

#### CONTACT INFORMATION:

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##### Instructor

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##### Teaching Assistant

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Please put "**Earth 221**" in your email subject line!

The main purpose of the tutorial is to have a scheduled time to meet with the teaching assistant (TA) to discuss assignments or to seek additional help. **However, some of the scheduled tutorial time MIGHT be used for class lectures or presentations or midterm test.** Advance notice will be given on LEARN and in class.

#### COURSE OBJECTIVES:

1. Broad survey of the field of geochemistry, including solid earth and aqueous geochemistry
2. Geochemical tools for applications in Earth System Science and Engineering.

#### RESOURCES:

##### Main Reference Textbooks:

Eby GN. 2004. *Principles of Environmental Geochemistry*. ISBN: 0-122-29061-5. Thompson Brooks/Cole (on reserve).

Gill, R. 2015. *Chemical Fundamentals of Geology and Environmental Geoscience*. ISBN: 978-0-470-65665-5. Wiley-Blackwell (on reserve).

##### Additional references:

Misra, KC. 2012. *Introduction to Geochemistry*. Wiley-Blackwell. (on reserve)

Walther, JV. 2009. *Essentials of Geochemistry*, 2<sup>nd</sup> edition. ISBN: 987-0-7637-5922-3. Jones & Barlett. (on reserve)

Readings are not mandatory. Knowledge to be tested in the midterm and final exams will be discussed in class or given in the assignments. Readings listed below are the pages in the textbook that are most closely aligned with the lecture material. Some lecture material is not covered or not covered well in the texts. Therefore, the text readings do not replace attendance at lectures.

This class assumes you remember topics covered in CHEM 132 or CHEM 102. Your Petrucci textbook may be useful if you forget chemistry basics such as balancing equations, equilibrium constants, etc.

## **LECTURE TOPICS:**

General sequence (class notes are in the Lectures folder in Learn):

### **1. Introduction**

### **2. Origin of the Elements:**

Readings: Gill Chapter 11  
Misra p. 225-227, 283-290, 294-295  
Element abundances, isotopes, chart of the nuclides  
Linking element abundances in the solar system to nucleosynthetic processes

### **3. Periodic Table and Crystal Chemistry:**

Readings: Misra p. 9-45  
(Eby p. 1-4, 207-212; Gill Chapters 6,7; Walther Chapter 5)  
Atomic structure and the Periodic Table  
Measures of metallic character, chemical bonding, crystal chemistry, chemical substitution in minerals

### **4. Earth's Formation & Differentiation:**

Readings: Misra p. 45-47, 290-305, 326-344, 354-362  
(Gill Chapter 11; Walther p. 25-28)  
Solar System geochemistry and planetary formation, composition of meteorites  
Earth's structure and bulk composition  
Distribution of elements in the Earth's atmosphere, oceans, crust, mantle, and core

### **5. Thermodynamics and Kinetics:**

Readings: Eby, pg. 27-36, 42-45 (Gill Chapter 1, Walther p. 60-75)  
Basic concepts, laws of thermodynamics  
Gibb's free energy, equilibrium constants, introduction to phase diagrams  
Basics of kinetics, practice problems10

### **6. Geochronology:**

Readings: Misra p. 227-241 (Gill Chapter 10, Eby pg. 165-169, 178-181, Walther Chapter 10)  
Law of radioactive decay, basic geochronology equation  
Timing of magmatic crystallization, sediment deposition, and ore mineralization

### **7. The Earth's Crust and Natural Resources:**

Readings: Misra p. 310-313, Eby p. 146-147, 314-323, Walther p. 30-32, 352-370, 591-602  
Igneous rock geochemistry, oceanic versus continental crust  
Chemical weathering, sedimentary rock geochemistry  
Introduction to petroleum and ore deposit geochemistry

**MIDTERM: Feb 14 or Feb 24, 2020**

### **8. Aqueous Geochemistry A: Introduction**

Readings: Eby, 59-90, 324-349, (Gill, Chapter 4)  
Introduction to water properties, the hydrological cycle, and global water issues  
Introduction to dissolved constituents in water: mineral solubility, activity, concentration  
Composition of waters: parameters & ranges (TDS, TSS, Conductivity, major ions, trace elements)

### **9. Aqueous Geochemistry B: The carbonate system and pH**

Readings: Eby, Chapter 3

Acid/base chemistry and pH  
Carbonate equilibria  
Alkalinity  
Metallic ions: sorption and complex formation

