

CURRICULUM

In

CHEMISTRY

For

**UNDER GRADUATE COURSES (B.Sc.)
(Annual System)**

**PASSED BY THE BOARD OF STUDIES
IN CHEMISTRY**

(Applicable w.e.f. the session 2019-2020)



**Department of Chemistry
Rishikesh Campus
Sridev Suman Uttarakhand University Badshahithaul
Tehri-Garhwal - 249001
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Proposed Syllabus: Chemistry Course for B.Sc (Annual System)

B. Sc. Chemistry Syllabus

Objective of the course

To teach the fundamental concepts of chemistry and their applications, the syllabus pertaining to B.Sc(3 year degree course) in the subject of chemistry has been prepared as per provision of UGC module and demand of the academic environment. The syllabus concepts are duly arranged unit wise and contents are included in such a manner so that due importance is given to requisite intellectual and laboratory skills. This B. Sc course of chemistry consists of three year course (annual system). Total marks: 600(200 per year).

B.Sc. First Year

Paper	Paper code	Course	Max. Marks	Work Hrs
I	CH-101	Inorganic Chemistry	50	60
II	CH-102	Organic Chemistry	50	60
III	CH-103	Physical Chemistry	50	60
	CH-104	Laboratory Practical	50	60
Grand Total			200	180

B.Sc. Second Year

Paper	Paper code	Course	Max. Marks	Work Hrs
I	CH-201	Inorganic Chemistry	50	60
II	CH-202	Organic Chemistry	50	60
III	CH-203	Physical Chemistry	50	60
	CH-204	Laboratory Practical	50	60
Grand Total			200	180

B.Sc. Third Year

Paper	Paper code	Course	Max. Marks	Work Hrs
I	CH-301	Inorganic Chemistry	50	60
II	CH-302	Organic Chemistry	50	60
III	CH-303	Physical Chemistry	50	60
	CH-304	Laboratory Practical	50	60
Grand Total			200	180

Note: Examiner should follow the below given pattern covering all the units for each section compulsorily:

- Twelve compulsory objective type questions of one mark each, $12 \times 1 = 12$ Marks
- Examinees to solve six short answer questions out of ten question (3 mark each) $3 \times 6 = 18$ Marks.
- Examinees to solve four long answer questions out of seven (5 mark each) $4 \times 5 = 20$ Marks

Distribution of marks for Practical exam will be as follows:

B.Sc. (FIRST YEAR)

(i)	Inorganic Mixture analysis (six radicals)	15
(ii)	Organic Experiment	12
(iii)	Physical Chemistry Experiment	10
(iv)	Viva-voce**	05
(v)	Annual record	08
	Total	50

B.Sc. (SECOND YEAR)

(i)	Inorganic Experiment	15
(ii)	Organic Experiment	12
(iii)	Physical Chemistry Experiment	10
(iv)	Viva-voce**	05
(v)	Annual record	08
	Total	50

B.Sc. (THIRD YEAR)

(i)	Inorganic Experiment	10
(ii)	Organic Experiment	12
(iii)	Physical Chemistry Experiment	15
(iv)	Viva-voce**	05
(v)	Annual record	08
	Total	50

*Full credit of marks shall be given upto 0.5% error after which for each 0.1% error, two marks shall be deducted in Quantitative analysis experiments.

**Viva-voce for ex-students shall carry 13 marks.

Three Years Degree Course Syllabus for
CHEMISTRY
B.Sc. (FIRST YEAR)

There shall be three written papers and a practical examination as follows:

Paper	Paper code	Course	Max. Marks	Work Hrs
I	CH-101	Inorganic Chemistry	50	60
II	CH-102	Organic Chemistry	50	60
III	CH-103	Physical Chemistry	50	60
	CH-104	Laboratory Practical	50	60
Grand Total			200	180

Candidate will be required to pass in Theory and Practical Separately.

B.Sc. – I Year
Chemistry Paper-I
Inorganic Chemistry (Paper Code: CH-101)

Unit – I

I. Atomic Structure:

Idea of de-Broglie matter waves (dual nature), Heisenberg uncertainty principle, atomic orbitals, Schrödinger wave equation, significance of Ψ and Ψ^2 , quantum numbers, radial and angular wave functions and probability distribution curves, shapes of s, p, d, orbitals, Aufbau and Pauli exclusion principles, Hund's multiplicity rule, Electronic configurations of the elements, effective nuclear charge.

Unit – II

II. Periodic Properties:

Atomic and ionic radii, ionization energy, electron affinity and electronegativity definitions, methods of determination or evaluation, trends in periodic table and applications in predicting and explaining the chemical behaviour.

Unit – III

III. Chemical Bonding:

(A) Covalent Bond – Valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions, valence shell electron pair repulsion (VSEPR) theory to NH_3 , H_3O^+ , SF_4 , ClF_3 , ICl_2^- and H_2O , MO theory, homonuclear and heteronuclear (CO , NO , CN^+ , CO , CN^- , CO^+ , CN^-) diatomic molecules, multicenter bonding in electron deficient molecules, bond strength and bond energy, percentage ionic character from dipole moment and electro-negativity difference.

(B) Ionic Solids – Ionic structures, radius ratio effect and coordination number, limitation of radius ratio rule, lattice defects, semiconductors, lattice energy and Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarisability of ions, Fajan's rule, Metallic bond-free electron, valence bond and band theories.

(C) Weak Interactions – Hydrogen bonding, Vander Waals forces.

Unit – IV

- IV. *s*-Block Elements:
Comparative study, diagonal relationship, salient features of hydrides, solvation and complexation tendencies including their function in biosystems, an introduction to alkyls and aryls.
- V. Chemistry of Noble Gases:
Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.

Unit – V

- VI. *p*-Block Elements:
Comparative study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides, oxides, oxyacids and halides of group 13-16, hydrides of boron-diborane and higher boranes, borazine, borohydrides, fullerenes, carbides, fluorocarbons, silicates (structural principle), tetrasulphur tetra nitride, basic properties of halogens, interhalogens and polyhalides.

B. Sc. Ist year
Paper-II
Organic Chemistry

Unit – I

- I. **Structure and Bonding:**
Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bonding, Van der Waals interactions, inclusion compounds, clathrates, charge transfer complexes, resonances, hyperconjugation, aromaticity, inductive and field effects, hydrogen bonding.
- II. **Mechanism of Organic Reactions:**
Homolytic and heterolytic bond fission, Types of reagents –electrophiles and nucleophiles, Types of organic reactions, Energy considerations.
Reactive intermediates – Carbocations, carbanions, free radicals, carbenes, arynes and nitrenes (with examples). Assigning formal charges on intermediates and other ionic species. Methods of determination of reaction mechanism (product analysis, intermediates, isotope effects, kinetic and stereochemical studies).
- III. **Alkanes and Cycloalkanes:**
IUPAC nomenclature of branched and unbranched alkanes, the alkyl group, classification of carbon atom in alkanes, Isomerism in alkanes, sources methods of formation (with special reference to Wurtz reaction, Kolbe's reaction, Corey-House reaction and decarboxylation of carboxylic acids), physical properties and chemical reactions of alkanes, Mechanism of free radical halogenation of alkanes: orientation, reactivity and selectivity.

Cycloalkanes – Nomenclature, methods of formation, chemical reactions, Baeyer's strain theory and its limitations. Ring strain in small rings (cyclopropane and cyclobutane), theory of strain less rings. The case of cyclopropane ring, banana bonds.

Unit – II

IV. **Stereochemistry of Organic Compounds:**

Concept of isomerism, Types of isomerism, Optical isomerism – elements of symmetry, molecular chirality, enantiomers, stereogenic center, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centers, diastereomers, threo and erythro diastereomers, meso compounds, resolution of enantiomers, inversion, retention and racemization. Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature.

Geometric isomerism – determination of configuration of geometric isomers, E & Z system of nomenclature, geometric isomerism in oximes and alicyclic compounds.

Conformational isomerism – conformational analysis of ethane and *n*-butane, conformations of cyclohexane, axial and equatorial bonds, conformation of monosubstituted cyclohexane derivatives, Newman projection and Sawhorse formulae, Fischer and flying wedge formulae, Difference between configuration and conformation.

Unit – III

V. **Alkenes, Cycloalkenes, Dienes and Alkynes:**

Nomenclature of alkenes, methods of formation, mechanisms of dehydration of alcohols and dehydrohalogenation of alkyl halides, regioselectivity in alcohol dehydration, The Saytzeff rule, Hofmann elimination, physical properties and relative stabilities of alkenes.

Chemical reactions of alkenes – mechanism involved in hydrogenation, electrophilic and free radical additions, Markownikoff's rule, hydroboration-oxidation, oxymercuration-reduction. Epoxidation, ozonolysis, hydration, hydroxylation and oxidation with KMnO_4 , Polymerization of alkenes, Substitution at the allylic and vinylic positions of alkenes, Industrial applications of ethylene and propene.

Methods of formation, conformation and chemical reactions of cycloalkenes, Nomenclature and classification of dienes: isolated, conjugated and cumulated dienes, Structure of allenes and butadiene, methods of formation, polymerization, chemical reaction – 1, 2 and 1, 4 additions, Diels-Alder reaction.

Nomenclature, structure and bonding in alkynes, Methods of formation, Chemical reactions of alkynes, acidity of alkynes, Mechanism of electrophilic and nucleophilic addition reactions, hydroboration-oxidation, metal-ammonia reductions, oxidation and polymerization.

Unit – IV

VI. **Arenes and Aromaticity:**

Nomenclature of benzene derivatives, The aryl group, Aromatic nucleus and side chain, Structure of benzene, molecular formula and Kekulé structure, stability and carbon-carbon

bond lengths of benzene, resonance structure, MO picture, Aromaticity: The Huckle rule, aromatic ions.

Aromatic electrophilic substitution – general pattern of the mechanism, role of σ and π complexes, Mechanism of nitration, halogenation, sulphonation, mercuration and Friedel-Crafts reaction. Energy profile diagrams. Activating and deactivating substituents, orientation and ortho/para ratio, Side chain reactions of benzene derivatives, Birch reduction; Methods of formation and chemical reactions of alkylbenzenes, alkynylbenzenes and biphenyl, naphthalene and Anthracene.

Unit-V

VII. **Alkyl and Aryl Halides:**

Nomenclature and classes of alkyl halides, methods of formation, chemical reactions, Mechanisms of nucleophilic substitution reactions of alkyl halides, S_{N2} and S_{N1} reactions with energy profile diagrams;

Polyhalogen compounds: Chloroform, carbon tetrachloride; Methods of formation of aryl halides, nuclear and side chain reactions, The addition-elimination and the elimination-addition mechanisms of nucleophilic aromatic substitution reactions, Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides, Synthesis and uses of DDT and BHC.

B.Sc. – I Chemistry

Paper-III

Physical Chemistry

Unit – I

I. **Gaseous States:**

Postulates of kinetic theory of gases, deviation from ideal behavior, Van der Waals equation of state, Critical Phenomena: PV isotherms of real gases, continuity of states, the isotherms of Van der Waals equation, relationship between critical constants and Van der Waals constants, the law of corresponding states, reduced equation of state.

Molecular velocities: Root mean square, average and most probable velocities, Qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter, Liquifiction of gases (based on Joule –Thomson effect).

Unit – II

II. **Liquid State:**

Intermolecular forces, structure of liquids (a qualitative description), Structural differences between solids, liquids and gases, Liquid crystals: Difference between liquid crystal, solid

and liquid, Classification, structure of nematic and cholestric phases, Thermography and seven segment cells.

