CHEM 1500 – 3 Credits

Chemical Bonding and Organic Chemistry (4,0,3)(L) (Section 3)

Fall 2012

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Description

CHEM 1500 comprises the first half of first year chemistry designed for all students with a background in Chemistry 11, Chemistry 12, CHEM 050, or CHEM 060. This course, in combination with CHEM 1510 or CHEM 1520, will serve as a prerequisite for second year Chemistry courses at TRU and other BC institutions.

Lecture topics include general concepts of the electronic structure of the atom, periodic properties of the elements, chemical bonding, Lewis structures, molecular shapes, Valence bond theory and half a semester of organic chemistry. The organic chemistry portion will include bonding and structure of organic compounds, compound naming, identity of functional groups, conformational and stereochemical aspects of organic compounds, as well as substitution reactions.

The laboratory stresses basic precision techniques in quantitative analytical chemistry as well as experiments in instrumental analysis and organic chemistry. The laboratory also introduces students to some spectroscopic techniques.

Prerequisites

Chemistry 11 or Chemistry 12 or CHEM 050 or CHEM 060, Principles of Math 12 or MATH 060/061

Lectures

Mon, Tue, Wed, Fri 2:30 – 3:20 pm T 200

Laboratory

A three-hour laboratory session per week is required.
You should be registered in **one** of the following lab sections:

In Lab Room S 261			In Lab Room S 269		
L01	Mon	14:30 - 17:20	**L02**	Mon	14:30 - 17:20
L03	Mon	18:30 - 21:20			
L04	Tue	14:30 - 17:20	**L05**	Tue	18:30 - 21:20
L06	Wed	10:30 - 13:20			
L07	Wed	15:30 - 18:20	**L08**	Wed	15:30 - 18:20
L09	Thu	9:30 - 12:20	**L10**	Thu	9:30 - 12:20
L11	Thu	14:30 - 17:20			
L12	Thu	18:30 – 21:20	**L13**	Mon	18:30 - 21:20

First year Chemistry labs begin the second week of classes (Sept. 10 - 14).
You must attend your scheduled lab section to claim your seat.
Any lab problems?; see Dr. Reed in S-342

Required Materials

Text: J.E. Brady and F. Sense, Jr., *Chemistry: Matter and Its Changes*, 5th Edition, Wiley, 2009. Main first year text, available at Bookies

Text: Vollhardt, K. Peter C. and Schore, Neil E., *Organic Chemistry: Structure and Function*, 6th Edition, W. H. Freeman, 2011. **Custom Edition for Thompson Rivers University entitled "Chem 160 Chemical Bonding and Organic Chemistry" (available exclusively at the TRU Bookstore).**

Laboratory Material: TRU CHEM 1500 Laboratory Manual Fall 2012; hard-covered data book; safety goggles; lab coat. **No student will be permitted to perform a lab experiment in any chemistry course without safety goggles and laboratory coat.** These items are available at Bookies.

Calculator:
A non-programmable, single numeric line calculator is required, such as the Casio fx-260 (available at the bookstore) or equivalent. **No electronic or paper dictionaries or translating devices may be used on any closed book Chemistry exam.** Chemistry does not permit textual input calculators to be used on quizzes, mid-terms, final exams, or lab exams. We reserve the right to inspect any student calculator at any time.

Optional Materials:

CHEM 1500 Powerpoint Lecture Notes: are available on myTRU Moodle. To access Moodle, use the Moodle quicklink from the TRU homepage (www.tru.ca). To access the lecture notes, you have to enroll in the Moodle CHEM 1500 course by using enrolment key: **1500-3**

Logging in to myMoodle.tru.ca for the first time? Students use their **student number** as their *username* and their **Birthdate** for their initial *password*. The Birthdate is in the format: **YYMMDD**. If your username/password combination does not work, you need to contact IT Services help desk in the computer lab in Old Main, or call the TRU IT Service Desk toll free at: 1-888-852-8533 or 250-852-6800.

