UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
DEPARTMENT OF CHEMISTRY
COURSE OUTLINE
WINTER 2018

1. **Course: CHEMISTRY 213, Foundations of Chemistry: Change and Equilibrium**

LEC	DAYS	TIME	ROOM	INSTRUCTOR	OFFICE	PHONE	EMAIL	OFFICE HOURS
L01	TR	11:00-12:15	EEEL161	Dr. Julie Lefebvre	EEEL 237-C	220-7602	jlefebv@ucalgary.ca	TBA

Course website via D2L: CHEM 213 L01 - (Winter 2018) - Foundations of Chemistry: Change and Equilibrium
Departmental Office: Room SA 229, Tel: 403-220-5341, e-mail: chem.info@ucalgary.ca

2. **Course Description:** Same core topics as Chem 203 but taught with a greater emphasis on critical thinking, scientific observation and problem solving and the application of chemistry to topics such as materials, explosives and medicine.

3. **Recommended/ Required Textbook(s):** ***"Chemical – Human Activity, Chemical Reactivity"***, 2nd Edition, by Mahaffy, Bucat, Tasker *et al*., Nelson, 2014

Chapter coverage in Chemistry 213:
**Some parts of the assigned chapters may be omitted (to be announced in lecture).*

Chapter 7 – Chemical Reactions and Energy Flows

Chapter 11 (selected sections only) – States of Matter

Chapter 13 – Dynamic Chemical Equilibrium

Chapter 14 – Acid-Base Equilibria in Aqueous Solutions

Chapter 15 – Solubility, Precipitations and Complexation

Chapter 16 – Electron Transfer Reactions and Electrochemistry

Chapter 17 – Spontaneous Changes: How Far?

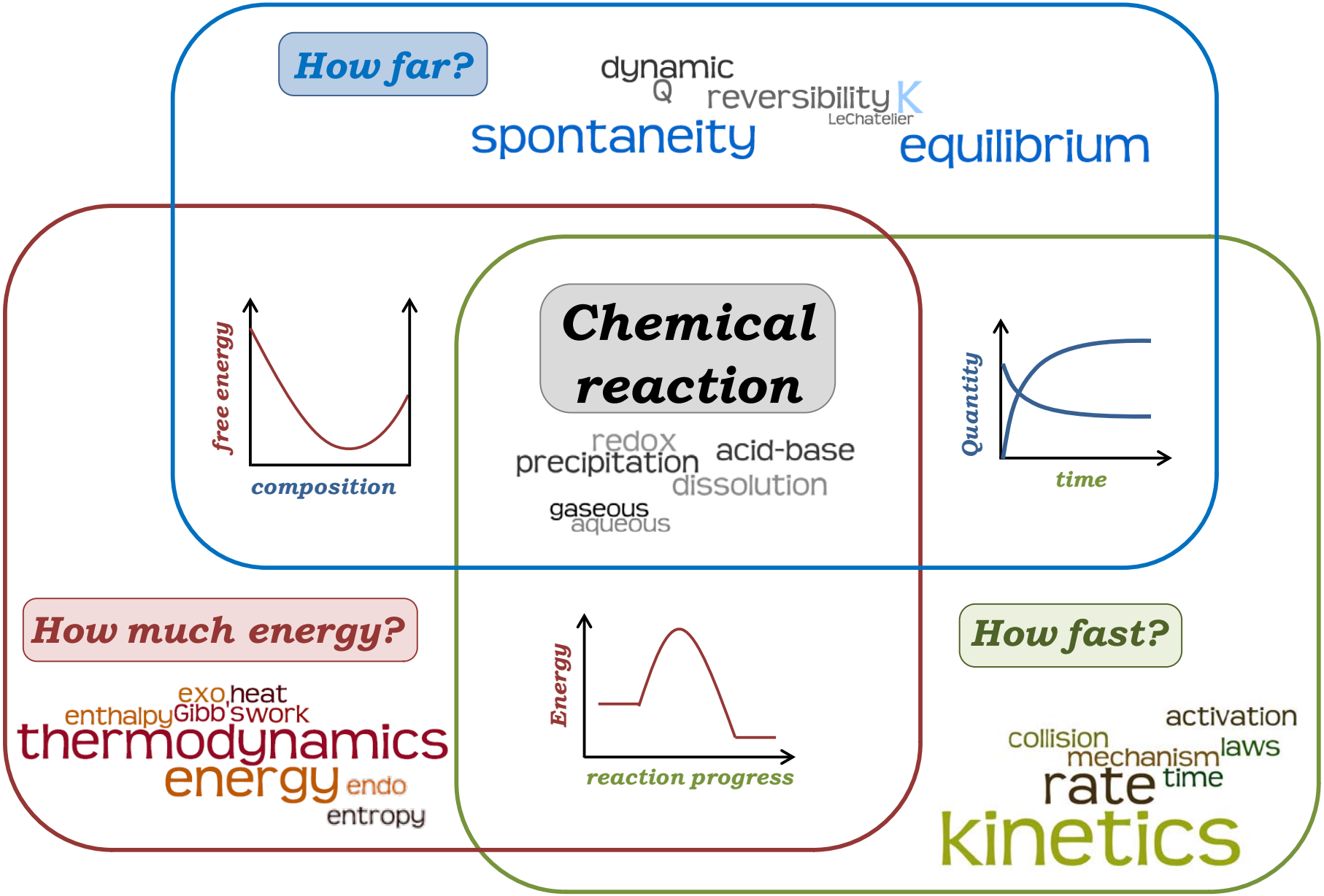
Chapter 18 – Spontaneous Changes: How Fast?

