LIST OF FIELDS OF ADVANCED DIFFICULTY

Problem(s)	Field	Subfields
1	Periodic trends	–
2, 3	Chemical bonding, quantum mechanics	Superposition principle. Molecular orbitals. Periodic wave functions. Uncertainty principle.
4	Photochemistry	Energy diagram of a chemical reaction. Activation energy. Relationship between energy and wavelength of light.
	Quantum mechanics	Particle-in-a-box model.
5-7	Equilibrium	Surface tension. Gibbs energy and its dependence on pressure for pure substance. The temperature dependence of the saturated vapor pressure. Relationship between $\Delta_r G°$ and equilibrium constant K. Using ΔG to predict direction of natural change. Dependence of $\Delta_r G$ on partial pressures of reactants and products. Le Chatelier's principle.
8	Phase diagrams, equations of state	Single component phase diagrams. Critical point. Van der Waals gas law.
9-11	Chemical kinetics	Determination of the reaction order. Rate-determining step. Steady-state approximation. Calculation of activation energy. Kinetic equations and kinetic curves. Autocatalysis. Enantiomeric enrichment. First-order reactions: Dependence of concentration on time, half-life. Carbon dating.
	Carbonyl compounds	Addition reactions. Stereochemistry: enantiomers.
12-14	Inorganic chemistry of elements	Fe(II) and Fe(III), redox processes, cyanide and tartrate complexes, hydroxides. MnO_4^- as an oxidizing agent in acidic media. As(III) and As(V), redox processes. Compounds of sulfur in lower oxidation states, oxidation with iodine. Zinc, sulfide and carbonate, their solubility. Phosphates, their thermal decomposition.
	Electrochemistry	Standard electrode potentials. Nernst equation. EMF. Direction of redox processes.
	Chemical equilibria	Acid-base and precipitation equilibria, calculation of pH, K_{sp} in complex mixtures.
	Analytical chemistry	Redox titration (direct and back-titration). Stoichiometric calculations.
	Carbonyl compounds	Nucleophilic addition of HSO_3^-.

15-17	Chemical bonding	VSEPR-concept (factors affecting distortion of an ideal polyhedron). Crystal Field Theory of coordination compounds. Calculation of Crystal Field Stabilization Energy.
	Solid state chemistry	Unit cell. Coordination number. Miller indices. Bragg's Law. Types of close packings. Calculation of density of packings. X-ray diffraction for f.c.c. lattice. NaCl, spinel, and perovskite structure.
	Equilibrium	Hard and Soft Acids and Bases (HSAB) concept. Hydrolysis, calculation of pH. Osmotic pressure. Free energy definition. Relationship between $\Delta G°$ and equilibrium constant K. Using ΔG to predict direction of natural change.
	Inorganic chemistry of elements	Group 14: oxocompounds ((+4) oxidation state of the elements). Group 15: oxoacids with the element having (+1), (+3) or (+5) oxidation states; structure of the acids; pK_a trends. Polymerization of oxoacids (oxoanions). Transition metals: tetrahedral and octahedral complexes of Co and Cr.
18-20	Carbonyl compounds	Aldehydes, ketones, carboxylic acid derivatives: properties, keto-enol tautomerism, enolates and enol derivatives.
	Condensations of carbonyl compounds	General principles, mechanism of base-catalyzed condensations.
	Concerted pericyclic reactions	General principles and common types of pericyclic processes.
21-24	Amino acids and peptides (without proteins)	Structure, sequencing, chemical properties of carboxyl, amino and functional side groups.
	Lipids	Structure, physical and chemical properties, synthesis and degradation.
	Bases, nucleosides and nucleotides: (without nucleic acids)	Structure and properties.
	Enzymes	Nomenclature, mechanisms of catalysis, specificity.
	Physico-chemical methods	^{1}H NMR and mass spectrometry.
25-27	Polymerization	Mechanisms, stages, kinetics, characteristics of obtained polymers
	Monomer structure and reactivity in polymerization	Inductive and mesomeric effects, ring strain, solvent effect, etc.
	Copolymers	Synthesis, architecture, distribution of units, properties.
	^{1}H NMR for studying polymers	Common ranges of chemical shifts of typical functional groups and simple fragments, integration of signals.
28	Quantum mechanics	Energy diagram of a chemical reaction. Tunneling. Relationship between frequency, energy and wavelength of light.