Solutions Manual for J.E. Brady, F. Sense, Jr., B.E. Bursten, *Chemistry: Matter and Its Changes*, 5th Edition, Solutions, 2009.

A set of Molecular Models (*e.g.*, Molecular Visions - The flexible molecular model kit) is available at Bookies and is very useful for the organic chemistry portion of the course, as well as for CHEM 2123 and CHEM 2223 in the second year of a science degree at TRU.

Student Evaluation

This one-semester course is worth 3 credits. A letter grade will be awarded for CHEM 1500 using the Grading System (Policy ED-3-5) from the Policy website at: http://www.tru.ca/policy/allpolicy.html

Grades will be assigned on the following basis:

Term Test 1*	16%	(Fri, Oct 12)
Term Test 2*	16%	(Fri., Nov 16)
Chemistry Project	3%	(out Oct 22, due in class Mon., Nov 5)
Laboratory**	20%	
Final examination*	45%	(Exam period: Dec. 3-15)

***An aggregate total of at least 50% (38.5/77) must be achieved on the sum of the term tests and final exam in order to receive a passing grade.**

****A total of 50% (10/20) must be achieved in the laboratory section to receive a passing grade in CHEM 1500**. Students **must** complete at least 75% of the experiments and at least one laboratory exam to pass the lab. This requirement will **not** change even with a valid excuse. A grade of zero will be given for missed labs and term tests/quizzes when appropriate reasons are not made clear to the instructor by the student for such absence.

Legal Stuff

It is the responsibility of all students to be aware of TRU Student Academic Policies, Regulations and Procedures. These include: Academic Honesty Policy ED-5-0; Appeals

Policy ED-4-0; Attendance ED-3-1; and Exams Policy ED-3-9. Forms of Academic Dishonesty are summarized and described in the TRU Policy website at: http://www.tru.ca/policy/allpolicy.html and include cheating, misconduct, fabrication and plagiarism. **Students must write lab reports independently, even when students work in pairs in a lab experiment.**

The Fall 2011 Final Exam period is Dec 3-15 inclusive. Students must be available to write their exam any time during this time period. There are no exceptions.

Lab Rules

No student will be permitted to perform a laboratory experiment in any chemistry course without safety goggles and laboratory coat. These items are available for purchase at the bookstore.

Open toed shoes and earphones from personal music-playing devices are **not permitted**.
Any safety problems encountered by students must be reported to Stacey Jyrkkanen, Manager, TRU Health and Safety Department; 371-5805 or sjyrkkanen@tru.ca

Take special note of which lab section and room you are in. Throughout the term, the ***different lab sections and different rooms will be doing different experiments*** so make sure you **check the lab manual** to see what's up for you!!!

TRU is a Scent Reduced Environment

Students may be attending TRU and have Multiple Chemical Sensitivities which can lead to Anaphylaxis. Anaphylaxis (anna - fill -axis) is a serious allergic reaction which can be life-threatening.

Although we cannot eliminate all scents and chemicals in a public setting, we are asking for your support and cooperation in reducing or eliminating your use of scented personal care products, such as perfume, cologne, after shave, cosmetics, hair spray/mousse, deodorant, scented soaps, etc.

The "Share the Air" website provides further information as well as suggestions for unscented alternatives for personal care products. Please review the website at http://www.tru.ca/wellness/sharetheair.html

Thank you very much for your attention to this serious issue. We appreciate your support as we all "Share the Air" at TRU!

Please contact the Disability Services Department if you have any questions.

