UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
DEPARTMENT OF CHEMISTRY
COURSE SYLLABUS
SPRING 2017

1. COURSE: CHEMISTRY 201, General Chemistry: Structure & Bonding

LEC	DAYS	TIME	ROOM	INSTRUCTOR	OFFICE	EMAIL
L01	MWF	12:00-1:50pm	EEEL 161	Dr. V. Iosub	SA 144C	viosub@ucalgary.ca

Course and Laboratory coordinator: Dr. V. Iosub

Tutorials start on **Monday, May 15th, 2017**.

Laboratories start on **Wednesday, May 24th, 2017**.

Course website d2l.ucalgary.ca: **CHEM 201 L01 - (Spring 2017) - General Chemistry: Structure and Bonding**

Chemistry Departmental Office: SA 229, 403-220-5341, chem.undergrad@ucalgary.ca.

2. Course Description: An introduction to university chemistry from theoretical and practical perspectives, that focuses on an exploration of the fundamental links between electronic structure, chemical bonding, molecular structure and the interactions of molecules using inorganic and organic examples.

3. Textbook references in this syllabus refer to:

J.C. Kotz, P.M. Treichel, J.R. Townsend, D.A. Treichel, Chemistry and Chemical Reactivity, 9th Edition. Brooks/Cole CENGAGE Learning.

4. Topics Covered and Suggested Readings:

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

Stoichiometry
Chapters 1-4.

Atoms
Chapter 6-1 & 6-2.

Chapter coverage in Chemistry 201:

Atoms
Chapter 6 – The Structure of Atoms (6-1 & 6-2 Review, 6-3 to 6-7) – majority, as covered in lecture.
Chapter 7 – The Structure of Atoms and Periodic Trends – all sections

Chemical Species
Chapter 8 – Bonding and Molecular Structure – all sections
Chapter 9 – Bonding and Molecular Structure: Orbital Hybridization and Molecular Orbitals – selected sections

Collections of Chemical Species

Chapter 11 – Intermolecular Forces and Liquids – all of: 11.1 through 11.5
11.6 selected topics only.

Applying Structure and Bonding Concepts - Organic Chemistry

Chapter 23 – Carbon: Not Just Another Element – parts of: 23.1-23.4

5. Laboratory Experiments (3 hours per experiment)

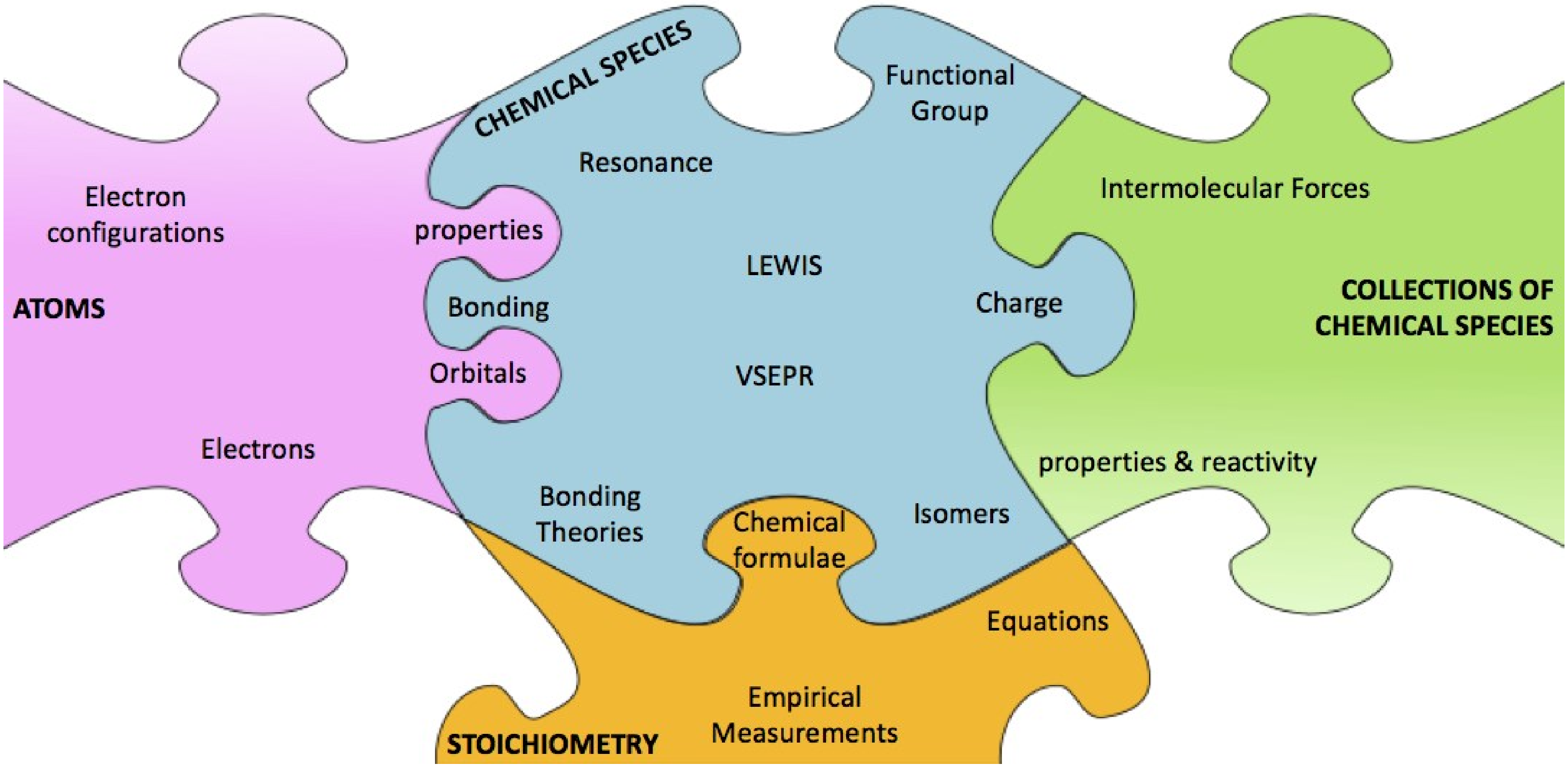
1. Determination of percent by mass of $NaHCO_3$ in Alka-Seltzer® tablets
   - **Stoichiometry & Previous background knowledge review**
2. Determination of Vitamin C content in lemonade
   - **Titration**
3. Determination of total acid concentration in lemonade
   - **Lewis & Resonance**
4. Synthesis of Cholesterol Nonanoate and Preparation of a Liquid Crystal Display (LCD)
   - **VSEPR & Line Drawings**
5. Structure and Physical Properties of Compounds
   - **Intermolecular Forces**

