M.Sc (Chemistry)

SEMESTER-I

(COURSE – I)
(INORGANIC CHEMISTRY)

Lectures-60
Max. Marks-80

Note: i. Ten questions will be set by the examiner selecting TWO from each unit. As far as possible every question will be divided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

ii. Students can ask for Character Tables (except for C_{2v} and C_{3v} point groups) if required.

UNIT-I
Group theory: The concept of group, Symmetry elements and symmetry operations, Assignment of point groups to Inorganic molecules, Some general rules for multiplications of symmetry operations, Multiplication tables for water and ammonia, Representations (matrices, matrix representations for C_{2v} and C_{3v} point groups irreducible representations), Character and character tables for C_{2v} and C_{3v} point groups. Applications of group theory to chemical bonding (hybrid orbitals for \sigma-bonding in different geometries and hybrid orbitals for \pi-bonding. Symmetries of molecular orbitals in BF_3, C_2H_4 and B_2H_6.

UNIT-II
Application of Group Theory in Vibrational Spectroscopy: A brief idea about Infrared and Raman scattering spectroscopy. Vibrational modes as basis of group representations w.r.t. SO_2, POCl_3, PtCl_2^2 and RuO_4. Mutual exclusion principle, Classification of vibrational modes (i.e. stretching and angle deformation vibrations w.r.t. SO_2, POCl_3 and PtCl_2^2).

UNIT-III
Non-Aqueous Solvents: Factors justifying the need of Non Aqueous solution Chemistry and failure of water as a Solvent. Solution chemistry of Sulphuric acid: Physical properties, Ionic self dehydration in H_2SO_4, high electrical conductance in spite of high viscosity, Chemistry of H_2SO_4 as an acid, as an dehydrating agent, as an oxidizing agent, as a medium to carry out acid-base neutralization reaction and as a differentiating solvent. Liquid BrF_3: Physical properties, solubilities in BrF_3, self ionization, acid base neutralization reactions, solvolytic reactions and formation of transition metal fluorides. Chemistry of Molten salts as Non-Aqueous Solvents: Solvent properties, solution of metals, complex formation, Unreactivity of molten salts, Low temperature molten salts.

UNIT-IV
Inorganic Hydrides: Classification, preparation, bonding and their applications. Transition metal compounds with bonds to hydrogen, carbonyl hydrides and hydride anions. Classification, nomenclature, Wade’s Rules, preparation, structure and bonding in boron hydrides (boranes),carboranes, metalloboranes and metallocarboranes.

UNIT-V
Organic Reagents in Inorganic Chemistry: Chelation, factors determining the stability of chelates (effect of ring size, oxidation state of the metal, coordination number of the metal); Use of the following reagents in analysis:
(a) Dimethylglyoxime (in analytical chemistry)
(b) EDTA (in analytical chemistry and chemotherapy)
(c) 8-Hydroxyquinoline (in analytical chemistry and chemotherapy)
(d) 1,10-Phenanthroline (in analytical chemistry and chemotherapy)
(e) Thiosemicarbazones (in analytical chemistry and chemotherapy)
(f) Dithiazone (in analytical chemistry and chemotherapy)
1. Chemical applications of Group Theory ñ F.A.Cotton  
2. Inorganic Chemistry ñ Durrant and Durrant  
3. Symmetry in Chemistry ñ Jaffe and Orchin  
4. Non-aqueous solvents ñ H.Sisler  
5. Non-aqueous solvents ñ T.C.Waddington  
6. Non-aqueous solvents ñ Logowsky  
8. Concise course in Inorganic Chemistry ñ J.D.Lee  
9. Nature of Chemical Bond ñ L. Pauling  
10. Chemistry of Elements ñ Greenwood and Earnshaw  
11. Inorganic Chemistry ñ T. Moeller  
13. Topics in Current Chemistry (Inorganic/Bio-Chemistry)ñ Vol. 64  
SEMESTER-I
(COURSE – II)
ORGANIC CHEMISTRY)

Lectures-60
Max. Marks-80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible every question will be divided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT-I

UNIT-II
Stereochemistry: Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity in acyclic and cyclohexane systems. Steric strain due to unavoidable crowding. Elements of symmetry: chirality, molecules with more than one chiral center, three and erythro isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, Optical activity due to chiral planes, Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape. Asymmetric Synthesis: Principle and categories with specific examples of asymmetric synthesis including newer methods involving enzymatic and catalytic reactions, enantio and diastereoselective synthesis. Stereoselective Reactions: Cyclopropanation, hydroboration, catalytic hydrogenation, and metal ammonium reduction, stereoselective synthesis of (-) ephedrine and (+) Ú- ephedrine. Stereospecific Reactions: Elimination of 2,3- dibromobutane densyl chloride(1,2-diphenyl-1-chloroethane), SN² reactions at chiral carbon.

UNIT-III
Effect of structure on reactivity: resonance and field effects, steric effect. Quantitative treatment: Hammett equation and linear free energy relationship, Substituent and reaction constants, Taft equation. Methods of determining reaction mechanism.

UNIT-IV
Aliphatic Nucleophilic Substitution: The SN₂, SN₁, mixed SN₁ and SN₂, SET mechanisms & SNi mechanism. The neighboring group mechanism, neighboring group participation by ´ and Ú bonds, anchimeric assistance. Non-classical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements-Wagner-Meerwein, Pinacol-Pinacolone and Demjanov ring expansion and ring contraction. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Esterification of carboxylic acid, transesterification, transetherification and preparation of inorganic esters. Phase-transfer catalysis, and ultrasound, ambident nucleophile, regioselectivity.

(B) Free radical reactions: Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighboring group assistance, Reactivity in aliphatic and aromatic substrates at a bridgehead and attacking radicals. Effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Gomberg Bachmann reaction, Sandmeyer reaction, Hoffmann -Loffler- Freytag reaction, Hunsdiecker reaction.

Books Recommended:
SEMESTER-I
(COURSE – III)
( PHYSICAL CHEMISTRY)

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible every question will be divided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT – I

UNIT - II

UNIT - III
Kinetics of complex reactions: Reversible / opposing reactions, consecutive / successive reactions, simultaneous side / parallel reactions, chain / free radical reactions viz. thermal (H₂ Î Br₂) and photochemical H₂ Î Cl₂ reactions. Rice – Herzfeld mechanism of dissociation of organic molecules viz. dissociation of ethane, decomposition of acetaldehyde as 3/2 or ½ order reactions. Kinetics of polymerization (molecular and free radical mechanisms). Reaction rates and chemical equilibrium, principle of microscopic reversibility, activation energy and activated complex.

UNIT - IV
Theories of reaction rates: The kinetic theory of collisions, transition state theory, comparison of collisions and transition state theories in simple gas reactions, steric factor, transmission coefficient, steady state hypothesis / transient phase theory, Lindmans theory of unimolecular reaction, the thermodynamic formulation of reaction rates.

UNIT - V

Books Recommended:
1. Chemical Kinetics : K.J. Laidler
3. Modern Chemical Kinetics: H. Eyring
4. Theories of Reaction Rates: K.J. Laidler, H. Eyring and S. Glasston
5. Fast Reactions: J. N. Braddy
6. Fast Reactions in Solutions: Caldin
7. Basic Principles of Spectroscopy: R. Chang
8. NMR and Chemistry: J. W. Akit
9. Introduction to Molecular Spectroscopy: G. M. Barrow
10. Physical Chemistry: P. W. Atkins
11. Fundamentals of Molecular Spectroscopy: C. N. Banwell
SEMESTER-I  
(COURSE – IV)  
(MATHEMATICS FOR CHEMISTS & APPLICATION OF COMPUTER IN CHEMISTRY)  
Lectures: 60  
Max. Marks: 80  

**Note:** Ten questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be subdivided into **Two – Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.

**Mathematics for Chemists**

**UNIT - I**
Cartesian coordinates: plane polar coordinates, spherical representation of functions, the complex plane, polar coordinates in trigonometric functions. Differential calculus: functions of single and several variables, partial derivatives, the total derivative, maxima and minima theorem, and simple examples related to chemistry. Vectors: representation and simple properties of vectors (addition and subtraction) vector addition by method of triangles, resolution of vectors. Scalar product of vector. Concept of normalization, orthogonality and complete set of unit vectors.

**UNIT – II**

**UNIT – III**

**Application of Computer in Chemistry**

**UNIT – IV**
Chemistry and FORTRAN Programming: Introductory FORTRAN concepts, character set, constant variables, data types, subscripted variables, and FORTRAN functions. FORTRAN expressions and naming FORTRAN programme, assignment statements, FORTRAN commands. Data transfer and program execution control: Introduction, format specification for READ and WRITE statements, format commands, control commands and transfer commands.

