Nanyang Technological University
Division of Chemistry and Biological Chemistry

Academic Year	2022/23	**Semester**	2
Course Coordinator	Zhao Yanli, Lee Hiang Kwee		
Course Code	CM4061		
Course Title	Materials Chemistry		
Pre-requisites	CM1021 or CM9001/CM5000 or CM1001 or CY1101 or by permission		
Mutually Exclusive	CM9021[1]		
No of AUs	3 AUs		
Contact Hours	Lectures: 39 hours (3 hours per week)		
Proposal Date	30 November 2021		

Course Aims

This course aims to provide a broad introduction to contemporary topics in materials science, with an emphasis on relating materials chemistry to their unique properties and real-world applications. We will discuss fundamental chemistry governing the properties of various materials, and gain insights on current material-based technologies and research. Upon completing this course, you will be able to appreciate the importance of materials in our everyday lives and explain their working principles. This course will provide students an opportunity to gain expertise in both chemistry and materials sciences, thereby supporting you for future career in relevant industries (e.g. semiconductors, energy and biomedical) and/or materials research.

Intended Learning Outcomes (ILO)

Upon the successful completion of this course, you (as a student) would be able to:

Introduction and fundamental principles of materials chemistry

1. Describe the differences between different classes of materials
2. Explain the relationships between molecular structure and physical/chemical properties
3. Describe the lattice and unit cell of different crystal structures
4. Explain the effects of defects on material properties

Characterization methods

5. Identify appropriate characterization techniques for different material properties
6. Describe the key components of various characterization techniques
7. Explain the working principles of characterization tools
8. Rationalize the data obtained from materials characterizations

Semiconductors

9. Describe and differentiate the band structures of semiconductor from metal and insulator
10. Explain the effect of doping on band structures
11. Explain the working principles of semiconductors
12. Determine the figure of merits for semiconductors
13. Explain the role of semiconductors in photo-catalysis and solar energy harvesting

[1] Replaced course

Energy storage materials

14. Describe key components and working principles of a battery and a capacitor
15. Quantify battery thermodynamics to select potential anodic/cathodic materials
16. Describe the differences between charging/discharging processes
17. Determine the figure of merits for different energy storage materials
18. Compare and contrast a battery and a capacitor

Optical materials

19. Explain the fundamental principles of optical materials
20. Identify and describe different types of optical materials
21. Identify and discuss main applications of optical materials
22. Design optical materials

Magnetic materials

23. Explain the fundamental principles of magnetic materials
24. Identify and describe different types of magnetic materials
25. Identify and discuss main applications of magnetic materials
26. Design magnetic materials

Porous materials

27. Explain the fundamental principles of porous materials
28. Identify and describe different types of porous materials
29. Identify and discuss main applications of porous materials
30. Design porous materials

Biomedical materials

31. Explain the fundamental principles of biomedical materials
32. Identify and describe different types of biomedical materials
33. Identify and discuss main applications of biomedical materials
34. Design biomedical materials

Course Content

1. Chapter 1 – Introduction and fundamental principles of materials chemistry
2. Chapter 2 – Characterization methods
3. Chapter 3 – Semiconductors
4. Chapter 4 – Energy storage materials
5. Chapter 5 – Optical materials
6. Chapter 6 – Magnetic materials
7. Chapter 7 – Porous materials
8. Chapter 8 – Biomedical materials

Formative feedback

You will be given feedback in five ways:

1. By response to postings on the course discussion board.
2. During online lectures.
3. Through face-to-face discussion during lecture.
4. Through the marking of assignments and mid-term tests.
5. Examiner report will be provided to the students after final exam.

Assessment (includes both continuous and summative assessment)

This is a graded course. There is a checklist of ALL the components of the assessments.

