

## Part B - Syllabus

### CHEMISTRY (CHM)

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**Physical Chemistry:** Quantum chemistry: Schrodinger equation, particle in a box, harmonic oscillator, hydrogen atom; atomic structure: electronic configuration, periodic properties; chemical bonding: VBT, MOT, hybridisation; thermodynamics: laws, entropy, free energy, chemical potential; chemical equilibrium: Le Chatelier's principle,  $K_p$ ,  $K_c$ ; solutions: Raoult's law, colligative properties, activity; electrochemistry: electrode potentials, EMF, Nernst equation, electrolysis, galvanic cells; kinetics: rate laws, Arrhenius equation, transition state theory, reaction mechanisms.

**Organic Chemistry:** Nomenclature; stereochemistry: chirality, optical activity, geometrical isomerism, conformational analysis; reaction mechanisms: nucleophilic and electrophilic substitution; addition, elimination reactions; carbonyl chemistry: aldehydes, ketones, carboxylic acids, and derivatives; aromatic compounds: electrophilic aromatic substitution, aromaticity, heterocyclic compounds; pericyclic reactions: Diels-Alder, sigmatropic, electrocyclic; organometallic chemistry: Grignard and organolithium reagents; retrosynthetic analysis; spectroscopic characterisation: IR, NMR, MS.

**Inorganic Chemistry:** Periodic table and periodic trends; coordination chemistry: Werner's theory, crystal field theory, ligand field theory, CFSE; coordination compounds: naming, isomerism, stability, and reactions; transition metals: electronic configurations, properties, and oxidation states; organometallic chemistry: metal carbonyls, metallocenes, oxidative addition; bioinorganic chemistry: metalloenzymes, haemoglobin, chlorophyll; acids and bases: hard and soft theory (HSAB); solid state chemistry: crystal systems, defects, and semiconductors; nuclear chemistry: radioactivity, decay, and applications.

**Analytical Chemistry:** Sampling and error analysis; titrimetric methods: acid-base, redox, complexometric; gravimetric analysis; electroanalytical methods: potentiometry, voltammetry, coulometry, conductometry; spectroscopic methods: UV-Vis, IR, Raman, atomic absorption/emission, fluorescence; chromatographic methods: GC, HPLC, TLC, ion exchange; mass spectrometry; NMR spectroscopy:  $^1\text{H}$  and  $^{13}\text{C}$ ; XRD and XRF; thermal analysis: TGA, DSC; chemometrics; quality assurance in analytical laboratories; sensor technology.

**Organic Spectroscopy:** UV-Visible spectroscopy: chromophores, auxochromes, Woodward's rules for conjugated dienes and enones; IR spectroscopy: functional group frequencies, interpretation of spectra;  $^1\text{H}$  NMR: chemical shift, coupling constants, spin-spin coupling, integration;  $^{13}\text{C}$  NMR; 2D NMR: COSY, HSQC, HMBC; mass spectrometry: fragmentation patterns, molecular ion, McLafferty rearrangement; combined spectral interpretation for structure elucidation of organic molecules.

**Green and Sustainable Chemistry:** Twelve principles of green chemistry; atom economy and E-factor; solvent selection and ionic liquids; catalysis: heterogeneous, homogeneous, biocatalysis, and organocatalysis; microwave and ultrasound-assisted synthesis; photochemistry and flow chemistry; renewable feedstocks and bio-based chemicals; benign by design; life cycle assessment; chemical waste minimisation; pharmaceutical green chemistry;  $\text{CO}_2$  utilisation; sustainable polymers.

**Polymer Chemistry:** Classification of polymers; addition and condensation polymerisation; radical, cationic, anionic, and coordination polymerisation mechanisms; living polymerisation: ATRP, RAFT, ring-opening; copolymerisation; molecular weight determination: number-average, weight-average, GPC, viscometry; polymer solutions: Flory-Huggins theory; thermal properties:  $T_g$ ,  $T_m$ , crystallinity; mechanical properties; conducting polymers; biodegradable polymers; polymer nanocomposites; processing techniques.

## NRIU Ph.D. ENTRANCE EXAMINATION : 2026-26

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**Supramolecular and Materials Chemistry:** Non-covalent interactions: hydrogen bonding, van der Waals, pi-pi stacking, hydrophobic effect; host-guest chemistry; crown ethers, cryptands, calixarenes, cucurbiturils; self-assembly; molecular recognition; rotaxanes, catenanes, and molecular machines; nanomaterials: synthesis and properties of nanoparticles, quantum dots, graphene, carbon nanotubes; porous materials: MOFs and COFs; soft matter: colloids, liquid crystals, and gels; surface chemistry and thin films.

**Biochemistry:** Amino acids, proteins, and enzymes: structure, function, and kinetics (Michaelis-Menten); carbohydrates: monosaccharides, polysaccharides, glycolysis, and gluconeogenesis; lipids: fatty acids, triglycerides, phospholipids, and membrane structure; nucleic acids: DNA and RNA structure, replication, transcription, and translation; vitamins and coenzymes; metabolic pathways: TCA cycle, oxidative phosphorylation, fatty acid oxidation; bioenergetics and ATP synthesis; enzyme inhibition and allosteric regulation.