CHEM 421: Advanced Topics in Physical Chemistry

Winter 2026

Course Information

General Course Information

Course: CHEM 421
Course title: Advanced Topics in Physical Chemistry
Instructor: Dr. Taleana Huff (taleana.huff@queensu.ca)
Office Hours: By appointment. Just send me an email! My calendar is generally up to date on Teams.
Pre-requisites: CHEM 313 or PHYS 345 (Quantum Mechanics)
Co-requisite: CHEM 322
Semester and year: Winter 2026
Number of credits: 3 credits
Learning hours: 110-130 learning hours
Modality (on campus, blended, or online): On campus
Classroom Location: [redacted]
Lecture Times (Jan 5-Apr 6, 2026):
[redacted]
Last day to drop: Jan 16, 2026 (full refund), Jan 31 (50% refund)
Holidays with no lecture: Feb 16-20th (reading week).
Classroom accessibility: Please reach out to me with accessibility concerns so I can facilitate them.

Course Description (mandatory)

This course is intended to bridge fundamental physics and chemistry principles with advanced methods used to measure the structural and electronic character of molecules and surfaces. More specifically, we will cover the derivation of band structures followed by tying those fundamental concepts into their application in methods like: X-ray adsorption spectroscopy, x-ray photoelectron spectroscopy, diffraction methods, electron microscopy, scanning probe microscopy, and surface-specific methods.

Topics

Week	Module	Topic
1	Atomic and Electronic Structure of Solids	Molecular Bonding to Solids
2	Atomic and Electronic Structure of Solids 2	3D Band Diagrams and what they mean: optical properties, conductivity, etc.
3	X-Ray Methods 1	Radiation sources, X-ray adsorption Methods

4	X-Ray Methods 2	X-ray photoelectron spectroscopy and Auger
5	Diffraction Methods	X-ray, Neutron, and Electron diffraction
6	Electron Microscopy Methods	TEM, SEM, STEM, EDS, EELS
7	Interface/Surface Specific Methods	Surface Science Fundamentals, TPD, LEED, SERS, Ellipsometry
8	Scanning Probe Methods STM	Scanning Tunnelling Microscopy
9	Scanning Probe Methods AFM	Atomic Force Microscopy
10	Ultra-fast/time-resolved methods	Pump probe, XFELs
11	Final Project -- Written	Self-Chosen Topic – See "Descriptions of Learning Activities" below.
12	Final Project -- Presentations	Self-Chosen Topic

Course Learning Outcomes (mandatory)

On successful completion of this course, students will be able to:

1. Explain the physical principles underlying electronic and structural characterization techniques.
2. Interpret spectroscopic and microscopic measurements.
3. Compare the strengths and limitations of different characterization methods for specific chemical, surface, and materials questions.
4. Perform quantitative data analysis on real or simulated datasets.
5. Evaluate the primary literature and summarize contemporary advances in electronic and structural characterization.
6. Know what techniques exist and how they are used in industry and research.

Important University Dates

Please visit the Faculty of Arts and Sciences Sessional Dates website for all academic deadlines.

Inclusion

Land Acknowledgement

The territory that Queen's University occupies is included in the Dish with One Spoon Wampum Belt Covenant, an agreement between the Iroquois Confederacy and the Confederacy of the Ojibwe and Allied Nations to peaceably share and care for the resources around the Great Lakes. The Kingston Indigenous community continues to reflect the area's Anishinaabek and Haudenosaunee roots. There is also a significant Métis community as well as First Peoples from other Nations across Turtle Island present here today.

Equity, Diversity, and Inclusivity Statement

Science is at its best when it is shaped by many perspectives. Diversifying the STEM community at every level strengthens science—not only because it is the right thing to do, but because scientific progress is most powerful when it draws from the full range of human creativity and experience. In this class, we will actively work together to counter STEM's historically exclusionary legacy. Every student, regardless of background, identity, or lived experience, is welcome here and deserves the opportunity to thrive. You are welcome here.