Unit – III

III. **Solid States:**

Definition of space lattice, unit cell, Laws of crystallography – (i) Law of constancy of interfacial angles, (ii) Law of rationality of indices (iii) Law of symmetry, Symmetry elements in crystals. X-ray diffraction by crystals, Derivation of Bragg equation, Determination of crystal structure of NaCl, KCl and CsCl (Laue's method and powder method).

IV. **Colloidal States:**

Definition of colloids, classification of colloids, Solids in liquids (sols): properties – kinetic, optical and electrical; stability of colloids, protective action, Hardy-Schulze law, gold number. Liquids in liquids (emulsions): types of emulsions, preparation, Emulsifier, Liquids in solids (gels): classification, preparation and properties, inhibition, general application of colloids, colloidal electrolytes.

Unit – IV

V. **Chemical Kinetics and Catalysis:**

Chemical kinetics and its scope, rate of a reaction, factors influencing the rate of a reaction – concentration, temperature, pressure, solvent, light catalyst, concentration dependence of rates, mathematical characteristics of simple chemical reactions – zero order, first order, second order, pseudo order, half life and mean life, Determination of the order of reaction – differential method, method of integration, method of half life period and isolation method. Radioactive decay as a first order phenomenon, Experimental methods of chemical kinetics: conductometric, potentiometric, optical methods, polarimetry and spectrophotometer. Theories of chemical kinetics: effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Simple collision theory based on hard sphere model, transition state theory (equilibrium hypothesis), Expression for the rate constant based on equilibrium constant and thermodynamic aspects.

Catalysis, characteristics of catalyzed reactions, classification of catalysis homogeneous and heterogeneous catalysis, enzyme catalysis, miscellaneous examples.

B.Sc. – I (PRACTICAL) 180 hrs (6 Hrs/week)

Atleast three practicals from each specialization should be carried out.

Inorganic Chemistry:

- I. Semi micro Analysis – Mixture analysis for six radicals (3 cations & 3 anions), including interfering radicals.

Organic Chemistry:

Laboratory techniques:

- II. Calibration of Thermometer- 80-82⁰(Naphthalene), 113.5-114⁰(Acetanilide) 132.5-133⁰(Urea), 100⁰(Distilled Water)
- III. Determination of melting point:

- Naphthalene 80-82⁰, Benzoic acid 121.5-122⁰, Urea 132.5-133⁰, Succinic acid 184.5-185⁰, Cinnamic acid 132.5-133⁰, Salicylic acid 157.5-158⁰, Acetanilide 113.5-114⁰, m-Dinitrobenzene 90⁰, p-Dichlorobenzene 52⁰, Aspirin 135⁰
- IV. Determination of boiling point:
Ethanol 78⁰, Cyclohexane 81.4⁰, Toluene 110.6⁰, Benzene 80⁰
Mixed melting point determination:
Urea-Cinnamic acid mixture of various compositions (1:4, 1:1, 4:1)
- V. Distillation:
Simple distillation of ethanol-water mixture using water condenser, Distillation of nitrobenzene and aniline using air condenser
- VI. Crystallization:
Concept of induction of crystallization, Phthalic acid from hot water (using fluted filter paper and steamless funnel) Acetanilide from boiling water, Naphthalene from ethanol, Benzoic acid from water
Decolorisation and crystallization using charcoal:
Decolorisation of brown sugar (sucrose) with animal charcoal using gravity filtration.
Crystallization and decolorisation of impure naphthalene (100g of naphthalene mixes with 0.3 g of Congo Red using 1g decolorizing carbon) from ethanol.
- VII. Sublimation (Simple and Vacuum): Camphor, Naphthalene, Phthalic acid and succinic acid.
Qualitative Analysis:
- VIII. Detection of extra elements (N, S and halogens) and functional groups (phenolic, carboxylic, carbonyl, esters, carbohydrates, amines, amides, nitro and anilide) in simple organic compounds.
Physical Chemistry:
- IX. Chemical Kinetics:
1. To determine the specific reaction rate of the hydrolysis of methyl acetate/ethyl acetate catalyzed by hydrogen ions at rooms temperature.
2. To study the effect of acid strength on the hydrolysis of an ester.
3. To compare the strengths of HCl and H₂SO₄ by studying the kinetics of hydrolysis of ethyl acetate.
4. To study kinetically the reaction rate of decomposition of iodide by H₂SO₄.
Distribution Law:
1. To study the distribution of iodine between water and CCl₄.
2. To study the distribution of benzoic acid between benzene and water.
- X. Viscosity, Surface Tension:
1. To determine the percentage composition of a given mixture (non interacting systems) by viscosity method.
2. To determine the viscosity of amyl alcohol in water at different concentration and calculate the excess viscosity of these solutions.
3. To determine the percentage composition of a given binary mixture by surface tension method (acetone & ethyl methyl ketone).

B.Sc. (SECOND YEAR)

There shall be three written papers and a practical examination as follows:

Paper	Paper code	Course	Max. Marks	Work Hrs
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I	CH-201	Inorganic Chemistry	50	60
II	CH-202	Organic Chemistry	50	60
III	CH-203	Physical Chemistry	50	60
	CH-204	Laboratory Practical	50	60
Grand Total			200	180

Candidate will be required to pass in Theory and Practical Separately.

B.Sc. – II
Chemistry Paper-I
Inorganic Chemistry

Unit – I

- I. Chemistry of Elements of First Transition Series:
Characteristic properties of d-block elements. Binary compounds (hydrides, carbides and oxides) of the elements of the first transition series and complexes with respect to relative stability of their oxidation states, coordination number and geometry.
- II. Chemistry of Elements of Second and Third Transition Series:
General characteristics, comparative treatment of Zr/Hf, Nb/Ta, Mo/W in respect of ionic radii, oxidation states, magnetic behavior, spectral properties and stereochemistry.

Unit – II

- III. Coordination Compounds
Werner's coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes.

Unit – III

- IV. Chemistry of Lanthanide Elements
Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, ceric ammonium sulphate and its analytical uses.
- V. Chemistry of Actinides
Electronic configuration, oxidation states and magnetic properties, chemistry of separation of Np, Pu and Am from U.

Unit – IV

- VI. Oxidation and Reduction
Electrode potential, electrochemical series and its applications, Principles involved in the extraction of the elements.

Unit - V

- VII. Acids and Bases

Arrhenius, Bronsted-Lowry, the Lux-Flood, solvent system and Lewis concept of acids and bases.

VIII. Non-aqueous Solvents

Physical properties of a solvent, types of solvents and their general characteristics, Reactions in non-aqueous solvents with reference to liquid NH_3 and Liquid SO_2 .

B.Sc. – II
Chemistry Paper-II
Organic Chemistry

Unit – I

I. Electromagnetic Spectrum Absorption Spectra

Ultraviolet (UV) absorption spectroscopy – absorption laws (Beer-Lambert law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation. Concept of chromophore and auxochrome, Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. U.V. spectra of conjugated enes and enones.

Infrared (I.R.) absorption spectroscopy – molecular vibrations, Hooke's law, selection rules, intensity and position of I.R. bands, measurement of I.R. spectrum, finger print region, characteristic absorptions of various functional groups and interpretation of I.R. spectra of simple organic compounds.

Unit – II

II. Alcohols

Classification and nomenclature, Monohydric alcohols – nomenclature, methods of formation by reduction of Aldehydes, Ketones, Carboxylic acids and Esters, Hydrogen bonding, Acidic nature, Reactions of alcohols.

Dihydric alcohols - – nomenclature, methods of formation, chemical reactions of vicinal glycols, oxidative cleavage [$\text{Pb}(\text{OAc})_4$ and HIO_4] and pinacol- pinacolone rearrangement.

Trihydric alcohols - nomenclature, methods of formation, chemical reactions of glycerol.

III. Phenols :

Nomenclature, structure and bonding, preparation of phenols, physical properties and acidic character, Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols – electrophilic aromatic substitution, acylation and carboxylation. Mechanisms of Fries rearrangement, Claisen rearrangement, Gatterman synthesis, Hauben-Hoesch reaction, Lederer-Manasse reaction and Reimer-Tiemann reaction.

Unit – III

IV. Ethers and Epoxides

Nomenclature of ethers and methods of their formation, physical properties, Chemical reactions – cleavage and autoxidation, Ziesel's method.

Synthesis of epoxides, Acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organo lithium reagents with epoxides.

- V. Aldehydes and Ketones:
Nomenclature and structure of the carbonyl groups, synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides, synthesis of aldehydes and ketones uses 1, 3-dithianes, synthesis of ketones from nitrites and from carboxylic acids, Physical properties. Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensations, Condensation with ammonia and its derivatives. Wittig reaction, Mannich reaction.
Use of acetals as protecting group, Oxidation of aldehydes, Baeyer-Villiger oxidation of Ketones, Cannizzaro reaction, MPV, Clemmensen, Wolff-Kishner, LiAlH_4 and NaBH_4 reductions. Halogenation of enolizable ketones, An introduction to O, P unsaturated aldehydes and Ketones.

Unit – IV

- VI. Carboxylic Acids:
Nomenclature, structure and bonding, physical properties, acidity of carboxylic acids, effects of substituents on acid strength, Preparation of carboxylic acids, Reactions of carboxylic acids, Hell-Volhard-Zelinsky reaction, Synthesis of acid chlorides, esters and amides, Reduction of carboxylic acids, Mechanism of decarboxylation. Methods of formation and chemical reactions of halo acids, Hydroxy acids: malic, tartaric and citric acids. Methods of formation and chemical reactions of unsaturated monocarboxylic acids. Dicarboxylic acids: methods of formation and effect of heat and dehydrating agents.
- VII. Carboxylic Acid Derivatives
Structure and nomenclature of acid chlorides, esters, amides (urea) and acid anhydrides. Relative stability of acyl derivatives, Physical properties, interconversion of acid derivatives by nucleophilic acyl substitution. Preparation of carboxylic acid derivatives, chemical reaction. Mechanisms of esterification and hydrolysis (acidic and basic)

Unit - V

- VIII. Organic Compounds of Nitrogen:
Preparation of nitroalkanes and nitroarenes, Chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media, Picric acid.
Halogenoarenes: reactivity, Structure and nomenclature of amines, physical properties, Stereochemistry of amines, Separation of a mixture of primary, secondary and tertiary amines. Structural features effecting basicity of amines. Amine salts as phase-transfer catalysts, Preparation of alkyl and aryl amines (reduction of nitro compounds, nitrites), reductive amination of aldehydic and ketonic compounds, Gabriel-phthalimide reaction, Hofmann-bromamide reaction. Reactions of amines, electrophilic aromatic substitution in aryl amines, reactions of amines with nitrous acid. Synthetic transformations of aryl diazonium salts, azo coupling.

Physical Chemistry

Unit – I

I. Thermodynamics – I

Definitions of thermodynamic terms: System, surroundings etc. types of systems, intensive and extensive properties, State and path functions and their differentials, Thermodynamic processes, concept of heat and work.

First Law of Thermodynamics: Statement, definition of internal energy and enthalpy, Heat capacity, heat capacities at constant volume and pressure and their relationship, Joule's law – Joule-Thomson coefficient and inversion temperature. Calculation of w , q , δU & δH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.

Thermochemistry: Standard state, standard enthalpy of formation – Hess's Law of heat summation and its applications, Heat of reaction at constant pressure and at constant volume, Enthalpy of neutralization, Bond dissociation energy and its calculation from thermochemical data, temperature dependence of enthalpy, Kirchhoff's equation

Unit – II

II. Thermodynamics – II

Second Law of Thermodynamics: Need for the law, different statements of the law, Carnot's cycle and its efficiency, Carnot's theorem. Thermodynamic scale of temperature.