Material from Chem 20, Chem 30 and CHEM 201/211 that is expected background knowledge:

Chapters 1 – 6 and Chapters 8, 9 & 10

4. **Learning Outcomes:** Students will learn about how chemical reactions are explained by equilibrium, kinetics and thermodynamic principles. This course will also focus on critical thinking, problem solving and laboratory skills (including teamwork and communication skills).

CHEM 213 – Chemical Changes and Equilibrium



Course Aims and Learning Objectives:

CRITICAL THINKING

What you will understand by the end of the course…….	***What you will be able to do by the end of the course…….***
Critical thinking is crucial to an experiential science like chemistry. Critical thinking requires constant re-evaluation of results and hypotheses.	Collect and recognize valid **observations** and data. Analyze observations and data and link them to the course content. Formulate a **hypothesis** based on the analysis of your observations and data. Evaluate the validity of your hypothesis.

CHEMICAL EQUILIBRIA

What you will understand by the end of the course…….	***What you will be able to do by the end of the course…….***
Chemical reactions can attain a state of dynamic equilibrium.	Describe dynamic **equilibria** both qualitatively and quantitatively and recognize under which conditions they occur.
Chemical equilibrium determines the extent of a reaction, i.e. whether the reactants or products are favoured.	Determine the expression and the value of the **equilibrium constant** and the reaction quotient; explain the implication(s) of their magnitude. Determine the reactant(s) and product(s) concentration(s) at equilibrium.
Chemists can manipulate the extent of a reaction.	Identify the experimental factors affecting a chemical equilibrium and determine their effect(s).
The extent to which a chemical reaction occurs has a relationship to both kinetic and thermodynamic principles.	Explain the kinetic basis of chemical equilibrium and its relationship to thermodynamics.

CHEMICAL KINETICS

What you will understand by the end of the course…….	***What you will be able to do by the end of the course…….***
The rate of any chemical reaction relates to the mechanism of the reaction.	Describe and apply the principles of **collision theory** to a given reaction. Propose and identify a valid **mechanism** for a given reaction.
A reaction mechanism can be the result of one or several successive and effective collisions.	Determine the **rate-determining step** in a reaction mechanism. Generate, interpret and relate a reaction coordinate diagram to the proper reaction mechanism. Identify and distinguish **transition state(s)** and **reaction intermediate(s)** in a given mechanism.
The molecular level understanding of kinetics is linked to the macroscopic observations.	Calculate the **average and instantaneous rates** of a given reaction. Determine the **differential and integrated rate law equations** for a given reaction, including the **order** and the **rate constant** for this reaction, using experimental data. Correlate concentration(s) and rate with time. Relate collision theory to a reaction rate determined experimentally.
Chemists can manipulate experimentally the rate of a reaction.	Describe the factors affecting the collision frequency. Explain how **catalysts** can alter the mechanism of a reaction.

