ORIGINAL COURSE IMPLEMENTATION DATE:	September 2001
REVISED COURSE IMPLEMENTATION DATE:	September 2016
COURSE TO BE REVIEWED: (six years after UEC approval)	December 2021

Course outline form version: 09/15/14

OFFICIAL UNDERGRADUATE COURSE OUTLINE FORM

Note: The University reserves the right to amend course outlines as needed without notice.

Course Code and Number: CHEM 324

Number of Credits: 4 Course credit policy (105)

Course Full Title: Chemical Kinetics and Thermodynamics

Course Short Title (if title exceeds 30 characters): Chem.Kinetics&Thermodynamics

Faculty: Faculty of Science

Department (or program if no department): Chemistry

Calendar Description:

Topics include an introduction to thermodynamics with applications to phase and chemical equilibria, and the principles of chemical kinetics including enzyme kinetics and reaction rate theory. Laboratory experiments and computational exercises illustrate lecture material.

Note: MATH 221 is recommended prior to this course.

Prerequisites (or NONE):	CHEM 114, (PHYS 105 or PHYS 111), MATH 111, and (MATH 112 or MATH 118).
Corequisites (if applicable, or NONE):	
Pre/corequisites (if applicable, or NONE):	

Equivalent Courses (cannot be taken for additional credit)

Former course code/number:

Cross-listed with:

Equivalent course(s):

Note: Equivalent course(s) should be included in the calendar description by way of a note that students with credit for the equivalent course(s) cannot take this course for further credit.

Transfer Credit

Transfer credit already exists: ☒ Yes No

Transfer credit requested (OReg to submit to BCCAT):
☐ Yes ☒ No (if yes, fill in transfer credit form)

Resubmit revised outline for articulation: ☐ Yes ☒ No

To find out how this course transfers, see **bctransferguide.ca**.

Total Hours: 90

Typical structure of instructional hours:

Lecture hours	45
Seminars/tutorials/workshops	
Laboratory hours	45
Field experience hours	
Experiential (practicum, internship, etc.)	
Online learning activities	
Other contact hours:	
Total	**90**

Special Topics

Will the course be offered with different topics?
☐ Yes ☒ No

If yes, different lettered courses may be taken for credit:
☐ No ☐ Yes, repeat(s) ☐ Yes, no limit

Note: The specific topic will be recorded when offered.

Maximum enrolment (for information only): 24

Expected frequency of course offerings (every semester, annually, every other year, etc.): every other year

Department / Program Head or Director: David Fenske	**Date approved:**	Sept 28, 2015
Faculty Council approval	**Date approved:**	November 6, 2015
Campus-Wide Consultation (CWC)	**Date of posting:**	December 12, 2015
Dean/Associate VP: Lucy Lee	**Date approved:**	November 6, 2015
Undergraduate Education Committee (UEC) approval	**Date of meeting:**	December 18, 2015

Learning Outcomes

Upon successful completion of this course, students will be able to:

- Describe the laws of thermodynamics.
- Apply the laws of thermodynamics to problems of physical, chemical, and biochemical interest.
- Explain the relationship between thermodynamic potentials, spontaneity, and equilibrium under different thermodynamic conditions.
- Derive reaction rate laws from reaction mechanisms, and apply them to kinetics in chemical and biochemical systems.
- Explain collision theory, transition state theory, and Marcus theory in the context of chemical kinetics.
- Use chromatographic and spectroscopic techniques and instruments to collect experimental kinetic data.
- Record experimental the results obtained in a laboratory notebook.
- Quantitatively analyze experimental data in the context of theoretical principles learned through the lectures.
- Communicate experimental results and conclusions through written lab reports.

Prior Learning Assessment and Recognition (PLAR)

☒ Yes ☐ No, PLAR cannot be awarded for this course because

Typical Instructional Methods (guest lecturers, presentations, online instruction, field trips, etc.; may vary at department's discretion)

Lectures, lab experiments, group problem solving sessions, computer-based lessons and problem solving.

Grading system: Letter Grades: ☒ Credit/No Credit: ☐ Labs to be scheduled independent of lecture hours: Yes ☒ No ☐

NOTE: The following sections may vary by instructor. Please see course syllabus available from the instructor.

Typical Text(s) and Resource Materials (if more space is required, download Supplemental Texts and Resource Materials form)

	Author (surname, initials)	Title (article, book, journal, etc.)	Current ed.	Publisher	Year
1.	Atkins	Physical Chemistry, 9th ed	X	Freeman and Co	2010
2.			☐		
3.			☐		
4.			☐		
5.			☐		

Required Additional Supplies and Materials (software, hardware, tools, specialized clothing, etc.)

