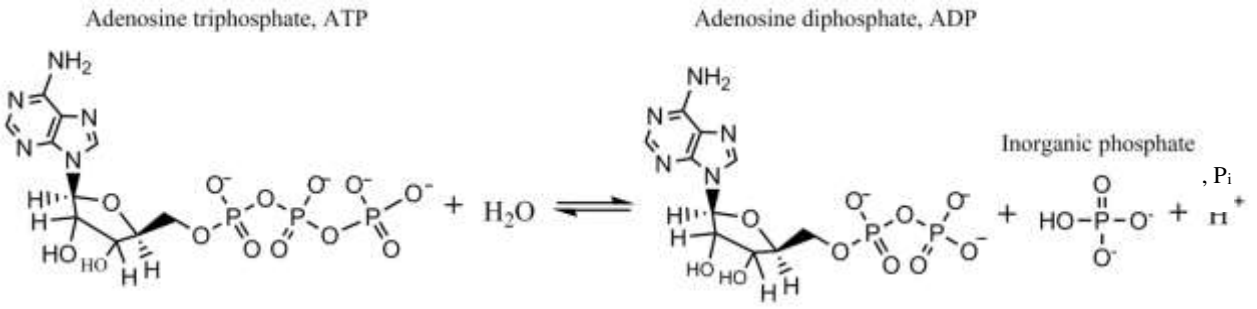




Chemistry Capstone Writing Assignment 3

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:



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

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 4

Name_____

Answer the following four questions and provide adequate justification.

1. Which gas, He or Xe, would you expect to deviate more from ideal behavior at a given temperature and pressure? Explain and justify your answer.

2. A supersaturated solution of sodium acetate trihydrate, which exist in a metastable state, will spontaneously crystallize if a seed crystal is added to it, and the process releases heat at room temperature as is evidenced by the container getting warmer to the touch.
   Based on this information, discuss what the signs of)G,)H, and)S should be, and then justify your choices.

3. Discuss the Arrhenius equation and its use to describe the temperature dependence of chemical reactions.

4. The energy levels for the one-dimensional particle in a box have been used to approximate the energies of the B electrons in linear conjugated molecules. Draw structures for the conjugated molecules butadiene and hexatriene, and predict using the particle in a box approximation which molecule requires more energy to excite an electron from its HOMO to its LUMO. Justify your answer.

Chemistry Capstone Writing Assignment 5

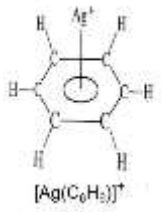
Name_____

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 more likely to to be paramagnetic? (d) Which complex is more likely to absorb light at the shorter wavelength? Justify your choice for each.

Chemistry Capstone Writing Assignment 6

Name_____

Using the flow chart below for determining point groups, explain in steps the determination of the point group for $[Ag(C_6H_6)]^+$ shown below. Be sure to also identify the point group for this cation.



Appendix IV. Chemistry Term Paper Rubric

Chemistry 499 Capstone Course 2021
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 (f) includes visual aids such as graphs, tables, equations, and schemes, etc, (g) each type of visual aid must be cited in text and in consecutive numerical order, (h) each table or graph must have an appropriate descriptive caption or title	**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, (g) includes visual aids such as graphs, tables, equations, and schemes, etc, (h) each type of visual aid must be cited in text and in consecutive numerical order, (i) each table or graph must have an appropriate descriptive caption or title	**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 tables, graphics, and other visual aids 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) term paper should be around 5-10 pages including visual aids, (b) Title is sufficiently narrowed down and reflects the content of the paper (c) shows some understanding of other relevant areas outside of chemistry, (d) engaging, (e) 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** _____

Appendix V. Chemistry Oral Presentation Rubric

Chemistry 499 Capstone Course 2021
Chemistry 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** _____

Appendix VI. Exit Questionnaire 2021

This is an exit questionnaire to determine your response to the department's programs, resources, and quality of instruction. You will also have a personal exit interview in which you will have another opportunity to help us improve. Your cooperation is appreciated. Thank you!

Date _____
First Enrolled at FMU _____

Name _____
Major(s) _____
Minor/Collaterals _____

ANSWER THOSE QUESTIONS WHICH ARE APPROPRIATE FOR YOU.