CHEMICAL THERMODYNAMICS

What you will understand by the end of the course…….	***What you will be able to do by the end of the course…….***
A chemical reaction involves an energy change which can result in work being done and heat being absorbed or released.	Distinguish system, surrounding, and universe for a chemical process. Determine the amount of **heat** produced or absorbed by a chemical process. Recognize and quantify the **pressure-volume work** done by or on a chemical process. Determine the change in **internal energy** when a chemical process takes place and relate it to the heat and work involved. Predict, determine and relate the heat and **enthalpy changes** for a chemical process.
Chemical reactions may or may not occur spontaneously.	Define and describe the **entropy** of chemical species; use them to predict the change in entropy occurring when a chemical process occurs. Relate the temperature and the enthalpy and entropy changes of a chemical process to its **spontaneity**. Relate the **free energy change** of a chemical process to its spontaneity and its equilibrium constant. Perform calculations for the thermodynamics quantities under standard and non-standard conditions.
Chemists can alter the spontaneity of some reactions.	Describe how the spontaneity of a chemical process can be altered.

CHEMICAL REACTIONS

What you will understand by the end of the course…….	***What you will be able to do by the end of the course…….***
Chemical reactions are described by chemical formulae and balanced chemical equations and used to solve stoichiometric problems. (*Review of pre-requisite course*)	Determine, balance and classify a chemical reaction given the reactant(s) and product(s). Determine the Lewis and VSEPR diagrams of reactant(s) and product(s). Determine the molar mass of reactant(s) and product(s). Identify the limiting and excess reagents given experimental data. Determine the theoretical and percent yield of a chemical reaction. Distinguish a pure liquid and a solution. Perform dilution calculations. Convert between the following quantities: number of moles, mass, concentration, volume.

All chemical reactions are explained by a combination of kinetic, thermodynamic and equilibrium principles:	Apply the principles of kinetics, thermodynamic and equilibrium to a given reaction to determine its spontaneity, its rate and the extent of conversion of reactants.
Chemical reactions that involve gases are good models for studying chemical reactivity due to limited intermolecular interactions.	Describe the behaviour of **ideal and real gases**. Describe and quantify a gas sample (pure and mixture) using the following variables: number of moles, volume, temperature, total and partial pressures, mole fraction.
Chemical reactions occurring in solution constitute a major class of reactions:	
In aqueous solutions, the pH characterizes acid and base.	Predict and explain the acid-base behaviour of the following chemical species in solution: **acids and bases, salts, indicators**. Perform calculations to relate the pH and pOH of a solution, the *K* and p*K* of the acid or base and the concentrations of all species present in solution.
Buffer solutions exploit the properties of weak acids and bases.	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.
Quantitative and qualitative studies on acid and base solutions can be accomplished using titration experiments.	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.
The forward and reverse processes of dissolution and precipitation for ionic compounds can be equally exploited depending on the desired application.	Determine the **solubility** of ionic compounds. Rationalize and predict how the solubility of an ionic compound is affected by other species present in solution.
Redox reactions generate a cell potential which can be used to perform electrical work.	Describe possible experimental set ups to perform a spontaneous **redox reaction.** Identify and explain the role of each component in an **electrochemical cell**. Calculate the potential of an electrochemical cell under standard and nonstandard conditions. Relate the cell voltage, the free energy change, the equilibrium constant and the electrical work of a redox reaction.