Concept of entropy: Entropy as a state function, entropy as a function of V & T , entropy as a function of P & T , entropy change in physical change, Clausius inequality, entropy as a criteria of spontaneity and equilibrium, Equilibrium change in ideal gases and mixing of gases.

Gibbs and Helmholtz functions: Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities, A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change, Variation of G and A with P , V and T .

Third Law of Thermodynamics: Nernst heat theorem, statement and concept of residual entropy. Nernst distribution law – thermodynamic derivation, applications.

Unit - III

III. Chemical Equilibrium

Equilibrium constant and free energy, Thermodynamic derivation of law of mass action, Le Chatelier's principle. Reaction isotherm and reaction isochore – Clapeyron-Clausius equation and its applications.

Unit – IV

IV. Electrochemistry – I:

Electrical transport: Conduction in metals and in electrolyte solutions, specific conductance molar and equivalent conductance, measurement of equivalent conductance, variation of molar equivalent and specific conductance with dilution.

Migration of ions and Kohlrausch's law, Arrhenius theory of electrolyte dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law its uses and limitations, Debye-Huckel-Onsager's equation for strong electrolytes (elementary treatment only),

Transport number, definition and determination by Hittorf's method and moving boundary method.

Applications of conductivity measurements: determination of degree of dissociation, determination of K_a of acids, determination of solubility product of a sparingly soluble salt, conductometric titrations.

V. Solutions:

Liquid – Liquid mixtures- Ideal liquid mixtures, Raoult's and Henry's law, Non-ideal system- azeotropes – HCl-H₂O and ethanol – water systems.

Partially miscible liquids- Phenol – water, trimethylamine – water, nicotine-water systems, Immiscible liquids, steam distillation.

Unit – V

VI. Electrochemistry – II:

Types of reversible electrodes – gas-metal ion, metal-ion, metal-insoluble salt anion and redox electrodes, Electrode reactions, Nernst equation, derivation of cell E.M.F. and single electrode potential, standard hydrogen electrode-reference electrodes and their applications, standard electrode potential, sign conventions, electrochemical series and its significance.

Electrolytic and Galvanic cells–reversible and irreversible cells, conventional representation of electrochemical cells, EMF of a cell and its measurements, Computation of cell EMF, Calculation of thermodynamic quantities of cell reactions (QG, QH and K) Concentration cell with and without transport, liquid junction potential, application of concentration cells, valency of ions, solubility product and activity coefficient, potentiometric titrations.

Definition of pH and pK_a, determination of pH using hydrogen, quinhydrone and glass electrodes, by potentiometric methods, Buffers – Mechanism of buffer action, Henderson-Hassel equation, application of buffer solution, Hydrolysis of salts

VII. Phase Equilibrium:

Statement and meaning of the terms-phase, component and degree of freedom, derivation of Gibb's phase rule, phase equilibria of one component system-water, 'CO₂' and 'S' systems

Phase equilibria of two component system – solid liquid equilibria simple eutectic – Bi-Cd, Pb-Ag systems, desilverisation of lead.

Solid solutions – compound formation with congruent melting point (Mg-Zn) and incongruent melting point, (FeCl₃-H₂O) and (CuSO₄-H₂O) system

B.Sc. – II (Laboratory Practical) 180 hrs. (6 hrs/week)

Atleast three practicals from each specialization should be carried out.

Inorganic Chemistry:

I. Calibration of fractional weights, pipettes and burettes, Preparation of standard solutions, Dilution – 0.1 M to 0.001 M solutions.

Quantitative Analysis:

II. Volumetric Analysis:

(a) Determination of acetic acid in commercial vinegar using NaOH.

(b) Determination of alkali content – antacid tablet using HCl.

- (c) Estimation of calcium content in chalk as calcium oxalate by permanganometry.
 - (d) Estimation of hardness of water by EDTA.
 - (e) Estimation of ferrous and ferric by dichromate method.
 - (f) Estimation of copper using thiosulphate.
- III. Gravimetric Analysis:
Analysis of Cu as CuSCN and Ni as Ni (dimethylglyoxime).
Organic Chemistry
Laboratory Techniques
- IV. A. Thin Layer Chromatography
Determination of R_f values and identification of organic compounds:
(a) Separation of green leaf pigments (spinach leaves may be used).
(b) Preparation of separation of 2, 4-dinitrophenylhydrazones of acetone, 2-butanone, hexan-2, and 3-one using toluene and light petroleum (40:60)
(c) Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5).
- V. B. Paper Chromatography: Ascending and Circular
Determination of R_f values and identification of organic compounds:
(a) Separation of a mixture of phenylalanine and glycine, Alanine and aspartic acid, Leucine and glutamic acid, Spray reagent – ninhydrin.
(b) Separation of a mixture of D, L – alanine, glycine, and L-Leucine using *n*-butanol: acetic acid:water (4:1:5), Spray reagent – ninhydrin.
(c) Separation of monosaccharide – a mixture of D-galactose and D-fructose using *n*-butanol:acetone:water (4:5:1), spray reagent – aniline hydrogen phthalate.
- VI. Qualitative Analysis:
Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives.
Physical Chemistry
- VII. Transition Temperature
1. Determination of the transition temperature of the given substance by thermometric /dilatometric method (e.g. $MnCl_2 \cdot 4H_2O/SrBr_2 \cdot 2H_2O$).
- VIII. Phase Equilibrium
2. To study the effect of a solute (e.g. NaCl, succinic acid) on the critical solution temperature of two partially miscible liquids (e.g. phenol-water system) and to determine the concentration of that solute in the given phenol-water system.
3. To construct the phase diagram of two component (e.g. diphenylamine –benzophenone) system by cooling curve method.
- IX. Thermochemistry
1. To determine the solubility of benzoic acid at different temperatures and to determine Q_H of the dissolution process.
2. To determine the enthalpy of neutralization of a weak acid/weak base versus strong base/strong acid and determine the enthalpy of ionization of the weak acid/weak base.
3. To determine the enthalpy of solution of solid calcium chloride and calculate the lattice energy of calcium chloride from its enthalpy data using Born Haber Cycle.

B.Sc. (THIRD YEAR)

There shall be three written papers and a practical examination as follows:

Paper	Paper code	Course	Max. Marks	Work Hrs
I	CH-301	Inorganic Chemistry	50	60
II	CH-302	Organic Chemistry	50	60
III	CH-303	Physical Chemistry	50	60
	CH-304	Laboratory Practical	50	60
Grand Total			200	180

Candidate will be required to pass in Theory and Practical Separately.

B.Sc. – III Chemistry (Paper-I)
Inorganic Chemistry

Unit – I

- I. Metal-ligand bonding in Transition Metal Complexes
Limitations of valence bond theory, an elementary idea of crystal field theory, crystal field splitting in octahedral, tetrahedral and square planar complexes, factors affecting the crystal-field parameters.
- II. Thermodynamic and Kinetic Aspects of Metal Complexes
A brief outline of thermodynamic stability of metal complexes and factors affecting the stability, stability constants of complexes and their determination, substitution reactions of square planar complexes.

Unit – II

- III. Magnetic Properties of Transition Metal Complexes
Types of magnetic behavior, methods of determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of μ_s and μ_{eff} values, orbital contribution to magnetic moments, application of magnetic moment data for 3d-metal complexes.
- IV. Electronic spectra of Transition Metal Complexes
Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series, Orgel-energy level diagram for d_1 and d_9 states, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion.

Unit – III

- V. Organometallic Chemistry
Definition, nomenclature and classification of organometallic compounds, Preparation, properties, bonding and applications of alkyls and aryls of Li, Al, Hg, Snl.
Metal carbonyls: 18 electron rule, preparation, structure and nature of bonding in the mononuclear carbonyls.
- VI. Silicones and Phosphazenes
Silicones and phosphazenes as examples of inorganic polymers, nature of bonding in triphosphazenes.

Unit – IV

- VII. Hard and Soft Acids and Bases (HSAB)

Classification of acids and bases as hard and soft, Pearson's HSAB concept, acid-base strength and hardness and softness, Symbiosis, theoretical basis of hardness and softness, electro negativity and hardness and softness, Drago wayland equation, donor acceptor number.

Unit - V

VIII. Bioinorganic Chemistry

Essential and trace elements in biological processes, metalloporphyrins with special reference to hemoglobin and myoglobin, cooperative effect, Biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+} .

B.Sc. – III Chemistry (Paper-II)

Organic Chemistry

Unit – I

I. Spectroscopy

Nuclear magnetic resonance (NMR) spectroscopy, Proton magnetic resonance (^1H NMR) spectroscopy, nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of signals, interpretation of ^1H NMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1, 1, 2-tribromoethane, ethyl acetate, toluene and acetophenone, Problems pertaining to the structures elucidation of simple organic compounds using UV, IR and ^1H NMR spectroscopic, techniques.

Unit – II

II. Organometallic Compounds

Organomagnesium compounds: the Grignard reagents, formation, structure and chemical reactions. Organozinc compounds: formation and chemical reactions. Organolithium compounds: formation and chemical reactions.

III. Organosulphur Compounds

Nomenclature, structural formation, methods of formation and chemical reactions of thiols, thioethers, sulphonic acids, sulphonamides and Sulphaguanidine.

IV. Hetrocyclic Compounds

Introduction: Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine, Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution, Mechanism of nucleophilic substitution reaction in pyridine derivatives, Comparison of basicity of pyridine, piperidine and pyrrole.

Introduction to condensed five and six membered heterocycles, Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fisher indole synthesis, Skraup synthesis and Bischler-Nepieralski synthesis, Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.

Unit – III

- V. Carbohydrates
Classification and nomenclature, Monosaccharides, mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and chain shortening of aldoses. Configuration of monosaccharides, Erythro and threo diastereomers, Conversion of glucose into mannose, Formation of glycosides, ethers and esters, Determination of ring size of monosaccharides, Cyclic structure of D(+)-glucose, Mechanism of mutarotation. Structures of ribose and deoxyribose,
An introduction to disaccharides (maltose, sucrose and lactose) and polysaccharides(starch and cellulose) without involving structure determination.
- VI. Amino Acids, Peptides, Proteins and Nucleic Acids:
Classification, structure and stereochemistry of amino acids, Acid-base behavior isoelectric point and electrophoresis, Preparation and reactions of O-amino acids, Structure and nomenclature of peptides and proteins, Classification of proteins, peptide structure determination, end group analysis, selective hydrolysis of peptides, classical peptide synthesis, solid-phase peptide synthesis, Structures of peptides and proteins, Levels of protein structure, Protein denaturation/ renaturation; Nucleic acids : Introduction, constituents of nucleic acids, Ribonucleosides and ribonucleotides, The double helical structure of DNA.

Unit – IV

- VII. Fats, Oils and Detergents
Natural fats, edible and industrial oils of vegetable origin, common fatty acids, glycerides, hydrogenation of unsaturated oils, Saponification value, iodine value, acid value, Soaps, synthetic detergents, alkyl and aryl sulphonates.
- VIII. Synthetic Polymers
Addition or chain-growth polymerization, Free radical vinyl polymerization, ionic vinyl polymerization, Ziegler-Natta polymerization and vinyl polymers, Condensation or step growth-polymerization, Polyesters, polyamides, phenol formaldehyde resins, urea formaldehyde resins, epoxy resins and polyurethanes, Natural and synthetic rubbers, Elementary idea of organic conducting polymers.
- IX. Synthetic Dyes
Colour and constitution (electronic Concept), Classification of dyes, Chemistry and synthesis of Methyl orange, Congo red, Malachite green, crystal violet, phenolphthalein, fluorescein, Alizarin and Indigo.

