

Faculty of Science Course Syllabus
Department of Chemistry
Introductory Inorganic Chemistry
CHEM 2101
Winter 2024

Dalhousie University is located in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq. We are all Treaty people.

Instructor: Dr. Saurabh S. Chitnis (Lecture), Dr. Marc Whalen (Lab)

Lectures: Mon, Wed, Fri 11:35–12:25; Location: Chemistry 226

Labs: Lab section 2101 B01: Wednesday 1:35-4:55, Lab section 2101 B02: Thursdays 9:05-12:25; Lab section 2101 B03: Thursdays 1:35-4:55; Lab section 2101 B04: Fridays 1:35-4:55; Location: Chemistry Podium 118 (see attached schedule)

Office Hours (Dr. Chitnis): Tue 9:00–10:00, Fri 1:00–2:00; Location: Chemistry 412

Office Hours (Dr. Whalen): By appointment *via* email (marc.whelen@dal.ca)

Course description: In the lecture component of the course, you will gain a deeper understanding of fundamental models introduced in first year chemistry. Molecular orbital theory and molecular symmetry (including symmetry operations, point groups, and character tables) will be emphasized to enable you to explain and predict the structures, spectroscopic features, and reactivity of main group compounds. Structures and thermodynamics of solids will also be introduced. The chemistry of main group ions in aqueous solutions will be considered. A special topic devoted to the chemistry of hydrogen is included. Finally, a survey of the prototypical chemistry of elements from Group 13–16 will be covered. In the laboratory portion of the course you will develop inorganic synthesis and characterization skills using modern methods, and engage in active learning exercises that will support the lecture component.

Course prerequisites: CHEM 1011/1012 or equivalent (grade of C– or better)

Course objectives/Learning outcomes:

- Derive first order molecular orbital (MO) diagrams for simple main group compounds and understand the relationship between MO manifold, molecular structure, and reactivity
- Identify symmetry elements in a molecule and use this information to determine the point group of the molecule and predict vibrational spectroscopic features using a character table
- Understand how solids pack, and how the size of ions and their packing is related to lattice thermodynamics
- Understand and predict how main group ions behave in aqueous solutions in terms of their acid base chemistry and solubility
- Understand and predict the chemistry of dihydrogen, and the H^+ and H^- ions, and understand the concept of hydrogen bonding, and the general properties of binary hydrides
- Become familiar with the characteristic chemistry of compounds derived from the elements of Group 13–15

Required texts:

- Course textbook: *Inorganic Chemistry*, 5th Edition (2018, Housecroft & Sharpe, Pearson Publications). The textbook can be purchased through the bookstore or other booksellers. The electronic text is available through the VitalSource website: <https://www.vitalsource.com/en-ca/products/inorganic-chemistry-catherine-housecroft-v9781292134161>.
- CHEM 2101 Lab Manual Winter 2024, available for purchase in the Dalhousie Bookstore.

The importance of the textbook: It is absolutely critical that you *acquire and regularly read* the course textbook. *I do not foresee students passing this course without carefully reading the relevant book chapters prior to lectures and doing the practice problems in the textbook.* The lectures are meant to supplement and enrich the textbook content to aid your learning; relying upon the lectures alone without regularly reading the textbook will not be sufficient in preparing you for tests and the final examination.

The importance of doing the practice problems: If you are regularly unable to get the correct answer for practice problems, you must review the course material (textbook, lecture notes, other resources provided) or come to office hours for help. The difficulty level of the practice questions will be comparable to that of the tests and final exam, but you have less time during tests and final exams. So, it is critical that you are able to do the practice problems with ease.

Course website: You should consult the Introductory Inorganic Chemistry (CHEM 2102 Winter 2024) Brightspace website regularly for information and announcements.

Lab website: All content and announcements for the laboratory component are found on the CHEM 2101 Laboratory – Introductory Inorganic Chemistry – 2024 Winter Brightspace website.

