UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
DEPARTMENT OF CHEMISTRY
COURSE SYLLABUS
FALL 2018

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

LEC	DAYS	TIME	ROOM	INSTRUCTOR	OFFICE	EMAIL
L01	MWF	13:00-13:50	SB 103	Dr. B. Wheatley	SA 156	bmmwheat@ucalgary.ca
L02	MWF	14:00-14:50	SB 103	Dr. B. Wheatley	SA 156	bmmwheat@ucalgary.ca
L03	TR	9:30-10:45	SB 103	Dr. E. Sullivan	SA 144D	ersulliv@ucalgary.ca

Course, Laboratory and Tutorial Coordinator: Dr. Erin Sullivan (SA 144D, ersulliv@ucalgary.ca)
Laboratories start September 18th, 2018, Tutorials start September 25th, 2018.
Course website d2l.ucalgary.ca: CHEM 201 L01-L03 - (Fall 2018) - General Chemistry: Structure and Bonding
Departmental Office: Room SA 229, Tel: (403) 220-5341, e-mail: chem.info@ucalgary.ca

Students must use their U of C account for all course correspondence.

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:

OpenStax: Chemistry: https://cnx.org/contents/havxkyvS@11.1:uXg0kUa-@4/Introduction

4. Topics Covered and Suggested Readings:

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

Stoichiometry
Chapters 1-4.
Major focus on Chapters 3 & 4 before Experiment #1

Chapter coverage in Chemistry 201:

Atoms
Chapter 6 – Electronic Structure & Periodic Properties of Elements – majority, to the depth addressed in lecture.

Chemical Species
Chapter 7 – Chemical Bonding and Molecular Geometry – All sections
Chapter 8 – Advanced Theories of Covalent Bonding – All sections

Collections of Chemical Species
Chapter 10–Liquids & Solids
10.1 Intermolecular Forces
10.2 Properties of Liquids

Applying Structure and Bonding Concepts - Organic Chemistry
Chapter 20 – Organic Chemistry – majority, to the depth addressed in lecture.

5. Laboratory Experiments (5 weeks, 3 hours every other week)

1. Determination of percent by mass of $NaHCO_3$ in Alka-Seltzer® tablets
    - **Stoichiometry & Previous background knowledge review** (Chapters 3 & 4)

2. Investigating the contents of lemonade: determining the amount of Vitamin C & Citric Acid present
    - **Topics: Stoichiometry** (Chapter 4) & **Lewis & Functional Groups** (Chapters 7 & 20)

3. Synthesis of Cholesterol Nonanoate and Preparation of a Liquid Crystal Display (LCD)
    - **Topic: VSEPR & Line Drawings** (Chapters 4, 7, 20 & http://www.chem.ucalgary.ca/courses/351/WebContent/orgnom/index.html)

4. Investigating Isomers: A look at how Maleic Acid can be Isomerized to Fumaric Acid.
    - **Topic: Isomers, Molecular Polarity & VSEPR** (Chapters 4, 7 & 20)

5. Structure and Physical Properties of Compounds
    - **Topic: Intermolecular Forces** (Chapter 10)

6. Tutorial Activities (5 weeks, 1.5 hours every other week)

1. **Atomic Properties** (Chapter 6)

2. **Lewis Structures** (Chapter 7)