**UNIT – V**
Arrays and repetitive computation; Introduction, arrays arrange storage, dimension statement, do control, Nested do loop continue statement, implied do. Sub programme (functions and sub routines): Introduction, sub programme, functions in FORTRAN, function arguments, subroutines, save variable function vs. subroutine programme. Global variables and file manipulation: Introduction, common statement, equivalence declaration, data command, block data subprogramme, declaration external, character expression and assignment, the open and closed statement, internal file, file input and output Developing Linear Least Squares fit programs in FORTRAN, as well as for involving simple formulae in organic, inorganic and physical chemistry.

**Books Recommended:**
1. Mathematical Preparation for Physical Chemistry: F. Daniel
3. Applied Mathematics for Physical Chemistry: T.R. Brrante
4. Fortran 77 & 90: V. Rajaraman
5. Computer in Chemistry: K.V. Raman
SEMESTER-II

(COURSE –V)

ORGANIC CHEMISTRY)

Lectures: 60

Max. Marks: 80

**Note:** Ten questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be divided into **Two – Three Parts.** The students shall attempt **FIVE** questions selecting **ONE** from each unit.

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**UNIT-I**

**Metal-Ligand Bonding-I:** Recapitulation of Crystal Field Theory including splitting of $d$-orbitals in different environments, Factors affecting the magnitude of crystal field splitting, structural effects (ionic radii, Jahn-Teller effect), Thermodynamic effects of crystal field theory (ligation, hydration and lattice energy), Limitations of crystal field theory, Adjusted Crystal Field Theory (ACFT), Evidences for Metal-Ligand overlap in complexes, *Molecular Orbital Theory* for octahedral, tetrahedral and square planar complexes (excluding mathematical treatment).

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**UNIT-II**

**Atomic Spectroscopy:** Energy levels in an atom, coupling of orbital angular momenta, coupling of spin angular momenta, spin orbit coupling, spin orbit coupling $p^2$ case, Determining the Ground State Terms-Hund’s Rule, Hole formulation (derivation of the Term Symbol for a closed sub-shell, derivation of the terms for a $d^2$ configuration), Calculation of the number of the microstates.

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**UNIT-III**

**Electronic Spectra-I:** Splitting of spectroscopic terms (S,P,F and G,H,I), $d^1$-$d^9$ systems in weak fields (excluding mathematics), strong field configurations, transitions from weak to strong crystal fields.

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**UNIT-IV**

**Electronic Spectra-II:** Correlation diagrams ($d^1$-$d^9$) in $O_h$ and $T_d$ environments, spin-cross over in coordination compounds. Tanabe Sugano diagrams, Orgel diagrams, evaluation of $B,C$ and $\beta$ parameters.

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**UNIT-V**

**Magnetochemistry:** Origin of Magnetic moment, factors determining paramagnetism, application of magnetochemistry in co-ordination chemistry (spin only moment, Russell Saunder’s coupling, quenching of orbital angular moment, orbital contribution to a magnetic moment) in spin free and spin paired octahedral and tetrahedral complexes. Magnetic susceptibility (diamagnetic, paramagnetic), magnetic moments from magnetic susceptibilities, Van Vlecks formula for magnetic susceptibility, temperature dependence of magnetic susceptibility.

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**Books Recommended:**

1. Advanced Inorganic Chemistry by Cotton and Wilkinson
2. Coordination Chemistry- Experimental Methods by K.Burger
3. Theoretical Inorganic Chemistry by Day and Selbin
4. Magnetochemistry by R.L.Carlin
5. Comprehensive Coordination Chemistry by Wilkinson, Gillars and McCleverty.
6. Inorganic Electronic Spectroscopy by A.B.P.Lever
7. Concise Inorganic Chemistry by J.D.Lee
8. Introduction to Ligand Fields by B.N.Figgis
**SEMESTER-II**  
(COURSE – VI)  
(ORGANIC CHEMISTRY)

Lectures: 60  
Max. Marks: 80

**Note:** Ten questions will be set by the examiner selecting **TWO** from each unit. As far as possible every question will be subdivided into **Two – Three Parts.** The students shall attempt **FIVE** questions selecting **ONE** from each unit.

### UNIT – I

**Aromatic Electrophilic Substitution:** Arenium ion mechanism, orientation and reactivity, energy profile diagrams, The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles, Diazonium coupling, Vilsmeir reaction, Scholl reaction, Amination reaction, Fries rearrangement, Reversal of Friedel Craft alkylation, Decarboxylation of aromatic acids.

**Aromatic Nucleophilic Substitution:** SNAr, SN¹, benzyn and SRN¹ mechanism. Reactivity, effect of substrate structure, leaving group and attacking nucleophile, Von Richter, Sommelet-Hauser, and Smiles rearrangements, Ullman reaction, Ziegler alkylation, Schiemann reaction.

### UNIT-II

**Common Organic Reactions and Their Mechanisms:** Perkin condensation, Michael reaction, Robinson annulation, Dieckmann reaction, Stobbe condensation, Mannich reaction, Knoevenagel condensation, Benzoin condensation, Witting reaction, Hydroboration, Hydrocarboxylation, Ester hydrolysis, Epoxidation.

### UNIT- III

**Reagents in Organic Synthesis:** Synthesis and applications of BF₃, NBS, Diazomethane, Lead tetra-acetate, Osmium tetraoxide, Woodward Prevorst hydroxylation reagent, LiAlH₄, Grignard reagent, organozinc and organolithium reagent.

### UNIT-IV

**Elimination Reactions:** Discussion of E₁, E₂, E₁cB and E₂c Mechanisms and orientation, Reactivity: Effects of substrate structures, attacking base, leaving group and medium. Cis elimination, elimination in cyclic systems, eclipsing effects, Pyrolytic eliminations, cleavage of quaternary ammonium hydroxides, Fragmentations: γ-Amino and γ-hydroxy halides, decarboxylation of β-hydroxy carboxlic acid and β-lactones.

### UNIT-V

**Pericyclic Reaction:** Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5 hexatrienes and allyl system. Classification of pericyclic reactions, Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions: conrotatory and disrotatory motions, 4n and 4n+2 and allyl systems. Cycloadditions- antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and chelotropic reactions. Sigmatropic rearrangements-Suprafacial and Antarafacial shifts of H, sigmatropic shifts involving carbon moieties, Claisen, Cope and aza-Cope rearrangements, Ene reaction.

### Books recommended:

SEMESTER-II

(COURSE – VII)

PHYSICAL CHEMISTRY)

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be divided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT – I
Brief resume of law of thermodynamics. Gibb’s and Helmholtz free energy functions and their significance. Partial molal quantities. Partial molal free energy and its variation with temperature and pressure. Determination of partial molar volume. Thermodynamic criteria for the fugacity of the process in terms of entropy change, internal energy change, enthalpy and free energy (Gibb’s and Helmholtz ) change. Gibb’s and Helmholtz equation and its utility in thermodynamics of cell reaction. Thermodynamics of ideal solutions. Fugacity and activity and their variation with temperature and pressure. Graphical method for the determination of fugacity.

UNIT – II

UNIT – III

UNIT – IV

UNIT – V

Books Recommended:
1. Thermodynamics for Chemists: S. Glasstone
2. Physical Chemistry: G.M. Barrow
3. Non eqilibrium Thermodynamics: C. Kalidas
4. Non eqilibrium Thermodynamics: I. Prigogene
5. Electrochemistry: S. Glasstone
6. Electrochemistry: P.H. Reiger
SEMESTER-II
(COURSE – VIII)
LIFE & ENVIRONMENTAL CHEMISTRY

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be divided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT-I
**Cell structure and function:** Overview of metabolic processes (catabolic and anabolic), energy transfer processes, role and significance of ATP (the biological energy currency). Introductory idea of metabolism of proteins and lipids, biosynthesis of proteins and glycerides.

UNIT-II
**Nucleic acids:** Purine and pyrimidine bases of nucleic acids, base pairing via H-bonding. Structure of ribonucleic acids (RNA) and deoxyribonucleic acids (DNA), double helix model of DNA and forces responsible for holding it. Chemical and enzymatic hydrolysis of nucleic acids. The Chemical basis for heredity, an overview of replication of DNA, transcription, translation and genetic code. Chemical synthesis of mono and trinucleoside.

UNIT-III
**Environmental Chemistry:** Atmosphere, environmental segments, composition of the atmosphere, earth's radiation balance, particulates, ions and radicals and their formation, chemical and photochemical reactions in the atmosphere, air pollution, oxides of C,N,S and their effects, acid-rain, smog formation, Green house effects (global warming and ozone depletion), air pollution controls and introduction to analytical methods for monitoring air pollution.

UNIT-IV
**Hydrosphere:** Chemical composition of water bodies-lakes, streams, rivers, sea etc, hydrological cycle, complexation in natural and waste water and microbiologically mediated redox reactions. Water pollution-inorganic, organic, pesticides, industrial and radioactive materials, oil spills and oil pollutants, eutrophication, acid-mine drainage, waste water treatment, domestic waste water (aerobic and anaerobic treatment), and industrial waste water treatment.

