UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
DEPARTMENT OF CHEMISTRY
COURSE SYLLABUS
FALL 2019

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

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

Course and Tutorial Coordinator: Dr. Erin Sullivan (SA 144D, ersulliv@ucalgary.ca)
Laboratory Coordinator: Dr. Roxanne Jackson (SA 156, rjjackso@ucalgary.ca)
Laboratories start September 17th, 2019, Tutorials start September 24th, 2019.
Course website: CHEM 201 - ALL - (Fall 2019) - 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
(The textbook has been updated to align with our course, the links to this are below in the learning objectives and can be **accessed through D2L**).

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: Stoichiometry, VSEPR, Line Drawings & Nomenclature** (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. **Lewis Structures** (Chapter 7)

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

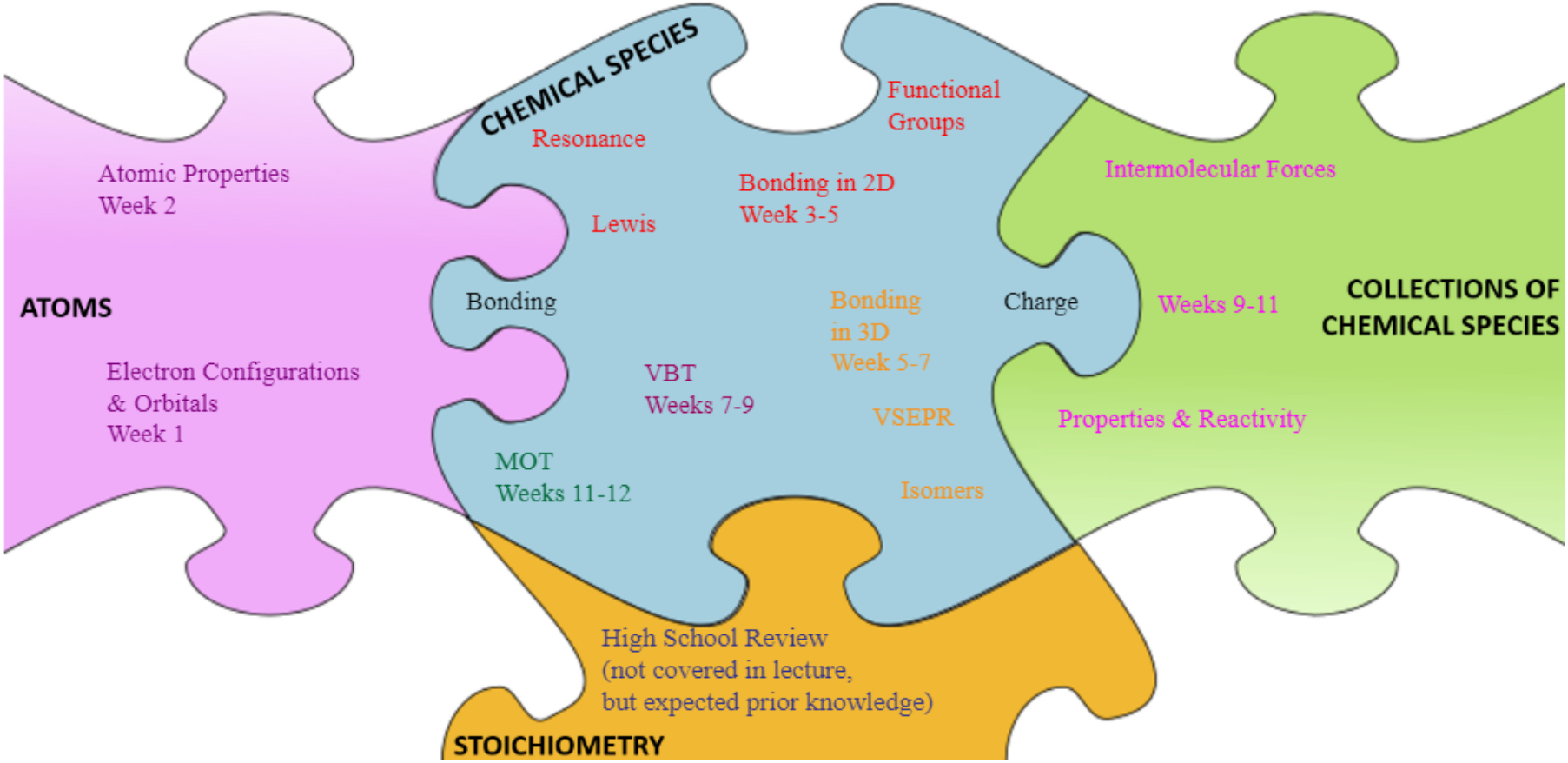
3. **Isomers** (Chapter 2.4, Chapter 20 & http://www.chem.ucalgary.ca/courses/351/Carey5th/Ch07/ch7-1.html)

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

5. **Molecular Orbital Theory** (Chapter 8)

Department Approval Electronically Approved Date August 29, 2019

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!



*Dates can fluctuate slightly, depending on lecture pacing; this puzzle will be updated in D2L as the semester progresses.