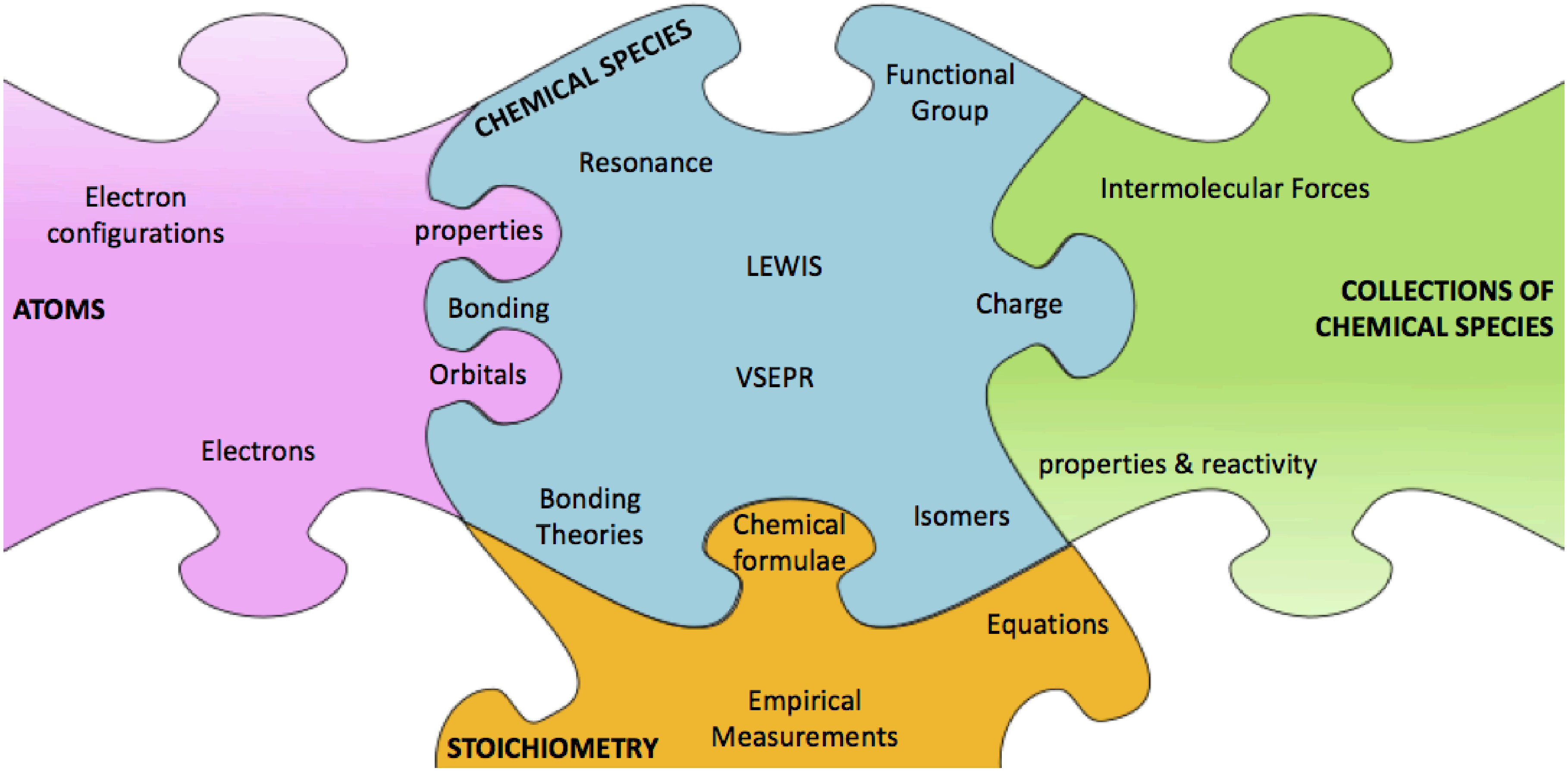
3. **VSEPR Structures** (Chapter 7)

4. **Isomers** (Chapter 2.4, Chapter 20 & http://www.chem.ucalgary.ca/courses/351/Carey5th/Ch07/ch7-1.html)

5. **Valence Bond Theory** (Chapter 8)

Department Approval: Approved by Department Head Date: August 30, 2018

Rationale for the course: Chemical reactivity is important across a broad set of disciplines and requires visualization skills. 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 you will gain problem solving (critical thinking), laboratory skills (teamwork and communication skills) and the importance of being able to communicate using visualization that enable you to discuss the structure and bonding of chemical substances within YOUR discipline................how cool is that!



Pre-requisite review material:

All of 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 to help us explain reactivity. 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 What you will understand by the end of the course…	**Learning Objectives *** What you will be able to do by the end of the course…**	**Textbook References**
Chemists describe chemical species using chemical formulae.	-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 Lewis structure. -Determine the molar mass of a chemical species.	Chapter 2.3 Chapter 2.4 Chapter 3.1
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.	Chapter 4.1 Chapter 4.3 & Chapter 4.4
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.	Chapter 3.3 & Chapter 3.4

Course aims and objectives:

Our Journey through CHEM 201:
Use the puzzle pieces on the previous page, when looking at the contents of the next three pages, to build links that show how different course concepts relate or depend on one another.

VISUALIZATION • Develop visual skills necessary to fully understand and communicate about the lecture, tutorial and laboratory content of CHEM 201.

What you will understand by the end of the course…	**What you will be able to do by the end of the course…**
Visualization is crucial to understanding the structure and bonding of chemical species Drawings, molecular & conceptual models and observations are tools of visualization Many visualizations have both static and dynamic components	When explaining any chemical concept or you will… -identify and/or generate the necessary 2D and/or 3D drawings -utilize molecular & conceptual models -make appropriate observations -recognize and identify the static and/or dynamic components of drawings and models

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…**	**Textbook References**
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.	Chapter 6.1 – some sections omitted AND Chapter 6.2 – some sections omitted
ELECTRON CONFIGURATIONS Every element has a unique arrangement of electrons.	-Draw the energy levels for the first four shells of an atom. -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 and valence e-s. -Identify the electron configuration for isoelectronic species, excited states and stable ions of the elements. -Recognize and explain the reason for exceptions to ground state configurations.	Chapter 6.3 & Chapter 6.4
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_{eff}). -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.	Chapter 6.5
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. -Identify a possible set of quantum numbers for any orbital or e-. -Draw the boundary, electron density and radial probability diagrams for the orbitals in the first three electron shells of an atom. -Define and identify node(s) within an orbital diagram.	Chapter 6.1 & Chapter 6.3

