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|---|---|---|---|
| **Academic Year** | 2020/2021 | **Semester** | 1&2 |
| **Course Coordinator** | So Cheuk-Wai<br>Kinjo Rei<br>Leung Pak Hing<br>Ito Shingo | | |
| **Course Code** | CM2021 | | |
| **Course Title** | Inorganic and Bioinorganic Chemistry | | |
| **Pre-requisites** | CM1021 Basic Inorganic Chemistry with Laboratory OR<br>CM9001 Conceptual Chemistry with Laboratory OR<br>CY1101 Principles of Modern Chemistry OR by permission | | |
| **No of AUs** | 3 AU | | |
| **Contact Hours** | Lecture: 39 hours<br>Tutorial: 5 hours | | |

**Course Aims**

This course builds upon the ideas introduced in General Chemistry and aims to provide the fundamental ideas of Inorganic Chemistry, in particular bonding theories, main-group element compounds and transition metal coordination complexes. You will learn different bonding theories to explain the structures and hence reactivity of main-group element compounds and transition metal coordination complexes.

**Intended Learning Outcomes (ILO)**

Upon the successful completion of this course, you should be able to:

1. **Simple Bonding Theory**
   (a) Describe and discuss the "Chemical and Physical Bonding" including, covalent bond, ionic bond, Van der Waals force, hydrogen bonding, dipole-dipole interaction, dative bond, and metallic bond.
   (b) Explain bonding and electronic structure found in heavier elements-containing molecules.
   (c) Discuss the relationship between bonding and physical property such as melting point, boiling point, and conductivity of molecules/ions.

2. **Molecular Orbitals**
   (a) Construct molecular orbital diagrams of diatomic molecules and ions by applying the basic principles learned.
   (b) Apply the molecular orbital theory to analyze the frontier orbitals, magnetic nature, bond orders of molecules/ions.
   (c) Explain the concept of ligand group orbitals (LGO) and construct molecular orbital diagrams of larger molecules/ions than contain more than 2 atoms.

3. **Chemistry of Main-Group Elements**
   (a) Describe the general property of main group elements.
   (b) Explain the synthesis, reactivity, and general application of typical main group molecules.
   (c) Interpret and explain the concepts of (i) isotope effect, (ii) hard and soft acids and bases (HSAB) theory, (iii) diagonal relationships, (iv) inert pair effect, (iv) substituent (alpha- and beta)-effects, (v) average oxidation state, (vi) Gauche effect.
   (d) Describe the name reactions related to the synthesis of main group molecules.
   (e) Explain the important industrial processes and product schemes of typical main group compounds.

**4. <u>Chemistry of Transition Metal Coordination Complexes</u>**

(a) Interpret molecular formula, nomenclature and structure of transition metal coordination complexes.
(b) Determine valence electrons and compute the oxidation state of a metal center in transition metal coordination complexes.
(c) Contrast the ligand combinations and oxidation states of a given metal atom.
(d) Contrast common oxidation states within transition metal elements.
(e) Interpret isomerism in transition metal coordination complexes and the corresponding reactivity.
(f) Compare thermodynamic and kinetic stability of metal-ligand bonds.
(g) Determine and interpret bonding in transition metal coordination complexes.
(h) Interpret UV-Vis spectroscopic signals and magnetic properties of transition metal coordination complexes
(i) Explain reaction mechanisms of transition metal complexes.

**Course Content**

1. Simple Bonding Theories
2. Molecular Orbitals
3. Chemistry of Main-Group Elements
4. Chemistry of Transition Metal Coordination Complexes

**Assessment (includes both continuous and summative assessment)**

| Component | Course LO Tested | Related Programme LO or Graduate Attributes | Weighting | Team/Individual | Assessment rubrics |
|---|---|---|---|---|---|
| 1. Continuous Assessment 1 (CA1): Mid-term test 1 | 1-3 | Competence, Creativity | 20% | Individual | Point-based marking (not rubrics based) |
| 2. Continuous Assessment 2 (CA2): Mid-term test 2 | 4 | Competence, Creativity | 20% | Individual | Point-based marking (not rubrics based) |
| 3. Final Examination | 1-4 | Competence, Creativity | 60% | 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 mid-term tests will be given. This will help you to achieve the intended learning outcomes 1 to 4 above.

