**UNIVERSITY OF CALGARY**
**FACULTY OF SCIENCE**
**DEPARTMENT OF CHEMISTRY**
**COURSE SYLLABUS**
**WINTER 2020**

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

| lecture ROOM | section | DAYS | TIME | INSTRUCTOR | OFFICE | EMAIL | OFFICE HOURS |
|---|---|---|---|---|---|---|---|
| Online | L01 | W | 2:00-3:50 PM | Dr. Roxanne Jackson | SA 258 | rjjackso@ucalgary.ca | See D2L |
| | | F | 2:00-2:50 PM | | | | |

**Course coordinator (including labs/tutorials):** Dr. Roxanne Jackson (SA 258 | rjjackso@ucalgary.ca)

Course website: d2l.ucalgary.ca [CHEM 203 (Spring 2020) - General Chemistry: Change and Equilibrium]
Department 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 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 or (ii) download the PDF to your own device.

**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.

**Other REQUIRED course materials (available from the bookstore):**
- A non-programmable scientific calculator (Casio FX 260 or equivalent)

4. **Course learning objectives and associated textbook references (OpenStax textbook):**
*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.<br><br>*Review:* Identify, generate and balance chemical equations.<br><br>*Review:* Identify limiting and excess reactant(s) and use them to calculate theoretical and percent yields.<br><br>*Review:* Interconvert between concentrations, moles and masses of chemical species in solution.<br><br>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.<br><br>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.<br><br>Describe the limitations of the ideal gas law |
| **Thermodynamics** | *Chapters 5 and 16* |
| Chemical changes usually involve energy changes. | Define the terms system, surrounding and universe as applied to a chemical change.<br><br>Identify standard states of common chemical compounds.<br><br>Define enthalpy of formation and bond dissociation enthalpy, and use these values to determine or estimate enthalpy change for a reaction.<br><br>Relate the enthalpy change for a chemical process to the heat released/absorbed during that process.<br><br>Relate the specific heat of a substance to the temperature change when heat is produced, absorbed, or transferred.<br><br>Compare the relative pressure-volume work done by or on a system in different scenarios.<br><br>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. |
| 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 $\Delta_r G$, $\Delta_r G°$, $Q$ and $K$. |

| Enduring Understandings | Learning Objectives |
|---|---|
| **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.<br><br>Use graphs of concentration vs. time to compare rates and rate laws for different reactions.<br><br>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.<br><br>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.<br><br>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.<br><br>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. |
| **Equilibrium** | *Chapter 13* |
| Most reactions attain a state of dynamic equilibrium. | Sketch and interpret graphs that qualitatively describe dynamic equilibria.<br><br>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.<br><br>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. |
| **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.<br><br>Quantitatively relate $K_a$, $pK_a$, $K_b$, $pK_b$, pH, $[H_3O^+]$ and $[OH^-]$.<br><br>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.<br><br>Calculate the pH of a buffer solution before and after the addition of strong acids or bases.<br><br>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.<br><br>Qualitatively and quantitatively describe how pH varies during a titration by identifying the major and minor species in solution at each stage.<br><br>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 $K_{sp}$.<br><br>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.<br><br>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.<br><br>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. **Online Experiential Learning Activities (Labs):** (5 activities, 2 hours weekly (Zoom meetings), *see schedule*)

Activity 1. Soap and Observations Lab
Activity 2. Investigation into Kinetics
Activity 3. Investigation into Equilibrium
Activity 4. Acid-Base Lab
Activity 5. Buffer Properties

6. **Online Tutorials:** (5 tutorials, 1.25 hours in tutorials (Zoom meetings), *see schedule*)

Weekly tutorial topics include:
- Gas laws and stoichiometry/Enthalpy, heat, and work
- Kinetics
- Equilibrium
- Acid and Base Solutions
- Solubility

Department Approval______Electronically Approved______Date________April 30, 2020_____

**Course Calendar CHEM 203 – Spring 2020:** For exact dates & time refer to your student center schedule. *Assignment of Lecture content is tentative & depends on the progress of the class.

**MAY 2020**

| SUN | MON | TUES | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 | 4 | 5 | 6 First day of Classes Gases | 7 | 8 Gases | 9 |
| 10 | 11 Thermodynamics Video | 12 Lab #1 B01, B02, B05, B06 Last day to drop Last day to add | 13 Thermodynamics Lab #1 B03,B04 | 14 Tut #1 T01, T02 | 15 Thermodynamics Tutorial #1 T03 | 16 |
| 17 **Quiz #1 Due** | 18 Kinetics Video **Victoria Day** | 19 Lab #2 B01, B02, B05, B06 | 20 Kinetics Lab #2 B03,B04 | 21 Tut #2 T01, T02 | 22 Tutorial #2 T03 Kinetics | 23 |
| 24 | 25 Equilibrium Video | 26 Lab #3 B01, B02, B05, B06 | 27 Lab #3 B03,B04 Equilibrium | 38 Tut #3 T01, T02 | 29 Tutorial #3 T03 Equilibrium | 30 |
| 31 **Quiz #2 Due** | | | | | | |

**JUNE 2020**

| SUN | MON | TUES | WED | THUR | FRI | SAT |
|---|---|---|---|---|---|---|
| | 1 Acids and Bases Video | 2 Lab #4 B01, B02, B05, B06 | 3 Lab #4 B03,B04 Acids and Bases | 4 Tut #4 T01, T02 | 5 Tutorial #4 T03 Acids and Bases | 6 |
| 7 | 8 Solubility Video | 9 Lab #5 B01, B02, B05, B06 | 10 Lab #5 B03,B04 Solubility | 11 Tut #5 T01, T02 | 12 Tutorial #5 T03 Solubility | 13 |
| 14 **Quiz #3 Due** | 15 Electrochemistry Video | 16 | 17 **Last Day of Classes** Electrochemistry | 18 | 19 Final Exams | 20 Final Exams |
| 21 Final Exams | 22 Final Exams | 23 Final Exams | 24 | 25 | 25 | 27 |
| 28 | 29 | 30 | | | | |