UNIT-V
**Water quality parameters and standards:** Analytical methods for measuring DO, BOD, COD, fluoride, oils and grease and metals (As, Cd, Hg, Pb, Zn,Cu,Cr), Biochemical effects of As, Cd, Hg, Pb, Cr, CN and pesticides. **Lithosphere:** Soil composition, micro and macro nutrients, soil pollution-fertilizers, pesticides.

Books Recommend:
1. Principles of Biochemistry – A.L.Lehringer
2. Introduction to Chemistry of Life – H.J.DeBay
3. Outlines of Biochemistry – Conn and Stumpf
5. Environmental Chemistry – Manaham
6. Environmental Pollution Analysis – Khopkar
1. Volumetric Analysis:

(a) **Potassium iodate titrations**: Determination of iodide, hydrazine, antimony(III) and arsenic (III)
(b) **Potassium bromate titrations**
   i) Determination of antimony (III) and arsenic (III) Direct Method
   ii) Determination of aluminium, cobalt and zinc (by oxine method)
(c) **EDTA titrations**
   i) Determination of copper, nickel, magnesium
   ii) Back titration
   iii) Alkalimetric titration
   iv) Titration of mixtures using masking and demasking agents
   v) Determination of hardness of water

2. Commercial Analysis:

   i) Determination of available chlorine in bleaching powder
   iii) Determination of Phosphoric acid in commercial phosphoric acid.
   iv) Determination of Boric acid in borax.
   v) Determination of metals: copper in copper oxychloride and zinc in zineb fungicides.

3. Analysis of mixtures by gravimetric and volumetric methods from the mixture solutions:

   1. Copper- Nickel
   2. Copper- Magnesium
   3. Copper- Zinc
   4. Iron- Magnesium
   5. Silver- Zinc
   6. Copper- Nickel- Zinc
   7. Fe(II)-Fe(III)

4. Green methods of Preparation of the following:

   (i) Bis(acetylacetonato)copper(II)
   (ii) Tris(acetylacetonato)iron(III)
   (iii) Tris(acetylacetonato)manganese(III)

**Books Recommended:**
3. Commercial Methods of Analysis: Shell & Biffen
Qualitative Analysis: Separation, purification and identification of binary mixture of organic compounds by chemical tests, TLC, column chromatography and IR spectroscopy.


Books Recommended:
SEMESTER I AND II
(COURSE – IXC)
(PHYSICAL CHEMISTRY PRACTICAL)

Time - 6 hr
Max. Marks - 50

1. **Refractive Index (RI) Measurements:** Refractive index (RI) measurements of pure solvents, analysis of mixtures of two miscible solvents, molar and atomic refraction determination, polarizability of liquids.

2. **Conductometric Measurements:** Determination of cell constant, limiting molar conductance of simple electrolytes in water, verification of Ostwald, dilution law for weak acetic acid.

3. **Surface Tension Measurements:** Surface tension of pure solvents, analysis of mixtures of two miscible solvents, verification of Gibbs Thomson Rule of surface tension.

4. **Partition – Coefficient:** Determination of partition coefficient for I₂ between water and CCl₄ and for benzoic acid between water and benzene.

5. **Adsorption Measurements:** Verification of Freundlich adsorption isotherm for I₂, acetic acid and oxalic acid on charcoal.

6. **Colloidal Solution:** Preparation of sol solution of arsenic sulphide and estimation of flocculation value for NaCl, KCl, BaCl₂, AlCl₃.

7. **Thermochemistry:** Determination of water equivalent of thermos flask, and estimation of heat of neutralization for strong acid strong base, weak acid strong base or vice versa, heat of hydration and solution of salts.

8. **Kinetic Measurement:** Kinetics of Hydrolysis of methylacetate and ethylacetate in the presence of HCl.

**Books Recommended:**

1. Senior Practical Physical Chemistry: B.D. Khosla, V.C. Garg and A. Khosla
4. Practical in Physical Chemistry: P.S. Sindhu
SEMESTER-III
(COURSE –X)
ORGANIC CHEMISTRY)

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be divided into Two–Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT-I
Metal π Complexes: Preparation, reactions, structures and bonding in carbonyl, nitrosyl, phosphine and related complexes, structural evidences from vibrational spectra, bonding and important reactions of metal carbonyls. Structure and bonding in metal cyanides, stabilization of unusual oxidation states of transition metals.

UNIT-II
Introductory Analytical Chemistry: Data Analysis – Types and sources of errors, propagation of errors, detection and minimization of various types of errors. Accuracy and precision, average and standard deviation, variance, its analysis and confidence interval, tests of significance (F-test, t-test and paired t-test), criteria for the rejection of analytical data (4d rule, 2.5d rule, Q-test, average deviation and standard deviation), least-square analysis.

Food and Drug Analysis - General methods for proximate and mineral analysis in food (moisture, ash, crude fiber, nitrogen (proteins) and minerals (iron, calcium, potassium, sodium and phosphorus). Discussion of official (pharmacopea) methods for the determination of following drugs as such: (i) Analgin/oxyphenbutazone, (ii) chloramphenicol and related nitro compounds, (iii) chloroquinine, (iv) phenyl butazone, (v) salicylic acid and (vi) sulphonamides.

UNIT-III
Photoelectron Spectroscopy: Basic principle, photoionization process, ionization energies, Koopman’s theorem, ESCA, photoelectron spectra of simple molecules, (N₂, O₂ and F₂) Photoelectron spectra for the isoelectronic sequence Ne, HF, H₂O, NH₃ and CH₄ , chemical information from ESCA, Auger electron spectroscopy I basic idea.

UNIT-IV
Lanthanides and Actinides:- Spectral and magnetic properties, comparison of Inner transition and transition metals, Transuranium elements (formation and colour of ions in aqueous solution), uses of lanthanide compounds as shift reagents, periodicity of translawrencium elements.

UNIT-V
Nuclear Chemistry: Nuclear binding energy and stability, nuclear models (nuclear shell model and collective model). Nuclear reactions: types of reactions, nuclear cross-sections, Q-value. Natural and artificial radioactivity, radioactive decay and equilibrium, Nuclear fission-fission product and fission yields, Nuclear fusion.

Radioactive techniques: Tracer technique, (neutron activation analysis), Counting techniques such as G.M. Ionization and proportional counters.

Books Recommended:
1. Advanced Inorganic Chemistry ı Cotton and Wilkinson
2. Fundamentals of Analytical Chemistry ı Skoog and West
3. Quantitative Inorganic Analysis ı Vogel
4. Chemistry of the Elements ı Greenwood and Earnshaw
5. Nuclear Chemistry-U.C.Dash
6. Nuclear Chemistry ı B.G.Harvey
7. Nuclear Chemistry ı Arnikar
8. Techniques in Inorganic Chemistry Vol. II (Nuclear Chemistry-Johnson and Others).
11. Analytical Chemistry-G.D.Christian
12. Chemical Structure and Bonding- Dekock and Gray
14. Electronic absorption spectroscopy and related techniques: D.N. Sathyanarayan
SEMESTER-III

(COURSE –XI)

ORGANIC CHEMISTRY)

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be subdivided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT – I

Spectroscopy:


(B) Infrared Spectroscopy: Instrumentation and sample handling, Characteristic vibrational frequencies of common organic compounds. Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance. Introduction to Raman spectroscopy. Applications of IR and Raman Spectroscopy in organic chemistry.

UNIT – II

Nuclear Magnetic Resonance (NMR) Spectroscopy: General introduction, chemical shift, spin-spin interaction, shielding mechanism, chemical shift values and correlation of protons present in different groups in organic compounds. chemical exchange, effect of deuterium, complex spin-spin interaction between two, three, four and five nuclei, virtual coupling. Stereochemistry, hindered rotation, Karplus- relationship of coupling constant with dihedral angle. Simplification of complex spectra-nuclear magnetic double resonance, spin tickling, INDO, contact shift reagents, solvent effects. Fourier transform technique, Nuclear Overhauser Effect (NOE). Introduction to resonance of other nuclei F, P, Principle and introduction to C^{13} NMR, 2-D and 3-D NMR, Applications of NMR in organic chemistry.

UNIT – III

Mass Spectrometry: Introduction, ion production EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, and ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, Molecular ion peak, Meta-stable peak, McLafferty rearrangement. Nitrogen Rule. High-resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination. Introduction to negative ion Mass spectrometry, TOF-MALDI. Problems based upon IR, UV, NMR and mass spectrometry.