Phone: 250-828-5023 ● Toll Free: 1-888-828-6644 ● Fax: 250-371-5772 ● Email:dso@tru.ca

Course Content

(This outline is provisional and may change as the course progresses)

Molecular Structure and Bonding (28 lectures)

Section 1: Electronic Structure of Atoms
Brady and Senese Text Chapter 7 (6 lectures)
Wave/particle duality of light; quantization of energy; atomic spectra of atoms; Bohr model of the atom; quantum theory and wave mechanics; wave functions; quantum numbers; shapes and sizes of atomic orbitals; electron spin; energy levels in multi-electron atoms; screening and effective nuclear charge; electron configurations of atoms and ions; the Periodic Table

Section 2: Periodic Properties of the Elements
Brady and Senese Text Chapter 7 (3 lectures)
Periodic variation of properties with atomic structure and position in Periodic Table; size of atoms and ions; ionization energy; electron affinity; periodic trends in chemical properties

Section 3: Basic Concepts of Chemical Bonding
Brady and Sense Text Chapter 8 (6 lectures)
Types of bonding; metallic, ionic, covalent and polar covalent; electronegativity; electron dot Lewis structures of organic and inorganic compounds; multiple bonds; expanded octets, formal charges, resonance, bond lengths, bond strengths and enthalpy changes

Section 4: Molecular Geometry and Bonding Theories
Brady and Sense Text Chapter 9 (9 lectures)
Ideas behind VSEPR and molecular shape; polar and non-polar molecules; hybridization; need and relationship to molecular shape; σ and π bonds and multiple bonding; bonding in organic molecules

Section 5: Intermolecular Forces, Liquids and Solids
Brady and Sense Text Chapter 11 (4 lectures)
Intermolecular forces and properties of liquids

Organic Chemistry (14 lectures)

Section 6: Bonding and Structure
Vollhardt and Schore Text Chapters 1, and 2 (5 lectures)
Structure of hydrocarbons; functional groups; structural isomers; nomenclature; physical properties; dipole moments; intermolecular forces in organic molecules; acidity and basicity; pK_a and substituent effect on pK_a; Lewis acids and bases, conjugation, partial p-orbital overlap, resonance stabilization of anions and cations.

Section 7: Conformational Analysis
Vollhardt and Schore Text Chapter 4 (5 lectures)
Conformations of alkanes and cycloalkanes**;** staggered/eclipsed/anti/gauche conformations; torsional energy barriers; ring angle strain; steric strain; cyclohexane and substituted cyclohexanes conformations; axial and equatorial bonds.

Section 8: Stereochemistry
Vollhardt and Schore Text Chapter 5 (2 lectures)
Configurational isomers; cis/trans; E/Z; stereogenic centres and R/S systems; compounds with more than one stereogenic centre; meso compounds; resolution of racemic mixtures; examples of stereochemistry using amino acids, peptides and carbohydrates.

Section 9: Substitution Reactions
Vollhardt and Schore Text Chapters 6 and 7
Mechanisms; stereochemistry and synthetic usefulness of S_N2 and S_N1 reactions; halides and phosphates as leaving groups

Laboratory Experiments: 2, 3, 4, 5, 6, 7, 8

Detailed List of Coarse Goals

From high school studies of chemistry and/or review prior to this course, students should be able to:

- Correctly use SI units, significant figures, and scientific notation.
- Explain the meaning of basic chemical terms (e.g., element, compound, metal, nonmetal, metalloid, homogeneous, heterogeneous, atom, ion, molecule, isotope).
- Distinguish between examples of homogeneous and heterogeneous matter, mixtures, pure substances, compounds, and elements.
- Name and give formulas for simple inorganic compounds, including acids and bases.
- Write balanced chemical equations.
- Carry out calculations involving moles, molecular weights, masses, and numbers of molecules.
- Calculate empirical formulas from mass composition data and vice versa, and relate these to molecular formulas.
- Perform stoichiometric calculations involving chemical reactions.
- Interrelate the units of volume, molarity, and density of a solution.
- Describe types of energy and energy changes.

