Nanyang Technological University
Division of Chemistry and Biological Chemistry

Academic Year	2022/23	**Semester**	2
Course Coordinator	Loh Zhi Heng		
Course Code	CM2062		
Course Title	Chemistry & Biological Chemistry Laboratory 2		
Pre-requisites	CM1041 or CM9001/CM5000 or CY1101 or CM1001		
No of AUs	3		
Contact Hours	9 experiments taking a maximum of 6 hours for each experiment – total 54 hours		
Proposal Date	21 October 2021		

Course Aims

This laboratory course aims to complement and supplement the lecture courses of CM1041, CM2011, and CM2041 by providing experimental demonstrations and verifications of the points discussed therein. This course allows you to hone your practical experimental skills in analytical and physical chemistry that are essential for chemists working in industry and academia. At the same time, taking this course will allow you improve your problem solving ability and your skills in scientific communication, both oral and written. Your experience of the experimental techniques used in analytical and physical chemistry will be enhanced, and you will be trained in the safe handling of chemicals and instruments, and in the assessment of risks associated with experimental procedures

Intended Learning Outcomes (ILO)

By the end of this course, you (as a student) would be able to:

1. Work independently and, where required, in collaboration with other students to safely perform experiments from the laboratory manual.
2. Follow detailed instructions in the laboratory manual to obtain desired experimental results.
3. Set up and interpret computational chemistry jobs for determining the electronic and vibrational properties of molecules.
4. Perform quantitative chemical analysis by employing basic measurements in electrochemistry, calorimetry, chromatography, and spectroscopy.
5. Operate state-of-the-art scientific laboratory equipment that is often used in industry.
6. Analyze the data from your experiments to fit a theoretical model.
7. Read scientific literature to gain a deeper understanding of your experimental results.
8. Work independently to prepare a detailed written report of your experimental findings.
9. Keep an accurate laboratory notebook of your experimental results in a form that is understandable by a third party.
10. Assess the potential risks of an experimental procedure before the procedure is carried out.
11. Review the experimental procedures after the experiments to see if there are more potential risks and propose how these can be alleviated.
12. Connect the experiments conducted with the relevant theories.

Course Content

S/N	Experiment	Approx. lab hours
1	Computational Chemistry: Introduction to *Gaussian*	6
2	Bomb Calorimetry	6
3	Conductivity and Electrochemical Cells	6
4	Absorption Spectroscopy of Conjugated Dyes	6
5	Fluoride Ion-Selective Electrode (ISE)	6
6	Spectrophotometric Determination of the Dissociation Constant of an Acid-Base Indicator	6
7	Halide (Cl^-) Quenching of Quinine Sulfate Fluorescence	6
8	Determining the CMC of a Surfactant by Contact Angle Measurements	6
9	High Performance Liquid Chromatography: Separation and Quantification of Caffeine in Cola Drinks	6

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/Individual	Assessment Rubrics
Experiments	1-10	Competence, Communication and Creativity	50%	Certain experiments will be performed as a team but reports must be prepared individually	See Appendix 1
Final exam	4,5,10	Competence and Creativity	50%	Individual	
Total			100%		

Formative feedback

You will be given feedback in three ways:
1. Through teaching assistants (TAs), who will be present for each individual experiment.
2. Through the graded lab reports.
3. Through consultation with the faculty member who designed the lab experiment.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
A mixture of performing experiments,	The majority of the course is conducted in the teaching laboratory where you will receive hands-on experience with the necessary equipment. The experiments will be conducted in a mixture of individually as well as part of

processing data and writing weekly reports.	a team, although you are expected to gain full knowledge of all parts of the experimental procedures. The reports for the experiments are expected to be done individually so that you have complete knowledge of all theoretical aspects of the experiments.

Reading and References

Reading references are provided in the laboratory manual. You will also be required to use the on-line databases of the library to find new relevant reference materials in the scientific literature.

Course Policies and Student Responsibilities

Absentees:

If you are unable to attend any of the assigned lab sessions, you must, within 7 days after the lab, provide the original supporting document (*e.g.*, medical certificate from a medical doctor, order for court appearance) to the SPMS office. In addition, you must email or present to the chief TA a copy of the supporting document within 2 days after your excuse has expired.

If you need to obtain a leave of absence for any of the labs, please lodge a formal application through the SPMS office. Only official approvals from the SPMS office are accepted by the instructors of this course. Failure to do so will result in a zero grade for the lab that the student is absent from.

You must complete at least 8 out of the 9 experiments in order to be allowed to sit for the final exam. There will NOT be any make-up laboratory experiments.

Laboratory safety and punctuality:

The instructors and chief TA of this module take a very serious stance on laboratory safety, punctuality and academic integrity.

