Contents of the written admission test

From a database 110 multiple-choice questions (in english) are selected by the computer subdivided in the following topics:
Analytical chemistry – 10 questions
Inorganic chemistry – 20 questions
Organic chemistry – 20 questions
Physical chemistry – 20 questions
Pharmaceutical chemistry – 20 questions
Pharmaceutical technology – 20 questions
Each candidate can freely choose which questions to answer, but should respond to 60 questions in total (no penalty is given for a wrong answer). In case more questions are answered, only the first 60 questions will be taken into consideration. In the last two years (2015+2016) around 75% of the candidates passed the threshold value for admission to the interview.

To facilitate preparation for the admission test, a detailed list of arguments for each area is given on the following pages.

ANALYTICAL CHEMISTRY

Data Acquisition and Use of Statistics
- Errors
- Statistical considerations

Solutions and Standardization
- Concentration terms
- Primary standards

Homogeneous Equilibria
- Acid-base
- Oxidation-reduction
- Complexometry

Heterogeneous Equilibria
- Gravimetric analysis
- Solubility
- Precipitation titrations
- Chemical separations

Instrumental Methods
- Electrochemical methods
- Spectroscopic methods
- Chromatographic methods
- Thermal methods
- Calibration of instruments

Environmental Applications

Radiochemical Methods
- Detectors, applications

INORGANIC CHEMISTRY

Atomic Structure
- The Periodic Table
- The Schrödinger Equation
- Periodic Properties of Atoms

Simple Bonding Theory
- Lewis Electron-Dot Diagrams
- Valence Shell Electron-Pair Repulsion
- Molecular Polarity
- Hydrogen Bonding

Molecular Orbitals
- Generation of Molecular Orbitals from Atomic Orbitals
- Molecular Orbitals from s Orbitals
- Molecular Orbitals from p Orbitals
- Molecular Orbitals from d Orbitals
- Nonbonding Orbitals

Acid–Base and Donor–Acceptor Chemistry
- Arrhenius Concept
- Brønsted–Lowry Concept
- Lewis Acid–Base Concept and Frontier Orbitals
- Intermolecular Forces
- Hard and Soft Acids and Bases

The Crystalline Solid State
- Structures of Binary Compounds
- Thermodynamics of Ionic Crystal Formation

Chemistry of the Main Group Elements
- General Trends in Main Group Chemistry
- Physical Properties
- Electronegativity
- Ionization Energy
- Chemical Properties

Coordination Chemistry
- Nomenclature
- Isomerism
- Coordination Numbers and Structures
- Bonding Theories
- Crystal Field Theory
- Ligand Field Theory
- The Jahn–Teller Effect

Coordination Chemistry: Reactions and Mechanisms
- Substitution Reactions
- Linear Free-Energy Relationships
- Associative Mechanisms
- The Conjugate Base Mechanism
- The Kinetic Chelate Effect
- Stereochemistry of Reactions
- Substitution in trans Complexes
- Substitution in cis Complexes
- Substitution Reactions of Square-Planar Complexes

- Kinetics and Stereochemistry of Square-Planar Substitutions
- The trans Effect
- Oxidation–Reduction Reactions
- Inner-Sphere and Outer-Sphere Reactions
- Conditions for High and Low Oxidation Numbers

Organometallic Chemistry

- The 18-Electron Rule
- Square-Planar Complexes
- Ligands in Organometallic Chemistry
- Hydride and Dihydrogen Complexes
- Ligands Having Extended π Systems
- Bonding between Metal Atoms and Organic π Systems
- Linear π Systems
- Cyclic π Systems
- Alkyl and Related Complexes
- Carbene Complexes
- Carbyne (Alkylidyne) Complexes

Organometallic Reactions and Catalysis

- Oxidative Addition and C-H Bond Activation
- Reductive Elimination and Pd-Catalyzed Cross-Coupling
- Sigma Bond Metathesis
- Reactions Involving Modification of Ligands
- Organometallic Catalysts
- Heterogeneous Catalysts

ORGANIC CHEMISTRY

The Structures of Organic Molecules
- Structural components of organic molecules
- Systematic nomenclature: IUPAC names
- Constitutional isomers and hydrocarbon substituents

