CHEM 220 - Fundamentals of Analytical Chemistry Lecture (Spring 2023)

*Note: this syllabus is subject to change by the instructor. Any changes will be announced in class, by email, and on OAKS*

Co-requisite: CHEM 220L  
Pre-requisites: CHEM 112, 112L, MATH 111 or equivalents

Instructor:  
Dr. Jay G. Forsythe (“Dr. Jay” or “Dr. Forsythe;” he/him)  
Office: SSMB 112  
Phone: 843-953-5052  
Email: forsythejg@cofc.edu

Lecture Time and Location: Tuesday / Thursday, 9:25 – 10:40 AM, SSMB 138 (in person)

Office Hours: Wed 9:00 AM – 12:00 PM (in-person) and other times by email appt (in-person or Zoom)

Final Exam Time and Location: Tuesday May 2, 8:00 – 10:00 AM, SSMB 138 (in person)

Student Learning Outcomes:

- Carry out concentration, titrimetric, equilibrium, and statistical calculations.
- Assess the quality of laboratory data and identify any sources of error.
- Construct and apply calibration curves used in chemical analysis.
- Explain chemical equilibria and its applications and perform appropriate calculations.
- Explain and apply the theory behind quantitative methods and modern instrumentation.
- Select the most appropriate method for a given chemical analysis.
- Demonstrate problem-solving abilities in the area of chemical analysis.

Effects of the COVID-19 Pandemic, Inclement Weather, and/or Other Interruptions of Instruction:

The health and safety of all persons is of utmost importance. Please do not come to class or in-person office hours if you are sick and/or have tested positive for COVID-19. Notes and materials will be posted to our OAKS page. If you need to miss multiple classes, please inform the instructor beforehand. If in-person classes are suspended for any reason in the semester, your instructor will announce a detailed plan for a change in modality to ensure the continuity of learning. All students must have access to a computer equipped with a web camera, microphone, and Internet access. Resources are available to provide students with these essential tools.

Name and Pronoun Statement: Dr. Forsythe will honor your request to be addressed by the name and/or pronouns of your choosing. Please inform him early in the term, via your CoC-issued email account or during office hours. All students are welcome in this class and will be respected at all times.

Communication: Major announcements will be discussed in class and sent via e-mail and/or OAKS. Writing assignments will be edited, uploaded, and graded through the OAKS Dropbox. Grades for individual assignments and tests will be uploaded to OAKS.

Necessary Materials:

- Exploring Chemical Analysis, 5th Edition, Daniel C. Harris (print or digital, whichever you prefer)
- Scientific calculator with log and exponential functions

Optional Materials:

Accommodations for Students with Disabilities: Any student eligible for and needing accommodations because of a disability is requested to speak with the instructor during the first two weeks of class or as soon as the student has been approved for services so that reasonable accommodations can be arranged. Center for Disability Services/SNAP.

Recommended Study Practices: Working (and re-working) book and/or practice problems on OAKS are the best ways to prepare for exams. Book problems will not be collected but are essential in preparing for exams and should be done throughout the course. In particular, OAKS problems should be useful as they are written similar to test questions. It is much more effective to work 30-45 minutes a day than to cram right before the exam. Also, the Student Learning Center (SLC) is a good resource and has science-specific assistance (http://csl.cofc.edu/).

Physical and Mental Health: If you find yourself experiencing physical health issues, please reach out to Student Health Services (843-953-5520). If you find yourself experiencing mental health challenges (anxiety, depression, stressful life events, sleep deprivation, loneliness/homesickness, etc.) please consider reaching out to either the Counseling Center (professional counselors at http://counseling.cofc.edu or 843-953-5640 3rd floor Robert Scott Small) or Students 4 Support (for certified volunteers text "4support" to 839863, visit http://counseling.cofc.edu/cct/index.php, or meet with them in person 3rd floor Stern Center).

Food & Housing Resources: Many students report experiencing food and housing insecurity. If you are facing challenges in securing food (e.g., not being able to afford groceries or get sufficient food to eat every day) and/or housing (such as lacking a safe and stable place to live), please contact the Dean of Students (http://studentaffairs.cofc.edu/about/salt.php). Also, you can go to http://studentaffairs.cofc.edu/student-food-housing-insecurity/index.php to learn about food and housing assistance that is available. In addition, there are several resources on and off campus to help. You can visit the Cougar Pantry in the Stern Center (2nd floor), a student-run food pantry that provides dry-goods and hygiene products at no charge to any student in need. Please also consider reaching out to the instructor if you are comfortable doing so.

Attendance Verification: Only students officially registered (graded or auditing) for this course may attend class. During the week following the drop/add deadline, the instructor will verify student enrollments in this course. Any student appearing on the class roll but determined not to have attended the class even once will be removed.

Honor Code: Lying, cheating, attempted cheating, and plagiarism are violations of our Honor Code that, when suspected, are investigated. Each incident will be examined to determine the degree of deception involved.

