Name of the Programme: M. Sc -I (Physical Chemistry)

Course Code: CHP-504 **Title of the course:** Electrochemistry and Surface Studies

Number of Credits: 04

Effective from AY: 2022-23

<table>
<tr><td>Prerequisites for the course:</td><td colspan="2">Students should have studied physical chemistry courses at M.Sc. Chemistry in semester I</td></tr>
<tr><td>Course Objective:</td><td colspan="2">1. To introduce some core concepts of electrochemical processes including ionic interaction theories, electrified interfaces, electrochemical kinetics and thermodynamics
2. To develop problem solving skills in electrochemistry
3. To introduce fundamental concepts and applications of electrochemistry in day-today life eg. batteries, solar cells, capacitors</td></tr>
<tr><td rowspan="3">Content</td><td>1. Ionic Interactions and Conductance in Electrolytes
a. Ion-solvent interactions. Born Theory, validity and limitations.
b. Solvation number and coordination number.
c. Ion-ion interactions and Debye-Huckel theory of ion cloud.
d. Applications of Debye- Huckel equation. Concept of ionic strength and activity coefficient.
e. Debye-Huckel limiting law and its modifications.
f. Debye-Huckel-Onsager equation, validity and limitations.
g. Einstein-Smoluchowski equation.
h. Influence of ionic atmospheres on ionic migration: Relaxation and Electrophoretic effects.
i. Conductance in strong and weak electrolytes.</td><td>No of hours

10</td></tr>
<tr><td>2. Electrified Interfaces
a. Formation of an electrode/electrolyte interface and its structure.
b. Polarizable and non-polarizable interfaces.
c. Potential difference across electrical double layer: outer potential, surface potential, inner potential and relationship between them, chemical and electrochemical potentials.
d. Thermodynamics of electrified interface: Surface tension, surface excess, Electro-capillary curves. Determination of surface excess. Condition for thermodynamic equilibrium at electrified interface.
e. Generalized Gibbs equation, Lippmann equation and electrical capacitance at the double layer.
f. Models of the electrified interface.
g. Ion adsorption at the electrode: hydrated electrodes, contact adsorption, Gibbs adsorption equation.</td><td>10</td></tr>
<tr><td>3. Pure Liquid Electrolytes: Ionic Liquids
a. Thermal loosening of ionic lattice.</td><td>8</td></tr>
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	b. Ionic liquids in surface electrochemistry: Electrode/electrolyte interfacial processes in ionic liquids. c. Electrochemistry of Ti (IV) in Ionic liquids.	
	4. Electrode Kinetics and Corrosion a. Disturbance of electrode equilibrium, cause of electron transfer, fast and slow systems and their current-potential relationship. b. Butler-Volmer equation and its low and high field approximations. c. Nernst equation as a special case of B-V equation. d. Tafel plots for anodic and cathodic processes. e. Fundamentals of Impedance spectroscopy; determining exchange current densities and rate constants from impedance plots. f. Principles of corrosion, electrochemical methods of avoiding corrosion. g. pH-potential diagrams: Pourbaix diagram for corrosion of iron and stability of water.	12
	5. Colloidal Chemistry a. Interaction of double layers and stability of Sols. DLVO theory. b. Colloidal electrolytes, critical micelle concentration, Kraft temperature. c. Electrokinetic phenomena: Electroosmosis, streaming potential and current, electrophoresis. Zeta potential. d. Donnan membrane equilibria. e. Micellesandreversemicelles, Emulsions and Microemulsions.	8
	6. Electrochemical Energies: Conversion and Storage a. Thermodynamics of electrochemical energy conversion. b. Batteries: Basic principles; rating and shelf life. Zinc-Manganese dioxide: Leclanche and alkaline batteries. Lithium ion batteries and recharge ability. c. Fuel cells: Principle of a hydrogen-oxygen fuel cell. Classification of fuel cell systems based on types of electrolytes/temperature. Efficiency w.r.t. thermodynamic efficiency, reliability and economic benefits. Direct methanol-polymer electrolyte fuel cell and electro-catalysts - a case study. Reactions occurring in various fuel cells and calculation of their electrode and cell potentials. d. Super-capacitors: Introduction: Origin of Supercapacitance.	7
	7. Photoelectrochemistry a. Semiconductor/Electrolyte Interface: Band edge and Band bending. b. Light absorption and carrier generation at the electrode: photoinduced charge transfer, hot carriers. c. Photoelectrodes: p-type photocathode, n-type photoanode. d. Determination of surface states. e. Photoelectrocatalysis: photoelectrochemical water splitting and CO_2 reduction. f. Types of photoelectrochemical devices.	5

Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.
References / Readings	1. J. O. M. Bockris &A. K. N. Reddy, Modern Electrochemistry, Springer India, Pvt.Ltd, 2000, Vol.1,2and3. 2. D. Crow, Principles and Applications of Electrochemistry, Blackie Academy and Professional, 1994. 3. C. M. A. Brett & A. M. O. Brett, Electrochemistry: Principles, methods and applications, Oxford, NewYork Oxford University Press, 1993. 4. R. D. Vold & M. J. Vold, Colloid and Interface Chemistry, Addison-Wesley, 1983. 5. A. Vincent & B. Sacrosati, Modern Batteries, John Wiley, NewYork,1997. 6. J. O. M. Bockris & S. Srinivasan, Fuelcells: Their Electrochemistry, McGraw-HillBook Co., 1969. 7. A. A. J. Torriero, Electrochemistry in Ionic Liquids, Vol. 1: Fundamentals, Springer International Publishing, 2015 8. B. A.J., Stratmann M., Licht D, Encyclopedia of Electrochemistry, Semiconductor Electrodes and Photoelectrochemistry, Wiley-VCH, 2002.
Course outcomes:	1. Students will be in a position to explain various fundamental and core concepts of electrochemistry. 2. Students should be in a position to apply the knowledge of electrochemistry for their dissertation and research work 3. Students should be in a position to apply these concepts during the lab course in physical chemistry 4. Students will be able to explain the concepts of Photoelectrochemistry.