

# SYLLABUS

**BACHELOR OF SCIENCE IN BIOTECHNOLOGY**

**B.Sc. Biotech I, II, III Year**



**FACULTY OF APPLIED SCIENCES**

**JODHPUR NATIONAL UNIVERSITY**

**JODHPUR**

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**Faculty of Applied Sciences**

**Ordinance, Scheme and Syllabus for Bachelor of Science in Biotechnology**

**Jodhpur National University, Jodhpur** offers Bachelor of Science in Biotechnology (B. Sc- Biotech.) Degree Course with effect from Academic Year (2013-2014)

<b>Course Title:</b>	Bachelor of Science in Biotechnology
<b>Abbreviation:</b>	B. Sc - Biotech
<b>Type of Course:</b>	A three years Degree Course
<b>Pattern:</b>	Semester
<b>Nomenclature of Year:</b>	Semester I & Semester II – First Year B. Sc – Biotech. Semester III & Semester IV – Second Year B. Sc - Biotech. Semester V & Semester VI– Third Year B. Sc – Biotech.

**O- 6.2.1**

**O- 6.2.1.1 Eligibility for admission**

No candidate shall be admitted to B. Sc – Biotech Part –I unless he/she secured 40% aggregate in senior secondary Certificate Examination (Standard-XII of the Board of Rajasthan **or** CBSE/ **or** recognized equivalent thereto) in all optional and compulsory subject with Physics, Chemistry and Biology / Biotechnology / Agriculture.

**O- 6.2.1.2 Duration of Course:** A three year degree course divided into six semesters ;each semester will be normally of 15 weeks duration for class room teaching/Lecture/Practical and University examination for that year will be held after the 16<sup>th</sup> week from the commencement of the Semester

**\* Clause for no enrolment with other University:** The students who are already enrolled in **Jodhpur National University** are not permitted to enroll in other university in the same academic year.

**O-6.2.2 Relates to fee structure which will cover the College fee, Enrolment fee, Examination fee, Library fee, Hostel fee etc:**

The College fee, Enrolment fee, Examination fee, Library fee, Hostel fee etc: are fixed by the Fees fixing committee of the university.

**O- 6.2.3 Relates to Scholarship/Freeship /Stipend/Fellowship/Studentship**

Scholarship/Freeship /Stipend/Fellowship/Studentship will be given to meritorious students as decided by the competent authority of the university

**O- 6.2.4 Includes rules regarding attendance and Dean's/ Vice –Chancellor's power for relaxation of attendance.**

No candidate shall be allowed to appear in any examination (Sessional & University) unless he / she have attended 75% of the classes held in each Theory and Practical separately in each subject.

A candidate can have a relaxation of 10% attendance on medical ground by producing a certificate from medical officer of government hospital and 5% relaxation by the Vice Chancellor in the recommendation of Dean, Faculty.

**O- 6.2.5 Examination**

**O- 6.2.5.1** The medium of instruction and Examination will be in English/Hindi

**O- 6.2.5.2** Candidates for the B. Sc – Biotech course shall be instructed and examined as per the teaching and Examination scheme and Course Content of respective semester.

**O- 6.2.5.3 Scheme of Examination:**

There are 6 theory papers per semester dedicated to biotechnology each carrying maximum 80 marks. In each semester, there will be combined practical examination of 200 marks. Three papers of chemistry are compulsory every semester each carrying maximum 80 marks. .

There shall be two Sessional (average of two will be taken as final Sessional marks) and one university examination in each semester. These examinations will be designated \_\_\_\_\_ as \_\_\_\_\_ follows:

**Scheme of Examination for B. Sc Biotech Semester-I**

Sub. Code	Subject	Hrs/week		Hrs/sem		Semester Exam.		Sessional Exam.	Total
		L	P	L	P	Th.	Prac.	Theory	
111	Inorganic Chemistry-I	3	2	45	30	80	100	20	100
112	Organic Chemistry-I	3	2	45	30	80		20	100
113	Physical Chemistry-I	3	2	45	30	80		20	100
114	Ecology and Evolution	4	2	60	30	80	100	20	100
115	Microbiology	4	2	60	30	80		20	100
116	Biophysics & Biotechniques –I	4	2	60	30	80		20	100
		<b>21</b>	<b>12</b>	<b>315</b>	<b>180</b>	<b>480</b>	<b>200</b>	<b>120</b>	<b>800</b>
	<b>TOTAL</b>								<b>800</b>

**Scheme of Examination for B. Sc Biotech Semester-II**

Sub. Code	Subject	Hrs/week		Hrs/sem		Semester Exam.		Sessional Exam.	Total
		L	P	L	P	Th.	Prac.	Theory	
121	Inorganic Chemistry-II	3	2	45	30	80	100	20	100
122	Organic Chemistry-II	3	2	45	30	80		20	100
123	Physical Chemistry-II	3	2	45	30	80		20	100
124	Biochemistry	4	2	60	30	80	100	20	100
125	Principle of Genetics	4	2	60	30	80		20	100
126	Cytology & Developmental Biology	4	2	60	30	80		20	100
		<b>21</b>	<b>12</b>	<b>315</b>	<b>180</b>	<b>480</b>	<b>200</b>	<b>120</b>	<b>800</b>
	<b>TOTAL</b>								<b>800</b>

**Scheme of Examination for B. Sc Biotech Part-I (Compulsory Subject)**

Sub. Code	Subject	Hrs / Week		Hrs / Year		Yearly Exam		Total
		L	P	L	P	Th.	Prac.	
101	Environmental Studies	1	-	30	-	75	25	100
102 (a)	General English	1	-	30	-	100	-	100
102 (b)	General Hindi							
103	Elementary Computer	1/2	1/2	15	15	60	40	100
<b>Total</b>		<b>2.5</b>	<b>0.5</b>	<b>75</b>	<b>15</b>	<b>-</b>	<b>-</b>	<b>300</b>

\* The compulsory papers are required to pass once in three year duration of degree course. The minimum passing marks for these three compulsory papers is 36% individually in theory as well as practical. The marks of compulsory papers will not be considered while determining rank and division. In paper Hindi and English students can choose only one subject.

**Scheme of Examination for B. Sc Biotech Semester-III**

Sub. Code	Subject	Hrs/ week		Hrs/sem		Semester Exam.		Sessional Exam. Theory	Total
		L	P	L	P	Th.	Prac.		
231	Inorganic Chemistry-III	3	2	45	30	80	100	20	100
232	Organic Chemistry-III	3	2	45	30	80		20	100
233	Physical Chemistry-III	3	2	45	30	80		20	100
234	Comparative Physiology	4	2	60	30	80	100	20	100
235	Biophysics & Biotechniques II	4	2	60	30	80		20	100
236	Molecular Biology	4	2	60	30	80		20	100
		<b>21</b>	<b>12</b>	<b>315</b>	<b>180</b>	<b>480</b>	<b>200</b>	<b>120</b>	<b>800</b>
	<b>TOTAL</b>								<b>800</b>

**Scheme of Examination for B. Sc Biotech Semester- IV**

Sub. Code	Subject	Hrs/ week		Hrs/sem		Semester Exam.		Sessional Exam. Theory	Total
		L	P	L	P	Th.	Prac.		
241	Inorganic Chemistry-IV	3	2	45	30	80	100	20	100
242	Organic Chemistry-IV	3	2	45	30	80		20	100
243	Physical Chemistry-IV	3	2	45	30	80		20	100
244	Plant Resource & Technology	4	2	60	30	80	100	20	100
245	Environmental Biotechnology	4	2	60	30	80		20	100
246	Immunology	4	2	60	30	80		20	100
		<b>21</b>	<b>12</b>	<b>315</b>	<b>180</b>	<b>480</b>	<b>200</b>	<b>120</b>	<b>800</b>
	<b>TOTAL</b>								<b>800</b>

**Scheme of Examination for B. Sc Biotech Semester- V**

Sub. Code	Subject	Hrs/ week		Hrs/sem		Semester Exam.		Sessional Exam. Theory	Total
		L	P	L	P	Th.	Prac.		
351	Inorganic Chemistry-V	3	2	45	30	80	100	20	100
352	Organic Chemistry- V	3	2	45	30	80		20	100
353	Physical Chemistry- V	3	2	45	30	80		20	100
354	Animal Resource & Technology	4	2	60	30	80	100	20	100
355	Industrial Biotechnology	4	2	60	30	80		20	100
356	Biostatistics	4	2	60	30	80		20	100
		<b>21</b>	<b>12</b>	<b>315</b>	<b>180</b>	<b>480</b>	<b>200</b>	<b>120</b>	<b>800</b>
	<b>TOTAL</b>								<b>800</b>

**Scheme of Examination for B. Sc Biotech Semester- VI**

Sub. Code	Subject	Hrs/ week		Hrs/sem		Semester Exam.		Sessional Exam.	Total
		L	P	L	P	Th.	Prac.	Theory	
361	Inorganic Chemistry-VI	3	2	45	30	80	100	20	100
362	Organic Chemistry-VI	3	2	45	30	80		20	100
363	Physical Chemistry-VI	3	2	45	30	80		20	100
364	Genetic Engineering	4	2	60	30	80	100	20	100
365	Biotech Enterprises & Socioeconomic Issues	4	2	60	30	80		20	100
366	Emerging Technologies	4	2	60	30	80		20	100
		<b>21</b>	<b>12</b>	<b>315</b>	<b>180</b>	<b>480</b>	<b>200</b>	<b>120</b>	<b>800</b>
	<b>TOTAL</b>								<b>800</b>

**O-6.2.5.4 Standard of passing**

**O-6.2.5.4.1** Each Theory paper and practical will be treated as separate subject. In each subject minimum 40% in Sessional and University examination taken together.

**O-6.2.5.4.2** Candidate who has been admitted in B.Sc. Biotech. 1<sup>st</sup> semester will be promoted to the higher class in accordance with the following sub-rules:

**O-6.2.5.4.3** No candidate will be awarded degree of Bachelor of Science in Biotechnology unless he/she has passed all the six semesters.

**O- 6.2.5.5 ATKT**

At the end of academic Year	Total subject heads at the End of academic year.	33 % of total subjects (To nearest full digit) for ATKT
First Theory	06 + 06 = 12	<b>03</b>
Practical	02 + 02 = 04	<b>01</b>
Second Theory	06 + 06 = 12	<b>03</b>
Practical	02 + 02 = 04	<b>01</b>

If candidate fail to appear in examination, then also his attempt will be counted.