Lab requirements summary (see Lab Requirements below for more details):

- Safety glasses (CSA-Z94-3 or ANSI-Z87 approved) and 100% cotton lab coat (both available in the Dalhousie Bookstore)
- WHMIS 2015 training (online: see lab manual page 5 for instructions and exemptions). *The deadline for completing this is Sunday, Jan 29.*
- Safety Module Winter 2024 (online: see lab manual page 6 and Brightspace for instructions and exemptions). *The deadline for completing this module is Sunday, Jan 14.*

Course assessment:

Component	Weight	Date
Test 1	20 %	Feb 05, 2024 (in class)
Test 2	20 %	Mar 08, 2024 (in class)
Final Examination	35 %	To be scheduled during exam period
Labs	25 %	Scheduled by Lab Instructor (see attached)

Performance expectations: The rubric explaining and defining Dalhousie's grading system and showing the GPA value that corresponds with each letter grade can be found at the following address: <https://www.dal.ca/campuslife/academic-support/grades-and-student-records/grade-scale-and-definitions.html>. Please refer to this rubric when considering how to prepare for testing and submitting assigned work.

Testable material:

- All material presented in lecture is testable in the tests and final exam. The annotated Power Point slides presented during each lecture will be posted on the course website after each lecture. These will not contain all information from the class (exercises and oral). Therefore it is strongly recommended that you attend lectures and regularly visit the course Brightspace site for updates.
- All concepts represented in assigned textbook problems

Short-term absence policy for missed academic requirements: In this course, the academic requirements are:

- Tests
- Laboratory session (lab quiz and performing the experiment)
- submittal of assigned work by due date

If you miss an academic requirement, Dalhousie University requires a Student Declaration of Absence (SDA) form to be submitted online (see course website). Sick notes should not be submitted. A full statement of the policy can be found at the following address: <https://www.dal.ca/dept/universitysecretariat/policies/academic/missed-or-late-academic-requirements-due-to-student-absence.html>. SDA forms should be submitted within 24 hours of a missed or late academic requirement. Students can use the SDA form a total of two times in this course, across both lecture and lab academic requirements (i.e. 1 test + 1 lab session, *or* 2 tests, *or* 2 lab sessions) Once an SDA is submitted, the student is also required to email the instructor as soon as possible to make arrangements for making up the academic requirement according to the discretion of the instructor and course policies.

Course Policies:

Meeting outside office hours: Please note that outside of office hours, meeting with Dr. Chitnis is by appointment only. If you wish to set up a meeting, please email Dr. Chitnis, clearly indicating the reason you wish to meet as well as your availability.

Missed academic requirements:

- *Missed term test:* If you miss a midterm for any reason, no make-up will be offered. You are required to submit a SDA form within 24 hours of the missed midterm. The instructor will then transfer the points from the missed midterm to the final exam.
- *Missed final examination:* No SDA form is required. The student is required to contact the instructor by email to make alternate arrangements for writing the final exam after the end of the exam period posted by the Registrar.
- *Missed laboratory session:* You are expected to attend the laboratory sessions scheduled for the Group to which you are assigned (see Laboratory Schedule below). Students cannot attend a different laboratory session unless prior arrangements have been made with the instructor. After submittal of the SDA form for an absence, it is at the discretion of the instructor as to whether or not the lab can be performed at another time. The Laboratory Schedule has space for the makeup of only one laboratory experiment.
- *Late submission of a graded assignment or laboratory report sheet:* For each weekday late after the posted due date, 10% will be deducted, to a maximum of 50%. A submitted SDA form will excuse one weekday (unless alternate arrangements are made with the instructor).

Laboratory requirements: Full details about the below points are given in the Lab Manual.

- *Mandatory online training:* You are required to complete two online courses (see lab manual for exemptions). You may already have met the completion requirements from previous courses (see page 5 of the Lab Manual): WHMIS 2015 (deadline Sun Jan 21) and Safety Module Winter 2024 (deadline Sunday Jan 14). After the deadlines, students who have not completed these courses will not be allowed to perform experiments in any Dalhousie undergraduate chemistry laboratory until the module is completed. If a lab session is missed for this reason, the instructor is not obligated to provide a make-up session.
- *Personal protective equipment in the laboratory:* No student will be allowed to work in the lab without approved safety glasses, closed toe shoes, and a properly fitting cotton lab coat (sleeves cannot be rolled up). Lab coats and glasses can be purchased in the Dalhousie Bookstore.

