UNIVERSITY OF CALGARY
FACULTY OF SCIENCE

Department of Chemistry
Science B 605
403 220-5385
chem.info@ucalgary.ca

COURSE OUTLINE

1. **Course:** CHEM 433, Inorganic Chemistry: Transition Metals - Winter 2024

Lecture 01 : TR 11:00 - 12:15 in ST 135

Instructor	Email	Phone	Office	Hours
Dr Farideh Jalilehvand	faridehj@ucalgary.ca	403 220-3855	SB 213	TW 1:00 - 2:00 pm - SB 213

Course Description

Lectures: Bonding models for metals and for transition metal compounds; interpretation of redox and thermodynamic properties based on ligand field theory; coordination and organometallic compounds of the transition metals; metal complexes as catalysts in industry and biology.

Laboratory: Synthesis, analysis, and physical investigations of transition metal compounds which illustrate their important properties.

To account for any necessary transition to remote learning for the current semester, courses with in-person lectures, labs, or tutorials may be shifted to remote delivery for a certain period of time. In addition, adjustments may be made to the modality and format of assessments and deadlines, as well as to other course components and/or requirements, so that all coursework tasks are in line with the necessary and evolving health precautions for all involved (students and staff).

In Person Delivery Details:

All course components of this course (lectures and labs) will be delivered in person.

Lectures will not be recorded - annotated lecture handouts, however, will be posted on OneNote after class.

Under extenuating COVID-pandemic driven circumstances (e.g. instructor self-isolating), lecture delivery may be temporarily switched online (Zoom - Synchronous delivery). In this case, notification will be posted on the classroom door and on D2L.

Laboratory activities will begin in the week of **January 15th, 2024** (EEEL 253); the first session will also include check-in.

Until **March 8th**, all laboratory sections will be split into two groups of ~10 students. **The complete laboratory schedule will be available on D2L by Friday, January 12th, 2024**. Students will need to contact the instructor (by email) as soon as possible if unable to attend any of the labs.

Course Site:

D2L: CHEM 433 L01-(Winter 2024)-Inorganic Chemistry: Transition Metals

(To access lecture handouts and practice problems)

OneNote: You will receive an access link via D2L (for annotated lecture notes)

Note: Students must use their U of C account for all course correspondence.

Equity Diversity & Inclusion:

The University of Calgary is committed to creating an equitable, diverse and inclusive campus, and condemns harm and discrimination of any form. We value all persons regardless of their race, gender, ethnicity, age, LGBTQIA2S+ identity and expression, disability, religion, spirituality, and socioeconomic status. The Faculty of Science strives to extend these values in every aspect of our courses, research, and teachings to better promote academic excellence and foster belonging for all.

The Chemistry EDI Committee acknowledges there are persistent barriers that prevent such accessibility and hinder our progress towards EDI. Our representatives (faculty, postdocs, graduate and undergraduate students) are committed to addressing any concerns and work towards proactive solutions that enact necessary change within the department. To submit anonymous questions, comments or concerns regarding EDI related issues, please reach out to our Associate Head EDI, Belinda Heyne (bjmheyne@ucalgary.ca)

2. **Requisites:**

See section 3.5.C in the Faculty of Science section of the online Calendar.

Prerequisite(s):
Chemistry 201 or 211, and 203 or 213, and 331 or 431. Also known as: (formerly Chemistry 333)

3. **Grading:**

The University policy on grading and related matters is described in F.1 and F.2 of the online University Calendar.

In determining the overall grade in the course the following weights will be used:

Course Component	Weight	Due Date (duration for exams)	Modality for exams	Location for exams
Laboratory (7)[1]	25%	Ongoing		
Term Test I	15%	Feb 09 2024 at 07:00 pm (1.5 Hours)	in-person	TBD
Term Test II	25%	Mar 15 2024 at 07:00 pm (2 Hours)	in-person	TBD
Registrar Scheduled Final Exam	35%	Will be available when the final exam schedule is released by the Registrar	in person	Will be available when the final exam schedule is released by the Registrar

[1] The material covered in these labs may be integrated into non-lab-based course assessments.

Each piece of work (reports, assignments, quizzes, midterm exam(s) or final examination) submitted by the student will be assigned a grade. The student's grade for each component listed above will be combined with the indicated weights to produce an overall percentage for the course, which will be used to determine the course letter grade.

The conversion between a percentage grade and letter grade is as follows.

	A+	A	A-	B+	B	B-	C+	C	C-	D+	D
Minimum % Required	95 %	85 %	80 %	75%	70%	65 %	60 %	55%	50%	45 %	40 %

This course will have a Registrar Scheduled Final exam that will be delivered in-person and on campus. The Final Examination Schedule will be published by the Registrar's Office approximately one month after the start of the term. The final exam for this course will be designed to be completed within 2 hours.