**O- 6.2.6 Promotion to higher classes**

**O- 6.2.6 .1 Promotions from odd semester to even semester in the same academic year**

a) A Candidate who appeared in Semester - I examination of First Year B.Sc. Biotech. will be allowed to keep term for his/her Semester –II Examination, of First Year B.Sc. Biotech.

b) A Candidate who appeared in Semester – III examination of Second B.Sc. Biotech. will be allowed to keep term for his/ her Semester – IV Examination of Second Year B.Sc. Biotech.

c) A Candidate who appeared in Semester – V examination of Third Year B.Sc. Biotech. will be allowed to keep term for his/her Semester – VI Examination of Third Year B.Sc. Biotech.

**O- 6.2.6 .2 Promotions to subsequent academic year-**

- i) No candidate will be admitted to the Semester III course unless he/she Passes in at least two third of total number of subjects at the Semester I and Semester II examination of B.Sc. Biotech.
- ii) Passes his/her Semester I and Semester II examination of B.Sc. Biotech. and fails in not more than One third of total number of subjects at the Semester III & Semester IV Examinations of B.Sc. Biotech. will be promoted to semester V.

**O- 6.2.7 Rules related to declaration of Result**

Candidate will be considered as passed the semester only when the candidate passes in all the subjects with ATKT. Candidate will be given maximum five years to complete his / her B.Sc. Biotech neither his enrollment stand cancel. The students who fall under the following conditions: The result of following class of students can not be declared

- 1. If any fee is due.
- 2. If he/she caught under UFM and decision of UFM committee is pending.
- 3. If any enquiry of misconduct is pending against him/her.

**O- 6.2.8 Rules related to Ex Students**

If students are declared fail than he/she has to reappear in all the theory subjects (if he/she is declared pass in practical) and is not allowed to sit in higher class till he/she passes in failing class.

**O- 6.2.9 Course of study for each degree, diploma and certificates**

**Professional Training and Project**

Every candidate shall be required to work for at least four weeks in an Industry/ Research Institute after the Semester- IV of the course of study. The candidate may undergo practical training in parts, each constituting not less than two weeks. Candidate shall undergo professional training in a training center (Pharmaceutical Manufacturing Unit /Analytical Laboratory / Bulk Drug Manufacturing Unit / Research Institute ) allotted by Training officer of \_\_\_\_\_ the \_\_\_\_\_ institute.



Candidate shall prepare and submit two copies of training report in prescribed format printed or type written in bound form. One copy is to be submitted to the research board and one copy to be retained by the candidate for his / her own reference. The report shall contain the certificate of training from the head of the respective training center and shall be duly accepted and certified by the Dean, faculty.

Marks for professional training shall be awarded on the basis of training report, interview and viva voce by a board consisting of training in-charge and one examiner (appointed by the Dean, faculty) and the Dean, faculty or his nominee who shall be the chairman of the board.

**O- 6.2.10 Award of Degree, Division and Rank**

**O- 6.2.10.1** Degree will be awarded to the candidates who have passed in all the subjects of all six semesters.

**O- 6.2.10.2** The division to a successful candidate shall be awarded on the basis of aggregate of marks obtained by him / her in B.Sc. Biotech. First year B.Sc. Biotech. Second year, B.Sc. Biotech third year examinations regardless of the number of attempts, as shown below:

<i>Percentage of marks</i>	<i>Division</i>
75% or above	Honors
60% or above	First Division
50% or above	Second Division

**O-6.2.10.3** Rank (I, II & III) and university gold medal shall be conferred on the basis of aggregate percentage of marks obtained in all the three years to those candidates who have passed the whole examination in first attempt.

The candidate who found indulges in any misconduct / indisciplinary activity will not be eligible for University medals / awards.

**O- 6.2.10.4 Re-totaling of marks:** There will be no rechecking of copies, only Re-totaling of marks can be done on the request of candidate with requisite

**SEMESTER – I**

**B.Sc. Part-I**

**111. INORGANIC CHEMISTRY- I**

**UNIT- I**

**(a) Atomic Structure**

Idea of de Broglie matter waves, Heisenberg uncertainty principle, atomic orbitals, schrodinger wave equation, significance of  $\psi$  and  $\psi^2$ , 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 configuration of the elements, effective nuclear charge.

**(b) Periodic Properties**

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

**UNIT- II**

**Chemical Bonding**

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  $\text{NH}_3$ ,  $\text{H}_3\text{O}^+$ ,  $\text{SF}_4$ ,  $\text{ClF}_3$ ,  $\text{ICl}_2^+$ , and  $\text{H}_2\text{O}$ , MO theory, homonuclear and heteronuclear (CO and NO) diatomic molecules, multicentre bonding in electron deficient molecules ( $3c-2e$ ).

**UNIT- III**

**Qualitative Analysis**

Theoretical basis of qualitative analysis, Systematic analysis of Acidic and Basic radicals (including interfering radicals). Chemical reactions involved. Common-ion effect, solubility product & their applications. Oxidizing and reducing agents and buffers used in analysis.

**112. ORGANIC CHEMISTRY-I**

**UNIT-I**

**(a) Structure and Bonding**

Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bond, Vander Waals interactions, inclusion compounds, clathrates, charge transfer complexes, resonance, hyperconjugation, aromaticity, inductive and field effects, hydrogen bonding.

**(b) Mechanism of Organic Reactions**

Curved arrow notation, drawing electron movements with arrows, half-headed and double headed arrows, homolytic and heterolytic bond breaking. Types of reagentselectrophiles and nucleophiles. Types of organic reactions. Energy considerations. Reactive intermediates- carbocations, carbanions, free radicals, carbenes, arynes and nitrenes (with example). Assigning formal charges on intermediates and other ionic species.

Methods of determination of reaction mechanism (products analysis, intermediates, isotope effects, kinetic and stereochemical studies.)

## UNIT-II

**Stereochemistry of Organic Compounds**

Concept of isomerism. Types of isomerism. Optical isomerism-elements of symmetry, molecular chirality, enantiomers, stereogenic centre, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centres, 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 mono substituted cyclohexane derivatives. Newman projection and Sawhorse formulae, Fischer and flying wedge formulae. Difference between configuration and conformation.

## UNIT-III

**(a) Alkanes and Cycloalkanes**

IUPAC nomenclature of branched and unbranched alkanes, the alkyl group, classification of carbon atoms in alkanes. Isomerism in alkanes, sources, methods of formation (with special reference to Wurtz reaction, Kolbe 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 strainless rings. The case of cyclopropane ring: banana bonds.

**(b) Alkenes**

Nomenclature of alkenes, methods of formation, mechanism 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-mechanisms involved in hydrogenation, electrophilic and free radical additions. Markownikoff's rule, hydroboration-oxidation, oxymercuration-reduction. Epoxidation, ozonolysis, hydration hydroxylation and oxidation with  $\text{KMnO}_4$ . Polymerization of alkenes. Substitution at the allylic and vinylic positions of alkenes. Industrial applications of ethylene and propene.

## 113. PHYSICAL CHEMISTRY-I

## UNIT-I

**Mathematical Concepts**

Logarithmic relations, curve sketching, linear graphs and calculation of slopes, differentiation of functions like  $a^x$ ,  $e^x$ ,  $x^n$ ,  $\sin x$ ,  $\cos x$ ,  $\tan x$ ,  $\log x$ ; maxima and minima, partial differentiation. Integration of some useful functions; like  $x^n$ ,  $1/x$ ,  $e^x$ , constant,  $\sin x$ ,  $\cos x$ , integration by parts. Permutations and combinations. Probability.

## UNIT-II

### **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 Vander Waals equation, relationship between critical constant and Vander 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. Liquefactions of gases (based on Joule-Thomson effect.)

## UNIT-III

### **Liquid State**

Intermolecular forces, structure of liquids (a qualitative description) Structural differences between solids, liquids and gases.

Liquids crystals: Difference between liquid crystal, solid and liquid. Classification, structure of nematic and cholestric phases.

## CHEMISTRY PRACTICAL-I

### **1. Inorganic Chemistry**

Semi micro Analysis-cation analysis, separation and identification of four ions from Groups I, II, III, IV, V and VI. Anion analysis including interfering radicals.

### **2. Organic Chemistry**

(A) Laboratory Techniques. (Any Three)

#### **(a) Calibration of Thermometer**

80-82° (Naphthalene), 113.5-114° (Acetanilide),  
132.5-133° (urea), 100° (Distilled Water)

#### **(b) Determination of Melting Point**

(Naphthalene), 80-82°, Benzoic acid 121.5-122°  
Urea 132.5-133°, Succinic acid 184.5-185°  
Cinnamic acid 132.5-133°, Salicylic acid 154.5-158°  
Acetanilide 113.5-114°, m-Dinitrobenzene 90°  
p-Dichlorobenzene 52°, Aspirin 135°

#### **(c) Mixed melting points**

Urea-Cinnamic acid mixture of various compositions (1:4, 1:1, 4:1)

#### **(d) Determination of boiling points**

Ethanol 78°, Cyclohexane 81.4°, Toluene 110.6° Benzene 80°

#### **(e) Crystallization**

Concept of induction of crystallization

Phthalic acid from hot water (using fluted filter paper and stemless funnel)

Acetanilide from boiling ethanol

Benzoic acid from water

### 3. PHYSICAL CHEMISTRY (ANY FIVE)

1. To determine the viscosity of amyl alcohol in water at different concentrations and calculate the excess viscosity of these solutions.
2. To determine the percentage composition of a given binary mixture by surface tension method (acetone & ethyl methyl ketone).
3. To determine the percentage composition of a given mixture (non interacting systems) by viscosity method.
4. To determine the specific reaction rate of the hydrolysis of methyl acetate/ ethyl acetate catalyzed by hydrogen ions at room temperature.
5. To study the effect of acid strength on the hydrolysis of an ester.

## 114. ECOLOGY AND EVOLUTION

### UNIT-I

Ecology as a System, Concept: Ecosystem concept, holistic approach, homeostasis, structure and functions of ecosystem. Habitat, niche, community, population, biome, ecotone, succession, ecological pyramids, trophic levels, food chains, food webs, guild, productivity.

### UNIT-II

Environmental factors: Atmosphere, Hydrosphere, Lithosphere and biosphere and their interrelationships Biotic and Abiotic factor, Limiting factors - Leibig's law of minimum and Shelford's law of tolerance, Ecological amplitude, fidelity.

