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

1. **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 237C	220-7602	jlefebv@ucalgary.ca

Course website via D2L: CHEM 211 L01 - (Fall 2018) - Foundations of Chemistry: Structure and Bonding
Departmental Office: SA 229, 220-5341, chem.undergrad@ucalgary.ca
To avoid IT problems, it is recommended that the students use their U of C account for all course correspondence.

2. **Course Description:** Same core topics as Chemistry 201 but taught with a greater emphasis on critical thinking, scientific observation and problem solving and the application of chemistry to topics such as drug design and environmental issues.

3. **Recommended/ Required Textbook(s):** ***"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

4. **Learning Outcomes:** 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).

Department Approval: Approved by Department Head Date:

Course Aims and Learning Objectives:

CRITICAL THINKING

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…***
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. These understandings and objectives will be constantly applied in both the lecture and laboratory settings.

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

CHEMICAL 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…***
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 charges when present). 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, which is important when naming a 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 resulting in isomerism, which is considered when 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**.

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

COLLECTION OF CHEMICAL 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…***
Chemical substances are collections of chemical species that interact which each other.	Explain the nature of the forces between chemical species. Identify and differentiate the types of forces existing between chemical species. Explain how the strength of **intermolecular interactions** differs in a solid, liquid and gas. Identify the intermolecular forces present within a collection of chemical species (pure samples and mixtures).
The physical properties and chemical reactivity of substances depend on the intermolecular interactions between chemical species.	Differentiate between a **physical and a chemical change**. Use intermolecular interactions to explain or predict relative **boiling points, viscosities, surface tensions, wetting and diffusion rates** for two different pure substances. Use intermolecular interactions to explain or predict **solubility** or mixing. Use intermolecular interactions to rationalize why molecules react at the site of functional groups. Use curly arrows and Lewis diagrams to explain bond breaking and bond making.

5. **Topics of Laboratory Activities (2h 50 min/week, 10 weeks)**

5 Critical Thinking Development (CTD) activities alternating with 5 wet experiments

CTD 1 – Clear and detailed observations are a crucial part of lab work

Practicing to collect meaningful and detailed observations on a time-independent system as well as a time-dependent system.

Lab 1 – Revisiting a childhood experiment – a qualitative and quantitative approach to the baking soda and vinegar experiment

Collecting and reporting detailed observations, using a balance and a pipette, collecting a gas sample.

CTD 2 – Correlating observations and theoretical concepts lead to formulation of hypotheses

Investigating the chemical reactivity of sodium and potassium and the formation of their ions and relating the observations and proposed chemical reactions to their electron configurations.

Lab 2 – Magnetic Nanoparticles – Synthesis and Application

Performing a temperature- and pH-controlled synthesis and using magnetic separation, writing a result and a discussion section for a formal report.

CTD 3 – Re-enforcing your ability to correlate observations and theoretical concepts to formulate hypotheses

Learn to propose and refine a chemical reaction based on observations and knowledge of Lewis diagrams, polarity and curly arrows.

Lab 3 – Determination of Vitamin C Content in Redoxon® Tablets

Using volumetric glassware (flasks, burette and pipettes), performing a titration, building data tables and writing a full formal report.

CTD 4 – Using discrepancies between theory and experiment to formulate hypotheses

Investigating the synthesis of nylon and examining the VSEPR structures of the monomers and a dimeric unit.

Lab 4 – Synthesis of Cholesterol Nonanoate and Preparation of a Liquid Crystal Display (LCD)

Preparing and isolating an ester (avoiding hydrolysis), determining melting points, observing liquid crystal behaviour, handling and disposing of toxic chemicals, writing a full lab report.

CTD 5 – Formulating and testing hypotheses about intermolecular interactions

Correlating observations collected during a salting out experiment to the molecular structure of the species involved and possible intermolecular interactions.

Lab 5 – Structure and the Physical Properties of Compounds

Observing solubility, determining boiling points using Thiele method, building molecular models and drawing VSEPR diagrams.

6. 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.

7. 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.

8. **CHEM 211 Course Calendar:** All lab activities (CTD's and Experiments) will take place in **EEEL 249**. To know exact days and time, you will need to refer to your own schedule in PeopleSoft.

SEPTEMBER 2018

SUN	MON	TUES	WED	THUR	FRI	SAT
2	Labour Day 3	4	5	6 Lectures begin	7	8
9	10	11	12	13 Last day to drop	14 Last day to add/swap	15
16	17 **CTD 1 *3%***	18	19	20	21	22
23	24 **Expt 1 *4%***	25	26	27 ***Graded In-class assignment 1 2%***	28	29

OCTOBER 2018

SUN	MON	TUES	WED	THUR	FRI	SAT
30	1 **CTD 2 *3%***	2	3	4	5	6
7	8 Thanksgiving Day	9 **Expt 2 *4%*** Monday's B01 section will be moved, TBA	10	11	12	13
14	15 **CTD 3 *3%***	16	17	18 ***Graded In-class assignment 2 4%***	19	20
21	22 **Expt 3 *4%***	23	24	25	26	27
28	29 **CTD 4 *3%***	30	31			

NOVEMBER 2018

SUN	MON	TUES	WED	THUR	FRI	SAT
				1	2	3
4	5 **Expt 4 *4%***	6	7	8 ***Midterm 18%***	9	10
11 Remembrance Day	12 Reading week	13	14	15	16	17
18	19 **CTD 5 *3%***	20	21	22	23	24
25	26 **Expt 5 *4%***	27	28	29 ***Graded In-class assignment 3 6%***	30	1

DECEMBER 2018

SUN	MON	TUES	WED	THUR	FRI	SAT
2	3 **Lab Checkout**	4	5	6	7 **Lectures End**	8
Final 35% 9	10 **Final exams begin**	11	12	13	14	15
Final 35% 16	17	18	19	20 **Final exams end**	21	22

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