Sul Ross State University
Syllabus for McNair Chemistry Research:
CHEM 4300 201- 31409 (Summer II, 2021)

Class: CHEM4300-201
Room: WSB 307
Time: 9:00 AM to 5:00 AM

Date: July 7 to August 9, 2021

Instructor: Dr. Hong Young Chang
Office: WSB 219
Office Hours: M-F 9:00AM-5:00PM
Face-to-Face
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Objectives:

Student Learning Objectives (SLO):

A student graduating with the ***chemistry major*** is expected to demonstrate that (s)he is able to do the following:

1. Organic Chemistry—Students will be able to draw organic molecular structures and explain organic reactions, stereochemistry, structural analysis and reactions in biological systems.

2. Inorganic Chemistry—the student will be able to demonstrate understanding of coordination chemistry, valence theory, elementary actions and advanced molecular theory.

3. Analytical Chemistry—the student will be able to demonstrate an understanding of theory of analytical chemistry and conduct analytical analysis, including data analysis and calibration, equilibrium chemistry, gravimetric analysis, titrimetric analysis, spectroscopic analysis, and electrochemical analysis.

4. Physical Chemistry—the student will be able to demonstrate an understanding of the application and theory of physical chemistry, including topics such as atomic structure, electrochemistry, surface chemistry, solid-state chemistry, and thermodynamics.

5. Research—the student will collect and analyze published chemical literature and undertake a chemistry research project.

CHEM 4300 Learning Objectives:

At the end of this course, a student should have a good understanding of:

1. 6-coordinated d^0 transition metal oxides (octahedral)
2. Out-of-center distortion in octahedral
3. Asymmetric lone pair cations and inert pair cations in non-metal groups
4. Principle of Single Crystal X-ray Diffraction

   (Crystal packing structures, Unit cell, cell parameters, 6 crystal systems and 14 Bravais Lattices, Primitive (P), Base-centered (A, B, or C), Body-centered (I), Face-centered (F))
5. Basic concepts on molecular symmetry elements and translation symmetry in crystallography (numbers of space group and translational symmetry including glade plane and screw axis, and other crystallographic symmetry (inversion, rotation axis, mirror plane, improper rotation, etc.))
6. Centrosymmetric, Noncentrosymmetric, and Asymmetric chirality in space groups
7. Applications of noncentrosymmetric and asymmetric chirality
8. Visualization of crystal structures and CIF (Crystal Information File)
9. Structural solution and refinement from single crystal X-ray diffraction
10. Structural classification of polyoxometalates (POM): Keggin, Lindqvist, Anderson, and Strandberg types, etc.
11. Design of new chemical reactions by hydrothermal methods
12. Set up composition space diagrams and the control of reaction conditions (pH, selection of counter-cations for POM anions)
13. Basic principle of single crystal growth

Core Objectives (CO):

1. **Critical Thinking Skills** – Students will gain/improve their critical thinking ability by solving research chemistry problems through inquiry, analysis, and evaluation of available information. Students will be tested on their critical thinking ability through lab experiments and research activities.

2. **Communication and Presentation Skills** – Students will have the opportunity of improving communication skills through oral presentations, poster presentation, and

writing research reports (i.e. observation, explanation, and conclusion, etc.) in their research activities.

3. **Empirical and Quantitative Skills** – Students will use the mathematical skills needed to manipulate and analyze numerical data obtained through experimentation in order to form conclusions.

4. **Teamwork** – Students will use team-spirit and consider different points of view to work effectively while conducting experiments as a team working toward a shared purpose or goal.

5. **Chemistry Literature Survey** – Students will survey on a variety of chemistry literatures (book and peer-reviewed journals) as their research activities and they will learn how to refer to the chemistry literatures as references.

Text Book: Basic Solid State Chemistry (Second Edition) by Anthony R. West, Publisher: JohnWiley & Sons, LTD

Several free-software are installed in students' personal notebook computer and they will be used to analyze the metal oxide structures and plot their data.

