Nanyang Technological University
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	Pre-lab self-study		18 hours
	Laboratory work		54 hours
	Post-lab data analysis and report writing		42 hours
Proposal Date	23 August 2022		

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 the experiments described in the laboratory manual.
2. Follow detailed instructions in the laboratory manual to obtain desired experimental results.
3. Perform quantitative chemical analysis by employing techniques in electrochemistry, calorimetry, chromatography, and spectroscopy.
4. Operate scientific equipment in the laboratory and describe their operating principles.
5. Analyze the experimental data by using various theoretical models.
6. Explain the scientific principles underlying each experiment.
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 a detailed laboratory notebook, recording your experimental findings in a form that is understandable by a third party.
10. Perform computational chemistry simulations to determine the electronic and vibrational properties of molecules.
11. Assess the potential risks of an experimental procedure before the procedure is carried out.
12. Review the experimental procedures after the experiments have been completed to identify additional potential risks and propose how they can be mitigated.

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 – 12	Competence, Creativity, Communication and Character	50%	Students will work in a team for some experiments, but data analysis, reports and proformas must be done individually	See Appendix 1
Final exam	3 – 6	Competence and Creativity	50%	Individual	Point-based marking (not rubrics based)
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 and lab proformas.
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?

Pre-lab self-study	Before reporting to lab, you are expected to read through the relevant section of the lab manual, watch the recorded lab briefing, prepare the lab notebook entries, complete the pre-lab exercises, and perform the pre-lab risk assessment. By familiarizing yourself with the experiment, including safety precautions to be taken, before setting foot in the lab, you will be work more efficiently in the lab and have a better appreciation for the various experimental procedures.
Performing experiments in the lab, analyzing data, and preparing lab reports or proformas	The majority of the course is conducted in the teaching laboratory where you will receive hands-on training for the various pieces of equipment. The experiments will be performed in groups, although you are expected to gain full knowledge of all parts of the experimental procedures. The data analysis and subsequent proformas or reports are expected to be done individually so that you are familiar with all the 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 CCEB 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 CCEB office. Only official approvals from the CCEB office are accepted by the instructors of this course. Failure to do so will result in a zero grade for the lab from which the student is absent.

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; students who miss more than one experiment will receive a "LOA" grade.

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/proformas 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/proformas 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/proforma to the lab before 10 a.m. on the next working day upon expiration of the MC.

Academic Integrity

While students are assigned to work in groups in the lab, they are expected to analyze the data and to write up their lab reports independently. Data analysis includes tabulating data, graphing data, and performing calculations to obtain various physical parameters. Each student is responsible for preparing his/her own set of tables and graphs to be used in the report. When preparing the lab report, students should not use illustrations from the lab manual or from other sources, including the internet, without proper attribution. Moreover, even with proper citation, students should not lift texts from other sources and use them in their lab reports without paraphrasing. Please note that plagiarism includes duplicating, either in part or in full, the lab report of either a lab mate or a senior.

Students are not to fabricate data or alter the collected data in any way. In some instances, a student might realize during data analysis that a particular data point deviates significantly from the best-fit line. In such cases, instead of removing the data point from the graph or changing the value of the data point, the student should provide an explanatory note as to what might have happened in lab during the data acquisition to have caused the significant deviation. If the student chooses to omit any data points from the analysis, e.g., in the generation of the best-fit line, the student should state this explicitly in the report, along with a justification of the omission.

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, 2, 5 – 10	Computer simulation; proforma provided
2	Bomb Calorimetry	1 – 12	Laboratory experiment; proforma provided
3	Conductivity and Electrochemical Cells	1 – 12	Laboratory experiment; proforma provided
4	Absorption Spectroscopy of Conjugated Dyes	1 – 12	Laboratory experiment; proforma provided
5	Fluoride Ion-Selective Electrode (ISE)	1 – 12	Laboratory experiment; proforma provided
6	Spectrophotometric Determination of the Dissociation Constant of an Acid-Base Indicator	1 – 12	Laboratory experiment; written report required
7	Halide (Cl^-) Quenching of Quinine Sulfate Fluorescence	1 – 12	Laboratory experiment; written report required
8	Determining the CMC of a Surfactant by Contact Angle Measurements	1 – 12	Laboratory experiment; written report required
9	High Performance Liquid Chromatography: Separation and Quantification of Caffeine in Cola Drinks	1 – 12	Laboratory experiment; written report required

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.

Appendix 1: Assessment Criteria for all components

Lab performance

Students will be assessed on their performance in the lab during each lab session. Teaching assistants will observe the work of the students and engage in oral Q & A with each student. Each assessment is worth 30 marks.

