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

Course Code: CHP-621 **Title of the course:** Solid State Chemistry: Concepts and Applications

Number of Credits: 4

Effective from AY: 2023-24

Prerequisites for the course:	Students should have studied the chemistry/physics courses at M.Sc. Part-I	
Course Objective:	1.To introduce concepts and provide fundamental knowledge of principles of materials chemistry, characterization methods and techniques 2. To provide fundamental knowledge of molecular solids, description of crystal chemistry and classification of phase structure and significance of imperfections in solids. 3. To provide basic understanding of temperature dependence of crystal structure, phase modifications and its influence on magnetic and electronic properties of materials 4. To provide a comparative evaluation of data obtained from various techniques and their use in elucidating the chemical and morphological structure of solid materials	
Content	**1. Solid State: Introduction** General Principles and experimental procedure. Various methods in solid-state synthesis c. Kinetics of solid-state reactions, ion exchange, and intercalation reactions.	No of hours 6
	2. Crystal Chemistry and X-Ray Diffraction: a. Crystal systems, Bravais lattices and Quasicrystals. b. Ionic structures and covalent networks. c. Some important structure types –rock salt, zinc blende, wurtzite, nickel arsenide, rutile, and van der Waals heterostructures. d. Factors that Influence Crystal Structures: valences and coordination numbers. e. Significance of radius ratio rule and non-bonding electron effects. f. Powder X-ray diffraction experiment, instrumentation g. Introduction to single-crystal X-ray diffraction. Applications of high-temperature powder diffraction. h. Identification of crystal phases and evaluation of lattice characteristics	15
	3. Crystal Defects and non-stoichiometry a. Types of defects. Point defects and thermodynamics.	6

	b. Colour Centres, vacancies, and interstitials in non-stoichiometric crystals. c. Dislocations, mechanical properties, and reactivity of solids	
	4. Phase Diagrams and Phase Transitions a. Basic Concepts and definitions. b. Three-component condensed systems. Martensitic transformations. Order-disorder transitions.	6
	5. Electronic Properties and Band Theory a. Electronic structure and band theory of solids. Band structure of metals and semiconductors. b. Magnetic properties of transition metal oxides and applications Electrical conductivity, free electron theory, fermi energy, insulators, semiconductor and conductors, band theory of semiconductor, Brilliouin zones, Hall effect, the Seebeck effect, Superconductivity, BCS theory, Meissner effect, high temperature superconductor.	6
	6. Electronic Microscopic Techniques a. Introduction to Electron Microscopy: Generation of electron beam, elastic and inelastic scattering of electrons by atoms. b. Scanning Electron Microscopy (SEM): Instrumentation, optics, resolution and compositional imagining, Preparation of specimen, crystallographic information from SEM and Environmental Scanning Electron Microscopy (E-SEM) c. High Resolution Transmission Electron Microscopy (HR-TEM): Instrumentation, contrast mechanism, high voltage and Scanning Transmission Electron microscopy (STEM), preparation of specimen and data interpretation. d. Cryogenic Electron Microscopy (Cryo-TEM)	8
	7. X-Ray Spectroscopy a. Intensities: scattering of X-Rays and factors that affect intensities, powder x-ray pattern b. XRF, X-ray absorption near edge structure (XANES) and extended x-ray absorption fine structure (EXAFS): Absorption coefficient, absorption edges, resonance emission, extended absorption and photoelectron scattering. c. X-ray photoelectron spectroscopy (XPS): Surface analysis, sensitivity and specificity, photoelectron intensities, binding energies and spectra analysis c. Instrumentation and design, characterization of transition metal oxides.	8
	8. Thermal Analysis a. Thermogravimetric analysis, Differential Thermal Analysis b. Differential scanning calorimetry	5

	c. Application to the characterization of materials	
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	A. R. West, Solid State Chemistry and Its Applications, John Wiley & Sons 2003. H. V. Keer, Principles of the Solid State, New Age International Publishers, 1993. C. N. Banwell, E. M. McCash, Fundamentals of Molecular Spectroscopy, McGraw-Hill Education (India) Private Limited, 1994 P. van der Heide, X-ray Photoelectron Spectroscopy: An Introduction to Principles and Practices, John Wiley & Sons, Inc. 2012	
Course Outcome:	1. Students will be in a position to explain the concept of solid state synthesis, identify different crystal structure 2. Students will be in a position to explain the design of the instrumental techniques, data acquisition, and analysis to elucidate structural information of solid materials 3. Students will be able to apply the concepts learned to make the best choice of a characterization technique(s) for elucidation of unknown solids under investigation. 4. Students will learn about electronic microscopic techniques.	