(i) Students who flaunt safety rules spelt out in the CM2062 laboratory manual will be barred from entering the laboratory.

(ii) The laboratory sessions begin promptly at 9.30 am. A significant amount of marks (up to 50%) will be deducted for students who are late for any of the laboratory sessions without a valid excuse. Students who arrive 20 minutes after the start of the lab session will **not** be allowed to enter the lab and will receive a grade of zero for that day's experiment.

(iii) Hand-in your lab reports/pro-formas in time. This is usually 1 week after you have completed the lab session unless you have been granted permission to delay submission by either an instructor or the chief TA. Lab reports/pro-formas submitted after the due date will not be accepted and you will receive a grade of zero for that experiment.

If you have a valid reason for missing a lab, you must submit the previous week's report to the lab before 10 am on the next working day upon expiration of the MC.

Academic Integrity

Students are expected to complete the pro-formas/lab reports by themselves. Copying and plagiarism will result in severe disciplinary actions including possible expulsion from the university. 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	E-mail
Loh Zhi Heng	SPMS-CBC-01-19A	6592 1655	zhiheng@ntu.edu.sg

Planned Weekly Schedule

Experiment	Topic	Course LO	Readings/ Activities
1	Computational Chemistry: Introduction to *Gaussian*	1-10	Computer-based exercise; Proforma provided
2	Bomb Calorimetry	1-10	Laboratory experiment; Proforma provided
3	Conductivity and Electrochemical Cells	1-10	Laboratory experiment; Proforma provided
4	Absorption Spectroscopy of Conjugated Dyes	1-10	Laboratory experiment; Proforma provided
5	Fluoride Ion-Selective Electrode (ISE)	1-10	Laboratory experiment; Proforma provided
6	Spectrophotometric Determination of the Dissociation Constant of an Acid-Base Indicator	1-10	Laboratory experiment
7	Halide (Cl^-) Quenching of Quinine Sulfate Fluorescence	1-10	Laboratory experiment
8	Determining the CMC of a Surfactant by Contact Angle Measurements	1-10	Laboratory experiment
9	High Performance Liquid Chromatography: Separation and Quantification of Caffeine in Cola Drinks	1-10	Laboratory experiment

The experiments will be conducted in a predetermined order depending on your group assignment. The class will be divided into nine groups (Groups 1 – 9), with each group performing a different experiment, so that all experiments will run each week. After you have completed one experiment, the next week you will move on to the next experiment, until you have finished all the experiments. The exact timetable for each student will be uploaded into NTULearn at the beginning of the semester so that each student will know their experimental timetable. You will

be required to carry out a risk assessment for each experiment in the week that you are performing it, before you enter the laboratory, using a template that is provided on-line on the course information page.

Appendix 1: Assessment Criteria for all components

Written report

There are 4 written reports, each worth 100 marks.

	Exceptional (81 – 100)	Good (61 – 80)	Acceptable (41 – 60)	Poor (0 – 40)
Safety	Performed safety checks, followed the safety instructions carefully and supported others to do so.	Performed safety checks and followed the safety instructions carefully.	Performed safety checks but did not follow the safety instructions carefully.	Did not conduct safety checks. Did not realise the potential threats and hazards.
Overall presentation	Appropriate as a piece of scientific writing. Words are chosen carefully and appropriately. Sentence structure is clear and easy to follow. The report is free of spelling, punctuation, and grammatical errors .	Minimal awkward phrasing or word choices. Report is easy to read and constructed properly. Evidence of editing with less than three grammatical and/or spelling errors.	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 narrative with frequent awkward phrases and poor word choices. Sentences are too long or short. Lacks cohesion, style and fluidity. Frequent spelling and grammatical errors.
Introduction	A cohesive, well-written summary of the background material pertinent to the experiment with appropriate references. Purpose of the experiment is clearly stated. References are used properly.	Mostly complete but does not provide context for minor points. Contains relevant information but certain information is not cohesive. Some references are provided.	Certain major introductory points are missing (ex: background, theory, etc.) or explanations are unclear and confusing. Few references are provided.	Very little background information is provided and/or information is incorrect. No reference is provided.
Methodology	Contains details on how the experiment was performed and the procedures followed. Written in the correct tense.	Narrative includes most important experimental details but is missing some relevant information.	Missing several experimental details or some incorrect statements.	Several important experimental details are missing or copied directly from the lab manual.