Unit – V

- X. Organic Synthesis via Enolates
Acidity of O-hydrogens, alkylation of diethyl malonate and ethyl acetoacetate, Synthesis of ethyl acetoacetate: the Claisen condensation, Keto-enol tautomerism of ethylacetoacetate. Alkylation of 1, 3-dithianes, Alkylation and acylation of enamines.

B.Sc. – III Chemistry (Paper-III)

Physical Chemistry

Unit – I

I. Introducton:

Black-body radiation, Planck's radiation law, photoelectric effect, heat capacity of solids, Bohr's model of hydrogen atom (without derivation) their solution of overall solution and its defects, Compton effect, de-Broglie's hypothesis, the Heisenberg's uncertainty principle, Hamiltonian Operator.

II. Elementary Quantum Mechanics:

Schrödinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one dimensional box. Schrödinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen like wave functions, radial wave functions, angular wave functions.

Molecular orbital theory, basic ideas – criteria for forming M.O. from A.O., construction of M.O's by LCAO – H^{2+} ion, calculation of energy levels from wavefunctions, physical picture of bonding and anti-bonding wave functions, concept of σ , σ^* , π , π^* orbitals and their characteristics, Hybrid orbitals – sp , sp^2 , sp^3 , calculation of coefficients of A.O's used in sp and sp^2 hybrid orbitals and interpretation of geometry.

Introduction to valence bond model of H_2 , comparison of M.O. and V.B. models.

Unit – II

III. Physical Properties and Molecular Structure:

Optical activity, polarization – (Clausius – Mossotti equation), orientation of dipoles in an electric field, dipole moment, induced dipole moment, measurement of dipole moment-temperature method and refractivity method, dipole moment and structure of molecules, magnetic properties-paramagnetism, diamagnetism and ferromagnetic, Magnetic susceptibility, its measurements and its importance.

Unit – III

IV. Spectroscopy:

Introduction: Electromagnetic radiation, regions of the spectrum, basic features of different spectrophotometers, statement of the born-oppenheimer approximation, degrees of freedom.

Rotational Spectrum: Diatomic Molecules: Energy levels of a rigid rotor (semi-classical principles), selection rules, spectral intensity, distribution using population distribution (Maxwell-Boltzmann distribution) determination of bond length, qualitative description of non-rigid rotor, isotope effect.

Vibrational Spectrum: Infrared Spectrum: Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups.

Raman Spectrum: Concept of polarizability, pure rotational and pure vibrational Raman spectra of diatomic molecules, selection rules.

Electronic Spectrum: Concept of potential energy curves for bonding and anti-bonding molecular orbitals, qualitative description of selection rules and Franck-Condon principle.

Qualitative description of σ , π and T M.O. their energy levels and the respective transition.

Unit – IV:

V. Photochemistry:

Interaction of radiation with matter, difference between thermal and photochemical processes, Laws of photochemistry: Grothus – Drapper law, Stark – Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non- radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions – energy transfer processes (simple examples), Kinetics of Photo chemical reaction.

Unit – V

VI. Solutions, Dilute Solutions and Colligative Properties:

Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination. Osmosis, laws of osmotic pressure, its measurement and determination of molecular weight from osmotic pressure. Elevation of boiling point and depression of freezing, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental methods for determining various colligative properties.

Abnormal molar mass, Van't Hoff factor, Colligative properties of degree of dissociation and association of solutes.

B.Sc. – III (LABORATORY PRACTICAL) 180 hrs. (12 hrs./week)

Atleast three practicals from each specialization should be carried out.

Inorganic Chemistry:

I. Synthesis and Analysis:

(a) Preparation of sodium trioxalato ferrate (III), $\text{Na}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$ and determination of its composition by permagnetometry.

(b) Preparation of Ni-DMG complex, $[\text{Ni}(\text{DMG})_2]$

(c) Preparation of copper tetra ammine complex. $[(\text{Cu}(\text{NH}_3)_4)\text{SO}_4]$.

(d) Preparation of cis-and trans-*bis*-oxalatochromate (III) ion.

II. Instrumentation:

Colorimetry- (a) Job's method (b) Mole-ratio method

Adulteration – Food stuffs.

Effluent analysis, water analysis

Solvent Extraction- Separation and estimation of Mg(II) and Fe(II)

Ion Exchange Method- Separation and estimation of Mg(II) and Zn(II)

Organic Chemistry:

III. Laboratory Techniques- Steam Distillation

Naphthalene from its suspension in water

Clove oil from cloves

Separation of o-and p-nitro phenols

IV. Column Chromatography-

Separation of fluorescein and methylene blue

Separation of leaf pigments from spinach leaves

Resolution of racemic mixture of (+) mandelic acid

V. Qualitative Analysis-

- Analysis of an organic mixture containing two solid components using water, NaHCO_3 , NaOH for separation and preparation of suitable derivatives
- VI. Synthesis of Organic Compounds-
- Acetylation of salicylic acid, aniline, glucose and hydroquinone, Benzoylation of aniline and phenol
 - Aliphatic electrophilic substitution
Preparation of iodoform from ethanol and acetone
 - Aromatic electrophilic substitution
Nitration:
Preparation of m-dinitrobenzene
Preparation of p-nitroacetanilide
Halogenation
Preparation of p-bromoacetanilide
Preparation of 2, 4, 6-tribromophenol
 - Diazotization/coupling
Preparation of methyl orange and methyl red
 - Oxidation
Preparation of benzoic acid from toluene
 - Reduction
Preparation of aniline from nitrobenzene
Preparation of m-nitroaniline from m-dinitrobenzene
- VII. Stereo chemical Study of Organic Compounds via Models
R and S configuration of optical isomers
E, Z configuration of geometrical isomers
Conformational analysis of cyclohexanes and substituted cyclohexanes
Physical Chemistry :
- VIII. Electrochemistry:
- To determine the strength of the given acid conductometrically using standard alkali solution.
 - To determine the solubility and conductivity of a sparingly soluble electrolyte conductometrically.
 - To study the saponification of ethyl acetate conductometrically.
 - To determine the ionization constant of a weak acid conductometrically.
 - To titrate potentiometrically the given ferrous ammonium sulphate solution using $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ as titrant and calculate the redox potential of $\text{Fe}^{2+}/\text{Fe}^{3+}$ system on the hydrogen scale.
- IX. Refractometry, Polarimetry:
- To verify law of refraction of mixtures (e.g. of glycerol and water) using Abbe's refractometer.
 - To determine the specific rotation of a given optically active compound.
 - To determine stoichiometry and stability constant of complexes.
- X. Molecular Weight Determination:
- Determination of molecular weight of a non-volatile solute by Rast method/ Beckmann freezing point method.
 - Determination of the apparent degree of dissociation of an electrolyte (e.g. NaCl) in aqueous solution at different concentrations by ebullioscopy.
- Colorimetry:

1. To verify Beer – Lambert Law for $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ and determining the concentration of the given solution of the substance from absorption measurement.

**SRIDEV SUMAN UTTARAKHAND UNIVERSITY, BADSHAHITHAUL, TEHRI,
GARHWAL**

SYLLABUS: BOTANY COURSE FOR B.Sc. STUDENTS (3 Years)

UNDER ANNUAL SYSTEM

To teach the fundamental concept of Botany and their applications the syllabus pertaining to B.Sc (3 year degree course) in the subject of Botany has been prepared as per provision of UGC module and demand of academic environment. The syllabus concepts are duly arranged unit wise and contents are included in a such manner so that due importance is given to requisite intellectual and laboratory skills. This B.Sc course of Botany consists of 3 year course (Annual System). Total marks 600(200per year).

B.Sc Ist Year

S.NO.	TITLE	PAPER CODE	MAX. MARKS
I	Fungi, Elementary Microbiology and Plant Pathology	BBO-101	50
II	Algae and Bryophytes	BBO-102	50
III	Pteridophytes, Gymnosperm and Elementary Palaeobotany	BBO-103	50
	Lab Course	BBO-10P	50

B.Sc IInd Year

S.NO.	TITLE	PAPER CODE	MAX. MARKS
I	Taxonomy of Angiosperms and Economic Botany	BBO-201	50
II	Anatomy, Embryology and Elementary Morphogenesis	BBO-202	50
III	Ecology and Remote Sensing	BBO-203	50
	Lab Course	BBO-20P	50

B.Sc IIIrd Year

S.NO.	TITLE	PAPER CODE	MAX. MARKS
I	Cytogenetics, Molecular Biology and Biotechnology	BBO-301	50
II	Plant Physiology and Elementary Biochemistry	BBO-302	50
III	Plant Breeding and Biostatistics	BBO-303	50
	Lab Course	BBO-30P	50

Note : Examiner should follow the below given pattern covering all the unit for each section compulsory :

- Twelve Compulsory subject objective type questions of one mark each, $12 \times 1 = 12$.
- Examinees to solve 6 short answer questions out of 10 questions (3 marks each) $3 \times 6 = 18$ marks.
- Examinees to solve 4 long answer questions out of seven (5 marks each) $4 \times 5 = 20$ Marks.

B.Sc Ist Year

PAPER I: (BBO-101) FUNGI, ELEMENTARY MICROBIOLOGY AND PLANT PATHOLOGY

UNIT I

1. Brief history and salient features of Fungi.
2. A broad outline of classification of Fungi (Ainsworth) and salient features of the important groups.
3. Structure, methods of reproduction and life history of following Genera:
Synchytrium, Saprolegnia, Albugo, Rhizopus, Penicillium, Saccharomyces, Phyllactinia, Erysiphe, Puccinia, Ustilago, Agaricus and Alternaria.
4. Heterothallism, Parasexuality and Economic importance of Fungi.

UNIT II

1. Lichens: Habitats, characteristics, general structure and classification.
2. Physiology (Symbiotic relationship) and reproduction in Lichens.
3. Economic importance of Lichens.

UNIT III

1. General account of diversity of microorganisms.
2. Elementary principles of isolation and purification of microorganisms.
3. Role of microorganisms in carbon and nitrogen cycles in nature.

UNIT IV

1. Bacteria: Structure, classification, nutrition, reproduction, gram positive and gram negative bacteria; Economic importance of bacteria.
2. Viruses: Structure, transmission and multiplication. Economic importance of viruses. Brief idea of Bacteriophages.
3. General account of Mycoplasma.

UNIT V

1. General symptoms of plant diseases and principles of infection and resistance.
2. General methods of chemical and biological control of the plant diseases.
3. The symptoms, morphology of the causal organism, disease cycle and control measures of the following diseases : Wart disease of Potato, White rust of Crucifers, Powdery mildew of Shisham, Black rust of Wheat, Red rot of Sugarcane.

Suggested Readings

Vashistha, B.R., Sinha, A.K. 2014. Botany for degree students: Fungi. S. Chand Publication, New Delhi

Singh, V., Pandey, P.C. and Jain, D.K. 1998. A text book of Botany. Rastogi Publication Meerut
Gangulee, H.C. and Kar, A.K. 1992. College Botany. Vol 2, Kolkatta

Dubey, R.C. and Maheshwari, D.K.2014. A text book of Microbiology. S. Chand Publication, New Delhi. Matthews, R.E. 2013. Fundamentals of Plant Virology, Elsevier India

PAPER II (BBO-102): ALGAE AND BRYOPHYTES

UNIT I

1. General characteristics of the group (Algae) and its position in Plant Kingdom.
2. Classification of algae, basic outlines of Fritsch's and Smith's classification.
3. Elementary knowledge of organisation of thallus in algae.

UNIT II

1. Structure, reproduction and life cycles of the following Genera:
Chlamydomonas, Volvox, Oedogonium, Vaucheria, Chara, Sargassum, Ectocarpus, Batrachospermum and Polysiphonia.
2. General account of Bacillariophyceae.
3. Cyanobacteria : General account of *Nostoc*.

