UGC CBCS
UG COURSE CURRICULUM
AND
SYLLABI

CHEMISTRY

DIBRUGARH UNIVERSITY

Adopted in the meeting of the BOS-Chemistry dated 14/12/2018

Contents

SYLLABUS

FOR

UNDER GRADUATE (UG)COURSE

IN

CHEMISTRY

(HONOURS & PASS)

UNDER

CHOICE BASED CREDIT SYSTEM

DIBRUGARH UNIVERSITY

2018

GENERAL INSTRUCTIONS TO THE STUDENTS

Under Choice Based Credit System in B.Sc. Courses of Chemistry (Honours & Pass, G.E, AEC & SEC)

1. **B.Sc. (Pass & Honours) Degree course consists of Six Semesters in a consecutive of three academic sessions from first admission. Each academic session consists of Two Semesters i.e. Odd Semester & Even Semesters.**

2. **Marks, credits, no of Theory & Practical/tutorial papers for Chemistry (Hons.) students for six semesters are given below.**

Total Marks – 2450 Total papers-49 Total Credits-142

1.	Honours Theory	Papers 14	Marks 1400	Credits 84
	Honours Lab	Papers 14		
2.	DSE Theory	Papers 04	Marks 400	Credits 24
	DSE Lab	Papers 04		
3.	GE Theory	Papers 04	Marks 400	Credits 24
	GE Lab	Papers 04		
4.	AEC Theory	Papers 03	Marks 150	Credits 06
5.	SEC Theory	Papers 02	Marks 100	Credits 04
		Total	Marks 2450	Credits 142

Semester - I

Sl no.	Courses	Paper Name	Marks	Credits	Total Marks
1	AEC - I	Commun. Eng.	IA - 10 End Sem - 40	**2**	**50**
2	AEC - II	MIL/Eng/Env	IA - 10 End Sem - 40	**2**	**50**
3	HONS C – I	Inorganic Chem - I	IA - 14 End sem - 56	**4**	**100**
4	HONS Lab C - I	Inorganic Lab - I	(Lab) 24 + (IA) 6 = 30	**2**	
5	HONS C - II	Physical Chem - I	IA - 14 End Sem - 56	**4**	**100**
6	HONS Lab C - II	Physical Lab – I	(Lab) 24 + (IA) 6 = 30	**2**	
7	Generic Elec.	Gen – I	IA- 14 End Sem- 56	**4**	**100**
8	Generic Elec.	Gen Lab – I	IA-6 Lab-24 total 24+ 6=30	**2**	
				22	**400**

Semester - II

Sl no.	Courses	Paper Name	Marks	Credits	Total Marks
1	AEC - III	MIL/Eng/Env	IA - 10 End Sem - 40	**2**	**50**
2	HONS C - III	Organic Chem - I	IA - 14 End Sem - 56	**4**	**100**
3	HONS Lab C - III	Org Lab – I	(Lab)24 + (IA) 6 = 30	**2**	
4	HONS C - IV	Physical Chemistry – II	IA - 14 End Sem - 56	**4**	**100**
5	HONS Lab C - IV	Physical Lab - II	(Lab)24 + (IA) 6 = 30	**2**	
6	Generic Elec.	Gen – II	IA - 14 End Sem - 56	**4**	**100**
7	Generic Elec.	Gen Lab - II	(Lab)24 + (IA) 6 = 30	**2**	
				20	**350**

Semester - III

Sl no.	**Courses**	Paper Name	**Marks**	**Credits**	**Total Marks**
1	SEC - I	SEC – I	IA - 10 End Sem - 40	**2**	**50**
2	HONS C - V	Inorg Chem - II	IA - 14 End sem- 56	**4**	**100**
3	HONS Lab C - V	Inorg Lab –II	(Lab)24 + (IA) 6 = 30	**2**	
4	HONS C - VI	Org l Chem –II	IA - 14 End Sem - 56	**4**	**100**
5	HONS Lab C - VI	Org Lab_II	(Lab)24 + (IA) 6 = 30	**2**	
6	HONS C - VII	Physical Chem II	IA - 14 End Sem - 56	**4**	**100**
6	HONS Lab C - VII	Physical Chem Lab II	(Lab)24 + (IA) 6 = 30	**2**	
7	Generic Elec.	Gen - III	IA - 14 End Sem - 56	**4**	**100**
8	Generic Elec.	Gen Lab – III	(Lab)24 + (IA) 6 = 30	**2**	
				26	**450**

