CEE 471/671
CEN 461/661
ENVIRONMENTAL CHEMISTRY AND ANALYSIS

TTh 2:00 – 3:20 PM

Link 152

Dr. Svetoslava Todorova

SPRING 2026

This is an introductory course in water chemistry covering topics in natural and built environmental systems – thermodynamics and kinetics of reactions; acid-base chemistry; carbonate chemistry; behavior of major elements in aquatic ecosystems. This course is required for undergraduate environmental engineering students and master's students in environmental engineering and science. It can be used as an elective in other disciplines, such as Earth Sciences, Chemistry, Chemical Engineering, and Paper and Pulp Engineering. The course was designed as a high-structured course.

Lectures and Laboratory Exercises

As a high-structured course, each module includes pre-assigned reading before each module, followed by interactive group work during class time and in-class knowledge checks. Similarly, each laboratory exercise is preceded by required preparatory reading and a pre-lab quiz. Laboratory reports are scheduled during the lecture periods. Details are provided on p. 3.

Assessment and Feedback

In the classroom. Student–instructor interaction will occur during class time through individual exercises, small-group problem solving, and full-class discussions designed to reinforce key concepts. When an activity includes an assessment component, it may require either an individual or paired submission. These activities are intended to enhance students' sense of belonging and deepen their understanding of the material. All activities are intentionally structured around specific learning outcomes (see p. 2 for Syracuse University Shared Competencies, ABET outcomes, and Course Outcomes).

Outside of the classroom. You are encouraged to practice the material and assess their understanding using homework assignments. These assignments help you develop skills for independent work and future professional success. Utilize the provided open hours to meet regularly with the instructor and the teaching assistant to review concepts and prepare for homework submissions. Homework assignments will be distributed on Thursday and will be due one week from the assigned date.

INSTRUCTOR

Dr. Svetoslava Todorova

Mailbox: 151 Link Hall

Office Location: 335C Link Hall

Office Hours: TTh 3:30- 4:30 PM and by appointment

Email: stodorov@syr.edu

TEACHING ASSISTANTS

Mr. Zekun Xin

Mailbox: 151 Link Hall

Office Hours Location: Link 269

Office Hours: TW 5:00 -6:00 PM

Email: zxino2@syr.edu

SUGGESTED TEXTBOOKS

Benjamin, M.M. Water Chemistry. 2nd edition. McGraw-Hill, New York, NY. 2014.

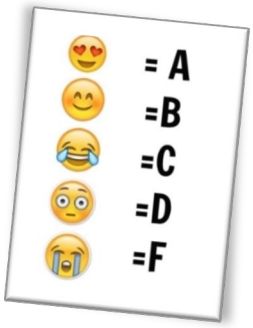
Brezonik, P. and Arnold, W. Water Chemistry: an Introduction to the Chemistry of Natural and Engineered Aquatic Systems. Oxford University Press, New York, NY,2022.

Evaluation and Grading

There will be one in-class exam (midterm) and one take-home exam (final) during the semester.

A weighted average grade will be calculated based on the following:

- 20% problem sets,
- 5% pre-lab quizzes
- 25% lab reports
- 25% mid-term exam
- 25% final exam



Final grades will be assigned as follows:

A	93-100%	**C+**	77-79.99%
A-	90-92.99%	**C**	73-76.99%
B+	87-89.99%	**C-**	70-72.99%
B	83-86.99%	**D**	60-69.99%
B-	80-82.99%	**F**	<59.99%

Students are expected to complete assignments on time. In an event of a family emergency, please, contact me to arrange for extension of your assignments.

GRADUATE STUDENTS

Homework assignments, midterm and the final exam for the graduate students will have either different or additional problems. For the final exam, graduate students will be given a dataset to analyze and write a short scientific paper on the topic. This dataset will serve as a take-home **individual exam**!