CHEMISTRY

1. Which Chemistry courses have you taken at FMU? (Check appropriate box.)
   - ~ Chem 150 (Chemistry for Everyday Life)
   - ~ Chem 101 (Gen Chem I)
   - ~ Chem 102 (Gen Chem II)
   - ~ Chem 201 (Organic Chem I)
   - ~ Chem 202 (Organic Chem II)
   - ~ Chem 203 (Quant)
   - ~ Chem 301 (P-Chem I)
   - ~ Chem 302 (P-Chem II)
   - ~ Chem 303 (Intrumental)
   - ~ Chem 313 (Environmental)
   - ~ Chem 402 (Inorganic Chem)
   - ~ Chem 404 (Biochem I)
   - ~ Chem 408 (Biochem II)
   - ~ Chem 405 (Adv Meth Org Syn & Char)
   - ~ Chem 407 (Intro to Polymer Sci)
   - ~ Chem 297 (Intro the Research)
   - ~ Chem 497 (Special Studies)
   - ~ Chem 498 (Chem Internship)
   - ~ Chem 499 (Capstone)
2. Does the department offer a sufficient variety of courses?
   Yes Comments
   No Comments
3. Do you find that the lab exercises improved your understanding of Chemistry?
   Yes Comments
   No Comments
4. Do you get enough "hands-on" experience in the lab?
   Yes Comments
   No Comments
5. Do you find the lower level Chemistry courses to be a good foundation for the upper level courses?
   Yes Comments
   No Comments
6. Were you able to take chemistry courses or labs at acceptable times of the day or week?
   Yes Comments
   No Comments
7. Did your chemistry classes have an appropriate number of students?

Yes Comments
No Comments

8. Were the chemistry courses offered on an appropriate semester basis?
   Yes Comments
   No Comments
9. Should a senior research project be required of all Chemistry majors?
   Yes Comments
   No Comments
10. After graduation, do you intend to:
    Teach High School Go to Graduate School
    Take a Job Other
11. Do you feel adequately prepared for your career after graduation?
    Yes Comments
    No Comments
12. In comparison with other courses in other departments, how challenging did you find your chemistry courses?
    Too demanding Not challenging enough Appropriate in difficulty
    Comments:

ADVISING AND INSTRUCTION QUALITY

1. Was your advisor knowledgeable about the Chemistry program (i.e., sequence, prerequisite)?
   Yes Comments
   No Comments
2. Did your advisor assist you in long-range planning?
   Yes Comments
   No Comments
3. How effective overall were the instructors in your Chemistry classes?
   Excellent Good Acceptable Poor Inadequate
   Comments:
4. Were your instructors appropriately available for help outside the class?
   Yes Comments
   No Comments
5. Did your instructors use a variety of teaching styles? (i.e. demonstrations, problem assignments, library assignments, class discussions)
   Yes Comments
   No Comments
6. Were the instructors explicit in stating the course objectives and the evaluation methods to be used?
   Yes Comments
   No Comments
7. Were lab manuals appropriate for the courses (detailed instructions, appropriate background, etc.)?
   Yes Comments
   No Comments
8. Do you feel that your professors cared about you and your progress in learning?
   Yes Comments
   No Comments
9. Did your chemistry classes prepare you to think independently and apply this knowledge to new situations?
   Yes Comments
   No Comments