Semester IV

Sl no.	**Courses**	Paper Name	**Marks**	**Credits**	**Total Marks**
1	SEC - II	SEC – II	IA -10 End Sem - 40	**2**	**50**
2	HONS C - VIII	Inorg Chem - III	IA - 14 End Sem - 56	**4**	**100**
3	HONS Lab C - VIII	Inorg Lab - III	(Lab) 24 + (IA)6 = 30	**2**	
4	HONS C - IX	Org Chem - III	IA - 14 End Sem - 56	**4**	**100**
5	HONS Lab C - IX	Org Lab - III	(Lab) 24 + (IA)6 = 30	**2**	
6	HONS C - X	Physical Chem - IV	IA - 14 End Sem - 56	**4**	**100**
7	HONS Lab C - X	Physical Chem Lab – IV	(Lab) 24 + (IA)6 = 30	**2**	
8	Generic Elec.	Gen - IV	IA - 14 End Sem - 56	**4**	**100**
9	Generic Elec.	Gen Lab - IV	(Lab) 24 + (IA)6 = 30	**2**	
				26	**450**

Semester V

Sl no.	**Courses**	Paper Name	**Marks**	**Credits**	**Total Marks**
1	DSE - I	DSE – I	IA - 14 End Sem - 56	**4**	**100**
2	DSE Lab - I	DSE Lab - I/Tutorial	(Lab) 24 + (IA)6 = 30	**2**	
3	DSE - II	DSE – II	IA - 14 End Sem - 56	**4**	**100**
4	DSE Lab - II	DSE Lab - II / Tutorial	(Lab) 24 + (IA)6 = 30	**2**	
5	HONS C - XI	Org Chem - IV	IA - 14 End Sem - 56	**4**	**100**
6	HONS Lab C - XI	Org Lab - IV	(Lab) 24 + (IA)6 = 30	**2**	
7	HONS C - XII	Physical Chem - V	IA - 14 End Sem - 56	**4**	**100**
8	HONS Lab C - XII	Physical Chem Lab – V	(Lab) 24 + (IA)6 = 30	**2**	
				24	**400**

Semester VI

Sl no.	**Courses**	Paper Name	**Marks**	**Credits**	**Total Marks**
1	DSE - III	DSE – III	IA - 14 End Sem - 56	**4**	**100**
2	DSE Lab - III	DSE Lab - III/tutorial	(Lab) 24 + (IA)6 = 30	**2**	
3	DSE - IV	DSE – IV	IA - 14 End Sem - 56	**4**	**100**
4	DSE Lab - IV	DSE Lab - IV/tutorial	(Lab) 24 + (IA)6 = 30	**2**	
5	HONS C - XIII	Inorg Chem - IV	IA - 14 End Sem - 56	**4**	**100**
6	HONS Lab C - XIII	Inorg Lab - IV	(Lab) 24 + (IA)6 = 30	**2**	
7	HONS C - XIV	Org. Chem - V	IA - 14 End Sem - 56	**4**	**100**
8	HONS Lab C - XIV	Org. Chem Lab – V	(Lab) 24 + (IA)6 = 30	**2**	
				24	**400**

Total Credit= 22+20+26+26+24+24=142

Total Marks =400+350+450+450+400+400=2450

Computation of SGPA &CGPA

Letter Grade with meaning		Grade Point
O	Outstanding	10 (Marks securing above 90%)
A^+	Excellent	9 (Marks securing above 80 to 90%)
A	Very Good	8 (Marks securing above 70 to 80%)
B^+	Good	7 (Marks securing above 60 to 70%)
B	Above Average	6 (Marks securing above 50 to 60%)
C	Average	5 (Marks securing above 40 to 50%)
P	Pass	4 (Marks securing from 30 to 40%)
F	Fail	0 (Marks securing below 30%)
Abs	Absent / Incomplete	0

Computation of SGPA

Semester	Course	Credit	% Obtained	Grade lett.	Grade Point	Credit Point
I	I	2	80	A	8	8 × 2 = 16
	II	4	80	A	8	8 × 4 = 32
	III	2	90	A^+	9	9 × 2 = 18
	IV	4	80	A	8	8 × 4 = 32
	V	2	88	A^+	9	9 × 2 = 18
	VI	4	80	A	8	8 × 4 = 32
	VII	2	70	B^+	7	7 × 2 = 14
		20				162

Thus, SGPA = 162/ 20 = 8.10

Computation of CGPA

Semester	Semester I	Semester II	Semester III	Semester IV	Semester V	Semester VI
Credit	20	20	26	26	24	24
SGPA	8	9	8	8	7	9

Thus, CGPA = (20 × 8 + 20 × 9 + 26 × 8 + 26 × 8 + 24 × 7 + 24 × 9) ÷ 140 = 8.14

CBCS UG - COURSE CURRICULUM (Basic structure)

B.Sc. (Honours)

CHEMISTRY (HONOURS)