- *Lab preparation and grading scheme:* For safety reasons, students are expected to come to the lab having completed adequate preparation in advance according to the guidelines stated in the Lab Manual (p. 2 – 16). For this reason, students will write a quiz at the beginning of each lab session. The instructor reserves the right to ask any student to leave the laboratory if they are deemed unprepared to conduct the lab in a safe manner. No make-up session will be provided in these cases.
- *Timely completion of laboratory sessions:* All lab sessions are 3.5 hours in length, which is ample time for a prepared student to complete the work and perform all clean up and organizational tasks. Students will complete their work (including clean up) by the end of the lab period in all cases, no exceptions. Budget your time accordingly.
- *Laboratory exemptions:* If you have taken this course before and earned a passing grade in the lab, you may apply for a laboratory exemption. To do so, contact the instructor by email by Friday, Jan 12 stating your request, and providing your B00 number. The instructor will then seek documentation within the department to obtain your previous lab grade. Once the exemption is granted, the grade you previously earned in the lab will be transferred over to this course.

Laboratory Schedule (tentative: consult Lab Brightspace website regularly): All labs will be performed in Podium 118 (inorganic chemistry teaching lab) unless stated otherwise below.

CHEM 2101 B01 Wed 1:30–4:55
 CHEM 2101 B02 Thu 9:05–12:25
 CHEM 2101 B03 Thu 1:35–4:55
 CHEM 2101 B04 Fri 1:35–4:55

Week	Dates	Activity	Post Lab Due
1	Jan 10, 11, 12	no labs	-
2	Jan 17, 18, 19	Check-in and ALE 1	-
3	Jan 24, 25, 26	ALE 2	ALE 1
4	Jan 31, Feb 1,2	no labs (Monroe Day)	-
5	Feb 7,8,9	ALE 3	ALE 2
6	Feb 14, 15, 16	ALE 4	ALE 3
7	Feb 21, 22, 23	no labs (Winter Break)	-
8	Feb 28, 29, Mar 1	ALE 5	ALE 4
9	Mar 6, 7, 8	ALE 6*	ALE 5
10	Mar 13, 14, 15	ALE 7	ALE 6*
11	Mar 20, 21, 22	ALE 8	ALE 7
12	Mar 27, 28, 29	no labs (Good Friday)	-
13	Apr 3, 4, 5	make ups	ALE 8
14	Apr 9 (last day classes)	-	final submissions

***ALE 6** will be conducted in the Chemistry Resource Centre. Consult Brightspace for the time to come to lab on your lab day.

Course Contents: The following chapter numbers correspond to the course textbook *Inorganic Chemistry*, 5th Edition (Housecroft & Sharpe). Topics that are striked out will not be tested in assessments. *Topic that are labelled ‘Assumed Knowledge’ will not be covered in class but they may be tested in assessments.* Students are therefore advised to review these topics prior to the start of the course, or immediately upon starting, by reading the relevant chapters and sections in the textbook.

