

**UNIVERSITY OF CALGARY  
FACULTY OF SCIENCE  
DEPARTMENT OF CHEMISTRY  
COURSE SYLLABUS  
Fall 2017**

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

LEC	DAYS	TIME	ROOM	INSTRUCTOR	OFFICE	PHONE	EMAIL	OFFICE HOURS
L01	TR	8:00-9:15	ST135	Dr. Ashley Causton	SA 144A	210-3968	<a href="mailto:acauston@ucalgary.ca">acauston@ucalgary.ca</a>	TBA

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 2017) - Appl Chem & Chem Path For Engg

Departmental Office: Room SA 229, Tel: (403) 220-5341, e-mail: [chem.undergrad@ucalgary.ca](mailto:chem.undergrad@ucalgary.ca)

- 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.
- 3. Recommended Textbook:** "Chemical Process Technology, 2nd Edition" by Jacob A. Moulijn, Michiel Makkee, Annelies E. van Diepen. ISBN: 978-1-4443-2025-1

**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
    - H<sub>2</sub>S 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**

## Bulk Chemicals and Synthetic Fuels Derived from 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 Cl<sub>2</sub>, NaOH (and H<sub>2</sub>) 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