NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

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| **Academic Year** | 2020/21 | **Semester** | 1 |
| **Course Coordinator** | Richard D. WEBSTER | | |
| **Course Code** | CM3062 | | |
| **Course Title** | Chemistry & Biological Chemistry Laboratory 4 | | |
| **Pre-requisites** | CM2062 | | |
| **No of AUs** | 3 | | |
| **Contact Hours** | Nine experiments taking a maximum of six hours for each experiment – Total 54 hours. | | |
| **Proposal Date** | 9 January 2020 | | |

**Course Aims**

The principle aims of the practical course are:

1. To complement the lecture courses of CM2011, CM2041 by providing experimental demonstrations and verifications of the points discussed therein and to supplement what you may have or will learn at a later time in the courses CM3011, CM3041 and CM4011 (note that these are not pre-requisites for reading CM3062).
2. To hone your practical experimental skills that are essential for chemists working in industry and academia.
3. To improve your problem solving ability.
4. To improve your scientific writing skills.
5. To extend your experience of the experimental techniques used by analytical chemists, (bio)physical chemists and (bio)spectroscopists.
6. To train you in the safe handling of chemicals and assessment of risks in 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. Operate state-of-the-art scientific laboratory equipment that is often used in industry.
4. Analyze the data from your experiments to fit a theoretical model.
5. Read scientific literature to gain a deeper understanding of your experimental results.
6. Work INDEPENDENTLY to prepare a detailed written report of your experimental findings.
7. Keep an accurate laboratory notebook of your experimental results in a form that is understandable by a third party.
8. Assess the potential risks of an experimental procedure before the procedure is carried out.
9. Review the experimental procedures after the experiments to see if there are more potential risks and propose how these can be alleviated.
10. Connect the experiments conducted with the relevant theories.

**Course Content**

| S/N | Experiment | Approx. Laboratory Hours |
|---|---|---|
| 1 | Computational Chemistry: *Gaussian* | 6 |
| 2 | Gas Phase Infrared Molecular Spectroscopy | 6 |
| 3 | A Kinetic Study of the Enzyme Papain | 6 |
| 4 | Environmental Analysis Using ICP-OES | 6 |
| 5 | Experimental Cyclic Voltammetry | 6 |
| 6 | Ion Chromatography | 6 |
| 7 | Melting Temperatures of Duplex DNA | 6 |
| 8 | Determining the Enthalpy of Vaporization by Gas Chromatography | 6 |
| 9 | Synthesis and Characterization of Silver Nanoparticles using UV-vis Absorption Spectroscopy and Atomic Force Microscopy | 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 experimental data will be collected as a team but the reports must be prepared individually | See Appendix 1 |
| Final exam | 4,5,10 | | 50% | Individual | |
| Total | | | 100% | | |

**Formative feedback**

You will be given feedback in three ways:

1. A teaching assistant (TA) will be present for each individual experiment who will instruct you in the technical details and will be able to answer any pertinent questions regarding the experimental procedures.
2. The TAs will mark each experiment that you submit and return it the next week so that you can see how you are progressing.
3. Each experiment was written by an academic staff member who you are able to contact for a one-on-one discussion.

**Learning and Teaching approach**

| Approach | How does this approach support students in achieving the learning outcomes? |
|---|---|
| A mixture of performing experiments, processing data and writing weekly reports. | The majority of the course is conducted in the 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 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.**

**Please be reminded that students must complete at least 7 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 CM3062 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 students 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 very 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 |
|---|---|---|---|
| Richard WEBSTER | SPMS-CBC-04-06 | 6316 8793 | webster@ntu.edu.sg |

**Planned Weekly Schedule**

| Experiment | Topic | Course LO | Readings/ Activities |
|---|---|---|---|
| 1 | Computational Chemistry: *Gaussian* | 1-10 | Computer based exercise<br>Proforma provided |
| 2 | Gas Phase Infrared Molecular Spectroscopy | 1-10 | Laboratory experiment |
| 3 | A Kinetic Study of the Enzyme Papain | 1-10 | Laboratory experiment<br>Proforma provided |
| 4 | Environmental Analysis Using ICP-OES | 1-10 | Laboratory experiment<br>Proforma provided |
| 5 | Experimental Cyclic Voltammetry | 1-10 | Laboratory experiment<br>Proforma provided |
| 6 | Ion Chromatography | 1-10 | Laboratory experiment<br>Proforma provided |
| 7 | Melting Temperatures of Duplex DNA | 1-10 | Laboratory experiment<br>Proforma provided |
| 8 | Determining the Enthalpy of Vaporization by Gas Chromatography | 1-10 | Laboratory experiment |
| 9 | Synthesis and Characterization of Silver Nanoparticles using UV-vis Absorption Spectroscopy and Atomic Force Microscopy | 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 (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**

*Experimental Reports (9 reports worth 10 marks each and then normalized to a mark out of 50).*

(a) For experiments that require self-prepared reports.

| | Exceptional (10-8) | Admirable (6-7) | Acceptable (4-5) | Poor (1-3) |
|---|---|---|---|---|
| **Safety** | Perform safety checks, follow the safety instructions carefully and support others to do so. | Perform safety checks and follow the safety instructions carefully. | Perform 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 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 | All figures, graphs, and tables are correctly drawn, but some have minor problems that | Most figures, graphs, and tables are included, but some important or required features | Figures, graphs, and tables are poorly constructed; have missing titles, captions or |

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| | tables, figures, etc. are explicitly mentioned in the text. Relevant experimental data are presented which are used in the discussion. | could be still be improved. All data and associated figures, etc. are mentioned in the text. Most relevant data are presented. | are missing. Certain data reported are not mentioned in the text or are missing. Captions are not descriptive or incomplete. | 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 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. |

(b) For experiments that use proformas.

| | Exceptional (10-8) | Admirable (6-7) | Acceptable (4-5) | Poor (1-3) |
|---|---|---|---|---|
| **Safety** | Perform safety checks, follow the safety instructions carefully and support others to do so. | Perform safety checks and follow the safety instructions carefully. | Perform 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. |

*Final exam – MCQs and short answer questions (exam worth 50 marks).*

| Standards | | |
|---|---|---|
| **Fail standard (0-20 marks)** | **Pass standard (21-39 marks)** | **High standard (40 -50 marks)** |
| Answers demonstrate the ability to repeat factual knowledge but not to apply it outside of the lecture context.<br>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.<br>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.<br>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.