PTYS 407 – Chemistry of the Solar System

Kuiper Space Sciences Building – Room 312

Fall 2026 – Mondays and Wednesdays – 9:30-10:45 am

Description of Course

This course examines the chemical origin and evolution of the solar system and its constituent materials and worlds. Topics include the origin of the elements, bulk elemental abundances, the formation and evolution of the protoplanetary disk, planetesimal and planet formation, planetary differentiation, and the subsequent geological, atmospheric, and chemical evolution of planetary bodies. Special emphasis is placed on the distribution and evolution of volatile elements, water, and organic matter, and their roles in the emergence of habitable environments on Earth and elsewhere in the Solar System.

Emphasis is placed on how cosmochemical knowledge is derived from diverse datasets, including bulk-rock and mineral chemistry, mineral identification and petrography, stable and radiogenic isotope measurements, spectroscopy, and geochronology. Students will work with authentic data obtained from meteorites, interplanetary dust particles, and returned samples from the Moon, asteroids, and comets, together with observations of Mars and other planetary bodies. The course also explores chemical information obtained through spacecraft remote sensing, *in situ* measurements, and telescopic observations. Through quantitative analysis, graphical visualization, and interpretation of these datasets, students will reconstruct the history of Solar System materials and evaluate how chemical processes have shaped planetary evolution and the conditions necessary for the origin and persistence of life.

Course Prerequisites

Two semesters of General Chemistry and one semester of College Algebra or their equivalents. These requirements may be waived by special permission of the instructor.

Instructor and Contact Information

Instructor: Professor Dante Lauretta, Lunar and Planetary Laboratory, University of Arizona

Office: Kuiper Space Sciences Building (1629 E University Blvd) 536

Email: lauretta@arizona.edu

Office Hours: Tuesdays: 11 am – 12 pm in person

By appointment: Zoom or in person, contact Dante to schedule.

Web Information

All class materials, including presentations, homework, oral presentation, and written report details are available on the course website on D2L: https://d2l.arizona.edu/d2l/home/1795534

Course Format and Teaching Methods

The course format will be in-person presentations from the instructor accompanied by assigned reading. Students will engage in active learning both in and out of the classroom through homework, an oral presentation, and a written report.

Throughout the semester, students will evaluate how cosmochemical and geochemical processes fractionate elements and isotopes, establish the chronology of solar system events, and control the

distribution and evolution of volatile elements, ices, noble gases, and organic matter. Emphasis is placed on quantitative data analysis, graphical visualization, reproducible methods, and interpretation of multiple lines of evidence within the broader context of solar system formation, planetary evolution, and habitability.

The course content will be presented and evaluated through a combination of:

- Classroom lectures focused on key topics in cosmochemistry
- Assigned reading
- Quantitative homework assignments (6)
- Student oral presentation (1)
- Student written report (1)

Learning in this course emphasizes scientific reasoning rather than memorization. Students will work with authentic cosmochemical datasets, construct quantitative visualizations, evaluate uncertainties, and develop evidence-based interpretations of solar system formation and evolution. Artificial intelligence tools may be used as part of the learning process, but students remain responsible for verifying results, documenting their use of AI, and demonstrating independent scientific judgment. Assessments are designed to measure the ability to analyze data, synthesize multiple lines of evidence, and communicate scientific conclusions clearly.

Course Objectives

During this course, students will:

- Use foundational concepts, theories, and quantitative methods from planetary science, chemistry, physics, and the geosciences to understand:
    - How cosmochemical data are acquired through laboratory analysis, spacecraft measurements, remote sensing, and telescopic observations.
    - How bulk-rock, mineralogical, petrographic, elemental, isotopic, spectroscopic, and chronological datasets are used to study extraterrestrial materials.
- Apply critical thinking and quantitative reasoning to analyze, visualize, and interpret chemical data in the context of planetary- and solar-system-scale processes.
- Examine how cosmochemical and geochemical processes, including nucleosynthesis, condensation, accretion, differentiation, aqueous alteration, volatile loss, and atmospheric evolution, modify the compositions of planetary materials.
- Integrate evidence from multiple disciplines to address fundamental questions:
    - How did the solar system form and evolve?
    - How did planetary bodies acquire their present-day chemical characteristics?
    - Why do planets, moons, asteroids, and comets exhibit such diverse compositions and evolutionary histories?
- Develop reproducible scientific practices by clearly documenting analytical methods, assumptions, uncertainties, and the transparent use of generative AI and other computational tools.

