A POLYTECHNIC INSTITUTION

Course Outline

School of Manufacturing, Electronics and Industrial Processes
Program: Mining
Option: 50A4

CHSC 4406
Assaying & Geochemistry

Start Date: January 4, 2006 **End Date:** May 26, 2006

Total Hours: 60 **Total Weeks:** 20 **Term/Level:** 4 **Course Credits:** 4
Hours/Week: 3 **Lecture:** 1 **Lab:** 2 **Shop:** **Seminar:** **Other:**

Prerequisites

Course No.	Course Name
CHEM 2201 or CHEM 2205	Chemistry 2 for Mining

CHSC 4406 is a Prerequisite for:

Course No.	Course Name

■ Course Description (required)

Covers methods for the determination of a wide variety of elements in various sample matrixes related to mining. Emphasis is placed on selection of the most suitable technique for the particular samples under investigation. Techniques include precious metals by fire assaying, base metals by geochemical analysis, classical wet assaying and analytical instrumentation. Modern sampling theories are used to explain the critical requirement and importance of a representative sample. Sample contamination avoidance strategy is discussed by understanding comminution techniques and cross contamination probability. Concepts of control, umpire analysis, role of reference materials, matrix effects, pre-concentration techniques, statistical analysis and quality control concepts are covered. Analytical Instrumentation used is electrochemical, UV-visible, atomic absorption, inductively coupled plasma-optical emission & mass spectrometers and X-ray (fluorescence & diffraction) spectrometers.

■ Evaluation

Final Examination	35%	Comments:
Laboratory & Participation	25%	
Tests	30%	
Assignments & Quizzes	10%	
TOTAL	100%	

■ Course Learning Outcomes/Competencies

Upon successful completion, the student will be able to:

1. Understand the principles and applications involved in sampling theories and sampling techniques.

2. Prepare samples from a wide variety of materials originated from mineral exploration, mining, metallurgical and fabrication industries.

3. Understand the important concepts of sample dissolution/digestion chemistry involved.
4. Apply the basic chemical principles and techniques to perform the analysis of common base metals.
5. Understand the principles involved in fire assaying, and employing these techniques to perform precious metals analysis.
6. Apply techniques to eliminate potential interference and cross contamination occurrence to optimize accuracy and precision in analyses.
7. Solve problems and correctly complete calculations related to fire assaying methods.
8. Select appropriate analytical instrumental technique (i.e. UV-Vis, AA, ICP-OES, ICP-MS, XRF, Specific ion electrode, etc.) to carry out analyses as required in the mining industry based on the capability and limitation of the chosen instrument.
9. Set up, optimize and operate the analytical instruments.
10. Understand the terms accuracy, precision, expected concentration range, detection limit, interference, and apply them towards instrumental analyses.
11. Prepare and use blanks, spikes and duplicates to verify analytical results.
12. Use spreadsheet to process analytical data and perform statistical analysis on analytical results.
13. Recognize the important relationship between quality control and accuracy of results in assaying.

■ Verification

I verify that the content of this course outline is current.

Authoring Instructor — Dec 30, 2005 — Date

I verify that this course outline has been reviewed.

Program Head/Chief Instructor — Jan 4/05 — Date

I verify that this course outline complies with BCIT policy.

Dean/Associate Dean — 2006/01/04 — Date

Note: Should changes be required to the content of this course outline, students will be given reasonable notice.

■ Instructor(s)

E. Woo Office Location: SW1-1085 Office Phone: 604-432-8393

Office Hrs.: TBA E-mail Address: ewoo@bcit.ca

■ Learning Resources

Required:

1. Laboratory notebook, lab coat, and safety glasses.

Recommended:

Reference Texts:

SAMPLING AND STATISTICS

1. Gy, P.; Sampling for Analytical Purposes; John Wiley & Sons, New York, 1998.
2. Gy, P.M.- Sampling of Particulate Materials, Theory and Practice; *Elsevier Scientific Publishing Co.* - New York, 1979.
3. Smith, R. and G.V. James; The Sampling of Bulk Materials; *771e Royal Society of Chemistry* London, 1981.
4. Eckscinager, K.; Errors, Measurements and Results in Chemical Analysis; Van Nostrand Reinhold, London, 1969.
5. Bauer, E.L.; A Statistical Manual for Chemists; *Academic Press* New York, 1971.
6. Miller, J.C. and J.N. Miller; Statistics for Analytical Chemistry, 2nd ed.; *Wiley*- Chichester, 1988.