	Excellent (25 – 30)	Good (19 – 24)	Average (13 – 18)	Below Average (7 – 12)	Poor (1 – 6)
Adherence to safety regulations	The student is properly attired, uses proper personal protective equipment (PPE), always takes safety precautions.	The student is properly attired, occasionally forgets to use proper personal protective equipment (PPE), takes almost all safety precautions.	The student is properly attired, occasionally forgets to use proper personal protective equipment (PPE), omits some safety precautions.	The student is properly attired, often neglects the use of proper personal protective equipment (PPE), omits numerous safety precautions.	The student is improperly attired, often neglects the use of proper personal protective equipment (PPE), omits safety precautions entirely.
Understanding of the scientific and operating principles	Demonstrates an excellent understanding of the scientific principles of the experiment, relates classroom knowledge of physical and/or analytical chemistry to the experiment with ease, confidently identifies the key components of the instrument and clearly explain their roles in the operation of the instrument.	Demonstrates a good understanding of the scientific principles of the experiment, relates classroom knowledge of physical and/or analytical chemistry to the experiment with limited prompting, identifies most of the key components of the instrument and explain their roles in the operation of the instrument.	Demonstrates a fair understanding of the scientific principles of the experiment, relates classroom knowledge of physical and/or analytical chemistry to the experiment with some prompting, identifies approximately half of the key components of the instrument and explain their roles in the operation of the instrument.	Demonstrates a poor understanding of the scientific principles of the experiment, unable to relate classroom knowledge of physical and/or analytical chemistry to the experiment even with repeated prompting, able to identify less than half of the key components of the instrument and explain their roles in the operation of the instrument.	Demonstrates a complete lack of understanding of the scientific principles of the experiment, unable to relate classroom knowledge of physical and/or analytical chemistry to the experiment even with extensive prompting, unable to identify the key components of the instrument and unable to explain their roles in the operation of the instrument.

Experimental technique	Operates laboratory equipment and accessories independently and in a manner that yields results with excellent accuracy and precision.	Operates laboratory equipment and accessories with limited assistance and in a manner that yields results with good accuracy and precision.	Operates the laboratory equipment and accessories with some assistance and in a manner that yields fairly accurate and precise results.	Operates the laboratory equipment and accessories to constant assistance and in a manner that yields results of limited accuracy and precision.	Mishandles and/or does not participate in the operation of laboratory equipment and/or accessories.
Teamwork, time manage-ment and communication skills	Leads group work and discussion, takes initiative to prioritize tasks and to work efficiently, leads the communication with group members.	Participates actively in group work and discussion, able to prioritize tasks and works efficiently when prompted, effectively communicates with group members on most occasions.	Participates in a fair share of group work and discussion, needs guidance to prioritize tasks and to work efficiently, communicates with group members.	Seldom participates in group work and discussion, needs to be prompted constantly to prioritize tasks and to work efficiently, communicates with group members intermittently.	Does not participate in group work and discussion, does not prioritize tasks and works inefficiently, does not communicate with group members.
Organization of lab workspace and lab notebook	Maintains a very well-organized workbench during the lab session, cleans up thoroughly after the lab session, all tables and fields are prepared in the lab notebook before reporting to lab, all lab notebook entries are neat and informative.	Maintains a well-organized workbench during the lab session, cleans up after the lab session, almost all the tables and fields are prepared in the lab notebook before reporting to lab, most lab notebook entries are neat and informative.	Maintains a fairly well-organized workbench during the lab session, must be reminded to clean up after the lab session, most of the tables and fields are prepared in the lab notebook before reporting to lab, a handful of lab notebook entries are untidy.	Maintains a well-organized workbench during the lab session only with constant prompting, must be reminded to clean up after the lab session, prepares some tables and fields in the lab notebook during the lab session, the majority of the lab notebook entries are untidy.	Workbench during the lab session is disorganized despite prompting, does not clean up satisfactorily after the lab session despite prompting, prepares tables and fields in the lab notebook during the lab session, almost all lab notebook entries are untidy.

Proforma

There are 5 proformas, each worth 6 marks.

	Good (5 - 6)	Average (3 – 4)	Poor (1 – 2)
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. Proforma is easy to read and constructed properly. Evidence of editing with just a handful of grammatical and/or spelling errors.	Many passages are phrased poorly, contained awkward word choices, or many long sentences. Narrative is disorganized in many places. Numerous grammatical and/or spelling 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. 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 either incomplete or not sufficiently descriptive.

Written report

There are 4 written reports, each worth 9 marks.

	Good (7 - 9)	Average (4 – 6)	Poor (1 – 3)
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.
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.
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.
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.

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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.
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.

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.