Expected Learning Outcomes

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

- Understand the scientific questions that motivate cosmochemistry.
- Recognize the strengths and limitations of different datasets.
- Read and interpret tables, spectra, plots, and conceptual diagrams.
- Integrate multiple lines of evidence into a coherent scientific interpretation.
- Communicate scientific arguments clearly.
- Document and critically evaluate the use of generative AI and other computational tools.

Makeup Policy for Students Who Register Late

Students who register after the first-class meeting may make up missed assignments. The missed assignments will be due within one week of students first class period attended.

Course Communications

The instructor is available during office hours, via email, and by appointment. All course material will be posted on D2L. Instructor presentations will be delivered in person. Grades will be updated regularly on D2L. Students are allowed to work in small groups outside of class for the homework assignments.

Required Readings

Readings will be assigned from these sources throughout the semester and posted on D2L:

- *Treatise on Geochemistry • Third Edition* (2024) Editors: Ariel D. Anbar, Dominique Weis
- *Elements Magazine: An International Magazine of Mineralogy, Geochemistry, and Petrology.*
- *Other sources as needed to fill conceptual gaps*

Assignments: Schedule/Due Dates

Homework (HW) Assignments

Six homework assignments will be given throughout the semester. The schedule for their assignment and due dates is:

Assignment	Date Assigned	Date Due
HW1	8/24/26	9/2/26
HW2	9/9/26	9/21/26
HW3	9/28/26	10/7/26
HW4	10/12/26	10/26/26
HW5	11/2/26	11/16/26
HW6	11/23/26	12/7/26

Oral Presentations (OP)

Students are required to present one in-class oral presentation. This presentation must be on a cosmochemical data set of relevance to the course topics. The data set may be from the scientific literature or from the student's own research. Presentations will be "conference style," with ten minutes for presentation and five minutes for questions. Students will be assigned one of these dates for their presentation:

Oral Presentation Slot	Date
OP1	9/30/26
OP2	10/14/26
OP3	10/28/26
OP4	11/18/26
OP5	12/2/26
OP6	Final Exam Period (if needed)

Final Project - Written Report (WR)

Students are required to submit a written report on a cosmochemical data set of relevance to the course topics. The data set may be from the scientific literature, from the student's own research, or a combination of both. Reports will be "Research Article" style, limited to 1500 words (not including references and figure captions), 5 display items (figures or tables), and a maximum of twenty citations. The main text should be divided into sections with brief subheadings. The data should be presented in figures as relevant. All plotted data should also be included as a supplementary file. Various milestones will be assigned throughout the semester, leading the final report date:

Report	Due Date
WR	12/9/26

Grading Scale and Policies

Final grades will be calculated based on:

60%: *Homework (10% each)*

20%: *Oral Presentation*

20%: *Written Report*

The grade distribution for the course is as follows:

A:	≥90%	= excellent (regular grade)
B:	≥80% – <90%	= good (regular grade)
C:	≥70% – <80%	= satisfactory (regular grade)
D:	≥60% – <70%	= poor (regular grade)
E:	<60%	= failure (regular grade)

Incomplete (I) or Withdrawal (W):

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policy, which is available at https://catalog.arizona.edu/policy/courses-credit/grading/grading-system.

Dispute of Grade Policy:

Students may dispute a grade on a homework, oral presentation, of project. The acceptable time period for registering a dispute is one week from receiving the grade.

Classroom Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, making phone calls, doom scrolling, posting on social media).

