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

1. **Course:** Chemistry 203, General Chemistry: Change and Equilibrium

LEC	DAYS	TIME	ROOM	INSTRUCTOR	OFFICE	EMAIL	OFFICE HOURS
L01	MWF	1:00-1:50	SB 103	Dr. Yuen-ying Carpenter	EEEL 237B	yyscarpe@ucalgary.ca	TBA
L02	MWF	2:00-2:50	SB 103	Dr. Bronwen Wheatley	SA 144C	bmmwheat@ucalgary.ca	
L03	TuTh	9:30-10:45					

Course & Tutorial coordinator: Dr. Yuen-ying Carpenter (EEEL 237B | yyscarpe@ucalgary.ca)

Laboratory coordinator: Dr. Bronwen Wheatley (SA 144C | bmmwheat@ucalgary.ca)

Course website: d2l.ucalgary.ca [CHEM 203 - (Fall 2018) - General Chemistry: Change and Equilibrium]
Departmental Office: Room SA 229 | Tel: 403-220-5341 | e-mail: chem.info@ucalgary.ca

To avoid IT problems, it is recommended that the students use their U of C account for all course correspondence. Please include 'CHEM 203' in the subject line of your email.

2. **Course Description:** An introduction to university chemistry from theoretical and practical perspectives that focuses on an exploration of the fundamental links between kinetics, equilibria and thermodynamics and explores acidity/basicity and redox behaviour using inorganic and organic examples.

3. **Recommended Textbook(s):** *Chemistry* by Flowers, Theopold, Langley, Robinson, *et al*. and published by Open Stax . Note: Our recommended text is an open-educational resource, freely available online through the Open Stax website (https://openstax.org/details/books/chemistry?Book%20details). You are welcome to (i) refer to the text online, (ii) download the PDF to your own device, or (iii) purchase a print copy through the bookstore.

   Recommended practice resources:
   Top Hat – *Active participation is an important part of your lectures.* You are strongly recommended to bring you cell phone, tablet, or laptop to lectures and participate during in-class Top Hat activity questions. Access to Top Hat is free for University of Calgary students.
   Sapling Learning – *Practice solving chemistry problems is a critical component of this course.* Recommended practice questions (with feedback) will be made available for the course on the online Sapling Learning platform. You can purchase a license for Sapling through the bookstore, or access Sapling for free on a limited number of computers on-campus.

   Other REQUIRED course materials (available from the bookstore):
   - Two Chemistry Laboratory Report booklets
   - Lab coat & safety glasses
   - A non-programmable scientific calculator (Casio FX 260 or equivalent)

4. Course learning objectives and associated textbook references:
Note: Not all sub-sections of each textbook chapter will be covered. More details will be provided during the term.

Enduring Understandings	Learning Objectives
Gases and Stoichiometry	*Chapter 9 and Selected Review from Chapters 1-4*
To determine what is happening quantitatively in chemical reactions one must use the principles of stoichiometry.	*Review:* Interpret, predict, and write formulas for chemical species. *Review:* Identify, generate and balance chemical equations. *Review:* Identify limiting and excess reactant(s) and use them to calculate theoretical and percent yields. *Review:* Interconvert between concentrations, moles and masses of chemical species in solution. Use the ideal gas law to do stoichiometric calculations involving gases.
Gases are good systems for understanding molecular behaviour and its relationship to properties such as temperature and pressure.	Interconvert between partial pressures, mole fractions of gases with and total pressure of a gaseous system. Describe the Kinetic Molecular theory of gases (KMT). Use this model to explain relationships between temperature and particle speeds. Use this model to explain why pressure varies as n, V and T are altered. Describe the limitations of the ideal gas law
Equilibrium	*Chapter 13*
Most reactions attain a state of dynamic equilibrium.	Sketch and interpret graphs that qualitatively describe dynamic equilibria. Calculate equilibrium constants from experimental data. Calculate equilibrium concentrations based on initial conditions and K_{eq}.
The reaction quotient is used to determine the progress or extent of a reaction mixture.	Write K/Q expressions for an equilibrium reaction. Use K and Q values to predict the direction of a reaction for a given set of reaction conditions (concentrations, P's, T etc.).
The extent of a reaction can be altered by changing the conditions of a system.	Qualitatively predict changes to a system at equilibrium resulting from adding a common ion or changing concentration, P, V or T.
Thermodynamics	*Chapters 5 and 16*
Chemical changes usually involve energy changes.	Define the terms system, surrounding and universe as applied to a chemical change. Identify standard states of common chemical compounds. Define enthalpy of formation and bond dissociation enthalpy, and use these values to determine or estimate enthalpy change for a reaction. Relate the enthalpy change for a chemical process to the heat released/absorbed during that process. Relate the specific heat of a substance to the temperature change when heat is produced, absorbed, or transferred. Compare the relative pressure-volume work done by or on a system in different scenarios. Relate changes in the internal energy of a system to the work done by/on the system and the heat released/absorbed by the system.
Reaction coordinate diagrams visually represent energy changes during a chemical change.	Generate and use reaction coordinate diagrams to explain the energy changes that occur during a chemical change.