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/ Individual	Assessment rubrics
CA1: Assignment	1 – 18	Competence, Creativity, Civic-mindedness	10%	Individual	See Appendix 1
CA2: Mid-term Test I	1 – 18	Competence	10%	Individual	Point-based marking (not rubrics based)
CA3: Assignment	19 – 34	Competence, Creativity, Civic-mindedness	10%	Individual	See Appendix 1
CA4: Mid-term Test II	19 – 34	Competence, Creativity, Civic-mindedness	10%	Individual	Point-based marking (not rubrics based)
Final Examination	1 – 34	Competence, Creativity, Civic-mindedness	60%	Individual	See Appendix 1
Total			100%		

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Lectures	Face to face or online lectures will be employed for ILO 1 – 34. This is to allow interactions between you and the instructors. You could also immediately clarify your doubt/question.
Assignments	Allow instructors to challenge you during lecture and to achieve instant feedback. It also allows you to review the knowledge point right after the delivery and to master the knowledge in-depth.
Videos	Supplementary videos and animations may be used as alternative learning materials to reinforce your understanding on the course contents.

Reading and References

1. Introduction to Materials Chemistry, by Harry R. Allcock, John Wiley & Sons, Inc., 2019, ISBN: 978-1-119-34725-5.
2. Fundamentals of Materials Science and Engineering, by William D. Callister, John Wiley & Sons, Inc., 2001, ISBN-10: 047139551X.

Course Policies and Student Responsibilities

(1) General

You are expected to complete all assignments in good time.

(2) Absenteeism

If you miss a lecture, you are expected to make up for the lost learning activities. If you are sick and unable to attend your class, you have to:

1. send an email to the instructor regarding the absence
2. submit the original Medical Certificate‖ to the administrator. (‖ the medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.)

If you miss the mid-term test with approval, you will be provided with make-up test.

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 Instructor

Instructor	Office Location	Phone	Email
Zhao Yanli	SPMS-CBC 06-18	63168792	zhaoyanli@ntu.edu.sg
Lee Hiang Kwee	SPMS-CBC 04-05	6592 2511	hiangkwee@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introduction and fundamental principles of materials chemistry	1 – 4	Lecture, Assignment
2	Characterization methods	5 – 8	Lecture, Assignment
3	Semiconductors	9 – 13	Lecture
4	Semiconductors	9 – 13	Lecture, Assignment
5	Energy storage devices	14 – 18	Lecture
6	Energy storage devices	14 – 18	Lecture, Assignment
7	Midterm I	1 – 18	Assessment
8	Optical materials	19-22	Lecture, Assignment
9	Magnetic materials	23-26	Lecture, Assignment

10	Porous materials	27-30	Lecture, Assignment
11	Biomedical materials	31-34	Lecture, Assignment
12	Midterm II	19-34	Assessment
13	Course review	19-34	Lecture

Note: The above schedule is for illustrative purposes and is subject to the exigencies of the calendar.

Appendix 1:

Example of Rubric for Assignment (CA1, 10%)

Students are expected to apply the knowledge learned to solve scientific problems. Marks will be scaled to 10% of the course.

0-3 marks	4-7 marks	8-10 marks
Shows little to no understanding of the contents covered in the lectures	Shows moderate to good understanding of the contents covered in the lectures	Shows comprehensive understanding of the contents covered in the lectures

Grading criteria for the Course

The following guideline describes the criteria expected of the different levels of performance in this course.

Standards	Criteria
A+ (Exceptional) A (Excellent)	Actively participate and answer questions correctly in and out of class. Complete assignment punctually and correctly. Able to apply the knowledge learned very well with referenced to the learning outcomes (LO) 1 to 34 in order to answer the questions in written exams.
A- (Very good) B+ (Good)	Actively participate in questions in and out of class. Complete assignment punctually and be correct on majority of the questions. Able to apply the knowledge learned with referenced to the LO 1 to 34 to answer most of the questions in written exams.
B (Average) B- (Satisfactory) C+ (Marginally satisfactory)	Participate in questions in and out of class. Complete assignment with average marks. Partially able to apply the knowledge learned with referenced to the LO 1 to 34 to answer some of the questions in written exams.
C (Bordering unsatisfactory) C- (Unsatisfactory)	Seldom participate in questions in and out of class. Not able to complete assignment on time or achieve average marks. Not able to apply the knowledge learned with referenced to the LO 1 to 34 to answer some of the questions in written exams.
D, F (Deeply unsatisfactory)	Does not participate in questions in and out of class. Not able to complete assignment. Not able to apply the knowledge learned with referenced to the LO 1 to 34 to answer most of the questions in written exams.

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.