CORE COURSE (C)		**Total Courses**	**×**	**Credits per course**	**Total Credits**
CORE	CHEMISTRY Theory + Practical	14	×	4 + 2	**84**
ELECTIVE COURSE (DSE and GE)					
DSE	Chemistry Theory + Practical or Chemistry Theory + tutorial	4	×	4 + 2 or 5+1	**24**
GE	Theory + Practical	4	×	4 + 2	**24**
	Or		**or**		
	Theory + Tutorial	4	×	5 + 1	
GE Courses are Mathematics, Physics (*any one*).					
Ability Enhancement Courses					
Ability Enhancement Compulsory Courses (AECC) 1) Communicative English 2) Alt. English/MIL 3) Environmental Science		 1 1 1	 × × ×	 2 2 2	**06**
Skill Enhancement Courses (SEC)		2	×	2	**04**
				Total Credits =	**142**

CBCS UG - Course Curriculum
B. Sc. with Chemistry

Discipline Specific Core (DSC) Courses		Papers	×	Credits	Total Credits
DSC	**DSC 1: Chemistry Theory + Practical**	4	×	4 + 2	
	DSC 2: other subject Theory + Practical	4	×	4 + 2	
	DSC 3: other subject Theory + Practical	4	×	4 + 2	**72**
	Or				
	DSC 3: other subject Theory+Tutorial	4	×	5 + 1	
Discipline Specific Elective (DSE) Courses					
DSE	**DSE 1: Chemistry Theory + Practical**	2	×	4 + 2	
	DSE 2: other subject Theory+Practical	2	×	4 + 2	
	DSE 3: other subject Theory+Practical	2	×	4 + 2	**36**
	Or				
	DSE 4: other subject Theory+Tutorial	2	×	5 + 1	
Skill Enhancement Courses (SEC)		4	×	2	**08**
Ability Enhancement Compulsory Courses (AECC) 1) Communicative English 2) English/MIL Communication 3) Environmental Science		3	×	2	**06**
			Total Credits =		**122**
Each credit is equivalent to 1 hour of activity per week					

CBCS
UG - SYLLABI

CHEMISTRY
(HONOURS)

SEMESTER-WISE COURSE STRUCTURE FOR CHOICE BASED CREDIT SYSTEM IN
B. Sc. Honours (CHEMISRY)

SEMESTER	CORE COURSE (14 papers) (6 credit per paper)	Ability Enhancement Compulsory Course (AECC) (2 papers) (2 credit per paper)	Ability Enhancement Elective Course(AEEC) (Skill Based) (2 papers) (2 credit per paper)	Elective: Discipline Specific DSE (4 papers) (6 credit per paper)	Elective: Generic(GE) 4 papers *(To be taken from other discipline)* (6 credit per paper
I	CHEMISRY-C-101	Communicative English			GE-1
	CHEMISRY -C-102	Alt. English/MIL			
II	CHEMISRY -C-201	Environmental Science			GE-2
	CHEMISRY -C-202				
III	CHEMISRY -C-301		CHEMISRY-SEC-301		GE-3
	CHEMISRY -C-302				
	CHEMISRY -C-303				
IV	CHEMISRY -C-401		CHEMISRY-SEC-401		GE-4
	CHEMISRY -C-402				
	CHEMISRY -C-403				
V	CHEMISRY -C-501			CHEMISRY-DSE-501	
	CHEMISRY -C-502			CHEMISRY-DSE -502	
VI	CHEMISRY -C-601			CHEMISRY-DSE -601	
	CHEMISRY -C-602			CHEMISRY-DSE -602	

Core Courses for Chemistry (Honours) with Course Code and Course Name

SEMESTER	Course No.	Course Name	Credit
I	**CHEMISTRY-C-101**	**Inorganic Chemistry –101** *Atomic Structure and Chemical Bonding*	4
	CHEMISTRY-C-101-PRACT.	***Practical***	2
	CHEMISTRY-C-102	**Physical Chemistry ¯102** *States of Matter and Ionic Equilibrium*	4
	CHEMISTRY-C-102- PRACT.	***Practical***	2
II	**CHEMISTRY-C-201**	**Organic Chemistry –201** *Hydrocarbons and Stereochemistry*	4
	CHEMISTRY-C-201- PRACT.	***Practical***	2
	CHEMISTRY-C-202	**Physical Chemistry –202** *Chemical Thermodynamics and its Applications*	4
	CHEMISTRY-C-202- PRACT.	***Practical***	2
III	**CHEMISTRY-C-301**	**Inorganic Chemistry –301** *s- & p-block Elements and Metallurgy*	4
	CHEMISTRY-C-301- PRACT.	***Practical***	2
	CHEMISTRY-C-302	**Organic Chemistry –302** *Halogen & Oxygen Containing Functional Groups*	4
	CHEMISTRY-C-302-LAB	***Practical***	2
	CHEMISTRY-C-303	**Physical Chemistry –303** *Phase Equilibria and Chemical Kinetics*	4
	CHEMISTRY-C-303- PRACT.	***Practical***	2
IV	**CHEMISTRY-C-401**	**Inorganic Chemistry –401** *Coordination Chemistry and its Applications*	4
	CHEMISTRY-C-401- PRACT.	***Practical***	2
	CHEMISTRY-C-402	**Organic Chemistry –402** *Heterocyclic Chemistry*	4
	CHEMISTRY-C-402- PRACT.	***Practical***	2
	CHEMISTRY-C-403	**Physical Chemistry –403** *Electrochemistry*	4
	CHEMISTRY-C-403- PRACT.	***Practical***	2
V	**CHEMISTRY-C-501**	**Organic Chemistry –501** *Biomolecules*	4
	CHEMISTRY-C-501 -PRACT.	***Practical***	2
	CHEMISTRY-C-502	**Physical Chemistry --502** *Quantum Chemistry and Spectroscopy*	4
	CHEMISTRY-C-502- PRACT.	***Practical***	2
VI	**CHEMISTRY-C-601**	**Inorganic Chemistry –601** *Organometallic Chemistry*	4
	CHEMISTRY-C-601- PRACT.	***Practical***	2
	CHEMISTRY-C-602	**Organic Chemistry –602** *Spectroscopy, Dyes and Polymers*	4
	CHEMISTRY-C-602- PRACT.	***Practical***	2