Syracuse University Shared Competencies

Syracuse University's created university-wide learning goals that aim to help undergraduate students develop competencies in six major areas - Ethics, Integrity, and Commitment to Diversity and Inclusion (EICDI); Critical and Creative Thinking (CCT), Scientific Inquiry and Research Skills (SIRS), Civic and Global Responsibility (CGR), Communication Skills, and Information Literacy and Technological Agility (ILTA). This course helps students develop skills in SIRS.

ABET Engineering Criteria

Engineering programs must demonstrate that their graduates have and ability to:

1. identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. communicate effectively with a range of audiences
4. recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. acquire and apply new knowledge as needed, using appropriate learning strategies.

Course Outcomes

At the completion of the course, you will be able to:

1. apply fundamental concepts of chemistry in environmental solutions;
2. understand errors and uncertainty in laboratory chemical analysis (ABET 6, SIRS);
3. develop the ability to evaluate and solve complex problems in environmental chemistry, involving multiple phases and/or components (ABET 1);
4. build computer skills, particularly in data visualization and analysis (ABET 6);
5. develop scientific writing skills (ABET 3, SIRS);
6. develop critical thinking and critically analyze scientific literature (ABET 6, SIRS);
7. build teamwork skills through group field and laboratory work (ABET 5).

Laboratory Exercises

The laboratory portion of this course provides the opportunity for "hands-on" explorations of a variety of chemical principles. The lab experiments have been chosen to complement the course material and to stimulate learning. Some labs will relate directly to topics discussed in class, while others will illustrate further applications or related ideas.

Students will perform four (4) laboratory exercises. **The labs will be in the Teaching Lab, Link 405**.

Your participation in the laboratory exercises is required because it is impossible to make them up.

Laboratory Groups

Laboratory groups will consist of two to three (2-3) students. You are free to choose your group members as long as they are from your academic level. Undergraduate students will be in a group with undergraduate students. Graduate students will be in a group with graduate students.

LABORATORY ANALYSIS

Standardization and Analytical Precision (January 22): you will learn the concept and practice of standardization and quality control. An ion-specific electrode will be used to determine copper concentrations in aqueous solutions. You will explore the precision, reproducibility, and uncertainty of laboratory chemical analyses.

Experimental Estimation of Equilibrium Constants (February 12): you will learn how to experimentally determine equilibrium constants using a cupric ion-selective electrode. By studying the extent of formation of aqueous copper complexes and free cupric ion, you will be able to calculate the equilibrium constant for the chemical reaction.

Acid-base Titrations (March 5): you will learn how to determine equivalence points and acid dissociation constants for monoprotic and polyprotic acids/bases and will understand how the degree of dissociation affects the determination of these two parameters. A pH meter and acid-base indicator solution will be used.

Alkalinity and Carbonate System (April 9): you will become familiar with the concept of alkalinity and the chemistry of the carbonate buffering system. The concentrations of components of the carbonate system will be calculated from alkalinity titration measurements. Samples from Onondaga Lake watershed will be used to construct an alkalinity budget for the lake.

FIRST LAB REPORT

You have the option to revise and resubmit your first laboratory report. It is your decision whether to do so. Any revised report will be awarded 5 points less than the maximum to discourage the initial submission of "rough draft" lab reports.

Laboratory Reports

There will be some brief classroom discussion about each experiment, but each group will be responsible for gathering the technical resources needed for the completion of the assignment (consult with the textbooks or other references for information on the topic).

Students are encouraged to work with their group members on laboratory analysis (results) and the methods portion of the reports. ***Graduate students are submitting individual laboratory reports. Undergraduate students submit group reports except for the first lab report.*** Laboratory reports will be due two weeks from the completion of the experimental work.

Structure of the Lab Reports

The typical structure of the lab reports for this class follows that of a scientific publication:

- Introduction and objectives
- Materials and methods
- Results
- Discussion
- Conclusions

Introduction provides relevant context information and gives enough background information to the reader about the topic and the experiment. Methods state the laboratory procedure the way your group performed it. Results present factual statements about the outcome of the experiment, while the discussion explains the result and their meaning. You restate the primary findings in the conclusions.