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…**	**Textbook References**
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.	Chapter 7.1 & Chapter 7.2
LEWIS Lewis diagrams show the connectivity between atoms as a result of the rearrangement of valence electrons.	-Generate valid Lewis diagrams for a chemical formula or condensed formula and vice versa. -Demonstrate how to determine formal charges of each atom in a valid Lewis diagram. -Analyze Lewis diagrams to determine their validity. -Recognize when the octet rule can be violated. -Determine bond orders within a chemical species and relate them to bond strength and length. -Identify bonds of significant polarity in a chemical species.	Chapter 7.3 & Chapter 7.4
RESONANCE Some chemical species may display resonance.	-Generate, identify and rank the stability of valid resonance structures. -Distinguish equivalent from non-equivalent resonance structures. -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 resonance structures.	Chapter 7.4, CHEM 351 textbook: curly arrows resonance resource
FUNCTIONAL GROUPS Regions of significant polarity can be used to identify functional groups and is important in naming a chemical species.	-For a chemical species, identify its functional group(s) (alkanes, alkenes, alkynes, alcohols, ethers, aldehyde, and ketone) and/or determine its IUPAC name based on structure or vice versa.	Chapter 20.1, 20.2, 20.3, 20.4 & CHEM 351 Textbook: Naming
VSEPR Valence Shell Electron Pair Repulsion (VSEPR) structures show the spatial arrangement of atoms within chemical species.	-Build VSEPR diagrams from valid Lewis diagrams or resonance hybrids 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.	Chapter 7.6
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.	Chapter 7.6
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 and generate constitutional, conformational, geometric and optical isomerism for a given set of atoms. -Identify chiral centers. -recognize that stereoisomerism needs to be identified in the name of the structure.	CHEM 351 textbook: Isomers Chem compound resource
BONDING THEORIES ***Collections of Chemical Species (Chapter 10) will be discussed before covering the learning outcomes related to advanced bonding theories (Chapter 8).*** 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. -Illustrate how atomic orbitals combine to give molecular orbitals. -Name the molecular orbitals for bonding and antibonding interactions in MOT.	Chapter 8.1

Course aims and objectives:

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…**	**Textbook References**
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 within pure samples and mixtures. -Explain how the strength of intermolecular interactions differ for a solid, liquid and gas.	Chapter 10.1
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, liquid/solid surface interactions, diffusion rates, and miscibility/solubility for two different pure substances. -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.	Chapter 10.1 Chapter 10.2 CHEM 351 textbook: curly arrows

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.

Tutorials are opportunities to work in groups and learn how to take good notes.

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:

What you can expect from the course and your instructors:

- 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.

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 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.

Course Calendar CHEM 201 – FALL 2018: For exact dates, rooms & time refer to your student centre schedule. *Assignment of Lecture content is tentative & depends on the progress of the class.

SEPTEMBER 2018

SUN	MON	TUES	WED	THUR	FRI	SAT
						1
2	3 Labour Day	4	5	6 First day of Classes Intro Classes	7 Intro Classes	8
9	10 Week #1 ATOMS	11	12	13 Last day to drop	14 Last day to add	15
16	17 Week #2 ATOMS	18 **Lab 1** STOICHIOMETRY	19	20	21	22
23	24 Week #3 ATOMS	25 **Tut 1** ATOMS	26	27	28	29
30						

OCTOBER 2018

SUN	MON	TUES	WED	THUR	FRI	SAT
	1 Term Test #1 Week #4 CHEMICAL SPECIES	2 **Lab 2** STOICHIOMETRY & CHEMICAL SPECIES	3	4	5	6
7	8 Thanksgiving	9 **Tut 2** Week #5 CHEMICAL SPECIES	10	11	12	13
14	15 Week #6 CHEMICAL SPECIES	16 **Lab 3** CHEMICAL SPECIES	17	18	19	20
21	22 Week #7 CHEMICAL SPECIES	23 **Tut 3** CHEMICAL SPECIES	24	25	26	27
28	29 Week #8 CHEMICAL SPECIES	30 **Lab 4** CHEMICAL SPECIES	31			

NOVEMBER 2018

SUN	MON	TUES	WED	THUR	FRI	SAT
				1	2	3
4	5 Term Test #2 Week #9 COLLECTIONS OF CHEMICAL SPECIES	6 **Tut 4** CHEMICAL SPECIES	7	8	9	10
11 Remembrance Day	12 Reading Days	13 Reading Days	14 Reading Days	15 Reading Days	16 Reading Days	17
18	19 Week #10 CHEMICAL SPECIES	20 **Lab 5** COLLECTIONS OF CHEMICAL SPECIES	21	22	23	24
25	26 Week #11 CHEMICAL SPECIES	27 **Tut 5** CHEMICAL SPECIES	28	29	30	

DECEMBER 2018

SUN	MON	TUES	WED	THUR	FRI	SAT
						1
2	3 Week #12 CHEMICAL SPECIES	4	5	6	7 Last day of classes	8
9	10 **FINAL EXAM**	11 **T.B.A. in Nov.**	12 **FINAL EXAMS**	13 **RUN UNTIL**	14 **Dec 20th, 2018**	15