



UNIVERSITY OF
CALGARY

DEPARTMENT OF CHEMISTRY
COURSE SYLLABUS
FALL 2014

COURSE: CHEMISTRY 211, Foundations of Chemistry: Structure and Bonding

| LEC | DAYS | TIME | ROOM | INSTRUCTOR | OFFICE | PHONE | EMAIL |
|-----|------|-------------|---------|--------------------|------------|----------|--|
| L01 | TR | 11:00-12:15 | EEEL161 | Dr. Julie Lefebvre | EEEL 237-B | 220-6908 | jlefebv@ucalgary.ca |

Course website via D2L: [CHEM 211 \(Fall 2014\) - Foundations of Chemistry: Structure and Bonding](#)
Departmental Office: SA 229, 220-5341, chem.undergrad@ucalgary.ca

Textbook references in this syllabus refer to:

"Chemical – Human Activity, Chemical Reactivity", 2nd Edition, by Mahaffy, Bucat, Tasker *et al.*, Nelson, 2014.

Chapter coverage in Chemistry 211:

**Some parts of the assigned chapters may be omitted (to be announced in lecture).*

Chapter 4 (selected sections only) – Carbon Compounds
Chapter 6 (selected sections only) – Chemistry of Water, Chemistry in Water
Chapter 8 – Modelling Atoms and Their Electrons
Chapter 9 (selected sections only) – Molecular Structures, Shapes and Stereochemistry – Our evidence
Chapter 10 – Modelling Bonding in Molecules
Chapters 19, 20 & 21 (selected sections only) – Understanding Structure, Understanding Reactivity

** Additional textbook subsections may be included.*

Material from Chem 20 and Chem 30 that is expected background knowledge:

Chapter 1 – Human Activity, Chemical Reactivity
Chapter 2 – Building Blocks of Materials
Chapter 3 – Models of Structure to Explain Properties
Chapter 5 – Chemical reaction, Chemical Equations

Department Approval:

Approved by Department Head

Date: August 26 2014

Course Aims and Learning Objectives:

Students will learn about the structure and bonding in chemical species and how it influences the physical properties and reactivity of collection of chemical species. This course will also focus on critical thinking, problem solving and laboratory skills (including teamwork and communication skills).

CRITICAL THINKING

| Enduring Understandings <i>What you will understand by the end of the course...</i> | Learning Objectives <i>What you will be able to do by the end of the course...</i> |
|---|--|
| Critical thinking is crucial to an experiential science like chemistry. Critical thinking requires constant re-evaluation of results and hypotheses. | Collect and recognize valid observations and data. Analyze observations and data and link them to the course content. Formulate a hypothesis based on the analysis of your observations and data. Evaluate the validity of your hypothesis. |

STOICHIOMETRY

We are assuming that, in your prerequisite chemistry courses, you developed the following understandings and are able to answer questions that are based on the following learning objectives.

| Enduring Understandings <i>What you will understand by the end of the course...</i> | Learning Objectives <i>What you will be able to do by the end of the course...</i> |
|---|--|
| Chemists describe chemical species using chemical formulae. | Understand the meaning of a chemical formula. Associate the chemical symbol to the name of the elements in the first 5 periods of the periodic table (H to Xe). Determine the chemical formula of a chemical species from its structure. Determine the molar mass of a chemical species. |
| Chemical formulas and equations are used to solve quantitative problems. | Write a balanced chemical reaction (any type, including redox reactions) given the reactant(s) and product(s). Identify the limiting and excess reagents given experimental data. Determine the theoretical and percent yield of a chemical reaction. |
| Empirical measurements are used to quantify a collection of chemical species. | Determine and convert between the following quantities: number of moles, mass, concentration (mol/L, % w/w, % w/v), volume, density. Perform dilution calculations and determine the consequences of using dilute vs concentrated solutions. Convert between magnitudes of measurement units commonly used in the metric system: kilo, deci, milli, micro, nano, pico. |