Incidents where the instructor determines the student’s actions are related more to misunderstanding will be handled by the instructor. The instructor designs an intervention or assigns a grade reduction to help prevent the student from repeating the error. The response is recorded on a form and signed both by the instructor and the student. It is forwarded to the Dean of Students and placed in the student’s file.

Cases of suspected academic dishonesty will be reported directly by the instructor and/or others having knowledge of the incident to the Dean of Students. A student found responsible by the Honor Board for academic dishonesty will receive a XXF in the course, indicating failure of the course due to academic dishonesty. This status indicator will appear on the student’s transcript for two years after which the student may petition for the XX to be expunged. The F is permanent.

Students can find the complete Honor Code and all related processes in the Student Handbook at: http://deanofstudents.cofc.edu/honor-system/studenthandbook/.
Course Structure / Recommended Book Problems for Practice:

Unit I: Concentration, Error, and Statistical Calculations

- Chapter 1 sections 1.3 and 1.4 (Chemical Concentrations and Preparing Solutions)
  - Recommended problems: 1-9, 1-10, 1-11, 1-12, 1-13, 1-14, 1-15, 1-17, 1-20

- Chapters 3 and 4 thru section 4.5 (Math Toolkit and Statistics: skip section 4-6)
  - Recommended problems: 3-1, 3-2, 3-3, 3-4, 3-5, 3-9, 3-11, 3-12, 3-13, 3-14, 3-15, 3-16, 3-20, 4-1, 4-2, 4-4, 4-5, 4-6, 4-7, 4-8, 4-9, 4-11, 4-12, 4-13, 4-14, 4-15

Unit II: Calibration and Titrations

- Chapter 4 sections 4.6 - 4.7 and Chapter 5 (Calibration Curves)
  - Recommended problems: 4-19 (use Excel), 5-4, 5-14, 5-18, 5-22

- Chapter 6 (Titrations: incorporate section 1-5 with 6-4; skip sections 6-5 and 6-6)
  - Recommended problems: 1-27, 1-28, 1-29, 1-31, 6-1, 6-5, 6-6, 6-12, 6-14, 6-15, 6-17, 6-18, 6-20

Unit III: Acid/Base Chemistry

- Chapter 8 (Acids/Bases)
  - Recommended problems: 8-1, 8-3, 8-4, 8-9, 8-11, 8-13, 8-14, 8-15, 8-16, 8-17, 8-18, 8-19, 8-21, 8-22, 8-23, 8-28, 8-32

- Chapter 9 (Buffers)
  - Recommended problems: 9-1, 9-2, 9-4, 9-6, 9-7, 9-8, 9-9, 9-12, 9-13, 9-14, 9-15, 9-16, 9-20, 9-22

- Chapter 10 (Acid and Base Titrations: skip derivatives in 10-4, skip section 10-6)
  - Recommended problems: 10-1, 10-2, 10-3, 10-6, 10-7, 10-8, 10-9, 10-11, 10-12, 10-13, 10-14, 10-15, 10-16, 10-17, 10-20, 10-23, 10-27

- Chapter 11 (Polyprotic Acids)
  - Recommended problems: 11-2, 11-3, 11-7, 11-9, 11-10, 11-12, 11-13, 11-17, 11-19, 11-20, 11-25, 11-26

Unit IV: Systematic Treatment of Equilibrium and Electrochemistry

- Chapter 12 (Equilibrium: skip Debye-Huckel equation in 12-2)
  - Recommended problems: 12-1, 12-2, 12-6, 12-7, 12-8, 12-9, 12-11, 12-16, 12-18, 12-22, 12-23, 12-24, 12-26, 12-29, 12-36, 12-37, 12-38

- Chapters 14 and 15 (Electrochemistry: skip section 15-5)
  - Recommended problems: 14-1, 14-2, 14-3, 14-4, 14-8, 14-9, 14-10, 14-11, 14-12, 14-14, 14-16, 14-17, 14-20, 14-23, 14-24, 14-25, 15-1, 15-2, 15-11

Unit V: Spectroscopy, Chromatography, and Mass Spectrometry

- Chapters 18 – 20 (Spectroscopy: skip sections 19-1 thru 19-3, 20-2, and 20-4 thru 20-6)
  - Recommended problems: 18-1, 18-2, 18-3, 18-4, 18-5, 18-7, 18-12, 18-14, 18-15, 18-19

- Chapters 21 and 22 (Chromatography: skip sections 22-2 and 22-4)
  - Recommended problems: 21-1, 21-2, 21-3, 21-4, 21-7, 21-11, 21-20, 21-22, 22-2, 22-5
Assessment:

Points for assignments are listed below. The lowest exam grade will be replaced by the ACS Final if higher.

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Points</th>
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<tbody>
<tr>
<td>Problem Sets 1-5</td>
<td>100 pts total (20 pts each)</td>
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<tr>
<td>Writing Assignment 1</td>
<td>30 pts</td>
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<tr>
<td>Writing Assignment 2</td>
<td>35 pts</td>
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<tr>
<td>Writing Assignment 3</td>
<td>35 pts</td>
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<tr>
<td>Units 1-2 Exam</td>
<td>100 pts</td>
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<tr>
<td>Unit 3 Exam</td>
<td>100 pts</td>
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<tr>
<td>Unit 4 Exam</td>
<td>100 pts</td>
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<tr>
<td>Unit 5 Exam</td>
<td>100 pts</td>
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<tr>
<td>ACS Final Exam</td>
<td>100 pts</td>
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<tr>
<td><strong>Total</strong></td>
<td>700 pts</td>
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Final grades will be based on the below scale. The instructor has the right to adjust grades up but may not.

