

Astrochemistry

General Information:

Department: Department of Astronomy and Planetary Science

Course: AST 570, Class Number 11418, Section 001

Term: Fall 2020

Meeting Time: Monday – Wednesday, 9:35 a.m. – 10:50 a.m., Bldg 19, Room 109

Mode of Instruction: Face-to-face

Credit Hours: 3

Course Prerequisites: Admission to Astronomy and Planetary Science PhD program or permission from Instructor

Instructor: Mark Loeffler

Office: Physical Science (Building #19), Room 225C. Phone: 523-0369. Email: mark.loeffler@nau.edu

Laboratory: Physical Science (Building #19), Room 313/313A.

Office Hours: 11:00 - 12:00 p.m. Monday and Wednesday. **You are welcome to contact me at any time; we can meet at different hours if these are not convenient.**

Course Purpose:

Compared to basic scientific disciplines, the topic of astrochemistry is a relatively new field of study, based heavily on chemistry and astronomy. However, the breadth of topics that fall within the field of astrochemistry necessitate that one have the ability to draw on concepts from a variety of other disciplines, such as physics, biology, geology, and materials science. The intention of this course is to illustrate astrochemistry's role in studying and predicting the physical and chemical processes that are important for the formation of new species in different extraterrestrial environments. This course will use specific examples to emphasize the diversity of environments that exist both inside and

outside our Solar System and to show how different astrochemical approaches can be combined to gain a more realistic picture of the likely chemical history and evolution of any object under study. Letter grade only.

Learning Outcomes:

Understand role of Astrochemistry plays the formation and evolution of objects in the Interstellar Medium and in our Solar System

Become familiar with the different approaches used to investigate Astrochemistry

Be able to make calculations to help quantify astrochemical effects on objects throughout our Solar System and the Interstellar Medium

Be able to apply astrochemical principles to different environments throughout our Solar System and the Interstellar Medium to understand, explain and predict general outcomes

Course Structure:

Required Textbook: There is no required textbook for this course. However, reference books that will be used to varying degrees in this class are:

Astrochemistry: From Astronomy to Astrobiology, by Andrew Shaw

Introduction to Astrochemistry: Chemical Evolution from Interstellar Clouds to Star and Planet Formation, by Satoshi Yamamoto

The Physics and Chemistry of the Interstellar Medium, by A.G.G.M. Tielens

Assessment/Grading:

Grades will be determined from the following categories:

Homework (30%): Assignments will be given approximately every week; the student will typically have a week to complete the assignment. The homework will be due at the beginning of class, unless otherwise specified. The assignments must be turned in by their stated due dates; 10% point deduction will be applied for every day assignment is late. If we are not in person, then the assignments can be turned in by either dropping them in my mailbox by the beginning of class time or by emailing me a single pdf of the assignment. If the latter is chosen, please double check that the material is both readable and readily printable (I won't print out an assignment if every page is a different file).

Mid-Term Exam (25%): This written exam will be given during class time. It will be based on lectures and homework assignments.

Class Project (20%): In the class project, the student will choose a topic within the realm of astrochemistry in which they are interested. After approval from the professor, they will research the topic, find an appropriate peer-reviewed article and meet with the instructor about the paper. After that, they will write a short paper (~1000 words) summarizing the main points and give a short in-class (conference style) presentation (10 - 15 minutes). This project has to be completed by the final class but can be completed earlier if so desired by the student.

Final Examination (25%): A cumulative written final exam will be given on November 23rd from 7:30 to 9:30 am.

Approximate Grading Scale:

≥ 90% A
≥ 80 – 90% B
< 80% C

Makeup Work:

A student must obtain permission in advance of a regularly scheduled examination in order to take a make-up examination. Make up examinations will be different than the in-class examination.

Academic Dishonesty:

A finding of academic dishonesty will result in a zero for the assignment and a record of the student's offense in NAU Academic Dishonesty Database. A repeat of a finding of academic dishonesty will result in a failing grade for the class.

Course Outline:

The schedule and topics shown below are tentative and are subject to change.

Week Beginning	Day 1	Day 2
8/12	Overview of Astrochemistry	N/A
8/17	ISM Environment	Observational Techniques
8/24	Observational Techniques	Modeling/Theoretical Techniques
8/31	Modeling/Theoretical Techniques	Laboratory Studies
9/7	N/A	Laboratory Studies
9/14	Detected Species	Drivers of Astrochemistry
9/21	Drivers of Astrochemistry	Applications
9/28	Applications	Exam 1
10/5	Solar System Formation/Chemical Time Line	Overview of Solar System Environments
10/12	Applications: Jupiter	Applications: Saturn's moons
10/19	Applications: Mars	Applications: Venus
10/26	Applications: Icy Satellites	Applications: Icy Satellites
11/2	Applications: Moon	Applications: Comets
11/9	Applications: Asteroids	Applications: Meteorites
11/16	Catch up/extra topic	Review for final

Special COVID-19 Pandemic Policies and Tools

The following policies in this sections are specific to the University's response to the COVID-19 pandemic are mandatory until further notice. These requirements and related information are on currently public health conditions and guidance may change as circumstances warrant or new information becomes available. Additional information about the University's response to the COVID-19 situation available from the **Jacks are Back!** web page available at <https://nau.edu/jacks-are-back/lumberjack-responsibilities>.