6. Tutorial Activities (1.5 hours per tutorial)

1. **Atomic Properties**
2. **Lewis Structures**
3. **VSEPR Diagrams**
4. **Isomers**
5. **Valence Bond Theory/Hybridization**

Department Approval: Approved by Department Head Date: May 10, 2017

Rationale for the course: Chemical reactivity is important across a broad set of disciplines. Evaluating chemical reactivity requires a sound understanding of chemical structure and bonding. In Chemistry 201 you will gain understandings relating to foundational concepts in structure and bonding (Atoms, Chemical Species and Collections of Chemical Species). The course map shown below is a basic skeleton and will become more detailed as the semester progresses. Through the learning objectives for each understanding you will gain problem solving (critical thinking) and laboratory skills (teamwork and communication skills) that enable you to discuss the structure and bonding of chemical substances within YOUR discipline................how cool is that!



Pre-requisite review material:

The stoichiometry learning objectives below are a **review** of CHEM 20/30 & will **not** be addressed in lecture. These objectives will be applied regularly within the laboratory component of the course. There is a review quiz of this material posted on D2L under *Prerequisite Chemistry Review*, along with links & references to relevant textbook sections to help you make sure you are up to speed with the review material.

STOICHIOMETRY*** • Perform basic chemical laboratory techniques to further examine stoichiometry along with physical properties & chemical reactivity of species.

Enduring Understandings **You are expected to understand…**	**Learning Objectives ***** **You are expected to be able to…**
Chemists describe chemical species using chemical formulae.	-Determine the chemical formula of a chemical species from its Lewis structure. -Associate the chemical symbol to the name of the elements in the first 5 periods of the periodic table (H to Xe). -Determine the molar mass of a chemical species.
Chemical formulas and equations are used to solve quantitative problems.	-Balance a chemical reaction given the reactant(s) and product(s) (for example: acid/base or redox reactions). -Identify the limiting and excess reagents given experimental data. -Determine the theoretical and percent yield of a chemical reaction.
Empirical measurements determine the type of calculations used to solve quantitative problems.	-Calculate and convert between the following quantities: number of moles, mass, concentration (mol/L, % w/w), volume, density. -Convert between magnitude of measurement units commonly used in the metric system: kilo, deci, milli, micro, nano and pico. -Perform dilution calculations and determine the consequences of using dilute vs. concentrated solutions.

Course aims and objectives:

<u>Journey through CHEM 201</u>:

Use your course map of the puzzle pieces on the previous page as a guide or road map when looking at the course learning objectives on the next three pages. It is important that you make reference to these puzzle pieces throughout the course so that you build links between different course concepts and see how they relate or depend on one another.