### UNIT-III

Biotic interactions .Neutralism, mutualism, commensalisms', antibiosis, parasitism, predation, competition .Adaptations; hydrophytes, halophiles, xerophiles.  
Biogeochemical cycles – Water, Carbon, Nitrogen, Sulphur and Phosphorus

### UNIT-IV

Evolution: Origin of life evidences of organic evolution and theories of evolution, Variation and its mechanism, Selection and Genetic drift. Molecular chronometers. Molecular method to study evolution.

### UNIT-V

Co evolution. Concept of niche and evolution of biodiversity, r and k selection, mimicry and adaptations, Speciation: sympatric and allopatric. Theory of genetic equilibrium: Hardy-Weinberg law.

## 115. MICROBIOLOGY

### UNIT-I

Classification of microorganisms .Haeckel's three kingdom and Whittaker's five kingdom concepts .Three domain concept of Carl Woese. Archaeobacteria and eubacteria .Classification of algae, fungi, lichen and protozoa up to class level. Thallus organization and importance.

### UNIT-II

Features and life history of Amoeba, Paramecium, Volvox, Oedogonium, Vaucheria, Ectocarpus. Economic importance of protozoa and algae.

### UNIT-III

Features and life history of Phytophthora, Mucor, Saccharomyces, Puccinia, Agaricus, Colletotrichum. Acellular living entities (Viruses, virusoids, viroids, prions). Structure, multiplication and important diseases caused by them in man, plants and cattle.

### UNIT-IV

Nutritional classification of bacteria. Functional diversity of bacteria (oxygenic and anoxygenic photosynthesis, fermentations, anaerobic respiration, diazotrophy, nitrification, denitrification, methylotrophy, methanogenesis, hydrogen production and uptake, sulfur oxidation and reduction). Economic importance of bacteria.

### UNIT-V

Gram positive and Gram negative bacteria. Biology and importance of methanogens, actinomycetes, fermentative bacteria, rhizobiaceae, cyanobacteria and yeasts.

## 116. BIOPHYSICS & BIOTECHNIQUES

### UNIT-I

Thermodynamics: Warning, Cooling, Heat capacity and specific heat, Latent heat, First law of thermodynamics. Temperature scales Coefficient of thermal expansion. Perspiration, heat regulation in warm and cold blooded animals. Pressure Cooker Metabolic rate and body size. Goose pimples Bergmann's law. Second and third law of thermodynamics. Information: definition, unit. DNA as information molecule. Entropy, Enthalpy and bonding energy, phosphorylation. Flow of energy through biosphere. Does life violate the second law?

### UNIT-II

Big Bang Theory. Condensation of primordial soup, Matter and anti matter, Fundamental particles, Quarks, Plasma, Models of self organization, pattern and network, dissipative structures, Eigen's hypothesis, Autopoiesis, requirements of life and living structures. Living beings as dissipative structures and non equilibrium thermodynamics. Simplest possible mechanism to yield energy, replicate information and contain the constituents.

### UNIT-III

ATP production, Transport, Mass and Energy balance in. Metabolism. Metabolic heat generation. Asepsis and observation techniques: Principles of asepsis. Principles, and techniques of sterilization, disinfection and antiseptics.

### UNIT-IV

Cultivation of microorganism's. Constructing nutrient media (Ingredients, Types). Environmental factors affecting growth of microorganisms. Isolation (Enrichment, selection, bait technique. Isolating single spores). Purification techniques maintenance and preservation of cells. Methods of cell; disruption. Physical and chemical methods.

### UNIT-V

Methods of separation .Filtration techniques .Angular momentum. Moment of inertia. Centrifugal and centripetal forces. Centrifugation .Principles, Types an applications .Chromatography and Electrophoresis. Principles types and applications.

### COMBINED BIOTECH PRACTICAL-I

#### General Microscopy

1. Parts of a microscope .Handling Precautions
2. Types and use of different bright field microscopes.-Dissection microscope. Calibration of a micrometer and micrometry of cells
3. Microscopic enumeration of cells using (a) Drop method and (b) Cell Counters (Neubauer chamber /Hemocytometer )
4. Numerical exercises on determination of volume of a cell counter
5. Simple staining of yeast / molds
6. Identifying different types of spores of fungi – conidiospores , ascospores , bacidiospores, uredospores , teleutospores , pycnidiospores )
7. Differentiating akinetes , heterocysts and vegetative cells in cyanobacteria
8. Microscopic identification of 5 types of protozoans
9. Differential staining ;Gram staining bacteria
10. Ubiquity of microorganisms

#### Microbiology

1. Methods of sterilization; Wet heat, dry heat, and filter sterilization. Sterilizing glassware.
2. Determining efficacy of aseptic techniques
3. Methods of disinfection; Physical and chemical
4. Need , use and cleaning of laminar flow
5. Preparation of stocks of inorganic compounds for culture media
6. Preparing culture medium , its sterilization and pouring the plates, preparing tubes (Liquid , slants ,stabs )
7. Isolation of pure culture : Streak plate method, serial dilution method
8. Selective cultivation of fungi, actinomycetes, bacteria and studies on their micro and macromorphological features.

## SEMESTER II

## 12I. INORGANIC CHEMISTRY- II

## UNIT- I

**(a) 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.

**(b) S-Block Elements**

Comparative study, diagonal relationships, salient features of hydrides, solvation and complexation tendencies including their function in biosystems, and introduction to alkyls and aryls.

## UNIT- II

**P-Block Elements**

Comparative study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides, oxides and halides of groups 13-16, hydrides of boron, diborane and higher boranes, borazine, borohydrides.

## UNIT- III

**(a)** Fullerenes, carbides, fluoro-carbons, silicates (Structural principle), tetrasulphur tetranitride, basic properties of halogens, interhalogens and polyhalides.

**(b) Chemistry of Noble Gases**

Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.

## 122. ORGANIC CHEMISTRY-II

## UNIT-I

**Cycloalkenes, Dienes and Alkynes**

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 reactions-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-II

**(a)** Aromatic electrophilic substitution- general pattern of the mechanism, role of  $\sigma$  and  $\delta$  Complexes. Mechanism of nitration, halogenation, sulphonation, mercuriation and Friedel-Crafts reaction. Energy profile diagrams. Activating and deactivating substituents, orientation and ortho/para ratio. Side chain reactions of benzene derivatives. Birch reduction.

**(b)** Methods of formation and chemical reactions of alkylbenzenes, alkynylbenzenes and biphenyl.

**(c) Arenes and aromaticity**

Nomenclature of benzene derivatives. The aryl group. Aromatic nucleus and side chain. Structure of benzene: molecular formula and Kekule structure. Stability and carbon- carbon



bond lengths of benzene, resonance structure, MO picture. Aromaticity: the Huckel rule, aromatic ions.

### UNIT-III

#### Alkyl and Aryl Halides

Nomenclature and classes of alkyl halides, Methods of formation, chemical reaction. Mechanisms of nucleophilic substitution reactions of alkyl halides, SN<sub>2</sub> and SN<sub>1</sub> 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.

## 123. PHYSICAL CHEMISTRY-II

### UNIT-I

#### Colloidal State

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 applications of colloids.

### UNIT-II

#### Solid State

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).

### UNIT-III

#### 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.

## CHEMISTRY PRACTICAL-II

### Organic Chemistry

#### (a) Distillation

Simple distillation of ethanol-water mixture using water condenser

Distillation of nitrobenzene and aniline using air condenser

#### (b) Decolorisation and crystallization using charcoal

Decolorisation of brown sugar (sucrose) with animal charcoal using gravity filtration.

Crystallization and decolorisation of impure naphthalene (100 g of naphthalene mixed with 0.3 g of Congo Red using 1 g decolorising carbon ) from ethanol.

#### (c) Sublimation (Simple and Vacuum)

Camphor, Naphthalene, Phthalic acid and Succinic Acid.

### Inorganic Chemistry

#### Qualitative Analysis

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

1. To compare the strengths of HCl and H<sub>2</sub>SO<sub>4</sub> by studying the kinetics of hydrolysis of ethyl acetate.
2. To study kinetically the reaction rate of decomposition of iodide by H<sub>2</sub>O<sub>2</sub>.
3. To study the distribution of iodine between water and CCl<sub>4</sub>
4. To study the distribution of benzoic acid between benzene and water.
5. To prepare arsenious sulphide sol and compare the precipitating power of mono-, bi- and trivalent anions.

## 124. BIOCHEMISTRY

### UNIT-I

Nature of biological material, identifying characteristics of living matter, molecular logic of life. Bioelements; General properties of biomolecules, Central role of carbon, Water: structure and unique properties. Acid, Base, Buffers, Polyprotic acids.

### UNIT-II

Amino acids: structure and properties. Protein their types with examples. Enzymes, mechanism of action, classification, Michaelis Menten equation. Regulation of enzymes: Allosteric, uncompetitive, competitive, Non competitive.

### UNIT-III

Carbohydrates: structure, functions, classification of different types of carbohydrates with examples. Aldoses and ketoses. Haworth projection. Epimers, isomers and Mucopolysaccharides.

### UNIT-IV

Structure and Function and classification. Triacylglycerides, waxes, Phospholipids, polar and non polar lipids. Cholesterol, Sphingolipids, cerebrolipids. Comparative account of types of lipid characteristics to plants, animals and microbial systems. Structure of cell membrane.

### UNIT-V

Nucleic Acid: structure of nucleotides, nucleosides. Types of Nucleic acids. Their functions. Structure in prokaryotes and eukaryotes. Structure of DNA. Types of DNA confirmation. Packaging of DNA into nucleosomes. Heterochromatin, Euchromatin, Repetitive DNA, Palindromes, concept of the gene. Introns and exons. Vitamins and hormones, their types and functions.

## 125. PRINCIPLES OF GENETICS

### UNIT-I

Mendelian principle: Principles of segregation, monoclinal cross, dominance, co dominance, semiominance, lethal genes, Principles of independent assortment: dihybrid rations, Trihybrid ratios, gene interaction, epitasis, multiple alleles. Meiosis and Mendel's principles.

### UNIT-II

Sex determination and linkage: Mechanisms of sex determination: Simple mechanisms, One or a few genes, identification of sex Chromosomes, XX-XY mechanism, Y Chromosome and sex determination in mammals, balanced concept of sex determination in Drosophila, haploidy and sex determination in hymenoptera, Mosaics and gynandromorphy, environmental factors in sex determination, sex differentiation sex influenced dominance. Sex limited gene expression, sex linked inheritance.

### UNIT-III

Principles of linkage ; Crossing over ,cytological basis of crossing over chromosome mapping by two factor crosses interference ordered tetrad data .somatic cell hybridization .Molecular mechanism of crossing over gene conversion

### UNIT-IV

Classical versus molecular concept of the gene. Cis Tran complementation, deletion, mapping, one gene-one band in Drosophila salivary gland chromosomes .Genes within genes.

