

## CBMS208 CHEMICAL ANALYSIS I

### INTRODUCTORY NOTES

Students in this unit should read this unit outline carefully at the start of semester. It contains important information about the unit. If anything in it is unclear, please consult one of the teaching staff in the unit.

#### Lecturers

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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.

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 of 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 Semester of 2010. **CBMS208 (P) is the sole prerequisite for CBMS308.**

**Learning objectives and outcomes 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.

**Prescribed Textbook:**

D.A.Skoog, D.M.West, F.J.Holler, S.R.Crouch, <i>Fundamentals of Analytical Chemistry</i> , 8th Edition, Thomson, Brooks/Cole (2004).
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**Other Recommended References:**

- D.C.Harris, *Quantitative Chemical Analysis*, 6th Edition, W.H.Freeman & Company (2003).
- D.C.Harris, *Exploring Chemical Analysis*, W.H.Freeman & Company (1997).
- H.H.Willard, L.L.Merritt, Jr., J.A.Dean, F.A.Settle, Jr., *Instrumental Methods of Analysis*, 7th Edition, Wadworth Publishing Company (1988).
- D.A.Skoog, F.J.Holler and T.A.Nieman, *Principles of Instrumental Analysis*, 5th Edition, Saunders College Publishing (1998).
- J.F.Rubinson and K.A.Rubinson, *Contemporary Chemical Analysis*, Prentice Hall (1998).

If you would like to strengthen your mathematical skills, you may like to refer to P.Monk, "Maths for Chemistry – A Chemist's toolkit of calculations", Oxford University Press (2006).

## Webpage for CBMS208

Some Lecture Notes, all Experimental Notes, solutions to assignments, etc can be downloaded from the webpage for CBMS208. The URL is

<http://www.cbms.mq.edu.au/~cbms208>

You are strongly encouraged to use the bulletin board on the webpage for general discussion of materials presented in this unit.

### Assessment:

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.

Students are required to have a scientific calculator as hand-held calculators will be used in laboratory sessions, for assignments, and in the final examination. Note that calculators with text retrieving, memory and graphing capabilities are not allowed in the final examination.

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

Assignments	15%
Laboratory work	35%
Final 3 hour examination	50%

The University Examination period in Second Half Year 2009 is from November 18 to December 4.

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 <http://www.reg.mq.edu.au/Forms/APSCon.pdf>

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, that is the final day of the official examination period.

### Plagiarism

The University defines plagiarism in its rules: "Plagiarism involves using the work of another person and presenting it as one's own." Plagiarism is a serious breach of the University's rules and carries significant penalties. You must read the University's practices and procedures on

plagiarism. These can be found in the *Handbook of Undergraduate Studies* or on the web at: <http://www.student.mq.edu.au/plagiarism/>

The policies and procedures explain what plagiarism is, how to avoid it, the procedures that will be taken in cases of suspected plagiarism, 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.

### **University Policy on Grading**

Academic Senate has a set of guidelines on the distribution of grades across the range from fail to high distinction. Your final result will include one of these grades plus a standardised numerical grade (SNG).

On occasion your raw mark for a unit (i.e., the total of your marks for each assessment item) may not be the same as the SNG which you receive. Under the Senate guidelines, results may be scaled to ensure that there is a degree of comparability across the university, so that units with the same past performances of their students should achieve similar results.

It is important that you realise that the policy does not require that a minimum number of students are to be failed in any unit. In fact it does something like the opposite, in requiring examiners to explain their actions if more than 20% of students fail in a unit.

The process of scaling does not change the order of marks among students. A student who receives a higher raw mark than another will also receive a higher final scaled mark.

For an explanation of the policy see <http://www.mq.edu.au/senate/MQUonly/Issues/Guidelines2003.doc> or <http://www.mq.edu.au/senate/MQUonly/Issues/detailedguidelines.doc>.

### **Effect of excessive paid work and other activities on student progress and success**

Several studies on student progress have demonstrated that excessive hours of paid work and/or other activities, especially regular commitments, can have a detrimental effect on successful completion of studies. As stated in the Undergraduate Handbook, the number of credit point for each unit reflects the amount of work required, and each credit point has an expectation of 3 hours of work per week (this includes both in class and out of class study).

If you are undertaking an average full-time program of study, i.e. 12 credit points, then you should expect to undertake 36 hours of study per week. Care should be taken with additional regular commitments to ensure that you are not overloading yourself. Options might include cutting back on outside commitments during the semester or reducing the number of units you undertake.

## UNIT OUTLINES<sup>#</sup>

### 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, Dixon's Q test, Chi-squared test, F-test
  - 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

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<sup>#</sup> Subject to change by the lecturers.

- Mobility and transport number of ions
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**