Course aims and objectives:

ATOMS • Describe how electrons are arranged in atoms using atomic spectra and quantum theory and how this arrangement can be used to help explain the physical properties of the elements and their compounds.

What you will understand by the end of the course…	**What you will be able to do by the end of the course…**
ELECTRONS Atomic Spectra can be used to elucidate the electronic structure of atoms. The electronic structure of atoms is key to how they come together to form chemical species.	-Demonstrate the relationship between frequency, wavelength and energy of light. -Explain qualitatively how an atomic spectrum is obtained experimentally. -Describe how the energy of an e- is quantized. -Discriminate between the ground and an excited state for an electron in an atom. -Explain how energy can be used to excite or remove e-s from atoms. -Relate the energy, wavelength or frequency of any photon in an atomic spectrum to the difference between ground and excited states.
ELECTRON CONFIGURATIONS Every element has a unique arrangement of electrons.	-Draw the energy levels for the first four shells of an atom. -Identify a possible set of quantum numbers for any orbital or e-. -Determine the ground state e- configurations for the first 36 elements using Aufbau, Pauli and Hund's principles. -Generate e- configurations in *spdf* notation, using energy diagrams or orbital box diagrams, and rationalize when to use one type versus another. -Identify and differentiate between core e-s, valence e-s and isoelectronic species. -Identify and differentiate between ground and excited states for atoms. -Determine the e- configurations for stable ions of the elements. -Recognize and explain the reason for exceptions to ground state configurations.
ATOMIC PROPERTIES The electron configurations of atoms can be used to help explain the physical properties of the elements and their compounds.	-Identify paramagnetic and diamagnetic species. -Rationalize physical properties using the distance the valence e-s are from the nucleus (n) and the pull of the nucleus on these e-s (Z*). -Explain changes in size, ionization energy and electron affinity for an atom and its ions. -Order a given series of elements or ions by size, ionization energy and/or electron affinity then justify the answer. -Recognize the relationship between electron affinity and electron attachment enthalpy.
ORBITALS The energy and spatial distribution of electrons in atoms is explained using Quantum Theory.	-Describe the wave character of e-s. -Explain how the wave character of an e- can be used to generate an orbital or the area in space within which an electron may be found. -Define the concept of a node & identify node(s) within an orbital diagram.

Course aims and objectives:

CHEMICAL SPECIES • Generate Lewis and VSEPR diagrams and use bonding theories to describe and evaluate the connectivity between atoms and spatial arrangement of bonding in a chemical species.

What you will understand by the end of the course…	**What you will be able to do by the end of the course…**
BONDING Bonding involves the rearrangement of valence electrons.	-Define electronegativity. -Predict and rationalize the type of bonding that occurs between atoms by using electronegativity differences. -Describe covalent and ionic bonding.
LEWIS Lewis diagrams show the connectivity between atoms as a result of the rearrangement of valence electrons.	-Generate valid Lewis diagrams that show all non-zero formal charges. -Generate valid Lewis diagrams for a chemical formula or condensed formula and vice versa. -Analyze Lewis diagrams to determine their validity. -Recognize when the octet rule can be violated. -Determine bond orders within a chemical species. -Identify bonds of significant polarity in a chemical species.
RESONANCE Some chemical species may display resonance.	-Generate and identify valid resonance structures. -Distinguish equivalent from non-equivalent resonance structures. -Recognize when a chemical species is said to display resonance. -Use curly arrows to interconvert resonance structures. -Generate and identify a valid resonance hybrid, which includes formal charges and bond orders, for a set of for a set of resonance structures.
FUNCTIONAL GROUPS Regions of significant polarity can be used to identify functional groups and is important in naming a chemical species.	-Identify the following functional groups: alkanes, alkenes, alkynes, alcohols, ethers, aldehyde, ketone, carboxylic acids, esters, amines, amides and acid chlorides. -Generate a name given the structure for an organic compound that possesses a single functional group and vice versa.
VSEPR Valence Shell Electron Pair Repulsion (VSEPR) structures show the spatial arrangement of atoms within chemical species.	-Build VSEPR diagrams from valid Lewis diagrams and vice versa. -Build Line drawings from valid VSEPR diagrams and vice versa. -Assign electron-pair geometry and molecular shapes to atoms bonded to two, three, four, five or six other atoms. -Assign approximate bond angles. -Recognize variations in orientation of VSEPR diagrams for the same geometries/shapes. -For species that display resonance describe why resonance hybrids are used to identify and draw valid VSEPR diagrams.
CHARGE The spatial arrangement of atoms determines the charge distribution of a chemical species.	-Distinguish between bond polarities, and molecular polarity. -Determine the overall molecular polarity of a chemical species. -Identify polar and non-polar molecules.
ISOMERS The same number and type of atoms can connect and orient themselves in space in several different ways. This results in isomerism, which is important in naming a chemical species.	-Recognize constitutional, conformational, geometric and optical isomerism. -Generate constitutional, conformational, geometric and optical isomers for a given set of atoms. -Identify chiral centers. -Generate a name given the structure of either a constitutional or geometric isomer and vice versa.

