**CHEM 4200 - Principles of Instrumental Analysis**

**TEXT:** Principles of Instrumental Analysis, Skoog, Holler, and Nieman, Sixth Edition, HBC.

**PREREQUISITE:** Organic Chemistry

The course will be a survey of major important instrumental analytical techniques; their principles, instrumentation, applications, merits and demerits will be discussed. Time constraints may dictate how much of the materials and the number of topics discussed.

 1. Introduction:

 1) The analytical process

 2) Figures of merits

 3) Calibration methods and matrix effects

 II. Spectroscopic methods:

1) Noise and Analytical Figures of Merits

a) Definitions

b) Types of noise:

c) Signal-to-noise enhancement: hardware and software techniques

2) Introduction to Spectroscopy

a) Electromagnetic radiation

 i) Wave-like properties

ii) Particle-like properties

b) Atomic and molecular energy levels, absorption

and emission processes.

3) Instrumentation for Optical Spectroscopy

a) Overview of instrumentation

b) Radiation sources

c) Wavelength selectors

d) Sample holders

e) Detectors

f) Data display and manipulation

g) Instrument designs: dispersive versus nondispersive,

 single versus double beam

4) Ultra-violet and Visible Absorption Spectroscopy

a) Definitions

b) Beer's Law and Quantitation

c) Deviations and limitations to Beer's Law

d) Instrumentation for UV-VIS spectroscopy

 i) Components and designs

 ii) Actual commercial instruments

e) Methods and applications of absorption spectroscopy

5) Molecular Fluorescence, Phosphorescence and Chemiluminescence

a) Principles of luminescence

b) Instrumentation for fluorescence and phosphorescence

c) Chemiluminescence

d) Applications of luminescence techniques

6) Atomic Absorption Spectroscopy

a) Principles

b) Atomization process

 i) Flame atomization

 ii) Electrothermal atomization

c) Atomic line widths and radiation sources for AA

d) Instrumentation

e) Interferences

f) Background correction methods

g) Merits, demerits, and applications

7) Atomic Emission Spectroscopy

a) Atomic spectra

b) Population distribution with temperature

c) Sources: arc, spark and plasma for atomic emission

d) Spectrometers

e) Merits, demerits, and applications

8) Infra-Red and Raman Spectroscopy

a) Principles of IR and Raman

b) IR sources, detectors, sample cells and instrumentation

c) Raman sources, detectors, sample cells and instrumentation

d) IR and Raman compared

e) Merits, demerits and applications

III. Electrochemical Methods:

 1) Introduction to Electrochemistry

a) Electrochemical cells

b) Nernst’s equation

c) Electrode potentials and cell potentials

d) Currents in electrochemical cells

 2) Potentiometric Methods

a) Reference electrodes

b) Indicator electrodes

c) Measurement of cell potentials

d) Applications

 3) Voltammetry

a) Polarography

b) Linear-scan voltammetry

c) Pulse methods

d) Strip methods

e) Cyclic voltammetry

 4) Coulometry

a) Current-voltages relationships

b) Different coulometric methods

 i) potentiostatic

ii) amperostatic

 IV. Separation Methods:

 1) Introduction to Chromatography

a) General overview, definitions, equations

b) Chromatographic processes

c) Band broadening and column efficiency

d) Optimization separations

 2) Gas Chromatography

a) Principles

b) Instrumentation

c) Columns and stationary phases

d) Applications

 3) Liquid Chromatography

a) Scope, principles

b) Instrumentation

c) Types of LC

d) Applications

 4) Other Chromatographic Techniques

a) TLC

b) Electrophoresis

c) Super critical fluids

 V. Others:

 1) Mass-Spectroscopy

a) Principles

b) ionization methods

 c) Mass spectrometer

 i) magnetic sector, single and double focusing

 ii) quadrupole

iii) time-of-flight

d) Mass spectra

e) Mass spectrometer as detector for GC, LC and ICP

 2) Nuclear Magnetic Resonance

a) Principles

b) Spectrometer, FT-NMR

c) Applications of proton NMR, C-13 NMR

d) NMR spectra