Equity and inclusion are not boxes to be checked, but ongoing processes of learning, reflection, and action. I am not an expert in social justice or equity studies, but I listen to those who are, regularly update my training when possible, and integrate that learning into my teaching and the classroom environment. Just as lab safety is a continual responsibility in chemistry, so too is the creation of an equitable, inclusive, and accessible learning space. You can expect that I will work to promote this ideal in every aspect of my classroom. Students are similarly encouraged to contribute to a more inclusive scientific community—whether by participating in outreach, supporting peers, engaging with campus EDIA initiatives, or fostering conversations about mental health, belonging, and equity in STM.

Together, we can help build a classroom culture where everyone feels that they belong, and where scientific curiosity, creativity, and respect are inseparable.

Building a Classroom Community

University is a place to share, question, and challenge ideas. Each student brings a different set of lived experiences. You can help to create a safer, more respectful classroom community for learners by following these guidelines:

- Make a personal commitment to learn about, understand, and support your peers.
- Assume the best of others and expect the best of them.
- Recognize and value the experiences, abilities, and knowledge each person brings to the course.
- Acknowledge the impact of oppression on other people's lives and make sure your words and tone are respectful and inclusive.
- Encourage others to develop and share their ideas.
- Pay close attention to what your peers say/write before you respond. Think through and re-read what you have written before you post online or send your comments to others.
- Be open to having your ideas challenged and challenge others with the intent of facilitating growth.
- Look for opportunities to agree with one another, building on and intentionally referencing peers' thoughts and ideas; disagree with ideas without making personal attacks, demeaning, or embarrassing others.
- Speak and interact respectfully both in written and oral communication with the professor and your classmates.

I reserve the right as the instructor to remove up to 5% of your annual grade for a lack of professionalism in the above guidelines. Extreme abuse will be assessed for academic integrity violation.

Fostering Accessibility

All of us have a shared responsibility for reducing barriers to learning and fostering accessibility and promoting meaningful inclusion of those with disabilities. The Accessibility Hub at Queen's University's Human Rights & Equity Office offer a host of tutorials that provide us all with practical tips for:

- creating accessible documents, e.g., to submit to your teaching team or share with peers in peer feedback activities/in a presentation,
- emails, e.g., while communicating with group members or your teaching team, and
- meeting practices (e.g., in tutorials/labs/seminars or virtual meetings.

Name/Pronoun

If, for whatever reason, you wish to change how your name appears in onQ and/or on class lists, please follow these steps. You may also use this process to add your pronouns to the appearance of your name.

1. Log into SOLUS.
2. Click on Personal Information tab.
3. Click on the Names tab
4. Click on the Add New Name tab
5. Choose Preferred from the Name Type drop down menu
6. Enter the name you would like to appear in onQ and/or on class lists.
7. Click Save.

Please allow 24 to 48 hours for your name to be registered within the system. If you have further questions or concerns, please contact ITS at Queen's University.

Course Materials & Technologies

Recommended (not Required!) Course Textbooks

Course Textbooks	Edition(s)	Publisher	For Purchase	Cost	At Queen's Library?
Solid State Physics – Ashcroft/Mermin	Any	Saunders College	Amazon, Queen's Bookstore, other resources	$50	Yes
Physical Chemistry P. Atkins	7^{th} to 8^{th} Addition	W.H. Freeman and Company	Amazon, Queen's Bookstore, other resources	$25	Yes

Many of the slides for this course were inspired by online lectures or resources, which will be cited as appropriate at the bottom of slides and are all free and publicly available resources.

This course uses QnQ to distribute material, collect non-proctored assessments, and make announcements. Make sure that you have access to the QnQ page for this course.

Privacy: Be aware that your independent use of the website(s), programs, and/or application(s) used in this course*, beyond what is required,* is subject to their terms of use and privacy policy. You are encouraged to review the applicable privacy statements before using the site. Please see below.

Accessibility: Queen's University is committed to developing courses that are accessible. For further information on accessibility compliance of the website(s), program(s) application(s) used in the course, please consult the links below.

