FACULTY OF SCIENCE — Department of Chemistry
Chemistry 209 – General Chemistry for Engineers
Fall 2016

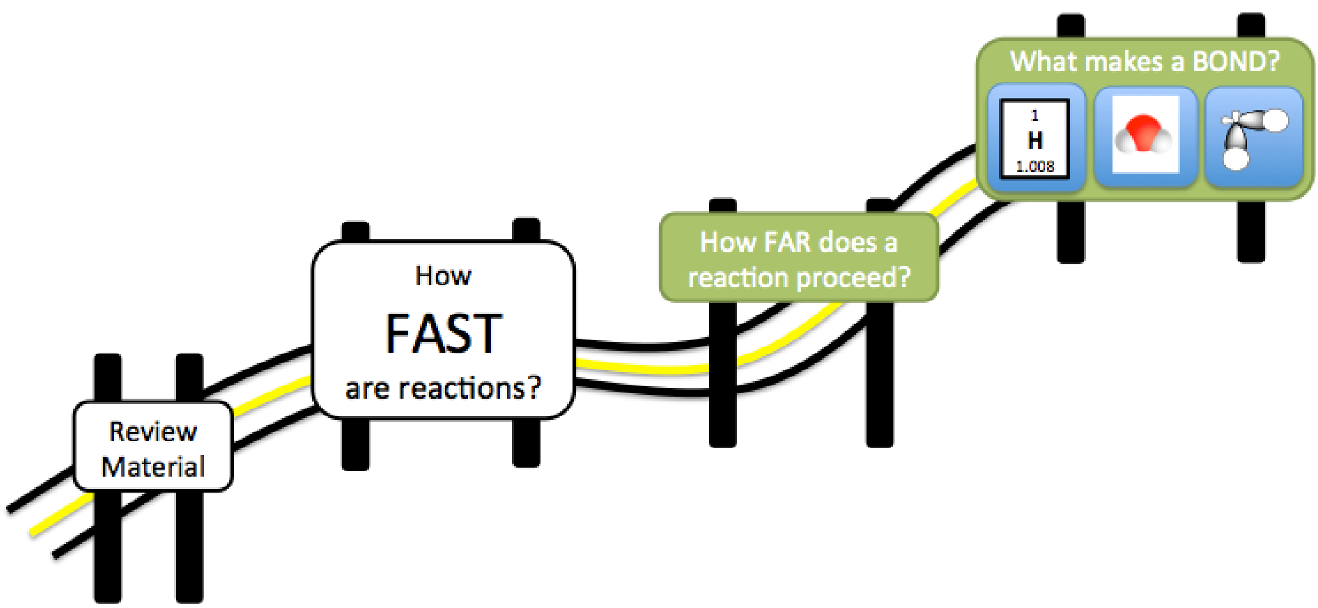
Overview

General Chemistry for Engineers is a required course offered by the Department of Chemistry for Schulich School of Engineering students. The overarching goal of this class is to help you develop your understanding of chemical concepts. By the end of this course, as a "chemically literate" engineer, you will be knowledgeable about the basic chemical principles you encounter in your career and be better able to satisfy your curiosity about the chemical problems solved by engineers.

Aims

During this course, you will develop an understanding of three Big Ideas in Chemistry:

	Essential Questions
How FAST are reactions?	What affects reaction speed? How can we depict reaction speed with symbols? How can we explain reaction speeds at the molecular level? How is reaction speed important to engineers?
How FAR does a reaction proceed?	What affects reaction extent? How can we depict reaction extent with symbols? How can we explain reaction extent at the molecular level? For our key examples (acids & bases, buffers & solubility, electrochemistry), how do different reactions behave? How is reaction extent important to engineers?
What makes a BOND?	How can we depict the electronic structure of an atom or ion? How can we depict the electronic structure of a molecule or polyatomic ion? How can we explain properties and shapes using electronic structure? Why is an understanding of bonding important to engineers?



Specific Learning Objectives:

By the end of the course, you will learn about the KEY CONCEPTS outlined in the tables below. To meet these objectives, you will develop the ESSENTIAL SKILLS also included in the tables. Suggested problems and readings from the textbook are linked for each skill (all references are to Silberberg et al. *Chemistry: The Molecular Nature of Matter and* Change, 2nd Canadian Edition).

