CBMS208 CHEMICAL ANALYSIS I

UNIT GUIDE, SYLLABUS AND TIMETABLE

CBMS208 UNIT GUIDE

Year and Semester: 2012, Session 2

Unit convenor: Dr Christopher McRae

Prerequisites / Corequisites: CBMS101 (P) pre-2010; CBMS101 (Cr); CBMS102 (P); Admission to GradCertBiotech.

ABOUT THIS UNIT

The measurement of chemical composition is a necessary requirement for forensic science, local and international trade, manufacture and production, government regulatory agencies, biotechnology and nearly every field of science. Thus, an understanding of the principles of chemical analysis is an essential part of any scientist's education. This unit is designed to serve the needs of students majoring in chemical, biomolecular, environmental, earth and medical sciences. The unit introduces the principles of chemical analysis that enable the separation, detection, identification and quantification of the chemical matter found in a variety of samples. Such samples may range from those associated with forensic science such as drugs in biological tissue to contaminants in river systems, soils and the general environment, to heavy metals in ores and alloys, to neurochemicals present in a single neuron. Topics include statistical analysis of chemical data; sampling methods; all modes of chromatographic separation with applications to environmental and biotechnological issues; methods of flow analysis of environmental and biological samples; ion-selective electrodes; potentiometric titration; titrimetry and buffer solutions. Understanding of these techniques is reinforced with practical, hands-on experience using state-of-the-art instrumentation in our well-equipped analytical teaching laboratory.

• Credit points – 3 (equivalent to at least 9 hours/week of contact and self-study)

CBMS208 is a 3-credit point unit half-year unit. Students are expected to invest an average of 9 hours’ work per week. This consists of 3 one-hour lectures per week and a four-hour laboratory session every two weeks, except the first two sessions. Therefore, students need to spend at least 4 hours on private study per week. Clearly, students with weak chemistry backgrounds will probably need to spend significantly more time than this. In order to successfully complete this unit, students will need to work hard, consistently and continuously throughout the semester.
Please note that more advanced analytical techniques will be covered and discussed in CBMS308 Chemical Analysis II (3 credit points) in First Session of 2013. **CBMS208 (P) is the sole prerequisite for CBMS308.**

### TEACHING STAFF

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There are no formal office hours for this unit. Dr McRae and Dr Wong are happy to receive students outside of the formal lecture but please be aware that we are not always to be found in our offices, so it is generally a good idea to organise an appointment **in advance.**

### TECHNOLOGY USED

It is important that you have a scientific calculator as hand-held calculators will be used during laboratory sessions, for assignments, and in the final examination. **Note that text retrieval calculators are not allowed in the final examination.**

Use will be made of Excel and other data processing and display software. Computers carrying this software are available in the teaching laboratories. Items of interest, links to other on-line material will be placed on the unit website.

Computers for general use are provided by the University, but it would be advantageous to have your own computer and internet access.

### CLASSES

**Timetable:** Please check http://www.timetables.mq.edu.au/ for the official timetable of the unit.

**Lectures:** The material presented in the lectures is important and you should not assume that all examinable material is available in the textbook or in printed notes. On the other hand, do not assume that all examinable material is to be found in the lecture notes.

**Tutorial:** There are three optional tutorial sessions organised in this unit.

**Laboratory Work:** Laboratory sessions commence in Week 2. You will undertake five experiments in the 2nd / 3rd Year Teaching Laboratories.
REQUIRED AND RECOMMENDED TEXTS AND/OR MATERIALS

Prescribed text:

Recommended references (all available in University Library)

If you feel you need to strengthen your mathematical skills, you might like to refer to Maths for Chemistry – A Chemist’s toolkit of calculations, P.Monk, Oxford University Press (2006).


UNIT WEB PAGE

The web page for this unit can be found on ilearn page:
http://ilearn.mq.edu.au
Some lecture notes will be available on the Web for downloading one week prior to the scheduled lecture. You are strongly encouraged to make use the discussion forum available on the CBMS208 website for general discussion of materials presented in this unit.