Enduring Understandings	Learning Objectives
Enthalpy and entropy changes both contribute to the free energy change of any chemical change.	Define and determine qualitatively and quantitatively the enthalpy and entropy changes for a chemical change.
The free energy change of a chemical change can be used to determine its spontaneity.	Qualitatively and quantitatively relate enthalpy and entropy to the free energy or spontaneity of a chemical change.
The spontaneity of chemical changes can be varied by changing conditions.	Qualitatively and quantitatively examine the temperature at which spontaneity changes.
The spontaneity of chemical changes relates to the extent of the reaction.	Interconvert between Δ_rG, $\Delta_rG°$, *Q and K.*
Kinetics	*Chapter 12*
The rate law is used to quantitatively examine the rate of a reaction.	Distinguish between average and instantaneous rates of reaction based on graphs of concentration *vs.* time.
	Use graphs of concentration vs. time to compare rates and rate laws for different reactions.
	Determine the differential and/or integrated rate laws for a given reaction using experimental data.
The rate of a reaction can be altered by changing the conditions of a system.	Predict the change in the rate of reaction that results from changing reactant concentrations or temperature, or from the addition of a catalyst.
Rates can be explained at a molecular-level using collision theory.	Use collision theory to qualitatively explain differing reaction rates.
	Use the Arrhenius equation to quantify the relationships between the activation energy, temperature and rate constant.
Reactions can occur via a series of steps or a mechanism.	Describe the concept of a reaction mechanism and identify reasonable reaction mechanisms consistent with the experimentally-determined rate law for a given reaction.
	Identify the rate-determining step, intermediates and catalysts present in a given reaction mechanism.
Reaction coordinate diagrams provide a representation of the energy changes that influence rate.	Identify plausible reaction coordinate diagrams based on information about a reaction mechanism.
	Label key kinetic components of a reaction coordinate diagram for a chemical change (*i.e.* transition state, intermediate, activation energy).
Catalysts provide alternative mechanisms, thereby altering the energy changes and rates for a reaction.	Describe the effect of a catalyst on the activation energy of a reaction.
Applying Chemical Equilibria: Acids & Bases	*Chapter 14*
The pH of an aqueous solution of an acid or base is determined by both concentration and the extent of their reaction with water.	Distinguish between *K* and p*K* and relate these values to acid/base strength and to hydronium ion concentrations [H_3O^+] in solution.
	Quantitatively relate K_a, pK_a, K_b, pK_b, pH, [H_3O^+] and [OH^-].
	Calculate the pH for an acid or a base in aqueous solution.
Weak acids and bases are used to prepare buffer solutions that are used to resist changes in pH.	Describe how a buffer functions and outline how to prepare a buffer with a given pH.
	Calculate the pH of a buffer solution before and after the addition of strong acids or bases.
	Qualitatively compare the acid or base buffer capacities of solutions.

Enduring Understandings	Learning Objectives
Titration experiments are important for studying acids and bases.	Distinguish between the titration of strong acids/bases and the titration of weak acids/bases. Qualitatively and quantitatively describe how pH varies during a titration by identifying the major and minor species in solution at each stage. Use titration to determine the identity of an acid or base.
Applying Chemical Equilibria: Solubility	*Chapter 15.1*
The solubility of salts in aqueous solution is related to their extent of dissociation in water.	Qualitatively and quantitatively relate the solubility of salts to K_{sp}. Predict how the solubility of a salt will be affected by changing conditions.
Applying Equilibria and Thermodynamics: Electrochemistry	*Selected parts of Chapter 17*
An electrochemical cell provides a means to generate an electric potential from a redox reaction. The electrical potential generated by an electrochemical cell is related to the spontaneity and extent of the redox reaction.	Compare standard and non-standard cell potentials by qualitatively predicting how the cell voltage will change with concentration. Relate the cell voltage ($E°_{cell}$) and free energy ($\Delta_r G°$) of reactions under standard conditions to the equilibrium constant (K) for a redox reaction.

5. **Laboratory Experiments:** (5 experiments on alternate weeks, 3 hours in laboratory biweekly, *see schedule*)

Experiment 1. I can't believe it's soap
Experiment 2. Determining the equilibrium constant for the formation of ferric thiocyanate, $Fe(SCN)^{2+}$
Experiment 3. Investigation into the kinetic behaviour of aqueous phenolphthalein solutions
Experiment 4. Identification of unknown acids by titration
Experiment 5. Preparation of a buffer solution & investigation of its properties

6. **Tutorials:** (5 tutorials on alternate weeks, 1.25 hours in tutorials biweekly, *see schedule*)

Bi-weekly tutorial topics include:
- Gas laws and stoichiometry
- Enthalpy, heat, and work
- Equilibrium
- Kinetics
- Acid and Base Solutions

Department Approval_________ Approved by Department Head ________Date_____January 7, 2019________

Schedule for Winter 2019

JANUARY 2019

SUN	MON	TUES	WED	THUR	FRI	SAT
		1	2	3	4	5
6	7	8	9	10 First day of classes	11	12
13	14	15	16	17 Last day to drop	18 Last day to add	19
20	21	22 Tut 1	23	24	25	26
27	28	29 Lab 1	30	31		

FEBRUARY 2019

SUN	MON	TUES	WED	THUR	FRI	SAT
					1 Lab 1	2
3	4	5 Tut 2	6	7	8	9
10	11 **Term test 1**	12 Lab 2	13	14	15	16
17	18 Family Day	19 Reading week	20 Reading week	21 Reading week	22 Reading week	23
24	25	26 Tut 3	27	28		

MARCH 2019

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

APRIL 2019

SUN	MON	TUES	WED	THUR	FRI	SAT
	1	2 Lab 5	3	4	5	6
7	8	9	10	11	12 Last day of classes	13
14	15 EXAMS BEGIN	16	17	18	19 Good Friday	20
21	22	23	24	25	26	27 EXAMS END