Big Idea: How FAST are reactions?

KEY CONCEPTS	ESSENTIAL SKILLS	TEXTBOOK READINGS:	TEXTBOOK QUESTIONS:
Chemical reactions occur at certain speeds.	✓ Qualitatively *describe* what the speed of a reaction depends upon.	14.1	Chapter 14: 3, 5
The speed of a reaction is measured by looking at concentration changes over time.	✓ *Determine* the instantaneous and average rate of reaction from experimental data.	14.2	12, 14, 18
	✓ *Generate* plots of concentration versus time for the chemical species of a reaction.	14.2	10
	✓ *Relate* reactant concentration to instantaneous reaction rates using rate laws.	14.3	32 Sample 14.2
	✓ Given experimental data, quantitatively *determine* the components of a rate law (*k* and order), using the method of initial rates.	14.3	34 Sample 14.4
	✓ *Use* integrated rate laws to *determine* the amount of product produced (or reactant remaining) at any given point within a reaction and *determine* the half-life of a reaction.	14.4	43, 45, 125
The speed of a reaction depends on a reactions mechanism.	✓ *Determine* the rate law given the mechanism of a reaction, and vice versa - for reactions with a slow first step.	14.5 14.6	~~72~~, 83
	✓ *Draw* and *interpret* a reaction energy diagram for a given reaction.	14.5 14.6	64 Sample 14.9
The speed of a reaction can be altered by changing temperature.	✓ *Determine* the effect of changing temperature on rate and activation energy.	14.5	59 Sample 14.8
The speed of a reaction can be altered by the use of a catalyst.	✓ Explain how reaction speed can be modified using a catalyst	14.7	77, 78

Big Idea: How FAR does a reaction proceed?

Key concepts	Essential Skills	Textbook Readings:	Textbook Questions:
Chemical reactions are dynamic equilibria.	✓ Qualitatively *describe* chemical equilibrium.	15.1	Chapter 15: 1
The equilibrium, or extent of a reaction, is described by an equilibrium constant, K.	✓ *Generate* and *manipulate* expressions for K and Q for reactions using concentrations or partial pressures, based on a given reaction or set of related reactions.	15.2 15.3	14, 16, 18, 20, 27, 29, 81,
	✓ *Determine* the direction in which a reaction will proceed using values of K and Q.	15.4	35 Sample 15.6
	✓ *Determine* either K, initial concentration, or equilibrium concentration, given the other two values.	15.5	41, 45, 51, 84, 87
Equilibria can be disturbed.	✓ *Describe* (qualitatively and quantitatively) the effect of changes in concentration, partial pressures, and volume on equilibrium.	15.6	63, 76, 84, 87
Equilibria can be altered.	✓ *Describe* (qualitatively and quantitatively) the effect of changes in temperature on equilibrium.	15.6	59, 105, 109
Acid and base solutions are equilibrium systems.	✓ *Identify* and *describe* solutions of acids and bases using K_a, pH, and pOH. (review material)	16.1	Chapter 16: 17, 23, 35, 37, 44, 49, 55
The key concepts of equilibria explain how buffers control the acidity (pH) of solutions.	✓ *Describe* (quantitatively and qualitatively) the relationship between the K_a of an acid, the K_b of its conjugate base, and K_w for the auto-ionization of water.	16.2 16.3	58 Sample 16.11
	✓ *Relate* K_a and pH to the equilibrium concentrations of all species present in a monoprotic acid or base solution.	16.4	74, 80, 86, 92, 102
	✓ *Compare* the relative strengths of acids or bases using pH, pK_a, pK_b, and % dissociation	16.1 16.2	96 Sample 16.10
	✓ *Predict* the relative pH of a salt solution.	16.6	119 Sample 16.13
	✓ *Identify* buffers and d*escribe* how to prepare buffers using a weak acid or base and its conjugate.	17.1	Chapter 17: 116
	✓ *Calculate* the pH of a buffer using the Henderson-Hasselbalch equation.	17.1	15, 19,
	✓ *Calculate* the pH of a buffer after the addition of strong acid or base.	17.1	7, 27, 31, 58, 60
	✓ *Interpret* titration curves and *calculate* the pH of a titration at any point along the curve.	17.2	46, 58, 60, 156