Notes

3.1. Students will be expected to understand at every stage the material covered in all components of the course. In order to achieve the prerequisite requirements (i.e., C-) for further Chemistry courses, a student must meet the following requirements:

(1) achieve a minimum 50% in the laboratory grading, and

(2) achieve a minimum 50% weighted average on the examinations (Term Tests and Final).

This means that if a student scores below 50% in either the laboratory component or the examinations, then the maximum course letter grade they can obtain in CHEM 433 is a D+.

3.2. All exams are cumulative. There will be no deferred Term Tests for this course. See also Section 4.

The University of Calgary offers a flexible grade option, Credit Granted (CG) to support student's breadth of learning and student wellness. Faculty units may have additional requirements or restrictions for the use of the CG grade at the faculty, degree or program level. To see the full list of Faculty of Science courses where CG is not eligible, please visit the following website: https://science.ucalgary.ca/current-students/undergraduate/program-advising/flexible-grading-option-cg-grade

4. **Missed Components Of Term Work:**

In the event that a student legitimately fails to submit any online or in-person assessment on time (e.g. due to illness, domestic affliction, etc...), please contact the course coordinator, or the course instructor if this course does not have a coordinator to arrange for a re-adjustment of a submission date, or possible exemption and reweighing of components. Absences not reported within 48 hours will not be accommodated. Students may be asked to provide supporting documentation (Section M.1) for an excused absence, See FAQ.

If an excused absence is approved, options for how the missed assessment is dealt with is at the discretion of the coordinator or course instructor. Some options such as an exemption and pro-rating among the components of the course may not be a viable option based on the design of this course.

4.1. If a student missed a Term Test, or did not perform an experiment, for non-legitimate reasons (e.g. vacation or incomplete pre-lab assignment), the contribution of that Term Test or experiment in the final course grade will be zero.

4.2. Term Tests: There will be no deferred Term Test for this course.

Excused absence may be considered for only ONE of the two Term Tests.

The missed Term Test weight will be shifted to the Final Exam for students with a legitimate reason for absence, i.e. the Term Test will be assigned a grade equal to the grade obtained on the Final Exam.

4.3. Laboratory. Given the essential nature of the hands-on skills taught during the CHEM 433 laboratory, one must complete at least 9 out of the 10 laboratory sessions to receive credit for the course.

For laboratory experiments, you must notify the Coordinator (Dr. Jalilehvand) of your absence either **10 business days** in advance for scheduled absences, or **within 48 h** of the missed experiment for emergency absences. If there is an extenuating circumstance, a make-up session or adjusted due date may be scheduled, at the discretion of the Coordinator, and if timing allows. If these options are not possible, the missed experiment may be pro-rated towards other lab components at the coordinator's discretion, provided that the student attends at least 9 out of the 10 laboratory sessions and submit related lab reports. When granted an excused laboratory absence, students are excused from all components of that specific laboratory experiment.

Lab reports may not be submitted without attending the corresponding in-person laboratory session, unless by special written permission of the lab coordinator.

5. **Scheduled Out-of-Class Activities:**

The following out of class activities are scheduled for this course.

Activity	Location	Date and Time	Duration
Term Test I	TBD	Friday, February 9, 2024 at 7:00 pm	1.5 Hours
Term Test II	TBD	Friday, March 15, 2024 at 7:00 pm	2 Hours

REGULARLY SCHEDULED CLASSES HAVE PRECEDENCE OVER ANY OUT-OF-CLASS-TIME-ACTIVITY. If you have a conflict with the out-of-class-time-activity, please contact your course coordinator/instructor no later than **14 days prior** to the date of the out-of-class activity so that alternative arrangements may be made.

6. **Course Materials:**

Recommended Textbook(s):

Missler, G. L.; Fischer, P. J., and Tarr, D. A., *Inorganic Chemistry (5th Ed)*: Pearson.
Housecroft, C.E. and Sharpe, A.G., *Inorganic Chemistry (4th or 5th Edition)*: Pearson.
Huheey, J. and Keither, E.A., *Inorganic Chemistry (4th Ed)*: Harper Collins College Publishers.
Szafran, Z., Pike, R.M. and Singh, M.M., *Microscale Inorganic Chemistry: A Comprehensive Laboratory Experience*: John Wiley & Sons.
Vogel A., *Qualitative Inorganic Analysis (7th Ed)*: Longman.
Nakamoto, K., *Infrared & Raman Spectra of Inorganic & Coordination Compounds (Parts A & B), 6th Ed*: Wiley (available at U of C library - Online).
Lippard, S.J., *Principles of Bioinorganic Chemistry*: University Science Books.

