**REDOX AND ELECTROCHEMICAL PROCESSES IN WATER**

**Instructor: Visiting Professor Roberto Candal**

**MWF 4:00 – 4:50 pm in Tech - M120**

## Course overview

Redox and electrochemical processes play a fundamental role in natural phenomena and water-related technologies, such as metal cycling, corrosion, electrolysis, electrocoagulation, and advanced oxidation-reduction, to name just a few. All of these are of great importance to society, both economically and environmentally. In order to control these processes—maximizing their benefits and minimizing drawbacks—it is essential to understand how various physicochemical variables influence them, either thermodynamically or kinetically. This course will present the fundamental principles of different redox and electrochemical processes occurring in aqueous media and their technological applications.

## 1. Course objective

The objective of the course is to deepen the understanding of redox chemistry and electrochemistry in aqueous media, building on concepts learned in previous foundational courses, primarily General Chemistry, and optionally Physical Chemistry and Analytical Chemistry. Basic redox and electrochemical phenomena will be linked to natural processes and/or technologies based on them. This will be achieved through theoretical lectures, problem-solving sessions, and the analysis of case studies.

## 2. Course Outcomes

Upon completion of this course, the students will be able to

1. Understand and apply basic principles of redox chemistry in aqueous media
2. Become familiar with thermodynamic and kinetic models of electrochemistry in water
3. Solve problems related to quantitative transformations
4. Relate electrochemical processes to natural phenomena in aqueous environments
5. Relate electrochemical processes to water-related technologies

## 3. Reading material

1) The electrochemistry of corrosion (D.L. Piron)
2) Bookshelves - Chemistry LibreTexts: AnalChem2.1.pdf
3) Redox equilibria in natural waters (Stephen K. Lower)

4. **Grading**

Problems and questionnaires: 30%

Midterm: 40%

Discussion of case studies: 30%

5. **List of Topics Covered**

| **Topics** | **Material expected to be covered** |
|---|---|
| #1 | Redox reactions and redox potential. Electron activity (pe). Electrodes and electrochemical cells. Reference electrodes. Reversible electrodes and Nernst equation. Potential-pH diagram (Pourbaix diagram) |
| #2 | Electrolyte conductivity. Faraday law. Electrode rate processes and overpotential. Tafel equation and Tafel plots. Butler-Volmer formulations |
| #3 | Fundamentals of electroanalysis. Controlled potential and controlled current techniques (Voltammetry, cyclic voltammetry; amperometry) |
| #4 | Redox processes in the environment. Water stability. Manganese and iron in aqueous environment: redox transformations. Oxidants in anaerobic conditions. Pyrite bio lixiviation |
| #5 | Corrosion and corrosion rates. Water as a corrosive environment (effect of O2, pH, chloride). Passivation and protection. Cathodic protection. Corrosion in pipes. |
| #6 | Advanced oxidation. Fenton and electro-Fenton processes. Photocatalysis and photoelectrocatalysis with semiconductor oxides |
| #7 | Electrocoagulation for water potabilization and waste water treatment. O3/UVC for water disinfection and purification |