KEY CONCEPTS	ESSENTIAL SKILLS	TEXTBOOK READINGS:	TEXTBOOK QUESTIONS:
	✓ *Describe* buffers using buffer range and buffer capacity.		
The key concepts of equilibria explain the solubility of salts.	✓ *Generate* expressions for K_{sp} and Q_{sp}, and use them to describe the saturation of a salt solution.	17.3	4, 119
	✓ *Calculate* solubility from K_{sp}, and vice versa.	17.3	79, 89
	✓ *Describe* how solubility is affected by a common ion, a change in pH, or formation of a complex.	17.3	85, 110
The key concepts of equilibria explain electrochemical processes.	✓ *Write* balanced reactions and half-reactions for redox reactions, and identify half-reactions as reduction or oxidation. (review material)	19.1	Chapter 19: 3, 10, 12, 14, 21
	✓ *Describe* voltaic and electrolytic cells, graphically or using cell notation.	19.2	27, 29, 78
	✓ *Calculate* E^o_{cell} for a given reaction using tabulated half-cell data, and use it to predict reaction spontaneity.	19.3	38, 42
	✓ *Calculate* E_{cell} using the Nernst equation.	19.4	53, 121
	✓ *Describe*, qualitatively and quantitatively, the relationship between the equilibrium constant and cell potential.	19.4	56, 70, 121
	✓ *Distinguish* between electrolytic and voltaic/galvanic processes, and predict the products of each type of reaction.	19.2 19.7	87, 89
	✓ *Identify* corrosion conditions and sacrificial anodes.	19.6	81
	✓ *Explain* how batteries and fuel cells use redox reactions to store electrical energy.	19.5	111

Big Idea: What makes a BOND?

KEY CONCEPTS	ESSENTIAL SKILLS	TEXTBOOK READINGS:	TEXTBOOK QUESTIONS:
The electronic structure of atoms explains atomic properties.	✓ *Recognize* atomic orbital shapes (*s, p* and *d*) and *predict* their relative energies.	6.4	49, 53
	✓ *Write* electron configurations (full and condensed) and orbital diagrams for *s* & *p*-block elements with $Z \leq 54$.	7.1 7.2	Chapter 7: 25, 37
	✓ *Identify* paramagnetic and diamagnetic elements from their electron configurations.	7.4	77
	✓ *Relate* electron configurations to periodic trends in atomic/ionic radius, ionization energy, and electron affinity.	7.3	9, 18, 50, 53, 59, 83
Atomic properties can be used to predict the type and organization of bonds in a molecule.	✓ Use periodic trends and electronegativity to *predict* the nature of bonding in chemical species.	8.1 8.4 8.5	Chapter 8: 6, 58, 60, 64
	✓ *Explain* how the type of bonding that characterizes a substance affects its physical and chemical properties.	8.2 8.3 8.7	97
	✓ *Draw* Lewis structures for atoms, molecules and ions that minimize formal charges and/or follow the octet rule	8.6	10, 69, 71, 73, 79, 89
	✓ *Identify* trends in covalent bond strength.	8.4	39, 132
Chemical properties are determined by atomic and molecular structures.	✓ *Draw* VSEPR structures for molecules and polyatomic ions and *name* each electron-group and molecular geometry.	9.1	Chapter 9: 6, 8, 14, 16, 20, 25, 37
	✓ *Assign* bond polarity and overall molecular polarity.	9.2	31, 45, 47 (& 8.60, 8.64)
	✓ *Explain* how overlapping atomic orbitals result in covalent bond formation, using valence bond theory.	8.3 10.1 10.2	Chapter 10: 20, 40(a,b)
	✓ *Identify* the hybridization of atoms in molecules and polyatomic ions. (s, sp, sp^2, sp^3 only)	10.1	1(a,c,d), 7, 13, 21, 44(a,c,e)