



An Institute for Civil Services

UPSC Syllabus

CHEMISTRY OPTIONAL



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TESTIMONIALS

“ Being in job of IRS, time management was extremely challenging. I express my immense gratefulness towards GS Score and Manoj Jha Sir for providing me best possible support in my success journey



Pratibha Verma
Rank 3

“ I am highly obliged towards GS SCORE for its best evaluation and assessment mechanism which helped me to crack UPSC in first attempt.



Mandar Patki
Rank 22

“ Answer writing is always considered as a vital part for success in UPSC. GS Score helped me in building a strong and solid foundation for development of answer writing skills. Thank You!



Hinanshu Gupta
Rank 27

“ Cracking UPSC was my childhood dream and I am highly thankful towards GS Score for guiding me in this journey. And special thanks to Manoj Jha Sir



Chandarjyoti Singh
Rank 28

“ I am very much Thankful to GS Score for building my capacity of Answer Writing Skills. Value addition, mentoring and personal evaluation by Piyush Choubey Sir did help a lot.



Pari Bishnoi
Rank 30

“ Managing sincere attempt while being in service of IPS was very tedious job. But GS Score helped me a lot in my smart preparation. I will always be thankful to Manoj Jha Sir for his mentoring.



Dipankar Chaudhary
Rank 42

“ History Optional was not an easy nut to crack. I express my sincere gratitude towards GS SCORE and Piyush Yadav Sir who helped me to sail through the rough water of UPSC.



Ashutosh Kulkarni
Rank 44

“ Being from family of Civil Servants, UPSC was a childhood dream for me. I express my humble gratitude towards Manoj Jha Sir for building my confidence in Ethics Paper.



Aranyak Saikia
Rank 59

“ UPSC style mock papers coupled with evaluation by faculty members of GS SCORE themselves enhanced my confidence to write answers as per the demand. I am



Chandrima Attri
Rank 72

“ I would always find lack of substance to fill my pages in Ethics and Essay. Manoj Jha Sir squarely took care of this. Thank you Sir!



Madhumita
Rank 86

“ Cracking UPSC in first attempt is considered as achievement within achievements. Thank You GS SCORE for the right guidance at right time.



Muskan Jindal
Rank 87

“ I am extremely grateful to GS SCORE for the guidance in improving my MCQs solving temperament which helped me to crack UPSC in my first attempt.



Shikhar Choudhary
Rank 97

PAPER - I

1. Atomic Structure:

Heisenberg's uncertainty principle Schrodinger wave equation (time independent); Interpretation of wave function, particle in one- dimensional box, quantum numbers, hydrogen atom wave functions; Shapes of s, p and d orbitals.

2. Chemical bonding:

Ionic bond, characteristics of ionic compounds, lattice energy, Born-Haber cycle; covalent bond and its general characteristics, polarities of bonds in molecules and their dipole moments; Valence bond theory, concept of resonance and resonance energy; Molecular orbital theory (LCAO method); bonding H_2 , He_2 to Ne_2 , NO, CO, HF, CN^- , Comparison of valence bond and molecular orbital theories, bond order, bond strength and bond length.

3. Solid State:

Crystal systems; Designation of crystal faces, lattice structures and unit cell; Bragg's law; X-ray diffraction by crystals; Close packing, radius ratio rules, calculation of some limiting radius ratio values; Structures of NaCl, ZnS, CsCl, CaF_2 ; Stoichiometric and nonstoichiometric defects, impurity defects, semi-conductors.

4. The Gaseous State and Transport Phenomenon:

Equation of state for real gases, intermolecular interactions, and critical phenomena and liquefaction of gases; Maxwell's distribution of speeds, intermolecular collisions, collisions on the wall and effusion; Thermal conductivity and viscosity of ideal gases.

5. Liquid State:

Kelvin equation; Surface tension and surface energy, wetting and contact angle, interfacial tension and capillary action.