Discipline Specific Elective (DSE) Courses for Chemistry Honours

SEMESTER	COURSE No.	*Couse Name*	Credit
V (Any Two Papers)	**CHEMISTRY-DSE-501**	*Analytical Methods in Chemistry*	4
	CHEMISTRY-DSE-501- PRACT.	**P***ractical*	2
	CHEMISTRY-DSE-502	*Green Chemistry*	4
	CHEMISTRY-DSE-502- PRACT.	*Practical*	2
	CHEMISTRY-DSE-503	*Research Methodology for Chemistry*	6
	CHEMISTRY-DSE-504	*Elementary Computational Chemistry*	6
VI (Any two Papers)	**CHEMISTRY-DSE-601**	*Inorganic Materials of Industrial Importance*	4
	CHEMISTRY-DSE-601- PRACT.	*Practical*	2
	CHEMISTRY-DSE-602	Industrial Chemicals &Environment	4
	CHEMISTRY-DSE-602-PRACT.	Practical	2
	CHEMISTRY-DSE-603	***Dissertation* (*Project Work*)**	6

Skill Enhancement Courses (SEC)
FOR CHEMISTRY HONOURS

III	**CHEMISTRY-SEC-301**	Basic Analytical Chemistry	2
IV	**CHEMISTRY–SEC-401**	*Fuel Chemistry*	2

Semester wise list of Chemistry Generic Elective papers for the students taking Honours in other disciplines

SEMESTER	COURSE No. *Course Name*	Credit
I	**CHEMISTRY-GE-101** *Atomic Structure, Bonding, General Organic Chemistry and Aliphatic Hydrocarbons*	**4**
	CHEMISTRY-GE-101-PRACT. *Practical*	**2**
II	**CHEMISTRY-GE-201** *Chemical Energetics, Equilibria and Functional Group Organic Chemistry-I*	**4**
	CHEMISTRY-GE-201- PRACT. *Practical*	**2**
III	**CHEMISTRY-GE-301** *Solutions, Phase Equilibrium, Conductance, Electrochemistry and Functional Group Organic Chemistry-II*	**4**
	CHEMISTRY-GE-301- PRACT. *Practical*	**2**
IV	**CHEMISTRY-GE-401** *Transition metals, Coordination Chemistry, States of Matter and Chemical Kinetics*	**4**
	CHEMISTRY-GE-401- PRACT. *Practical*	**2**

CBCS
UG - SYLLABI

B. Sc. with
CHEMISTRY

SEMESTER-WISE COURSE STRUCTURE FOR CHOICE BASED CREDIT SYSTEM IN B. Sc. with Chemistry

	DISCIPLINE SPECIFIC CORE COURSE (DSC) (12 papers) [4 papers each from 3 disciplines i.e. DSC-1,DSC-2 & DSC-3] (6 credit per paper)	Ability Enhancement Compulsory Course(AECC) (2 papers) (2 credit per paper)	Skill Enhancement Course (SEC) (4 papers) (2 credit per paper)	Discipline Specific Elective (DSE) (6 papers) (6 credit per paper) [2 papers for chemistry and 2 papers each for other 2 disciplines]
I	DSC-1A-Chemistry-101 DSC- 2 A DSC- 3 A	Communicative English Alt. English/MIL		
II	DSC-1B-Chemistry-201 DSC- 2 B DSC- 3 B	Environmental Science		
III	DSC-1C-Chemistry-301 DSC- 2 C DSC- 3 C		CHEMISRY-SEC-301	
IV	DSC-1D-Chemistry-101 DSC- 2 D DSC- 3 D		CHEMISRY-SEC-401	
V			CHEMISRY-SEC-501	DSC-1A-Chemistry-501 DSE-2 A DSE-3 A
VI			CHEMISRY-SEC-601	DSC-1A-Chemistry-601 DSE-2 B DSE-3 B