Notice of Recording (Mandatory for online and if relevant blended courses)

While the course is intended to be in person, it is possible some classes will be delivered through Zoom and/or Teams video conferencing platforms supported by the University. Steps have been taken by the University to configure these platforms in a secure manner. Classes may be recorded with video and audio (and, in some cases, transcription) and may be made available to students in the course for the duration of the term. The recordings may capture your name, image or voice through the video and audio recordings. By attending these live classes, you are consenting to the collection of this information for the purposes of administering the class and associated coursework. If you are concerned about the collection of your name and other personal information in the class, please contact the course instructor to identify possible alternatives.

To learn more about how your personal information is collected, used and disclosed by Queen's University, please see the Notice of Collection, Use and Disclosure of Personal Information.

Copyright of Course Material

Course materials created by the course instructor, including all slides, presentations, handouts, tests, exams, and other similar course materials, are the intellectual property of the instructor. It is a departure from academic integrity to distribute, publicly post, sell or otherwise disseminate an instructor's course materials or to provide an instructor's course materials to anyone else for distribution, posting, sale or other means of dissemination, without the instructor's express consent. A student who engages in such conduct may be subject to penalty for a departure from academic integrity and may also face adverse legal consequences for infringement of intellectual property rights.

Communication

Questions about the Course and Contacting the Teaching Team

If you have questions about the course material or administration, please contact the instructor directly. Email works best, and every effort will be made to answer the email within a business day of receipt.

Queen's Email

The university communicates with students via Queen's email and QnQ. Please check both regularly to ensure you do not miss important information related to your course.

Course Feedback

At various points during the course, you may be asked to take part in a variety of feedback activities, such as surveys and questionnaires. This feedback enables the teaching team to improve the course. All surveys are anonymous and are directly related to activities, assessments, and other course material.

Assessments

Weighting and Alignment with Course Learning Outcomes (CLOs) -Mandatory

Assessment	Alignment with CLOs	Anticipated Due Date (finalized dates announced in class)	Weighting
Assignment 1	1	[redacted]	6%
Assignment 2	1	[redacted]	6%
Assignment 3	1-6	[redacted]	6%
Assignment 4	1-6	[redacted]	6%
Assignment 5	1-6	[redacted]	6%
Assignment 6	1-6	[redacted]	6%
Assignment 7	1-6	[redacted]	6%
Assignment 8	1-6	[redacted]	6%
Assignment 9	1-6	[redacted]	6%
Assignment 10	1-6	[redacted]	6%
Final Project – Written	1-6	[redacted]	20%
Final Project Oral	1-6	[redacted]	20%
Total			100%

Assessment Flexibility

While the assignments are designed to provide you with practice applying the concepts and interpreting literature, to build in flexibility for all students, only your best 9 assignments (out of 10) will count towards your final grade (i.e you get one dropped assignment evaluated at 100% of 6%). I still strongly recommend you do all 10 if possible, for the best learning outcomes.

The final project and final project oral presentation are mandatory, unless accommodations require otherwise. A student unable to give their presentation on their scheduled date (all presentations will be scheduled by week 10) must find a student in another assigned slot to swap with.

For information regarding what is considered extenuating circumstances and qualifications for Academic Consideration, please visit the Faculty of Arts and Science's Academic Consideration webpage.

Descriptions of Learning Activities and Assessments (mandatory)

Assessment 1
Defining Crystal Structure
Assessment 2
Inferring Properties from Band Structure
Assessment 3
X-Ray Adsorption Methods and Interpretation
Assessment 4
X-Ray Photoelectron Spectroscopy Methods and Interpretation
Assessment 5
Diffraction Methods and Interpretation
Assessment 6
Electron Methods and Interpretation
Assessment 7
Surface Structure and Surface Sensitive Methods
Assessment 8
Scanning Probe Microscopy STM Methods and Interpretation
Assessment 9
Scanning Probe Microscopy AFM Methods and Interpretation
Assessment 10
Time Resolved Methods and Interpretation
Final Project Written
This course contains a detailed, independent investigation of either:

(1.) The fundamentals and application of a structural/electronic determination technique NOT covered in lecture.

(2.) Advanced application of a technique covered in lecture.