LEARNING OBJECTIVES AND OUTCOMES

The objectives of this unit include:

• To achieve fundamental understanding of the principles of some commonly used analytical techniques;
• To acquire fundamental laboratory skills and to gain hands-on experience in performing experiments involving some basic analytical techniques;
• To familiarise with data processing and to draw scientifically sound conclusions from experimental results, leading to an appreciation of the significance and validity of analytical results involving real-life samples;
• To acquire some scientific writing ability;
• To acquire some interpersonal skills through teamwork and communication during laboratory sessions.
Following the successful completion of this unit, you should be able to:

- appreciate and understand the basic principles of some commonly used analytical techniques;
- perform basic analytical experiments with awareness of uncertainty in measurements;
- interpret and draw sound conclusions from analytical chemical data obtained;
- prepare written scientific documents at a satisfactory level;
- develop fundamental interpersonal skills during laboratory sessions.

Practical laboratory experiments in instrumentally based chemical analysis will be undertaken, which

- provide experience in preparation of procedures for carrying out experiments, including safe laboratory practices;
- give practice in data measurement and evaluation through explanation of fundamental concepts of analytical chemistry;
- demonstrate some modern experimental equipment and techniques;
- develop the ability to use standard data analyses to correctly describe the numerical significance of experimental results and an appreciation of the source and significance of uncertainty in scientific investigations;
- contribute to the development of graduate capabilities, as described below.

**Graduate Capabilities:** The course work and laboratory work in this unit will help you to develop the graduate capabilities that “the University’s graduates would need to develop to address the challenges and to be effective, engaged participants in their world”. Graduate capabilities are viewed as essential for all graduates, irrespective of their course of study. Thus, in conjunction with discipline-specific skills and knowledge, they are the building blocks for developing the attributes valued in a university graduate. Some of the attributes and skills that CBMS208 can help you develop are:

**Discipline Specific Knowledge and Skills:** The topics explored in CBMS208 are fundamental to the discipline of chemistry. You will be applying problem-solving skills in the chemistry context, applying chemistry theory to practice in order to design and carry out laboratory experiments, using chemistry specific apparatus and techniques, and to apply safe laboratory practices, performing data analysis applying appropriate statistical treatment to data and using standard and specialised computer programs in the analysis of data and presentation of results.

**Critical, Analytical and Integrative Thinking:** Within this unit you will be developing and practicing your ability to apply strategic problem-solving in situations where there is a clear solution and in situations demanding critical, analytical and integrative thinking. You will be solving problems by analysing the information given or discovered, looking for other sources of information to apply, looking for the scope and limitation of the context in which the problem and solution lie. In many cases you will be using standard and specialised IT technology for the discovery of information, the analysis of data and the presentation of results.

**Problem Solving and Research Capability and being Creative and Innovative:** In both the theory and the laboratory component of this unit you will have ample opportunities to develop your problem solving skills and research capabilities. Through set assignment and additional exercises in laboratory work, and through performing the laboratory experiments, where procedures, data collection and data analysis will require you to make various decisions, you will be deeply involved in problem solving and research processes in the chemistry context.
Effective Communication: CBMS208 will help equip you with written communication skills and some oral communication skills, through your written laboratory reports and your assignments, and with your lecturers and your classmates. Part of your assessment will be concerned with your ability to communicate in clear, concise and appropriate, context-dependent modes (formal reports, informal team discussions, etc).

Engaged and Ethical Local and Global citizens: Engaged and ethical behaviour will be addressed in the professional chemist context, that is, you will be concerned with collecting data and information with appropriate acknowledgement of sources, you will learn ways of performing experiments and recording outcomes in a manner that conforms to the expectations of the profession and community at large. You will be working with people for a variety of cultural and economic backgrounds and you will be expected to be able to form cohesive and effective teams with anybody in your class.