Results	All figures, graphs, and tables are numbered with appropriate captions. All tables, figures, etc. are explicitly mentioned in the text. Relevant experimental data are presented which are used in the discussion.	All figures, graphs, and tables are correctly drawn, but some have minor problems that could be still be improved. All data and associated figures, etc. are mentioned in the text. Most relevant data are presented.	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.	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.
Discussion/ Conclusions	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, references collected data and analysis, refers to the literature when appropriate, and demonstrates accountability by providing justification for any errors. Address all the specific questions posed in the lab manual.	Demonstrates an understanding of the majority of important experimental concepts, forms conclusions based on results and/or analysis but either lacks proper interpretation, suggests inappropriate improvements in the experiment, refers to the literature insufficiently, or lacks overall justification of error. Address most of the specific points or questions posed in the lab manual.	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 lab manual.	Does not demonstrate an understanding of the important experimental concepts, forms inaccurate conclusions, suggests inappropriate improvements in the experiment, refers to the literature insufficiently, and lacks overall justification of error. Address none of the specific points or questions posed in the lab manual.
References	All sources (information and graphics) are accurately documented in consistent format.	All sources are accurately documented, but format is not consistent. Some sources are not accurately documented.	All sources are accurately documented, but many are not in consistent format. Most sources are not directly cited in the text.	All sources are accurately documented but not directly cited in the text.

Proforma

There are 5 proformas, each worth 100 marks.

	Exceptional (81 – 100)	Good (61 – 80)	Acceptable (41 – 60)	Poor (0 – 40)
Safety	Performed safety checks, followed the safety instructions carefully and supported others to do so.	Performed safety checks and followed the safety instructions carefully.	Performed safety checks but did not follow the safety instructions carefully.	Did not conduct safety checks. Did not realise the potential threats and hazards.
Overall presentation	Appropriate as a piece of scientific writing. Words were chosen carefully and appropriately. Sentence structure was clear and easy to follow. The proforma is free of spelling, punctuation, and grammatical errors .	Minimal awkward phrasing or word choices. Report is easy to read and constructed properly. Evidence of editing with less than three grammatical and/or spelling errors.	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 narrative with frequent awkward phrases and poor word choices. Sentences are too long or short. Lacks cohesion, style and fluidity. Frequent spelling and grammatical errors.
Results	All figures, graphs, and tables are labelled with appropriate captions. All tables, figures, etc. are explicitly discussed when required. Relevant experimental data are referred to in answer to specific questions.	All figures, graphs, and tables are correctly drawn, but some have minor problems that could be still be improved. All data and associated figures, etc. are mentioned when required. Most relevant data are presented in answer to specific questions.	Most figures, graphs, and tables are included, but some important or required features are missing. Certain obtained data are not mentioned when specifically required in answering questions. Captions are not descriptive or incomplete.	Figures, graphs, and tables are poorly constructed; have missing titles, captions or numbers. Certain obtained data are not mentioned when specifically required in answering questions. Important data missing or incorrectly interpreted.

Oral report

There is 1 oral report, worth 100 marks.

	Exceptional (81 – 100)	Good (61 – 80)	Acceptable (41 – 60)	Poor (0 – 40)
Overall presentation	Structure of the presentation is well-organized. Presentation materials are informative and appropriate. Able to communicate the objectives and results clearly, and able to discuss the results confidently without any prompting. Speaks fluently and concisely, and demonstrates good time management.	Structure of the presentation is fairly organized. Presentation materials are informative and mostly appropriate, with some minor problems. With some prompting, able to communicate the objectives and results clearly, and able to discuss the results confidently. Occasional pauses in the presentation, but able to keep to the time.	Structure of the presentation is fairly organized. Some presentation materials are unclear and/or unnecessary. With some prompting, able to communicate the objectives and results, and able to discuss the results. Occasional pauses in the presentation and slightly exceed time allocated.	Structure of the presentation is disorganized. Presentation materials are not informative and inappropriate. Unable to communicate the objectives and results clearly, and lacks confidence in discussing the results. Many pauses in the presentation, unnecessarily verbose, and exceeds time allocated.
Scientific principles and technical knowledge	Demonstrates a logical, coherent working knowledge and understanding of the important scientific principles that underlie the experiment and the operation principles of the instruments, forms appropriate conclusions based on interpretations of results, and demonstrates accountability by providing justification for any errors.	Demonstrates an understanding of the majority of the important scientific principles that underlie the experiment and the operation principles of the instruments, forms conclusions based on results and/or analysis but sometimes lacks proper interpretation, lacks overall justification of error.	While some of the results have been correctly interpreted and discussed, partial understanding of the scientific principles of the experiment is still evident. Limited knowledge of the operation principles of the instrument. Student fails to make one or two connections to underlying theory.	Does not demonstrate an understanding of the important experimental concepts and operation principles of the instrument, forms inaccurate conclusions, and does not provide any justification of error.

Final exam – MCQs and short answer questions

The final exam is worth 100 marks.

Standards		
Fail standard (0 – 39 marks)	**Pass standard (40 – 80 marks)**	**High standard (81 – 100 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.

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.