Academic Year	AY20/21	**Semester**	1
Course Coordinator	Sumod Pullarkat & Rei Kinjo		
Course Code	CM1021		
Course Title	Basic Inorganic Chemistry with Laboratory		
Pre-requisites	A or H2 Level Chemistry or equivalent		
No of AUs	4		
Contact Hours	Lectures: 39; Laboratory: 18; Tutorial: 6		

Course Aims

The course covers fundamental concepts and organizing principles of inorganic and general chemistry that provide the basis for many aspects of chemistry and related fields, including spectroscopy, organic and bio-related chemistry. It will bring everyone to the same level of command of basic chemistry that is essential to progress to higher levels of core chemistry courses. The concepts espoused in the course will be illustrated and connected with real world applications whenever relevant. Practical work is at the heart of chemistry. The laboratory component of the course therefore aims to expose you to chosen experiments, which are meant to further consolidate the theoretical aspects learned during the course and required in the realm of chemical science. The laboratory component will also help you gain familiarity with a variety of laboratory techniques and equipment and instill in you the ability to work independently as well as part of a team.

Intended Learning Outcomes (ILO)

Upon successfully completing this course, you should be able to:

1. **Structure of atom**
   (a) Describe and discuss the quantum numbers including spin quantum number and structure of atom in terms of shells and subshells.
   (b) Explain the shapes of atomic orbitals
2. **Periodic trends**
   (a) Apply the Pauli Exclusion principle and related rules to electronic configuration
   (b) Discuss atomic subshell energies and electron assignments
   (c) Examine and determine the rules dictating the electronic configuration of various atoms and ions.
   (d) Analyze the electronic configurations and atomic properties and connect them to key periodic trends
   (e) Analyze periodic trends in atomic radii, electron affinity, ionization energy etc.
3. **Basics of NMR Spectroscopy**
   (a) Explain the basic concepts involved in using NMR spectroscopy as a structure elucidation tool
   (b) Interpret 1D-1H NMR spectra of simple organic molecules by applying the basic principles learned.
4. **Basics of Infra-red spectroscopy**
   (a) Explain the basic concepts involved in using IR spectroscopy as a structure elucidation tool.
   (b) Interpret IR spectra of simple organic molecules by applying the principles learned.

5. Bonding and Molecular Structure

(a) Analyze the formal charge, oxidation state, valency, and coordination number of atoms in molecules and ions.

(b) Explain the concept of the Octet rule, and provide examples of molecules/ions that follow/do not follow the principle by drawing the Lewis structure.

(c) Explain the concept of resonance.

(d) Determine the electron pair geometry and molecular geometry

(e) Analyze the bond and molecular polarity.

(f) Explain the relationship among bond distance, bond order, bond (dissociation) energy.

(g) Calculate the net reaction enthalpy based on bond energy of reactants and products.

6. Valence Bond Theory and Molecular Orbital Theory

(a) Analyze the hybridization of atoms in molecules and ions.

(b) Explain and illustrate the orbital diagram of molecules and ions including multiple bonds.

(c) Explain the concept of cis- and trans-isomerism.

(d) Construct molecular orbital diagram of diatomic molecules and ions by applying the basic principles learned.

(e) Analyze the frontier orbitals, magnetic nature, bond order of molecules and ions on the basis of the Molecular Orbital theory.

7. Introduction to Transition Metals

(a) Analyze the electronic configuration of transition metals

(b) Explain and illustrate the terminologies used in describing coordination complexes and their nomenclature.

(c) Describe the isomerism associated with coordination complexes

(d) Administer the crystal field theory to associate transition metal complexes and their magnetic properties.