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

Scheduled Topics/Activities/Due Dates

Date	Topic	Reading	Due
8/24/26	Class Introduction and Solar System Overview	NA	
8/26/26	Early History of Meteoritics and Asteroid Science	01 - All About Asteroids	
8/31/26	Spaceflight Instrumentation	02 - Instrumentation for Planetary Exploration Missions	
9/2/26	Laboratory Techniques for Sample Analysis	03 - Laboratory technology and cosmochemistry	HW1
9/7/26	Labor Day - No Class		
9/9/26	Nucleosynthesis	04 - A Cosmochemical View of the Solar System	
9/14/26	Solar Abundances and Classification of the Elements	05 - Abundances of elements in solar systems	
9/16/26	Protoplanetary Disks	06 - The Formation of the Solar System	
9/21/26	Planetary Materials	07a - Planetary materials (pp. 205-226)	HW2
9/23/26	Disk composition and evolution	07b - Planetary materials (pp. 226-246)	
9/28/26	K-ALFAA Lab Tour	NA	
9/30/26	Oral Presentations		OP1
10/5/26	Asteroids	08 - One's Trash is Another's Treasure: Cosmic Rubble Piles	
10/7/26	Comets	09 - The Rosetta Mission	HW3
10/12/26	Abiotic Organic Molecular Evolution	10 - Extraterrestrial Organic Matter	
10/14/26	Oral Presentations		OP2
10/19/26	Planet Formation	11a - Origin of the Earth (pp. 326-349)	
10/21/26	Core Formation and Timescales of Earth's Accretion	11b - Origin of the Earth (pp. 349-373)	
10/26/26	Composition and Interior Structure of the Moon	12a - Composition, structure, and origin of the Moon (pp. 418-438)	HW4
10/28/24	Oral Presentations		OP3
11/2/26	Formation of the Moon	12b - Composition, structure, and origin of the Moon (pp. 438-467)	
11/4/24	The Early History of Life on Earth	13 - The First Billion Years: When Did Life Emerge?	
11/9/26	Mercury	14 - Mercury	
11/11/24	Veteran's Day - No Class		
11/16/26	Venus	15 - Venus	HW5
11/18/24	Oral Presentations		OP4
11/23/26	Martian Meteorites	16a - Formation and interior evolution of Mars (pp. 482-493)	
11/25/24	Formation and Differentiation of Mars	16b - Formation and interior evolution of Mars (pp. 493-512)	
11/30/26	The Search for Life on Mars	17 - Water on Mars and the Prospect of Martian Life	
12/2/26	Oral Presentations		OP5
12/7/26	The Evolutionary Divergence of Mars, Venus, and Earth	18 - The evolutionary divergence of Mars, Venus, and Earth	HW6
12/9/26	Class Recap	NA	WR

Legend

- No class
- Instructor out of town (none currently identified)
- HW due date
- Student oral presentations
- Written Report due date

Safety on Campus and in the Classroom

For a list of emergency procedures for all types of incidents, please visit the website of the Critical Incident Response Team (CIRT): https://cirt.arizona.edu/case-emergency/overview

Also watch the video available at https://arizona.sabacloud.com/Saba/Web_spf/NA7P1PRD161/common/learningeventdetail/crtfy0000000000003560

Additional Resources for Students

UA Academic policies and procedures are available at http://catalog.arizona.edu/policies

Campus Health

http://www.health.arizona.edu/

Campus Health provides quality medical and mental health services through virtual and in-person care.
Phone: 520-621-9202

Counseling and Psych Services (CAPS)
https://health.arizona.edu/counseling-psych-services
CAPS provides mental health care, including short-term counseling services.
Phone: 520-621-3334

The Dean of Students Office's Student Assistance Program
https://deanofstudents.arizona.edu/support/student-assistance
Student Assistance helps students manage crises, life traumas, and other barriers that impede success. The staff addresses the needs of students who experience issues related to social adjustment, academic challenges, psychological health, physical health, victimization, and relationship issues, through a variety of interventions, referrals, and follow up services.
Email: DOS-deanofstudents@arizona.edu
Phone: 520-621-7057

Survivor Advocacy Program
https://survivoradvocacy.arizona.edu/
The Survivor Advocacy Program provides confidential support and advocacy services to student survivors of sexual and gender-based violence. The Program can also advise students about relevant non-UA resources available within the local community for support.
Email: survivoradvocacy@arizona.edu
Phone: 520-621-5767

Confidentiality of Student Records

http://www.registrar.arizona.edu/ferpa

University-wide Policies link

Links to the following UA policies are provided here, http://catalog.arizona.edu/syllabus-policies:

- Absence and Class Participation Policies
- Threatening Behavior Policy
- Accessibility and Accommodations Policy
- Code of Academic Integrity
- Nondiscrimination and Anti-Harassment Policy
- Subject to Change Statement