By the end of this course, students should be able to:

- Describe the observations and experiments that led to the theory of the nuclear atom and the atomic structure.
- Explain Bohr's theory of the hydrogen atom structure and its relationship to the atomic spectrum of hydrogen.
- Perform calculations involving wavelengths, velocities, frequencies, and energies of electromagnetic radiation in atomic spectroscopy.
- Explain terms such as quantization, Heisenberg uncertainty principle, wave nature of matter, Schrodinger wave equation, orbital, and probability as applied to atomic structure.
- Perform calculations using the de Broglie relationship and explain the significance of the answers.
- Use the quantum number rules to determine the allowable values of quantum numbers and hence relate these to the arrangement of electrons in atoms.
- Describe the correct electronic configurations and energy level diagrams for the elements
- Describe periodic trends of ionization potential, electron affinity, and atomic and ionic size.
- Explain Mendeleev's contribution to the modern periodic table.
- Describe the modern periodic table and know the names given to the various groups, transition metals, and periods.
- Discuss trends in chemical and physical properties in the periodic table.

- Describe ionic bonds.
- Explain the concept of electronegativity and its consequences in bonding.
- Draw Lewis structures for molecular and ionic species.
- Calculate formal charges of atoms in molecules and ions.
- Explain the concept of resonance.
- Use bond dissociation energies to calculate reaction enthalpies.
- Use the VSEPR model to deduce molecular geometry of molecules.
- Predict which molecules will possess a dipole moment.
- Use the hybridization method to deduce molecular geometry of molecules.
- Describe sigma (σ) and pi (π) bonds.
- Explain valence bond (VB) and molecular orbital (MO) theories of bondingand the difference between them.
- Draw MO energy level diagrams for the homonuclear diatomic molecules and ions, and deduce the number of bonds and the paramagnetism of these species.
- Describe the differences between the liquid and the solid state.
- Explain the terms surface tension, capillary action, meniscus, and viscosity.
- Describe different intermolecular attractions, including the hydrogen bond.
- Discuss the anomalous properties of water.
- Predict the order of melting points and boiling points between various compounds based on their intermolecular forces.
- Explain different concepts of bonding in organic molecules, including formal charge, hybridization, multiple bonding and resonance.
- Draw Lewis structures and condensed, bond-line, three-dimensional, and 3D dash structural formulas of organic compounds.
- Identify compounds where resonance occurs and draw resonance contributors and hybrids.
- Predict shapes of simple molecules and molecular polarity.
- Identify and name various functional groups.
- Explain how the Brønsted-Lowry and Lewis acid-base theories differ fromeach other.
- Explain the relationship between intermolecular attractions and the physical properties of organic molecules.
- Using molecular models, build three-dimensional models of simple organic molecules from two-dimensional diagrams and demonstrate isomerism and free rotation around single bonds
- Draw structural formulas for the constitutional isomers of alkanes and cycloalkanes in both 2D and 3D representations.
- Using the IUPAC system, *name* alkane chains and monocyclic rings, including those with alkyl group, halide, and alcohol substituents.
- Explain trends in the physical properties of alkanes.
- Predict the stability of various substituted alkane and cyclohexane conformations.
- Determine the relative stability of conformers and isomers of substituted cyclohexanes.
- Identify enantiomers, diastereomers, chiral and achiral molecules, stereogenic carbon atoms, meso molecules and molecular planes of symmetry.

- Name enantiomers and meso compounds using the (*R*)-(*S*) system.
- Explain plane-polarized light, optical activity, and racemic mixtures.
- Calculate specific rotation from data for an observed rotation.
- Distinguish between the designations (*R*) and (*S*), (+) and (–), D and L, and between absolute and relative configuration.
- Draw Fischer projection formulas.
- Draw, using curved arrows correctly, mechanisms for S_N1 and S_N2 reactions.
- Identify leaving groups, substrates, and nucleophiles.
- Determine the order of a reaction from kinetic data.
- Explain the effect of structure, solvent, and nucleophile on substitution reactions.
- Distinguish between protic and aprotic solvents, good and poor nucleophiles, and good and poor leaving groups.
- Explain the stereochemistry involved in S_N1 and S_N2 reactions with chiral molecules.
- Predict substitution products under a variety of reaction conditions.
- Plan the synthesis of simple organic compounds using appropriate substitution reaction conditions and predict the major product(s) of a given substitution reaction.