POLICIES

ACADEMIC INTEGRITY

As a pre-eminent and inclusive student-focused research institution, Syracuse University considers academic integrity at the forefront of learning, serving as a core value and guiding pillar of education. Syracuse University's Academic Integrity Policy provides students with the necessary guidelines to complete academic work with integrity throughout their studies. You are required to uphold both course-specific and university-wide academic integrity expectations such as crediting your sources, doing your own work, communicating honestly, and supporting academic integrity. The full Syracuse University Academic Integrity Policy can be found by visiting class.syr/edu, selecting, "Academic Integrity," and "Expectations and Policy."

Upholding Academic Integrity includes the protection of faculty's intellectual property. You should not upload, distribute, or share instructors' course materials, including presentations, assignments, exams, or other evaluative materials without permission. Using websites that charge fees or require uploading of course material (e.g., Chegg, Course Hero) to obtain exam solutions or assignments completed by others, which are then presented as your own violates academic integrity expectations in this course and may be classified as a Level 3 violation.

Artificial Intelligence. Based on the specific learning outcomes and assignments in this course, artificial intelligence may be permitted on some assignments. Check each assignment, quiz, or exam instructions for more information about whether and to what extent artificial intelligence tools may be permitted. If no instructions are provided for a specific assignment, then no use of any AI tool is permitted. Any AI use beyond that which is detailed in course assignments is explicitly prohibited except when documented permission is granted.

Turn-It-In. When appropriate, this class will use the plagiarism detection and prevention system Turn-it-in, which compares submitted documents against documents on the Internet and against student papers submitted to Turnitin at Syracuse University and at other colleges and universities. You will have the option to submit your papers to Turnitin to check that all sources you use have been properly acknowledged and cited before you submit the assignment. Note that papers submitted to Turn-it-in become part of the Turnitin.com reference database solely for the purpose of detecting plagiarism of future assignments.

All academic integrity expectations that apply to in-person assignments, quizzes, and exams also apply online. If you are found in violation of the policy, you will be subject to grade sanctions determined by me and non-grade sanctions determined by the ECS College. You may not drop or withdraw from the course if you face a suspected violation. **Any established violation in this course may result in course failure regardless of violation level**.

ATTENDANCE

Attendance in classes is expected in all courses at Syracuse University. I am federally required to promptly notify the university of students who do not attend or cease to attend my class. I will use Early-Semester Progress Reports and Mid-Semester Progress Reports in Orange SUccess to alert the Registrar and Financial Aid Office on non-attendance.

If you are unable to participate in-person for an extended period of time (48 hours or more), please request absence notification from ECS Records Office or through Student Outreach and Support office. As an instructor for the course, I will be notified via the "Absence Notification" flag in Orange SUccess. For absences lasting less than 48 hours, reach out to me to discuss academic arrangements.

Barnes Center at the Arch (Health, Counseling, etc.) staff does not provide medical excuse notes for students. When Barnes Center staff determine it is medically necessary to remove a student from classes, they will coordinate with Student Outreach and Support case management staff to provide appropriate notification to faculty through Orange Success. Additional information may be found at Absence Notifications - Student Outreach and Support – Syracuse University.

DIVERSITY, INCLUSION, DISABILITIES

Syracuse University values diversity and inclusion; we are committed to a climate of mutual respect and full participation. **My goal is to create a learning environment that is equitable, inclusive and welcoming.** If there are aspects of my instruction or design of this course that result in barriers to your inclusion and full participation in this course, I invite you to contact me to discuss strategies and/or accommodations that will be essential to your success. You can also reach out to the Center for Disability Resources (CDR) and discuss disability-accommodations or to register with CDR via phonel (315) 443-4498 or email disabilityresources@syr.edu.

