

## ES2230B – Course Outline

### Introduction to Geochemistry

#### 1. Course Information

**Course Information:** ES 2230B – Introduction to Geochemistry

**Academic Term:** Winter 2026; **Course Duration:** Jan 5 – April 9; **Exam Period:** Apr 11– 30

**Location & Time:**

**Lecture Hours:** 2 hours/week

**Lab Hours:** 3 hours/week

**Prerequisites:** Chemistry 1301A/B or the former Chemistry 1100A/B and Earth Sciences (ES) 2200A/B; or permission of the Department

Unless you have either the prerequisites for this course or written special permission from the Department of Earth Sciences to enroll in it, you may be removed and withdrawn from this course in accordance with university policy. This may be done after the add/drop deadline of the academic term, and the course will be marked as withdrawn (WDN) on your academic record. This decision may not be appealed.

#### 2. Instructor Information

Instructor	Email	Phone	Office Hours
Dr. Neil R. Banerjee	<a href="mailto:neil.banerjee@uwo.ca">neil.banerjee@uwo.ca</a>	Ext 83727	By appointment

I encourage you to post questions about the course content in the online Forums. If you need to contact me about something private, please email at [neil.banerjee@uwo.ca](mailto:neil.banerjee@uwo.ca)

Students must use their Western (@uwo.ca) email addresses when contacting their instructors and put the course code (1021) in the subject line. Please read the syllabus before asking or posting a question.

Office hours – There are no regular office hours. If you need to speak with me, please email and I'll set up an appointment to meet. Don't be shy – I'm happy to talk with you.

TAs	Email	
TBD		

Your TA will act as your first point of contact for any inquiries. Please ask to set up appointments with them using your Western (@uwo.ca) email address and put the course code (1021) in the subject line.

### 3. Course Syllabus, Schedule, Delivery Mode

#### Course Description

The course introduces the field of Geochemistry to undergraduate students, emphasizing the chemical principles governing the Earth and other planetary bodies. Students will explore the formation of the elements, the origin and evolution of the Earth and Solar System, the chemistry of minerals and rocks, and the behavior of major and trace elements in geologic processes.

#### Learning Outcomes

By the end of this course, students will be able to:

- Define the formation and evolution of the Solar System.
- Describe the formation and evolution of the Earth and Moon.
- Describe the formation and evolution of the Earth's atmosphere.
- Explain the formation and distribution of the chemical elements in the Solar System.
- Apply radioisotopic concepts and systems (e.g., Sm–Nd) to determine absolute ages of rocks, minerals, and fossils.
- Apply binary and ternary phase diagrams to interpret magma genesis, mantle processes, and mineral stability.
- Interpret major-element and trace-element compositions of igneous, sedimentary, and metamorphic rocks, including their evolution during fractionation, weathering, and metamorphism.
- Explain and use concepts of chemical potential and distribution (partition) coefficients to describe element partitioning between minerals, melts, and fluids.

#### Key dates

- ☐ Classes begin: **January 5**
- ☐ Spring Reading Week: **February 14 – 22, 2026**
- ☐ Mid-term Test: **Wednesday, February 25<sup>th</sup>**
- ☐ Mid-term \***Makeup** Test: **Wednesday, March 4<sup>th</sup>**  
\* Only available to students with an approved accommodation from your faculty advisors. If you miss the makeup and have an approved accommodation you will be able to write the mid-term the next time the course is run. This is the only makeup available. No exceptions.
- ☐ Classes end: **Thursday, April 9<sup>th</sup>**
- ☐ Final Exam set by the Registrar's office **April 12<sup>th</sup> to 30<sup>th</sup>**
- ☐ Final Exam Makeup **TBD**

#### Major topics\*

1. **Primordial and Stellar Nucleosynthesis, Radioisotopic Systems and Ages**
  - Formation of the Elements, Solar System, Earth and Moon.
  - Stable and unstable nuclei and rate of decay of unstable nuclei
  - Absolute Ages of Rocks, Earth and the Solar System
  - The Sm/Nd system as example: The isochron, Ages and Model Ages.

