

SEMESTER V**CHE-301-MJ-T: PHYSICAL CHEMISTRY II****Course Type: Major Theory****Credits: 2****A. Course Objectives:**

1. To provide fundamental knowledge of electrochemistry, nuclear chemistry, and quantum chemistry.
2. To develop conceptual understanding of energy transformations and atomic-level phenomena.
3. To familiarize students with electrode potentials, radioactivity, and quantum models.
4. To build a strong foundation in theoretical approaches of physical chemistry.
5. To promote insight into modern chemical and energy-related systems.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) <i>After learning the course, the students are able to -</i>
CO-1	Recall basic concepts of electrochemistry, nuclear chemistry, and quantum chemistry.
CO-2	Explain principles of electrochemical cells, radioactive decay, and quantum models.
CO-3	Apply Nernst equation, decay laws, and quantum models to solve problems.
CO-4	Analyze electrochemical systems, nuclear processes, and quantum models.
CO-5	Evaluate applications of batteries, radioisotopes, and quantum concepts.
CO-6	Formulate solutions using electrochemical, nuclear, and quantum principles.

C. Contents:

Prerequisites	
Students should have a basic understanding of physical chemistry concepts such as thermodynamics, chemical equilibrium, and atomic structure from undergraduate level. Familiarity with elementary mathematics (logarithmic and exponential relations) and basic theoretical concepts of chemistry is required.	
Chapter 1: Electrochemical Cells	10 Hours
Electrochemical cells: concept, construction, working. Reversible and irreversible cells. Electromotive force (e.m.f.) and its measurement. Reference electrodes: Standard Hydrogen Electrode (SHE), Calomel, Ag/AgCl electrode. Weston standard cell (historical mention).	

Nernst equation for electrode potential and cell e.m.f. Sign convention, cell representation. Thermodynamics of reversible cells: Relationship between E , ΔG , and K . Electrochemical series and applications. Concentration cells, liquid junction potential, salt bridge. Applications: pH determination (Hydrogen & Glass electrode). Potentiometric titrations (Acid-base & Redox). Batteries: Primary and Secondary types, applications. Fuel cells: Types, principle, advantages, limitations. Comparison of batteries and fuel cells.

Chapter 2: Nuclear Chemistry**10 Hours**

Radioactivity: Types (α , β , γ) and properties of radiations. Detection & Measurement: Geiger-Muller Counter, Scintillation Counter, Ionization Chamber, Film Badges. Nuclear structure. Classification of nuclides (Isotopes, Isobars, Isotones, Isomers). Radioactive decay processes, Group Displacement Law. Kinetics of decay: Decay constant, half-life, average life. Nuclear energy: Mass defect, Binding energy. Applications of radioisotopes as tracers: Chemical investigation (Esterification, Friedel-Crafts), Structural determination (PCl_5), Age determination (Tritium, C-14 dating).

Chapter 3: Quantum Chemistry**10 Hours**

Introduction: Need for quantum mechanics. Recapitulation: de Broglie hypothesis, Heisenberg's uncertainty principle. Postulates of quantum mechanics, operators, and observables. Time-independent Schrödinger wave equation, conditions for a well-behaved wave function. Particle in a 1-D box (derivation), 2-D and 3-D box (concept). Physical interpretation of ψ and ψ^2 , sketching for 1-D box. Degeneracy. Applications to conjugated systems. Vibrating particle: vibrational energy levels, zero-point energy, concept of quantum tunneling. Numerical.

References:

1. Principles of Physical Chemistry, B. R. Puri, L. R. Sharma, M. S. Pathania, Vishal Publishing Co., 50th Edition, 2025
2. Essentials of Physical Chemistry, B. S. Bahl, G. D. Tuli, Arun Bahl, S. Chand & Company Ltd., 28th Edition, 2022
3. Elements of Nuclear Chemistry, H. J. Arnikar, S. Chand & Company Ltd., 4th Edition, 2009
4. Modern Electrochemistry, Volume 2, J. O'M. Bockris, A. K. N. Reddy, Plenum Press (Springer), 2nd Edition, 2000
5. Physical Chemistry, Peter Atkins, Julio de Paula, Oxford University Press, 11th Edition, 2018