The University does not discriminate and prohibits harassment or discrimination

related to any protected category including creed, ethnicity, citizenship, sexual orientation, national origin, sex, gender, pregnancy, disability, marital status, age, race, color, veteran status, military status, religion, sexual orientation, domestic violence status, genetic information, gender identity, gender expression or perceived gender. Any complaint of discrimination or harassment related to any of these protected bases should be reported to Sheila Johnson-Willis, the University's Chief Equal Opportunity & Title IX Officer (005 Steele Hall, Syracuse University, Syracuse, NY 13244-1120; by email: titleix@syr.edu; or by telephone: 315-443-0211). **If you have a name and/or set of pronouns that differ from those that appear in your official SU records, please let me know.**

HEALTH AND WELLNESS

Mental health and overall well-being are significant predictors of academic success. As such it is essential that during your college experience you develop the skills and resources effectively to navigate stress, anxiety, depression, and other mental health concerns. Please familiarize yourself with the range of resources at the Barnes Center and seek out support for mental health concerns as needed https://ese.syr.edu/bewell/. Counseling services are available at 315-443-8000.

RELIGIOUS OBSERVANCES

Syracuse University's religious observances policy recognizes the diversity of faiths represented among the campus community and protects the rights of students, faculty, and staff to observe religious holydays according to their tradition. Under the policy, students are provided an opportunity to make up any examination, study, or work requirements that may be missed due to a religious observance provided they notify their instructors **before the end of the second week of classes**. Eenter your observances in MySlice under Student Services/Enrollment/My Religious Observances/Add a Notification.

COMMUNICATION

Email. I welcome email questions and comments. Syracuse Umiversity has established email as a primary vehicle for official communication. An official syr.edu email address is assigned by ITS for each registered student and will be used for educational dialogue with the students in this class. If you use different primary e-mail, forward your syr.edu email address. When you write to me, you should compose your email as you would any piece of professional correspondence. **On the subject line indicate "{section} {number} – {purpose}"**. E-mails will be answered between 24 – 36 hours, in the order received, excluding weekends. Plan accordingly!

MS Teams. I use MS Teams for vitrual communication. MSTeams allows for multiple participant to be on the meeting; file sharing and white board are also available features. Make sure to install the software on an electronic devise that will allow you to share screen with files. If you download the MSTeams app on your phone be aware that it sometimes gives issues with the video and sound.

Cell Phones. The use of cell phones and other electronic devices that do not aid your comprehension of the material are **not allowed** in class. Keep the devices away from you to allow you to focus during class (unless otherwise instructed during class!).

Office Hours. Office hours are the designated time that I set aside each week specifically for meeting with you. These hours are your chance to talk to me about course material or chat so we can get to know each other. I am also happy to meet with you outside of the designated time, but for that you need to schedule an appointment in advance. We can also meet on MSTeams.

It is easiest for everyone if you talk to me as early as possible about any issues or questions. Instead of waiting until you get a bad grade in an exam and asking how you can "make up" for it, come talk to me before the exam and ask questions about the material. That way, we can walk through the material together and I can explain a course concept in a different way. Similarly, rather than waiting until the end of the semester to tell me about issues that prevented you from focusing on school,

INTELLECTUAL PROPERTY

Original class materials (handouts, assignments, tests, etc.) and recordings of class sessions are copyrighted and the intellectual property of the course instructor. You may download these materials for your use in this class. However, you may not provide these materials to other parties (e.g., web sites, social media, other students) without permission. Doing so is **a violation of intellectual property law** and of the Academic Integrity Policy.