**Learning and Teaching approach**

| **Approach** | **How does this approach support students in achieving the learning outcomes?** |
|---|---|
| Lecture with incomplete notes and hand-written examples | To encourage you to remain engaged in lectures by taking notes and working on in-class examples. The engagement facilitates you to understand the chemistry delivered in lectures. You are also less likely to sit back, relax, and watch a performance while understanding nothing. |
| Video clips relevant to the class | To help you visualize chemistry concepts and enhancing your understanding. |
| Lectures with in-class practice examples | To help you verify your understanding of lectures in real time as well as your ability to apply precise and correct chemistry concepts in problem-solving questions.<br><br>Through practice, you learn to what extent you need to master and apply a particular knowledge point.<br><br>To show you common mistake(s) you can make and difficult points to master. |
| Clickers | To provide instant feedback in lectures in real time about the level of understanding and the level of difficulty of the concept.<br><br>To give you the opportunity to measure and compare your learning in class<br><br>To highlight common mistakes and tricky pointed related to lectures |
| Tutorials conducted by teaching assistants | To let you familiarize with types of questions related to learning points in lectures, and to what extent you need to master and apply<br><br>To help you to apply precise and correct chemistry concepts in problem-solving questions<br><br>To develop soft skills such as critical thinking, team work from tackling difficult questions and presentation skills from providing answers to peers |

**Reading and References**

Textbook: *Inorganic Chemistry,* 5/e by Gary L. Miessler, Paul J. Fischer, and Donald A. Tarr [ISBN 10: 1-292-02075-X; ISBN 13: 978-1-292-02075-4]

Reference book: *Inorganic Chemistry*, 4th Edition by Catherine Housecroft and Alan G. Sharpe [ISBN: 978-0-273-74275-3]

**Course Policies and Student Responsibilities**

**(1) General**

You are expected to complete all assigned pre-class readings and activities, attend all seminar classes punctually and take all scheduled assignments and tests by due dates. You are expected to take responsibility to follow up with course notes, assignments and course related announcements for seminar sessions you have missed. You are expected to participate in all seminar discussions and activities.

**(2) Absenteeism**

Attendance of classes is strongly encouraged for discussion with lecturers as well as for participation in clicker and in-class practice.

For those absent, you must catch up each week and follow the pack of lectures and tutorials each week.

When you miss a lecture, you are expected to make up for the lost learning activities. If you miss any mid-term tests due to valid reasons, the overall grading will be based on other tests that you have attended or the final exam score.

**Academic Integrity**

Good academic work depends on honesty and ethical behaviour. 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 |
|---|---|---|---|
| So Cheuk-Wai | SPMS-CBC 06-17 | 6513 2730 | CWSo@ntu.edu.sg |
| Kinjo Rei | SPMS-CBC 06-22 | 6592 2625 | rkinjo@ntu.edu.sg |
| Leung Pak Hing | SPMS-CBC 06-01 | 6513 8471 | pakhing@ntu.edu.sg |
| Ito Shingo | SPMS-CBC 05-17 | 6597 7581 | sgito@ntu.edu.sg |

**Planned Weekly Schedule**

| Week | Topic | Course ILO | Readings/ Activities |
|---|---|---|---|
| 1 | Simple Bonding Theory | 1 | (1) Reading lecture notes and textbook (2) Answering tutorial questions based on scientific literatures. |
| 2 | Molecular Orbitals Theory | 2 | (1) Reading lecture notes and textbook (2) Answering tutorial questions based on scientific literatures. |
| 3-6 | Chemistry of Main-Group Elements | 3 | (1) Reading lecture notes and textbook (2) Answering tutorial questions based on scientific literatures. |
| 7-8 | Nomenclature and Structure of Transition Metal Coordination Complexes | 4a-4e | (1) Reading lecture notes and textbook (2) Answering tutorial questions based on scientific literatures. |
| 9-10 | Bonding Theories of Transition Metal Coordination Complexes | 4f-4g | (1) Reading lecture notes and textbook (2) Answering tutorial questions based on scientific literatures. |
| 11-12 | UV-Vis Spectroscopy and Magnetic Properties of Transition Metal Coordination Complexes | 4h | (1) Reading lecture notes and textbook (2) Answering tutorial questions based on scientific literatures. |
| 13 | Reactions and Mechanisms of Transition Metal Complexes | 4g-4h | (1) Reading lecture notes and textbook (2) Answering tutorial questions based on scientific literatures. |

## 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.