This is to test your ability to generalize the information in the course to new techniques/sub fields, distil relevant literature, research a topic comprehensively, and explain your findings to others in a written form. The written report on this topic will be ~1600-2000 words, including an overview of how it works, relevant history to its development, applications, and a discussion of limitations or ongoing areas of challenge or interest for the technique/research area. It is expected students will consult multiple resources in researching the topic, including refereed

journal articles, covered in a comprehensive bibliography that does not count toward the word count (suggested 15-30 citations). All project topics must be approved by the instructor by Feb 27th 2026, and cannot overlap with any current research the student is participating in.

Final Project Oral

A 15 min presentation followed by 5 min of questions on your report topic. The oral component is to test public speaking, assessing your ability to explain a topic in a clear and informative way to others, as well as demonstrate depth of understanding in answering questions about your topic from the audience.
Grade based on:
Scientific Content (depth, complexity, etc.)
Presentation Technique (delivery, engagement with audience, pacing, etc.)
Timeliness (presentation on time)
Organization and Clarity
Responses to Questions (instructors and class)

Proctored Exams

This course contains no exams. The presentation schedule for the Oral component will be announced and finalized by end of week 10. Students should delay finalizing any travel plans during the last two weeks of term when presentations are taking place. Oral presentations will not be moved or deferred to accommodate employment, travel/holiday plans or flight reservations. For information regarding what is considered extenuating circumstances and qualifications for Academic Consideration, please visit the Faculty of Arts and Science's Academic Consideration webpage.

If you are unable to attend your assigned presentation slot, you either must find a student in another assigned slot to swap with, or, if you receive approval for a deferred proctored oral exam under academic consideration.

Assignment Submission Policy

Assignments should be uploaded to QnQ by 23:59 on the given due date. It is 100% your responsibility to make sure it is submitted on time and in a format accessible to the instructor. No exceptions. A full letter grade will be deducted from the assignment for each day late, including weekends. The absolute last day to submit a late assignment is 3 days after its due date. Anything past this three-day window will be evaluated as 0%.

Students with letters of accommodation should, if possible, confirm the implementation of their accommodations prior to the listed due dates. Please see the "Accommodations for Disabilities" section of this syllabus for more information.

Students experiencing short-term extenuating circumstances that are beyond their control and may affect their academic work should submit a request to their faculty office for academic consideration. Please see the "Academic Considerations for Students in Extenuating Circumstances" section of this syllabus for more details.

Policy Review of Graded Work

Students who have questions about how their work was graded should see the instructor. If you think your grade was incorrectly calculated or misassigned, all grade appeals must be made in person at a mutually agreed/scheduled time with the instructor. The instructor will have the final say in assigning grades in the course unless a process under the Academic Petitions and Appeals is initiated.

Policies

Class Attendance

Your instructor is old school. I won't force your attendance for weeks 1-10. However, I will say that it is highly valued, contributing to the knowledge and skills that you will develop throughout this course. Part of lectures or entire lectures may be group literature reading and evaluations. It is a shame to miss these. Thus, I encourage you to attend class regularly and participate in class conversations and learning activities (unless you are sick or unwell). These types of activities provide active engagement, promote a deeper understanding of the course content, and contribute to your success in this course and your future endeavors.

Do note, attendance of the oral project evaluations is mandatory. Exemptions for oral evaluations will only be given for extenuating circumstances and qualifications for Academic Consideration, as per the Faculty of Arts and Science's Academic Consideration webpage**.** If you think you may miss a presentation day, please notify the instructor with as much notice as possible.

Academic Support

All undergraduate students face new learning and writing challenges as they progress through university: essays and reports become more complex; effectively incorporating research into writing becomes more important; the types of assignments become more diverse; managing your time and developing the skills you need to read and think critically gets more challenging. I encourage students to contact Student Academic Success Services (SASS). SASS offers many different ways to receive support:

- Free online or in-person appointments to get personalized support on writing and academic skills from expert staff and trained peers.
- Workshops and drop-in programs. SASS' Events Calendar lists events coming soon.
- Online resources that provide strategies for academic skills and writing development at university.
- If English is not your first language, SASS has specific resources for English as Additional Language students, including weekly programs and EAL academic skills appointments. You can meet on an ongoing basis with an EAL consultant to work on your academic writing, speaking, listening, and reading skills.