### UNIT-V

Population Genetics ;Behavioral genetics ,Hardy Weinberg frequencies , inbreeding ,calculating F from pedigrees, out breeding and assorted mating ,genetic equilibrium, chemotaxis , inheritance and learning in bees .Drosophila behavioral genetics ,genetic and environmental interactions in dogs.

## 126. CYTOLOGY AND DEVELOPMENT BIOLOGY

### UNIT-I

Discovery of the cell. Cell Theory. Cell composition. Cell constituents. Biogenic elements. Properties of water and carbon that help in sustenance of life. Eukaryotic and prokaryotic cells. Plant and animal cell. Cell inclusions. Advantage of compartmentalization. Membrane systems not bound by unit membrane (Mesosomes, thylakoids, chlorosomes, magnetosomes, carboxysomes). Cytoskeletal structures (Microvilli, microtubules) and cell inclusions (storage bodies, pyrenoids, oil droplets, sulfur particles, volutin granules)

### UNIT-II

Diversity of cell types and their differences. Archaeobacterial and Eubacterial cell, Cell walls; structure and function. Cell membranes; Structure, function and models, Protein mosaic and lipid raft model. Translocation through membranes. Excretion and uptake. Membranes as sites for energy generation and photo-entrapment systems.

### UNIT-III

Cell appendages and surface architecture (Flagella, cilia, pili, capsule, sheath) Cell organelles, their structure and function; Endoplasmic reticulum, Golgi bodies, Mitochondria, Chloroplast, Ribosomes, Lysosomes, Peroxisomes, Nucleus, Vacuoles. Cell cycle, Cell differentiation in prokaryotes (endospores, exospores, cysts, akinetes, heterocysts, asexual spores) and its need. Vegetative propagation. Somatic division. Asexual reproduction. Diversity of spores in algae, fungi, protozoa) and comparison of their structure and genesis. Reproductive division. Sexual reproduction. Cell senescence and apoptosis.

### UNIT-IV

Tissues, their types, structure and function, Comparative histology of plants and animals. Growth and differentiation. Organs and organ systems. Vascular system in plants. Common features of Digestive, Excretory, Circulatory, Respiratory, Muscular, Skeletal, Nervous and sensory system in animals and evolution of complexity.

### UNIT-V

Embryology of plants and animals. Placentation in mammals. Embryonic stem cells, Biology of aging. Developmental biology; morphogenesis, Gametogenesis, cleavage, differentiation, organogenesis. Developmental biology; neuroendocrine regulations. Reproductive system, estrous and menstrual cycle.

## COMBINED BIOTECH PRACTICAL-II

### Biochemistry

1. Numerical exercises on normality, molarity, molality, percent solution, ppm, ppb solutions
2. Measurement of pH
3. Preparing buffer Preparation of phosphate buffer and calculation of pH using Handerson Hasselbach equation
4. Estimation of intra and extracellular protein by Lowry's method
5. Estimation of total carbohydrates by anthrone method

6. Phytochemical tests of the following; Glucose, Starch, Proteins, Fats, Tannins, Ascorbic acid and anthocyanin.
7. Soxhlet separation of oils from seeds and its gravimetric estimation.
8. Estimation of DNA content
9. Estimation of RNA content
10. Using a centrifuge, determine minimum time that will be required to settle algal/blood cells.

**Cell biology & development biology**

1. Endospore staining in bacteria.
2. Sectioning, staining and observation of leaf stem and root of monocot and dicot plants.
3. Histological slides of cleavage, blastula, gastrula, neurula and tail bud stages.
4. Mitotic and meiotic studies in yeast/ onion root tips/ flower buds.
5. Demonstration of sexual reproduction in algae and protozoa by permanent slides.

**SEMESTER – III**

**B.Sc. Part-II**

**231 INORGANIC CHEMISTRY-III**

**UNIT-I**

**(a) Chemistry of Elements of First Transition Series**

Characteristic properties of d-block elements.

Properties of the elements of the first transition series, their binary compounds and complexes illustrating relative stability of their oxidation states, coordination number and geometry.

**(b) Chemistry of Elements of Second and Third Transition series**

General characteristics, comparative treatment with their 3d-analogues in respect of ionic radii, oxidation states, magnetic behavior, spectral properties and stereochemistry.

**UNIT-II**

**Quantitative analysis**

Types of quantitative analysis: Gravimetric and volumetric analysis.

Precipitation, Co-precipitation and Post precipitation.

Errors in chemical analysis: types of error and their minimization; Accuracy, Precision, Standard Deviation.

**UNIT-III**

**Oxidation and Reduction**

use of redox potential data-analysis of redox cycle, redox stability in water-Frost, Latimer and Pourbaix diagrams. Principles involved in the extraction of the elements.

**232 ORGANIC CHEMISTRY-III**

**UNIT-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. Bathchromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated enes and enones. Infrared (IR) absorption spectroscopy-molecular vibrations, Hooke's law, selection rules, intensity and position of IR bands, measurement of IR spectrum, fingerprint region, characteristic absorption of various functional groups and interpretation of IR spectra of simple organic compounds.

**UNIT-II**

**(a) 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 [Pb(OAc)<sub>4</sub> and HIO<sub>4</sub>] and pinacol-pinacolone rearrangement. Trihydric alcohols- nomenclature and methods of formation, chemical reactions of glycerol.

**(b) 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****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 organolithium reagents with epoxides.

**233. PHYSICAL CHEMISTRY-III****UNIT-I****Thermodynamics-I**

Definition of thermodynamic terms: system, surroundings etc. Types of systems, intensive and extensive properties. State and path functions and their differentials. Thermodynamic process. 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  $w, q, dU,$  &  $dH$  for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.

**Thermo chemistry:** 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****Thermodynamics-II**

Second law of thermodynamics: need for the law, different statements of the law. Carnot cycle and its efficiency, Carnot 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. Entropy change in ideal gases and mixing of gases.

**Third law of thermodynamics:** Nernst heat theorem, statement and concept of residual entropy, evaluation of absolute entropy from heat capacity data. 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  $G$  with  $A$  with  $P, V$  and  $T$ .

**UNIT-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 equation and Clausius- Clapeyron equation, applications.

## CHEMISTRY PRACTICAL-III

### Inorganic Chemistry

(a) Calibration of fractional weights, pipettes and burettes. Preparation of standard solutions. dilution 0.1 M to 0.001 M solutions.

### Organic Chemistry-III

#### Chromatography (Any Four)

- (i) Separation of Rf values and identification of organic compounds.
- (ii) Preparation and separation of 2,4-dinitrophenylhydrozone of acetone, 2-butabibe, hexan-2- and 3-one using toluene and light petroleum (40:60:).
- (iii) Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5)
- (iv) Separation of a mixture of phenylalanine and glycine. Alanine and aspartic acid. Leucine and glutamic acid. Spray reagent-ninhydrin.
- (v) Separation of a mixture of D,L- alanine, glycine and L-Leucine using n-butanol:acetic acid: water(4:1:5), spray reagent-ninhydrin.
- (vi) Separation of monosachharides- a mixture of D-galactose and Dfructose using n-butanol:acetone water (4:5:1) spray reagent-aniline hydrogen phthalate.

### Physical Chemistry

1. Determination of the transition temperature of the given substance by thermometric/dialometric method (e.g.  $\text{MnCl}_2 \cdot 4\text{H}_2\text{O} / \text{SrBr}_2 \cdot 2\text{H}_2\text{O}$ ).
2. To study the effect of a solute (e.g.  $\text{NaCl}$ , 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.

## 234 COMPARATIVE PHYSIOLOGY

### UNIT-I

Comparative account of the mechanisms of food uptake in animals. Digestion of food. Uptake of the nutrients by plants, animals and microorganisms. Transport of nutrients across the cell membrane for energy, structure and storage. Concept of exoenzymes and endoenzymes, bound and soluble enzymes.

### UNIT-II

Metabolism; Integration of catabolism and anabolism. Secondary metabolism, regulation of metabolic pathways, compartmentalization of metabolic pathways in microorganism and higher organism.

### UNIT-III

Photosynthesis. Diversity of Phototrophs. Chloroplast structure. Pigments involved in photosynthesis chlorophylls, carotenoids, xanthophylls and phycobillins. Light and dark reaction. C3 and C4 pathways.

### UNIT-IV

Comparison of photosynthetic systems of plants and bacteria. Photorespiration. Respiration; Glycolytic pathway. Citric acid cycle, glyoxylate cycle, Pentose phosphate pathway, their significance, energetics and enzymology.



### UNIT-V

Electron transport chain, phosphorylation and ATP production, anaerobic respiration, Fermentation .A comparative account of respiratory processes of microorganisms, plants and animals

## 235 BIOPHYSICS & BIOTECHNIQUES-II

### UNIT-I

Electromagnetic radiations: Light rays, refraction, Snell's law, Image by spherical surface. Magnifying lens, pinhole cameras, bifocals, prism, and prisms as mirrors and in binoculars, negative lens. Diffraction, Interference. Single slit, many slit and 2- D gratings, resolving power of a grating, dispersion of a grating. Polarization, Polaroid wind shields .Polarization of skylight –the bees, Brewster's Law. Law of Malus, Spectrum. Michelson interferometer.

### UNIT-II

Observing cells and microorganisms; Principles of microscopy, magnification, numerical aperture, resolving power, chromatic aberrations. Development of microscopes from simple bright field to electron microscope. Types of microscopy, principles and usage. Visible light (dark and bright field), fluorescence microscopes .UV and Electron based microscopy techniques. Stereo microscopes and their uses .Transmission (TEM), Scanning, (SEM) and Scanning Tunneling Microscopes

### UNIT-III

Photons, LASER, Momentum of radiation. Compton Effect and X- rays, Bragg's law. Project seafarer, microwave ovens, Black- body radiation, Photomultiplier, Solar battery, Laser surgery (photocoagulation), Principles of Spectroscopy. Energy levels, excitation, absorption, electronic, vibration, rotational spectra. Types of spectroscopy and their use.

### UNIT-IV

Density and specific gravity, Archimedes principle, Pressure and Buoyant force. Units of pressure, Sphygmomanometer, Deep sea diving and autoclaving and pressure cooking. Fluid flow, Bernoulli's principle .Viscosity and Poiseuille's law, Units of viscosity .Stoke's law .Reynolds's number. Osmosis, Edema, Osmotic hemolysis , Surface tension.