Other Course Materials:

Lab coat & safety glasses (required)
Molecular Model Kit (Molymod recommended)
A non-programmable scientific calculator (Casio FX 260 or equivalent)

In order to successfully engage in their learning experiences at the University of Calgary, students taking online, remote and blended courses are required to have reliable access to the following technology:

- A computer with a supported operating system, as well as the latest security, and malware updates;
- A current and updated web browser;
- Webcam/Camera (built-in or external);
- Microphone and speaker (built-in or external), or headset with microphone;
- Current antivirus and/or firewall software enabled;
- Stable internet connection.

For more information please refer to the UofC ELearning online website.

7. **Examination Policy:**

   All exams will be **cumulative** in **closed book** format, and written in-person.

   All students must start writing the Term Tests and Final exams within 30 min of the exam's start time.

   Students who require accommodation must be registered with Student Accessibility Services (see section 12 (e.) below), and must identify themselves to their instructor as soon as possible.

   Students who are unable to write the Term Test during the scheduled time, due to conflict with another U of C scheduled course/ lab, must contact the instructor (by email) at least **14 days** in advance of the scheduled assessment. Note that there will be no deferred Term Test for this course.

   Since all exams are in **closed book** format, you may not access your lecture notes or course materials on One Note/ D2L, or any other resources during exams. The use of camera devices, MP3 Players and headphones, or wireless access devices such as cell phones, ipads or smart watches, etc., during exams will not be allowed. Violation of these rules is considered academic misconduct (see also Item 12(d), below).

   Students are allowed to have a **molecular model kit**, pencils, pens, erasers, their ID card, and non-programmable calculators. Students will receive a **Periodic Table** as part of their exam package.

   Students should also read the Calendar, Section G, on Examinations.

8. **Approved Mandatory And Optional Course Supplemental Fees:**

   There are no mandatory or optional course supplemental fees for this course.

9. **Writing Across The Curriculum Statement:**

   For all components of the course, in any written work, the quality of the student's writing (language, spelling, grammar, presentation etc.) can be a factor in the evaluation of the work. See also Section E.2 of the University Calendar.

10. **Human Studies Statement:**

    Students will not participate as subjects or researchers in human studies.

    See also Section E.5 of the University Calendar.

11. **Reappraisal Of Grades:**

    A student wishing a reappraisal, should first attempt to review the graded work with the Course coordinator/instructor or department offering the course. Students with sufficient academic grounds may request a reappraisal. Non-academic grounds are not relevant for grade reappraisals. Students should be aware that the grade being reappraised may be raised, lowered or remain the same. See Section I.3 of the University Calendar.

    a. **Term Work:** The student should present their rationale a s effectively and as fully as possible to the Course coordinator/instructor within **ten business days** of either being notified about the mark, or of the item's return to the class. If the student is not satisfied with the outcome, the student shall submit the Reappraisal of Graded Term work form to the department in which the course is offered within 2 business days of receiving the decision from the instructor. The Department will arrange for a reappraisal of the work within the next ten business days. The reappraisal will only be considered if the student provides a detailed rationale that outlines where and for what reason an error is suspected. See sections I.1 and I.2 of the University Calendar

    b. **Final Exam:**The student shall submit the request to Enrolment Services. See Section I.3 of the University Calendar.

12. **Other Important Information For Students:**

    a. **Mental Health** The University of Calgary recognizes the pivotal role that student mental health plays in physical health, social connectedness and academic success, and aspires to create a caring and supportive campus community where individuals can freely talk about mental health and receive supports when needed. We encourage you to explore the mental health resources available throughout the university community, such as counselling, self-help resources, peer support or skills-building available through the SU Wellness Centre (Room 370, MacEwan Student Centre, Mental Health Services Website) and the Campus Mental Health Strategy website (Mental Health).

    b. **SU Wellness Services:** For more information, see their website or call 403-210-9355.

    c. **Sexual Violence:** The Sexual Violence Support Advocate, Carla Bertsch, can provide confidential support and information regarding sexual violence to all members of the university community. Carla can be reached by email (svsa@ucalgary.ca) or phone at 403-220-2208. The complete University of Calgary policy on sexual violence can be viewed here.

d. **Student Ombuds Office:** A safe place for all students of the University of Calgary to discuss student related issues, interpersonal conflict, academic and non-academic concerns, and many other problems.

e. **Student Union Information:** SU contact, Email your SU Science Reps: science1@su.ucalgary.ca, science2@su.ucalgary.ca, science3@su.ucalgary.ca,

f. **Academic Accommodation Policy:**

It is the student's responsibility to request academic accommodations according to the University policies and procedures listed below. The student accommodation policy can be found at: https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Student-Accommodation-Policy.pdf

Students needing an accommodation because of a disability or medical condition should communicate this need to Student Accessibility Services in accordance with the Procedure for Accommodations for Students with Disabilities: https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Accommodation-for-Students-with-Disabilities-Procedure.pdf.