UNIT – IV


UNIT – V

Photochemistry – II: Photochemistry of Carbonyl compounds: Norrish Type I and II, Intermolecular and Intramolecular hydrogen abstraction, Paterno-Buchi reaction, U and S cleavage reactions of cyclic and acyclic carbonyl compounds, Formation of oxetane and cyclobutane from
α, β-unsaturated ketones, Photo-reduction of carbonyl compounds, Photo-rearrangement of enones, dienones, epoxyketones, Photo-Fries rearrangement.

Books Recommended:
6. Organic spectroscopy by Jagmohan
7. Organic spectroscopy by W. Kemp.
Statistical Thermodynamics

UNIT – I
Basic Terminology: probability, phase space, micro and macro states, thermodynamic probability, statistical weight, assembly, ensemble, probability considerations and chemistry. The most probable distribution: Maxwell-Boltzmann distribution, Thermodynamic properties from statistical Thermodynamics, The Partition Function for monoatomic gas, State functions in terms of partition function, separating partition function: the nuclear and electronic partition function, for molecules, electronic and vibrational partition function,

UNIT – II
Diatomic molecules: Rotations, Polyatomic molecules: Rotations, The partition function of a system, Thermodynamic properties of molecules from partition function: Total energy, entropy, Helmholtz free energy, pressure, heat content, heat capacity and Gibb’s free energy, equilibrium constant and partition function, Heat capacity of crystals and statistical thermodynamics, quantum statistics: The Bose- Einstein statistics and Fermi- Dirac Statistics.

Basic Quantum Chemistry

UNIT – III

UNIT – IV
Quantum mechanical treatment of translational motion of a particle, particle in one and three dimensional boxes, harmonic oscillator, rotational motion of a particle: particle on a ring, particle on a sphere, rigid rotator and hydrogen atom. Graphical presentation of orbitals (s, p and d), radial and angular probability distribution plots.

UNIT – V

Books Recommended:
1. Physical Chemistry: D.W. Ball
2. Theoretical Chemistry by S. Glasston
3. Statistical Chemistry by I. Prigogine
4. Quantum Chemistry An Introduction: H.L. Strauss
5. Introductory Quantum Chemistry: A.K. Chandra
6. Quantum Chemistry: A. Mcquarrie
7. Quantum Chemistry: I.N. Levine
UNIT-I

Inorganic Photochemistry: Basic principles, Basic photochemical processes, Kashiaâ€™s rule, Thexi state, Photochemical behaviour of transition metal complexes, charge transfer spectra of crystalline and gaseous alkali halides, photochemical reactions of coordination compounds, oxidation-reduction reactions, Photo substitution reactions, Adamsonâ€™s rules and photo-substitution reactions of cobalt(III) complexes i.e. [Co(NH$_3$)$_5$X]$^{2+}$, [Co(en)$_3$]$^{3+}$, and chromium(III) complexes i.e. [Cr(H$_2$O)$_6$]$^{3+}$ and [Cr(NH$_3$)$_6$]$^{3+}$ and ruthenium (II) polypyridyl complexes.

UNIT-II


UNIT-III

Polymeric Inorganic Compounds: General chemical aspects (synthesis, properties and structure) of phosphazenes, borazines, silicones, sulphur-nitrogen cyclic compounds and condensed phosphates.

UNIT-IV

Stability of Coordination Compounds – Stability constants, stepwise formation constants, overall formation constants, relationship between stepwise and overall formation constants, difference between thermodynamic and kinetic stability.

Determination of stability constants by:

(i) Spectrophotometric methods (Jobâ€™s method, Mole ratio and slope ratio method).
(ii) Bjerrumâ€™s method
(iii) Ledenâ€™s method
(iv) Polarographic method

Factors affecting the stability constants (with special reference to metal and ligand ions).

UNIT-V


Books Recommended:

1. Instability Constants- Yttermiskii
2. Advanced Inorganic Chemistry- Cotton and Wilkinson
3. Inorganic Chemistry- T.Moeller
4. Concise Inorganic Chemistry- J.D.Lee
5. Introduction to Ligand Fields- B.N.Figgis
7. Inorganic chemistry: A Unified Approach W.W.Porterfield
8. Inorganic Reaction Mechanism Edberg
9. Inorganic Reaction Mechanism Basoloavd Pearsor
UNIT-I
Carbohydrates: Types of naturally occurring sugars: Deoxy-sugars, amino sugars, branched chain sugars. General methods of structure and ring size determination with particular reference to maltose, lactose, sucrose, pectin, starch and cellulose, photosynthesis of carbohydrates, metabolism of glucose, Glycoside- (amygdalin).

UNIT-II

UNIT-III
Vitamins: A general study, detailed study of chemistry of thiamine (Vitamin B₁), Ascorbic acid (Vitamin C), Pantothenic acid, biotin (Vitamin H), α-tocopherol (Vitamin E), Biological importance of vitamins.

UNIT-IV
Enzymes: Nomenclature and classification, extraction and purification, Remarkable properties of enzymes like catalytic power, specificity and regulation, Proximity effects and molecular adaptation, Chemical and biological catalysis. Mechanism of enzyme action: Transition state theory, orientation and steric effect, acid base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanisms (chymotrypsin, ribo nuclease, lysozyme and carboxypetidase A). Fischer’s lock and key and Koshland’s induced fit hypothesis, concept and identification of active site by the use of inhibitors affinity labeling and enzyme modification by site directed mutagenesis. Enzyme kinetics, Michaelis-Menten and Lineweaver-Burk plots, reversible and irreversible inhibition.

UNIT-V
(A) Kinds of reactions catalyzed by Enzymes: Nucleophilic displacement on a phosphorus atom, multiple displacement reactions and the coupling of ATP cleavage to endergonic processes. Transfer of sulphate addition and elimination reactions, enolic intermediates in isomerization reactions, β-cleavage and condensation, some isomerization and rearrangement reactions. Enzyme catalyzed carboxylation and decarboxylation reactions.

(B) Coenzyme Chemistry: Cofactors as derived from vitamins, coenzymes, prosthetic groups, and apoenzymes. Structure and biological functions of coenzyme A, thamine pyrophosphate pyridoxal phosphate, NAD⁺, NADP⁺, FMN, FAD, Lipoic acid, vitamin B₁₂. Mechanisms of reactions catalyzed by the above cofactors.

Books recommended:

2. Understanding Enzymes, Trevor Palmer, Prentice Hall.
11. Carbohydrates by Gutherie.
13. The Nucleic Acids (Vol I-III) by Chargoff and Davidson.
14. Protein Structures and Functions by A. Light.
17. The chemistry of Natural Products by P.S. Kalsi.
SEMESTER-III
(COURSE –XIII (C))
CHEMISTRY SPECIAL THEORY - I)

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be divided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT –I

UNIT –II

UNIT –III
Solution and Interfacial Behaviour of Surfactants: Definition and classification of surfactants. Solution properties of surfactants: micelle and reverse micelle formation, critical micelle concentration (CMC), dependence of CMC on chain length of the surfactant, micelle shape and size. Thermodynamics of micelle formation, hydrophobic effect (a qualitative view only). Aggregation at high surfactant concentration (a qualitative aspect). to micelles. Surface tension and detergent., Practical application of surfactants.

UNIT –IV

UNIT –V
Chemistry of nano materials: Definition and historical perspective. Effect of nanoscience and nanotechnology in various fields. Synthesis of nanoparticles by chemical routes and their characterization techniques. Properties of nanostructured material: optical, magnetic and chemical properties. An overview of applied chemistry of nanomaterials.

Books Recommended:
1. Physical Chemistry of Surfaces: A.W. Admson
2. Adsorption from Solutions: J.J. Kipling
5. Physical Chemistry: P.W. Atkins
7. Introduction to nanotechnology: Charles P. Poole, Jr. Frank, J. Owens: Wiley India
SEMESTER III

(COURSE – XIV A)

(INORGANIC CHEMISTRY PRACTICAL)

Time - 6 hr
Max. Marks - 50

1. Analysis of the given sample (Ores)/Both Qualitative and Quantitative Dolomite, Pyrolusite, Galena.
2. Analysis of the given alloys: Coin, Gunmetal, Brass and Bronze.
3. To prepare a pure and dry sample of the following compounds:
   1. Potassium tris(oxalato)aluminate(III)
   2. Sodium hexa(nitro)cobaltate(III)
   3. Potassium tris(oxalato)cobaltate(III)
   4. Hexa(ammine)cobalt (III)chloride
   5. Tetrapyridine copper(II)persulphate
   6. Dinitrotetrapyridine nickel(II)
   7. Lead tetraacetate
   8. Mercury (tetraisothiocyanato)cobaltate(II).

and characterize them by the following techniques:
   i) Elemental analysis
   ii) Molar conductance values
   iii) I.R. Spectral interpretation
   iv) Thermal analysis
   v) UV-Visible Spectra

Books Recommended:
   1. A Text Book of Qualitative Inorganic Analysis Î A.I. Vogel


**Books Recommended:**

1. **Solubility Measurements**: Heat of solution of electrolytes by solubility measurements.

