KIE 232/3 - Colloids and Surface Science

Course Objectives :

1) To introduce the behavior of different kinds of surfaces and, in particular, the nature of adsorption.
2) To study the thermodynamics and statistical mechanics of adsorption, and the mechanisms of chemical reactions at surfaces.
3) To introduce the properties of colloids.
4) To introduce experimental techniques for the investigation of solid surfaces.

Topic	Content	Number of lecture hours	Expected outcome – upon completion of this course, the student should be able to:
1. Introduction to Colloids Chemistry	• Some historical aspects of colloid science • Occurrence and nature of colloids with reference to some examples • General and specific features leading to classification of colloidal systems • Basic properties of colloids • Thermodynamics of surface formation; work of separation, surface free energy, surface tension, free energy of attraction and repulsion, total free energy curves • Surface molecular and bulk interaction, origin of attractive and repulsive forces, Van der Waals, London, and Born interactions, Leonard-Jones potential curve, Hamaker constant, factors affecting medium-dispersed phase interaction • Colloidal stability; origins of repulsive forces in electrostatic and sterically hindered systems, criteria of stability and factors that control stability.	10	• Articulate some key historic developments, benefits and applications. • Differentiate the fundamental features of colloids from solution and suspension. • Comprehend the origin of attractive and repulsive forces governing colloidal stability. • Relate work of a separation process to free surface energy of the surface formed, its surface tension, dependence on surface distance, interaction with dispersing medium and free energy of attraction curves. • Apply Leonard-Jones potential and Hamaker expression and effect of intervening dispersing media to explain the origin of surface attractive forces at molecular and macroscopic levels. • Apply electric double layer theory to explain the origin of surface repulsive forces of charged particles in electrolyte solutions. • Apply the osmotic and entropic effects to explain surface-modified particles in an intervening medium.

Topic	Content	Number of lecture hours	Expected outcome – upon completion of this course, the student should be able to:
	• Charged particles in an electrolyte; types of charged surfaces and mechanism of formation, discussion of electric field, electrical potential, concentration of charges in the electrolyte using combined Boltzmann and electrical potential expression, electric double-layer formation, effect of electrolyte concentration. • Surface modified particles (core-shell type) in dispersing medium; origin of a repulsive force, osmotic and entropic effects, magnitude and dependence on nature and density of shell materials.		
2. Introduction: Physisorption and chemisorption	• Definition of Physi- and Chemisorptions	2	• Understand the concept of physical and chemical adsorption and differentiate between them.
3. Types of Isotherms and Its Pores	• Methods of adsorption measurements • Analysis of adsorption data • Interpretation of isotherms	2	• Measure and obtain adsorption data from gravimetric or volumetric methods. • Determine the porosity of solids and pore structures.
4. Surface Tension and Surface Forces	• Discussion of forces involved in physical adsorption	2	• Understand the concept of forces involved in the adsorption.
5. Adsorbents	• Porous and non-porous	2	• Know the different types of adsorbents and their formations.
6. Theories of Adsorption	• Application of adsorption theory in the determination of solid surface properties	2	• Formulate the equation and its applications in determining the surface properties of a solid.
7. Heat of Adsorption	• Interpretation of heat plots	2	• Determine the heat of adsorption and understand the surface properties of solids.
8. Surface Analysis: Introduction	• Fundamental concept of surface analysis • The importance of surface analysis in industry • Basic principles and modes of analysis	1	• Understand the concepts of surface analysis and the importance of various techniques and modes of analysis in industry. • Understand the basic principles and criteria for surface analysis.

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9. Electron-Specimen Interaction	• Electron - specimen interaction: Transmitted, secondary, Auger and backscattered electrons; X-ray and cathodoluminescence; elastically and inelastically scattered electrons • Specimen interaction volume • Techniques of analysis of respective signals	1	• Differentiate among various types of signals emitted from an electron-specimen interaction and the respective techniques of analysis. • Discuss the various factors affecting the interaction volume and identify the area that produces a specific signal for analysis.
10. Scanning Electron Microscopy (SEM)	• Basic principles and the features of SEM • Instrumentation, electron source, ray diagrams and electron detector (SSD) • Resolving power and image resolution • Specimen damage • Energy dispersive spectrometer (EDS): principles, detection and interpretation of the spectrum • Sample preparation • Comparison of SEM and light microscopy	2	• Understand the basic concept of SEM and image formation. • Understand resolving power and image resolution. • Understand production and detection of X-Rays in SEM. • Interpret EDS spectrum for compositional analysis. • Discuss specimen preparation.
11. Transmission Electron Microscopy (TEM)	• Basic principles and the features of TEM. • Image formation and resolution • Electron diffraction and determination structure of materials • Sample preparation	1	• Understand the basic principles of TEM and the image formation. • Interpret electron diffraction patterns for structural determination. • Understand the criteria of sample preparation for analysis.
12. Electron Probe Microanalysis (EPMA)	• Basic principles of EPMA and instrumentation • Production and detection of X-Ray • Interpretation of EPMA spectrum • Comparison between SEM-WDS and EPMA • X-Ray imaging and mapping • The features of EPMA	1	• Understand the basic principles of EPMA. • Distinguish between the types of X-Ray detector used in EPMA and SEM-EDS. • Discuss the advantages and disadvantages of WDS and SSD detectors. • Interpret the EPMA spectrum. • Distinguish clearly between the X-Ray analysis in SEM-EDS and EPMA.

Topic	**Content**	**Number of lecture hours**	**Expected outcome – upon completion of this course, the student should be able to:**
13. Auger Electron Spectroscopy (AES)	• Production and transition of Auger electron • Basic principles of AES, instrumentation and spectrum • Interpretation of AES spectrum • Thickness profile analysis • The features of AES	1	• Understand the formation, transition state and energy of Auger electron. • Understand the basic principles of AES. • Interpret the AES spectrum. • Discuss the advantages and disadvantages of AES in surface analysis.
14. X-Ray Photospectroscopy (XPS) or Electron Spectroscopy for Chemical Analysis (ESCA)	• X-Ray – specimen interaction • Basic principles and instrumentation of XPS • Electron energy detector • Interpretation of XPS spectrum • Chemical shift and molecular structure determination • XPS images and elemental mapping • The features of XPS	2	• Understand the interaction between X-Ray with specimens and identify the signal for XPS analysis. • Interpret XPS spectrum. • Discuss chemical shift in relation with molecular structure. • Discuss the advantages and disadvantages of XPS in surface analysis.
15. Secondary Ion Mass Spectroscopy (SIMS)	• Ion – specimen interaction • Basic principles and instrumentation of SIMS • Detector and mass spectrum for ion, molecule and isotope • Static and dynamic SIMS • Depth profiling analysis of SIMS • The features of SIMS	2	• Discuss the various signals emitted during the interaction of ions with specimens. • Understand the basic principles of SIMS. • Interpret the SIMS spectrum. • Discuss the depth profiling analysis by means of SIMS. • Distinguish between static and dynamic SIMS analyses.
16. Atomic Force Microscopy (AFM)	• Basic principles and instrumentation of AFM • Production of images • Mode of AFM analysis • Image resolution • The features of AFM	1	• Understand the basic principles of AFM. • Discuss the modes of analysis within AFM. • Discuss the advantages and disadvantages of AFM in surface analysis.
TOTAL		**34**	