1. **Olex2:** GUI program for Single Crystal Structure Solution and Refinements **by Shelx** Olex2 | OlexSys

2. **VESTA (Visualization for Electronic and Structural Analysis):** to analyze the metal oxides VESTA (jp-minerals.org)

3. **Diamond** (Crystal and Molecular Structure Visualization): **Demo Version** Diamond Download Area (crystalimpact.com)

4. **OriginLab** (**Demo Version**): to graph and to plot their research results OriginLab - Origin and OriginPro - Data Analysis and Graphing Software

5. **PowderCell** (2.3 Version): to analyze and plot the powder X-ray peak patterns. BAM Berlin PowderCell (ucl.ac.uk)

6. **PowDLL converter**: to interconvert a variety of file format from powder X-ray Diffractometer PowDLL (uoi.gr)

Availability: This research class is mainly done ***via lab experiments and research activities.*** As the face-to-face style, students meet the professor and students will participate in the advanced research projects.

Recording on Lab Note: the students who participate in this research project have to write down their lab note for their research activities such the mole of starting chemicals,

reaction conditions (reaction methods, time, and temperatures), and the powder peak analysis on the synthesized chemicals.

Research Reports and Group or Personal Meeting: students have to report their research results as weekly report style to the professor and their research results will be discussed with the professor as a personal meeting. Sometimes, students have to give their oral-presentation in front of group members (group meeting).

Students with Special Needs: *Sul Ross State University (SRSU) is committed to equal access in compliance with Americans with Disabilities Act of 1973. It is SRSU policy to provide reasonable accommodations to students with documented disabilities. It is the student's responsibility to initiate a request for accessibility service. Please contact Ms. Rebecca Greathouse Wren, M.Ed., LPC-S, Director/Counselor, Accessibility Services Coordinator, Ferguson Hall (Suite 112) at 432.837.8203; mailing address is P.O. Box C-122, Sul Ross State University, Alpine, Texas 79832. E-mail: rebecca.wren@sulross.edu Students should then contact the instructor as soon as possible to initiate the recommended accommodations.*

Academic Integrity: *Academic dishonesty hurts everyone and reduces the value of college degrees. Doing someone else's work, presenting the ideas and work of others as your own, submitting the same paper for multiple classes, and/or failing to cite your sources when you utilize the ideas of others, are all examples of academic dishonesty. It is your responsibility to read and understand the university's policy on academic dishonesty in the SRSU Student Handbook, as all violations will be taken seriously and handled through the appropriate university process. The Student Handbook can be found at: https://www.sulross.edu/catalog/undergraduate-academic-regulations-2/#1605412215143-c8b265dc-3e01*
In addition, please note that plagiarism detection software will be used in this class for written assignments.

Research project:

Title: Synthesis and Characterization on New Polyoxomatales (POMs) for their asymmetric and chiral properties.

The goal of this project is to develop chemical insight for the rational design of new polyoxometalate (POM) clusters based on the *Strandberg* polyoxoanion with chiral functionality. Thus, this research aims to elucidate the transfer of asymmetric environments from d^0 transition metal cations or *p*-block element cations into the POM

chiral structure. In addition, this project uses the structural aspect that the chirality of *Strandberg* polyoxoanion is delivered to an extended POM cluster in order to design and synthesize chiral POM clusters. By synthesizing new bulk POM clusters through a composition space diagram similar to a ternary phase diagram under hydrothermal technique, this research will ultimately provide for the rational design of new sub-class of materials based on POMs. By connecting transition metal cations (Mn^{2+}, Cu^{2+}, Fe^{2+}, Sn^{2+}, La^{3+}, Ce^{3+}, Sn^{4+}, or Te^{6+}, etc.) or organic moieties to *Strandberg* polyoxoanion, asymmetric or enantiomorphic properties will appear in new POM clusters. In addition, pure bulk phases and single crystals are essentially required for analyzing new materials by powder XRD or single crystal diffractometer. To achieve this requirement, we will also focus in purifications of bulk synthesis and single crystal growth.