Students needing an accommodation in relation to their coursework or to fulfil requirements for a graduate degree, based on a Protected Ground other than Disability, should communicate this need, by filling out the Request for Academic Accommodation Form and sending it to Associate Head, Undergraduate by email ahugchem@ucalgary.ca preferably 10 business days before the due date of an assessment or scheduled absence.

g. **Misconduct:** Academic integrity is the foundation of the development and acquisition of knowledge and is based on values of honesty, trust, responsibility, and respect. We expect members of our community to act with integrity. Research integrity, ethics, and principles of conduct are key to academic integrity. Members of our campus community are required to abide by our institutional Code of Conduct and promote academic integrity in upholding the University of Calgary's reputation of excellence. Some examples of academic misconduct include but are not limited to: posting course material to online platforms or file sharing without the course instructor's consent; submitting or presenting work as if it were the student's own work; submitting or presenting work in one course which has also been submitted in another course without the instructor's permission; borrowing experimental values from others without the instructor's approval; falsification/fabrication of experimental values in a report. Please read the following to inform yourself more on academic integrity:

Student Handbook on Academic Integrity
Student Academic Misconduct Policy and Procedure
Faculty of Science Academic Misconduct Process
Research Integrity Policy

Additional information is available on the Student Success Centre Academic Integrity page

h. **Copyright of Course Materials:** All course materials (including those posted on the course D2L site, a course website, or used in any teaching activity such as (but not limited to) examinations, quizzes, assignments, laboratory manuals, lecture slides or lecture materials and other course notes) are protected by law. These materials are for the sole use of students registered in this course and must not be redistributed. Sharing these materials with anyone else would be a breach of the terms and conditions governing student access to D2L, as well as a violation of the copyright in these materials, and may be pursued as a case of student academic or non-academic misconduct, in addition to any other remedies available at law.

i. **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIPP). Students should identify themselves on all written work by placing their name on the front page and their ID number on each subsequent page. For more information, see Legal Services website.

j. **Surveys:** At the University of Calgary, feedback through the Universal Student Ratings of Instruction (USRI) survey and the Faculty of Science Teaching Feedback form provides valuable information to help with evaluating instruction, enhancing learning and teaching, and selecting courses. Your responses make a difference - please participate in these surveys.

13. Laboratory Information:

Laboratory activities will begin in the week of **January 15th, 2024**; the first session will also include check-in. It is mandatory that students wear a lab coat and safety glasses at all times when working in the lab. Students wearing inappropriate laboratory attire will not be permitted to conduct experiments for safety reasons. The manual can be found online through course D2L site. You must consult the online laboratory manual prior to attending any of your scheduled lab periods and printout the required portion of the manual that outlines the procedures you will be doing. **Before entering the lab, you must show to the TA the answers you have written for all Pre-lab questions of the experiment**, otherwise you will not be allowed to perform the experiment.

14. Laboratory Safety Training:

All undergraduate students taking chemistry laboratories are required to complete an online training (approx. 50 minutes) on laboratory safety. The Safety Training must be completed before the first laboratory experiment (before **January 15th, 2024**). Details about how to enroll in this online training is available on course D2L. The material is considered to be part of the course

and is therefore appropriate for inclusion into laboratory pre-labs and exams. Students who have previously completed the Chemistry Online Safety Training at the University of Calgary in the past five years are NOT required to repeat it.

15. Laboratory Exemption:

Students repeating the course within the last two years (Winter 2022 or after) can be exempted from the Laboratory Component of the course if a grade of 75% or higher was obtained. Students choosing to exempt from the lab should be aware that,

- the material covered in labs may be integrated into non-lab-based course assessments; and,
- the lab grade achieved on the previous attempt will be carried forward.

Prior to applying for an exemption, students are encouraged to connect with their course instructor or coordinator to better understand the *risks* and *benefits* in their specific course, particularly if these labs are not in the same format (online or in-person) this semester. Instructors can tell you what access you will have (or not have) to lab materials as an exempt student, and how the lab materials may be integrated.