### **10. Electrochemistry: Energy for Life**

Readings: Eby, Chapter 4 (Walther Chapter 14)  
Redox couples, electrochemical cells, Nernst equation  
Redox in natural environments, Eh-pH diagrams  
Natural water quality: biogeochemistry, human impact  
Case Study

### **11. Stable isotopes: Tools for Waters, Biogeochemistry and Minerals**

Readings: Eby, Chapter 6  
Stable isotope abundances, standards, methods of measurement, isotopic fractionation  
 $\delta^{18}\text{O}$  and  $\delta^2\text{H}$  applications; global meteoric water line  
Applications: C, S, N carbon isotopes/Class Review

### **12. Presentations:**

15 or 16 Group oral presentations by class members (see details below)

The PowerPoint slides will be available on LEARN prior to each section. It is highly recommended that you bring the slides on a tablet/laptop or print them at a size that allows you to read the numbers in the tables or on the axes of the figures (suggest 2 per page) and bring them to class. These powerpoint slides will be used in class but are **NOT** complete class notes and do not replace attendance at lectures. We will do example problems and work through some ideas together.

### **ASSESSMENT:**

Participation (in-class discussion, questions for presentations/final exam, attendance to presentations): 3%  
Assignments: 25%  
Presentation, abstract, and preliminary topic description: 12%  
Midterm: 20%  
Final Exam: 40%

Please note that only "pink tie," "yellow hammer," and "blue goggle" calculators may be used on the midterm and final exams.

If the lecture midterm is missed due to illness or extenuating circumstances, then the student must notify the professor as soon as possible, fill out a VIF (see below), and provide the relevant funeral home/newspaper obituary announcement. Another date will be selected at a mutually agreeable time for the student to write the midterm.

If the lecture final exam is missed due to illness or extenuating circumstances, then the student should notify the professors as soon as possible, fill out an **Incomplete Grade Agreement Form** (see below), and provide the relevant supporting documentation such as a VIF or funeral home/newspaper obituary announcement to the Science Undergraduate Office. Students will be expected to write their final exam during a makeup session offered by the Faculty of Science at the beginning of the next term.

## STUDENT PRESENTATIONS:

You will be required to prepare a **12 minute group presentation** on an aspect of geochemistry that interests you. **Groups are of 3 students.** The tentative title of your presentation, a short description of the topic and 3 relevant references (textbooks and peer-reviewed journal articles only) are due on **Friday, February 7<sup>th</sup>, 2020 (11:50 PM)** so that your topic can be approved by the instructor. Marks will be deducted for lateness (-10% per day).

An extended abstract and a list of 3 references for your topic must be prepared, total length **not to exceed 1 page**. The extended abstract is due the day **before** your presentation. Post the abstract on UW-LEARN at a minimum of 24 hours before your presentation (or marks will be deducted for lateness). These abstracts will be posted on the UW-LEARN site for access by all members of the class. This way, students will be able to print the abstract and bring them to the presentations if desired. Please do not include your student number on the abstract. To aid in studying these presentations for the final exam, please **include 3 questions worth 3 marks each** (working at 1 mark per minute) on your presentation at the bottom of your abstract. A selection of these questions will be chosen for the final exam.

Upload your PowerPoint slides to your group's Learn Dropbox **by 8:00 AM on the day of your talk**. They will be pre-loaded on the computer for your presentation. The slides will not be marked separately, but rather your visual material will be included in your presentation mark. **You may not bring your slides right before class as this gets the class behind schedule and you MUST have your slides uploaded by 8 AM that day for full marks.**

Each member of the group receives the same mark, so we strongly encourage you to select a group of people you trust and communicate with group members if you feel they are not pulling their weight. I hope you all will be successful in working together as a team.

### Tentative Schedule:

- a) **Friday, March 27, 2020 (3 presentations)**
- b) **Monday, March 30, 2020 (5 presentations)**
- c) **Wednesday, April 1, 2020 (5 presentations)**
- d) **Friday, April 3, 2020 (3 presentations)**

Attendance at the presentations is part of the participation mark.

More details can be found in the Presentations folder on Learn.

## ASSIGNMENTS:

This course includes weekly assignments based on course material. Students are encouraged to attempt assignments before tutorial time, which generally will be used for answering questions and taking up old assignments. Assignments will be posted on LEARN.