CBCS: B. Sc. with Chemistry

Semester wise list of Chemistry papers to be studied as Discipline Specific Core (DSC) Courses by students of BSc with Chemistry (Regular)

SEMESTER	COURSE No. *Course Name*	Credit
I	**CHEMISTRY-DSC-101** *Atomic Structure, Bonding, General Organic Chemistry and Aliphatic Hydrocarbons*	4
	CHEMISTRY-DSC-101-PRACT. *Practical*	2
II	**CHEMISTRY-DSC-201** *Chemical Energetics, Equilibria and Functional Group Organic Chemistry-I*	4
	CHEMISTRY-DSC-201- PRACT. *Practical*	2
III	**CHEMISTRY-DSC-301** *Solutions, Phase Equilibrium, Conductance, Electrochemistry and Functional Group Organic Chemistry-II*	4
	CHEMISTRY-DSC-301- PRACT. *Practical*	2
IV	**CHEMISTRY-DSC-401** *Transition metals, Coordination Chemistry, States of Matter and Chemical Kinetics*	4
	CHEMISTRY-DSC-401- PRACT. *Practical*	2

Discipline Specific Elective (DSE) Courses

V	**CHEMISTRY-DSE-501** *Analytical Methods in Chemistry*	4
	CHEMISTRY-DSE-501- PRACT. *Practical*	2
VI	**CHEMISTRY-DSE-601** *Inorganic Materials of Industrial Importance*	4
	CHEMISTRY-DSE-601- PRACT. *Practical*	2

Skill Enhancement Courses (SEC)

III	**CHEMISTRY-SEC-301** *Basic Analytical Chemistry*	2
IV	**CHEMISTRY-SEC-401** *Fuel Chemistry*	2
V	**CHEMISTRY-SEC-501** *Chemistry of Cosmetics and Perfumes*	2
VI	**CHEMISTRY-SEC-601** Pharmaceutical Chemistry	2

Detailed Syllabi

SEMESTER-I

CBCS: B. Sc. (Honours) with CHEMISTRY
CORE COURSE

CHEMISTRY
(Honours)
(1st Semester)
Course No.: **CHEMISTRY-C-101**
(Inorganic Chemistry)
Contact Hours: 60
Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To develop the basic knowledge of chemistry in relation to atomic structure, bonding, periodicity etc.

Expected Learner Outcome: Students will gain an understanding of

i. Sign of wave function, counter boundary and probability diagrams etc.
ii. Variations of orbital energy with atomic number.
iii. Properties of elements, atomic radii, ionic radii, size effect of ionic bond, solvation energy, covalent character of ionic bond, redox equations, principle involved in volumetric analysis etc.

Unit I: Atomic Structure

Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f- orbitals. Contour boundary and probability diagrams.

Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations.Variation of orbital energy with atomic number

14 Lectures, Marks-13

Unit II: Periodicity of Elements

Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.
(b) Atomic radii (van der Waals)
(c) Ionic and crystal radii.
(d) Covalent radii (octahedral and tetrahedral)
(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.
(f) Electron gain enthalpy, trends of electron gain enthalpy.

(g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.

16 Lectures, Marks-15

Unit III: Chemical Bonding

i) *Ionic bond*: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Lande equation with derivation, lattice energy,Madelung constant, Born-Haber cycle and its application, Solvation energy.

ii) *Covalent bond*: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ– and π–bond approach) and bond lengths.

Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

iii) *Metallic Bond*: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

iv) *Weak Chemical Forces*: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Hydrogen bonding (theories of hydrogen bonding, valence bond treatment).

26 Lectures, Marks - 24

Unit IV: Oxidation-Reduction:

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class.

4 Lectures, Marks - 4

Reference Books:

1. Lee, J. D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B. E. and Mc Daniel, D. H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
3. Atkins, P. W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
4. Day, M. C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.
5. R. Sarkar. General Inorganic Chemistry (Part-1), New Central Book Agency(P) Ltd.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(1st Semester)

Course No.: **CHEMISTRY-C-101-LAB**

(Inorganic Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

(A) Titrimetric Analysis (any one) **Marks - 4**

(i) Calibration and use of apparatus
(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations (any one) **Marks - 6**

(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(C) Oxidation-Reduction Titrimetry (any one) **Marks - 10**

(i) Estimation of Fe(II) or oxalic acid using standardized $KMnO_4$ solution.
(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using diphenylamine as internal indicator.

(D) Viva-Voce **Marks - 4**

Reference Books:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* 6^{th} *Ed.,* Pearson, 2009.
2. Nad, A.K., Mahapatra, B., Ghoshal, A., An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd., Kolkata, India.
3. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY

(Honours)

(1st Semester)

Course No.: **CHEMISTRY-C-102**

(Physical Chemistry)

Contact Hours: 60

Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To emphasize on different states of matter & their mechanical treatment.

