The program in chemistry

The program in chemistry is based on a shortened version of the International Chemistry Olympiad program.

Theoretical chemistry

Quantum numbers (n,l,m) and orbitals (s,p,d) in hydrogen-like atoms. Electronic configuration of main group and the first row transition metal atoms and their ions. Periodic table and trends. Bond types (covalent, ionic, metallic), intermolecular forces and relation to properties.
Molecular structures and simple VSEPR theory. Simple crystal field theory.

Balancing equations, empirical formulae, mole concept and Avogadro constant, stoichiometric calculations, density, calculations with different concentration units;

Energy, heat and work, enthalpy and energy, heat capacity, Hess' law, standard formation enthalpies, solution, solvation and bond enthalpies.
Definition and concept of entropy and Gibbs' energy, second law of thermodynamics, direction of spontaneous change.
Chemical equilibrium, Le Chatelier's principle, equilibrium constants in terms of concentrations, pressures and mole fractions. Relation of equilibrium constants and standard Gibbs energy.

Basics of electrochemistry: Electromotive force and its relation to thermodynamic functions, Nernst equation; Electrolysis, Faraday's laws.

Rate of chemical reactions, elementary reactions, factors affecting the reaction rate, rate law for homogeneous and heterogeneous reactions, rate constant, reaction order, reaction energy profile, activation energy, catalysis, influence of a catalyst on thermodynamic and kinetic characteristics of a reaction. Integrated rate law for first order reactions, half-life, Arrhenius equation, determination of activation energy.

Analytical chemistry
Chemical equilibrium in solution. Arrhenius and Bronsted acid-base theory, pH, self ionization of water, equilibrium constants of acid-base reactions, pH of weak acid solutions, pH of very dilute solutions and simple buffer solutions, hydrolysis of salts.
Solubility constants and solubility.
Complexation reactions, definition of coordination number, complex formation constants.

Principles of direct and indirect titration (back titration).
Acidi- and alkalimetry, acidimetric titration curves, choice and color of indicators for acidimetry.
Redox titrations (permanganometric and iodometric).
Simple complexometric and precipitation titrations.

Inorganic chemistry

Basic principles of inorganic qualitative analysis for ions specified in factual knowledge, flame tests.

Main classes of inorganic compounds (oxides, hydroxides, salts).

Physical and chemical properties of hydrogen, halogens, oxygen, sulfur, nitrogen, phosphorus, carbon, silicon and their compounds (water, hydrogen peroxide, oxides of sulfur, nitrogen,

phosphorus, carbon, silicon). Volatile hydrogen compounds. The most important oxoacids of non-metals and their salts. The binary compounds of non-metals (hydrides, carbides, nitrides, etc).
The reactivity of main group metals (alkaline, beryllium, magnesium, aluminium, alkaline-earth), their oxides and hydroxides.
Properties of d-transition elements (chromium, manganese, iron, copper, silver, zinc), their salts, oxides and hydroxides.

Coordination compounds, structure, isomerism and magnetic properties. Simple crystal field theory.

The main principles of chemical technology. The traditional inorganic materials (metals, alloys, ceramics, glass).

Organic chemistry

Organic structure-reactivity relations (polarity, electrophilicity, nucleophilicity, inductive effects, relative stability). Structure-property relations (boiling point, acidity, basicity).

Simple organic nomenclature.

Hybridization and geometry at carbon centers. Sigma and pi bonds, delocalization, aromaticity, mesomeric structures.
Isomerism (constitutional, configuration, conformation, tautomerism).
Stereochemistry (E-Z, cis-trans isomers, chirality, optical activity, Cahn-Ingold-Prelog system, Fisher projections).

Common electrophiles and nucleophiles.
Electrophilic addition: addition to double and triple bonds, regioselectivity (Markovnikoff's rule), stereochemistry.
Electrophilic substitution: substitution on aromatic rings, influence of substituents on the reactivity and regioselectivity, electrophilic species.
Nucleophilic substitution: SN1 and SN2 reactions at sp^3 carbon centers, stereochemistry.
Nucleophilic addition: addition to carbon-carbon and carbon-hetero atom double and triple bonds, addition-elimination reactions, acid-base catalysis.
Oxidations and reductions: switching between the different oxidation levels of common functional groups.

Chemical properties of: alcohols and phenols, carbonyl compounds, heterocyclic compounds.

Biochemistry

General information about major classes of biomolecules (proteins, nucleic acids, carbohydrates, lipids): principles of structure organization, major representatives, biological role.
Metabolism. Catabolism and anabolism. The most common metabolic pathways: glycolysis, Krebs cycle, electron-transport chain. Steps and intermediates.
Enzymes, enzyme catalysis. Role of enzymes in metabolic processes, bioregulation via enzymes, enzyme classes commonly involved in metabolic reactions.

Laboratory skills

Awareness of experimental errors, use of significant figures.
Heating in the laboratory, heating under reflux, drying of a solid, distillation.
Mass and volume measurement (with electronic balance, measuring cylinder, pipette and burette, volumetric flask).
Preparation and dilution of solutions and standard solutions.
Operation of a magnetic stirrer.
Carrying out of test tube reactions.
Qualitative testing for organic functional groups (using a given procedure).
Volumetric determination, titrations, use of a pipette bulb.
Measurement of pH (by pH paper or calibrated pH meter).
Thin layer chromatography.
Measurement of a melting point and refractive index.
Separation procedures: using separation funnel, decanting, filtration.