Socially and Environmentally Active and Responsible: You will be working in small teams for much of CBMS208, especially in the laboratory component of the unit, giving you the opportunity to develop your ability to work with others as a leader and a team player and to have a sense of connectedness and mutual obligation with others.

Capable of Professional and Personal Judgement and Initiative: Especially during your laboratory work, you will be expected to develop discernment and common sense in your professional and personal judgement. You will also be given assignment and test questions that will give you the opportunity to exhibit these capabilities, especially in the context of the application of “models” in scientific knowledge and theorising.

Commitment to Continuous Learning: We hope that you will have your enquiring minds and curiosity extended by CBMS208, and that the topics covered and skills developed will lead you to continue to pursue knowledge for its own sake. You will have opportunities to reflect on your experiences, learn from them, and grow personally, professionally and socially.

**TEACHING AND LEARNING STRATEGY**

- Students are required to attend lectures and laboratory classes. Active participation by the students in all of these fora is expected. This means that you are expected to ask questions during lectures, and particularly in laboratory sessions. Learning is an active process, and as such, you must engage with the material. This means reading the textbook (and beyond) **before** and **after** lectures, attempt the assignment questions and other questions, discuss the concepts with your classmates and lecturers. Do not be afraid to ask questions – your classmates will probably want to ask the same thing.

- Assignment questions are issued so that you will have the opportunity to use the information provided in the lectures and textbook and to test your degree of understanding of those topics.

- Laboratory exercises are designed to provide a concrete example of the abstract topics covered in the course work, and to give you the opportunity to discover the principles and applications for yourself. Laboratory exercises also offer the opportunity to explore the uncertainty inherent in scientific investigations and the limitations of models and theories by allowing comparison with real systems.
**Assessment:** The grades you achieve at Macquarie University are descriptive rather than numeric. The assessments and conditions on your performance (attendance, completion, etc) help to decide which of these descriptive grades applies to your work for the entire unit.

Your raw marks from assessments are combined into a weighted sum. The weighted sums for the whole class are ranked, and compared with rankings for the same unit in previous offerings and across other appropriate consistency. This process of comparison allows for the identification any unusual influences on class performance that might warrant the weighted sums of marks being scaled or otherwise altered. The numerical cut-offs for each descriptive grade are then determined. The numerical value that you will be issued with (the standardised numerical grade, SNG) is determined to match your descriptive grade by standardising the weighted sums of raw marks to match standard scores out of 100. The SNG gives you an indication of how you have performed within the band for your descriptive grade. As the SNG is the result of scaling the weighted sum of your raw marks, you won't be able to:

- work out your exam mark based on the assignment marks you already know and the SNG;
- determine that you were "one mark away" from a different grade.

It is our professional responsibility as your teachers to assign you a descriptive grade that accurately reflects your performance in a unit. Our grading decisions are subject to scrutiny from our academic colleagues at the Department, Faculty and University Senate level.

The Grades range from High Distinction to Fail, and are defined in the Handbook as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>SNG</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD</td>
<td>85-100</td>
<td>Work of outstanding quality. This may be demonstrated in areas such as criticism, logical argument, interpretation of materials or use of methodology. This grade may also be awarded to recognise a high order of originality or creativity in student performance.</td>
</tr>
<tr>
<td>Distinction</td>
<td>75-84</td>
<td>Work of superior quality in the same areas of performance as above. This grade may also be awarded to recognise particular originality or creativity in student performance.</td>
</tr>
<tr>
<td>Credit</td>
<td>65-74</td>
<td>Work of predominantly good quality, demonstrating a sound grasp of content together with efficient organisation, selectivity and use of techniques.</td>
</tr>
<tr>
<td>Pass</td>
<td>50-64</td>
<td>Satisfactory achievement of unit objectives.</td>
</tr>
<tr>
<td>Conceded Pass</td>
<td>45-49</td>
<td>Marginal achievement of unit objectives.</td>
</tr>
<tr>
<td>Fail</td>
<td>0-44</td>
<td>Failure to achieve unit objectives.</td>
</tr>
</tbody>
</table>
In order to complete this unit satisfactorily students must
(a) attend and participate satisfactorily in ALL laboratory sessions;
(b) submit satisfactory efforts at fortnightly assignments;
(c) perform satisfactorily in a final examination of three hours' duration.