### UNIT-V

Radioactivity, radioactive nuclei. Physical and biological half life , Emitting isotopes, Uranium , Radium, Plutonium and Thorium, Radioactive series, Nuclear systematics, Nuclear fission and fusion, and Breeder reactors, ecological fall outs. Biological applications, Radiolabelling, Diagnosis (RIA ), Tracers, GM and Scintillation Counters .Therapy (Neutron activation therapy ), Radiation dose (Roentgen, Rad and Rem) and safety .Uses in molecular biology, Shielding and other precautions .Radiocarbon dating .Tritium dating .

## 236 MOLECULAR BIOLOGY

### UNIT-I

DNA as the genetic material .Hershey and Chase experiment .Conrat and Senger's experiment .Structure of DNA .Watson & Crick's Model, Types of DNA. Meselsen & Stahl's experiment, DNA replication, genome complexity, packaging of DNA into chromosomes.

Euchromatin, heterochromatin, repetitive DNA, DNA denaturation and renaturation .Genetic information content –C-value paradox and reassociation kinetics

#### UNIT-II

Genetics code, steps of protein synthesis and their details. Structure and types of RNA and their functions .Transcription of RNA in prokaryotes and eukaryotes. Steps in transcription .Maturation and processing of RNA .Translation; Comparison between prokaryotic and eukaryotic translation .Post translational processing of proteins.

#### UNIT-III

Genetic recombination .Molecular aspects of recombination .Homologous and heterologous recombination. Holliday Model. Gene expression and organization in mitochondrion and chloroplast

#### UNIT-IV

Regulation of expression in prokaryotes and eukaryotes. Operon concept .Inducible and repressible operons. Negative and positive regulation .Details of lac and trp operon.

#### UNIT-V

Gene control of development in Drosophila, hormonal control of gene expression, regulation of alternate pathways of transcript splicing, regulation of complex circuits of gene expression in eukaryotes

### COMBINED BIOTECH PRACTICAL-III

#### Physiology

1. Internal anatomy of cockroach (dissection ), ruminants and men (models)
2. Demonstration of plasmolysis using *Roheo discolors* leaves/ red blood cells.
3. Demonstration of osmosis by potato osmoscope
4. Estimation of chlorophyll by not methanol extraction method
5. Estimation of photosynthetic rate using light and dark bottle method
6. Estimation of respiratory rate by Warburg method
7. Demonstration of catalase activity and peroxidase
8. Demonstration of exoenzyme activities – cellulases and amylases
9. Demonstration of fermentation by yeast

#### Molecular Biology

1. Extraction, estimation and purification of protein from animal/ microbial source by salt precipitation and organic solvent method.
2. Separation of proteins by poly of proteins by polyacrylamide gel electrophoresis
3. Demonstrations of DNA transfer by transformation and conjugation in bacteria by teaching kits.
4. Extraction of DNA from plant/animal/microbial cells
5. Restriction digestion of DNA followed by agarose gel electrophoresis
6. Isolation of plasmid DNA from *Escherichia coli*

## SEMESTER – IV

### 241 INORGANIC CHEMISTRY -IV

#### UNIT-I

##### **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-II

##### **(a) Chemistry of Lanthanide Elements**

Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, lanthanide compounds.

##### **(b) Chemistry of Actinides**

General features and chemistry of actinides, chemistry of separation of Np, Pu and Am from U, similarities between the later actinides and the later lanthanides.

#### UNIT-III

##### **(a) Acids and Bases**

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

##### **(b) 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<sub>3</sub> and liquid SO<sub>2</sub>.

### 242 ORGANIC CHEMISTRY-IV

#### UNIT-I

##### **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.

##### **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 reactions. Mechanisms of esterification and hydrolysis (acidic and basic).

## UNIT-II

### Aldehydes and Ketones

Nomenclature and structure of carbonyl group. Synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides, synthesis of aldehydes and ketones using 1,3-dithianes, synthesis of ketones from nitriles and from carboxylic acid. 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,  $\text{LiAlH}_4$  and  $\text{NaBH}_4$  reductions Halogenation of enolizable ketones.

An introduction to  $\alpha$ ,  $\beta$  unsaturated aldehydes and ketones.

## UNIT-III

### 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.

Halonitroarenes: 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. Amines salts as phase transfer catalysts. Preparation of alkyl and aryl amines (reduction of nitro compounds, nitriles), reductive amination of aldehydic and ketonic compounds. Gabriel phthalimide reaction, Hofmann bromamide reaction.

Reaction of amines, electrophilic aromatic substitution in aryl amines, reaction of amines with nitrous acid. Synthetic transformation of aryl diazonium salts, azo coupling.

## 243 PHYSICAL CHEMISTRY-IV

### UNIT-I

#### Electrochemistry-I

Electrical transport-conduction in metals and in electrolyte solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution. Migration of ions and Kohlrausch 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 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.

### UNIT-II

#### Electrochemistry-II

Types of reversible electrodes-gas-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-standard electrode potential, sign conventions, electrochemical series and its significance.

Electrolytic and Galvanic cells-reversible and irreversible cells, conventional representation of electrochemical cells.

### UNIT-III

EMF of a cell and its measurements. Computation of cell EMF. Calculation of thermodynamic quantities of cell reactions ( $\Delta G$ ,  $\Delta H$ , and  $K$ ), polarization, over potential and hydrogen overvoltage. 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 pKa determination of pH using hydrogen, quinhydrone and glass electrodes, by potentiometric methods.

Buffers-mechanism of buffer action, Henderson-Hasselbalch equation. Hydrolysis of salts. Corrosion-types, theories and methods of combating it.

### CHEMISTRY PRACTICAL-IV

#### Inorganic Chemistry

##### (a) Volumetric Analysis (Any Four)

- (ii) Determination of acetic acid in commercial vinegar using NaOH.
- (iii) Determination of alkali content-antacid tablet using HCl.
- (iv) Estimation of calcium content in chalk as calcium oxalate by permanganometry.
- (v) Estimation of hardness of water by EDTA.
- (vi) Estimation of ferrous and ferric dichromate method.
- (vii) Estimation of copper using thiosulphate.

##### (b) Gravimetric Analysis.

- (i) Analysis of Cu as CuSCN
- (ii) Ni as Ni-dimethylglyxime.

#### Organic Chemistry

##### (a) Qualitative Analysis

Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives.

#### Physical Chemistry

1. To construct the phase diagram of two component (e.g. diphenylamine-benzophenone) system by cooling curve method.
2. To determine the solubility of benzoic acid at different temperatures and to determine  $\Delta H$  of the dissolution process.
3. To determine the enthalpy of neutralisation of a weak acid/weak base versus strong base/strong acid and determine the enthalpy of ionisation of the weak acid/weak base.
4. 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.

## 244. PLANT RESOURCES AND TECHNOLOGY

### UNIT-I

Basic feature of anatomy of cryptogams and phanerogams. Diversity of forms of seeds. Fruits, flowers, leaves, stems and roots.

### UNIT-II

Classifications of plants upto family level. Vegetative and floral characteristics and economic importance of cucurbitaceae, Fabaceae, Cruciferae and Poaceae (Graminae). Pteridophytes with specific reference to *Azolla*.

### UNIT-III

Forest products; *Tectona*, *Delbergia*, *Tecomella*, Medicinal plants; *Cinchona*, *Withania*. Pharmacological and ethnobotanical traditional medicines. Characterization and formulation of crude drugs in Ayurvedic system. Plant sources of homeopathic medicines. Fuel crops: *Jajoba*, *Euphorbia antisyphilitica*, *Calotropis procera* Characteristics, cultivation and extraction of oil. Edible and poisonous fungi. Cultivation of different types of mushrooms

### UNIT-IV

*In situ* and *ex situ* methods of conservation of phytodiversity. In vitro methods in plant tissue culture. Nutrient media. Use of growth regulators. In vitro fertilization. Ovary and ovule culture. Micropropagation (clonal propagation) organ culture – anther, embryo, endosperm culture and their applications. Organogenesis and somatic embryogenesis – techniques and applications.

### UNIT-V

Protoplast culture; Isolation, regeneration, viability test. Somatic hybridization, methods of protoplast fusion. Practical application of somatic hybridization and cybridization. Somaclonal variations and their significance. In vitro production of secondary metabolites- techniques and significance. Plant cell suspension culture to produce saffron and capsaicin.

## 245 ENVIRONMENTAL BIOTECHNOLOGY

### UNIT-I

Global environmental problems: Ozone depletion, UV-B, green house effect and acid rain, their impact and biotechnological approaches for management. Air, noise and thermal pollution, their causes, harmful effects and control.

### UNIT-II

Water pollution and its control. Water as scarce natural resource, need for water management, sources of water pollution, measurement of water pollution, Eutrophication, Ecological indicators and Biomarkers. water supply treatment, waste water collection, waste water treatment – physical, chemical and biological treatment processes. Water purification methods – desalination, reverse osmosis etc.

### UNIT-III

Aerobic processes – activated sludge, oxidation ditches, trickling filter, towers, rotating discs, rotating drums, oxidation ponds, anaerobic processes – anaerobic digestion, anaerobic filters. Treatment schemes for waste waters of dairy, distillery, sugar and antibiotic industries. Ore leaching (Biomining), Biofuels, biodiesel, petrocrops, gasohol, biogas, hydrogen production.

#### UNIT-IV

Environmental biotechnology: Scope and application. Concept of Cleaner Technology. Solid wastes: Sources and management (composting and methane production) general hazardous wastes, radioactive and other hazardous wastes and their management. Sources and safety. Application of microbes as biofertilizers and bioinsecticides for productivity improvement and crop protection. Green technologies .Fuels and their alternatives .Biofertilizers v/s fertilizers, pesticides v/s biopesticides .plastic v/s bioplastics

#### UNIT-V

Principles of biomonitoring and applications of biosensors for detection of environmental pollutants. Biomining: Use of microbes in biohydrometallurgy and biomineralization Bioremediation: Degradation of pesticides, oil spills and other xenobiotics. Phytoremediation of disturbed ecosystems. Microbes and their genetic engineering for degradation of environmental pollutants.

### 246. IMMUNOLOGY

#### UNIT-I

Semiochemicals: Allomones, Kairomones, Pheromones, Hormones, Allarmones. Allelochemicals .Antibiosis, antibiotics, bacteriocins. Cell–cell recognition and adhesion .Signal transduction in cells: Electrical signals, messenger and receptors

#### UNIT-II

Defense in microorganisms; against other microorganisms, heavy metals. Plant defenses; unfavorable environment, hormonal regulation, drought survival, air pollution, heavy metals, infection, signaling molecules in defense. Defense in invertebrates: Internal defense in Molluscs and Arthropods.

