KFE 331/3 - Special Topics in Physical Chemistry - Fundamentals of Adsorption and Catalysis

Course objectives:
This course covers concepts on adsorption as well as the principles of homogeneous and heterogeneous catalysis. It also introduces the kinetic models for catalysis, gives insight on various characterization techniques available to investigate the properties of catalysts as well as recent developments in catalysis research.

Topic	Content	Number of lecture hours	Expected outcome – upon completion of these topics, the student should be able to
1. Adsorption	• Definitions, types of adsorption, classification of adsorption isotherms, adsorption models, adsorption measurements	7	• Define and differentiate between absorption and adsorption. • Differentiate between physisorption and chemisorption. • Classify the types of porosity. • Use Freundlich, Langmuir, BET, Henry, Temkin and Polanyi adsorption isotherm models to describe the adsorption process. • Classify adsorption isotherms in porous media according to IUPAC standard. • Describe how hysteresis loop occurs in adsorption-desorption isotherm curves. • Calculate the surface textural properties such as BET surface area, Langmuir surface area, pore volume, pore size, etc.
2. Homogeneous catalysis	• Acid base catalysts • Organometallic catalysts • Enzyme catalysts	2	• Differentiate and discuss the types of homogeneous catalysts. • Discuss the application of homogeneous catalysts in various industries.
3.Heterogeneous catalysis	• Definitions, types of solid catalysts, catalyst supports, preparation of solid catalysts.	9	• Define the meaning of catalyst. • Classify the types of heterogeneous catalysts • Describe the difference between unsupported and supported catalysts. • Describe several porous supports such as amorphous silica, alumina, zeolite, mesoporous silica, activated carbon, carbon nanotubes and metal organic framework.

4. Kinetics in catalysis	• Reaction rates • Activation energy • Rate laws • Langmuir adsorption expressions • Kinetic models in heterogeneous catalysis	8	• Understand how catalysts influence the rate, activation barrier etc. • Apply rate laws for homogeneous catalytic reactions: acid-base and enzyme catalysis • Derive the Langmuir adsorption expressions for non-competitive and competitive adsorptions, molecular and dissociative adsorptions. • Understand process in heterogeneous catalytic reaction • Know unimolecular processes on Langmuir type surfaces • Discuss bimolecular processes on Langmuir type surfaces. The Langmuir-Hinshelwood and Eley-Rideal mechanisms
5. Physical characterization techniques	• Basic theory and application of various instruments required for characterization of catalysts. • XRD, EM, TPD, FTIR, XPS, Raman Spectroscopy etc.	7	• Identify the different types of instruments relevant for catalysts characterization. • Discuss the basic theory for instruments. • Recognize how different instruments can provide various information on the characteristics of a catalyst.
6. Current developement in catalysis	• Nanoscience in catalysis	3	• Discuss the significance of nanoscience in catalysis • Apply various techniques to synthesize nano-catalysts. • To discuss the potential of nano-catalysts in industries.
	TOTAL	36	