Assignments, laboratory work and the final examination will carry the following proportions of the total assessment.

<table>
<thead>
<tr>
<th></th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Assignments</td>
<td>15%</td>
</tr>
<tr>
<td>Laboratory work</td>
<td>35%</td>
</tr>
<tr>
<td>Final 3 hour examination</td>
<td>50%</td>
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</tbody>
</table>

The top student with a High Distinction grade in CBMS208 will be awarded a $500 cash prize by PANanalytical Australia. The presentation will be conducted during the annual Faculty of Science Prize Ceremony in early 2013.

**Levels of Achievement:** The lowest passing level is to be able to identify and use correctly the appropriate formulae from those supplied, in familiar circumstances (*i.e.*, problems similar to those practised in tutorial questions or from past exams). In this case you would expect to obtain a low Pass grade.

A creditable level of achievement is to display knowledge of the meaning and significance of the topics in relation to molecular parameters, and to correctly use formulae in unfamiliar situations.

The highest level of achievement is to display a deep knowledge of the models being used, its uses and limitations, and to apply knowledge from beyond that which is taught in the unit, and even to challenge the material presented.

**Assignments:** The assignments are designed to help you learn the material during the semester, rather than trying to cram on the day before the examination. They are relatively low risk (a small component of the aggregate score) but they are very valuable for you as measures of your understanding of the topics.

The laboratory sessions will allow you to put the material that you have been exposed to in the lectures into practice. They will provide concrete expositions of theory. They also provide the opportunity for you to continue your development of bench, data collection and data analysis skills. Writing up the experiments and verbal presentation of the results obtained will give you skills in communicating in the chemistry context.

**Examinations:** The final examination will be 3 hours in length and will cover all sections of the unit (lectures, tutorial problems, assignments and laboratory exercises).

The University Examination period for the Second Half Year 2012 is from November 12 to November 30.

You are expected to present yourself for examination at the time and place designated in the University Examination Timetable. The timetable will be available in Draft form approximately eight weeks before the commencement of the examinations and in Final form approximately four weeks before the commencement of the examinations.

http://www.timetables.mq.edu.au/exam

The only exception to not sitting an examination at the designated time is because of documented illness or unavoidable disruption. In these circumstances you may wish to
consider applying for Special Consideration. Information about unavoidable disruption and the special consideration process is available at


If a Supplementary Examination is granted as a result of the Special Consideration process the examination will be scheduled after the conclusion of the official examination period.

You are advised that it is Macquarie University policy not to set early examinations for individuals or groups of students. All students are expected to ensure that they are available until the end of the teaching semester, which is the final day of the official examination period.

**Attendance:** Attendance at laboratory sessions is compulsory, and non-attendance may be taken as grounds for applying a failing grade. A poor attendance record will certainly result in reduction of the aggregate mark. Students unable to attend due to illness or misadventure and who are unable to catch up in a reserve session must provide formal documentary evidence to the University as soon as possible after the absence. For one such justified absence students will receive the average mark from the sessions that they did attend. For any unjustified absences students will receive a zero mark and may be subject to compulsory withdrawal from the unit.

If an absence is anticipated (perhaps for a mandatory religious event, etc), the student must inform teaching staff in advance that this will be the case and make alternative arrangements. It is the responsibility of the student to undertake this. Notification after the event of an anticipatable absence will not be looked upon favourably.

**Due Dates and Submission of Material:** In general, you will submit laboratory experiment reports two weeks after completing the exercise. Submission dates for assignments will be provided with the assignment.

Assignments and laboratory reports must be submitted with a cover sheet, which is provided in Lecture 1. The cover sheet can also be downloaded from the CBMS208 website. If no staff member can be found, the material may be given to the departmental executive officer, Mrs Michelle Kang, F7B 220. Every effort will be made by the staff to return the material within the next seven days, but this may not always be possible.