UNIT III

1. Types of life cycles – Haplontic, Diplontic, Diplohaplontic, Haplodiplontic and Diplobiontic; Alternation of generation in Algae.
2. Ecology of Algae: Brief idea of freshwater and marine, terrestrial, epiphytic, parasitic, symbiotic algae and phytoplanktons.
3. Economic importance of algae as food, fodder, in agriculture, industry and public health.

UNIT IV

1. Outlines and basic principles of classification of the Bryophytes in accordance with the International Code of Botanical Nomenclature.
2. Comparative account of the gross morphology, anatomy, vegetative and sexual reproduction, development and structure of the sporophyte and mechanism of spore dispersal based on *Riccia and Marchantia*.
3. Habitat, distribution and economic importance of Bryophytes.

UNIT V

1. Comparative account of the gross morphology and anatomy of the gametophytes, vegetative and sexual reproduction, development and structure of the sporophyte and mechanism of spore dispersal in *Anthoceros* and Mosses (*Funaria*).
2. General account of Jungermanniales (*Porella*).
3. A brief account of the alternation of generation in Bryophytes.

Suggested readings

- Kumar, H.D. 1999. Introductory Phycology, Affiliated East West Press, New Delhi
- Vashistha, B.R., Sinha, A.K. and Singh, V.P. 2014. Botany for degree students: Algae. S. Chand Publication, New Delhi
- Vashistha, B.R., Sinha, A.K. and Kumar, Adarsh 2014. Botany for degree students: Bryophyta. S. Chand Publication, New Delhi
- Parihar, N.S. 1991. An Introduction to Bryophyta. Vol 1&2. Central Book Depot, Allahabad
- Puri, P.1980. Bryophytes. Atma Ram and Sons, New Delhi

PAPER III: (BBO-103) PTERIDOPHYTES, GYMNOSPERMS AND ELEMENTARY PALAEOBOTANY

UNIT I

1. General characters of the Pteridophytes and classification as proposed by Pichi-Sermolli.
2. A comparative study of *Rhynia*, *Selaginella*, *Lycopodium*, *Equisetum*, *Adiantum*, and *Marsilea* on the basis of following features:
3. Morphology and anatomy of the vegetative plant body and spore production organs (strobilus, sporocarp, sporophyll, sporangium and spores), sexual reproduction, male and female gametophytes, fertilization.

UNIT II

1. A brief account of Telome theory, Stelar system and its evolution.
2. Heterospory and seed habit in Pteridophytes.
3. Apogamy, agamospory and apospory in ferns.

UNIT III

1. Outlines of classification as proposed by D D Pant and distinguishing features of Gymnosperms.
2. Comparative account of the structure, life history and evolutionary trends based on the following Genera:
Cycas, *Pinus* and *Ephedra*
3. General anatomy- Types of wood thickening, tracheids, medullary rays, pitting and resin canals, mesarch and pseudomesarch, foliar bundles and types of stomata.

UNIT IV

1. Distribution of Gymnosperms in India.
2. Economic importance of the Gymnosperms.

UNIT V

1. Fossils: Types of fossils and process of fossilization.
2. A general idea about Geological era.
3. Living fossils.

Suggested Readings

Parihar, N.S.1996. Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad

Vashistha, P.C., Sinha, A.K and Kumar, Anil 2012. Botany for degree students: Pteridophyta. S. Chand Publication, New Delhi

Bhatnagar, S.P. and Moitra, A.1996, Gymnosperms, New Age International Pvt. Ltd, New Delhi

Vashistha, P.C., Sinha, A.K and Kumar, Anil 2012. Botany for degree students: Gymnosperms. S. Chand Publication, New Delhi

Lab Course (BBO-10P)

Prepared slides and specimens should be shown to the students for demonstration of the general features. The students are required to make temporary slide preparation of the important plant material themselves. They are also required to submit a collection of plant species studied by them either on herbarium sheets or as specimen or live planted material as directed by the department.

FUNGI, ELEMENTARY MICROBIOLOGY & PLANT PATHOLOGY

1. To study identify and comment upon the following fungal materials by preparing the temporary slides/ specimens: *Saprolegnia*, *Albugo*, *Rhizopus*, *Saccharomyces*, *Phyllactinia*, *Morchella*, *Agaricus*, *Puccinia*, *Ustilago*, and *Alternaria*.
2. Study of morphology and structure of different types of lichens: Foliose, Fruticose, and Crustose.
3. Symptoms, morphology of pathogen and host parasite relationship of plant diseases: White rust of crucifers, Wart disease of potato, Loose smut of wheat, Black rust of wheat, Red rot of sugar cane and Powdery mildew of shisham
4. Different methods of isolation of microbes.
5. Staining of bacteria with gram stain.
6. Morphological features of viral infected plants; study of bacterial infections in plants.

ALGAE AND BRYOPHYTES

1. To study, identify and comment upon the following algal materials by preparing temporary slides/specimens: *Nostoc*, *Chlamydomonas*, *Volvox*, *Oedogonium*, *Vaucheria*, *Chara*, *Sargassum*, *Batrachospermum* And *Polysiphonia*.
2. To study the morphological and anatomical features of the following material and identify them by preparing temporary slides: *Riccia*, *Marchantia*, *Anthoceros*, *Jungermanniales* and *Funaria*.

PTERIDOPHYTES, GYMNOSPERMS AND ELEMENTARY PALAEOBOTANY

1. Study of the external features, internal structures, rhizome, leaves, roots, sporangia and strobili of *Selaginella* and *Equisetum*, sporocarp of *Marsellia* and prothallus of *Selaginella*, *Equisetum*, *Adiantum* and *Marselia*.
2. Study of the morphological features and anatomical structures of vegetative and reproductive parts of *Cycas*, *Pinus* and *Ephedra*.
3. Study the fossil specimen: Impression, Casts and Petrification.

Second Year

PAPER I (BBO-201) TAXONOMY OF ANGIOSPERMS AND ECONOMIC BOTANY

UNIT I

1. Angiosperms origin and evolution. Some examples of primitive angiosperms. Angiosperm taxonomy- fundamental components.
2. Comparison and evolution of the system of classification as proposed by Linnaeus, Betham and Hooker and Hutchinson.
3. Nomenclature: International Code of Botanical Nomenclature (ICBN), History, scientific naming of plants, priority, types, validity, *nomina conservanda*.
4. Collection and preservation techniques of specimens for Herbarium and Museum, Botanical gardens and Herbaria, Botanical Survey of India (BSI).

UNIT II

1. Taxonomy, important distinguishing characters, classification and economics importance of the following families:

Dicotyledonae

Polypetalae : Ranunculaceae, Brassicaceae, Caryophyllaceae, Rutaceae, Malvaceae, Rosaceae and Apiaceae

UNIT III

1. Gamopetalae: Solanaceae, Apocynaceae, Acanthaceae, Lamiaceae
2. Monochlamydae: Euphorbiaceae, Polygonaceae
3. Monocotyledonae: Orchidaceae, Liliaceae, and Poaceae

UNIT IV

1. Origin of cultivated plants, monophyletic and polyphyletic origin, centres of origin of some important crop plants.
2. Origin, history, botanical features and cultivation of cereals and millets: Wheat, Rice, Maize and Bajra.
3. Legumes: An introduction to the economically important legumes.
4. Oils: Castor oil, linseed oil and mustard oil.

UNIT V

1. General account of fruits (Apple, Banana, Citrus, Mango) and Vegetables (Root, stem, leaf, and fruit vegetables).
2. Fibres (Coir, Cotton, Flax, Jute) and Medicinal plants (*Aconitum*, *Atropa*, *Cinchona*, *Rauwolfia*, *Ephedra*).
3. Common Timber yielding plants of Western Himalayas (Chir, Deodar, Sal Shisham and Teak).

Suggested Readings

- Singh, V. And Jain, D.K.2012. Taxonomy of Angiosperms. Rastogi Publications,, Meerut
- Singh, G.2012. Plant Systematic: Theory and Practice. Oxford and IBH Pvt Ltd, New Delhi
- Pandey, B.P.2001. A text book of Angiosperms. S. Chand Publication, New Delhi
- Sharma, O.P.2016. Plants and Human Welfare, Pragati Prakshan, Meerut
- Sharma, A.K. and Sharma, R. Taxonomy of Angiosperms and Utilization of Plants

PAPER II: (BBO-202) ANATOMY, EMBRYOLOGY AND ELEMENTARY MORPHOGENESIS

UNIT I

1. The techniques for the study of plant anatomy.
2. Meristems: Primary and secondary meristems, characteristics and functions. Various types of permanent tissues- Simple and complex tissues.
3. Structure of dicot and monocot root, stem and leaf.

UNIT II

1. Secretory structures
2. Origin structure and function of vascular cambium including anomalous behaviour with special reference to the following taxa: *Bougainvillea*, *Salvadora*, *Nyctanthes*, *Dracaena*, *Orchids* and *Tinospora*.
3. Structure of xylem and phloem.

UNIT III

1. Structure of anther, micro sporogenesis and development of male gametophyte in angiosperms.
Structure of ovule, mega sporogenesis and development of the female gametophyte with reference to the *Polygonum* type. Comparison with the bio sporic and tetra sporic types
2. Pollination, fertilization and life history of a typical angiosperm.

UNIT IV

1. Endosperm and embryo development with special reference to the onagrad type.
2. Polyembryony and apomixis.
3. Seed germination and dormancy, elementary plant movements.

UNIT V

1. Basic body plan of a flowering plant- modular type of growth.
2. Diversity in plant forms in annuals, biennials and perennials. Development of tree habit in higher plants
3. Plant growth regulators: Auxin, Gibberellin, Cytokinin and Abscissic acid.
4. Physiology of flowering: Photoperiodism and vernalization.

Suggested Readings

- Pandey, S.N. 1992, Plant Anatomy, Rastogi Publication, Meerut
Tayal, M.S. 1996, Plant Anatomy, Rastogi Publication, Meerut
Bhojwani, S.S. and Bhatnagar, S.P.1994. Embryology of Angiosperms
Maheshwari, P. An Introduction to Embryology of Angiosperms

PAPER III: (BBO-203) ECOLOGY AND REMOTE SENSING

UNIT I

1. Definition and scope of ecology, Principles of environment, atmosphere, light, temperature, water and soil.
2. Ecosystem: Types , biotic and abiotic components, food chain, food web, ecological pyramids and ecological niche.
3. Productivity, type, measurement of primary productivity, energy flow and ecological energetics, Lindeman's concept of Energy Flow.

UNIT II

1. Biogeochemical cycles: A brief discussion of concept by citing examples of carbon, nitrogen and phosphorous cycles.
2. Population ecology: Definition, population characteristics, growth curves, carrying capacity and population fluctuation.
3. Community ecology: Structure and community characteristics, quantitative, qualitative and synthetic features, life forms, biological spectrum and ecological succession.

UNIT III

1. Pollution of air, water and soil, noise incidence, thermal and radioactive pollution; prevention and control of pollution.
2. Global warming, desertification and ozone depletion.
3. Biogeographical regions of India ; Vegetation types in Uttarakhand

UNIT IV

1. Biodiversity: Basic concept, types, causes and loss of biodiversity.
2. Biodiversity conservation: In situ and ex situ conservation, gene bank, introductory account of Biosphere reserves, National parks and Sanctuaries
3. Soil erosion and conservation, conservation and management of some natural resources: forest and rangeland management.

