# University of Arkansas Department of Geosciences

# GEOS 40603 / 52703 – Principles of Geochemistry

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Required textbooks:	<u>Geochemistry</u> (2013), William M. White (textbook I) <u>Geochemistry – Pathways and Processes</u> (2003), H. McSween, S. Richardson, and M. Uhle (textbook II)
Additional textbooks:	Solutions, Minerals, and Equilibria (1966), R. M. Garrels and C. L. Christ Thermodynamics for Geologists (1967), R. Kern and A. Weisbrod

# **Course Description:**

Introduction to fundamental principles of geochemistry from historic development to modern concepts.

# **Course Objectives:**

- 1. Explain how elements behave
- 2. Describe the basic principles and techniques of modern geochemistry, including thermodynamics and kinetics
- 3. Explain the concept of solution
- 4. Present the basic geochemical processes operating in aqueous systems
- 5. Explain the behavior of trace elements in igneous processes
- 6. Present the basic principles of isotope geochemistry
- 7. Explain the importance and use of trace elements and isotope geochemistry
- 8. Present the oceans, atmosphere, and solid Earth as geochemical systems
- 9. Present basic Cosmochemistry concepts
- 10. The <u>graduate students</u> will investigate a geochemical system (ranging in size anywhere between a small clay particle or as large as the Solar System) and report their findings and interpretations related to the chemical processes and principles involved in their generation. The project will consist of a written report (6-8 pages) and brief PowerPoint presentation.

# Learning Outcomes:

- 1. Understand chemical bonds
- 2. Become familiar with basic concepts of thermodynamics and kinetics
- 3. Understand the concept of solution
- 4. Understand reduction and oxidation reactions
- 5. Understand dissolution and precipitation reactions
- 6. Know how to construct phase diagrams and Eh-pH diagrams
- 7. Understand how solubility diagrams work
- 8. Understand the importance and use of trace elements and isotope geochemistry to decipher various processes occurring in the Solar System and the Earth
- 9. Know how the Elements and the Solar System formed

#### Evaluation

GEOS 40603 (400 points)				GEOS 52703 (600 points)		
Exam 1	100 poi	nts		Exam 1	100 points	
Exam 2	Exam 2 100 points			Exam 2	100 points	
Exam 3 100 points			Exam 3	100 points		
Homework 100 points			Homework	100 points		
				Final Project	200 points	
Undergrade Grade:		A = 330 - 400	B = 260 - 329	C = 190 - 259	<b>D</b> = 120 - 189	F < 120
Graduate Grade:		A = 510 - 600	B = 420 - 509	C = 330 - 419	D = 240 - 329	F < 240

# Lecture Outline and Reading Assignments

<u>Class date</u> Week 1	Lecture topic/exams Geochemical aspects of systems of planetary scale	Assigned reading (by chapter) 10 (I); 15 (II)				
	Why Cosmochemistry? Origin and abundance of the elements Meteorites: Essential Clues to the Beginning Cosmochemical behavior of elements Condensation of the elements					
Week 2	Controls on elemental behavior in the Earth Elements, atoms, and the structure of matter Bonding	1 (I); 2 (II)				
Week 3	Trace Elements in Igneous Processes The geochemical periodic table Distribution of trace elements between co-existing phases Factors governing the value of partition coefficients Trace element distribution during melting and crystallization	7 (I); 12 (II)				
Week 4	Radioactive isotopes Principles of radioactivity Geochronology Geologic applications	8 (I); 14 (II)				
Week 5	Stable isotopes Basic principles Mass fractionation and bond strength Geologic applications	9 (I); 13 (II)				
	Exam one					
Week 6	The solid Earth as a geochemical system Composition of the mantle and core Composition of the crust	11 (I); 12 (II) 12 (I); 12 (II)				
Week 7	The oceans and atmosphere as a geochemical system Composition of the Oceans Composition of the Atmosphere Carbonate and the great marine balancing act Global mass balance and steady state in the Oceans	15 (I); 8 (II)				
Week 8	Fundamental thermodynamic concepts I Thermodynamic systems and equilibrium Temperature and the zeroth law of thermodynamics	2 (I); 3 (II)				
Week 9	Fundamental thermodynamic concepts II Energy and First law of thermodynamics The second law and entropy	2 (I); 3 (II)				
Week 10	Fundamental thermodynamic concepts III Enthalpy; Heat capacity The third law and absolute entropy Free energy The Maxwell relations	2 (I); 3 (II)				
	Exam two (not cumulative)					
Week 11	Solutions and thermodynamics of multicomponent systems I Phase equilibria Solutions Chemical potential Ideal and real solutions	3 (I); 4 (II); 9 (II)				

### Lecture Outline and Reading Assignments

Class date	Lecture topic/exams	Assigned reading (by chapter)		
Week 12-13	Solutions and thermodynamics of multicomponent systems II Electrolyte solutions	3 (I); 4 (II); 9 (II)		
	Equilibrium constants Oxidation-Reduction Processes Redox in aqueous solutions	3 (I); 7 (II)		
Week 14	Applications of thermodynamics Thermodynamics and phase diagrams Problem solving	4 (I); 10 (II)		
Week 15	Aquatic Chemistry Acid-base reactions Complexation Dissolution and precipitation reactions	6 (I); 7 (II)		
Week 16	Graduate Student presentations of final projects			
ТВА	Final Exam (not cumulative)			

# POLICIES

**STUDENT SUPPORT**: U of A Cares offers a supportive and encouraging partnership with students by linking them with appropriate resources that will allow them the opportunities to overcome barriers on their path to success; both personal and educational at **uofacares.uark.edu** 

**STUDENTS WITH DISABILITIES:** University of Arkansas Academic Policy Series 1520.10 requires that students with disabilities are provided reasonable accommodations to ensure their equal access to course content. Students who have a documented disability and require accommodations must contact the instructor at the beginning of the semester to make arrangements for necessary classroom adjustments or accommodations. Please note, students must first verify eligibility for these through the Center for Educational Access (contact 479–575–3104 or visit <u>http://cea.uark.edu/</u> for more information on registration procedures).