#### UNIT-III

Defense in non mammalian vertebrates; cell and tissues of immune system in fish and birds. B-lymphocytes, its structure and function. Effect of temperature, stress on fish immunity.

#### UNIT-IV

Mammalian defense; physicochemical barriers, Immunology, Passive, active and acquired immunity. Humoral and cell mediated immunity. Cells and organs of immune responses and their function. Antigens, Factors affecting antigenicity. Antibodies, their structure and types .Production of antibodies. Complement system .Hypersensitivity and allergic reactions.

#### UNIT-V

Immunodiagnostics in Typhoid , Syphilis , Typhus fever and HIV. RIA & ELISA . Vaccines; history , types and their production strategies. Vaccines available and vaccination schedules for children. Importance of cold chain and precautions in vaccinations.

### COMBINED BIOTECH PRACTICAL-IV

#### Plant resources and Technology

1. Preparation of plant tissue culture medium: MS, Nitsche and White's media
2. Production of callus and suspension culture.
3. Isolation of plant protoplasts.
4. Plant production through tissue culture (shoot tip and nodal culture)
5. Anther culture.
6. Preparation of synthetic seeds

#### Biotechniques

1. Mechanical methods of cell disruption of animal/plant cells.
2. Chemical methods of cell disruption of Gram negative bacteria
3. Ultrasonication to break cells of Gram positive bacteria
4. Methods of concentrating thermolabile solutions rotary evaporator, lyophilizer.
5. Paper chromatographic separation of pigments
6. Phytochemical tests of the following; Glucose, starch, proteins, fats, tannins, ascorbic acid and anthocyanin.
7. TLC of sugars/amino acids.
8. Demonstration of Beer and Lambert's law

#### Ecology and Environmental Biotechnology

1. Calculate diversity index of a community of plants/algae
2. Oligodynamic effect of metals on bacterial populations
3. Microscopic and macroscopic differentiation of root nodules and root galls
4. Demonstration of antibiotic activity of *Penicillium* or any other organism
5. Determination of pollution in water/food using *Escherichia coli* as indicator.
6. Determination of Blood groups.
7. Demonstration of DO, COD and BOD
8. Demonstration of ELISA



**SEMESTER – V**

**B.Sc. Part-III**

**351 INORGANIC CHEMISTRY-V**

**UNIT-I**

**(a) 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.

**(b) Magnetic properties of transition metal complexes:** Types of magnetic behaviour, magnetic properties of metal complexes, spin only formula, methods of determining magnetic moment and magnetic susceptibility.

**UNIT-II**

**Thermodynamic and Kinetic Aspect of Metal Complexes**

Stability of metal complexes: A brief outline of thermodynamic stability of metal complexes and factors affecting the stability. Kinetic stability, labile and inert complexes, colour of transition metal complexes, effective atomic number (EAN), pi acceptor ligands, experimental determination of stability constant and composition of complex ( Job's Method and Bjerrum's Method).

**UNIT-III**

**Organometallic Chemistry**

Definition, nomenclature and classification of organometallic compounds. Preparation, properties, bonding and applications of alkyls and aryls of Li, Al, Hg, Sn and Ti, a brief account of metal-ethylenic complexes and homogeneous hydrogenation, mononuclear carbonyls and the nature of bonding in metal carbonyls.

**352 ORGANIC CHEMISTRY-V**

**UNIT-I**

**Spectroscopy**

Nuclear Magnetic resonance (NMR) spectroscopy.

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

**UNIT-II**

**(a) Organometallic Compounds**

Organomagnesium compounds: the Grignard reagents-formation, structure and chemical reaction.

Organozinc compounds: formation and chemical reactions.

Organolithium compounds: formation and chemical reactions.

**(b) Fats, Oil 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.

**UNIT-III**

**Organic Synthesis via Enolates**

Acidity of  $\alpha$ -hydrogens, alkylation of diethyl malonate and ethyl acetoacetate. Synthesis of ethyl acetoacetate: the Claisen condensation. Keto-enol tautomerism of ethyl acetoacetate. Alkylation of 1,3-dithianes. Alkylation and acylation of enamines.

**353 PHYSICAL CHEMISTRY -V**

**UNIT-I**

**Elementary Quantum Mechanics**

Black-body radiation, Planck's radiation law, photoelectric effect, Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect. De Broglie hypothesis, the Heisenberg's uncertainty principle, Hamiltonian operator, Schrodinger wave equation and its importance, particle in a one dimensional box. Schrodinger wave equation for H-atom, separation into three equations (without derivation),

**UNIT-II**

**Spectroscopy**

Introduction : electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation, degrees of freedom.

**Electronic Spectrum**

Qualitative description of selection rules and Frank-Condon principle. Qualitative description of  $\sigma$ ,  $\pi$ , and n M.O., their energy levels and the respective transitions.

**UNIT-III**

**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.

## CHEMISTRY PRACTICAL-V

### 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 Qualitative Analysis

Analysis of an organic mixture containing two solid components using water, NaHCO<sub>3</sub>, NaOH for separation and preparation of suitable derivatives.

### Laboratory Techniques

#### Steam Distillation

Naphthalene from its suspension in water

Clove Oil from cloves

Separation of o-and-p-nitrophenols

### PHYSICAL CHEMISTRY

1. To determine the strength of the given acid conductometrically using standard alkali solution.
2. To determine the solubility and solubility product of a sparingly soluble electrolyte conductometrically.
3. To study the saponification of ethyl acetate conductometrically
4. To determine the ionization constant of a weak acid conductometrically.
5. To titrate potentiometrically the given ferrous ammonium sulphate solution using KMnO<sub>4</sub>/K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> as titrant and calculate the redox potential of Fe<sup>++</sup>/Fe<sup>+++</sup> System on the hydrogen scale.
6. To verify law of refraction of mixtures (e.g. of glycerol and water) using Abbe's refractometer.

## 354 ANIMAL RESOURCES AND TECHNOLOGY

### UNIT-I

Chordates and non chordates. General characters of all phyla upto orders with examples emphasizing their biodiversity, economic importance and conservation measures where required. Classification, habits, habitat and features of obelia, sycon, fasciola, taenia, nereis, hirudianaria, palaemon.

### UNIT-II

Classification, habits, habitat and features of Pila, Lamellidens, Asterias. Herdmania, Branchiostoma, Peteromyzon, Myxine, Biology of Insecta., Morphology, Anatomy, life history and importance of Lepidoptera, Hemiptera. Isoptera. Orthoptera and Hymenoptera.

### UNIT-III

Sericulture, Apiculture, Lac culture, Aquaculture – pisciculture, prawn and pearl culture, Vermiculture.

### UNIT-IV

Scope of animal tissue culture. Natural media – plasma clot , biological fluids , tissue extracts .Importance of serum .Chemically defined media , primary culture – cell lines , cloning. Disaggregation of tissue, isolation of tissue ,. Enzymatic disaggregation and mechanical disaggregation.

### UNIT-V

Secondary culture- transformed animal cells and continuous cell lines. Stem cells and their cultivation. Importance of stem cell cultivation and ethical issues involved. Production and application of monoclonal antibodies and vaccines.

## 355 INDUSTRIAL BIOTECHNOLOGY

### UNIT-I

Growth and its requirement (environment and nutritional) .Factors affecting growth .Growth Kinetics .Synchronous non synchronous .Continuous and batch cultivation. Types of industrial bioprocesses (aerobic, anaerobic and light based processes, solid state and submerged fermentation).

### UNIT-II

Design and parts of a fermenter (photobioreactor).Types of fermenter. Stirred tank, membrane reactors and continuous flow reactor. Maintenance of asepsis , pH, gaseous environment and temperature in a fermenter.

### UNIT-III

Upstream and downstream processes. Examples of fermentations involving biomass production. Production of single cell protein and single cell oil, *Spirulina* .Separation and harvesting the desired product .Immobilization of cells and enzymes and its advantages. Bioprocesses involving extra cellular liberation of biomolecules .Production of Alcoholic beverages. Penicillin, amylase, separation and harvesting of desired product.

### UNIT-IV

Bioprocesses involving intracellular production of biomolecules. Production of polyhydroxyalkanoates.Separation and harvesting of desired product.

### UNIT-V

Fermented foods. Yoghurt, buttermilk, idli, dosa and cheese. Strategies to reduce cost of production. Techniques to improve yield of the desired production (Strain improvement and other strategies).

## 356 BIOSTATICS

### UNIT-I

Introduction of samples, random sampling, sampling procedures – stratified, systematic and cluster sampling, sampling in quality control measurement of spread of data coding, precision, accuracy.

### UNIT-II

Statistical Inference Statistical estimation (confidence of intervals), statistical hypothesis testing composition of variances in independent samples, test of equality, population mean, variance in case of two population, large sample tests.

### UNIT-III

Linear regression and correlation. Introduction, analysis of standard curves in Drug analysis-application of linear regression, assumption of tests in hypothesis in linear regression, variance of sample estimates of the parameters, a Drug stability study – an example of the application of linear regression, confidence intervals in regression coefficients, nonlinear regression.

### UNIT-IV

Analysis of variance Linear models One-way analysis of variance, planned versus a Posteriori (Unplanned) comparisons in ANOVA, example of one-way analysis of variance-unequal sample size and fixed and random models, two-way analysis of variance (Randomized blocks). Analysis of covariance, ANOVA for pooling regression lines as related to stability data.

### UNIT-V

Quality control Introduction, control charts, acceptance sampling and operating characteristic curves, statistical procedures in Assay. Department establishing in-house limits, some statistical aspects of quality and the “Barr Decision”.

## COMBINED BIOTECH PRACTICAL-V

### Animal resources and biotechnology

1. Cultivation of Daphnia.
2. Microscopic identification of crustaceans: Daphnia, Cero daphnia.
3. Earthworms used in vermiculture.

### Genetic Engineering

1. Barr bodies in buccal smears.
2. Karyotype analysis in man and onion.
3. Producing autotrophic mutants of Escherichia coli by chemical mutagens
4. Transfect ion of bacterial cells using plasmid / phage vector

### Fermentation Technology

1. Preparing serial dilutions to count bacteria
2. Determining growth rate of any bacteria
3. Demonstration of diauxy in bacteria to demonstrate lac operation activity.
4. Immobilization of cells.(algal / yeast cells)
5. Immobilization of enzyme (invertase may be obtained from yeast cells and observed for glucose production )

6. Production of citric acid by *Aspergillus* and its estimation.
7. Prospecting amylase producing microorganisms
8. Preparation of yoghurt and wine
9. Estimation of alcohol by specific gravity method.

