Sul Ross State University
Syllabus for Undergraduate Research:
CHEM 4300_101 (CRN:31356)
(Summer Section I, 2024)

Class: CHEM 4300
Room: WSB 306
Time: 3:00 PM to 5:30 PM

Date: May 29th to July 3rd, 2024

Instructor: Dr. Hong Young Chang
Office: WSB 219
Office Hours: after appointment
Face-to-Face
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Objectives:

Student Learning Objectives (SLO):

A student graduating with a ***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 an 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, compare, and analyze synthesized chemicals from 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. Inorganic Molecular Structures

   (For d^0 transition metal oxides including non-metal group cations)

2. Principle of Powder X-ray diffraction (Bragg's Law, Miller indices, X-ray diffractions)

3. Basic concepts of Crystallography

   (Space group and symmetry including glade plane and screw axis, and other crystallographic symmetry)

4. Structural classification of transition metal oxides

5. Design of new chemical reactions by hydrothermal methods

6. Set up composition space diagrams

7. Basic principle of single crystal growth

8. Measurement of thermal behaviors for transition metal oxides and fluorides

9. Element Analysis for new synthesized compounds

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: John Wiley & Sons, LTD

Several free software will be installed on students' personal computers and they will be used to analyze the metal oxide structures and plot their data.

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

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

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

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

5. **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 in a weekly report style to the professor and their research results will be discussed with the professor in a personal meeting. Sometimes, students have to give their oral presentations in front of group members (group meetings).

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: Rational design on new functional fluoride and oxides with their single crystal growth (supported by Welch Foundation Departmental Grant)

The objective of this research is to develop the chemical and physical insights required for the atomic scale rational design of new complex materials with targeted macroscopic phenomena such as ferroelectricity, magnetism, and nonlinear optics (NLO). As proposed the mixed metal fluorides, i.e., $NaBaMCO_3F$ ($M = Sn^{2+}$, B^{3+}, Bi^{3+}, or I^{5+}), and $AMM'O_xF_y$ ($A=Li^+$, Na^+, or Ba^{2+}, $M = Sn^{2+}$, B^{3+}, Bi^{3+}, or I^{5+}, $M'=Zr^{4+}$, W^{6+}, or Mo^{6+}) will be synthesized through hydrothermal methods or conventional solid-state methods. All of the proposed materials present challenges with respect to pure phase synthesis. The high electronegativity of fluorine in conjunction with the large bond energies observed in many fluorides is among the reasons that fluorine chemistry is substantially different from the other halogens. It is also important to note that fluorides can be very corrosive, often requiring very specialized equipment. In order to address these issues, a hydrothermal

technique in conjunction with composition space diagrams is required. The proposed reactions will take place in the hydrothermal autoclaves including Teflon reaction vessel and the similar reaction scheme of the figure below, which has been used in the synthesis of pure and bulk $BaNiF_4$ material, will be used.