1. Atoms (Assumed Knowledge, read Chapter 1 to review)
 - 1.1 Introduction
 - 1.2 Fundamental particles of an atom
 - 1.3 Atomic number, mass, and isotopes
 - 1.4 Successes in early quantum theory
 - 1.5 An introduction to wave mechanics
 - 1.6 Atomic orbitals
 - 1.7 Many electron atoms
 - 1.8 The Periodic Table
 - 1.9 The *aufbau* Principle
 - 1.10 Ionization energies and electron affinities
2. Molecules
 - 2.1 Bonding models: an introduction
 - 2.2 Homonuclear diatomics: Valence Bond (VB) theory
 - 2.3 Homonuclear diatomics: Molecular Orbital (MO) theory
 - 2.4 The octet rule and isoelectronic species
 - 2.5 Electronegativity Values
 - 2.6 Dipole moments
 - 2.7 MO theory: heteronuclear diatomics
 - 2.8 Molecular shape and VSEPR model (Assumed Knowledge)
3. Introduction to Molecular Symmetry
 - 3.1 Introduction
 - 3.2 Symmetry operations and symmetry elements
 - 3.3 Successive operations
 - 3.4 Point groups
 - 3.5 Character tables: an introduction
 - 3.6 Why do we need to recognize symmetry elements?
 - 3.7 Vibrational spectroscopy
4. Experimental Techniques
 - 4.1 Introduction
 - 4.8 Nuclear Magnetic Resonance (NMR) Spectroscopy
5. Bonding in polyatomic molecules
 - 5.1 Introduction
 - 5.5 MO theory: ligand group orbital approach & application to triatomics
 - 5.6 MO theory applied to polyatomics BH₃, NH₃, and CH₄
 - 5.8 MO theory: learning to use the theory objectively
6. Structures and energetics of metallic and ionic solids
 - 6.1 Introduction
 - 6.2 Packing of spheres
 - 6.3 Packing of spheres model applied to the structure of elements
 - 6.10 Sizes of ions
 - 6.11 Ionic lattices
 - 6.13 Lattice energy estimates – electrostatic model
 - 6.14 Lattice energy: the Born-Haber cycle
 - 6.15 Lattice energy: ‘calculated’ vs. ‘experimental’ values

- 6.16 Estimating lattice energies of new materials
- 6.17 Applications of lattice energies
- 7. Acids bases and ions in aqueous solution
 - 7.1 Introduction
 - 7.2 Properties of water
 - 7.3 Definitions and units in aqueous solutions
 - 7.4 Some Bronsted acids and bases
 - 7.5 The energetics of acid dissociation in aqueous solution
 - 7.6 Trends within a series of oxoacids $\text{EO}_n(\text{OH})_m$
 - 7.7 Aquated cations: formation and acidic properties
 - 7.8 Amphoteric oxides and hydroxides
 - 7.9 Solubilities of ionic salts
- 8. ~~Reduction and Oxidation~~
- 9. ~~Non-aqueous media~~
- 10. Hydrogen
 - 10.1 Hydrogen: the simplest atom
 - 10.2 The H^+ and H^- ions
 - 10.3 Isotopes of hydrogen
 - 10.4 Dihydrogen
 - 10.5 Polar and nonpolar E-H bonds
 - 10.6 Hydrogen bonding
 - 10.7 Binary hydrides: classification and general properties
- 11. ~~The Group 11 elements~~
- 12. ~~The Group 12 elements~~
- 13. The Group 13 elements
- 14. The Group 14 elements
- 15. The Group 15 elements
- 16. The Group 16 elements
- 17. The Group 17 elements

Schedule of Lectures (subject to change):