Late submission may incur a penalty of 10% for each late day.

**Extension and Special Consideration Requests**

Extension requests for assessable material must be made to your lecturer with appropriate evidence to support the request. Each request will be treated on its merits.

The University is committed to equity and fairness in all aspects of its learning and teaching. In stating this commitment, the University recognises that there may be circumstances where a student is prevented by unavoidable disruption from performing in accordance with their ability. The University has a policy on special consideration requests that may be found at:

www.mq.edu.au/policy/docs/special_consideration/policy.html

The University recognises that at times an event or set of circumstances may occur that:

- Could not have reasonably been anticipated, avoided or guarded against by the student AND
- was beyond the student’s control AND
• Caused substantial disruption to the student’s capacity for effective study and/or completion of required work AND
• Substantially interfered with the otherwise satisfactory fulfilment of unit or program requirements AND
• Was of at least three (3) consecutive days duration within a study period and/or prevented completion of a formal examination.

This policy is instituted to support students who experience serious and unavoidable disruption such that they do not reach their usual demonstrated performance level. The form required to submit for a request for special consideration can be found at http://www.reg.mq.edu.au/academic-index.html.

**ACADEMIC HONESTY**

The University declares that it is a ‘fundamental principle’ that “all staff and students act with integrity in the creation, development, application and use of ideas and information. This means that:

- all academic work claimed as original is the work of the author making the claim
- all academic collaborations are acknowledged
- academic work is not falsified in any way
- when the ideas of others are used, these ideas are acknowledged appropriately.”

You should be familiar with the University’s Policy on Academic Honesty practices and its Statement on Ethics. These can be found in the *Handbook of Undergraduate Studies* or on the web at:


Academic Honesty Policy: www.mq.edu.au/policy/docs/academic_honesty/policy.htm


The policies and procedures explain what academic dishonesty is, how to avoid it, the procedures that will be taken in cases of suspected dishonesty, and the penalties if you are found guilty. Penalties may include a deduction of marks, failure in the unit, and/or referral to the University Discipline Committee.

**Examples** of dishonest academic behaviours are:

**Plagiarism:** Using the work or ideas of another person and presenting this as your own without clear acknowledgement of the source of the work or ideas. This includes, but is not limited to, any of the following acts:

a) copying out part(s) of any document or audio-visual material or computer code or website content without indicating their origins
b) using or extracting another person's concepts, experimental results, or conclusions
c) summarising another person's work
d) submitting substantially the same final version of any material as another student in an assignment where there was collaborative preparatory work
e) use of others (paid or otherwise) to conceive, research or write material submitted for assessment
f) submitting the same or substantially the same piece of work for two different tasks (self-plagiarism).

**Deception:** includes, but is not limited to, false indication of group contribution, false indication of assignment submission, collusion, submission of a work previously submitted, creating a new article out of an existing article by rewriting/reusing it, using the same data to
form the same arguments and conclusion, presenting collaborative work as one's own without acknowledging others' contributions, cheating in an examination or using others to write material for examination.

**Fabrication**: includes, but is not limited to, creating fictitious clinical data, citation(s), or referee reports.

**Sabotage**: includes, but is not limited to, theft of work, destruction of library materials.

Assignments are to be your own work. Using someone else’s words (either another student’s or from a book or journal article or a web site) without clear acknowledgement is plagiarism and can incur serious penalties. If it is ever necessary to use someone else’s words for a phrase or sentence, they should be placed in quotation marks and acknowledged at the end of the sentence. If you use or modify a diagram or figure from another author, that must be acknowledged underneath (e.g. Figure 3 from Brown et al., 1995; figure modified from Green, 1997). Lecturers want to read your own words and ideas.

In the event that a Lecturer identifies a case of academic dishonesty, the student will be advised, either on the submitted work or by separate letter, and a record kept in the Faculty office. Students will always have the opportunity to discuss each case with their Lecturer if they indicate they wish to do so by either contacting the Lecturer or the Head of Department. Proven cases of academic dishonesty may result in the immediate award of an “F” grade.