QUALITY ASSURANCE/ QUALITY CONTROL

1. Dux, J.P.; Handbook of Quality Assurance for the Analytical Chemistry Laboratory, 2nd ed.; *Van Nostrand Reinhold;* New York, 1990.
2. Mesley, R.J., W.D. Pocklington and R.F. Walker (1991); Analytical Quality Assurance - A Review; *The Analyst;* October, Vol. 116, No. 10, pages 975-990.
3. ISO Guide 25 "General Requirements for the Competence of Calibration and Testing laboratories"; International Organization for Standardization: Geneva, 1990.
4. Kateman, G.; Buydens, L.; Quality Control in Analytical Chemistry, 2nd ed., Wiley: New York, 1993.

FIRE ASSAYING

1. Bugbee, Edward E. (1940), and A textbook of Fire Assaying. Golden, Colorado: Colorado School of Mine Press.

2. Beamish, F.E. and J.C. Van Loon; Analysis of Noble Metals; Overview and Selected Methods; Academic Press; New York, 1977.

CLASSICAL ASSAYING

1. Skoog, D.A., D.M.West, and F.J.Holler; Fundamentals of Analytical Chemistry; 7th ed.; Holt, Rinehart and Winston; New York, 1991.

2. Bassett, J., R.C. Denney, G.H. Jeffery and J.Mendham; Vogel's Textbook of Quantitative Inorganic Analysis; 5th ed.; Longman Group Ltd.; London, 1989.

3. Donaldson,E.M.; Methods for the Analysis of Ores, Rocks and Related Materials; 2nd ed.; CANMET Monograph 881 (1982).

ANALYTICAL INSTRUMENTATION

1. Price, W.J.; Spectrochemical Analysis by Atomic Absorption, 2nd ed.; *Heydell & Son Ltd.:* London, 1979.

2. Tertian, R. and F. Claisse; Principles of Quantitative X-ray Fluorescence Analysis; *Heyden & Son Ltd.,* - London, 1982.

3. Thompson, M. and J.N. Walsh; A Handbook of Inductively Coupled Plasma Spectroscopy; *Blackie & Son;* London, 1983.

4. Willard, H.H., L.L. Merritt and J.A. Dean, F.A. Settle; Instrumental Methods of Analysis, 7th ed.; *D. Van Nostrand Co.,* New York, 1988.

5. Skoog, D.A, Holler and Nieman; Principles of Instrumental Analysis, 5th ed.; *Saunders college publishing,* Fort Worth Tex, 1999.

■ Information for Students

(Information below can be adapted and supplemented as necessary.)

Information for Students:

Note: Please refer to BCIT policy number 5002, Student Regulations Policy, for additional information. Policies are available at **http://www.bcit.ca/about/administration/policies.shtml**.

Ethics: BCIT assumes that all students attending the institute will follow a high standard of ethics. Incidents of cheating or plagiarism may, therefore, result in a grade of zero for the assignment, quiz, test, exam or project for all parties involved and/or expulsion from the course.

Assignments: Assignments, lab reports or projects must be done on an individual basis unless otherwise specified by the instructor. Late assignments, lab reports or projects will be devalued 10% per day late to a maximum of 3 days late.

Makeup Tests, Exams or Quizzes: There will be **no** makeup tests, exams or quizzes. If you miss a test, exam or quiz, you will receive zero marks. Exceptions may be made for **documented** medical reasons or extenuating circumstances. In such a case, it is the responsibility of the student to inform the instructor **immediately**.

Attendance: The attendance policy as outlined in BCIT Policy 5002 will be enforced. Attendance will be taken at the beginning of each session. Students not present at that time will be recorded as absent.

Illness: If you miss an evaluation such as an assignment, quiz, exam, or project, or you miss 3 or more consecutive days of class, you must provide the department with a BCIT Student Medical Certificate (available at http://www.bcit.ca/admission/downloads.shtml). You may be asked to complete the work that you missed or the course evaluation may be adjusted to reflect the missed component(s).

Attempts: Students must successfully complete a course within a maximum of three attempts. Students with two attempts in a single course must get written permission from the Associate Dean to attempt the course for the third time. Students who have not successfully completed a course within three attempts will not be eligible to graduate from the program.

Advancement: Students who fail three or more courses in a term cannot advance to the next term and may be asked to discontinue from the program.

Course Outline Changes: The material or schedule specified in this course outline may be changed by the instructor. If changes are required, they will be announced in class.