Expected Learner Outcome: Students will gain an understanding of

i. Kinetic molecular model of a gas, behaviour of real gases etc
ii. Effect of addition of various solute on surface tension and viscosity. Cleansing action of detergents.
iii. Nature of solid state, elementary idea of symmetry.
iv. Idea of solubility and solubility product of sparingly soluble salts.

Unit I: Gaseous state

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η, variation of viscosity with temperature and pressure.

Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behavior: van der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

18 Lectures, Marks - 18

Unit II: Liquid state

Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.

Qualitative discussion of structure of water.

6 Lectures, Marks - 8

Unit III: Solid state

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.

16 Lectures, Marks - 12

Unit IV: Ionic equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment).

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.

Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.

Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

20 Lectures, Marks - 18

Reference Books:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press (2006).
1. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
2. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
3. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
4. Negi,A.S; Anand,S.C. *A Text book of Physical Chemistry* New Age International Publishers
5. Pahari,S *Physical Chemistry Vol I &II* New Central Book Agency (P) Ltd.
6. Puri,Sharma,Pathiana *Principles of Physical Chemistry* Vishal Publishing Co.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(1st Semester)

Course No.: **CHEMISTRY-C-102-LAB**

(Physical Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

One physical experiment from each group is to be carried out in examination.

Group A **Marks - 12**

1. **Surface tension measurements.**
   a. Determine the surface tension of various liquids by drop number method.
   b. Study the variation of surface tension of detergent solutions with concentration.
2. **Viscosity measurement using Ostwald's viscometer**.
   a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
   b. Study the variation of viscosity of sucrose solution with the concentration of solute.

Group B **Marks - 8**

3. pH metry

a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
b. Preparation of buffer solutions of different pH
   i. Sodium acetate-acetic acid
   ii. Ammonium chloride-ammonium hydroxide
c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
d. Determination of dissociation constant of a weak acid.

Viva Voce **2+2=4**

Reference book :

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Ho

SEMESTER-II

CBCS: B. Sc. (Honours) with CHEMISTRY
CORE COURSE

CHEMISTRY
(Honours)
(2nd Semester)
Course No.: **CHEMISTRY-C-201**
(Organic Chemistry)
Contact Hours: 60
Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To develop preliminary knowledge in basic organic chemistry, Hydrocarbons, stereochemistry & conformational analysis.

Expected Learner Outcome: Students will gain an understanding of ---

i. Knowledge of basic organic chemistry, definition, classification of stereoisomerism, optical activity, absolute and relative configuration etc.
ii. Knowledge of elimination reaction, electrophilic and nucleophilic addition.
iii. Relative stability of cyclic hydrocarbon, Bayer's strain theory etc.

Unit I: Basic Organic Chemistry

Organic Compounds: Classification and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic effects: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment;

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes, Nitrenes.

Organic acids and bases; their relative strength, Hard and soft acids & bases.

Energy profile diagrams of one step, two steps & three steps reactions, Activation energy, Kinetically Controlled & Thermodynamically Controlled reactions.

8 Lectures, Marks - 8

Unit II: Stereochemistry

Definition and classification of streoisomerism, Representation of organic molecules in two & three dimensions, Fischer, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: Restricted rotation about C=C bonds, Physical & Chemical properties of Geometrical isomers, Cis–trans and, syn-anti isomerism, E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures & Epimers,

Racemic mixture and resolution, Threo & Erythro forms, Relative and absolute configuration: D/L and R/S designations.

16 Lectures, Marks - 12

Unit III: Chemistry of Aliphatic Hydrocarbons
A. Carbon-Carbon sigma bond

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Corey House Reaction, Free radical substitutions: Halogenation -relative reactivity and selectivity.

Lecture 4, Marks - 4

B. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Special emphasis on preparation of alkenes by syn elimination – Pyrolysis of esters, Chugaev, Wittig and Heck Reaction.

Reactions of alkenes: Electrophilic additions and their mechanisms (Markownikoff/ Anti Markownikoff addition), Regioselective (directional selectivity) and Streoselective addition reactions. Mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation), Simple effect of Streoselectivity & Streospecificity;

1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

14 Lectures, Marks - 14

Unit IV: Cycloalkanes and Conformational analysis:

A. Cycloalkanes: Preparation and their relative stability, Baeyer strain theory,
B. Conformation analysis of alkanes (Ethane and Butane): Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

10 Lectures, **Marks - 10**

Unit V Aromatic Hydrocarbons

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

12 Lectures, Marks - 8

ReferenceBooks

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(2nd Semester)

