COURSE SYLLABUS – SPRING 2022

CHEM 408 ADVANCED ORGANIC CHEMISTRY (SPECTROSCOPY)

Instructor: Dr. Fasil Abebe
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Lecture: 11:00-11:50 am MWF
Laboratory: 1-4pm T
Office Hours: 10:00–11:0 W and F; or by appointment

Course description: Undergraduate course in organic spectroscopy. Modern methods used in structure determination of organic molecules. Topics include separation of mixtures, chemical methods, infrared spectroscopy (IR), mass spectroscopy (MS), nuclear magnetic resonance (NMR) and ultraviolet -visible spectroscopy (UV/vis). Prerequisites: CHEM 203 and CHEM 204 or departmental permission.

Objectives: The course is designed to prepare students for graduate study, as well as position in industrial and government laboratories where state of the art technique and concepts are used. The course also designed students can develop strategies and skills for solving spectroscopy problems.

Text:

- ✓ L. Pavia, G.M. Lampman, and G.S. Kriz, J.R. Vyvyan "Introduction to Spectroscopy", 5th Ed. Cengage Learning 2015.
- ✓ J.C. Gilbert and S.F. Martin "Experimental Organic Chemistry, A Miniscale and Microsclae Approach" 5th ed. Brooks/Cole Cengage learning 2011.
- ✓ "Spectrometric Identification of Organic Compounds" by Silverstein, Wiley.

Policies on Due Dates, Late Work and Make-Up Tests: Assigned work will be due at the beginning of the lecture period on the advertised due date. All late work will automatically lose 10% of its assigned value each day it is late (up to 50%).

If you can not take an exam at its scheduled time, please inform me before the exam date. If an unforeseen emergency or illness results in your missing an exam, it may be possible to take a make-up exam. If a lab period is missed for an acceptable reason, you must arrange to make it up before the next lab period.

Class Participation

Significant class time will be spent in discussion, active learning, in-class problem solving, and discussion on literature. Students will be assigned grades based on their test result, presentation, participation in class activities as well as follow-up questions to be done after class.

Three 50 minutes exams and Final Exams

The three examinations will each cover approximately 1/4 of the course material. The final exam will review the entire course as well as more intensively cover the last 1/4 of the course material. Because scientific knowledge is cumulative, the tests and examinations will always have a

cumulative nature to them. The tests and exams will be mixtures of quantitative chemical problems, short answer questions and short essay questions. Most exam and test questions will be graded primarily for scientific content and your understanding of the concepts involved.

Writing Assignment: You will find an article in the primary literature where spectroscopy (limit yourself to IR, MS, and NMR) has been used to answer a question or solve a problem. Summarize the overall problem and explain how spectroscopy was used to solve the problem. Try to determine why a specific spectroscopic technique was used instead of some other method. Explain why the technique used was suited to address the specific research problem.

Academic Integrity

Academic honesty is expected of students enrolled in this course. Cheating on examinations, unauthorized collaboration, falsification of research data, plagiarism, and undocumented use of materials from any source constitute academic dishonesty and may be grounds for a grade of 'F' in the course and/or disciplinary actions. For additional information, see the university policy manual.

Lecture Rules

a. Participation Policy: You are expected to attend all lecture classes. Class attendance is important since many of the exam questions will be drawn from the class lectures, demonstrations, and discussions. Taking good class notes is essential. Reading the chapter prior to coming to class is also recommended. You are expected to participate in all team project exercises.

b. Course Etiquette: You are expected to be courteous towards the instructor and your classmates. You are expected to be on time for lecture. Cell phones should be turned off during lecture. You should not talk to your classmates while the instruct.

Disability Accommodations

Students with disabilities may request reasonable accommodations through the Morgan State University Disability Service Office by calling call 443-885-4767.

Additional Notes: The instructor reserves the right to modify this syllabus at any time as deemed necessary. Any modifications will be announced as soon as possible. The faculty of the College of SCMNS is committed to the continuous improvement in the quality of instruction. Student input is important and will be obtained at the end of the course.

<u>Required Class Activities</u>

1. Regular attendance at lecture and laboratory sessions
2. Literature assignment
3. Assignments
4. Laboratory reports
5. Independent Project
6. Three 50-minute examinations and a final examination

Final Exam: 20%
Test: 20%
Assignments: 10%
Lab activity, reports, and simulations: 10%
Attendance and class participation: 10%

Grading and Evaluation

Grading Scale: 90-100 A; 80-89 B; 70-79 C; 55-69 D; below 55 F

Discussion Topics

Chapter 1

1. Determination of structure of pure substances:
   1.1 Molecular formula
   1.2 Index of hydrogen deficiency
   1.3 Functional groups and solubility tests

Chapter 2

2. Infrared (IR) Spectroscopy
   2.1 The infrared absorption process
   2.2 Uses of the infrared spectrum
   2.3 The modes of stretching and bending
   2.4 Bond properties and absorption trends
   2.5 The infrared spectrometer
   2.6 Trends in absorption frequencies
   2.7 Preparation of samples for infrared spectrometer
   2.8 Interpretation of spectra
   (Hydrocarbons, Aromatic rings, Alcohols, Ethers, Carbonyl compounds, Amines, Nitro compounds, Nitriles, Halides etc)

Chapter 3

3. Mass spectrometry (MS)
   3.1 Basic principles
   3.2 Molecular weight and molecular formula
   3.3 Ionization Methods
   3.4 Fragmentation and Structural Analysis
   3.4.1 The initial ionization event
   3.4.2 Fundamental fragmentation processes (Stevenson's rule, α-cleavage, Inductive cleavage, Two-bond cleavage, Retro diels-alder cleavage and McLafferty rearrangements)
   3.5 Fragmentation pattern of hydrocarbons
   3.6 Fragmentation pattern of alcohols, phenols, and thiols
   3.7 Fragmentation pattern of ethers and sulfides

3.8 Fragmentation pattern of carbonyl-containing compounds
3.9 Fragmentation pattern of amines
3.10 Fragmentation pattern of alkyl chlorides and alkyl bromides

Chapter 4

4. Nuclear Magnetic Resonance (NMR)
4.1 Nuclear spin states
4.2 Nuclear magnetic moments
4.3 The chemical shift and shielding
4.4 The nuclear magnetic resonance spectrometer
4.5 Magnetic equivalence
4.6 Integrals and integration
4.7 Chemical environment and chemical shift
4.8 Local diamagnetic shielding (Electronegativity effect, hybridization effects and hydrogen bonding)
4.9 Proton NMR
4.10 Spin-spin splitting
4.11 Coupling constant
4.12 Tree diagrams
4.13 Shift reagents
4.14 Decoupling
4.15 Survey of typical ^{1}H NMR Absorptions by Type of Compounds
4.16 How to solve NMR Spectra problems
4.17 Carbon-13 spectra
4.18 Proton-coupled ^{13}C spectra
4.19 Proton-decoupled ^{13}C spectra

Chapter 5

1. Ultraviolet spectroscopy
5.1 The nature of electronic excitations
5.2 The origin of UV band structure
5.3 Principles of absorption spectroscopy
5.4 Instrumentation
5.5 Chromophore
5.6 Effect of conjugation
5.7 The woodward-fieser rules
5.8 Aromatic compounds
5.9 Polynuclear aromatic hydrocarbons and heterocyclic compounds
5.10 Model compound studies