Bonding in Organic Molecules
- Lewis structures
- Bond properties
- Resonance structures
- Hybrid orbitals and shapes of molecules
- Delocalized π-electron systems
- Noncovalent interactions

The Conformations of Organic Molecules
- Conformations of acyclic compounds
- Conformations of cyclic compounds
- Conformations of substituted cyclohexanes and cyclic compounds

The Stereochemistry of Organic Molecules
- Geometric isomers of alkenes
- Chirality and enantiomers
- Diastereomers
- Fischer projections

Chemical reactions and mechanisms
- General aspects of reactions
- Acid-base reactions
- Reaction mechanisms
- Reaction coordinate diagrams

Substitution reactions of alkyl halides
- The SN1-reaction and the SN2-reaction of alkyl halides

Substitution reactions of alcohols and related compounds
- Substitution reactions of alcohols
- Substitution reactions of ethers and epoxides
- Substitution reactions of thiols and thioethers

Elimination reactions of alkyl halides, alcohols and related compounds
- The E1-reaction
- The E2-reaction

Addition reactions of alkenes and alkynes
- Electrophilic addition reactions of alkenes
- Electrophilic addition reactions of alkynes
- The formation of carbon-carbon bonds
- Hydroboration reactions of π-bonds
- The addition of carbenes to π-bonds

Addition reactions of conjugates dienes
- The structures of dienes
- Bonding in conjugated dienes
- Electrophilic addition to conjugates dienes

Oxidation and reduction reactions
- Oxidation states in organic molecules
- Hydrogenation reactions
- Oxidation reactions of alkenes

- Oxidation reactions of alcohols
- Oxidation reactions of amines

Free radical reactions

- Free radical halogenation reactions
- Reduction via radical intermediates
- Free radical addition reactions
- Oxidation via radical intermediates

Proton and carbon NMR spectroscopy

- Chemical shifts and proton equivalence
- Spin coupling
- Interpreting and predicting 1H NMR spectra
- Carbon NMR spectra

Determining the structures of organic molecules

- Mass spectrometry
- Infrared spectroscopy

Organometallic reagents and chemical synthesis

- Carbon-carbon fond formation
- Organomagnesium and lithium compounds
- Transition metal organometallic compounds

Asymmetric reactions and synthesis

- Chiral compounds
- Enantiomeric resolution
- Asymmetric synthesis

The chemistry of benzene and its derivatives

- Structural aspects of aromatic molecules
- Electrophilic substitution reactions of benzene
- Electrophilic substitution reactions of benzene derivatives
- Nucleophilic substitution reactions of benzene derivatives
- Aromatic diazonium salts

Nucleophilic addition reactions of aldehydes and ketones

- General aspects of nucleophilic addition reactions
- Nucleophilic addition reactions
- Reduction reactions of aldehydes and ketones
- Oxidation reactions of aldehydes and ketones

Addition-substitution reactions of aldehydes and ketones

- Hemiacetals and acetals
- Acetals as protecting groups
- Carbohydrates

Addition-elimination reactions of aldehydes and ketones

- Compounds with carbon-nitrogen double bonds
- Imines, enamines, ylides

Addition-elimination reactions of carboxylic acids and derivatives

- Reactions of carboxylic acids
- The chemistry of acid chlorides, thioesters, and anhydrides
- The chemistry of esters
- The chemistry of amides
- The chemistry of nitriles
- Reactions with organometallic compounds
- Reduction reactions of carboxylic acids and derivatives

The acid-base chemistry of carbonyl compounds

- Acidity of carbonyl compounds

- Enols and enolate ions
- Reactions of enolate ions
- Dicarbonyl compounds

The nucleophilic addition reactions of enolate ions

- The aldol reaction
- The Claisen-condensation

Conjugate addition reactions of unsaturated carbonyl compounds

- α,β-Unsaturated carbonyl compounds
- Conjugate addition reactions
- Conjugate addition reactions of carbanions

The chemistry of polycyclic and heterocyclic arenes

- Polycyclic aromatic compounds
- Pyridine, pyrrole, azoles and related heterocycles

Amino acids, peptides, and proteins

- Amino acids
- Chemical synthesis of amino acids
- Peptide synthesis and analysis