2. **Heat of transfer Measurements**: Heat of transfer for benzoic acid between benzene and water and I₂ between CCl₄ and water.

3. **Conductometric Measurements**: Precipitation titration (AgNO₃ + KCl), acid + base neutralization titration, determination of relative strength of acids in the given mixtures, solubility of sparingly soluble salt.

4. **Construction of Phase Diagram**: Phase diagram for liquids, (benzene and methanol, ----) and phase diagram for solids, (benzoic acid and cinnamic acid, benzoic acid and naphthalene and acetamide and salicylic acid).

5. **Colorimetric Measurements**: Verification of Beer-Lambert’s law for aqueous solutions of KMnO₄, K₂Cr₂O₇ and CuSO₄ and construction of calibration plot to estimate the unknown concentration.

6. **Kinetic Measurement**: Saponification of ethylacetate by NaOH solution.

**Books Recommended:**

1. Senior Practical Physical Chemistry: B.D. Khosla, V.C. Garg and A. Khosla
4. Practical in Physical Chemistry: P.S. Sindhu
SEMMESTER-IV

(COURSE – XV A)

(INORGANIC CHEMISTRY SPECIAL THEORY - II)

(ADVANCED ORGANOMETALLICS)

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be subdivided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT-I
Organometallic Compounds of transition elements: Types of ligands and their classifications in organometallic compounds, 16 and 18 electron rule and its limitations. Hapto-nomenclature, synthesis, structure and bonding aspects of following organometallic compounds with carbon-

A) Two electron donor (olefin and acetylenic complexes of transition metals)
B) Three electron donor (α-allyl complexes of transition metals)
C) Four electron donor (butadiene and cyclobutadiene complexes of transition metals)
D) Five electron donor (cyclopentadienyl complexes of transition metals with special emphasis to ferrocenes)
E) Six electron donor [Benzene (arene) complex]

Fluxional and dynamic equilibria in compounds such as \( \eta^2 \)-olefin, \( \eta^3 \)-allyl and dienyl complexes.

UNIT-II
Homogeneous Transition metal catalysis: General considerations, Reason for selecting transition metals in catalysis (bonding ability, ligand effects, variability of oxidation state and coordination number), basic concept of catalysis (molecular activation by coordination and addition), proximity interaction (insertion/inter-ligand migration and elimination, rearrangement). Phase transfer catalysis. Homogeneous hydrogenation of unsaturated compounds (alkenes, alkynes, aldehydes and ketones). Asymmetric hydrogenation.

UNIT-III
Some important homogeneous catalytic reactions:- Ziegler Natta polymerization of ethylene and propylene, oligomerisation of alkenes by alumnumalkyl, Wackers acetaldehyde synthesis, hydroformylation of unsaturated compounds using cobalt and rhodium complexes, Monsanto acetic acid synthesis, carboxylation reactions of alkenes and alkynes using nickel carbonyl and palladium complexes. Carbonylation of alkynes (acetylene) using nickel carbonyls or Palladium complexes.

UNIT-IV
Metal-metal bonding in carbonyl and halide clusters:- Polyhedral model of metal clusters, effect of electronic configuration and coordination number, Structures of metal carbonyl clusters of three atoms \( \text{M}_3(\text{CO})_{12} \) (M=Fe, Ru & Os), Four metal atoms (tetrahedra) \( \text{M}_4(\text{CO})_{12} \) (M=Co, Rh &Ir) and octahedron of type \( \text{M}_6(\text{CO})_{16} \) (M=Co & Rh), and halide derivatives of Rhenium (III) triangles, metal carbonyls involving bridged-terminal exchange and scrambling of CO group.

UNIT-V
Transition Metal-Carbon multiple bonded compounds:- Metal carbenes and carbynes (preparation, reactions, structure and bonding considerations). Biological applications and environmental aspects of organometallic compounds, Organometallic compounds in medicine, agriculture and industry.
Books Recommended:
1. Principles of organometallic compounds – Powell
2. Organometallic chemistry (an Introduction) – Perkin and Pollar
3. Organometallic chemistry – Parison
4. Advanced Inorganic Chemistry – Cotton and Wilkinson
5. Organometallic Chemistry – R.C.Mehrotra
6. Organometallic compounds of Transition Metal – Crabtree
7. Chemistry of the Elements – Greenwood and Earnshaw
8. Inorganic Chemistry – J.E.Huheey
9. Homogeneous transition metal catalysis – Christopher Masters
10. Homogeneous Catalysis – Parshall
11. Principles and Application of Homogeneous Catalysis – Nakamura and Tsutsui
14. Principles and applications of organotransition metal chemistry by Ccollmen and Hegden
SEMESTER-IV

(COURSE – XVI A)

(CHEMISTRY SPECIAL THEORY - III)

(MODERN TECHNIQUES OF CHEMICAL ANALYSIS)

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be subdivided into Two — Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT-I
Spectrophotometry: i) Introduction, fundamental laws of photometry, the electromagnetic spectrum and spectrochemical methods, UV/Visible instrumentation, absorption spectra, Beer-Lambert’s Law, deviation from Beer-Lambert’s Law. ii) Photometric Titrations:- Simultaneous spectrophotometric determination, differential spectrophotometry, titration curves and applications to quantitative analysis. iii) Molecular Fluorescence Spectroscopy:- Theory, relaxation processes, relationship between excitation spectra and fluorescence spectra, fluorescent species, effect of concentration on fluorescence intensity, instrumentation and application of fluorescence methods.

UNIT-II
Atomic Spectroscopy: Theory of flame photometer, intensities of spectral lines, selection of optimal working conditions, applications of flame photometry to quantitative analysis. The Theory of Atomic Absorption Spectroscopy (AAS), Origin of atomic spectra, line width effects in atomic absorption, instrumentation and its application, Atomic emission spectroscopy (AES) and the detailed description of the techniques of inductively coupled plasma AES (ICP-AES) and its instrumentation. Chemical and spectral interferences encountered in both techniques and how to overcome them.

UNIT-III
Electroanalytical Methods:
  a) Electrogravimetric methods:- i) Current-voltage relationship during electrolysis, operation of a cell at a fixed applied potential, constant current electrolysis, physical properties of electrolytic precipitates, chemical factors of importance in electrodeposition, anodic deposition. ii) Spontaneous electrogravimetric analysis (internal electrolysis), apparatus and applications. iii) Electrolytic method with and without potential control, apparatus and applications.
  b) Coulometric Methods: i) Controlled potential Coulometry, instrumentation and applications. ii) Coulometric titrations, cell for coulometric titrations, applications of coulometric titrations (neutralization, precipitation, and complex formation titrations), comparison of coulometric and volumetric titrations.

UNIT-IV
Polarographic Methods: General introduction: Theoretical measurements of classical polarography, polarographic measurements, polarograms, interpretation of polarographic waves, equation for polarographic waves, half-wave potential, effect of complex formation on polarographic waves, dropping mercury electrode (advantages and limitations), current variation with a dropping electrode, polarographic diffusion current, the ilkovic equation, effect of capillary characterization on diffusion current, diffusion coefficient temperature, kinetic and catalytic current, polarograms for mixtures of reactants, anodic waves and mixed anodic and cathodic waves, current maxima and its suppression, residual current, supporting electrolytes, oxygen waves, instrumentation and applications to inorganic and organic analysis.
(a) **Thermogravimetric analysis**: Introduction, Factors affecting thermogravimetric curves, instrumentation, applications to inorganic compounds (analysis of binary mixtures i.e. Ca and Mg, TG curves of calcium oxalate, determination of Ca, Sr & Ba ions in the mixture, drying of sodium carbonate, analysis of clays and soils, decomposition of potassium hydrogen phthalate, oxidation of nickel sulphide, determination of titanium content of non-stoichiometric sample of titanium carbide).

(b) **Differential thermal analysis**: Introduction, Factors affecting DTA curves, instrumentation, applications, to inorganic compounds (thermal decomposition of mixtures of lanthanum-cerium and praseodymium oxalate, DTA curves for CuSO$_4$.5H$_2$O, sulphur, detection of organic contamination in ammonium nitrate, thermal decomposition for different magnesium carbonate samples, determination of uncalcined gypsum in plaster of paris.