Accommodations for Disabilities

Queen's University is committed to working with students with disabilities to remove barriers to their academic goals. Queen's Student Accessibility Services (QSAS), students with disabilities,

instructors, and faculty staff work together to provide and implement academic accommodations designed to allow students with disabilities equitable access to all course material (including in-class as well as exams). If you are a student currently experiencing barriers to your academics due to disability related reasons, and you would like to understand whether academic accommodations could support the removal of those barriers, please visit the QSAS website to learn more about academic accommodations or start the registration process with QSAS by clicking ***Access Ventus*** button at **Ventus | Accessibility Services | Queen's (queensu.ca)**

VENTUS is an online portal that connects students, instructors, Queen's Student Accessibility Services, the Exam's Office and other support services in the process to request, assess, and implement academic accommodations.

To learn more go to: https://www.queensu.ca/ventus-support/students/visual-guide-ventus-students

Academic Consideration for Students in Extenuating Circumstances

Academic Consideration is a process for the University community to provide a compassionate response to assist students experiencing unforeseen, short-term extenuating circumstances that may impact or impede a student's ability to complete their academics. This may include but is not limited to any extenuating circumstance (illness, bereavement, traumatic event, injury, family emergency, etc.) which is short-lived, begins within the term, and will not last longer than 12 weeks - see Academic Consideration webpage for details (https://www.queensu.ca/artsci/undergraduate/student-services/academic-consideration)

> Each Faculty has developed a protocol to provide a consistent and equitable approach in dealing with requests for academic consideration for students facing extenuating circumstances. For more information, undergraduate students in the Faculty of Arts and Sciences should consult the Faculty's webpage on Academic Consideration in Extenuating Circumstances and submit a request via the Academic Consideration Request Portal. Students in other Faculties and Schools who are enrolled in this course should refer to the protocol for their home Faculty.

Students are encouraged to submit requests as soon as the need becomes apparent and to contact their instructor and/or course coordinator as soon as possible once academic consideration has been granted. Any delay in contact may limit the options available for academic consideration. While we encourage instructors to accommodate, each instructor has discretion in deciding whether or how to apply the Academic Consideration. For more information on the Academic Consideration process, what is and is not an extenuating circumstance, and to submit an Academic Consideration request, please see the Faculty of Arts and Science's Academic Consideration website. ASO courses include links to information on **Academic Consideration** on your **Course Homepage** in onQ.

Please see the Teaching Team page for contact information for your instructor and TA(s), where relevant.

For more information, please see the Senate Policy on Academic Consideration for Students in Extenuating Circumstances.

Queen's Policy Statement on Academic Integrity

Queen's University is dedicated to creating a scholarly community free to explore a range of ideas, to build and advance knowledge and to share the ideas and knowledge that emerge from a range of intellectual pursuits. Each core value of academic integrity, as defined in the Senate Academic Integrity Policy, gives rise to and supports the next.

Honesty appears in presenting one's own academic work, whether in the context of an examination, written assignment, laboratory or seminar presentation. It is in researching one's own work for course assignments, acknowledging dependence on the ideas or words of another and in distinguishing one's own ideas and thoughts from other sources. It is also present in faithfully reporting laboratory results even when they do not conform to an original hypothesis. Further, honesty is present in truthfully communicating in written and/or oral exchanges with instructors, peers and other individuals (e.g. teaching assistants, proctors, university staff and/or university administrators).

Trust exists in an environment in which one's own ideas can be expressed without fear of ridicule or fear that someone else will take credit for them.

Fairness appears in the proper and full acknowledgement of the contributions of collaborators in group projects and in the full participation of partners in collaborative projects.