- A 651 – 700 pts
- A- 650 – 627 pts
- B+ 626 – 606 pts
- B 605 – 577 pts
- B- 576 – 557 pts
- C+ 556 – 536 pts
- C 535 – 508 pts
- C- 507 – 487 pts
- D+ 486 – 466 pts
- D 465 – 438 pts
- D- 437 – 413 pts
- F 412 – 0 pts

Writing Assignments:

Documents should be ≤ 1 page, single spaced. Be sure to include a proper bibliographic citation of your article. These will be graded on:

- Content (accuracy and clarity)
- Writing style and grammar
- Citation(s) in ACS format (see [http://library.williams.edu/citing/styles/acs.php](http://library.williams.edu/citing/styles/acs.php))

**Assignment 1:** Find an article in *Chemical and Engineering News* ([http://cen.acs.org](http://cen.acs.org); you may need to be on campus to access this) of interest to you that involves analytical or environmental chemistry (examples: a new innovation, a real-world problem to be solved, employment opportunities, or government regulations). Discuss why you selected the article, and include a proper bibliographic citation.

1. Briefly summarize the article.
2. Who is the intended audience for this article? How does the writing style/content reflect that?
3. What new chemistry concepts did you learn? If you did not learn new chemistry, then what was reinforced for you?

Be sure to include a proper bibliographic citation of your article.

**Assignment 2:** You will be provided a journal article and will address the following points:

1. Summarize the article, as with previous ones.
2. Who is the intended audience for this article? How does the writing style/content reflect that?
3. Find and discuss terms and concepts in the paper that we have gone over in class this semester.
4. Discuss strengths and weaknesses of the paper and/or the presented research.
**Assignment 3**: Find an article in one of the following journals that describes a new chemical analysis: *Analytical Chemistry* or *Environmental Science and Technology*. *NOTE*: You may need to be on campus to access these journals. Be sure to include a proper bibliographic citation.

1. Summarize the method employed and the results that were found.
2. Describe how well you understood the article (or not). What, if anything, was confusing?
3. What would you do as an analytical chemist to improve the procedure?

*Anal. Chem.* link: [http://pubs.acs.org/journal/ancham](http://pubs.acs.org/journal/ancham)

*Environ. Sci. & Tech.* link: [http://pubs.acs.org/journal/esthag](http://pubs.acs.org/journal/esthag)

**Tentative Calendar:**

Problem Sets and Writing Assignments will be uploaded to OAKS before the start of class (9:25 AM) for the dates below. *Test dates are unlikely to change, but material may change* depending on lecture pace.

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Due Date</th>
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<tbody>
<tr>
<td>Problem Set 1 (Unit 1a. Concentrations)</td>
<td>Thursday, January 19</td>
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<tr>
<td>Problem Set 2 (Unit 1b/2. Error, Statistics, Calibration)</td>
<td>Tuesday, January 31</td>
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<tr>
<td><strong>Units I/II Exam</strong></td>
<td><strong>Thursday, February 2 (in-class)</strong></td>
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<tr>
<td>Writing Assignment 1 (<em>C&amp;E News</em>)</td>
<td>Thursday, February 9</td>
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<tr>
<td>Problem Set 3 (Acids and Bases)</td>
<td>Thursday, February 23</td>
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<tr>
<td><strong>Unit III Exam</strong></td>
<td><strong>Thursday, March 2 (in-class)</strong></td>
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<tr>
<td>Spring Break (no class)</td>
<td>March 6-10</td>
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<tr>
<td>Writing Assignment 2 (Dr. Forsythe’s assigned paper)</td>
<td>Thursday, March 16</td>
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<td>Last Day to Withdraw From Class</td>
<td>Friday, March 24</td>
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<tr>
<td>Problem Set 4 (Equilibrium and Electrochemistry)</td>
<td>Tuesday, March 28</td>
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<tr>
<td><strong>Unit IV Exam</strong></td>
<td><strong>Tuesday, April 4 (in-class)</strong></td>
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<tr>
<td>Writing Assignment 3 (your choice of article)</td>
<td>Thursday, April 13</td>
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<tr>
<td>Problem Set 5 (Spectroscopy, Chromatography, MS)</td>
<td>Thursday, April 20</td>
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<tr>
<td><strong>Unit V Exam</strong></td>
<td><strong>Tuesday, April 25 (in-class)</strong></td>
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<tr>
<td>Reading Day</td>
<td>Thursday, April 27</td>
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<tr>
<td><strong>ACS Final Exam</strong></td>
<td><strong>Tuesday, May 2 (8:00 AM)</strong></td>
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