GEORGE MASON UNIVERSITY **Dr. Abul Hussam**
CHEM 625- Electroanalytical Chemistry **Planetary Hall 337/402**
Fall 2017 **ahussam@gmu.edu**

The objective of this course is to introduce the principles of electrochemical science for analytical purpose. It includes potentiometric, and voltammetric techniques and their applications. Although the scope of applications covers almost all branches of science, the course will only cover selected and important applications of electrochemical techniques as an analytical tool i.e., how to measure and study low level concentrations of redox species in solution and their reaction kinetics and thermodynamics. The course also has a three-week laboratory component, where you will perform a series of basic experiments. The laboratory work has been designed to strengthen the theoretical background in electrochemistry. The course will be graded based on assigned homework problems, laboratory reports, and examinations.

Requirements and Preparation

This is a 600-level graduate course that requires good math and chemistry background. The minimum course requirements are: Quantitative Chemical Analysis (CHEM 321), Physical Chemistry I (CHEM 331) and Physical Chemistry II (CHEM 332) or Instrumental Analysis (CHEM 422) as an undergraduate. Equivalent courses can be substituted with instructor's permission.

Text

Electrochemical Methods: Fundamentals and Applications, 2nd Edition
Allen J. Bard, Larry R. Faulkner, ISBN: 978-0-471-04372-0, Wiley.

COURSE TOPICS

1. Introduction and review of basic electrochemistry: Electrochemical reactions and cells (parts from Chapter 2)
2. Chapter 1: Overview of electrode processes, Faradaic and non faradaic processes, nature of electrode solution interface (Chapter 13: double layer structure and equations), semiemirical treatment of mass transfer and homogenous solution kinetics.
3. Chapter 2: Thermodynamics of cell: Reversible cells, measurement of potential differences, examples of electrochemical potentials, liquid junction, selective electrodes and potentiometric ion selective sensors.
4. Chapter 3: Kinetics of Electrode Reactions- Butler-Volmer model (BVM), One-step-one-electron process, implications of BVM for simple electrode processes, rate determining electron transfer, tunneling and extended charge transfer
5. Chapter 4: Mass transfer by migration and diffusion, Fick's laws of diffusion and boundary conditions
6. Chapter 5: Controlled Potential Techniques- Solving simple boundary value problems with Laplace transform. Applications in chronoamperometry and chronocoulometry. The role of ultra-microelectrodes in electroanalytical science.

7. Chapter 6 and 7: Potential sweep techniques: Dropping mercury electrode, cyclic voltammetry, pulse polarography, stripping voltammetry, and convolution voltammetry.
8. Chapter 8: Controlled current technique- Chronopotentiometry and charge step techniques
9. Chapter 11: Bulk electrolysis methods- Controlled potential and current based coulometry, electrochemistry in a flow system and applications, electrochemistry in a thin layer and stripping voltammetry
10. Additional topics from distributed literature: Amperometric, galvanic, potentiometric, ion-channel biosensors and electrochemistry in organized media

LABORATORY EXPERIMENT

1. Measurement of Solution Resistance, Double Layer Capacity of the Electrode and Time Constant of the Potentiostat
2. Double Potential Step Chronoamperometry and Chronocoulometry of a Redox Couple.
3. Chronopotentiometry of $[Fe(CN)_6]^{3-}/[Fe(CN)_6]^{4-}$ Redox Couple.
4. Cyclic Voltammetry of a Redox Couple. Comparison of macro and ultramicroelectrodes.
5. Differential Pulse and Square-Wave Voltammetry and Anodic Stripping Voltammetry of trace metal ions.
6. Discover What's Going On

You are required to submit laboratory reports on these experiments.

HOMEWORK PROBLEMS

(These are suggested problems. Assigned and handout problems are collected on due dates)

1. Problems in handout: Problem Set #1
2. Chapter 1: 3, 4, 5, 6, 7, 10
3. Chapter 2: 12, 14, 16
4. Chapter 3: 3, 5, 6, 10
5. Chapter 4: 2, 3, 4
6. Chapter 5: 2, 3, 7, 14, 15
7. Chapter 6: 3, 4, 8,
8. Chapter 7: 3, 9
9. Chapter 10: 1, 4, 8, 10, 14, 15

(Submission due date will be announced in the class)

GRADE DISTRIBUTION

1. Homework problems: 30%
2. Laboratory reports: 30%
3. Midterm Examination: 10% (Oct 18, 2017, 90 minutes)
4. Final Examination: 30% (December 13, 2017, 4:30-7:10 PM)