Indian Institute of Technology Hyderabad
Kandi – 502 285, Sangareddy District, Telangana

Syllabus for the Written Test for Junior Technician (JT) Post in Chemistry (2020)

PART-A

Section 1: Arithmetic: basic arithmetic, logical reasoning, basic computer-related arithmetic, & MS office

Addition, Subtraction, Multiplication and Division, Decimals, Fractions, Ratio and Proportion, Percentage, Time and Work, Time and Distance, Data Interpretation, Numbers and Sequences, Arrangements, Logical sequences, Blood relations, Calendars, Cubes and Clocks, Binary and Decimal conversion, Binary addition, and subtraction, Basic knowledge in Word, Excel, PowerPoint, Internet, Windows explorer.

Section 2: General English: Synonyms, Opposite & grammatically correct phrase

Spot the Error, Fill in the Blanks, Synonyms, Antonyms, Spellings/Detecting Mis-spelt words, Idioms & Phrases, One-word substitution, Active/Passive Voice of Verbs, Conversion into Direct/Indirect narration, Shuffling of Sentence parts, Shuffling of Sentences in a passage, Comprehension Passage.

PART-B

Section 1: Physical Chemistry

Quantum Chemistry: Rutherford's theory, Photoelectric effect, Bohr's theory Uncertainty principle, de-Broglie equation, Postulates of quantum mechanics, Schrodinger equation, operators, particle in a 1D box, Zeeman effect, Pauli's exclusion principle,

Chemical Bonding: Valence bond theory and molecular orbital theory (MOT), Hybrid orbitals. Applications of LCAO-MOT to H_2 and other homonuclear diatomic molecules, heteronuclear diatomic molecules like HF, CO, NO, and to simple delocalized π-electron systems. Hückel approximation and its application to annular π-electron systems.

Gaseous, Liquid and Solid State of Matter: Kinetic molecular theory of gasses, Maxwell distribution, Real gas, Ideal gas, van der Waal's equation, P-V isotherm, Physical properties of Liquids, Viscosity, surface tension, Crystalline and amorphous solids, Space lattice and Unit

cell, Bravais lattices, Crystal system, Miller Indices, Radius ratio, Packing fraction, X-ray diffraction, Schottky and Frenkel defects.

Thermodynamics and Equilibrium: Laws of thermodynamics. Standard states. Thermochemistry. Thermodynamic functions and their relationships: Gibbs-Helmholtz and Maxwell relations, van't Hoff equation. Criteria of spontaneity and equilibrium. Absolute entropy. Partial molar quantities. Activity and activity coefficients. Chemical equilibria. Law of mass action, Kc, Kp, Ksp, Dependence of equilibrium constant on temperature and pressure. Phase rule: Phase rule. Phase diagram of one-component systems: CO_2, H_2O.

Ionic equilibrium: Acid and Bases, Dissociation of weak acid and bases, Dissociation of water, pH, Normality, Molarity, Molality, Percentage, Common ion effect, buffer solution, Hydrolysis of salt, Acid-base Indicator, Acid-Base titration, Raoult's law, Henry's law, Non-ideal solutions, Chemical potential, Ionic mobility, and conductivity,

Chemical Kinetics: Order, Molecularity, half-life, 1^{st}, 2^{nd}, and n^{th} order reactions, Arrhenius equation; Effect of temperature, surface area, and catalyst on reaction rate, Collision state theory, the kinetics of nuclear reactions, fission and fusion reactions.

Electrochemistry- Galvanic cells, Electrolytic cells, Nernst equations, Redox reactions, Standard hydrogen electrode, Reference electrodes, Concentration cells, Faraday's law, Activity, Activity coefficient, Conductivity electrolyte solutions, Kohlarausch's law, Potentiometric, and conductometric titrations.

Surfaces Interfaces: Physisorption and chemisorption. Langmuir, Freundlich and BET isotherms. Surface catalysis: Langmuir-Hinshelwood mechanism. Surface tension, viscosity. Self-assembly. Physical chemistry of colloids, micelles, and macromolecules.

Section 2: Inorganic and Analytical Chemistry:

Some basic concepts: (Modern view of atomic structure,
wave mechanical description of electron and orbitals, Modern periodic table, trends and unde rlying reasons,etc.). Molecular symmetry (Symmetry operation and symmetry elements, Poin t groups, Character table,etc.). Acid bases and ions in aqueous solution (Bronsted acid and ba ses, Energetic of acid dissociation in aqueous solution, Amphoteric oxides,
and hydroxides, Common ion effects, etc.).

Main Group Elements: Hydrides, halides, oxides, oxoacids, nitrides, sulfides – shapes and reactivity. Structure and bonding of boranes, carboranes, silicones, silicates, boron nitride, borazines, and phosphazenes. Allotropes of carbon. Chemistry of noble gases, pseudohalogens, and interhalogen compounds. Acid-base concepts.

Transition Elements: Coordination chemistry – structure and isomerism, theories of bonding (VBT, CFT, and MOT). Energy level diagrams in various crystal fields, CFSE, applications of CFT, Jahn-Teller distortion. Electronic spectra of transition metal complexes: spectroscopic term symbols, selection rules, Orgel diagrams, charge-transfer spectra. Magnetic properties of transition metal complexes. Reaction mechanisms: kinetic and thermodynamic stability, substitution and redox reactions.