**Books Recommended:**
1. Instrumental methods of analysis.-H.H.Willard, LL.Marritt and J.A.Dean
2. Fundamental of analytical Chemistry -D.A.Skoog & D.M.West
3. Basic concepts of analytical Chemistry-S.M.Khopkar
4. Instrumental Methods of Chemical Analysis-G.K.Ewring
5. Quantitative Inorganic Analysis-A.I.Vogel
6. Ion Exchange-AellFerish
7. Modern Polarographic Methods in Analytical Chemistry-A.M.Bond
SEMESTER-IV
(COURSE - XVII A)
CHEMISTRY SPECIAL THEORY - IV
(INORGANIC SPECTROSCOPY)

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be divided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT-I
Infrared Spectroscopy: Theory of IR absorption, Types of vibrations, Observed number of modes of vibrations, Intensity of absorption bands, Theoretical group frequencies, Factors affecting group frequencies and band shapes (Physical state, Vibrational Coupling, Electrical effects, Resonance, Inductive effects, Ring strain) Vibrational-rotational fine-structure. Experimental method. Application of IR to the following:
  i) Distinction between
    a) Ionic and coordinate anions such as NO$_3^-$, SO$_4^{2-}$ and SCN$^-$
    b) Lattice and coordinated water.
  ii) Mode of bonding of ligands such as urea, dimethylsulphoxide and hexamethylphosphoramid.

UNIT-II
Nuclear Magnetic Resonance Spectroscopy:- Introduction to Nuclear Magnetic Resonance, Chemical shift, Mechanism of electron shielding and factors contributing to the magnitude of chemical shift, Nuclear overhauser effect, Double resonance, Chemical exchange, Lanthanide shift reagents and NMR spectra of paramagnetic complexes. Experimental technique(CW and FT).
Stereochemical non-rigidity and fluxionality: Introduction, use of NMR in its detection, its presence in trigonal bipyramidal molecules(PF$_5$), Systems with coordination number six ( Ti(acac)$_2$Cl$_2$, Ti(acac)$_2$Br$_2$, Ta$_2$(OMe)$_{10}$).

UNIT-III
Nuclear Quadrupole Resonance Spectroscopy: Basic concepts of NQR (Nuclear electric quadrupole moment, Electric field gradient, Energy levels and NQR frequencies), Effect of magnetic field on spectra, Factors affecting the resonance signal (Line shape, position of resonance signal) Relationship between electric field gradient and molecular structure. Interpretation of NQR data, Structural information of the following: PCl$_5$, TeCl$_4$, Na’GaCl$_4$, BrCN, HIO$_3$ and Hexahalometallates

UNIT-IV
Mössbauer Spectroscopy: Introduction, Principle, Conditions for Mössbauer Spectroscopy, parameters from Mössbauer Spectra, Isomer shift, Electric Quadrupole Interactions, Magnetic Interactions MB experiment, Application of MB spectroscopy in structural determination of the following:
  i) High spin Fe (II) and Fe (III) halides FeF$_2$, FeCl$_2$, 2H$_2$O, FeF$_3$, FeCl$_3$.6H$_2$O. Low spin Fe(II) and Fe(III) Complexes-Ferrocyanides, Ferricyanides, Prussian Blue.
  ii) Iron carbonyls. Fe$_2$(CO)$_5$, Fe$_2$(CO)$_9$ and Fe$_3$(CO)$_{12}$
  iii) Inorganic Sn(II) and Sn(IV) halides.

UNIT-V
Electron Spin Resonance Spectroscopy:- Introduction, Similarities between ESR and NMR, Behaviour of a free electron in an external Magnetic Field, Basic Principle of an Electron Spin
Resonance Spectrometer, Presentation of the spectrum, Hyperfine coupling in Isotropic Systems (methyl, benzene and Naphthalene radicals). Factors affecting the magnitude of g-values. Zero field splitting and Kramer’s Degeneracy, Line width in solid state ESR, Double resonance experimental method. Applications of ESR to the following:

1. Bis-Salicylaldiimine – Copper II
2. CuSiF₆·6H₂O & (NH₃)₅Co-O-Co(NH₃)₅

Books Recommended:

2. Modern Optical methods of Analysis - Eugens D.Olsen
3. Infrared spectra of Inorganic and coordination compounds - Kazuo Nakamoto
5. Fundamentals of Molecular Spectroscopy - C.N.Banwel
8. Quarterly reviews Vol 11 (1957)
9. Progress in Inorganic Chemistry Vol 8
10. Organic Spectroscopy - W. Kemp
SEMESTER-IV
(COURSE – XVIII A)
CHEMISTRY SPECIAL THEORY - IV)
(INORGANIC CHEMISTRY AND SUPRAMOLECULAR CHEMISTRY)

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting **TWO** from each unit. As far as possible, every question will be divided into **Two – Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.

UNIT-I

(a) **Metalloporphyrins**: (ref. Books No. 1,5,6): Porphyrins and their salient features, characteristic absorption spectrum of porphyrins, chlorophyll (structure and its role in photosynthesis). Transport of Iron in microorganisms (sidrophores), types of siderophores (catecholate and Hydroxamato siderophores).

(b) **Metalloenzymes**: (Ref. Book No. 1,2): Definitions: Apoenzyme, Coenzyme, Metalloenzyme, structure and functions of carbonic anhydrase A & B, carboxy peptidases.

UNIT-II

**Oxygen Carriers**: (Ref. Book No. 1,8):

- **Natural oxygen carriers**: Structure of hemoglobin and myoglobin, Bohr effect, Models for cooperative interaction in hemoglobin, oxygen Transport in human body (-perutz machanism), Cyanide poisoning and its remedy. Non-heme protiens (Hemerythrin & Hemocyanin).
- **Synthetic oxygen carriers**: Oxygen molecule and its reduction products, model compounds for oxygen carrier (Vaskaâ€§ Iridium complex, cobalt complexes with dimethyl glyoxime and schiff base ligands).

UNIT-III

Transport and storage of metals: (Ref. Books No. 1,2) The transport mechanism, transport of alkali and alkaline earth metals, ionophores, transport by neutral macrocycles and anionic carriers, sodium/potassium pump, transport and storage of Iron (Transferrin & Ferritin).

UNIT-IV

**Inorganic compounds as therapeutic Agents** (Ref. Books N. 1,4,8):- Introduction chelation therapy, synthetic metal chelates as antimicrobial agents, antiarthritis drugs, antitumor, anticancer drugs (Platinum complexes), Lithium and mental health.

UNIT-V

**Supramolecular Chemistry** (Ref. Book 9): Introduction, Some important concepts, Introduction to Recognition, information and complementarity, Principles of molecular receptor designs, Spherical recognition (cryptates of metal cations) Tetrahedral recognition by macrotricyclic cryptands, Recognition of ammonium ions, Recognition of neutral molecules and anionic substrates (anionic coordination)

**Books Recommended:**
1. The Inorganic Chemistry of Biological processes - M.N.Hughes.
2. Bio Inorganic Chemistry - Robert Wittay
4. Topics in current chemistry (Inorganic Biochemistry) vol. 64 (1976) ï Davison and Coworkers.
5. An Introduction to Biochemical Reaction Mechanism - James N.Lowe and Lloyalt Ingraham.
6. General Biochemistry - Fruton J.S. and Simmonds S.
8. Inorganic chemistry î James E. Huheey.
SEMESTER-IV
(COURSE – XV B)
(ORGANIC CHEMISTRY SPECIAL THEORY - II)
(SYNTHETIC STRATEGIES)
Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be divided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT-I
Organic Reagents: Reagents in organic synthesis: Willkinson catalyst, Lithium dialkyl cuprates (Gilman’s reagents), Lithium diisopropylamide (LDA), 1,3-Dithiane (Umpolung) Dicyclohexylcarbodiimide (DCC), and Trimethylsilyliodide, DDQ, SeO₂, Baker yeast, Tri-n-butyltinhydride, Nickel tetracarbonyl, Trimethylchlorosilane.

UNIT-II
Oxidations: Introduction, Different oxidative process. Aromatization of six membered ring, dehydrogenation yielding C-C double bond, Oxidation of alcohols, Oxidation involving C-C double bond, Oxidative cleavage of ketones, aldehydes and alcohols, double bonds and aromatic rings, Ozonolysis, Oxidative decarboxylation, Bisdecarboxylation, Oxidation of methylene to carbonyl, Oxidation of olefines to aldehydes and ketones.

UNIT-III
Reductions: Introduction, Different reductive processes. Reduction of carbonyl to methylene in aldehydes and ketones, Reduction of nitro compounds and oximes, Reductive coupling, bimolecular reduction of aldehydes or ketones to alkenes, metal hydride reduction, acyloin ester condensation, Cannizzaro reaction, Tishchenko reaction, Willgerodt reaction.

UNIT-IV
Rearrangements: General mechanistic considerations-nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements: Benzil-Benzilic acid, Favorovski, Arndt-Eistert synthesis, Neber, Backmann, Hofmann, Curtius, Schmidt, Benzidine, Baeyer-Villiger, Shapiro reaction, Witting rearrangement and Stevens rearrangement.