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**UNIVERSITY POLICY ON ASSESSMENT**

The University considers that assessment “of student learning performance and feedback on progress are pivotal and important processes in University learning and teaching. Assessment tasks communicate to students what must be learned and are vehicles by which the University assures itself, and society, of its graduates’ capabilities” and is based on the “premise that it is important that through assessment students are encouraged to engage in their education, rather than merely pursue grades. Student engagement is best facilitated by learner managed learning in which students are active partners in the process through undertaking challenging responsibilities and making choices.” There are responsibilities and rights for both staff and students respect to assessment. These include, but are not limited to, the right of academic staff to require that students:

- be focused on learning rather than merely the achievement of grades;
- make the effort to be informed of the rules and requirements for progression in their degree program;
- assistance from the department, faculty and/or institution if they so require it;
- behave ethically and responsibly in their conduct of assessment tasks;
- engage in critical self evaluation in terms of their progress towards the espoused learning expectations;
- submit work on time that is their own except when shared ownership is part of the task;
- notify their lecturers as soon as possible if difficulties arise with timing, online access, availability of resources or other requirements of the task;

Students have a right to:

- be informed about all aspects of assessment policy and practices in each unit of study including criteria, standards and procedures to be met and penalties for breaches;
- consistent application of policies, procedures and penalties;
- timely return of results with feedback to enable improved performance
- information that allows them to calibrate their own performance against the expected performance standards;
The full statement on the Assessment Policy, Code of Practice and Procedure can be found at:


**STUDENT SUPPORT SERVICES**

Macquarie University provides a range of Academic Student Support Services. Details of these services can be accessed at http://www.student.mq.edu.au.

**CHANGES TO THE UNIT SINCE LAST OFFERING.**

No changes have been made to the unit since the last offering.

**FEEDBACK**

We are always open to suggestions for improving the content and delivery of this course. We are also very happy to receive any constructive criticism that you may wish to provide. Dr Christopher McRae and Dr Danny Wong hope that you will find this unit to be a rewarding experience.

Chris McRae and Danny Wong
Analysis of Chemical Data

1. **Experimental Errors**
   - Mean, standard deviation, precision, accuracy
   - Indeterminate and determinate errors, propagation of errors

2. **Statistics**
   - Population and Sample
   - Normal Distribution, hypothesis testing
   - Student's t test, Grubb’s test, Chi-squared test, F-test, Analysis of Variance
   - Calibration, Linear regression
   - Sampling methods

Titrimetry

1. **Revision of chemical equilibrium**
   - Equilibrium constant
   - Le Châtelier's Principle
   - Solubility product
   - Acids and bases
   - Activity and activity coefficient

2. **Volumetric analysis**
   - Titration calculations
   - Standardisation of titrants
   - Back titration
   - Monoprotic acid-base equilibria

3. **Buffers**
   - The Henderson-Hasselbalch Equation
   - How does a buffer work?
   - Preparing buffers
   - Buffer capacity

4. **More volumetric analysis**
   - Acid-base titrations
   - Polyprotic acids and bases
   - EDTA and iodine titrations

Electroanalytical Techniques

1. **Fundamentals of Electrochemistry**
   - Electrochemical Cells and Redox Reactions
   - The Nernst Equation
   - Conductance and conductivity
   - Ostwald's dilution law
   - Mobility and transport number of ions

# Subject to change by the lecturers.
2. **Potentiometric Methods**
   - Reference Electrodes
   - The measurement of pH
   - Ion-selective electrodes, selectivity coefficients
   - Potentiometric titrations

### Flow Injection and Chromatography

1. **Flow Injection Analysis**
   - Principles
   - Instrumentation
   - Applications

2. **Chromatography**
   - General principles of chromatography
   - Partition ratio, retention times, plate number, plate height, column efficiency and resolution, band shapes and band broadening, van Deemter equation