6. Thermodynamics:

Work, heat and internal energy; first law of thermodynamics. Second law of thermodynamics; entropy as a state function, entropy changes in various processes, entropy-reversibility and irreversibility, Free energy functions; Thermodynamic equation of state; Maxwell relations; Temperature, volume and pressure dependence of U, H, A, G, C_p and C_v , and; J-T effect and inversion temperature; criteria for equilibrium, relation between equilibrium constant and thermodynamic quantities; Nernst heat theorem, introductory idea of third law of thermodynamics.

7. Phase Equilibria and Solutions:

Clausius-Clapeyron equation; phase diagram for a pure substance; phase equilibria in binary systems, partially miscible liquids—upper and lower critical solution temperatures; partial molar quantities, their significance and determination; excess thermodynamic functions and their determination.

8. Electrochemistry:

Debye-Huckel theory of strong electrolytes and Debye-Huckel limiting Law for various equilibrium and transport properties. Galvanic cells, concentration cells; electrochemical series, measurement of e.m.f. of cells and its applications fuel cells and batteries. Processes at electrodes; double layer at the interface; rate of charge transfer, current density; overpotential; electroanalytical techniques : amperometry, ion selective electrodes and their use.

9. Chemical Kinetics:

Differential and integral rate equations for zeroth, first, second and fractional order reactions; Rate equations involving reverse, parallel, consecutive and chain reactions; Branching chain and explosions; effect of temperature and pressure on rate constant. Study of fast reactions by stop-flow and relaxation methods. Collisions and transition state theories.

10. Photochemistry:

Absorption of light; decay of excited state by different routes; photochemical reactions between hydrogen and halogens and their quantum yields. Surface Phenomena and Catalysis: Government strives to have a workforce which reflects gender balance and women candidates are encouraged to apply. Adsorption from gases and solutions on solid adsorbents; Langmuir and B.E.T. adsorption isotherms; determination of surface area, characteristics and mechanism of reaction on heterogeneous catalysts.

11. Bio-inorganic Chemistry:

Metal ions in biological systems and their role in ion-transport across the membranes (molecular mechanism), oxygen-uptake proteins, cytochromes and ferredoxins.

12. Coordination Chemistry:

- Bonding in transition of metal complexes. Valence bond theory, crystal field theory and its modifications; applications of theories in the explanation of magnetism and electronic spectra of metal complexes.
- Isomerism in coordination compounds; IUPAC nomenclature of coordination compounds; stereochemistry of complexes with 4 and 6 coordination numbers; chelate effect and polynuclear complexes; trans effect and its theories; kinetics of substitution reactions in square-planar complexes; thermodynamic and kinetic stability of complexes.
- EAN rule, Synthesis structure and reactivity of metal carbonyls; carboxylate anions, carbonyl hydrides and metal nitrosyl compounds.
- Complexes with aromatic systems, synthesis, structure and bonding in metal olefin complexes, alkyne complexes and cyclopentadienyl complexes; coordinative unsaturation, oxidative addition reactions, insertion reactions, fluxional molecules and their characterization; Compounds with metal—metal bonds and metal atom clusters.

13. Main Group Chemistry:

Boranes, borazines, phosphazenes and cyclic phosphazene, silicates and silicones, Interhalogen compounds; Sulphur—nitrogen compounds, noble gas compounds.

14. General Chemistry of 'f' Block Element:

Lanthanides and actinides: separation, oxidation states, magnetic and spectral properties; lanthanide contraction.

PAPER - II

1. Delocalised Covalent Bonding:

Aromaticity, anti-aromaticity; annulenes, azulenes, tropolones, fulvenes, sydnones.