UNIT-V
Disconnection Approach: An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity cyclisation reactions, amine synthesis. Protecting Groups: Principle of protection of alcohol, amine, carbonyl and carboxyl groups. One Group C-C Disconnection: Alcohols and carbonyl compounds, regioselectivity. Alkene synthesis, use of acetylenes in organic synthesis.

Books Recommended:
2. Organic Synthesis- Concept, Methods and Starting Materials, J. Fuhrhop and G. Penzillin, Verlage VCH.


**SEMESTER-IV**

**(COURSE – XVI B)**

**(CHEMISTRY SPECIAL THEORY - III)**

**(NATURAL PRODUCTS)**

Lectures: 60  
Max. Marks: 80

**Note:** Ten questions will be set by the examiner selecting **TWO** from each unit. As far as possible, every question will be divided into **Two – Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.

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**UNIT-I**

**Terpenoids:** Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, biosynthesis and synthesis of the following representative molecules: Monoterprenoids: Citral, geraniol (acyclic), Îµ-terpeneol, menthol (monocyclic). Sesquiterpenoids: Farnesol (acyclic), zingiberene (monocyclic), santonin (bicyclic), Diterpenoids: Phytol and abietic acid.

**UNIT-II**


**UNIT-III**

**Alkaloids:** Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure, synthesis and biosynthesis of the following: Ephedrine, Coniine, Nicotine, Atropine, Quinine and Morphine.

**UNIT-IV**

**Steroids:** Occurrence, nomenclature, basic skeleton, DielÔ hydrocarbon and stereochemistry. Isolation, structure determination and synthesis of Cholesterol, Androsterone, Testosterone, Estrone, Progestrone. Biosynthesis of steroids

**UNIT-V**

**Plant Pigments:** Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of Anthocyanins (Cyanin and pelargonidin), polyphenols: Flavones (chrysin), Flavonols (quercitin) and isoflavones (daidzein) coumarin, Quinones (lapachol), Hirsutidin. Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway.

**Books Recommended:**

1. Natural Products- Chemistry and Biological Significance, J. Mann, R.S. Davidson, J. B. Hobbs, D.V. Banthorpe and J. B. Harborne, Longman, Essex.
Note: Ten questions will be set by the examiner selecting **TWO** from each unit. As far as possible, every question will be divided into **Two – Three Parts**. The students shall attempt **FIVE** questions selecting **ONE** from each unit.

**UNIT-I**

**UNIT-II**

**UNIT-III**

**UNIT-IV**

**UNIT-V**
Cardiovascular Drugs: Antihypertensive and hypotensive drugs, antiarrhythemic agents, arteriolar dilators. Biological action of methyldopa, propranolol hydrochloride, verapamil, Atenolol.

Antihistaminic agents: Ethylene diamine derivatives, amino alkyl ether analogues, cyclic basic

Antifertility agents: General antifertility agents.

Diuretics: Mercurial diuretic, Non mercurial diuretics (Thiazides, carbonic-anhydrase inhibitors, xanthine derivatives, pyrimidine diuretics and osmotic diuretics)

Books Recommended:

1. An Introduction to Medicinal Chemistry, Graham L. Patrick.
4. Introduction to Medicinal Chemistry, Alex Gringuage.
SEMESTER-IV  
(COURSE – XVIII B)  
HEMISTRY SPECIAL THEORY - V)  
POLYMER CHEMISTRY)  

Lectures: 60  
Max. Marks: 80  

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be divided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT -I  

UNIT - II  
Stereoisomerism in Polymers: Types of stereoisomerism in polymers, Monosubstituted ethylenes (Site of steric isomerism, Tacticity), Disubstituted ethylenes (1,1-disubstituted ethylenes, 1,2-disubstituted ethylenes), 1,3- Butadiene and 2-Substituted 1,3-Butadienes (1,2- and 3,4- Polymerizations, 1,4-Polymerizations), 1- Substituted and 1,4- Disubstituted 1,3- Butadienes (1,2- and 3,4- Polymerizations, and 1,4- Polymerizations). Stereoregular polymers: Significance of stereoregularity (isotactic, syndiotactic, and atactic polypropenes), Cis- and trans-1,4-poly-1,3-dienes, Cellulose and amylose. Coordination polymerization: Ziegler Natta catalyst.

UNIT - III  
Structure and Properties of Polymers: Morphology and order in crystalline polymers-configurations of polymer chains. Crystal structures of polymers. Strain-induced morphology, crystallization and melting. Polymer structures and physical properties- crystalline melting point, Tm- melting points of homogeneous series, effect of chain flexibility and other steric factor, entropy and heat of fusion. The glass transition temperature, Tg, relationship between Tm and Tg, Effect of molecular weight, diluents, chemical structure, chain topology, branching and cross linking. Property requirement and polymer utilization.

UNIT - IV  

UNIT-V  
(A) Commercial Polymers: Polyethylene, Polyvinyl chloride, Polyamides, Polyesters, phenolic resins, epoxy resins and silicone polymers. Functional polymers-Fire retarding polymers and electrically conducting polymers.

4. Introduction to Theoretical Organic Chemistry and Molecular Modeling, W.B. Smith, VCH, Weinheim.
SEMESTER-IV
(COURSE – XV C)
(PHYSICAL CHEMISTRY SPECIAL THEORY - II)
(ADVANCED QUANTUM CHEMISTRY)

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be divided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT - I
Time independent perturbation theory for non – degenerate states (first order correction to energy and wave function), and its application to particle in a one – dimensional box, ground state helium atom (without spin consideration) and perturbed harmonic oscillator. Variational method: theory and application to ground state hydrogen and helium atoms and one – dimensional oscillator.

UNIT - II

UNIT - III

UNIT – VI

UNIT – V

Books Recommended:

1. Quantum Chemistry An Introduction: H.L. Strauss
2. Introductory Quantum Chemistry: A.K. Chandra
3. Quantum Chemistry: D.A. McQuarri
4. Quantum Chemistry: I.N. Levine
5. Molecular Quantum Mechanics: P.W. Atkins
7. Introductory Quantum Chemistry: S.R. LaPaglia
8. Fundamental Quantum Chemistry: T.E. Peacock
UNIT - I

UNIT - II

UNIT - III

UNIT – IV

UNIT – V
Solid State Reactions: General principles: experimental procedures, kinetics of solid state reactions, vapour phase transport methods, interaction or ion exchange reaction, electrochemical reduction methods, preparation of this films, growth of single crystal, high pressure and hypothetical method.

Books Recommended:
1. Introduction to Solids: Azaroff
2. Solid State Chemistry and its applications: West
3. Solid State Chemistry: Charkrabarty
5. Solid State Physics: Kiittal
SEMESTER-IV
(COURSE –XVII C)
(PHYSICAL CHEMISTRY SPECIAL THEORY - IV)
(BIOPHYSICAL CHEMISTRY)

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be divided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT – I

UNIT – II
Thermodynamics of Biopolymers Solutions: osmotic pressure, membrane equilibrium, muscular contraction and energy generation in mechanochemical system. Statistical mechanics in biopolymers chain configuration of macromolecules, statistical distribution end ũ to - end dimensions, calculation of average dimensions for various chain structures. Polypeptide and protein structures and protein folding.

UNIT – III

UNIT – IV
Biomolecular Interactions: Interactions between biomolecules (proteins), Interaction of biomolecules with small ligands, independent ligand binding sites, the Scatchard plot, forces involved in the stability of proteins, hydrophobic interactions, hydrogen bonding, electrostatic interactions, electron delocalization, van der Waal’s forces Scope of Genomics, proteomics and bioinformatics, ribosomes: Site and Function of protein synthesis.

UNIT – V
Protein molecules: Protein sequence and structure (primary structure), secondary structure: Ý-Helix, ß-Sheet, classification of proteins, torsion angles, tertiary structure, quarternary structure, Protein folding and refolding, computer simulation: thermodynamic-kinetic approach, statistical mechanics approach, Homolog Modelling, De Novo prediction, Protein misfolding, Biological factors (Chaperones) and chemical factors(Intra and intermolecular interactions) leading tofolding/refolding/misfolding. Brain diseases associated with it.

Books Recommended:
1. Physical Chemistry of Macromolecules: S.F.Sun
2. The Enzyme Molecules: W. Ferdinand
4. Biochemistry: Zubay
5. Principles of Biochemistry: A.I. Leninger
6. Physical Biochemistry: D. Friefelder
7. iophysics: Volkenstein
SEMESTER-IV
(COURSE – XVIII C)
(PHYSICAL CHEMISTRY SPECIAL THEORY – V)
(Y OF MACROMOLECULES)

Lectures: 60
Max. Marks: 80

Note: Ten questions will be set by the examiner selecting TWO from each unit. As far as possible, every question will be divided into Two – Three Parts. The students shall attempt FIVE questions selecting ONE from each unit.