**Biostatistics**

1. Numerical exercises on precision, accuracy, randomization in experiments, tests of significance on experiments conducted earlier or being conducted.

## SEMESTER – IV

### 361 INORGANIC CHEMISTRY-VI

#### UNIT-I

##### **Bioinorganic Chemistry**

Essential and trace elements in biological processes, metalloporphyrins with special reference to hemoglobin and myoglobin. Biological role of alkali and alkaline earth metal ions with special reference to Ca<sup>2+</sup>. Nitrogen fixation.

#### UNIT-II

##### **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.

#### UNIT-III

##### **Silicones and Phosphazenes**

Silicones and phosphazenes as examples of organic polymers, nature of bonding in triphosphazenes.

### 362 ORGANIC CHEMISTRY-VI

#### UNIT-I

##### **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. Structure of ribose and deoxyribose.

An introduction to disaccharides (maltose, sucrose and lactose) and polysaccharides (starch and cellulose) without involving structure determination.

#### UNIT-II

##### **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  $\alpha$ -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, level of protein structure. Proteins denaturation/ renaturation.

Nucleic acids: introduction, Constitution of nucleic acids. Ribonucleosides and ribonucleotides. The double helical structure of DNA.

### UNIT-III

#### (a) 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.

#### (b) Synthetic Dyes

Color and constitution (electronic concept). Classification of dyes. Chemistry and synthesis of Methyl orange, Congo red, malachite green, Crystal violet, Phenolphthalein, Fluorescein, Alizarin and indigo.

### 363 PHYSICAL CHEMISTRY-VI

#### UNIT-I

**Adsorption:** Difference between adsorption, absorption and sorption, Chemisorption, adsorbent and adsorbate, reversible and irreversible adsorption, characteristics of adsorption, adsorption of gases by solids, factors affecting adsorption, types of adsorption, types of adsorption isotherms, Freundlich and Langmuir adsorption isotherms.

#### UNIT-II

#### 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)

#### UNIT-III

#### Solutions, Dilute Solutions and Colligative Properties

Ideal and non-ideal solutions, methods of expressing concentration of solutions, activity and activity coefficient. Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination. Osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure. Elevation of boiling point and depression in freezing point. Experimental methods for determining various colligative properties. Abnormal molar mass, degree of dissociation and association of solutes.



## CHEMISTRY PRACTICAL-VI

### Synthesis of (Any six)

- (a) Sodium trioxalato ferrate (III),  $\text{Na}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$
- (b) Ni-DMG complex,  $[\text{Ni}(\text{DMG})_2]$
- (c) . (c) Copper tetrammine complex  $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$ .
- (d) Cis-and trans-bisoxalato diaqua chromate (III) ion.
- (e) m-dinitrobenzene
- (f) p-nitroacetanilide
- (g) p-bromoacetanilide
- (h) 2,4,6- tribromophenol
- (i) Methyl orange
- (j) Methyl red
- (k) Benzoic Acid
- (l) Aniline
- (m) m-nitroaniline

### Column Chromatography

- a) Separation of fluorescein and methylene blue
- b) Separation of leaf pigments from spinach leaves
- c) Resolution of racemic mixture of ( $\pm$ ) mandelic acid

OR

### Stereochemical Study of Organic Compounds via Models

- a) R and S configuration of optical isomers.
- b) E,Z configuration of geometrical isomers.
- c) Conformational analysis of cyclohexanes and substituted cyclohexanes.

### Physical Chemistry:

1. To determine the specific rotation of a given optically active compound
2. Determination of molecular weight of a non-volatile solute by Rast method/ Backmann freezing point method.
3. Determination of the apparent degree of dissociation of an electrolyte (e.g. NaCl) in aqueous solution at different concentrations by ebullioscopy.
4. To verify Beer- Lambert law for  $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$  and determine the concentration of the given solution of the substance.

## 364 GENETIC ENGINEERING

### UNIT-I

Mutations: molecular mechanism of mutation. Types of mutations (insertions deletions, frame shift, cryptic), spontaneous and induced mutations, chemical mutagenesis with examples. Ames test, site directed mutagenesis, mobile genetic elements: Insertion elements, transposons, and maize elements .Ty elements in yeast, copia elements PCR and its use in genetic engineering.

### UNIT-II

Concept of cloning, Restriction enzymes their types and properties , properties of a Cloning vehicles , plasmids as cloning vectors , viruses (phage lambda and mu ) as a cloning vectors, insertion of a DNA molecule into a vector, expression of cloned genes, recombinant selection and screening , genomic and DNA libraries.

### UNIT-III

Gene transfer mechanisms in bacteria: Principles and applications of transformation, conjugation and transduction, applications of microbial genetic engineering in biotechnology.

### UNIT-IV

Gene transfer mechanisms in plants. Techniques of transformation .Agrobacterium mediated and physical methods (microprojectile and electroporation) .Applications of transgenic plants. Edible vaccines from plants.

### UNIT-V

Gene transfer mechanisms in animals .Transfection of animal cell lines .HAT selection .Selectable markers and transplantation of cultured cells.. Expressions of cloned proteins in animal cells – expressions vector, over production cell cloning.

## 365 BIOTECH ENTERPRISES AND SOCIOECONOMIC ISSUES

### UNIT-I

Draft paper Biodiversity – Ministry of Environment and Forests and Draft paper Biotechnology – Department of Biotechnology .National Nanotechnology .Initiative.

### UNIT-II

Entrepreneurship in biotechnology .Funding agencies .Concepts and advantages of Biotechnological parks and incubators. Prospecting and preparing a project report .Market survey, and decision making .Estimating the budget. None recurring and recurring costs. Long and short term capital for the enterprise. Registering the firm with department of industries. Clearance from the department of environment, Fire and safety.

### UNIT-III

Globalization : Concept and issues , International treaties affecting national policies related to biotechnology .Patents ,Copy rights .Trade marks Choice of IPR .Role of WTO ,General Agreement of Trade and Tariffs (GATT), Trade related IPRs (TRIPS) .Legal issues concerning biotechnology.

#### UNIT-IV

Biohazards, Biosafety guidelines and regulations. Biological contaminants. Biowaste disposal. Release of Genetically Engineered Microorganisms in environment, its fate and fears. Ethical issues in biotechnology. Genetically modified crops (BT crops) and environment and ethical issues.

#### UNIT-V

Biological warfare. Gene banks. Importance of type cultures. Cryopreservation methods. Plant cell banks, pollen banks, blood banks. sperm banks, microbial germplasm collections and international regulations.

### 366 EMERGING TECHNOLOGIES

#### UNIT-I

Bioinformatics Concept, scope and application. Biological databases. Database searches. BLAST and its relatives.

#### UNIT-II

Genomics. Concept, scope and applications. Human Genome project. Functional genomics. DNA Micro arrays.

#### UNIT-III

Proteomics, Concept scope and application. Protein classification. enzyme nomenclature. Families and super families. Tools: 2-D electrophoresis. MALDI Mass spectrometry, Protein micro arrays. Concept of metabolomics.

#### UNIT-V

Nanotechnology and Nan biotechnology. Concept and, Scope (nanotubes, nanometals, nanoreactors, Nan composites, nanocrystals) and application. Concept of nanotribology. nanoelectronics. MEMS

#### UNIT-V

Biomimetics: Concept, scope and applications. Biomaterials and their scope in health and medicine. Trends in medical biotechnology: Genetic diseases and gene therapy. Bone marrow transplantation, artificial skin, molecular methods in diagnostics. Forensic medicine; identifying criminals using DNA fingerprinting.

### COMBINED BIOTECH PRACTICAL-VI

#### **Biotech Enterprises and socioeconomics issues.**

1. Preparing project report to begin a biotechnology based enterprise.
2. Preparing a report on the biosafety and environment safety practices being followed by any institution and pointing out deficiencies

#### **Emerging Technology**

1. Elementary knowledge of biological databases. Submitting sequences on databases in public domain and practicing homology calculations.
2. Observation of slides of genetics diseases in man (Down, Turner and other syndromes) and comments on them.

Faculty of Applied Sciences

Plan and Scheme of Examination for B. Sc Biotech Part-I (Compulsory Subject)

Sub. Code	Subject	Hrs / Week		Hrs / Year		Yearly Exam		Total
		L	P	L	P	Th.	Prac.	
101	Environmental Studies	1	-	30	-	75	25	100
102 (a)	General English	1	-	30	-	100	-	100
102 (b)	General Hindi							
103	Elementary Computer	1/2	1/2	15	15	50	50	100
<b>Total</b>		<b>2.5</b>	<b>0.5</b>	<b>75</b>	<b>15</b>	-	-	<b>300</b>

\* The compulsory papers are required to pass once in three year duration of degree course. The minimum passing marks for these three compulsory papers is 36% individually in theory as well as practical. The marks of compulsory papers will not be considered while determining rank and division. In paper Hindi and English students can choose only one subject.

101 ENVIRONMENTAL STUDIES

(Syllabus of Environmental studies for all Undergraduate courses as per UGC Guideline)

**Unit 1 : Multidisciplinary nature of environmental studies**

Definition, scope and importance Need for public awareness.

**Unit 2: Natural Resources:**

**Renewable and non-renewable resources:**

Natural resources and associated problems.

- a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.
- b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
- c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
- d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.
- e) Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Case studies.
- f) Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification.
  - Role of an individual in conservation of natural resources.
  - Equitable use of resources for sustainable lifestyles.

**Unit 3 : Ecosystems**

- Concept of an ecosystem.
- Structure and function of an ecosystem.
- Producers, consumers and decomposers.

- Energy flow in the ecosystem.
- Ecological succession.
- Food chains, food webs and ecological pyramids.
- Introduction, types, characteristic features, structure and function of the following ecosystem:-
  - a. Forest ecosystem
  - b. Grassland ecosystem
  - c. Desert ecosystem
  - d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

#### **Unit 4 : Biodiversity and its conservation**

- Introduction – Definition: genetic, species and ecosystem diversity.
- Biogeographical classification of India
- Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values
- Biodiversity at global, National and local levels.
- India as a mega-diversity nation
- Hot-spots of biodiversity.
- Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts.
- Endangered and endemic species of India
- Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

#### **Unit 5: Environmental Pollution**

Definition Cause, effects and control measures of:-

- a. Air pollution
  - b. Water pollution
  - c. Soil pollution
  - d. Marine pollution
  - e. Noise pollution
  - f. Thermal pollution
  - g. Nuclear hazards
- Solid waste Management: Causes, effects and control measures of urban and industrial wastes.
  - Role of an individual in prevention of pollution.
  - Pollution case studies.
  - Disaster management: floods, earthquake, cyclone and landslides.

