HWRS 562a Chemical Hydrogeology I
Fall 2025

Catalog Description

This course will cover fundamental knowledge of the chemistry of waters in hydrologic systems. Students will learn to quantify, predict, and describe common processes controlling the geochemistry of natural waters in the environment. They will explore how water evolves through reactions with rocks, minerals, and solutes driven by chemical equilibrium, kinetics, adsorption/desorption, and oxidation-reduction processes.

Course Prerequisites or Co-requisites

No pre-requisites, but must be enrolled in the MS Hydrogeology program. Required co-registration in HWRS 599 Section 001 (Recitation), HWRS 561a Physical Hydrogeology I, HWRS 563a Hydrogeologic Measurement Methods I, HWRS 564a Hydrogeologic Analysis Tools & Methods I, and HWRS 565a Communications in Hydrogeology I

Required Textbooks/Materials

Specific chapters will be assigned from the following textbook, which is freely available online:

The Geochemistry of Natural Waters: Surface and Groundwater Environments
By James I. Drever (last updated in 1997)
https://gw-project.org/books/the-geochemistry-of-natural-waters/

Additional reading materials from other texts and articles will be provided for free on the course website.

Reference Readings (Optional)

References for case studies discussed in class will be provided as needed through D2L. You will not need to purchase these references.

Course Objectives

Students will…

1. Practice converting between concentration units, calculating basic chemical properties, and balancing chemical reactions.
2. Use thermodynamics and chemical equilibrium data to make predictions about the likelihood of water-rock reactions to progress under environmental conditions.
3. Describe environmental factors controlling chemical weathering and sources of solutes in natural waters.
4. Explain how adsorption and cation exchange processes can alter solute and contaminant transport.
5. Constrain oxidation-reduction (redox) potential of hydrologic environments and make predictions for transport and reaction of redox sensitive species.
6. Describe how the geochemistry of groundwater evolves along flowpaths from recharge to discharge.

Expected Learning Outcomes

Students will be able to…

1. Calculate basic hydrogeochemical parameters, such as total dissolved solids, ionic strength, activities, and charge balance with necessary unit conversions and balance chemical reactions.
2. Analyze sources and sinks of solutes in groundwater considering chemical equilibrium and kinetic controls of mineral weathering, as well as sorption and cation-exchange processes.
3. Constrain environmental redox conditions and presence of redox-sensitive chemical species.

Course Format and Teaching Methods

Lecture, in-class discussions and collaborative work on in-class practice problems. There may be some hands-on learning activities in-class.

Schedule of Topics & Activities

Week	Monday date	Project	Weekly Learning Objectives	Associated Activities	HW Due Date
1	8/25/2025	**Road Trip**	- practice taking water quality field parameter measurements and discuss how they can be informative.	During the field trip, we will discuss what can be measured and how it can be measured. Then we will make measurements! We will start habits related to field note taking and we will see drilling and core logging in person. (see schedule below)	N/A
2	9/1/2025	**1 – Describe your home watershed**	Basic chemical concepts: convert between different units, balance chemical reactions, calculate and	In-class practice problem sets as warm up for homework HW #1 – Course assignment: Basic chemical concepts	9/8/2025

			evaluate charge balance, and quantify total dissolved solids		
3	9/8/2025	**1 – Describe your home watershed**	Define laws of thermodynamics and apply laws to calculate chemical equilibrium constants	In-class practice problem sets as warm up for homework HW #2 – Course assignment: Thermodynamic properties and Keq values	9/15/2025
4	9/15/2025	**1 – Describe your home watershed**	Calculate ionic strength, activity coefficients and activities, and mineral saturation indices	In-class practice problem sets as warm up for homework HW #3 – Course assignment: Mineral saturation	9/22/2025
5	9/22/2025	**1 – Describe your home watershed**	Describe geochemical models for speciation, saturation, etc.; practice different techniques to visualize different water types (Piper plots, stiff diagrams, cross-plots)	In-class computer modeling activities (can be done on personal iPads or laptops, or shared student computers) HW #4 – Project-relevant assignment: Make plots and equilibrium calculations (using models) of Tucson Basin groundwater	10/6/2025
6	9/29/2025	**2 – Tucson Basin water and chemical balance**	pH, acid/base reactions and carbonate buffering capacity	Extra time to work on HW #4 – relevant for Project #2 ***1st Self-reflection due by 10/10/2025***	
7	10/6/2025	**2 – Tucson Basin water and chemical balance**	Carbonate system continued	In-class discussion of rising CO_2 impacts on carbonate weathering and processes that drive mineral precipitation HW #5 – Course assignment: Carbonate speciation and mineral precipitation/dissolution	10/13/2025
8	10/13/2025	**2 – Tucson Basin water and chemical balance**	Chemical kinetics, including role of biology in increasing reaction rates	HW #6 – Course assignment: Calculation and evaluation of mineral dissolution reaction rates	10/27/2025
9	10/20/2025	**2 – Tucson Basin water and chemical balance**	Environmental controls on mineral weathering and sources of solutes		
10	10/27/2025	**3 – Impacts of pumping on flow**	Solute chemical mass balance	HW #7 – Course assignment: Attributing solute chemistry to specific silicate weathering reactions	11/3/2025