Course Content

1. Structure of atom
2. Periodic trends
3. Basics of NMR Spectroscopy
4. Basics of Infra-red spectroscopy
5. Bonding and Molecular Structure
6. Valence Bond Theory and Molecular Orbital Theory
7. Introduction to Transition Metals

Assessment (includes both continuous and summative assessment)

Component	Course ILO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/Individual	Assessment rubrics

1. Midterm Test 1	1,2,3	Competence, Creativity	15%	Individual	Point-based marking (not rubrics based)
2. Midterm Test 2	5,6	Competence, Creativity	15%	Individual	Point-based marking (not rubrics based)
3. Final Examination	1,2,3,4,5,, 6,7	Competence, Creativity	50%	Individual	Point-based marking (not rubrics based)
4. Team Laboratory	1,2,5,6,7	Competence, Creativity	20%	Individual	Point-based marking (not rubrics based)
Total			*100%*		

Formative feedback

Formative feedback: Lecturers and TAs will be closely working with you to monitor your learning progress. They will provide you with timely feedback to improve your understanding of concepts. Furthermore, you will be given opportunities to express your ideas and discuss them with lecturers and TAs.

Summative Feedback: Summative feedback on laboratory reports and mid-term tests will be given. For laboratory reports, you will be provided with comments on mistakes, areas of improvement and examples of good practice in scientific writing etc.

This will help you to achieve the intended learning outcomes 1 to 7 above.

Learning and Teaching approach

Lectures (39 hours)	The lectures will convey key concepts in inorganic and general chemistry, providing critical information and background on how the concepts come about, with relevant theories and illustrative examples . The concepts will also be further illustrated with worked examples and with real world applications to show the relevance and importance of learning chemistry and its links to other disciplines.
Tutorials (6 hours)	TAs will provide materials containing concepts taught in classes and cover related applications derived from corresponding lectures. You will be assigned to a small group for interactive discussions, which will help you to develop your own critical thinking capability and problem solving skills in a team-based learning environment.

Laboratory (18 hours)	Laboratory session will consist of three main parts. Pre-laboratory exercises will involve online pre-lab quiz to be attempted prior to a lab session and consists of risk assessment and questions based on the lab manual to ensure that students have read and understood the respective experimental description before starting the actual lab session. During the actual lab session, you will typically work in pairs and conduct the assigned experiment under the supervision of laboratory TAs following the instructions provided in the lab manual. This will train you in applying concepts learned to real life situations. Subsequent to the lab session you are to submit an individual post-lab report in the prescribed format which will help to develop your critical thinking ability, ability to assimilate, evaluate and present the data gathered during a lab experiment.

Reading and References

Recommended textbooks:

Chemistry & Chemical Reactivity, 10th Ed (2019), Kotz/Treichel (KT), Cengage Learning Asia Pte. Ltd., ISBN 978-1-337-39907-4.

Chemistry: The Molecular Nature of Matter and Change, 8th Ed (2018), Silberberg/Amateis (SA); McGraw-Hill Education; ISBN 978-I-259-92175-9

For NMR and IR: Organic Chemistry, 8th Ed (2014), Wade (WD), Pearson Education Ltd, ISBN 978-1-29202-165-2.

Course Policies and Student Responsibilities

1. You are expected to read the lecture/tutorial/laboratory materials prior to the respective lecture/tutorial/laboratory session. This will help you to learn much more efficiently as you will already have an impression on the topics to be covered. For laboratory sessions, besides reading the laboratory manual and understanding the experimental procedure, you should also complete the pre-lab quiz (online) and risk assessment component of the lab report in which you should list possible hazards and their prevention steps. You should also read through the recommended textbooks as outlined in the references.

Academic Integrity

Good academic work depends on honesty and ethical behavior. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Sumod Pullarkat	CBC-06-02	63168906	sumod@ntu.edu.sg
Rei Kinjo	CBC-06-22	65922625	rkinjo@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/Activities
1	Structure of Atoms	1	KT Ch 06
2	Periodic Trends	2	KT Ch 07
3,4	NMR Spectroscopy	3	WD Ch 13
5	Infrared Spectroscopy	4	WD Ch 12
6-7	Bonding and Molecular Structure	5	KT Ch 08
8-11	Valence Bond Theory and Molecular Orbital Theory	6	KT Ch 09
13	Introduction to Transition Metals	7	KT Ch 22

CBC Programme Learning Outcome

The Division of Chemistry and Biological Chemistry (CBC) offers an undergraduate degree major in Chemistry that satisfies the American Chemical Society (ACS) curricular guidelines and equips students with knowledge relevant to the industry. Graduates of the Division of Chemistry and Biological Chemistry should have the following key attributes:

1. Competence
Graduates should be well-versed in the foundational and advanced concepts of chemical science, be able to evaluate chemistry-related information critically and independently, and be able to use complex reasoning to solve emergent chemical problems.