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 should know…	**Learning Objectives *** What you will be able to do by the end of the course…**	**Textbook References**	**Recommended Practice Questions ****
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	11, 13 & 15. 27, 29, 33, 35 5, 13, 15, 17, 19, 21, 29, 31 See: Test your understanding on Chemical Formulae D2L quiz
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 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 & 4.4 & 4.5	1, 3, 8, 11 See: Test understanding on balancing equations D2L quiz 47, 49, 51, 57, 61, 65, 67, 69, 71, 73, 75, 79, 81, 87, 89, 91 & 92. See: Test your understanding on limiting reagent, theoretical yield & percent yield D2L quiz
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	45-63, 67, 71 See: Test your understanding of converting between units & diluting D2L quiz

****For recommended practice questions all odd numbered questions have answers in the book. Any even number question will be addressing the same learning objective(s) as the odd numbered questions nearby, so if you understand the odd numbered question, you should be able to extrapolate what the answer should be for the even numbered question next to it. If for any reason, there is confusion, please do not hesitate to see your instructor or TA during office hours.****

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

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	Recommended Practice Questions
ELECTRONS 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 20 elements using Aufbau, Pauli and Hund's principles. -Identify ground and excited states. -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.	Chapter 6.4	**6.4:** 47, 48(a,b), 49(a,b), 51, 53(a,b), 54(a-d), 58-61, 65
An electron's wave character defines an orbital	-Explain how the wave character of an e- generates an orbital or a visual of the area in space within which an electron may be found. -Draw the boundary diagrams for the orbitals in the first three electron shells of an atom. -Define and identify node(s) within p and d orbital diagrams.	Chapter 6.3	**6.3:** 31, 39, 41(a,b&d) & 42-43
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	**6.5:** 67-86 See: Atomic Properties Test your understanding quiz in D2L

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**	**Recommended practice questions**
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 and whether something is a metal or a non-metal. -Describe covalent and ionic bonding.	Chapter 7.1 & Chapter 7.2	**7.1:** 1, 3,5, 7, 9 **7.2:** 11,13,15, & 17
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 Chapter 7.5 Chapter 7.2	**7.3:** 23-43 (odd numbered Qs) **7.4:** 51-54, & 56- 59 **7.5:** 64 & 73 **7.2:** 19-22
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	**7.4:** 44-49, 55, & 62
FUNCTIONAL GROUPS Regions of significant polarity can be used to identify functional groups & 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	**20.1:** 1, 5, 7, 9, 11, 13, 17 & 19 **20.2:** 31, 33 & 35 **20.3:** 43 **20.4:** 59
REACTION MECHAMISMS Bonds of significant polarity may react with each other to form different products.	-Identify bonds of significant polarity in a chemical species. -Use structures and curved arrows to explain bond breaking and bond making.	Curly arrows Partial charges & arrows	
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 & 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	**7.6:** 85-95, 105-110 & 113-116
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	**7.6:** 97-103 & 113
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 Chapter 20.1, 20.2, 20.3, 20.4 Chem compound resource	**20.1**: 15 **20.3**: 47
VALENCE BOND THEORY ***Jump to Chapter 10 next.***	-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.	Chapter 8.1 Chapter 8.2 Chapter 8.3	**8.1**: 1, 3-8 **8.2**: 9, 13-22 **8.3**: 23-27(no e) & 29-31 **20.4**: 55, 57, 61 & 63

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	Recommended Practice Questions
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	**10.1:** 1, 3, 5, 7 & 21
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.	Chapter 10.1 Chapter 10.2	**10.1:** 9-19 **10.2:** 23-25

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	Recommended practice questions
MOLECULAR ORBITAL THEORY Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT) are used to explain the spatial arrangement of bonds.	-Illustrate how atomic orbitals combine to give molecular orbitals. -Name the molecular orbitals for bonding and antibonding interactions in MOT. -Contrast VBT and MOT.	Chapter 8.4	**8.4**: 32-33(no b) & 34-39 & 41-50

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 1-2 business days.
- 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 2019: 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 2019

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

OCTOBER 2019

SUN	MON	TUES	WED	THUR	FRI	SAT
29	30 **Term Test #1** **Week #4** **Bonding in 2D**	1 **Lab 2** STOICHIOMETRY & CHEMICAL SPECIES	2	3	4	5
6	7 **Week #5** **Bonding in 2D**	8 **Tut 2** VSEPR	9	10	11	12
13	14 Thanksgiving **No classes**	15 **Lab 3** CHEMICAL SPECIES **Week #6** **Bonding in 3D**	16	17	18	19
20	21 **Week #7** **Bonding in 3D**	22 **Tut 3** CHEMICAL SPECIES	23	24	25 **Term Test #2**	26
27	28 **Week #8** **VBT**	29 **Lab 4** CHEMICAL SPECIES	30	31	1	2

NOVEMBER 2019

SUN	MON	TUES	WED	THUR	FRI	SAT
3	4 **Week #9** **VBT & COLLECTIONS OF CHEMICAL SPECIES**	5 **Tut 4** CHEMICAL SPECIES	6	7	8	9
10	11 Remembrance Day	12 Reading Days No Classes	13 Reading Days This	14 Reading Days Week!	15 Reading Days	16
17	18 **Week #10** **VBT & COLLECTIONS OF CHEMICAL SPECIES**	19 **Lab 5** COLLECTIONS OF CHEMICAL SPECIES	20	21	22	23
24	25 **Week #11** **MOT**	26 **Tut 5** CHEMICAL SPECIES	27	28	29	30

DECEMBER 2019

SUN	MON	TUES	WED	THUR	FRI	SAT
1	2 **Week #12** **MOT & Review (if time)**	3	4	5	6 Last day of classes	7
8	9 **FINAL EXAM**	10 **T.B.A. in Nov.**	11 **FINAL EXAMS**	12 **RUN UNTIL**	13 **Dec 19th, 2019**	14