3. **Gas-Liquid Chromatography (GLC)**
   - Principles
   - Instrumentation

4. **High-Performance Liquid Chromatography (HPLC)**
   - Principles
   - Normal-phased chromatography, reversed-phase chromatography,
   - Ion-exchange chromatography, instrumentation

### Thermal Methods

1. **Thermogravimetry**
   - Interpretation of results
   - Factors affecting thermogravimetric curves

2. **Differential methods of thermal analysis**
   - Differential thermal analysis (DTA)
   - Differential scanning calorimetry (DSC)
   - Interpretation of DTA/DSC curves
   - Calibration procedures in DSC/DTA

3. **Some Applications of Thermal Analysis**
# SUGGESTED LECTURE AND LABORATORY SCHEDULE 2012

<table>
<thead>
<tr>
<th>Week</th>
<th>Week starting</th>
<th>Tuesday 10 am</th>
<th>Thursday 11 am</th>
<th>Thursday 1 pm</th>
<th>LABORATORY 2 – 6 pm</th>
<th>E7B 349</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>July 30</td>
<td>Introduction, Statistics</td>
<td>Statistics</td>
<td>Statistics</td>
<td>Workshop (E7B 346 or F7B 322)</td>
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<tr>
<td>2</td>
<td>August 6</td>
<td>Statistics</td>
<td>Statistics</td>
<td>Statistics</td>
<td>Experiment 1 (E7B 349)</td>
<td></td>
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<td>3</td>
<td>August 13</td>
<td>Statistics</td>
<td>Sampling methods</td>
<td>Sampling methods</td>
<td>Experiment 2 (E7B 349)</td>
<td></td>
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<tr>
<td>4</td>
<td>August 20</td>
<td>Titrimetry</td>
<td>Titrimetry</td>
<td>Titrimetry</td>
<td>–</td>
<td></td>
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<tr>
<td>5</td>
<td>August 27</td>
<td>Titrimetry</td>
<td>Titrimetry</td>
<td>Titrimetry</td>
<td>Experiment 3 (E7B 349)</td>
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<tr>
<td>6</td>
<td>September 3</td>
<td>Flow injection</td>
<td>Flow injection</td>
<td>Flow injection</td>
<td>Optional Tutorial</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>September 10</td>
<td>Flow injection</td>
<td>Flow injection</td>
<td>Electroanalytical chemistry</td>
<td>Experiment 4(i) / 4(ii) / 5</td>
<td></td>
</tr>
</tbody>
</table>

**Mid-Semester Break (September 17 – September 28)**

<table>
<thead>
<tr>
<th>Week</th>
<th>Week starting</th>
<th>Tuesday 10 am</th>
<th>Thursday 11 am</th>
<th>Thursday 1 pm</th>
<th>LABORATORY 2 – 6 pm</th>
<th>E7B 349</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>October 1</td>
<td>Labour Day Public Holiday</td>
<td>Labour Day Public Holiday</td>
<td>Electroanalytical chemistry</td>
<td>Experiment 4(i) / 4(ii) / 5</td>
<td></td>
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<tr>
<td>9</td>
<td>October 8</td>
<td>Electroanalytical chemistry</td>
<td>Electroanalytical chemistry</td>
<td>Electroanalytical chemistry</td>
<td>Optional Tutorial</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>October 15</td>
<td>Electroanalytical chemistry</td>
<td>Electroanalytical chemistry</td>
<td>Chromatography</td>
<td>Experiment 4(i) / 4(ii) / 5</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>October 22</td>
<td>Chromatography</td>
<td>Chromatography</td>
<td>Chromatography</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>October 29</td>
<td>Chromatography</td>
<td>Chromatography</td>
<td>Chromatography</td>
<td>Experiment 4(i) / 4(ii) / 5</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>November 5</td>
<td>Chromatography</td>
<td>Thermal methods</td>
<td>Thermal methods</td>
<td>Optional Tutorial</td>
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* The schedule is subject to change.