Lanthanides and Actinides: Recovery. Periodic properties, spectra, and magnetic properties.

Organometallics: 18-Electron rule; metal-alkyl, metal-carbonyl, metal-olefin, and metal-carbene complexes and metallocenes. Fluxionality in organometallic complexes. Types of organometallic reactions. Homogeneous catalysis - Hydrogenation, hydroformylation, acetic acid synthesis, metathesis, and olefin oxidation. Heterogeneous catalysis - Fischer- Tropsch reaction, Ziegler-Natta polymerization.

Radioactivity: Decay processes, the half-life of radioactive elements, fission and fusion processes.

Bioinorganic Chemistry: Ion (Na^+ and K^+) transport, oxygen binding, transport and utilization, electron transfer reactions, nitrogen fixation, metalloenzymes containing magnesium, molybdenum, iron, cobalt, copper, and zinc.

Solids: Crystal systems and lattices, Miller planes, crystal packing, crystal defects, Bragg's law, ionic crystals, structures of AX, AX_2, ABX_3 type compounds, spinels, band theory, metals, and semiconductors.

Instrumental Methods of Analysis: UV-visible spectrophotometry, NMR and ESR spectroscopy, mass spectrometry. Chromatography including GC and HPLC. Electroanalytical methods- polarography, cyclic voltammetry, ion-selective electrodes. Thermo-analytical methods.

Section 3: Organic Chemistry

Concepts:
Structural and geometrical isomerism. IUPAC nomenclature of organic compounds. Determination of empirical and molecular formulae of organic compounds using the combustion method. Polarity, Inductive effects, Resonance, Hyperconjugation, Keto-enol tautomerism. Hydrogen bonding – definition and their effects on the physical properties of various organic compounds. Reactive intermediates – carbocations, carbanions, and free radicals. Reaction mechanism concepts – kinetic versus thermodynamic control. Methods of determining reaction mechanisms through the identification of products, intermediates, and isotopic labeling.

Organic Synthesis: Synthesis, reactions, mechanistic aspects and selectivity involving the following classes of compounds – alkanes, alkenes, alkynes, aromatic hydrocarbons, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, nitriles, halides, nitro compounds, amines and amides (both aliphatic and aromatic). Uses of organometallic (e.g. Mg, Li, Cu, B, Zn, Cd, and Si) based reagents in organic synthesis. Addition reactions to multiple bonds. Elimination reactions. Reactive intermediates – carbocations, carbanions, carbenes, nitrenes, arynes, and free radicals. Molecular rearrangements involving electron deficient atoms. Nucleophilic and electrophilic substitution reactions (both aromatic and aliphatic). Aromatic electrophilic substitution reactions. Williamson's Synthesis. Perkin reaction. Cannizzaro reaction. Haloform reaction and nucleophilic addition reactions (Grignard addition). Carboxylation of Grignard reagents. The Arndt-Eistert method. Electrolytic (anodic) coupling. Oxidation reactions. Reduction reactions. Michael addition reaction. Aromatic diazonium salts and their reactions. Umpolung reactivity – formyl and acyl anion equivalents. Selectivity in organic synthesis – chemo-, regio- and stereoselectivity. Protection and deprotection of functional groups. Concepts of asymmetric synthesis – resolution (including enzymatic), desymmetrization and use of chiral auxiliaries. Carbon-carbon bond forming reactions through enolates (including

boron enolates), enamines and silyl enol ethers. Stereoselective addition to C=O groups (Cram and Felkin-Anh models). Separation of a mixture of organic compounds. Functional group identification of organic compounds. Preparation of derivatives of organic compounds.

Stereochemistry:
Chirality of organic molecules with or without chiral centers and determination of their absolute (R/S) configurations. Relative stereochemistry in compounds possessing more than one stereogenic center. Homotopic, enantiotopic and diastereotopic atoms/groups/faces. Stereoselective and stereospecific synthesis. Conformational analysis of acyclic and cyclic compounds. Configurational and conformational effects and neighboring group participation on reactivity and selectivity/specificity.

Heterocyclic Compounds: Structure, preparation, properties, and reactions of furan, pyrrole, thiophene, pyridine, indole, quinoline and isoquinoline.

Biomolecules: Structure, properties and reactions of mono- and disaccharides, physicochemical properties of amino acids, chemical synthesis of peptides, structural features of proteins, nucleic acids, steroids, terpenoids, carotenoids, and alkaloids.

Spectroscopy: Applications of UV-visible, IR, NMR and Mass spectrometry in the structural determination of organic molecules.

Sample Questions:

Q1. Hitting …… key and …… will open a dialogue box for searching a word in pdf file:

A) Alt, S
B) Ctrl, F
C) Ctrl, S
D) Alt, F

Q2. Choose the correct option: which complex has the oxidation state of the metal is +2 and its d^n configuration is d^8?

A) $[Mn(CN)_6]^{4-}$
B) $[CoCl_3(py)_3]$
C) $[Ru(bipy)_3](PF_6)_2$
D) $[Ni(en)_3]^{2+}$

Q2. The following symbol is a symbol for:

A) Radio Active
B) Health Hazard
C) Acute Toxic
D) Corrosive

Q4. The correct geometry around oxygen in CH_3OCH_3 is:

A) Linear
B) Bent
C) tetrahedral
D) trigonal planar

Q5. How many grams of $Ca(OH)_2$ present in 100 ml of 0.1 (*N*) solution?

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