Face Covering and Physical Distancing Requirements: Appropriate face masks or other suitable coverings must be worn by all individuals when present in classrooms, laboratories, studios, and other dedicated educational spaces. To maximize the benefits of physical distancing as an important strategy to help reduce community transmission of the SARS-CoV-2 virus, instructors may implement mandatory student seating arrangements or specific seat assignments. Instructors may remove students who do not cooperate with these requirements in the absence of an approved accommodation arranged through Disability Resources. Failing to comply with these requirements will

constitute a violation of the University's *Disruptive Behavior in an Instructional Setting* policy available at <https://nau.edu/university-policy-library/disruptive-behavior>.

Use NAUFlex to Help Maintain Physical Distancing: NAUFlex (available at <https://nau.edu/nauflex/student>) enables all students to actively participate in their coursework during the required day and time of a course, even if they are not physically present in the classroom. The hope is that this model will allow students to be fully engaged with faculty and peers.

Class Session Records for Students and Faculty Use Only: Certain class sessions may be audio or video recorded to help reinforce live instruction during the COVID-19 pandemic. These recordings are for the sole use of the instructor and students enrolled in the course. Recordings will be stored in approved, accessible repositories. By enrolling, students hereby agree to have their image and classroom statements recorded for this purpose, and to respect the privacy of their fellow students course-mates and University-owned intellectual property (including, but not limited to, all course materials) by refraining from sharing recordings from their courses. Questions regarding restrictions on the use of audio or video classroom recordings may be addressed to the appropriate academic unit administrator.

University and Course Policies:

Safe Environment Policy: NAU's Safe Working and Learning Environment Policy prohibits discrimination and promotes the safety of all individuals within the University. The goal of this policy is to prevent the occurrence of discrimination on the basis of sex, race, color, age, national origin, religion, sexual orientation, disability, or veteran status and to prevent sexual harassment, sexual assault or retaliation by anyone at this University.

Students With Disabilities: If you have a documented disability, you can arrange for accommodations by contacting Disability Resources (DR) at 523-8773 (voice) or 523-6906 (TTY), dr@nau.edu (e-mail) or 928-523-8747 (fax). Students needing academic accommodations are required to register with DR and provide required disability related documentation. Although you may request an accommodation at any time, in order for DR to best meet your individual needs, you are urged to register and submit necessary documentation (www.nau.edu/dr) 8 weeks prior to the time you wish to receive accommodations. DR is strongly committed to the needs of student with disabilities and the promotion of Universal Design. Concerns or questions related to the accessibility of programs and facilities at NAU may be brought to the attention of DR or the Office of Affirmative Action and Equal Opportunity (523-3312).

Academic Integrity: The university takes an extremely serious view of violations of academic integrity. As members of the academic community, NAU's administration, faculty, staff and students are dedicated to promoting an atmosphere of honesty and are committed to maintaining the academic integrity essential to the education process. Inherent in this commitment is the belief that academic dishonesty in all forms violates

the basic principles of integrity and impedes learning. Students are therefore responsible for conducting themselves in an academically honest manner. Individual students and faculty members are responsible for identifying instances of academic dishonesty. Faculty members then recommend penalties to the department chair or college dean in keeping with the severity of the violation. The complete policy on academic integrity is in Appendix G of NAU's Student Handbook <http://www4.nau.edu/stulife/handbookdishonesty.htm>.

Academic Contact Hour Policy: The Arizona Board of Regents Academic Contact Hour Policy (ABOR Handbook, 2-206, Academic Credit) states: "an hour of work is the equivalent of 50 minutes of class time...at least 15 contact hours of recitation, lecture, discussion, testing or evaluation, seminar, or colloquium as well as a minimum of 30 hours of student homework is required for each unit of credit."

The reasonable interpretation of this policy is that for every credit hour, a student should expect, on average, to do a minimum of two additional hours of work per week; e.g., preparation, homework, studying.

A Final Comment: This semester will be unique. If there is an issue with presentation of material or something that I can do to improve the course, I will be happy to hear feedback from anyone at any point during the course. Also, if you are struggling in the course, then please reach out to me or other students sooner than later. I am happy to help, as I want you to get something out of this course.