UNIT V

1. Definition of remote sensing, aerial photography, principles and fundamentals of aerial photo interpretation.
2. Electromagnetic spectrum, satellite and sensors, remote sensing data acquisition, physical basis of remote sensing, aerial and space platforms.
3. Image interpretation, role of remote sensing in ecology.

Suggested Readings

Odum, E.P. 1983, Basics of Ecology, Saunders College Publication, New York

Tiwari, S.C.2005. Concepts of Modern Ecology, Bishen Singh Mahendra Pal Singh, Dehradun

Sharma, P. D, 2014.Ecology and Environment, Rastogi Publications, Meerut

Shukla, R.S. and Chandel. P.S. 2014. Plant Ecology. S Chand Publications, New Delhi

Shukla, R.S. and Chandel. P.S. Biostatistics. S Chand Publications, New Delhi

LAB COURSE (BBO-20P)

TAXONOMY OF ANGIOSPERMS AND ECONOMIC BOTANY

1. Identification of locally available plants belonging to the families mentioned in the syllabus, their description in semi technical language.
2. Collection of plant specimens: Herbarium and/live specimens. Excursions should be organised to acquaint the students with the local flora.
3. To identify study and comment upon the economically important plants and their economic products mentioned in the syllabus.

ANATOMY, EMBRYOLOGY AND ELEMENTARY MORPHOGENESIS

1. Demonstration of usual techniques of plant anatomy, section cutting, TS, LS of dicot and monocot leaf, stem and root.
2. Normal and abnormal secondary growth in *Boerhavia*, *Bougainvillia*, *Nyctanthes*, , *Dracaena*, *Orchid* and *Tinospora*.
3. TS of anther.
4. Study of various types of pollen grains, placentations, embryo sacs, ovules and stages of embryo development using temporary and permanent preparations.
5. Influence of growth regulators on root formation, senescence and pollen germination (hanging drop method).
6. Structure and organization of the shoot apex/ root apex.

ECOLOGY AND REMOTE SENSING

1. To determine the minimum size of quadrat by species area curve method.
2. To determine the minimum number of quadrats to be laid down for the vegetation analysis of the given area.
3. To determine the frequency, density and abundance of each species in a community by quadrat method.
4. To prepare frequency diagram and compare it with that of the Raunkiaer's normal frequency diagram.
5. To determine the mean basal cover and total basal cover.
6. To study the physical characters of soil in terms of temperature, colour, texture and pH.
7. To find out bulk density and porosity of different soils.
8. To estimate the moisture percentage of various soil samples.
9. Statistical problems of central tendencies, standard deviation, Correlation and X^2 test.
10. Study of types of aerial photographs and satellite data products.
11. Study of types of stereoscopes

THIRD YEAR

Paper I (BBO– 301) CYTOGENETICS, MOLECULAR BIOLOGY AND BIOTECHNOLOGY

UNIT 1

1. Structure and functions of Nucleus: Ultra structure, nuclear membrane, nucleolus, structure and functions of other cell organelles: Golgi body, endoplasmic reticulum, peroxysomes and vacuoles. The cell envelope: Plasma membrane, bilayer lipid structure and functions of cell wall.
2. Cell division: Comparison of mitosis and meiosis.
3. Chromosome organization: Morphology, centromere and telomere, chromosome alteration in chromosome numbers, aneuploidy, polyploidy and sex chromosomes.
4. Extra nuclear genome: Presence and functions of mitochondrial and plastid DNA, plasmids.

UNIT II

1. Genetic Inheritance: Mendelism: Law of segregation and independent assortment, incomplete dominance.
2. Interaction of genes: Linkage- complete and incomplete linkage and crossing over.
3. Sex linked inheritance: Determination of sex.
4. Genetic variation: Mutations, transposable genetic elements, DNA damage and repair.

UNIT III

1. DNA,-the genetic material: DNA structure, replication, DNA- protein interaction, the nucleosome model, satellite and repetitive DNA.
2. RNA: Structure and types.
3. Gene concept: Classical and modern concept of gene, operon concept.

UNIT IV

1. Protein Structure: 1D, 2D and 3D structure.
2. Genetic code and protein synthesis.
3. Regulation and gene expression in prokaryotes and eukaryotes.

UNIT V

1. Introduction to Biotechnology: Functional definition, role in modern life, history and ethical issues connected with biotechnology.
2. Genetic engineering: Tools and techniques of DNA technology, cloning vectors, genome, cDNA libraries, transposable elements and techniques of gene mapping.
3. Basic concept of tissue culture, cryopreservation, differentiation and morphogenesis, biology of *Agrobacterium*, vectors for gene delivery and marker genes.
4. A brief account of Industrial biotechnology (fermentation and alcohol production), Agricultural biotechnology (biofertilizers and biopesticides) and Nutritional biotechnology (Mycotoxins and health hazards, control of mycotoxin production, single cell protein).

Suggested Readings

Gupta P.K. 2000. Cytology, Genetics And Evolution. Rastogi Publication, Meerut

Gupta P.K. 2012. Genetics. Rastogi Publication, Meerut

Gupta P.K. 2001. Elements of Biotechnology. Rastogi Publication, Meerut

Power, C.B. 1994. Cell Biology. Himalaya Publishing House, New Delhi

PAPER II (BBO– 302): PLANT PHYSIOLOGY AND ELEMENTARY BIOCHEMISTRY

UNIT I

1. Cell physiology, diffusion, permeability, plasmolysis, imbibition, water potential and osmotic potential.
2. Types of soil water, water holding capacity, water requirement, wilting coefficient.
3. Active and passive absorption, anatomical features of xylem in relation to path of water transport and ascent of sap.

UNIT II

1. Loss of water from plants, transpiration, factors affecting transpiration, Guttation, anatomy of the leaf with special reference to the loss of water.
2. Structure of stomata, mechanism of stomatal
3. Movement and diffusion capacity of the stomata.
4. Mechanism of absorption of mineral salts.
5. Translocation of solutes, theories and mechanism of translocation. Anatomical features of the phloem tissue with reference to the translocation of solutes.

UNIT III

1. Elementary knowledge of macro and micro nutrients.
2. Symptoms on mineral deficiency, techniques of water and sand culture.
3. Nitrogen cycle and nitrogen fixation, importance of nitrate reductase and its regulation, ammonium assimilation.

UNIT IV

1. Photosynthesis: Historical background and importance of the process, role of primary pigments, concept of two photosystems, Z- scheme, photophosphorylation, Calvin cycle, factors affecting photosynthesis, chemosynthesis.
2. Respiration, glycolysis, Krebs's cycle, Electron transport mechanism (Chemiosmotic theory), ATP- the biological energy currency, redox potential, oxidative phosphorylation, pentose phosphate pathway, CAM plants, factors affecting respiration, fermentation.

UNIT V

1. Types and strength of solutions, acid base and salts, pH, buffer solutions and their importance.
2. Enzyme action, active sites, Michaelis-Menton constant, classification of enzymes, factors affecting the enzyme activity, coenzymes and co factors.
3. Carbohydrates: Classification, properties, structure and biological role.
4. Protein and amino acids: Classification, structure and chemical bonds in protein structure and properties.
5. Lipids: Structure and functions, fatty acid biosynthesis, beta- oxidation, saturated and unsaturated fatty acids, storage and mobilization of fatty acids.

Suggested Readings

- Jain, V.K. 2014. Fundamentals of Plant Physiology. S. Chand Publications, New Delhi
- Verma, S.K. and Verma M.2014. A text book of Plant Physiology and Biochemistry. S. Chand Publications, New Delhi
- Devlin, R.M. 1996, Plant Physiology. Indian Print New Delhi
- Pandey, S.N.2000. Plant Physiology.
- Srivastava, H.S. Biochemistry. Rastogi Publication, Meerut

PAPER III: (BBO– 303) PLANT BREEDING AND BIOSTATISTICS

UNIT 1

1. Plant breeding: Aims and objectives, basic techniques of plant breeding.
2. Methods of plant breeding in relation to self pollinated and cross pollinated plants.

UNIT 2

1. Crop improvement methods: Plant introduction, selection, acclimatization and hybridization, vegetative propagation and grafting.
2. Heterosis: Genetic and physiological basis
3. Mutational breeding and breeding for disease resistance.

UNIT 3

1. Improved seed production, multiplication and distribution.
2. Maintenance and seed testing.
3. National Seed Corporation (NSC), seed testing laboratories, International and National Centre for plant breeding.

UNIT IV

1. Bio-statistics and its applications.
2. Methods of representation of statistical data diagrams.
3. Measurements of Central tendencies: Mean, Median and Mode

UNIT V

1. Measures of dispersion: Range, mean deviation , standard deviation and standard error.
2. Coefficient of correlation.
3. Test of significance: Chi- square test.

Suggested Readings

Singh, B.D. 2002. Plant Breeding: Principles and Methods. Kalyani Publishers, New Delhi

Chaudhary, H.C. Plant Breeding

Banerjee, P.K. 2007. Introduction to Biostatistics

Prasad, Satguru, 1992. Fundamentals of Biostatistics

LAB COURSE (BBO30P)

CYTOGENETICS, MOLECULAR BIOLOGY AND BIOTECHNOLOGY

1. To study Prokaryotic cells (Bacteria) and Eukaryotic cells with the help of light and electron micrographs.
2. To study cell structure from onion leaf peels, demonstration of staining and mounting methods.
3. Study of mitosis and meiosis (temporary mounts and permanent slides).
4. Exercises on genetical problems out of the following : Mendel's Law Of Inheritance, Incomplete Dominance, Sex Linked Inheritance, Sex Determination, Cytoplasmic Inheritance.
5. To study the working of following instruments: Incubator, Water Bath, Spectrophotometer, Oven and Centrifuge.
6. To study about life history of various scientists and their contribution in the field of molecular biology.
7. To study the working of the following instruments PCR, Laminar Airflow, Autoclave, etc
8. Culture media preparation.
9. Comment upon the given photograph, specimens, slides etc.

PLANT PHYSIOLOGY AND ELEMENTARY BIOCHEMISTRY

1. To perform endosmosis and exosmosis using potato tuber and egg osmoscope. Demonstration of imbibition, plasmolysis and deplasmolysis.
2. To study the effects of temperature on the permeability of plasma membrane.
3. Structure of stomata, their opening and closing, stomatal frequency.
4. Comparison of the rate of transpiration using four leaf method, cobalt chloride paper or by different types of potometers under different climatic conditions.
5. Separation of photosynthetic pigments by circular paper and strip chromatography.
6. To study the effect of light and darkness on starch synthesis.
7. To study the effect of intensity and quality of light on the rate of photosynthesis by Wilmott's bubbler.
8. Study of R.Q by Ganong's respirometer in different seeds.
9. Comparison of the rate of respiration of various plants.
10. Demonstration of colour tests and micro- chemical tests for carbohydrates, proteins and lipids.

PLANT BREEDING AND BIostatISTICS

1. Study of the floral biology of some of the locally available crops such as Wheat, Pea, Bean, Mustard, Brinjal, Orka, Tomato etc.
2. Emasculation techniques in the field along with bagging and labelling.
3. Estimation of dockage percentage in seed samples.
4. Estimation of moisture content in seed samples.
5. National and International Institutes of crop research and improvement, their abbreviations.
6. Representation of data through graphs and diagrams.
7. Comment upon given graphs and diagrams.
8. Statistical problems of Central Tendencies, Standard Deviation, Correlation and Chi Square Test.