5. Topics of Laboratory Activities (2h 50 min/week, 10 weeks)

5 Critical Thinking Development (CTD) activities alternating with 5 wet experiments

CTD 1 – Energy and chemical processes

Lab 1 – Determining the equilibrium constant for the formation of ferric thiocyanate

CTD 2 – Chemical kinetics (multistep reactions)

Lab 2 – Investigation into the kinetic behaviour of aqueous crystal violet solutions

CTD 3 – Chemical equilibria principles

Lab 3 – Application of acid-base aqueous equilibria (salts and buffer solutions)

CTD 4 – Gel forming polymers

Lab 4 – Determination of the concentration and identity of an unknown acid (using a potentiometric titration)

CTD 5 – Investigating salt solutions

Lab 5 – Determination of an equilibrium constant (K_{sp}) using an electrochemical cell

6. Responsibilities and Expectations:

What you can expect from your instructor

- Your instructor will try to help you as much as possible. Do not be afraid to contact your instructor. Their contact information is available on the course website.
- You will have several opportunities for formal feedback on your progress throughout the term (there are three graded in-class activities, one midterm, one final exam, five prelab assignments, five reports/worksheets and five CTDs write-ups). Each activity should help inform you of your strengths and weaknesses but also help inform future course offerings.
- We recognize that unforeseeable events happen. If this results in you having problems meeting any of your assignment submission dates, accommodations are possible. Procedures for making these accommodations are found in the appropriate sections of the D2L website.

What is expected from you

- Be respectful of everyone
- Come prepared for and be willing to participate in all class activities
- Be as organized as possible so that assignments are submitted on time
- Continually assess your performance and if you are struggling please ask or email either your instructor or TA's as soon as possible. In emails, however, please include your name and make sure to use full sentences so that responses can be effective. Please anticipate that replies may take up to 24 hours.
- In lecture you need to make sure you understand how something is being communicated but in order to truly understand a concept YOU MUST PRACTICE and this is why suggested problems from the textbook, class homework or past examinations will be provided.

7. Format and Procedures:

All classes are cumulative so what will be learned at the start of the course will be continually applied throughout the term.

In-class demonstrations will highlight the experiential nature of the discipline and allow for group discussion while participation to laboratory activities allow for hands-on experience.

The use of TopHat Monocle for in-class polling is designed to help inform you about your strengths and weaknesses in knowledge or its application and inform lecturers how to pace coverage of course material.

In-class activities, CTDs and experiments as a whole will help you to prepare for graded activities, midterm and final examinations. Examinations are a combination of multiple choice, short answer and written answer questions. Examinations are given to assess your strengths and weaknesses regarding the knowledge and application of structure/bonding concepts.

8. **Course Calendar:** All lab activities will take place in **EEEL 249**. To know exact days and time, you will need to refer to your own schedule in PeopleSoft.

JANUARY 2018

SUN	MON	TUES	WED	THUR	FRI	SAT
	1	2 Block week	3	4	5	6
7	8 Lectures begin	9	10	11	12	13
14	15 CTD 1	16	17	18	19 Last day to drop	20
21	22 Last day to add/swap Lab 1	23	24	25 In-class assignment 1 (2%)	26	27
28	29 CTD 2	30	31			

FEBRUARY 2018

SUN	MON	TUES	WED	THUR	FRI	SAT
				1	2	3
4	5 Lab 2	6	7	8	9	10
11	12 CTD 3	13	14	15 In-class assignment 2 (4%)	16	17
18	19 Reading Week	20	21	22	23	24
25	26 Lab 3	27	28			

MARCH 2018

SUN	MON	TUES	WED	THUR	FRI	SAT
				1	2	3
4	5 CTD 4	6	7	8 Midterm (18%)	9	10
12	12 Lab 4	13	14	15	16	17
19	19 CTD 5	20	21	22	23	24
25	26	27	28	29 In-class assignment 3 (6%)	30 Good Friday	31

APRIL 2018

SUN	MON	TUES	WED	THUR	FRI	SAT
1	2 Lab 5	3	4	5	6	7
8	9 Check out	10	11	12	13 Lectures End	15
16	17	18	19	20	21	22
23	24	25	26			

Department Approval: Approved by Department Head Date: January 4th, 2018