■ Assignment Details

TBA

Lectures (Materials Covered)

Part I: Assaying & Geochemistry

1. Introduction
2. General Overview
3. Types of Assaying and Geochemistry methods available
4. Compare & contrast types/costs of analyses offered
5. Steps to be used in selecting the proper analytical method
6. Review the important considerations in selecting the type of analytical method

Part II: Sampling, Sample preparation and Sampling Theories

1. Introduction to Sampling, Sample preparation and Sampling Theories

2. Sampling: - Plan
   - Methods
   - Types of samples involved
   - Errors
   - Contamination
   - Losing material

3. Sampling Preparation: - Typical sample preparation scheme
   - Typical sample preparation steps
   - Layout and classification
   - Contamination introduced by equipment
   - Pulp and reject storage

4. Sampling theories: - Introduction
   - Applications of sampling theories

Part III: Fire Assaying (Precious Metals Analysis)

(1) Introduction to Fire Assaying

(2) Assay reagents:
- definitions
- acids and bases
- reagents

(3) Balances and weights:
- pulp assay
- review of theory
- silicate degree
- assay ton (metric oz/ton)

(4) Crucible fusion:
- charges used
- normal products
- undesirable products
- problems encountered and corrections

(5) Cupellation:
- process involved
- loss of silver
- loss of gold & silver in cupelling

(6) Parting:
- inquartation
- errors as result of improper technique
- impurities in bead

(7) Scorification:
- chemical reactions
- losses in scorification
- distribution of slag, matte, spiess, and lead button

(8) Annealing:
- process involved

(9) Weighing:
- reporting

(10) Characteristic of the Platinum Group Metals – special assay techniques

(11) Cyanide leaching - testing & determination

(12) Recovery of gold from solutions

(13) Melting and refining of gold

(14) Bullion – sampling & assay of bullion

Part IV: Classical Assaying (Base Metals Analysis)

(1) Decomposition (dissolution) of samples in various sample matrixes:

- review of qualitative analysis
- general considerations
- rate of decomposition/dissolution
- decomposition methods
- quality assurance of chemical reagents
- interference
- final determination

(2) Treatment of analytical data evaluation:

- statistic
- confidence limits
- significance figures
- types of error
- rejection tests
- applications of statistical treatment
- estimation of detection limits
- reporting experiment data

(3) Quality assurance and quality control:

- terminology
- establishing accuracy and precision
- control samples
- control charting
- handling outliers
- documentation
- audits and ethics

(4) Principles of Volumetric analysis:

- aqueous-solution chemistry
- effect of electrolytes on ionic equilibria
- application of equilibrium calculations to complex systems
- titration curves for complex acid/base systems
- internal and external indicators
- theory and applications of neutralization, precipitation, oxidation/reduction, and complex-formation titrations

(5) Principles of Gravimetric analysis:

- properties of precipitates and precipitating agents
- Separations
- ion exchange
- co-precipitation

- gravimetric factor and calculations

(6) Iodometry and related methods

(7) Calculation examples

Part V: Analytical Instrumentation

1. Electrochemical Cells and Electrode Potentials

- Principles
- Electrochemical Cells
- The Nernst Equation
- Formal Potential
- Limitations of Electrode Potentials

2. Potentiometry

- metallic indicator electrodes
- membrane electrodes
- instruments for measurement of cell potentials
- potentiometric determination of pH
- specific ion electrodes

3. Electro-gravimetric Methods

- current-voltage relationship
- effects of experimental variables
- instrumentation
- applications

4. Spectrometry

- Electromagnetic Radiation
- Theory of Absorption
- Applications of Ultraviolet and Visible Absorption
- Spectrometric Error
- Deviation from Beer's Law

- Quantitative Calculations

5. Atomic Spectrometric methods

- Emission Spectroscopy
- Flame Emission Spectrometry
- Plasma Emission Spectrometry
- Distribution between ground and excited states
- Atomic Absorption Spectrophotometry
- Internal Standard and Standard Addition Calibration
- Interferences associated with techniques
- Applications

6. X-rays Methods

- Basic principles
- Instrumentation
- Absorption methods
- Fluorescent methods
- Diffraction methods
- Interferences associated with techniques
- Applications
- Comparison to other techniques

7. Compare and contrast of the following instrumental techniques

- Visible, UV, FES, AAS, ICP-OES, ICP-MS, X-Ray techniques

Laboratory Exercises

TBA