Molecular recognition and catalysis

- Crown ethers, cryptands, cyclodextrins
- Recognition and catalysis using hydrogen bonds
- Structure-reactivity correlation
- Kinetics of organic reactions
- Kinetic and thermodynamic control on selectivity

PHYSICAL CHEMISTRY

Thermodynamics

- The gas laws
- The van der Waals equation
- The principle of corresponding states
- Work, heat, and energy
- The internal energy
- Expansion work
- Heat transactions and enthalpy
- Standard enthalpy changes and enthalpies of formation
- The temperature-dependence of reaction enthalpies
- State functions
- Exact and inexact differentials
- Changes in internal energy
- The Joule–Thomson effect
- The dispersal of energy
- Entropy, entropy changes accompanying specific processes
- The Third Law of thermodynamics
- The Helmholtz and Gibbs energies
- Standard reaction Gibbs energies
- Supercritical fluids
- Partial molar quantities
- The thermodynamics of mixing
- The chemical potentials of liquids
- Colligative properties
- The activities of regular solutions
- The activities of ions in solution
- Phases, components, and degrees of freedom
- The phase rule
- Two-component systems
- Vapour pressure diagrams
- Temperature–composition diagrams
- The Gibbs energy minimum
- The description of equilibrium
- The response of equilibria to pressure
- The response of equilibria to temperature
- Half-reactions and electrodes
- Varieties of cells
- The electromotive force
- Standard potentials
- Applications of standard potentials

Quantum theory & molecular structure

- Wave–particle duality
- The Schrödinger equation
- The uncertainty principle
- The postulates of quantum mechanics
- A particle in a box
- Motion in two and more dimensions
- Tunnelling
- Vibrational motion

- Rotation in two and three dimensions
- Spin
- Time-independent perturbation theory
- Time-dependent perturbation theory
- The structure of hydrogenic atoms
- Atomic orbitals and their energies
- Spectroscopic transitions and selection rules
- The structures of many-electron atoms
- The orbital approximation
- Self-consistent field orbitals
- The spectra of complex atoms
- Singlet and triplet states
- Spin–orbit coupling
- Term symbols and selection rules
- The Born–Oppenheimer approximation
- Molecular orbital theory
- The hydrogen molecule-ion
- Homonuclear diatomic molecules
- Heteronuclear diatomic molecules
- Molecular orbitals for polyatomic systems
- The Hückel approximation
- The prediction of molecular properties
- Operations and symmetry elements
- Vanishing integrals and selection rules

Molecular spectroscopy

- Experimental techniques
- The intensities of spectral lines
- Linewidths
- Pure rotation spectra
- Moments of inertia
- The rotational energy levels
- Rotational transitions
- Molecular vibrations
- Selection rules
- Anharmonicity
- Vibration–rotation spectra
- The vibrations of polyatomic molecules
- Normal modes
- Infrared absorption spectra of polyatomic molecules
- Symmetry aspects of molecular vibrations
- The electronic spectra of diatomic molecules
- The electronic spectra of polyatomic molecules
- Fluorescence and phosphorescence
- Dissociation and predissociation
- General principles of laser action
- Applications of lasers in chemistry
- The energies of electrons in magnetic fields
- The energies of nuclei in magnetic fields
- Magnetic resonance spectroscopy
- The chemical shift
- The fine structure

- Electron paramagnetic resonance
- The g-value
- Hyperfine structure

Statistical thermodynamics & chemical kinetics

- Configurations and weights
- The molecular partition function
- The internal energy
- The statistical entropy
- The canonical ensemble
- The thermodynamic information in the partition function
- Independent molecules
- The molecular partition function
- Electric dipole moments
- Polarizabilities
- Empirical chemical kinetics
- Experimental techniques
- The rates of reactions
- Integrated rate laws
- Reactions approaching equilibrium
- The temperature dependence of reaction rates
- Elementary reactions
- Consecutive elementary reactions
- Unimolecular reactions
- The rate laws of chain reactions
- Explosions
- Stepwise polymerization
- Chain polymerization
- Features of homogeneous catalysis
- Enzymes
- Kinetics of photophysical and photochemical processes
- Complex photochemical processes
- Collision theory
- Diffusion-controlled reactions
- Transition state theory
- Thermodynamic aspects
- The rates of electron transfer processes
- Theory of electron transfer processes

PHARMACEUTICAL SCIENCES

Principles of Medicinal Chemistry

- Physical, chemical and pharmaceutical properties of drugs;
- Hit discovery strategies;
- Hit to lead optimization strategies;
- Structure-based and mechanism-based design methods;
- Combinatorial chemistry;
- General concepts on pharmacodynamics, pharmacokinetics and drug metabolism.