Assignments will be marked by the TA, but you are responsible for making sure you understand the complete solution (hint: attend and ask questions during tutorial!). Due to the relatively large class size, the TA will not necessarily carefully mark each question, i.e. some questions will be marked for participation. In that case, the final answers will be posted, but the complete solutions will be discussed in tutorial.

You may hand assignments in (on paper) in class or use the appropriate Learn Dropbox. You are responsible for files uploading correctly.

Late penalties for assignments are -10% per day late, starting immediately after the time due. Assignments will not be accepted once marks are posted and they are returned.

## PARTICIPATION:

Class participation marks are awarded for:

Handing in all assignments: 0.75% of final mark

Attending all presentation times: 1.95% of final mark

Attempting a midterm study quiz (your mark doesn't matter): 0.15% of final mark

Attempting a final exam study quiz (your mark doesn't matter): 0.15% of final mark

For a total of 3%. In-class participation (i.e. asking and answering questions) is strongly encouraged and the instructor will increase your participation mark (up to 3%) if an effort is made in class.

## ACADEMIC INTEGRITY:

- [Office of Academic Integrity](#) provides relevant information for students, faculty and staff.
- **Academic Integrity:** In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility.
- **Plagiarism:** Plagiarism is the act of directly copying material from another source word-for-word without acknowledging (citing) the source. Copying material from another student word-for-word (collusion) also constitutes plagiarism. It is unacceptable to claim another person's words as your own. Acts of plagiarism are not tolerated at the University of Waterloo and are subject to disciplinary action according to Policy 71, Student Discipline (see below). If you have not already done so, it is strongly recommended that you take the Academic Integrity Tutorial at <http://www.lib.uwaterloo.ca/ait/>. An answer to a question that consists solely of a quote to a properly cited source is also **not** acceptable. Although this does not constitute plagiarism, professors are unable to assess whether any actual learning, specifically the synthesis/application of knowledge, has been achieved by the student. Although finding sources is part of learning, this type of work by itself does not merit a passing grade. Students are expected to cite the source of information (e.g., website, textbook, journal article, class slides) but ALSO to **paraphrase** the material (rewrite the information in your own words) when answering questions on tasks that require an internet and/or literature search. When writing scientific or engineering reports it is standard professional practice to cite the appropriate work of other research scientists when discussing ideas or information that are not our own. Plagiarism is a very serious charge and can ruin promising careers.
- **Grievance:** Students, who believe that a decision affecting some aspect of their university life has been unfair or unreasonable, may have grounds for initiating a grievance. Students should read [Policy #70](#), Student Petitions and Grievances, Section 4. When in doubt, students must contact the department's/school's administrative assistant who will provide further assistance.
- **Discipline:** Students are expected to know what constitutes academic integrity, to avoid committing academic offenses, and to take responsibility for their actions. Students who are unsure whether an action constitutes an offense, or who need help in learning how to avoid offenses (e.g., plagiarism, cheating) or about 'rules' for group work/collaboration should seek guidance from the course instructors, academic advisor, or the Associate Dean of Science for Undergraduate Studies. For information on categories of offenses and types of penalties, students should refer to [Policy #71](#), Student Discipline. For information on typical penalties, students should check [Guidelines for the Assessment of Penalties](#).
- **Appeals:** A decision or penalty imposed under Policy 33 (Ethical Behavior), Policy #70 (Student Petitions and Grievances) or Policy #71 (Student Discipline) may be appealed, if there is a ground. Students, who believe they have a ground for an appeal, should refer to [Policy #72](#) (Student Appeals).

## **COURSE RULES AND CONSIDERATIONS:**

### Verification of Illness Forms

Science students should be aware that the only Verification of Illness forms (VIFs) accepted for accommodation for missed assessments will be those issued by the University of Waterloo's Health Services, when this service is open (<https://uwaterloo.ca/health-services/>). VIFs issued by walk-in clinics will not be accepted, except when obtaining a VIF from Health Services is not possible. If a student is sick on a weekend, during off-hours, while out of town or receiving ongoing care from a family physician or specialist, it is acceptable to provide documentation from other health service providers. Information should include (1) date of the physician assessment, (2) dates of illness, (3) level of incapacitation and (4) whether the diagnosis was made by the physician or based on description by the student.

Keeping the playing field level for all of our students is a priority. Students are reminded that obtaining a VIF under false pretences is an academic offense. For tests and exams, a student found guilty of misrepresentation will receive a failing grade in the course and be suspended. Any questions concerning this policy can be directed to an undergraduate advisor in the Science Undergraduate Office.