Applications for lab exemptions (https://science.ucalgary.ca/usc-lab-exemption-application) must be submitted to the Undergraduate Science Center as soon as possible, but no later than the drop date **Thursday January 18, 2024** (midnight)**.**

16. Laboratory Experiments (10 weeks, 3 hrs/ week):

1. Coordination Complexes of Cobalt (III) Amine Complexes

Syntheses of $[Co(NH_3)_5Cl]Cl_2$ and $Co(NH_3)_4(NO_3)(CO_3)$, comparing their electrical conductance

2. Coordination Complexes - Geometrical Isomerism in Octahedral Complexes

Syntheses of *cis*- and *trans*- isomers of [Co(en)2Cl2]Cl, comparing their UV-vis. spectra

3. Optical Activity of an Octahedral Cobalt Complexes

Preparing a racemic mixture of (+), (-)$[Co(en)_3]Cl_3$, separating these enantiomers and measuring their optical activity

4. Chemistry of Titanium(III)

Determining the crystal field stabilization energy of Ti(III) aqua complex

5. Carbonyl Complexes

Syntheses of two isomers of $Mo(CO)_4(PPh_3)_2$ from $Mo(CO)_6$; their structural characterization using IR spectroscopy

6. The Paramagnetic Complex $Mn(acac)_3$

Synthesis of $Mn(acac)_3$ complex (Hacac = acetylacetone) and finding its spin state (high-spin or low-spin) by measuring its magnetic susceptibility

7. Magnetochemistry & Electronic Spectra of Ni(II) Complexes

Syntheses of $[NiBr_2(PPh_3)_2]$, $[Ni(NH_3)_6]Cl_2$ and bis(triphenylphosphine)dithiocyanatonickel(II), correlating their magnetic susceptibilities and UV-vis spectra with their coordination geometries; identifying SCN- coordination mode to Ni(II) ion using IR spectroscopy.

Course Outcomes:

- By completing this course, students will be able to:
- 1) write name, formula and charge of coordination compounds; recognize common ligands, their donor atoms and denticity; determine the oxidation state of the metal and its electronic configuration; perform conductivity test in the lab to identify the number of ions constituting a coordination compound (when dissolved in water), making a distinction between inner-sphere and outer-sphere coordination; recognize symmetry elements and operations in a coordination compound, and determine its Point Group.
- 2) distinguish between different types of isomers for coordination compounds; prepare geometrical isomers of an octahedral complex in the lab, recognizing differences in their colors and UV-vis absorption spectra; learn in the lab how to separate two optical isomers (enantiomers) in a racemic solution, and determine the optical purity of the isolated enantiomer by measuring its optical activity using a polarimeter.
- 3) use 18-electron rule, crystal field theory and MO theory to explain bonding in octahedral, tetrahedral, square planar complexes and organometallic compounds, and calculate their crystal field stabilization energies; predict a ligand's field strength (weak vs. strong) and its position in the spectrochemical series based on its ability to be sigma-donor, pi-donor or pi-acceptor, leading to high-spin vs. low-spin electronic state in a complex; generate MO energy level diagrams for different ligand field strengths in an octahedral field; recognize metal ions that gain further stability through tetragonal distortion (Jahn-

Teller effect); synthesize metal complexes in the lab, explaining their colors based on the color wheel and absorption bands in their visible spectra, justifying those electronic transitions according to crystal field splitting of d-orbitals, recognizing their spin-state by measuring their magnetic susceptibilities, identifying the nature of isomers formed using IR spectroscopy; explain nature of bonding and orbital overlaps in complexes with metal-metal bonds (delta bonding); describe sigma-donation and pi-back-bonding in metal-carbonyl complexes, preparing such complexes in the lab, using IR spectroscopy to determine their structures.

- 4) recognize thermodynamic stability of a metal complex in solution; distinguish between metal ions that form kinetically inert or labile complexes; describe the mechanisms (Associative, Dissociative, Intermediate) of ligand substitution reactions for octahedral and square planar complexes, and interpret the corresponding rate laws; discuss the electronic and steric factors that influence the reactivity of square planar complexes (such as Trans effect); recognize the mechanism of electron transfer (inner-sphere vs. outer-sphere) in a redox reaction for metal complexes based on supporting evidence (rate constants, presence of bridging ligands, use of radioisotopes, etc), and discuss factors contributing in the “self-exchange” and “cross-exchange” outer-sphere redox reactions.
- 5) use their knowledge about structure, bonding and reactivity of transition metal complexes to describe the mechanism of some fundamental catalytic processes, and the role of transition metal ions and their complexes in selected biological systems.

Electronically Approved - Jan 05 2024 14:47

Department Approval

Electronically Approved - Jan 05 2024 16:36

Associate Dean's Approval