Schedule of Activities

Topic	Date	Laboratory Exercises	Learning Outcomes	Location
Introduction – syllabus and projects	1/13			Link 152
Stoichiometry	1/15			Link 152
Quantitative Analysis (*small group work; whole class discussion*)	1/20		ABET SO1; CO#2	Link 152
	1/22	Analytical Precision	SIRS; ABET SO3, 5, and 6; CO #2, 4 and 5	Link 405
Reading and Critiquing Scientific Articles (*small group work; whole class discussion*)	1/27		SIRS; ABET SO4 and 7; CO #3 and 6	Link 152
Balancing Redox Reactions (MB Ch.12, *individual work, small group discussion*)	1/29		ABET SO1 and 3; CO#2	Link 152
Reaction Thermodynamics (MB and AB, Ch.4)	2/3		ABET SO1; CO #1 and 3	Link 152
Activity Concentration Relationships (AB Ch.4)	2/5		ABET SO1; CO #1 and 3	Link 152
Equilibrium Calculations (MB Ch.3 and 4)	2/10		ABET SO1; CO #1 and 3	Link 152
	2/12	Experimental Estimation of Equilibrium Constants	SIRS; ABET SO3, 5, and 6; CO #2, 4 and 5	Link 405
Solving Ionic Equilibria Problems (*small group work; whole class discussion*)	2/17		ABET SO1 and 3; CO #1 and 3	Link 152
Solving Ionic Equilibria Problems (*individual work; small group discussion*)	2/19		ABET SO1 and 3; CO #1 and 3	Link 152
Acid-base Reactions (AB Ch.8, MB Ch.5)	2/24		ABET SO1; CO #1 and 3	Link 152
Developing log C-pH diagrams (MB Ch.6)(*small group work; whole class discussion*)	2/26		ABET SO1 and 3; CO #1 and 3	Link 152

Solving Problems with log C-pH diagrams *(individual work, small group discussion)*	3/3		ABET SO1 and 3;CO #1 and 3	Link 152
	3/5	Acid-base Titrations	SIRS; ABET SO3, 5, and 6; CO #2, 4 and 5	Link 405
Spring Break – no class	3/10		-	Link 152
Spring Break – no class	3/12		-	Link 152
Review for Midterm	3/17		-	Link 152
Midterm: thermodynamics, equilibrium calculations, acid-base reactions	**3/19**		-	Link 152
The Carbonate System *(small group work)*	3/24		ABET SO1 and 3;CO #1 and 3	Link 152
Solving Carbonate System Problems *(individual work, small group discussion)*	3/26		ABET SO1, 2 and 3;CO #1 and 3	Link 152
Titrations (MB Ch.8)	3/31		ABET SO1 and 3;CO #1 and 3	Link 152
Alkalinity (AB Ch.8, MB Ch.6)	4/2		ABET SO1 and 2;CO #1 and 3	Link 152
Solving Alkalinity Problems (*small group work; whole class discussion*)	4/7		ABET SO1,2 and 3; CO #1 and 3	Link 152
	4/9	Alkalinity and the Carbonate System	SIRS; ABET SO3, 5, and 6; CO #2, 4 and 5	Link 405
Solving Alkalinity Problems (*individual work; small group discussion*)	4/14		ABET SO1, 2 and 3; CO #1 and 3	Link 152
Reaction Kinetics (MB, Ch. 3)	4/16		ABET SO1;CO #1	Link 152
Application of Reaction Kinetics -Dissolved oxygen (AB Ch. 12) (*small group work; whole class discussion*)	4/21		ABET SO1,2 and 3; CO #1 and 3	Link 152
Application of Reaction Kinetics – Fate of Pollutants *(whole class work and discussion)*	4/23		ABET SO1, 2 and 3; CO #1 and 3	Link 152
Final Exam per Registrar **Take-home Exam for Graduate Students**	**5/1**		**10:15 AM -12:15 PM** **Send over email by Midnight on May 5**	

NOTES

Remember

Lab 1: Jan 22

Lab 2: Feb 12

Lab 3: Mar 5

Lab 4: Apr 9

Midterm: Mar 19

Final Exam: May 1

Dr. Svetoslava Todorova
335C Link Hall
stodorov@syr.edu