No.	Date	Content
1	Mon, Jan 08	Intro and Chapter 1 Review
2	Wed, Jan 10	2.1–2.3
3	Fri, Jan 12	2.4–2.6
4	Mon, Jan 15	2.7
5	Wed, Jan 17	3.1–3.2
6	Fri, Jan 19	3.3–3.4
7	Mon, Jan 22	3.4
8	Wed, Jan 24	3.5–3.6
9	Fri, Jan 26	3.7
10	Mon, Jan 29	3.7
11	Wed, Jan 31	Catch-up & Review
–	Fri, Feb 02	Munro Day, University Closed
12	Mon, Feb 05	Test 1 (in class, covers chapters 1, 2, 3)
13	Wed, Feb 07	Snow day OR start chapter 5 early
14	Fri, Feb 09	5.1, 5.5
15	Mon, Feb 12	5.5
16	Wed, Feb 14	5.6, 5.8
17	Fri, Feb 16	6.1–6.3
–	Mon, Feb 19	Reading Week, No Class
–	Wed, Feb 21	Reading Week, No Class
–	Fri, Feb 23	Reading Week, No Class
18	Mon, Feb 26	6.10, 6.11, 6.13
19	Wed, Feb 28	6.14–6.17
20	Fri, Mar 01	7.1–7.6
21	Mon, Mar 04	7.7–7.9
22	Wed, Mar 06	Review
23	Fri, Mar 08	Test 2 (in class, covers chapters 5, 6, 7)
24	Mon, Mar 11	7.11–7.13
25	Wed, Mar 13	10.1, 10.2
26	Fri, Mar 15	10.3–10.5
27	Mon, Mar 18	10.6, 10.7
28	Wed, Mar 20	4.1, 4.8
29	Fri, Mar 22	4.1, 4.8
30	Mon, Mar 25	Chapter 13 – Group 13 (Triels)
31	Wed, Mar 27	Chapter 14 – Group 14 (Tetraels)
–	Fri, Mar 29	Good Friday, No Class
32	Mon, April 01	Chapter 15 – Group 15 (Pnictogens)
33	Wed, April 03	Chapter 16 – Group 16 (Chalcogens)
34	Fri, April 05	Chapter 17 – Group 17 (Halogens)
35	Mon, April 8	Catch-up & Review

University Policies and Statements

This course is governed by the academic rules and regulations set forth in the University Calendar and by Senate.

Academic Integrity: At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity.

Information: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility: The Advising and Access Services Centre is Dalhousie's centre of expertise for student accessibility and accommodation. The advising team works with students who request accommodation as a result of a disability, religious obligation, or any barrier related to any other characteristic protected under Human Rights legislation (Canada and Nova Scotia).

Information: https://www.dal.ca/campus_life/academic-support/accessibility.html

Student Code of Conduct: Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner—perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution.

Code: <https://www.dal.ca/dept/universitysecretariat/policies/student-life/code-of-student-conduct.html>

Diversity and Inclusion – Culture of Respect: Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness

Statement: <http://www.dal.ca/cultureofrespect.html>

Recognition of Mi'kmaq Territory: Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel and support. Visit or e-mail the Indigenous Student Centre (1321 Edward St) (elders@dal.ca).

Information: https://www.dal.ca/campus_life/communities/indigenous.html

Important Dates in the Academic Year (including add/drop dates):

https://www.dal.ca/academics/important_dates.html

University Grading Practices:

https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-policy.html

Student Resources and Support

Advising:

- **General Advising:**
https://www.dal.ca/campus_life/academic-support/advising.html
- **Science Program Advisors:**
<https://www.dal.ca/faculty/science/current-students/academic-advising.html>
- **Indigenous Student Centre:**
https://www.dal.ca/campus_life/communities/indigenous.html
- **Black Students Advising Centre:**
https://www.dal.ca/campus_life/communities/black-student-advising.html
- **International Centre:**
https://www.dal.ca/campus_life/international-centre/current-students.html

Academic supports:

- **Library:**
<https://libraries.dal.ca/>
- **Writing Centre:**
https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html
- **Studying for Success:**
https://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html
- **Copyright Office:**
<https://libraries.dal.ca/services/copyright-office.html>
- **Fair Dealing Guidelines:**
<https://libraries.dal.ca/services/copyright-office/fair-dealing.html>

Other supports and services:

- **Student Health Wellness Centre:**
<https://www.dal.ca/campuslife/health-and-wellness/services-support/student-health-and-wellness.html>
- **Student Advocacy:**
<https://dsu.ca/dsas>
- **Ombudsperson:**
<https://www.dal.ca/campuslife/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html>

Safety:

- **Biosafety:**
<https://www.dal.ca/dept/safety/programs-services/biosafety.html>
- **Chemical Safety:**
<https://www.dal.ca/dept/safety/programs-services/chemical-safety.html>
- **Radiation Safety:**
<https://www.dal.ca/dept/safety/programs-services/radiation-safety.html>

Scent-Free Program:

<https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html>

Dalhousie COVID-19 information and updates:

<https://www.dal.ca/covid-19-information-and-updates.html>