- **Reaction mechanisms:** General methods (both kinetic and non-kinetic) of study of mechanisms of organic reactions : isotopies, method cross-over experiment, intermediate trapping, stereochemistry; energy of activation; thermodynamic control and kinetic control of reactions.
- **Reactive intermediates:** Generation, geometry, stability and reactions of carbonium ions and carbanions, free radicals, carbenes, benzyne and nitrenes.
- **Substitution reactions** :— S_N1 , S_N2 , and S_Ni , mechanisms ; neighbouring group participation; electrophilic and nucleophilic reactions of aromatic compounds including heterocyclic compounds—pyrrole, furan, thiophene and indole. Government strives to have a workforce which reflects gender balance and women candidates are encouraged to apply.
- **Elimination reactions** :— $E1$, $E2$ and $E1c_b$ mechanisms; orientation in $E2$ reactions—Saytzeff and Hoffmann; pyrolytic syn elimination—acetate pyrolysis, Chugaev and Cope eliminations.
- **Addition reactions** :—Electrophilic addition to $C=C$ and $C\equiv C$; nucleophilic addition to $C=O$, $C\equiv N$, conjugated olefins and carbonyls.
- **Reactions and Rearrangements** :—
 - ▶ Pinacol-pinacolone, Hoffmann, Beckmann, Baeyer-Villiger, Favorskii, Fries, Claisen, Cope, Stevens and Wagner—Meerwein rearrangements.
 - ▶ Aldol condensation, Claisen condensation, Dieckmann, Perkin, Knoevenagel, Wittig, Clemmensen, Wolff-Kishner, Cannizzaro and von Richter reactions; Stobbe, benzoin and acyloin condensations; Fischer indole synthesis, Skraup synthesis, Bischler-Napieralski, Sandmeyer, Reimer-Tiemann and Reformatsky reactions.
- **Pericyclic reactions** :—Classification and examples; Woodward-Hoffmann rules—electrocyclic reactions, cycloaddition reactions [$2+2$ and $4+2$] and sigmatropic shifts [$1,3$; $3,3$ and $1,5$], FMO approach.
- Preparation and Properties of Polymers: Organic polymers polyethylene, polystyrene, polyvinyl chloride, teflon, nylon, terylene, synthetic and natural rubber.
 - ▶ Biopolymers: Structure of proteins, DNA and RNA.
- Synthetic Uses of Reagents: OsO_4 , HIO_4 , CrO_3 , $Pb(OAc)_4$, SeO_2 , NBS, B_2H_6 , Na-Liquid NH_3 , $LiAlH_4$, $NaBH_4$, $n-BuLi$, MCPBA.

- **Photochemistry** :—Photochemical reactions of simple organic compounds, excited and ground states, singlet and triplet states, Norrish-Type I and Type II reactions.
- **Spectroscopy**: Principle and applications in structure elucidation :
 - Rotational—Diatomic molecules; isotopic substitution and rotational constants.
 - Vibrational—Diatomic molecules, linear triatomic molecules, specific frequencies of functional groups in polyatomic molecules.
 - Electronic—Singlet and triplet states. n and transitions; application to conjugated double bonds and conjugated carbonyls Woodward-Fieser rules; Charge transfer spectra.
 - Nuclear Magnetic Resonance (^1H NMR): Basic principle; chemical shift and spin-spin interaction and coupling constants.
 - Mass Spectrometry :—Parent peak, base peak, metastable peak, McLafferty rearrangement.

OUR CLASSROOM & ONLINE COURSES

GS FOUNDATION

- ☑ 1 Year IAS Foundation
- ☑ 3 & 2 Year IAS Foundation
- ☑ GS Mains Foundation

OPTIONAL FOUNDATION

- ☑ Political Science
- ☑ History
- ☑ Geography
- ☑ Public Administration
- ☑ Anthropology

MAINS COURSES

- ☑ GS Mains Advance
- ☑ GS Mains QIP
- ☑ Ethics Integrity & Aptitude
- ☑ Essay Writing
- ☑ GS Paper 3

TEST SERIES

- ☑ Prelims Test Series
- ☑ GS Mains Test Series
- ☑ Essay Test Series
- ☑ Ethics Test Series
- ☑ Optional Test Series
 - Political Science
 - Geography
 - History
 - Public Administration
 - Anthropology
 - LAW