*Lab #1 - Scientific paper relevant to formation, composition & evolution of solar system*

*Lab #2 - Calculate the Molar and Atomic proportions of elements in Minerals*

*Lab #3 - Applications of Sm/Nd system to basalts, recent and ancient.*

## **2. Composition and Stability of Minerals, Glasses and Fluids (i.e., liquids and gases)**

- Some geochemically important properties of the elements of the periodic table
- Substitutions in minerals, Immiscibility in Glasses and Natural Fluids
- Stability of phases in natural settings: thermodynamic and kinetic stability
- Heat Capacity, Enthalpy and the First Law of Thermodynamics
- Entropy and the Second Law of thermodynamics
- Free Energy, the Clausius-Claperyon Equation and phase stability as a function of T and P

*Lab #4 - Thermodynamic stability of SiO<sub>2</sub> and Al<sub>2</sub>SiO<sub>5</sub> polytypes at STP and calculation of the Al<sub>2</sub>SiO<sub>5</sub> phase boundaries in P-T space*

## **3. The Phase Rule, Phase Diagrams and Their Interpretation**

- The Unary Phase Diagram and the Phase Rule (H<sub>2</sub>O system as example)
- Binary Phase Diagrams (Olivine and Plagioclase, NaCl-H<sub>2</sub>O, MgO-SiO<sub>2</sub>, systems)
- Ternary Phase Diagrams (Qz-Ab-Ksp system as example).

*Lab #5 - Interpretation of Phase diagrams*

## **4. Major Element Geochemistry**

- The Major Elements: Rock and mineral compositions, Wt.% and Molar Proportions
- Compositions of Igneous, Sedimentary and Metamorphic Rocks and Ternary Diagrams
- Igneous Rocks: Magmas and Crystal Fractionation
- Sedimentary Rocks and Chemical Weathering
- Metamorphic Rocks and Mineralogical Changes during prograde metamorphism

*Lab#6 - Compositional changes during fractionation and weathering*

## **5. Trace Element Geochemistry**

- Igneous Petrology: Compatible and Incompatible Elements
- Sedimentary Petrology: Labile and Conservative Elements
- Rare Earth and Incompatible Elements in Igneous and Sedimentary Environments.

*Lab #7 - Partitioning of Trace elements between minerals and liquids*

## **6. The Chemical Potential and the Distribution (Partition) Coefficient**

- The Chemical Potential and phase stability as a function of composition
- Theory and use of Distribution Coefficients.
- Calculated and observed distribution of Fe and Mg between melts and basaltic magma.

## Delivery Mode

The course is designed with flexibility and accessibility at its core. While lectures and labs are held weekly in person, most of the course content will be available on the Brightspace online platform, which gives you the freedom to engage with course materials on your own schedule and at your own pace. Because so much of the foundational material is available 24/7 through Brightspace, in-person lectures are designed to deepen your understanding, explore complex ideas, and connect the science to real-world examples. If circumstances require lectures may temporarily shift to an online format.

## 4. Course Materials

There is no single required printed textbook that will be used in a traditional chapter-by-chapter manner. Instead, the course will rely on:

1. Selected readings provided as PDFs or scans where permitted (posted on Brightspace).
2. Instructor lecture notes and problem sets (posted on Brightspace).
3. Laboratory handouts and datasets (posted on Brightspace).

All course material will be posted to Brightspace: <https://westernu.brightspace.com/>

Students are responsible for checking the course Brightspace site regularly for news and updates. This is the primary method by which information will be disseminated to all students in the class.

If students need assistance with the course OWL site, they can seek support on the [OWL Brightspace Help](#) page. Alternatively, they can contact the Western Technology Services Helpdesk. They can be contacted by phone at 519-661-3800 or ext. 83800.

## 5. Methods of Evaluation

### Grading Scheme and Assessment Dates

The overall course grade will be calculated as listed below:

- ☐ 20% Mid-Term **Wednesday, February 25<sup>th</sup>**
- ☐ 30% Final Exam (**Date and time to be determined by the Registrar's office**)
- ☐ 40% Labs – (Weekly or Bi-weekly; Top 5 of 7 will be counted)
- ☐ 10% Class participation

\* Students have the option of reweighting their midterm if their grade on the final exam is between one grade point (9%) but not more than 20% higher than their mid-term mark. If a student is able to demonstrate this improvement, they can have the final exam count for 50% of their final grade.

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## The Exceptional Contributor: “The Class Was Better Because You Were Here”

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As part of the learning process, I expect all students to participate actively. Please make your comments and questions engaging, thought provoking, and relevant. Remember that 10% of your grade is assigned to participation. Here are some guidelines to keep in mind:

- You come to class prepared and ready to learn.
- You make highly attentive and constructive comments.
- You ask questions that are penetrating or help clarify.
- You contribute strategically (understanding that there are other students in the class).
- You actively encourage others to express their ideas.
- You use language that communicates interest in what others are saying.
- You come to class on time and complete assignments on time.
- You interact constructively with the TAs and instructor.
- You are aware of your responsibilities for the course as outlined in this Syllabus.

### General information about missed coursework

Students must familiarize themselves with the *University Policy on Academic Consideration – Undergraduate Students in First Entry Programs*, posted on the Academic Calendar:

[https://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/academic\\_consideration\\_Sep24.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/academic_consideration_Sep24.pdf),

This policy does not apply to requests for Academic Consideration submitted for **attempted or completed work**, whether online or in person.