ATOMS

| Enduring Understandings <i>What you will understand by the end of the course...</i> | Learning Objectives <i>What you will be able to do by the end of the course...</i> |
|--|---|
| <p>The electronic structure of atoms is key to explain how atoms come together to form chemical species.</p> <p>Atomic spectra can be used to elucidate the electronic structure of atoms.</p> | <p>Demonstrate the relationship between frequency, wavelength and energy of light.</p> <p>Describe how the energy of an electron in an atom is quantized.</p> <p>Discriminate between the ground and an excited state for an electron in an atom.</p> <p>Explain how photons can be used to excite or remove electrons from atoms.</p> <p>Explain qualitatively how an atomic spectrum arises.</p> <p>Relate the energy, wavelength or frequency of any photon in an atomic spectrum to the energy-level diagram for this atom.</p> |
| <p>The energy and spatial distribution of electrons in atoms are explained using quantum theory.</p> | <p>Describe the wave character of electrons.</p> <p>Explain how the wave character of an electron is used to generate an orbital.</p> <p>Associate quantum numbers with orbitals.</p> <p>Draw the boundary, electron density and radial probability diagrams for the orbitals in the first three electron-shells of an atom.</p> <p>Draw the energy-level diagram for the first four shells of an atom.</p> <p>Identify a possible set of quantum numbers for any electron in the first four shells of an atom.</p> |
| <p>Every element has a unique arrangement of electrons.</p> | <p>Determine the ground state electron configurations for the first 54 elements using Aufbau, Pauli and Hund's principles.</p> <p>Generate electron configurations in simple terms (<i>spdf</i> notation), using energy or orbital box diagrams, and rationalize when to use one type versus another.</p> <p>Identify and differentiate core and valence electrons.</p> <p>Identify and generate excited states for atoms.</p> <p>Determine the electron configurations for stable ions.</p> <p>Recognize and explain the reason for exceptions to ground state electron configurations.</p> |
| <p>The electron configurations of atoms can be used to explain the physical properties of the elements and their compounds.</p> | <p>Rationalize physical properties using the distance the valence electrons are from the nucleus (n) and the pull of the nucleus on these electrons (Z_{eff}).</p> <p>Explain differences in size, ionization energy, electron affinity and electronegativity for different type of atoms.</p> <p>Explain differences in size and ionization energy for an atom compared to its ions.</p> <p>Order a given series of elements or ions by size, ionization energy and/or electron affinity and justify their ranking.</p> <p>Identify paramagnetic and diamagnetic species.</p> |

CHEMICAL SPECIES

| Enduring Understandings <i>What you will understand by the end of the course...</i> | Learning Objectives <i>What you will be able to do by the end of the course...</i> |
|---|---|
| Bonding involves the rearrangement of valence electrons. | Describe covalent and ionic bonding. Predict and rationalize the type of bonding that occurs between atoms by using electronegativity differences. |
| Lewis diagrams show the connectivity between atoms as a result of the rearrangement of valence electrons. | Generate valid Lewis diagrams for a set of atoms (including formal charge calculations). Analyze Lewis diagrams to determine their validity. Determine the bond orders in a chemical species. Identify bonds of significant polarity in a chemical species. |
| Some chemical species display resonance. | Generate and identify valid resonance structures. Use curly arrows to interconvert resonance structures. Distinguish equivalent from non-equivalent resonance structures. Recognize when a chemical species is said to display resonance. Generate and identify a valid resonance hybrid for a set of resonance structures. Determine formal charges and bond orders in a resonance hybrid. |
| Regions of significant polarity can be used to identify functional groups and name chemical species. | Describe what a functional group is. Identify the following functional groups: alkane, alkene, alkyne, alcohol, ether, ketone, aldehyde, carboxylic acid, ester, amine, amide, acid halide. Generate a name for organic compounds that possess a single functional group. Generate a structure for a named organic compound. |
| Valence Shell Electron Pair Repulsion (VSEPR) structures show the spatial arrangement of atoms within chemical species. | Draw VSEPR diagrams from valid Lewis diagrams and vice versa. Draw line drawings from valid VSEPR diagrams and vice versa. Assign electronic geometry and molecular shapes to atoms bonded to two, three, four, five or six other atoms. Assign approximate bond angles. Recognize variations in VSEPR diagrams for the same geometries or shapes. Explain why, if present, a resonance hybrid should be used to identify and draw valid VSEPR diagrams. |
| The same number and type of atoms can connect and orient themselves in space in several different ways, which results in isomerism. | Recognize constitutional, conformational, geometric and optical isomerism. Generate constitutional, conformational, geometric and optical isomers for a given set of atoms. Identify chiral centers. |
| Valence Bond (VB) and Molecular Orbital (MO) theories are used to explain the spatial arrangement of bonding. | Contrast VB and MO Theories. Draw the energy diagrams for unhybridized and hybridized atoms. Draw the sigma and pi overlaps for a chemical species. |

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|---|--|
| | <p>Name hybridized orbitals and orbital overlaps according to VBT.</p> <p>Draw and name the molecular orbitals for bonding and antibonding interactions in MOT.</p> <p>Draw complete energy diagrams for homonuclear diatomic molecules.</p> |
| <p>The spatial arrangement of atoms determines the charge distribution of a chemical species.</p> | <p>Distinguish between bond polarities, regions of polarity and molecular polarity.</p> <p>Determine the overall molecular polarity of a chemical species.</p> <p>Identify polar and non-polar molecules.</p> |