*Student travel plans not considered acceptable grounds for granting an alternative examination time. Only illness and extenuating circumstances (such as a death in the family) will be considered.*

### Students with Disabilities

[AccessAbility Services](#), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If students require academic accommodations to lessen the impact of their disability, they should register with AccessAbility Services at the start of each academic term.

### Changes to Course Outlines

Revised course outlines will be posted/provided, if course details change (e.g., topics covered). Course elements that will **not** change are the grading scheme and course elements related to evaluation.

## Changes to the Course due to Corona Virus (COVID-19) Disease Outbreak

### CLASS ACTIVITIES

March 16 – March 20: all in-person class activities were suspended

March 23 – March 27: class activities (lecture, tutorial, office hour) moved online via WebEx

March 30 – April 3: class activities (lecture, tutorial, office hour) moved online via WebEx

Assignment 8 was removed (students completed seven assignments in total)

Group's Project:

Oral presentation was cancelled

A short Paper (3 – 4 pages) was submitted by each student's group in lieu of the Oral Presentation and Abstract components.

### ASSESSMENT

Final exam weight was reduced to 25% (online)

Below are the methods of calculating the total mark (100%)

Because final exam is switched to online and becomes a second midterm, we follow max recommended weight by UW policy is 25%. Thus, we have 15% to distribute to other activities. The highest mark calculated by four options below will be your final mark.

15% is proportionally distributed to Assignments, Presentation, and Midterm      15% is distributed as: 7.5% toward Assignments and 7.5% toward Midterm      15% is distributed as: 7.5% toward Assignments and 7.5% toward Presentation      15% is distributed as: 7.5% toward Midterm and 7.5% toward Presentation

<u>New PLAN</u>		<u>Option A</u>	<u>Option B</u>	<u>Option C</u>	<u>Option D</u>
<u>Grade Item</u>	<u>Max. Points</u>				
<u>Assignments</u>		<u>31.6</u>	<u>32.5</u>	<u>32.5</u>	<u>25</u>
<u>Assignment 1</u>	<u>22</u>	<u>10</u>	<u>10</u>	<u>10</u>	<u>10</u>
<u>Assignment 2</u>	<u>25</u>	<u>11</u>	<u>11</u>	<u>11</u>	<u>11</u>
<u>Assignment 3</u>	<u>25</u>	<u>11</u>	<u>11</u>	<u>11</u>	<u>11</u>
<u>Assignment 4</u>	<u>35</u>	<u>16</u>	<u>16</u>	<u>16</u>	<u>16</u>
<u>Assignment 5</u>	<u>25</u>	<u>11</u>	<u>11</u>	<u>11</u>	<u>11</u>
<u>Assignment 6</u>	<u>30</u>	<u>20</u>	<u>20</u>	<u>20</u>	<u>20</u>
<u>Assignment 7</u>	<u>33</u>	<u>21</u>	<u>21</u>	<u>21</u>	<u>21</u>
<u>Midterm</u>		<u>25.3</u>	<u>27.5</u>	<u>20</u>	<u>27.5</u>
<u>Midterm Test</u>	<u>45</u>				
<u>Final Exam</u>		<u>25</u>	<u>25</u>	<u>25</u>	<u>25</u>
<u>Final Examination</u>					
<u>Presentation</u>		<u>15.2</u>	<u>12</u>	<u>19.5</u>	<u>19.5</u>
<b><u>Short Report</u></b>	<u>90</u>	<u>90</u>	<u>90</u>	<u>90</u>	<u>90</u>
<u>Presentation - Communication Grade</u>	<u>0</u>				

<u>Presentation Proposal</u>	<u>10</u>	<u>10</u>	<u>10</u>	<u>10</u>	<u>10</u>
<u>Presentation - Technical Component</u>	<u>0</u>				
<u>Participation</u>		<u>3</u>	<u>3</u>	<u>3</u>	<u>3</u>
<u>Number of Assignments Handed In</u>	<u>8</u>	<u>90</u>	<u>90</u>	<u>90</u>	<u>90</u>
<u>Attendance at Talks</u>	<u>6</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
<u>Midterm Quiz completed</u>	<u>20</u>	<u>5</u>	<u>5</u>	<u>5</u>	<u>5</u>
<u>Final Exam Practice Quiz Completed</u>	<u>20</u>	<u>5</u>	<u>5</u>	<u>5</u>	<u>5</u>
<u>Final Calculated Grade</u>		<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>
<u>Final Adjusted Grade</u>					