Course No.: **CHEMISTRY-C-201-LAB**

(Organic Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

1. Purification of organic compounds by crystallization using the following solvents:

   a. Water
   b. Alcohol
   c. Alcohol-Water **Marks - 4**

2. (Any One Experiment) **Marks - 4**

   a . Determination of the melting points of above compounds and unknown organic compounds **(Kjeldahl method and electrically heated melting point apparatus)**

   b. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds

3. Chromatography (Any two experiments):

   a. Separation of a mixture of two amino acids by paper chromatography
   b. Separation of a mixture of two sugars by paper chromatography
   c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Marks - 6+6 =12

4. VIVA **Marks = 4**

Reference Books

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY

(Honours)

(2nd Semester)

Course No.: **CHEMISTRY-C-202**

(Physical Chemistry)

Contact Hours: 60

Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To develop a strong knowledge on chemical thermodynamics, their mathematical expression & application.

Expected Learner Outcome: Students will gain an understanding of

i. The application of mathematical tools to calculate thermodynamic properties
ii. The concept of free energy change and spontaneity.
iii. Thermodynamics derivation of relation between Gibbs free energy of reaction and reaction quotient.
iv. Derive relation between the four colligative properties using chemical potential (Thermodynamics derivation)

Unit I: Chemical Thermodynamics

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, *q*, work, *w*, internal energy, *U*, and statement of first law; enthalpy, *H*, relation between heat capacities, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

36 Lectures, Marks -26

Unit II: Systems of Variable Composition

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

8 Lectures, Marks-6

Unit III: Chemical Equilibrium

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p , K_c and K_x. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

8 Lectures, Marks-12

Unit IV: Solutions and Colligative Properties

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions.

Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

8 Lectures, Marks-12

Reference Books

1. Peter, A. & Paula, J. de. *Physical Chemistry 9th Ed.,* Oxford University Press (2011).
2. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004).
3. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
4. McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi (2004).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).
6. Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill (2010).
7. Metz, C.R. *2000 solved problems in chemistry,* Schaum Series (2006)
8. Negi,A.S; Anand,S.C. *A Text book of Physical Chemistry* New Age International Publishers
9. Pahari,S *Physical Chemistry Vol I &II* New Central Book Agency (P) Ltd.
10. Puri,Sharma,Pathiana *Principles of Physical Chemistry* Vishal Publishing Co.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(2nd Semester)

Course No.: **CHEMISTRY-C-202-LAB**

(Physical Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

1. Thermochemistry

Two experiments from the following : **Marks - 2×10=20**

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).

(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(c) Calculation of the enthalpy of ionization of ethanoic acid.

(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.

(e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.

(f) Determination of enthalpy of hydration of copper sulphate.

(g) Study of the solubility of benzoic acid in water and determination of ΔH.

2. Viva voce : **Marks - 2+2=4**

Reference Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New Age International: New Delhi (2001).
3. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing House

SEMESTER-III

CBCS: B. Sc. (Honours) with CHEMISTRY
CORE COURSE

CHEMISTRY
(Honours)
(3rd Semester)
Course No.: **CHEMISTRY-C-301**
(Inorganic Chemistry)
Contact Hours: 60
Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To make the student familiar with the chemistry of s, p block elements, noble gases, inorganic polymers & metallurgy.

Expected Learner Outcome: Students will gain an understanding of ---

i. Predict the purification of metal, study of compounds with emphasis on structure, bonding, preparation and properties.
ii. Real world applications, shapes etc of noble gas.
iii. Structural aspects and applications of inorganic polymer

Unit I: General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refinig

6 Lectures, Marks - 5

Unit II: Acids and Bases

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

8 Lectures, Marks - 7

Unit III: Chemistry of *s* and *p* Block Elements:

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of *s* and *p* block elements.
Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses.
Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

30 Lectures, Marks - 30

Unit IV: Noble gases

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds (VSEPR theory).

8 Lectures, Marks - 7

Unit V: Inorganic Polymers

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

8 Lectures, Marks - 7

Reference Books:

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth- Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, 5th ed., Wiley, VCH, 1999.
5. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
6. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed., Pearson, 2010
7. Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

CHEMISTRY PRACTICAL
(Honours)
(3rd Semester)
Course No.: **CHEMISTRY-C-301-LAB**
(Inorganic Chemistry)
Contact Hours: 60
Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

A. Iodo / Iodimetric Titrations (any one) **Marks - 12**

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
(ii) Estimation of available chlorine in bleaching powder iodometrically.

B. Inorganic preparations (any one) **Marks - 8**

(i) Cuprous Chloride, Cu_2Cl_2

(ii) Preparation of Manganese(III) phosphate, $MnPO_4.H_2O$

(iii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.

C. **Viva-voce** **Marks - 4**

Reference Books

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis* 6^{th} *Ed.*, Pearson, 2009.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY

(Honours)

(3rd Semester)

Course No.: **CHEMISTRY-C-302**

(Organic Chemistry)

Contact Hours: 60

Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To develop preliminary knowledge on the synthesis, properties of organic compounds of Halogen & oxygen containing Functional groups.