11	11/3/2025	**3 – Impacts of pumping on flow**	Sorption and cation exchange processes altering water chemistry		
12	11/10/2025	**3 – Impacts of pumping on flow**	Oxidation-Reduction (redox) processes	HW #8 – Course assignment: Calculating redox potential and identifying electron donors and acceptors in reactions ***2nd Self-reflection due by 11/14/2025***	12/1/2025
13	11/17/2025	**3 – Impacts of pumping on flow**	Redox processes continued		
13	11/24/2025		NA - Thanksgiving		N/A
14	12/1/2025	**3 – Impacts of pumping on flow**	Hydrogeochemical evolution of waters	HW #9 – Course assignment: Review and synthesize a case study of geochemical evolution of waters along flowpaths due to fluid-rock reactions, mixing, biological activity, etc.	12/8/2025
15	12/8/2025	**3 – Impacts of pumping on flow**	Synthesis and review	Review of term 1, a look ahead to term 2	

Course Assessments and Grading Breakdown

You will be assessed based on weekly assignments. You will also be assessed based on how you apply the understanding gained in this class to the projects.

Course Assignments: are designed to develop your understanding of elements of the course and to give you practice in applying that knowledge. A time budget will be given for each Course Assignment. They may include calculations, analysis, synthesis, and written elements. Course Assignments count toward your grade in the course and should be turned in as a hard copy in class with any Excel sheet calculations turned in on d2L. In this course, Course Assignments will be given at least one week in advance and due on Mondays at the beginning of class.

Project-Relevant are designed to help you to apply the content of this class to the program-wide projects. In some cases, these Project-Relevant Assignments will produce outcomes that can be included directly in your project. In other cases, the Project-Relevant Assignments will act as a bridge between the course material and the project requirements. Even if the project is team-based, every student must complete all Project-Relevant Assignments. A time budget will be given for each Project-Relevant Assignments. They may include calculations, analysis, synthesis, and written elements. Project-Relevant Assignments count toward your grade in the course and should be turned in through the D2L site unless otherwise indicated. In this course, there is one Project-Relevant Assignment (Homework #4). It will be given out two weeks in advance and due on a Monday in-class. Please turn in the assignment as a hardcopy with any Excel calculations submitted through D2L by the due date.

Self-Reflections: A couple self-reflections are required specifically for this course throughout the term. These will be announced at least one week in advance and will be worth relatively few points. The intent of these self-reflections is to provide an opportunity for the students and instructors to check in on the progress and expectations of the course.

The percentage distribution of your grade will be as follows.

Course Assignments (8)	: 70%
Project-relevant assignments (1)	: 20%
Course-specific self-reflections (2)	: 10%

University policy regarding grades and grading systems is available at this link.

Final Examination or Project

There is no final examination in this course. However, students will be completing three projects this semester that cut across all courses in the MS Hydrogeology program and will require students to utilize and synthesize the skills they learned in all five courses to address a hydrogeologic question/problem. Presentation of the third and last Term Project of the semester will take place on December 10, 2025, the last scheduled day of classes. These presentations will be organized as a mini-conference and professional hydrogeologists will be invited to attend in person or online.

Grading Scale

Your final grade will be informed via D2L. Letter grades are determined using the following scale:

A:	>= 90.0%
B:	>= 80 - 89%
C:	>= 70 – 79 %

D: >= 60 to 69 %

E: below 59 %

University policy regarding grades and grading systems is available at https://catalog.arizona.edu/policy/courses-credit/grading/grading-system.

Late Work Policy

This class and the entire program depend strongly on student participation and you are only able to participate fully if you have done the homework on time. Therefore, no late assignments will be accepted for credit. We do understand that life happens, so we will automatically drop your **two** lowest course assignment grades for this course when calculating your final grade.

Incomplete (I) or Withdrawal (W)

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at this link associated with the registrar.

University of Arizona Course Policies

All University of Arizona course and syllabi policies, as well as other helpful information and resources, can be found at this link.

If you are in need of basic needs care, here is another helpful link, in addition to what you can find at the policy link above.

Subject to Change Statement

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.