UNIT – I
The science of macromolecules, Importance of macromolecules / polymers, basic concepts of polymers viz. monomers, repeat units, degree of polymerization, classification of polymers on the basis of molecular weight and special arrangement viz. linear, branched and network polymers. Types of macromolecules (synthesized and natural), polymerization by condensation and addition reactions only. Molecular forces and chemical bonding in simple molecules and macromolecules and their effects on the physical properties. Polymer solutions, criteria for polymer solubility, conformations of dissolved polymer chains. Different models for describing the size and shape of dissolved macromolecules, configuration and conformation of macromolecules.

UNIT – II
Thermodynamics of polymer solutions, thermodynamics of simple liquid mixtures, ideal solutions, regular solutions, lattice model of solutions (Flory Ŧ Huggins Theory), Flory Ŧ Krigbaum theory for dilute polymer solutions. Phase separation in polymer solutions involving binary polymer Ŧ solvent systems, ternary systems and multi Ŧ component systems. Fractionation of polymers by different techniques, theory of swelling of cross Ŧ linked / network polymers.

UNIT – III
Measurements of molecular weights and size of macromolecules by osmotic pressure measurement, light scattering method, diffusion measurement, sedimentation and ultracentrifuge methods and viscosity methods. Molecular weights of macromolecules viz., number average and weight average molecular weights and related numerical problems.

UNIT – VI
Rheology and Mechanical Properties of Polymers: Brief introduction to rheology and mechanical properties of polymers, phenomena of viscous flow, kinetic theory of rubber elasticity, amorphous polymers and practical importance of their aggregation states, viscoelasticity (experimental and dynamic method), general mechanical models for an amorphous polymer, molecular structure and viscoelasticity. The glassy state and glass transition temperature. The mechanical properties of crystalline polymers.

UNIT – V
1. Mechanical strength of polymers: Mechanical strength and life time of polymer mechanism of polymer fracture, effect of various factors on the mechanical properties of polymers (effect of size and shape, effect of fillers, effect of cross Ŧ linked density).
2. Polyelektrolytes: The water soluble charged polymers and their applications. Ionomers (ion containing polymers) conducting polymers solid polymer electrolytes, mechanism of conductivity, polymer colloids and their applications in commercial and industrial formulations (adhesives, coating, paper, pharmaceutical and medical applications), polymer microgels, biomedical polymers. Polymers in combating environmental pollution and as chemical reagents.

Books Recommended:
1. Text Book of Physical Chemistry: G.M. Barrow
2. Text Book of Polymer Chemistry: Billmeyer
3. Polymer Chemistry: P.J. Flory
4. Physical Chemistry of Polymers: A Tagger
5. Physical Chemistry of Macromolecules: C. Tanford
6. Introduction to Polymer Science: V.R. Gowarikar, N.V. Vishwanathan and J. Sridhar
7. Principles of Polymer Science: P. Bhadur and N.V. Sastry
PREPARATION of the following compounds and a study of the important properties viz. Molar conductance, magnetic susceptibility, electronic and infrared spectra.

1. Stannic iodide
2. Bis(acetylacetonate) oxovanadium (IV)
3. Tris (acetylacetonate) siliconchloride.
5. Hexa ammine nickel (II) chloride.
6. Pyridine perchromate.

INSTRUMENTAL ANALYSIS:

(A) Conductometric Titrations:
i) Differential behaviour of acetic acid to determine the relative acid strength of various acids and basic strength of various bases.
ii) Strong acid-strong base titration in acetic acid.

B) Potentiometric Titrations.
1. Neutralisation reactions:
i) Sodium hydroxide-hydrochloric acid.
ii) Sodium hydroxide-Boric acid
iii) Acetic acid and hydrochloric acid-sodium hydroxide.
2. Oxidation-Reduction Reactions.
i) Ferrous-dichromate
ii) Ferrous-Ceric
iii) Iodine-Thiosulphate
3. Precipitation Reactions:
i) Silver nitrate-sodium halides.
4. Complexation Reactions
i) Potassium cyanide-silver nitrate.

C) Colorimetric Analysis:
1) Verification of Beer’s law for KMNO₄, K₂Cr₂O₇ solutions and determination of the conc. of KMNO₄, K₂Cr₂O₇ in the given solution.
2) Colorimetric determination of Iron (III) with potassium thiocyanate reagent or o-Phenanthroline method.
3) Determination of traces of manganese (in steel samples) colorometrically by oxidation to permanganic acid with potassium periodate.
4) Spectrophotometric determination of pK value of an indicator (acid dissociation constt. of methyl red)

(D) pH metric –titrations
1) Copper and catechol
2) Copper and salicylic acid
3) Acid base titrations
4) Mixtures of acids with a base
Polarography:
1) Determination of half wave potentials of cadmium ion in potassium chloride solution.
2) Determination of half wave potentials of zinc and manganous ions in potassium chloride solution.
3) Determination of cadmium in solution
4) Investigation of the influence of dissolved oxygen.

(F) Amperometric Titrations:
1. Zinc with EDTA
2. Lead vs. chromate
3. Nickel as isoquinoline thiocyanate

(G) Flame Photometry:
1) Determination of sodium
2) Determination of potassium
3) Determination of calcium

H) Miscellaneous:
2. Determination of magnetic susceptibility of complexes
3. Estimation of periodate, iodate and bromate in the same solution.
4. Determination of bromide and chloride in the same solution.
5. Analysis of a solution containing chloride and iodide.

Books Recommended:
1. A Text Book of Quantitative Inorganic Analysis- A.I. Vogel
(A) **Extraction of Organic Compounds from Natural Sources**: Isolation of Caffeine from tea leaves, casein from milk (the students are required to try some typical color reactions of proteins), lactose from milk (purity of sugar should be checked by TLC and PC and Rf value reported), lycopene from tomatoes and β-carotene from carrots.

(B) **Paper Chromatography**: Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of Rf values.

(C) **Spectroscopy**: Identification of some organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR and MS)

**Multistep Synthesis**
- Synthesis of Vacor
- Synthesis of Indigo
- Synthesis of p-nitro aniline

**Books Recommended:**

1. **Viscosity Measurements:** Verification of the Jones – Dole equation, determination of viscosity A and B coefficients for simple electrolytes in water and in aqueous mixtures of organic solvents.

2. **Conductometric Measurements:** Kinetics of saponification of ethylacetate by NaOH. Solubility of sparingly soluble salts.

3. **Potentiometric Titration:** Titration of HCl with NaOH, determination of dissociation constant of acetic acid and phosphoric acid. Oxidation reduction titration (ferrous ammonium sulphate with KMnO₄ and K₂Cr₂O₇).

4. **Flamephotometric Measurements:** Establishing the calibration plots for Na⁺ and K⁺ ions and determination of their concentration in the given solution at ppm level.

5. **Determination of Molar Mass:** Cryoscopic and Rast's methods. Determination of molar mass of polymer by viscosity measurement.

6. **Colometry Measurements:** Determination of composition ferric ions – salicylic acid complex using Job's method.

7. **Polarimetry Measurements:** Determination of specific and molecular rotation, percentage of tow optically active substances, kinetics of acid catalysed inversion of cane sugar, comparison of strengths of two acids.

**Books Recommended:**

1. Senior Practical Physical Chemistry: B.D. Khosla, V.C. Garg and A. Khosla
4. Practical in Physical Chemistry: P.S. Sindhu
5. Senior Practical Physical Chemistry: B.D. Khosla, V.C. Garg and A. Khosla
Every candidate will have to deliver a seminar of 30 minutes duration on a topic (not from the syllabus) which will be chosen by him/her in consultation with the teacher of the department. The seminar will be delivered before the students and teachers of the department. A three member committee (one coordinator and two teachers of the department of different branches) duly approved by the departmental council will be constituted to evaluate the seminar. The following factors will be taken into consideration while evaluating the candidate.

(i) Expression
(ii) Presentation
(iii) Depth of the subject matter and answers to the questions.
Unity is the ultimate game development platform. Use Unity to build high-quality 3D and 2D games, deploy them across mobile, desktop, VR/AR, consoles or the Web, and connect with loyal and enthusiastic players and customers. Unity’s flexible real-time development platform offers incredible possibilities for all industries and applications. Games. Unity gaming solutions is everything you need to create, operate and monetize your Mobile games, Instant games, AR and VR Games, PC and Console games. A Unity ID allows you to buy and/or subscribe to Unity products and services, shop in the Asset Store and participate in the Unity community. Log in Create a Unity ID. Home. Products. The world’s leading real-time creation platform. Unity is used to create half of the world’s games. Our real time platform, powered by tools and services, offer incredible possibilities for game developers, and creators across industries and applications. Pro. "Unity", Unity logos, and other Unity trademarks are trademarks or registered trademarks of Unity Technologies or its affiliates in the U.S. and elsewhere (more info here). Other names or brands are trademarks of their respective owners. Got it.