UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
DEPARTMENT OF CHEMISTRY
COURSE SYLLABUS
Fall 2021

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

lecture ROOM	Section	DAYS	TIME	INSTRUCTOR	OFFICE	EMAIL	OFFICE HOURS
Online synchronous	L01	MWF	9:00-9:50 AM	Dr. Todd Sutherland	ZOOM	todd.sutherland@ucalgary.ca	See D2L
	L02	TuTh	8:00-9:15 AM	Dr. Yuen-ying Carpenter	ZOOM	yyscarpe@ucalgary.ca	

Course coordinator (exams/tutorials): Dr. Yuen-ying Carpenter (yyscarpe@ucalgary.ca)

Lab and Tutorial Coordinator: TBD – Contact information be posted to D2L when labs and tutorials begin

Course website: d2l.ucalgary.ca [CHEM 203 - Fall 2021 - General Chemistry: Change and Equilibrium]
Chemistry Department 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 2nd edition* 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-2e). 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 use your 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.

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 *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…*
Stoichiometry of Reactions	*Selected Review from Chapters 1-4 and 9*
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** given the reactant(s) and product(s). *Review:* Identify **limiting and excess reactant(s)** and use them to calculate **theoretical and percent yields**. *Review:* Interconvert between number of **moles**, mass, concentration, and volume. *Review:* Perform **dilution** calculations. *Review:* Describe and quantify a **gas** sample (pure and mixture) using the following variables: number of moles, volume, temperature, total and **pressure**. Describe and quantify **partial pressure** for a component in a gas mixture.
How far? (*Equilibrium*)	*Chapter 13*
Most reactions attain a state of dynamic equilibrium.	Describe **dynamic equilibria** both qualitatively and quantitatively and recognize under which conditions they occur. Sketch and interpret graphs that qualitatively describe dynamic equilibria.
Chemical equilibrium determines the extent of a reaction. The reaction quotient is used to determine the progress or extent of a reaction mixture.	Determine the expression and the value of the equilibrium constant (***K***) and the reaction quotient (***Q***); explain the implication(s) of their magnitude. Use *K* and *Q* values to predict the **direction** of a reaction for a given set of reaction conditions. Determine the reactant(s) and product(s) concentration(s) at equilibrium.
The extent of a reaction can be altered by changing the conditions of a system. The extent to which a chemical reaction occurs has a relationship to both kinetic and thermodynamic principles.	Identify the experimental **factors** affecting a chemical equilibrium and determine their effect(s). Explain the kinetic basis of chemical equilibrium and its relationship to thermodynamics.
How fast? (*Kinetics*)	*Chapter 12*
Chemical reactions that involve gases are good models for studying chemical reactivity due to limited intermolecular interactions. The rate of any chemical reaction relates to the mechanism of the reaction.	Describe the behaviour of **ideal and real gases** using the **kinetic molecular theory** of gases. Describe and apply the principles of **collision theory** to a given reaction. Describe the factors affecting the **collision frequency**. Use the **Arrhenius** equation to quantify the relationships

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	between the **activation energy**, temperature and rate constant.
A reaction mechanism can be the result of one or several successive and effective collisions.	Propose and identify a valid **mechanism** for a given reaction. Identify the **rate-determining step**, **intermediates**, **transition states** and **catalysts** present in a given reaction mechanism.
Reaction coordinate diagrams provide a representation of the energy changes that influence rate.	Generate, interpret and relate a plausible **reaction coordinate diagram** to the proper reaction mechanism.
The rate law is used to quantitatively examine the rate of a reaction.	Determine and distinguish between **average** and **instantaneous rates** of reaction Determine the **differential and/or integrated rate laws** for a given reaction, including the **order** and the **rate constant** for this reaction, using experimental data. Generate and interpret graphs of concentration vs. time to compare rates and rate laws for different reactions.
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, temperature, or from the addition of a catalyst.
Catalysts provide alternative mechanisms, thereby altering the energy changes and rates for a reaction.	Describe the effect of a **catalyst** on the mechanism of a reaction.
How much energy? (*Thermodynamics*) *Chapters 5 and 16*	
Chemical processes involve energy changes.	*Review:* Define the terms **system**, **surrounding** and **universe** as applied to a chemical process. *Review:* Relate the **specific heat** of a substance to the temperature change when heat is exchanged. Relate the **enthalpy change** for a chemical process to the heat released/absorbed during that process. Determine or estimate the enthalpy change for a reaction using the **enthalpies of formation** or **bond dissociation enthalpies**. 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 process.	Generate and use reaction coordinate diagrams to explain the energy changes that occur during a chemical change.
Enthalpy and entropy changes both contribute to the free energy change of any chemical process. The free energy change of a chemical process can be used to determine its spontaneity.	Define and describe the **entropy** of chemical species; use these values to predict the change in entropy occurring when a chemical process occurs. Qualitatively and quantitatively relate enthalpy and entropy to the **free energy** or **spontaneity** of a chemical change.
The spontaneity of chemical processes can be varied by changing conditions.	Describe qualitatively and quantitatively how the spontaneity of a chemical process can be altered.