2. Creativity
Graduates should be able to synthesize and integrate multiple ideas across the curriculum, and propose innovative solutions to emergent chemistry-related problems based on their training in chemistry.

3. Communication
Graduates should be able to demonstrate clarity of thought, independent thinking, and sound scientific analysis and reasoning through written and oral reports to audiences with varying technical backgrounds. They should also be able to effectively engage other professional chemists in collaborative endeavours.

4. Character
Graduates should be able to act in responsible ways and uphold the high ethical standards that the society expects of professional chemists.

5. Civic-mindedness
Graduates should be aware of the impact of chemistry on society, and how chemistry can be applied to benefit mankind. They should also be aware of and uphold the best chemical safety practices.

Appendix 1: Assessment Criteria for mid-term test and final exam

mid-term test 1 and 2- MCQ questions

Standards		
Fail standard (0-4 marks)	**Pass standard (5-7 marks)**	**High standard (8-10 marks)**
Answers to the questions are mostly incorrect.	Answers to the questions are mostly correct.	Answers to the questions are almost always correct.

final exam – short answer questions

Standards		
Fail standard (0-4 marks)	**Pass standard (5-7 marks)**	**High standard (8-10 marks)**
Answers demonstrate the ability to repeat factual knowledge but not to apply it outside of the lecture context. Answers do not have a strong logical underpinning or maybe attempts to answer both ways at the same time.	Answers to the standard level question are correct and show the ability to apply concepts from the course, but a high level of critical thinking is absent. Answers are reasonably logical, but with gaps.	Answers to all questions show a high and consistent level of critical analysis of the information presented and creative solutions to the problems. Answers are highly logical and demonstrate strong reasoning. Answers are concise and to the point.

Appendix II – Assessment criterion for lab proforma

	Exceptional (8-10)	Admirable (6-7)	Acceptable (4-5)	Poor (1-3)
Overall presentation	Appropriate as a piece of scientific writing. Words were chosen carefully and appropriately. Sentence structure was clear and easy to follow. The report is free of spelling, punctuation, calculation and grammatical errors.	Minimal awkward phrasing or word choices. Minimal mistakes in calculations and explanations	Many passages are phrased poorly, contained awkward word choices, or many long sentences. Narrative is disorganized in many places. Multiple grammatical and/or spelling errors.	Poorly organized report with frequent awkward phrases, poor word choices and wrong inferences/calculations. Lacks cohesion, style and fluidity.
Answers to Proforma questions	Relevant experimental data/calculation steps are presented which are used for answering proforma questions. Demonstrates a logical, coherent working knowledge and understanding of important experimental concepts, forms appropriate conclusions based on interpretations of results, includes applications of and improvements in the experiment, collected data and analysis and demonstrates accountability by providing justification for any errors. Address all specific questions posed in the proforma.	All data and associated figures, calculations etc. are presented. Demonstrates an understanding of most important experimental concepts, forms conclusions based on results and/or analysis but either lacks proper interpretation, suggests inappropriate improvements in the experiment or lacks overall justification of error. Address most of the specific points for questions posed in the proforma.	Most figures, graphs, and tables are included, but some important or required features are missing. Certain data reported are not mentioned in the text or are missing. Captions are not descriptive or incomplete. While some of the results have been correctly interpreted and discussed, partial but incomplete understanding of results is still evident. Student fails to make one or two connections to underlying theory. Address some of the specific points or questions posed in the proforma.	Figures, graphs, and tables are poorly constructed; have missing titles, captions or numbers. Certain data reported are not mentioned in the text. Important data missing. Does not demonstrate an understanding of the important experimental concepts, forms inaccurate conclusions, suggests inappropriate improvements in the experiment and lacks overall justification of error. Address none of the specific points or questions posed in the proforma.