#### **Unit 6 : Social Issues and the Environment**

- From Unsustainable to Sustainable development
- Urban problems related to energy
- Water conservation, rain water harvesting, watershed management
- Resettlement and rehabilitation of people; its problems and concerns. Case Studies
- Environmental ethics : Issues and possible solutions.
- Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies.
- Wasteland reclamation.
- Consumerism and waste products.
- Environment Protection Act.
- Air (Prevention and Control of Pollution) Act.
- Water (Prevention and control of Pollution) Act

- Wildlife Protection Act
- Forest Conservation Act
- Issues involved in enforcement of environmental legislation.
- Public awareness.

#### **Unit 7 : Human Population and the Environment**

- Population growth, variation among nations.
- Population explosion – Family Welfare Programme.
- Environment and human health.
- Human Rights.
- Value Education.
- HIV/AIDS.
- Women and Child Welfare.
- Role of Information Technology in Environment and human health.
- Case Studies.

#### **Unit 8: Field work**

- Visit to a local area to document environmental assets- river/ forest/grassland/hill/mountain
- Visit to a local polluted site-Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds.
- Study of simple ecosystems-pond, river, hill slopes, etc. (Field work Equal to 5 Lecture hours)

### **SIX MONTHS COMPULSORY CORE MODULE COURSE IN ENVIRONMENTAL STUDIES: FOR UNDERGRADUATES**

#### **Teaching Methodologies**

The core Module Syllabus for Environment Studies includes class room teaching and Field Work. The syllabus is divided into eight units covering 50 lectures. The first seven units will cover 45 lectures which are class room based to enhance knowledge skills and attitude to environment. Unit eight is based on field activities which will be covered in five lecture hours and would provide student first hand knowledge on various local environmental aspects. Field experience is one of the most effective learning tools for environmental concerns. This moves out of the scope of the text book mode of teaching into the realm of real learning in the field, where the teacher merely acts as a catalyst to interpret what the student observes or discovers in his/her own environment. Field studies are as essential as class work and form an irreplaceable synergistic tool in the entire learning process.

Course material provided by UGC for class room teaching and field activities be utilized.

The universities/colleges can also draw upon expertise of outside resource persons for teaching purpose.

Environmental Core Module shall be integrated into the teaching programmes of all undergraduate courses.

**Annual System:** The duration of the course will be 50 lectures. The exam will be conducted along with the Annual Examination.

**Semester System:** The Environment course of 50 lectures will be conducted in the second semester and the examination shall be conducted at the end of the second semester.

**Credit System:** The course will be awarded 4 credits.

**Exam Pattern:** In case of awarding the marks, the question paper should carry 100 marks. The structure of the question paper being:

**Part-A, Short answer pattern /Objective- 25 marks**

**Part-B, Essay type with inbuilt choice - 50 marks**

**Part-C, Field Work - 25 marks**

### 101.a GENERAL ENGLISH

Duration: 3 hrs

Min. Pass Marks 36

M.M. 100

**Objectives:** This is essentially a language based course. It aims at making students read English prose with a view to enlarging their comprehension of the language and encouraging them to develop reading habits. It also aims at giving them basic skills in grammar, widening their vocabulary and teaching them to write simple and correct English.

#### 1. Comprehension and vocabulary

- |  |          |
|--|----------|
| a. Question based on content from the prescribed text  | 10 marks |
| b. Question based on a passage from the prescribed text to test the candidate's comprehension and Vocabulary | 10 marks |
| c. Question based on an unseen passage to test the candidate's comprehension and vocabulary                  | 10 marks |
- [There will be text of essays and short stories between 100 and 120 pages in length. The test book prescribed is "The Many World of Literature" ed. Jasbir Jain (Macmillan)]

#### 2. Composition

- |                                       |          |
|---------------------------------------|----------|
| (a.) Letter/ Application writing      | 10 marks |
| (b.) Paragraph writing/précis writing | 10 marks |
| (c.) Report writing                   | 10 marks |

#### 3. Translation

This exercise will require candidates to render into English ten simple sentences in Hindi. At least 15 sentences will be set. 10 marks

#### 4. Grammar and Usage

This Question in this exercise will be set with the purpose of testing the candidate's knowledge of grammar and familiarity with correct usage.

Candidate's knowledge of grammar and familiarity with correct usage.

- |  |         |
|--|---------|
| (a) Elements of Sentence   | 2 Marks |
| (b) Transformation of sentences including Active and Passive Voice | 2 Marks |
| (c) Modals   | 2 Marks |
| (d) Tense Usage  | 2 Marks |
| (e) Determiners  | 2 Marks |
| (f) Common English Error   | 2 Marks |

- (g) Phrasal verbs  
(h) Idioms

4 Marks  
4 Marks

**Phrasal Verbs**

Break :	Break away, break down, break off, break up.
Bring :	Bring about, bring in, bring up, bring down.
Come :	Come by, come across, come upon
Carry :	Carry out, carry on, carry off carry over
Call :	Call on, Call off Call at,
Get :	Get along, Get away Get by, get through, get
Give :	Give up, give away, give in
Hard :	Hard up, hard of hearing, hard nut to crack,
Look :	Look after, look into, look forward to, look up
Put :	Put out, put off, put up, put up with
Run :	Run after, run down, run over, run out of
Take :	Take after, take up, take to

**Idioms:**

To be born with a silver spoon in one's mouth, To be at daggers drawn, To be at sea, To be in the dark, To be in hot water, To be on the run, To be out of the woods, To be under someone's thumb, To break the ice, to break fresh ground, To make a mountain out of a molehill, to put a spoke in some one's wheel, To put two and two together, To turn a deaf ear, To turn a new leaf,. To turn the tables (On someone), to blow one's own trumpet, To burn the candle at both ends, to curry favour, To cut one's coat according to one's cloth, To fish in troubled waters, To hit the nail on the head, To kill two birds with stone, To know where the shoe pinches, To let the cat out of the bag, To nip something in the bud, To smell a rat, To wash one's hands of something.

**To following chapters are prescribed for study:**

- |                    |   |                                      |
|--------------------|---|--------------------------------------|
| 1. Rudyard Kipling | : | The story of Muhammad Din .          |
| 2 Kamala Devi      | : | Indian Woman and the Salt Satyagraha |
| 3. Ardeshir Vakil  | : | Mr. Krishanan's Family and I         |
| 4. Uma Rao         | : | A Special Child                      |
| 5. Goh Sin         | : | The Shoes of My Sensei               |
| 6. Vandana Shiva   | : | Women in the food chain.             |
| 7. Boman           | : | Between the Mosque & the             |

**Books Recommended :**

- |                                 |   |  |
|---------------------------------|---|--|
| 1. A.J. Thomson and AN Martinet | : | A Practical English Grammar (Oxform Paperback)                   |
| 2. S.Pit Corder                 | : | Intermediate English Piarce Book                                 |
| 3. Bhaskaran and Horsburg       | : | Strengthen Your English (O.U.P                                   |
| 4. F.T. Wood                    | : | A Remedial English Grammar for Foreign student (Macmillan, 1965) |
| 5. T.L.H Smith-Pearse           | : | The English Indian Student                                       |

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## 103 ELEMENTARY COMPUTER APPLICATIONS

### SCHEME OF EXAMINATION

Paper	Duration	Max Marks	Min Marks
Theory	3	60	22
Practical	2	40	14

Theory Examination paper will consist of two parts

Duration 3 hours, maximum marks 60. Consisting of 30 questions of? marks each.

#### **Note:**

Passing in Theory and Practical examinations separately shall be necessary by securing at least 36% marks.

Maximum marks for theory will be 60 and maximum marks for practical paper will be.

40 Minimum passing marks for theory and practical shall be 22 and 14 respectively.

### Syllabus

1. Introduction to Information Technology. evolution and generation of computers. type of computers. micro. mini. mainframe and super computer. Architecture of a computer system: CPU. ALU. Memory (RAM. ROM families) cache memory input/output devices. pointing devices.
2. Number system (binary, octal, decimal and hexadecimal) and their inter-conversions, character codes (ASCII. EBCDIC and Unicode). Logic gates. Boolean Algebra. machine, assembly and high level language including 3GL and 4GL.
3. Concept of Operating system. need and types of operating systems. batch. single user, multi-processing, distributed and time shared operating systems. Process and memory management concepts. Introduction to Unix. Linux Windows. Windows NT systems and their simple commands.
4. Internet: Concepts. email services. world wide web. web browsers. search engines. simple programs in HTML. type of HTML documents, document structure element, type and character formation, tables, frames and forms.
5. Word processing packages. standard features like tool bar, word wrap. text formatting. paragraph formatting, effect to text. mail-merge.
6. Presentation Packages: Slide creation. slide shows. adding graphics. formatting, customizing and printing.
7. Computer Networking: Type of networks. LAN. MAN and WAN concept of technology. bridges and routers. gateways and modems. ISDN and leased lines, teleconferencing and videoconferencing.
8. Multimedia technology: Introduction. framework for multimedia devices. image compression standards. JPEG. MPEG and MIDI formats.
9. Database Management systems data field mid records. information database. creation of a database file. insertion. deletion and updating of records modifying structure. editing and browsing of records searching- sorting and indexing of records, retrieving of records and report generation. Data processing in government organizations
- 10 E-commerce: Concept of e-commerce. benefits and growth of e-commerce. security considerations and hazards of virus and other security risks. antivirus software electronic payment system.

**Laboratory :**

The laboratory exercises will be designed to help in the understanding of concepts of computer and the utilization in the areas outlined in the theory syllabus. The emphasis should be on practical usage rather than on theoretical concepts only. In addition, MS-Office package is to be practiced in the lab.

1. The practical examination scheme should be as follows.
  - a. Record/sessionals 6 marks
  - b. Viva-voce 6 marks
  - c. Practical Exercise (DOS) 7 marks
  - d. Practical Exercise (Window 98) 7 marks
  - e. Practical Exercise (MS-Word) 7 marks
  - f. Practical Exercise (MS-Excel) 7 marks
2. Duration for practical examination shall be of 2 hours and more than 2 batches of 20 students each should be examined in a day by single examiner.