Department of Zoology

Sri Dev Suman Uttarakhand University, Badshaithaul

New Tehri



Course Contents & Syllabus

Based on

Annual System

for

Undergraduate Course

BOS held on 7th February 2020

Sri Dev Suman University, Badshahithaul, Tehri Garhwal
B.Sc. (Zoology)
(All affiliated colleges)

The BSc examination will be spread over three years. There will be three theory papers and one practical examination every year. Each theory paper has been divided into five units. There will be 12 objective questions (1 mark each) (Multiple choice/true & false, fill in the blanks); Six short answer questions type (3 marks each) and four long answer type (5 marks each). There will be internal choice in short and long answer questions. The total duration of paper will be 2.30 hours.

Course Content and Teaching Schedule:

Class		No of lecture/periods 45 minutes, 25 weeks	Teaching hours		
			Weekly	Total	MM
B.Sc. 1st Year			Weekly	Total	MM
Paper-1 st	Non-Chordata (Animal Diversity)	50	1.5	37.5	50
Paper 2 nd	Cell Biology and Genetics	50	1.5	37.5	50
Paper 3 rd	Taxonomy, Evolution, Biostats & Computer	50	1.5	37.5	50
Practical based on paper 1,2 &3		100	03	75	50
B.Sc. 2nd Year			Weekly	Total	MM
Paper 4 th	Chordata	50	1.5	37.5	50
Paper 5 th	Animal Physiology and Biochemistry	50	1.5	37.5	50
Paper 6 th	Molecular Biology, Microbiology and Biotechnology	50	1.5	37.5	50
Practical based on paper 4,5 &6		100	03	75	50
B.Sc. 3rd Year			Weekly	Total	MM
Paper-7 th	Endocrinology and Applied Zoology	50	1.5	37.5	50
Paper 8 th	Ecology, Conservation biology and Animal Behaviour	50	1.5	37.5	50
Paper 9 th	Developmental Biology and Toxicology	50	1.5	37.5	50
Practical based on paper 7,8 &9		100	03	75	50

20% marks will be on the basis of internal assessment (10% for attendance + 10% for performance in the practical).

Sri Dev Suman University, Badshahithaul, Tehri Garhwal
B.Sc. 1st Year (Zoology)
Paper I: Animal Diversity (Non-Chordata)

UNIT-I

Protozoa: General characters and classification up to classes; locomotion and nutrition in Protozoa.

Porifera: General characters and classification up to classes; Canal system in sponges

UNIT-II

Coelenterata: General characters and classification up to classes; Polymorphism in Coelenterates; Corals and coral reefs.

Helminthes: General characters of Nematelminthes and Platyhelminthes; Life history of *Ascaris lumbricoides* and *Taenia solium* and their parasitic adaptations

UNIT-III

Annelida: General characters and classification up to classes; Metamerism in Trochophore larva and its significance.

Arthropoda: General characters and classification up to classes; Zoological importance of *Peripatus* and *Limulus*. Metamorphosis in Insects.

UNIT-IV

Mollusca: General characters and classification up to classes; Torsion in Gastropoda; Pearl formation.

UNIT-V

Echinodermata: General characters and classification up to classes; Water vascular system in star fish; Echinoderm larvae and their significance.

Books Recommended:

1. Kotpal, Agrawal & Khetrapal: Modern Text-book of Zoology, Invertebrates.11/E. Rastogi publication.
2. Nigam: Biology of Non-Chordates, Nagin Chand,.
4. B.Sc. Zoology Series -Animal Diversity ,Tata McGraw Hill Edu Pvt. Ltd. N.Delhi
5. Jordan E.L. et al.: Invertebrate Zoology. S.Chand & Company Ltd.
6. Barnes: Invertebrate Zoology (4th ed.), Holt-Saunders.
7. Barrington: Invertebrate Structure and Function, Nelson.
8. Iyer: A Manual of Zoology, Part I. Visawanathan

Sri Dev Suman University, Badshahithaul, Tehri Garhwal
B.Sc. 1st Year (Zoology)
Paper 2: Cell Biology and Genetics

Unit -I

Introduction to Cell biology; Cell theory
Comparative study of the Prokaryotic and Eukaryotic Cell.

Unit -II

Elementary knowledge of the structure & functions of plasma membrane;
Introduction to the organelles constituting endomembrane system (Endoplasmic reticulum, Golgi complex, Lysosome & Peroxisome).

Unit -III Nucleus & nucleolus; Ribosome; Mitochondria. Introduction to cytoskeleton.

Cell Division-Mitosis & Meiosis. Basic features of Cell cycle;
Elementary idea of cell transformation and cancer

Unit-IV

Mendel's law; Exceptions to Mendel's law. Incomplete dominance and Co-dominance, Multiple alleles, Lethal alleles, Epistasis.
Sex-linked inheritance; Extra chromosomal inheritance

Unit-V

Linkage & Crossing over. Sex determination.
Chromosome structure; Euchromatin; Heterochromatin; Histones.
Polytene & lampbrush chromosomes, Eugenesis

Books Recommended:

1. Alberts et al.: Molecular Biology of the Cell, Garland Publ., New York, 1989.
2. Strickberger: Genetics, Prentice Hall, 1996.
3. DeRobertis & DeRobertis: Cell & Molecular Biology, 1996
4. Verma, P.S. and Agrwal, V. K. Cell Biology, Genetics, Molecular biology and Evolution (S. Chand & Co.)

Sri Dev Suman University, Badshahithaul, Tehri Garhwal
B.Sc. 1st Year (Zoology)
Paper 3rd: Taxonomy and Evolution, Biostat & Ccomputer

Unit -I

Taxonomy: Definition & scope; relationship with Systematic, Zoological nomenclature: Binominal & Trinominal; ICZN.

Components of classification: Linnaean hierarchy. Concepts of species: Typological, Nomenclastic & Biological

Unit -II

Geological distribution of animals, period of evolution and extinction of major groups. Direct Evidences of Evolution: Type of Fossils & fossilization. Dating of fossils. Significance of fossil record.

Unit - III

Evolutionary theories: Lamarckism, Darwinism, Neo-Darwinism;

Processes of Evolutionary Change: Organic variations; Isolating Mechanisms; Natural selection (Example: Industrial melanism); Types of natural selection (Directional, Stabilizing, Disruptive). Evolution of Horse

Unit -IV

Biostatistics as a tool in research. Data collection: Random & non-random sampling. Data tabulation; Data presentation (Graph, Frequency Polygon, Histogram, Bar diagram, Scatter diagram).

Measures of central tendency- Calculation of Mean, Mode, Median

Unit -V

Introduction to computers types; Components of computer (Input unit, Memory, Central Processing Unit, Output unit). Problem solving with computers. Elementary idea of memory (RAM, ROM). Uses of computers in different fields. e.g. Biology, Medical, Environment etc.

Books Recommended:

1. Ashok Verma - Animal Taxonomy
2. Ernst Mayr- Principals of Systematic
3. Simpson- Principals and Practices of Animal Taxonomy
4. Kapoor- Theory and Practices of Animal Taxonomy, Oxford & Ibh
5. Strickberger: Evolution, CBS Publ. 1994.
6. Douglas, J. Futuyma. *Evolutionary Biology*. Sinauer Associate (1997)
7. Jain P.C. : Paleontology, Vishal Publ. Co.
8. Arora M.P.: Organic Evolution, Himalaya Publ
9. Rajaraman & V. Rajaraman: Computer Primer (2nd ed.) Prentice Hall of India, New Delhi.
10. Mahajan: Methods in Biostatistics, (4th ed.) Jaypee Bros. 1984

PRACTICAL SYLLABUS B.Sc. First Year (Zoology)

A. Non-Chordata:

Kingdom Protista: Amoeba, Euglena, Plasmodium, Paramecium

Phylum Porifera: Sycon (including T.S. and L.S.), Hyalonema, and Euplectella

Phylum Cnidaria: Obelia, Physalia, Aurelia, Tubipora, Metridium

Phylum Platyhelminthes: Liver Fluke, Taenia solium and Study of its life history stages (*Liver Fluke, Taenia solium*)

Phylum Nematelminthes: Male and female Ascaris lumbricoides

Phylum Annelida: Aphrodite, Nereis, Pheretima, Hirudinaria

Phylum Arthropoda: Palaemon, Cancer, Limulus, Palamnaeus, Scolopendra, Julus, Apis, Peripatus

Phylum Mollusca: Chiton, Dentalium, Pila, Unio, Loligo, Sepia, Octopus

Phylum Echinodermata: Pentaceros, Ophiura, Echinus, Cucumaria and Antedon

An "animal album" containing photographs, cut outs, with appropriate write up about the above mentioned taxa.

B. Cell Biology and Genetics:

1. Cell Structure and Cell Division- Prepared slides/photographs

2. Preparation of giant chromosome

3. Preparation of onion root tip for the stage of mitosis

4. Using suitable examples of Mendelian Inheritance and gene interactions verify the results through Chi-square test.

5. Study of Human Karyotypes (normal and abnormal).

C. Evolution:

1. Study of fossil evidences from plaster cast models and pictures

2. Study of homology and analogy from suitable specimens/ pictures and charts:

3. Phylogeny of horse with diagrams/ cut outs of limbs and teeth of horse ancestors

4. Darwin's Finches with diagrams/ cut outs of beaks of different species

5. Visit to Museums, National parks and sanctuaries and submission of report.

B. Biostatistics

Practical application of statistics- Data presentation (Bar diagram, Histogram, Frequency distribution curve and scattered diagram), Measures of central tendency (Calculation of Mean, Mode, Median).

C. Computer application

Practical demonstration –preparation of Power Point presentation, Spread sheet, Chart and Design etc.

Distribution of marks: Duration 4 hrs.

1. Spotting (10) (Protozoa to Echinodermata)

2. Exercise on Cell Biology

3. Exercise on Genetics

4. Record and Collection

5. Viva Voice

6. Sessional Marks

Total 50

Sri Dev Suman University, Badshahithaul, Tehri Garhwal
B.Sc. 2nd Year (Zoology)
Paper 4th: Chordata

Unit- I

Protochordates: General features and Phylogeny of Protochordates. Body organization of *Balanoglossus*, *Herdmania* and *Amphioxus*.

Unit - II

Agnatha: General features of Agnatha and classification of cyclostomes up to Classes, Comparison between Lampreys and Hagfishes.

Pisces: General features and Classification up to orders; Scales and fins of fishes, Hill stream adaptations

Unit - III

Amphibia: General features and Classification up to orders; Parental care; Neoteny

Reptiles: General features and Classification up to orders; Poisonous and non-poisonous snakes; Biting mechanism in snakes; Venum and antivenum.

Unit - IV

Aves: General features and Classification up to orders; Feathers in Birds; Adaptations for aerial mode of life;

Unit - V

Mammalia: General features; Origin of mammals; distribution and affinities of Prototheria, Metatheria and Eutheria; Aerial and aquatic adaptations in mammals.

Books Recommended:

1. Pandey B.N. and Mathur V. Biology of Chordates, PHI Learning, 2018
2. R.L. Kotpal: Modern Text-book of Zoology, Vertebrates. Rastogi Publication.
3. E.L. Jordan and P.S. Verma: Chordate Zoology. S. Chand & Co. Ltd.
4. Hildebrand: Analysis of Vertebrate structure.
5. Romer & Parsons: The Vertebrate Body, Saunders.

Sri Dev Suman University, Badshahithaul, Tehri Garhwal

B.Sc. 2nd Year (Zoology)

Paper 5th: Animal Physiology & Biochemistry

Unit - I

Digestion: Intracellular and Extracellular digestion. Digestion and absorption of Carbohydrates, Lipids and Proteins.

Respiration: Pulmonary ventilation, Respiratory volumes and capacities,. Transport of Oxygen and Carbon dioxide in Blood. Dissociation of oxyhaemoglobin

Unit - II

Circulation: Composition of blood; Blood coagulation; Structure of Heart; Origin and conduction of the cardiac impulse, Cardiac cycle.