COLLECTION OF CHEMICAL SPECIES

| <p>Enduring Understandings <i>What you will understand by the end of the course...</i></p> | <p>Learning Objectives <i>What you will be able to do by the end of the course...</i></p> |
|--|--|
| <p>Chemical substances are collections of chemical species that interact with each other.</p> | <p>Explain the nature of the forces between chemical species.</p> <p>Identify and differentiate the types of forces existing between chemical species.</p> <p>Explain how the strength of intermolecular interactions differs in a solid, liquid and gas.</p> <p>Identify the intermolecular forces present within a collection of chemical species (pure samples and mixtures).</p> |
| <p>The physical properties and chemical reactivity of substances depend on the intermolecular interactions between chemical species.</p> | <p>Differentiate between a physical and a chemical change.</p> <p>Use intermolecular interactions to explain or predict relative boiling points, viscosities, surface tensions, wetting and diffusion rates for two different pure substances.</p> <p>Use intermolecular interactions to explain or predict solubility or mixing.</p> <p>Use intermolecular interactions to rationalize why molecules react at the site of functional groups.</p> <p>Use curly arrows and Lewis diagrams to explain bond breaking and bond making.</p> |

Responsibilities and Expectations:

What you can expect from your instructor

- Your instructor will try to help you as much as possible. Do not be afraid to contact your instructor. Their contact information is available on the course website.
- You will have several opportunities for formal feedback on your progress throughout the term (there are three graded in-class activities, one midterm, one final exam, five prelab assignments, five reports and five CTDs write-ups). Each activity should help inform you of your strengths and weaknesses but also help inform future course offerings.
- We recognize that unforeseeable events happen. If this results in you having problems meeting any of your assignment submission dates, accommodations are possible. Procedures for making these accommodations are found in the appropriate sections of the D2L website.

What is expected from you

- Be respectful of everyone.
- Come prepared for and be willing to participate in all class activities.
- Be as organized as possible so that assignments are submitted on time.
- Continually assess your performance and if you are struggling please ask or email either your instructor or TA's as soon as possible. In emails, please include your name and make sure to use full sentences so that responses can be effective. Please anticipate that replies may take up to or more than 24 hours. If it is an urgent question, go directly to your instructor's office.
- In lecture, you need to make sure you understand how something is being communicated but in order to truly understand a concept YOU MUST PRACTICE and this is why suggested problems from the textbook, class homework or past examinations will be provided.

Format and Procedures:

All classes are cumulative so what will be learned at the start of the course will be continually applied throughout the term.

In-class demonstrations will highlight the experiential nature of the discipline and allow for group discussion while participation to laboratory activities allow for hands-on experience.

The use of TopHat Monocle for in-class polling is designed to help inform you about your strengths and weaknesses in knowledge or its application and inform your instructor how to pace coverage of course material.

In-class activities, CTDs and experiments as a whole will help you to prepare for midterm and final examinations. Examinations are a combination of multiple choice, short answer and written answer questions. Examinations are given to assess your strengths and weaknesses regarding the knowledge and application of structure/bonding concepts.

Course Calendar: All lab activities will take place in **EEEL 249**. To know exact days and time, you will need to refer to your own schedule in PeopleSoft.

SEPTEMBER 2014

| SUN | MON | TUES | WED | THUR | FRI | SAT |
|-----|----------------------------------|-----------------------------------|-----|------|------------------------|-----|
| 7 | Lectures Begin 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | CTD 1 15 | 16 | 17 | 18 | 19 Last day to drop | 20 |
| 21 | Last day to add/swap Lab 1 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | CTD 2 29 | 30 Graded in-class activity | | | | |

OCTOBER 2014

| SUN | MON | TUES | WED | THUR | FRI | SAT |
|-----|---------------------|-----------|-----|---------------|-----|-----|
| | | | 1 | 2 | 3 | 4 |
| 5 | Lab 2 6 | 7 | 8 | 9 | 10 | 11 |
| 12 | Thanksgiving Day 13 | CTD 3* 14 | 15 | 16 | 17 | 18 |
| 19 | Lab 3 20 | 21 | 22 | 23 Midterm | 24 | 25 |
| 26 | CTD 4 27 | 28 | 29 | 30 | 31 | |

NOVEMBER 2014

| SUN | MON | TUES | WED | THUR | FRI | SAT |
|-----|----------------|-----------------|-----|-----------------------------------|-----|-----|
| | | | | | | 1 |
| 2 | Lab 4 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | Reading Day 10 | Remember Day 11 | 12 | 13 Graded in-class activity | 14 | 15 |
| 16 | CTD 5 17 | 18 | 19 | 20 | 21 | 22 |
| 23 | Lab 5 24 | 25 | 26 | 27 Graded in-class activity | 28 | 29 |
| 30 | | | | | | |

DECEMBER 2014

| SUN | MON | TUES | WED | THUR | FRI | SAT |
|-----|------------|------|-----|------|----------------|-----|
| | Checkout 1 | 2 | 3 | 4 | Lectures End 5 | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 | 16 | 17 | 18 | 19 | 20 |