The policy also does not apply to students experiencing longer-term impacts on their academic responsibilities. These students should consult [Accessible Education](#).

For procedures on how to submit Academic Consideration requests, please see the information posted on the Office of the Registrar’s webpage:

[https://registrar.uwo.ca/academics/academic\\_considerations/](https://registrar.uwo.ca/academics/academic_considerations/)

All requests for Academic Consideration must be made within 48 hours after the assessment date or submission deadline. All Academic Consideration requests must include supporting documentation; however, recognizing that formal documentation may not be available in some extenuating circumstances, the policy allows students to make one Academic Consideration request **without supporting documentation** in this course. However, the following assessments are excluded from this, and therefore always require formal supporting documentation:

- Midterm (Wednesday, February 25<sup>th</sup>)
- Final Examination scheduled during official examination periods

When a student mistakenly submits their one allowed Academic Consideration request **without supporting documentation** for the assessments listed above or those in the **Coursework with Assessment Flexibility** section below, the request cannot be recalled and reapplied. This privilege is forfeited.

## Evaluation Scheme for Missed Assessments

**Midterm:** Students that have an excused absence (accommodation from an academic advisor) will receive the following accommodations:

- A make-up midterm will be offered on **Wednesday, March 4<sup>th</sup> at 7:00 pm**
- If you have a legitimate reason for missing both the mid-term and the make-up midterm, you will receive an “incomplete” (INC) in the course and write the midterm the next time the course is offered.

### Lab Reports

- For 5 days following the normal “**Due Dates**” (including weekend days) reports may be submitted but will be subject to a mark deduction of **10 % per day late**.
- No reports will be accepted after 5 days.
- Late penalties may be reduced only upon the recommendation of an academic advisor.

When a student misses the Final Exam and their Academic Consideration has been granted, they will be allowed to write the Special Examination (the name given by the University to a makeup Final Exam). See the Academic Calendar for details (under [Special Examinations](#)), especially for those who miss multiple final exams within one examination period.

### Essential Learning Requirements

Even when Academic Considerations are granted for missed coursework, the following are deemed essential to earn a passing grade.

You must receive a 50% overall to pass the course. Because this is an “Lab course” completion of the all labs and a grade of 50% on 5 of 7 is also required to pass the course.

### Coursework with Assessment Flexibility

**Lab Reports:** This course has 7 Lab that are available on the Brightspace online platform. Completing them on time is expected and will contribute to your participation mark. Should extenuating circumstances arise during the term, students do not need to request Academic Consideration for 2 of the 7 labs. Instead, students should make up any missed Labs when they are able. All Labs must be completed by **Thursday, April 9<sup>th</sup> at 5:00 pm**. NO EXCEPTIONS. If you will miss the deadline for more than 3 Labs you must seek Academic Consideration.

## 6. Additional Statements

### 6.1 Religious Accommodation

When a recognized religious holiday or observance conflicts with an examination, test, or other scheduled academic obligation, students must request accommodation via the University’s Student Absence Portal (SAP). This request should identify the conflict and specify which course component(s) (e.g. test, midterm, exam) are affected.

Students are encouraged to submit the SAP request as early as possible, but no later than two weeks before any examination, or one week before any mid-term test or quiz, to allow sufficient time for adjustment.

The SAP request serves as official notification to both the course instructor and the Academic Advising Office, in accordance with University policy:

[https://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/accommodation\\_religious.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf)

The Faculty of Science considers religious accommodations as scheduling conflicts. Instructors should provide either a make-up exam or an earlier sitting of the same exam to accommodate the student.

For more information on recognized religious holidays, please visit the Diversity Calendar posted on the Equity, Diversity & Inclusion website - <https://www.edi.uwo.ca>

## **6.2 Academic Accommodation Policies**

Students with disabilities are encouraged to contact Accessible Education, which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The policy on Academic Accommodation for Students with Disabilities can be found at:

[https://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/Academic\\_Accommodation\\_disabilities.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic_Accommodation_disabilities.pdf).

## **6.3 General Academic Policies**

The website for Registrar Services is <https://www.registrar.uwo.ca/>.

**Use of @uwo.ca email:** In accordance with policy, [https://www.uwo.ca/univsec/pdf/policies\\_procedures/section1/mapp113.pdf](https://www.uwo.ca/univsec/pdf/policies_procedures/section1/mapp113.pdf), the centrally administered e-mail account provided to students will be considered the individual's official university email address. It is the responsibility of the account holder to ensure that emails received from the University at their official university address are attended to in a timely manner.