Excretion: Structure of nephron; Physiology of urine formation

Unit - III

Nervous system: Types of neurons; Myelinated and non-myelinated nerve fibres. Initiation and conduction of nerve impulse; Resting and action potential; Synapse and chemical transmission.

Muscles: Types of muscles; Ultrastructure of skeletal muscles; Molecular and Chemical basis of muscle contraction; Brief idea of tetanus and fatigue

Unit – IV

Carbohydrates Metabolism: Glycolysis, Kreb's Cycle, Gluconeogenesis, Glycogenesis and Glycogenolysis; Lipids: Biological significance, structure and classification.

Unit-V

Proteins: structure and classification; Transamination and Deamination

Enzymes: types and properties, factors affecting their functions. Mechanism of enzyme Action,

Books recommended:

1. Singh & Neeraj: Graduate Animal Physiology & Biochemistry, Vishal Publ
2. Prosser and Brown: Comparative Animal Physiology, Wiley.
3. Nielson: Animal Physiology, Cambridge.
4. Jain A.K: Textbook Of Physiology 6/E, Avichal Publishing Company
5. Conn and Stumpf: Outlines of Biochemistry. John Wiley.
6. Pandey B N: B.Sc. Zoology Series-Biochemistry, Physiology, Endocrinology; Tata McGraw Hill Edu Pvt. Ltd. N. Delhi

Sri Dev Suman University, Badshahithaul, Tehri Garhwal
B.Sc. 2nd Year (Zoology)
Paper 6th: Molecular Biology, Biotechnology and Microbiology

Unit I

Structure of DNA: nucleosides, nucleotides, polynucleotide chain, Watson and Crick DNA double helix model. DNA as genetic material, Packaging of DNA, Types of DNA

Unit II

Enzymes involved in prokaryotic and eukaryotic DNA replication; Mechanism & Type of replication.

DNA damage and repair: causes and types of DNA damage, mechanism of DNA repair:

Unit III

RNA: Structure and types of RNA, Clover leaf model of tRNA,

Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains.

Processing of pre-mRNA: 5' cap formation, polyadenylation, splicing, rRNA and tRNA splicing.

Unit IV

Biotechnology: Definition and scopes; Enzyme used in genetic engineering, Recombinant DNA technology, DNA fingerprinting. A Brief knowledge of PCR and its significance.

Biotechnological innovations in the area of medical, agriculture, industrial and forensic sciences

Unit V

General account of Cyanobacteria, fungi, yeast and viruses,

Bacteria: Structure, classification, nutrition and reproduction.

Books recommended:

1. Alberts et al.: Molecular Biology of the cell. Garland Publ., New York.
2. De Robertis- Cell and Molecular Biology
3. Friefelder: Molecular Biology. Narosa Publ. House.
4. Smith: Biotechnology. Cambridge.
5. Verma, P.S. and Agrwal, V. K. Cell Biology, Genetics, Molecular biology, Evolution and Ecology (S. Chand & Co.)
6. Tortora- Microbiology: an Introduction

Sri Dev Suman University, Badshahithaul, Tehri Garhwal
PRACTICAL SYLLABUS of B.Sc. 2nd year (Zoology)

A. Chordata:

Protochordata: *Balanoglossus, Herdmania, Branchiostoma, Agnatha: Petromyzon*

Pisces: *Sphyrna, Pristis, Torpedo, Labeo, Exocoetus, Anguilla, Tor putitora*, Hill stream fishes

Amphibia: *Ichthyophis/Ureotyphlus, Salamandra, Bufo, Hyla, Axolotal larva*

Reptilia: *Chelone, Hemidactylus, Chamaeleon, Draco, Vipera, Naja, Crocodylus, Gavialis*

Key for Identification of poisonous and non-poisonous snakes

Aves: Study of six common birds from different orders

Mammalia: *Sorex, Bat, Funambulus, Loris,*

An “animal album” containing photographs, cut outs, with appropriate write up about the above mentioned taxa.

B. Physiology

Preparation of hemin crystals, Estimation of Haemoglobin percentage, Blood group test

Examination of permanent slides of spinal cord, duodenum, liver, lung, kidney, bone, cartilage etc.

C. Biochemistry

Identification of unknown carbohydrates in given solutions (Starch, Sucrose, Lactose, Galactose, Glucose, Fructose)

Colour reactions to identify functional group in the given solution of proteins

Study of activity of salivary amylase under optimum conditions

D. Molecular biology and Biotechnology:

Study of Watson & Crick Model of DNA through model/photographs

Study of Clover leaf structure of tRNA through model/photographs

Agarose gel electrophoresis of genomic DNA & plasmid DNA

Preparation of restriction enzyme digests of DNA samples

E. Microbiology

Media preparation and sterilization, Gram’s staining of Bacterial Cell

Distribution of marks: Duration 4 hrs.

1. Spotting (05) 15
2. Exercise on Molecular Biology/Biotechnology 05
3. Exercise on Immunology 05
4. Exercise on Microbiology 05
5. Record and Collection 05
6. Viva Voice 05
7. Sessional Marks 10

Total 50

Sri Dev Suman University, Badshahithaul, Tehri Garhwal
B.Sc. 3rd Year (Zoology)
Paper 7th: Endocrinology and Applied Zoology

UNIT I

Basic idea of endocrine, paracrine & autocrine secretion. Mechanism of action of hormones. Structure and function of Pituitary, Thyroid, Adrenal, Pancreas, Testes and ovary. Hormonal control of menstrual cycle

Unit II

Structure and function of Pituitary, Thyroid, Adrenal, Pancreas, Testes and ovary. Hormonal control of menstrual cycle.

Unit III

Sericulture: Types of silk worms (Mulberry & Nonmulberry), Rearing of Mulberry Silkworm

Lac culture: cultivation practices of host plants, extraction and uses of lac

Unit IV

Medicinal Pests: Identification, Characteristics of Mosquitoes, Housefly, Bedbug, Sand Medicinal Pests fly, Human lice, Tse Tse fly, Rat flea

Unit V

Aquaculture (Fish Culture): Monoculture and composite culture.

Hatchery management – development of fish hatcheries, types of hatcheries, production of spawn, fry and fingerlings, Pond management and fertilization - pre and post stocking management.

Induced breeding with special reference to Indian major carps.

Suggested Readings

Hadley, M.E.: Endocrinology. Pearson Education Pvt. Ltd. Singapore.

Sri Dev Suman University, Badshahithaul, Tehri Garhwal
B.Sc. 3rd Year (Zoology)
Paper 8th: Ecology, Conservation Biology and Animal Behaviour

Unit -I

Ecology: Definition, scope and importance,
Introduction to laws of Limiting factors: Liebig's law of the minimum, Shelford's law of tolerance. Factor interaction

Unit -II

Biogeochemical cycles: Concept and types of biogeochemical cycle (Water, Carbon, Nitrogen and Phosphorus cycle)

Unit -III

Ecosystem concept: Component & types (Grassland, Forest, Pond, River); Abiotic, biotic & edaphic factors and their interdependence,
Energy flow in ecosystem. Primary and secondary productivity. Food chains, food web and ecological pyramids

Unit -IV

Conservation Biology: Definition & scope. Concept of biodiversity; Biodiversity as a resource; Biodiversity loss and its Causes.
Conservation & Management of Biodiversity. Concept of Protected Areas: *Ex-situ* & *In-situ* Conservation. Biodiversity hot spots.
India's wildlife: Habitats & Distribution; Protected areas: National Parks & Sanctuaries.

Unit-III

The science of behaviour: History, scope and terminology. Biological rhythms. Biological Clock. Circadian rhythms and their synchronisation seasonal rhythms. Photoperiodism

Recommended Books:

1. Alcock : Animal behaviour Sinaur Associates, Inc. 1989.
2. Drickamer & Vessey: Animal Behaviour: Concepts, Processes and Methods (2nd ed.)1986
3. Goodenough et al.: Perspectives on animal behaviour. Wiley & Sons, New Youk. 1993.
4. Grier : Biology of animal behaviour, Mosby 1984.
5. M P Arora. Anilam behaviour. Himalayan Publishing house
6. Negi: An introduction to Wildlife Management, 1983.
7. Negi: Himalayan Wildlife: Habitat and Conservation. 1992. Indus Publ. Com., New Delhi.
8. Pullin: Conservation Biology, Cambridge, 2002.
9. Rawat & Agarwal : Biodiversity: Concept, threats and conservation.
10. Sharma, High Altitude Wildlife of India. Oxford 7 IBH Publ. Co. Pvt. Ltd. 1994.

Sri Dev Suman University, Badshahithaul, Tehri Garhwal
B.Sc. 3rd Year (Zoology)
Paper 9th: Developmental Biology and Toxicology

Unit - I

Gametogenesis: Spermatogenesis in mammals, Morphology of mature mammalian spermatozoon: Oogenesis in mammals, Vitellogenesis in birds.
Fertilization: external (amphibian), Internal (mammals), Block to polyspermy

Unit - II

Early Development of Frog and Human: types of egg; patterns of cleavage; role of yolk during cleavage; Morphogenetic movements; Development up to formation of gastrula.

Neurulation in frog embryo, Extra embryonic membranes.

Unit - III

Implantation of embryo in human; Types of placenta on the basis of histology; Formation of human placenta and its functions.

Elementary concept of primary organizer; Induction. Differentiation and organogenesis of vertebrate eye.

Unit - IV

Definition, history, scope of toxicology.

Classification of toxic agents, natural toxins, food toxins, and chemical toxins

Environmental toxicology of heavy metal (lead)

Unit - V

Air pollution-types of air pollutants, their effects and remedial measures.

Water pollution- types of water pollutants, their effects and remedial measures.

General introduction to pesticides;, herbicides, fungicides, and insecticides

Books recommended:

1. Jain P C . Development Biology.
2. Gilbert, Developmental Biology. 3rd ed. Sinauer, 1991.
3. Berril: Developmental Biology, McGraw-Hill. Indian ed. 1974.
4. Laycock, J.F. and Wise, P.H.: Essential Endocrinology. Oxford University Press.
5. Hadley, M.E.: Endocrinology. Pearson Education Pvt. Ltd. Singapore

PRACTICAL SYLLABUS of B.Sc. 3rd Year (Zoology)

A. Endocrinology

Study of slides; pituitary, adrenal gland, thymus, testes, ovary

B. Ecology

Models Based on different aspects of ecology.

Population study of available terrestrial and aquatic animals

Physico-chemical study of soil and water (pH, DO, Free CO₂, Turbidity etc)

Study of an ecosystem, its biotic components and food chains

C. Animal Behavior &

Models Based on different aspects of animal behavior.

Study of Birds Nest showing Nesting Behaviour

Experiments related to learning behaviour/conditional learning.

Conservation Biology: Definition & scope. Concept of biodiversity; Biodiversity as a resource; Biodiversity loss and its Causes.

D. Conservation Biology

Study of Biodiversity hot spots with the help of maps..

Study of Protected areas: National Parks & Sanctuaries with the help of maps.

D. Developmental Biology

Frog - Study of developmental stages - whole mounts and sections through permanent slides – cleavage stages, blastula, gastrula, neurula, tail bud stage, tadpole-external and internal gill stages.

Study of the different types of placentae- histological sections through permanent slides or photomicrographs.

E. Toxicology

Distribution of marks: Duration 4 hrs.

Spotting (05) 15

(Ecological adaptation, Wildlife, Animal behaviour)

Exercise on Ecology/ Conservation Biology 10

Exercise on Animal Behaviour 05

Record and Collection 05

Viva Voice 05

Sessional Marks 10

Total: 50