Course aims and objectives:

BONDING THEORIES Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT) are used to explain the spatial arrangement of bonds.	-Contrast VBT and MOT. -Draw the energy diagrams for unhybridized and hybridized atoms. -Draw and show orientation of the sigma and pi overlaps for a chemical species. -Name hybridized orbitals and orbital overlaps according to VBT. -Draw energy diagrams for atomic orbitals and show how they combine to give molecular orbitals. -Build, draw and name the molecular orbitals for bonding and antibonding interactions in MOT.

COLLECTIONS OF CHEMICAL SPECIES • Identify the charge distribution in a chemical species & use it to illustrate how collections of chemical species will interact with each other & how both physical properties and chemical reactivity of substances depend on these interactions.

What you will understand by the end of the course…	**What you will be able to do by the end of the course…**
INTERMOLECULAR FORCES Chemical Substances are collections of chemical species that interact with each other.	-Explain the nature of the forces between chemical species. -Identify and differentiate the types of forces exist between chemical species (pure samples and mixtures). -Explain how the strength of intermolecular interactions differ for a solid, liquid and gas.
PROPERTIES & REACTIVITY The physical properties and chemical reactivity of substances depend on the interactions between chemical species.	-Understand the difference between a physical and chemical change. -Use intermolecular interactions to explain or predict relative boiling points, viscosities, surface tension, wetting and diffusion rates for two different pure substances. -Use interactions between chemical species to explain or predict solubility or miscibility. -Use intermolecular interactions to rationalize why molecules react at the site of functional groups. -Use structures and curved arrows to explain bond breaking and bond making.

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 in laboratory experiments allows for hands-on experience.

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

In-class activities, tutorials and experiments as a whole will help you to prepare for Term Tests 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.

Responsibilities and Expectations:

<u>What you can expect from the course and your instructors:</u>

- All instructors will try to help you as much as possible. Do not be afraid to contact them. 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 two term tests, one final exam, five Pre-lab assignments, five reports and five tutorial quizzes). 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.

<u>What is expected from you:</u>

- 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 use your @ucalgary.ca email address, include your name, CHEM 201 and make sure to use full sentences so that responses can be effective. Please anticipate that replies may take up to 24 hours between Monday and Friday.

- 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.

Selected exercises from the textbook – *use these exercises as a launching point when learning how to solve problems involving…*

Review Material:

Stoichiometry

Chapter 1: 1, 11 & 23
Chapter 2: 33, 61, 63, 69, 73, 75 & 85
Chapter 3: 1(b), 3 & 5
Chapter 4: 1, 6, 11, 13, 21, 41, 49, 61

Atoms

Chapter 6: 7, 9 & 57

See also review quizzes posted on D2L to check your understanding.

Course Material:

Atoms

Chapter 6;
Odd Qs: 7, 9, 27, 37, 39, 53, 57, 61, 67, 77.
Even Qs: 8, 30, 68.
Chapter 7:
Odd; 1, 3, 11, 13, 15, 17, 21, 23, 25, 27, 31, 41, 43, 49, 51, 57, 67. Even; 2, 26, 44, 46, 48.

Chemical Species.

Chapter 8:
Odd Qs: 5, 9, 11, 13, 17, 19, 23, 25, 33, 37, 41, 43, 45, 47, 65, 67, 69, 77, 79 and 85 (parts a through c).
Even Qs: 10, 16, 18, 62, 76.
Chapter 9:
Odd; 3, 7, 9, 11, 17, 19, 23, 35, 45, 57, 61, 69.
Even; 2, 18, 22, 54, 68.
Chapter 23
Odd: 3, 5, 7, 11 or 15, 19, 21, 27, 31, 37, 39, 41, 47, 49, 57, 61, 67, 69, 77, 83
Even: 4, 6, 12, 20, 40, 58.

Nomenclature Website - http://www.chem.ucalgary.ca/courses/351/WebContent/ion/orgnom/index.html

Collections of Chemical Species.

Chapter 11

Odd: 3, 5, 7, 17, 25, 27, 29, 43, 45, 51, 55, 61

Even: 8, 10, 18, 26, 56, 62