**Requests for Relief** (formally known as "appeals")

Policy on Request for Relief from Academic Decision:

[https://uwo.ca/univsec//pdf/academic\\_policies/appeals/requests\\_for\\_relief\\_from\\_academic\\_decisions.pdf](https://uwo.ca/univsec//pdf/academic_policies/appeals/requests_for_relief_from_academic_decisions.pdf)

Procedures on Request for Relief from Academic Decision (Undergraduate):

[https://uwo.ca/univsec//pdf/academic\\_policies/appeals/undergrad\\_requests\\_for\\_relief\\_procedure.pdf](https://uwo.ca/univsec//pdf/academic_policies/appeals/undergrad_requests_for_relief_procedure.pdf)

## **6.4 Scholastic Offences**

Policy on Scholastic Offences:

[https://uwo.ca/univsec//pdf/academic\\_policies/appeals/scholastic\\_offences.pdf](https://uwo.ca/univsec//pdf/academic_policies/appeals/scholastic_offences.pdf)

Procedures on Scholastic Offences (Undergraduate):

[https://uwo.ca/univsec//pdf/academic\\_policies/appeals/undergrad\\_scholastic\\_offence\\_procedure.pdf](https://uwo.ca/univsec//pdf/academic_policies/appeals/undergrad_scholastic_offence_procedure.pdf)

**Use of Electronic Devices During Assessments**

In courses offered by the Faculty of Science, the possession of unauthorized electronic devices during any in-person assessment (such as tests, midterms, and final examinations) is strictly prohibited. This includes, but is not limited to: mobile phones, smart watches, smart glasses, and wireless earbuds or headphones.

Unless explicitly stated otherwise in advance by the instructor, the presence of any such device at your desk, on your person, or within reach during an assessment will be treated as a *scholastic offence*, even if the device is not in use.

Only devices expressly permitted by the instructor (e.g., non-programmable calculators) may be brought into the assessment room. It is your responsibility to review and comply with these expectations.

### Use of Generative AI Tools

Unless otherwise stated the use of generative AI tools (e.g., ChatGPT, Microsoft Copilot, Google Gemini, or similar platforms) is **not permitted** in the completion of any course assessments, including but not limited to: assignments, lab reports, presentations, tests, and final examinations.

Using such tools for content generation, code writing, problem solving, translation, or summarization—when not explicitly allowed—will be treated as a **scholastic offence**.

If the use of generative AI is permitted for a particular assessment, the conditions of use will be specified by the instructor in advance. If no such permission is granted, students must assume that use is prohibited. It is your responsibility to seek clarification before using any AI tools in academic work.

Computer-marked multiple-choice tests and exams may be subject to submission for similarity review by software that will check for unusual coincidences in answer patterns that may indicate cheating. This class will use iClicker Cloud, a student response system for you to answer questions about the course content and receive immediate feedback. You will access iClicker Cloud by downloading the iClicker Student app to your mobile device or access it from the iClicker site (iclicker.com) through a laptop. Further instructions will be provided on OWL and in class.

In the event of a health lockdown, tests and examinations in this course will be conducted using a remote proctoring service. By taking this course, you are consenting to the use of this software and acknowledge that you will be required to provide **personal information** (including some biometric data) and the session will be **recorded**. Completion of this course will require you to have a reliable internet connection and a device that meets the technical requirements for this service. More information about this remote proctoring service, including technical requirements, is available on Western's Remote Proctoring website at:

<https://remoteproctoring.uwo.ca>.

### 6.5 Support Services

Please visit the Science & Basic Medical Sciences Academic Advising webpage for information on adding/dropping courses, academic considerations for absences, requests for relief, exam conflicts, and many other academic-related matters: <https://www.uwo.ca/sci/counselling/>.

Students who are in emotional/mental distress should refer to Mental Health@Western (<https://uwo.ca/health/>) for a complete list of options about how to obtain help.



Western is committed to reducing incidents of gender-based and sexual violence (GBSV) and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced GBSV (either recently or in the past), you will find information about support services for survivors, including emergency contacts at:

[https://www.uwo.ca/health/student\\_support/survivor\\_support/get-help.html](https://www.uwo.ca/health/student_support/survivor_support/get-help.html)

To connect with a case manager or set up an appointment, please contact [support@uwo.ca](mailto:support@uwo.ca).

Please contact the course instructor if you require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to you. If you have any questions regarding accommodations, you may also wish to contact Accessible Education at

[http://academicsupport.uwo.ca/accessible\\_education/index.html](http://academicsupport.uwo.ca/accessible_education/index.html)

Learning-skills counsellors at Learning Development and Success (<https://learning.uwo.ca>) are ready to help you improve your learning skills. They offer presentations on strategies for improving time management, multiple-choice exam preparation/writing, textbook reading, and more. Individual support is offered throughout the Fall/Winter terms in the drop-in Learning Help Centre, and year-round through individual counselling.

Additional student-run support services are offered by the USC, <https://westernusc.ca/services/>.