Typical Evaluation Methods and Weighting

Final exam:	35%	Assignments:	10%	Midterm exam:	20%	Practicum:	%
Quizzes/tests:	%	Lab work:	25%	Field experience:	%	Shop work:	%
Other:	%	Other: Computer lab	10%	Other:	%	Total:	100%

Details (if necessary):

Typical Course Content and Topics

Kinetics:

- Reaction rate. Rate law. Rate constant. Order of reaction. Integrated rate laws (simple cases). Linearizing coordinates for the zeroth, first, and second order.
- Collision theory. Reactive and elastic collisions. Elementary processes. Molecularity. Relationship between orders of elementary processes and their molecularity and stoichiometric coefficients. Multistep processes. Intermediates. Steady state approximation. Chain reactions.
- Unimolecular reactions. Lindemann mechanism. Reversible reactions at equilibrium. Relationship between rate and equilibrium constants. Pre-equilibria.
- Homogeneous catalysis. Enzymes. Michaelis-Menten mechanism. Michaelis constant. Maximum velocity. Maximum turnover number. Lineweaver-Burk plot. Inhibition.
- Determination of reaction orders. Method of initial rates. Pseudo-n-th-order. Half-life and its relation to the rate constant. Dependence of the half-life on the initial concentration. Integrated rate laws (more complex cases). Reversible reactions approaching equilibrium.
- Temperature dependence of the rate constant. Arrhenius equation. Preexponential factor and activation energy. Relationship between reaction enthalpy and activation energies of forward and reverse reactions. Potential energy surface. Transition state theory. Enthalpy, entropy, and Gibbs energy of activation. Relationship between reaction enthalpy and enthalpy of activation. Marcus relation. Evans-Polanyi rule. Hammond postulate.

Thermodynamics:

- System and surroundings. State. Parameters. Volume. Pressure. Zeroth law. Temperature. Equation of state. Ideal gas equation. Van der Waals equation.
- Processes. Cyclic, isobaric, isochoric, isothermal, and adiabatic processes. Infenitesimal change. Reversible and irreversible processes. Energy. Work. Heat. First law. Work of expansion. Indicator diagrams of isobaric, isochoric, and isothermal

processes.

- Heat capacity. Molar heat capacity. Heat of isochoric and isobaric processes. Isobaric and isochoric heat capacities. Enthalpy. Energy and enthalpy of an ideal gas. Relationship between isobaric and isochoric heat capacities of an ideal gas.
- Work, heat, energy, and enthalpy calculations for cyclic, isochoric, isobaric, isothermal, and adiabatic processes.
- Exact and inexact differentials. State functions. Energy and enthalpy as a state functions.
- Reaction enthalpy. Endothermic, exothermic, and thermoneutral processes. Standard conditions. Standard enthalpy of formation. Standard enthalpy of combustion.
- Change of enthalpy with temperature: cases of constant and variable isobaric heat capacity. Effect of temperature on reaction enthalpy (Kirchhoff's law).
- Kinetic model of ideal gas. Equation of state. Equipartition theorem. Translational, rotational, and vibrational degrees of freedom. Molar energy and isochoric molar heat capacity. Internal pressure and internal volume. Intermolecular interactions and equations of state: ideal gas; gas of non-interacting hard spheres, liquid of hard spheres with constant attraction, van der Waals gas. Compression factor. Virial equation.
- Indicator diagrams of isobaric, isochoric, and isothermal processes. Graphs of these processes in (T,V) and (T,P) coordinates.
- Entropy. Calculation of entropy change for isobaric, isochoric, and isothermal (ideal gas and phase transition) processes. Fundamental equation of thermodynamics. Free energy. Gibbs energy. Thermodynamic potentials. Criteria of spontaneity and equilibria. Maxwell relations. Thermodynamic equations of state.
- Third law. Relative stability of solid, liquid, and gas phases at different temperatures and pressures. Phase diagram. Triple and critical points. Supercritical fluid. Polymorphism.
- Chemical potential. Molar and partial molar quantities. Chemical potential and its relation to Gibbs energy, free energy, enthalpy and energy. Pressure dependence of chemical potential for ideal and real gases. Fugacity; fugacity coefficient.
- Mixing. Gibbs energy, enthalpy, and entropy of mixing for ideal gas systems (binary and multi-component). Ideal solutions. Chemical potential of a component of an ideal solution. Gibbs energy, enthalpy, and entropy of mixing. Nonideal systems. Fugacity. Activity. Fugacity and activity coefficients.
- Chemical reactions. Extent of reaction. Gibbs energy of a reaction system. Reaction Gibbs energy. Standard reaction Gibbs energy. Calculation of standard reaction Gibbs energy from standard Gibbs energies of formation. Relation between reaction Gibbs energy and standard reaction Gibbs energy. Reaction quotient. Equilibrium. Equilibrium constant.

Lab Experiments:

Experiment 1: Kinetics of fading of phenolphthalein in alkaline solution

Experiment 2: Kinetics of two-step oxidation of glutathione

Experiment 3: Enzyme kinetics: oxidation of *o*-phenylenediamine

Experiment 4: Regioselectivity in keto-enol tautomerization of butanone

Experiment 5: Enthalpy of vaporization

Experiment 6: Bomb calorimetry

Experiment 7: Literature research

Experiments 8-9: Computer modeling of complex reactions