1. COURSE: CHEMISTRY 409, Applied Chemistry and Chemical Pathways for Engineers

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<td>8:00-9:15</td>
<td>ICT121</td>
<td>Dr. Ashley Causton</td>
<td>SA 144A</td>
<td>403-210-3968</td>
<td><a href="mailto:acauston@ucalgary.ca">acauston@ucalgary.ca</a></td>
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To avoid IT problems, it is recommended that the students use their U of C account for all course correspondence. Please use “CHEM 409” in the Subject of your e-mail.

Desire 2 Learn (D2L) Site: CHEM 409 L01 - (Fall 2019) - Appl Chem & Chem Path For Engg

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2. Course Description: Analysis of industrial chemical processes based on reaction pathways to infer system performance including co-product formation and the role of catalysts. Examples from oil, gas, coal and petrochemical processing.


4. Topics Covered:
   Introduction to the Chemical Industry

   Sources of raw materials:
   - Application of phase and phase change to purify/separate raw materials
     - e.g. Frasch process for mining sulfur
     - e.g. Claude process for distillation of air to produce nitrogen, oxygen and argon

   Processes in the Oil Refinery
   - Petroleum Refining:
     - Simple purification
       - H₂S removal from crude oil (Acid-Base Chemistry)
       - Distillation (purification by phase change)
     - Pyrolysis – bond strength and understanding radical reactions
     - Catalytic Cracking – understanding carbocationic reactions
       - Elimination
       - Substitution (and polymerization)
       - Rearrangement

   Production of Light Alkenes
   - Thermodynamics and kinetics

   Production of Synthesis Gas
Inorganic Bulk Chemicals
- General Considerations in the Design of an Industrial Chemical Process:
  - Green Chemistry
  - Reaction Thermodynamics (equilibria – application of LeChatelier’s principle in industry)
  - Reaction Kinetics (activation energy)
    - The Contact Process for sulfuric acid production
    - Synthesis of ammonia
    - Synthesis of nitric acid
- Electrochemistry:
  - Definitions of oxidation and reduction
  - Direct and indirect redox processes
  - Basic electrochemical cell
    - Corrosion
  - Balancing redox equations
  - Standard cell potential
  - Electrolysis (active and passive electrodes)
    - Production of Cl₂, NaOH (and H₂) from NaCl(aq.)
- Acid-Base Chemistry:
  - Three definitions of acid and base
  - Fundamental concepts (on an atomic level) that determine acid-base properties of compounds
    - Ammonium Nitrate and Ammonium Sulfate
- Catalysts:
  - General Introduction – Activity / Selectivity / Stability
  - Heterogeneous – Mechanisms, Physical adsorption, chemisorption
    - Hydrogenation
    - Zeolites (uses as water softeners and catalytic cracking)
  - Homogenous – Mechanisms, 16/18 electron rule
    - Monsanto Acetic Acid Process
- Polymer Chemistry:
  - Nucleophilic alkyl and acyl substitution (and potential side reactions)
    - Polyurethane
    - Epoxy resins
  - Thermoplastics and thermosets
  - Chain growth and step growth polymerization
  - How chemical structure of a polymer relates to its bulk properties
    - Kevlar versus Nylon
- Selected Topics
  - Reactions of Arenes:
    - Benzene structure
    - Electrophilic Aromatic Substitution (and ways of generating the carbocation)
      - The Cumene Process (and a mechanistic explanation of the associated side reactions)
      - BHT synthesis
      - Bisphenol A synthesis
  - Corrosion and Corrosion Control
  - Fouling and fouling control
  - Biotechnology
  - Process Development

Department Approval: Electronically Approved Date September 3, 2019