**EXCUSED UNIVERSITY ABSENCES** are: (1) illness of the student, (2) serious illness or death of a member of the student's immediate family or other family crisis, (3) University-sponsored activities for which the student's attendance is required by virtue of scholarship or leadership/participation responsibilities, (4) religious observances, (5) jury duty or subpoena for court appearance, and (6) military duty. The instructor has the right to require that the student provide appropriate documentation for any absence for which the student wishes to be excused.

**INCLEMENT WEATHER:** If the University is open, class will be in-session. The University's inclement weather policy is available at <u>emergency.uark.edu</u>

**ACADEMIC HONESTY STATEMENT:** "As a core part of its mission, the University of Arkansas provides students with the opportunity to further their educational goals through programs of study and research in an environment that promotes freedom of inquiry and academic responsibility. Accomplishing this mission is only possible when intellectual honesty and individual integrity prevail. Each University of Arkansas student is required to be familiar with and abide by the University's 'Academic Integrity Policy' which is found at <u>https://honesty.uark.edu/policy/index.php</u> Students with questions about how these policies apply to a particular course or assignment should immediately contact their instructor."

Academic Integrity: Exams and assignments must be a student's own work. No cheating or plagiarism will be tolerated. If you are suspected of academic dishonesty, the Academic Integrity process will be utilized to its fullest extent.

**SEXUAL ASSAULT AND DOMESTIC/DATING VIOLENCE:** If you are in danger, dial 9-1-1. For confidential help, call the University Victim Advocate at (479) 575-7252. The University of Arkansas prohibits sexual harassment or acts of sexual assault, domestic violence, dating violence and stalking committed against students, employees, campus visitors, and other persons who use University facilities. Sexual assault is any form of sexual activity where consent is not consciously and voluntarily given. Anyone can be a victim of sexual assault. Sexual harassment is prohibited by University policy and is a form of sex discrimination prohibited by Title VII of the Civil Rights Act of 1964 and by Title IX of the Education Amendments of 1972. Sexual assault is a crime, as defined by the Arkansas criminal code. Important sexual assault information and guidance to file a formal report is available at respect.uark.edu.

**DIVERSITY AND INCLUSION MISSION STATEMENT:** The Department of Geosciences is committed to enhancing diversity and promoting inclusion at all levels of the department. The department is dedicated to maintaining an organizational and educational climate where differing ideas, abilities, backgrounds, and needs are fostered with opportunities for faculty, staff and students from divergent experiences to participate and contribute. The Department of Geosciences recognizes that a wide variety of perspectives, from all its members are important and necessary components of a diverse and inclusive department and of a genuinely wide-ranging contemporary education.

**TECHNOLOGY POLICY:** The use of cell phones, smart phones, tablets, laptops, etc., for purposes other than note taking or learning Geochemistry concepts is not allowed during class. You are in class to learn, not socialize with your media! <u>Flagrant</u> violation of this policy will result in you being dismissed from class for the day!

**EMERGENCY PROCEDURES:** Many types of emergencies can occur on campus. Instructions for specific emergencies such as severe weather, an active shooter, or fire can be found on the web at <u>emergency.uark.edu</u>

# SEVERE WEATHER (e.g., Tornado Warning):

- Follow the directions of the instructor or emergency personnel.
- Seek shelter in the basement or an interior room or hallway on the lowest floor, putting as many walls as possible between you and the outside.
- In a multi-story building, if you cannot get to the lowest floor, go to a hallway in the center of the building.
- Stay in the center of the room, away from exterior walls, windows, and doors.

# VIOLENCE or ACTIVE SHOOTER (C.A.D.D.):

- CALL. 9-1-1
- AVOID. If possible, evacuate to a safe area outside the building. Follow directions of police
- officers.
- DENY. Barricade the door with desks, chairs, bookcases, or any items. Move to a place inside the
- room where you are not visible. Turn off the lights and remain quiet. Remain there until told by
- police it is safe.
- DEFEND. Use desks, chairs, cell phones, or whatever is immediately available to distract and/or
- defend yourself and others from attack.

**CONCEALED CARRY ON CAMPUS:** Handguns are only allowed on campus (including all classrooms) to the extent specifically authorized by state law. Everyone who lawfully possesses a handgun and an enhanced carry permit is always required to keep the handgun concealed from public view and is responsible for carrying the handgun in a safe manner. If an individual carries a concealed handgun in a personal carrier such as a backpack, purse, or handbag, the carrier must remain within the individual's immediate vicinity (within arm's reach). During this class, you may be required to engage in activities that require you to be physically separate from your belongings and you should plan accordingly. Any student who violates the concealed carry laws while on campus may be subject to criminal prosecution and/or discipline by the University, up to and including dismissal. If you observe someone displaying a handgun or other weapon on campus, it should be reported to the University of Arkansas Police Department (<u>uapd.uark.edu</u>). For more information: <u>safety.uark.edu</u>.