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The spontaneity of chemical processes relates to the extent of the reaction.	Relate thermodynamic and equilibrium parameters and interconvert between ***$\Delta_r G$, $\Delta_r G°$, Q and K***.
Chemical reactions – Acids & Bases (*Applying Chemical Equilibria*) *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. Weak acids and bases are used to prepare buffer solutions that are used to resist changes in pH. Titration experiments are important for studying acids and bases.	Perform calculations to relate the **pH** and **pOH** of a solution, and the concentrations of all species present in solution. Relate K and pK to the **acid/base strength**. Describe the principles of **buffer** solutions. Determine the identity and quantity of chemical species needed to prepare a buffer solution with a desired pH value. Describe what happens to a buffer solution after the addition of a strong acid or strong base and quantify the result. Generate and analyze theoretical and experimental **titration curves** to determine the identity and concentration of the species being titrated. Select an appropriate **acid-base indicator** for a given titration experiment. Qualitatively and quantitatively describe how pH varies during a titration by identifying the major and minor species in solution at each stage.
Chemical reactions – Solubility (*Applying Chemical Equilibria*) *Chapter 15.1*	
The solubility of salts (ionic compounds) in aqueous solution is related to their extent of dissociation in water.	Qualitatively and quantitatively relate the **solubility** of salts to their equilibrium constant ($\boldsymbol{K_{sp}}$). Predict how the solubility of a salt will be affected by changing experimental conditions.
Chemical reactions – Electrochemistry (*Applying Equilibria & Thermodynamics*) *Selected parts of Chapter 17*	
An electrochemical cell provides a means to generate an electric potential from a redox reaction. This electrical potential is related to the spontaneity and extent of the redox reaction.	Compare **standard** and **non-standard cell potentials** and explain the implication(s) of their magnitude and sign. Predict qualitatively how the cell potential will change with concentration. Relate the cell potential, free energy change and equilibrium constant of a redox reaction.
Communication	
Communication is crucial to an experiential science like chemistry.	Communicate the results of chemical processes in terms of observable macroscopic outcomes, molecular scale models/representations, mathematical equations, and graphs. Convey explanations using appropriate chemistry language.

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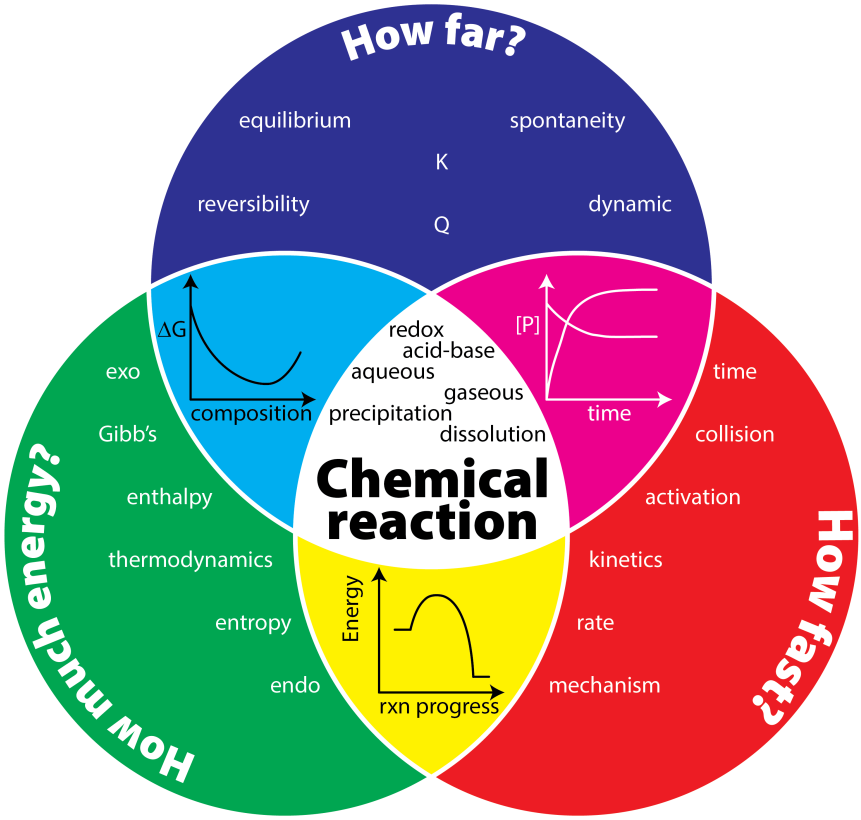
Lab safety	
Safety is essential when working in a chemistry laboratory.	Develop an understanding of the principles of **chemical safety**. Recognize common **laboratory hazards** and understand how they contribute to **risk**. Appreciate how risk is mitigated in the laboratory.