Respect, in a general sense, is part of an intellectual community that recognizes the participatory nature of the learning process and honours and respects a wide range of opinions and ideas. However, "respect" appears in a very particular sense when students attend class, pay attention, contribute to discussion and submit papers on time; instructors "show respect by taking students' ideas seriously, by recognizing them as individuals, helping them develop their ideas, providing full and honest feedback on their work, and valuing their perspectives and their goals" ("The Fundamental Values of Academic Integrity", 3rd Edition, p. 8).

Ultimately, responsibility is both personal and collective and engages students, administrators, faculty and staff in creating and maintaining a learning environment supported by and supporting academic integrity.

Courage differs from the preceding values by being more a quality or capacity of character – "the capacity to act in accordance with one's values despite fear" ("The Fundamental Values of Academic Integrity", 3rd edition, p. 10). Courage is displayed by students who make choices and integrous decisions that are followed by action, even in the face of peer pressure to cheat, copy another's material, provide their own work to others to facilitate cheating, or otherwise represent themselves dishonestly. Students also display courage by acknowledging prior wrongdoing and taking proactive measures to rectify any associated negative impact.

All of these values are not merely abstract but are expressed in and reinforced by the University's policies and practices.

Generative Artificial Intelligence (AI) Tools

This course is entirely take-home assignments followed by personal research culminating in a year-end report. While I understand it is tempting to use AI to accelerate these kinds of assignments, especially as busy undergrads, I ask you to exercise caution. That is, it is fine to utilize AI to point you toward resources or aid you in understanding concepts so you can build intuition and competency yourself. However, use of AI in place of critical thinking to write, answer portions of this course, or generate references you do not understand/read, especially regarding your year-end project, is not permitted. This is not because I wish to make the course burdensome or difficult, but because I care about producing students with the skills, experience, and critical thinking to be impactful in whatever they do next. Generative AI is a tool and not evil. Thus, use it as tool for suggestions, not a replacement for effort and fundamental understanding. I am excited to see your character as writers and researchers shine through in what you produce, even if it is not perfect!

All this said, I reserve the right to ask students to re-derive and/or explain their choices for turned in assignments (including the year-end project) whenever I wish during the academic term, along with potential grade adjustments. I also reserve the right to ask students to turn in tracked history for the year-end report in .docx or google doc format, showing genuine editing history. Please reach out to the instructor for any clarifications, exceptions, or concerns.

As an additional resource, Queen's Student Academic Success Services (SASS) offers a self-directed, online academic integrity module which we encourage all students to take which will help with:

- Understanding the nature of the academic integrity departure
- Understanding the expectations of and role of sources in scholarly writing
- Integrating sources into your writing (paraphrasing, quoting, summarizing)
- Understanding when and how to cite your sources
- Managing your time effectively to avoid the need for shortcuts
- Taking effective notes to ensure accuracy of source material and correct attribution

Turnitin Statement

This course makes use of Turnitin, a third-party application that helps maintain standards of excellence in academic integrity. Normally, students will be required to submit their course assignments through onQ to Turnitin. In doing so, students' work will be included as source documents in the Turnitin reference database, where they will be used solely for the purpose of detecting plagiarized text in this course. Data from submissions is also collected and analyzed by Turnitin for detecting Artificial Intelligence (AI)-generated text. These results are not reported to your instructor at this time but could be in the future.

Turnitin is a suite of tools that provide instructors with information about the authenticity of submitted work and facilitates the process of grading. The similarity report generated after an assignment file is submitted produces a similarity score for each assignment. A similarity score is the percentage of writing that is similar to content found on the internet or the Turnitin extensive database of content. Turnitin does not determine if an instance of plagiarism has occurred. Instead, it gives instructors the information they need to determine the authenticity of work as a part of a larger process.

Please read Turnitin's Privacy Policy, Acceptable Use Policy and End-User License Agreement, which govern users' relationship with Turnitin. Also, please note that Turnitin uses cookies and other tracking technologies; however, in its service contract with Queen's Turnitin has agreed that neither Turnitin nor its third-party partners will use data collected through cookies or other tracking technologies for marketing or advertising purposes.

For further information about how you can exercise control over cookies, see Turnitin's Privacy Policy.

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