Mechanisms of Drug Action

- antibiotics,
- antifungals,
- antileprotics
- antituberculous drugs,
- antimalarials,
- anthelmintics,
- amoebicides,
- antiprotozoals,
- antivirals,
- antineoplastic drugs,
- antipyretics,
- analgesics,
- bronchodilators,
- antitussives,
- mucolytics,
- decongestants,
- β-receptor blockers,
- calcium channel blockers,
- diuretics,
- cardiac glycosides,
- antiarrhythmics,
- antianginals,
- vasoconstrictors,
- vasodilators,
- antihypertensive drugs,
- psychedelics,
- hypnotics,
- anaesthetics,
- antipsychotics,
- antidepressants (including tricyclic antidepressants, monoamine oxidase inhibitors, lithium salts, and selective serotonin reuptake inhibitors - SSRIs),
- antiemetics,
- anticonvulsants/antiepileptics,
- anxiolytics,
- barbiturates,
- movement disorder (e.g. Parkinson's disease) drugs,
- stimulants (including amphetamines),
- benzodiazepines,
- dopamine antagonists,
- antihistamines,
- cholinergics,

- anticholinergics,
- emetics,
- cannabinoids,
- 5-HT (serotonin) antagonists.,
- hormone replacement.

PHARMACEUTICAL TECHNOLOGY AND DRUG DELIVERY

A good knowledge of main drug delivery systems is expected, in particular:

- Current methodologies in preparation of conventional pharmaceutical dosage forms and advanced formulations.
- Background in physical pharmaceutics and biopharmaceutics.
- Knowledge of main physicochemical and biopharmaceutical properties of major classes of pharmaceutical structural ingredients, namely polymers, lipids, surfactants, sugars etc
- Familiarity with classical analytical techniques for physicochemical and biopharmaceutical characterization of ingredients and dosage forms.
- Basic principles dictating the selection and the design of dosage forms, traditional formulations and micro- and nanopharmaceuticals.
- Concepts of bioavailability, pharmacokinetics and drug availability.
- Knowledge of principles of controlled drug delivery and drug targeting.
- Biopharmaceutical performance of solubilizers, stabilizers, targeting agents, cell penetrating enhancers, mucoadhesive materials, stimuli sensitive materials.
- Principles of pharmaceutical technology
- Bioavilability
- Membrane transport mechanisms: paracellular and transcellular pathways. Passive, active, facilitated, pinocytosis, ion-pairing. Influx and efflux pumps.
- Principles of pharmacokinetics: non compartmental and compartmental analyses. Monocompartimental model with and without absorption step, binocompartimental model with and without absorption step, pharmacokinetic parameter analysis.
- Drug release: principles and mechanisms
- Dissolution and solubility, physical state, polymorphism, micro and nanoization, micellesm cyclodextrins etc.
- Preformulation and micrometrics
- Particle size, particle shape, porosity, surface area
- Density of powders, flow of powders
- Mechanical properties: elasticity, plasticity etc.
- Principles of rheology
- Main processes of pharmaceutical technology: mixing and blending, milling, dessication.
- Solid forms: tablets and capsules,
- Disperesed systems: suspensions and emulsions,
- Injectables and sterilization, lyophilization.
- Aerosols,
- Topical systems,
- Polymeric and inorganic microparticles
- Colloidal systems polymeric nanoparticles, inorganic nanoparticles, liposomes, micelles , polymersomes, physical assemblies, polymer bioconjugates, solid lipid nanoparticles.
- Cyclodextrins,
- pH sensitive formulations, stimuli-sensitive drug delivery systems,
- Hydrogels
- Principles of drug targeting