FACILITIES AND EQUIPMENT

1. Overall, how would you rate the department's facilities (i.e. classroom space, desks, lighting, temperature control, readable screens and chalkboards, etc)?
   Excellent Good Acceptable Poor Inadequate
   Comments:
2. How would you rate the effectiveness of the use of equipment in lecture demonstrations in terms of helping you master the course material?
   Excellent Good Acceptable Poor Inadequate
   Comments:
3. How would you rate multimedia and online integration in your chemistry lectures/labs?
   Excellent Good Acceptable Poor Inadequate
   Comments:
4. How would you rate the department's laboratory equipment in terms of operating condition?
   Excellent Good Acceptable Poor Inadequate
   Comments:
5. Would you say the department's laboratory equipment is sufficiently up-to-date?
   Yes Comments
   No Comments
6. Would you say the department's laboratory equipment is sufficiently maintained?
   Yes Comments
   No Comments
7. Are instruments available in sufficient number for the labs?
   Yes Comments
   No Comments
8. How would you rate the department in terms of access to computers and various types of software (i.e. internet access, Office)
   Excellent Good Acceptable Poor Inadequate
   Comments:
9. Would you say the department's computer facilities/software are sufficiently up-to-date?
   Yes Comments
   No Comments
10. Would you say the department's computer facilities are sufficiently maintained?
    Yes Comments
    No Comments
11. If you were involved in a research project, how would you rate the department in terms of obtaining any equipment necessary for your project?
    Excellent Good Acceptable Poor Inadequate
    Comments:
12. How would you rate the department in terms of availability and proper use of safety related equipment?
    Excellent Good Acceptable Poor Inadequate
    Comments:
13. How would you rate the James A. Rogers Library for book holding, facilities, and reference materials?
    Excellent Good Acceptable Poor Inadequate
    Comments:

FINAL COMMENTS:

Appendix VII. Exit Interview 2021

Date _____

Interviewer _____

Student Name _____

Major _____

Minor/Collaterals _____

Your Chemistry Degree is the Basic or ACS-Approved?

Why did you choose your chemistry degree track and not the other one?

CIRCLE ANSWERS WHERE APPROPRIATE

1. If you are going to graduate school, do you feel adequately prepared in your major subject?

   Yes Comments No Comments

If you are going to work in industry, do you feel competent in your technical skills and knowledge of your major subject?

   Yes Comments No Comments

   If you are going to teach, do you feel prepared to teach your major subject?

   Yes Comments

   No Comments

2. Which Chemistry courses would you like to have removed or modified in the curriculum?

3. Which Physics courses would you like to have removed or modified in the curriculum?

4. What changes would you like to recommend for the required mathematics courses?

5. What recommendations would you make concerning computers and their uses at FMU?

6. What changes would you like to see in the Chemistry major at FMU?

7. What other suggestions for improvement in your Chemistry program would you like to make?

8. The best thing about the Chemistry program is:

9. The worst thing about the Chemistry program is:

10. Any other comments?

Appendix VIII. Gen Ed Goals 2020-2021

2019-2020 & 2020-2021 Catalogs
Francis Marion University

2019-2020 General Education Goals		2020-2021 General Education Goals	
Goal 1	The ability to write and speak English clearly, logically, creatively, and effectively.	Goal 1	The ability to compose effectively with rhetorical awareness, integrate relevant research when appropriate, and produce developed, insightful arguments.
Goal 2	The ability to read and listen with understanding and comprehension.	Goal 2	The ability to demonstrate comprehension of different forms of communication.
Goal 3	The ability to use technology to locate, organize, document, present, and analyze information and ideas.	Goal 3	The ability to explain artistic processes and evaluate artistic product.
Goal 4	The ability to explain artistic processes and evaluate artistic product.	Goal 4	The ability to use fundamental math skills and principles in various applications.
Goal 5	The ability to use fundamental mathematical skills and principles in various applications	Goal 5	The ability to describe the natural world and apply scientific principles to critically analyze experimental evidence and reach conclusions.
Goal 6	The ability to demonstrate an understanding of the natural world and apply scientific principles to reach conclusions.	Goal 6	The ability to recognize historical processes, to identify historical periodization, and to explain historical connections among individuals, groups, and ideas around the world.
Goal 7	The ability to recognize the diverse cultural heritages and other influences which have shaped civilization and how they affect individual and collective human behavior.	Goal 7	The ability to recognize diverse social and cultural practices and to articulate connections between individual behavior and sociocultural processes.
Goal 8	The ability to describe the governing structures and operations of the United States, including the rights and responsibilities of its citizens.	Goal 8	The ability to describe the governing structures and operations of the United States, including the rights and responsibilities of its citizens.
Goal 9	The ability to reason logically and think critically in order to develop problem solving skills and to make informed and responsible choices.	Goal 9	The ability to apply critical thinking skills to assess arguments and solve problems.