5. Laboratory Experiments: (4 experiments, 1.25 hours *online synchronous* laboratory biweekly, *see schedule*)

You will practice collecting and interpreting observations and analyzing laboratory dats through the claim-evidence-reasoning model as part of the laboratory program.

Experiment titles and details will be posted to D2L. Past experiments have included the following:

- Collecting and interpreting observations
- Determining the equilibrium constant for the formation of ferric thiocyanate
- Investigation into the kinetic behaviour of aqueous crystal violet solutions
- Identification of unknown acids by titration
- Preparation of salt solutions & investigation of their properties

6. Tutorials: (5 tutorials, 1.25 hours *online synchronous* tutorials biweekly, *see schedule*)

Bi-weekly tutorial topics include:

- Review of gas laws and stoichiometry & intro to excel
- Equilibrium
- Kinetics
- Acid and Base Solutions
- Enthalpy, heat, and work

Schedule for Fall 2021

SEPTEMBER 2021

SUN	MON	TUES	WED	THUR	FRI	SAT
	BLOCK WEEK		1	2	3	4
5	6 Labour Day University Closed	7 1st day of classes	8	9	10	11
12	13	14 **Meet your group** *Get-to-know you survey*	15	16 Last day to drop	17 Last day to add/swap	18
19	20	21 **Tutorial 1** *Check-in 1*	22	23	24	25
26	27	28 *No labs/tutorials* *Check-in 2*	29	30 Reconciliation Day University Closed	OCTOBER 1	2

OCTOBER 2021

SUN	MON	TUES	WED	THUR	FRI	SAT
3	4	5 **Tutorial 2** *No check-in*	6 **TERM TEST 1** (10%)	7	8	9
10	11 Thanksgiving University Closed	12 **Lab 1** *Check-in 3*	13	14	15	16
17	18 *Hand in Lab 1* (6%) *this week*	19 **Tutorial 3** *Check-in 4*	20	21	22	23
24	25	26 **Lab 2** *Check-in 5*	27	28	29	30

NOVEMBER 2021

SUN	MON	TUES	WED	THUR	FRI	SAT
OCT 31	1 *Hand in Lab 2* (6%) *this week (OR next)***	2 **Tutorial 4** *No check-in*	3 **TERM TEST 2** (15%)	4	5	6
7	8 Fall break	9 Fall break	10 Fall break	11 Fall break	12 Fall break	13
14	15	16 **Lab 3** *Check-in 6*	17	18	19	20
21	22 *Hand in Lab 3* (6%) *this week*	23 **Tutorial 5** *Check-in 7*	24	25	26	27

DECEMBER 2021

SUN	MON	TUES	WED	THUR	FRI	SAT
NOV 28	NOV 29 *Hand in Lab 4* (6%) *this week*	NOV 30 **Lab 4** *Check-in 8*	DEC 1	2	3	4
5	6	7	8	9 ***Wrap-up due*** (8%) Last day of classes	10	11
12	13 Final exams (28%)	14	15	16	17	18
19	20	21	22	23	24	25