Expected Learner Outcome: Students will gain an understanding of ---

i. The prediction of mechanism for organic reactions
ii. How to design synthesis of organic molecule.
iii. The reactivity and stability of organic molecule based on structure
iv. An idea of alcohols, phenols, carbonyl compounds, acids and their derivatives etc

Unit I: Chemistry of Halogenated Hydrocarbons

Part A

Alkyl halides: Methods of preparation including Hunsdiecker Reaction, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

14 Lectures, Marks - 12

Part B

Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

2 Lectures, **Marks - 2**

Unit II: Alcohols, Phenols, Ethers and Epoxides

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by OsO_4 ,alkaline $KMnO_4$, periodic acid and lead tetraacetate Pinacol-Pinacolone rearrangement;

Trihydric alcohols : Glycerol /Preparation & Properties .

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism;

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$

16 Lectures, **Marks -14**

Unit III: Carbonyl Compounds:

Part A

Structure, reactivity and preparation;

Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α- substitution reactions, Clemmensen, Wolff-Kishner, MPV

$LiAlH_4$, $NaBH_4$, PDC , PCC , SeO_2, $Pb(OAc)_4$ & HIO_4 .(Synthetic applications only)

Addition reactions of unsaturated carbonyl compounds: Michael addition.

Unsaturated Aldehydes (Acrolein, Crotonaldehyde, Cinnamaldehyde) Unsaturated Ketone (MVK) .

12 Lectures, Marks - 12

Part B

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

2 Lectures, Marks - 2

Unit IV: Carboxylic Acids and their Derivatives:

Preparation, physical properties and reactions of monocarboxylic acids (Acidity and factors affecting it): Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic, phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids;

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation and Curtius rearrangement.

12 Lectures, Marks - 10

Unit V: Sulphur containing compounds:

Preparation and reactions of thiols, thioethers and sulphonic acids.

6 Lectures, Marks - 4

Reference Books:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(3rd Semester)

Course No.: **CHEMISTRY-C-302-LAB**

(Organic Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

1. Functional group tests for alcohols, carbonyl, and carboxylic acid group . **Marks -4**

2. **Organic preparations: (Any Two)**

i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method:
   a. Using conventional method.
   b. Using green approach

ii. Benzolyation of one of the following amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-,*m*-, *p*-anisidine) and one of the following phenols (β-naphthol, resorcinol, p- cresol) by Schotten-Baumann reaction.

iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).

iv. Nitration of any one of the following:
   a. Acetanilide/nitrobenzene by conventional method
   b. Salicylic acid by green approach (using ceric ammonium nitrate).

v. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.

vi. Hydrolysis of amides and esters.

vii. Aldol condensation using either conventional or green method.

viii. Benzil-Benzilic acid rearrangement.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

Marks - 8+8=16

3. VIVA **Marks - 4**

Reference Books

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).
4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: QualitativeAnalysis,* University Press (2000)

CBCS: B. Sc. (Honours) with CHEMISTRY
CORE COURSE

CHEMISTRY
(Honours)
(3rd Semester)
Course No.: **CHEMISTRY-C-303**
(Physical Chemistry)
Contact Hours: 60
Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To acquaint students in details on phase equilibria, chemical kinetics, catalysis and surface chemistry.

Expected Learner Outcome: Students will gain an understanding of ---

i. Types of catalysis, Michaelis – Menten mechanism, mechanism of catalysed reaction at solid state.
ii. Steady - state approximation in reaction mechanism.
iii. Concept of phases, phase diagrams for systems of solid- liquid equilibria involving eutectic, congruent and incongruent mp, solid solution etc

Unit I: Phase Equilibria

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications.

Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions.

Three component systems, water-chloroform-acetic acid system, triangular plots.

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation.

Nernst distribution law: its derivation and applications.

28 Lectures, Marks - 20

Unit II: Chemical Kinetics

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

18 Lectures, Marks - 16

Unit III: Catalysis

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

8 Lectures, Marks - 12

Unit IV: Surface chemistry

Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state.

6 Lectures, Marks - 8

Reference Books:

1. Peter Atkins & Julio De Paula, *Physical Chemistry 9th Ed.,* Oxford University Press (2010).
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books Pvt. Ltd.: New Delhi (2004).
4. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).
6. Zundhal, S.S. *Chemistry concepts and applications* Cengage India (2011).
7. Ball, D. W. *Physical Chemistry* Cengage India (2012).
8. Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP (2009).
9. Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill (2011).
10. Metz, C. R. *Physical Chemistry 2nd Ed.,* Tata McGraw-Hill (2009).
11. Negi,A.S; Anand,S.C. *A Text book of Physical Chemistry* New Age International Publishers
12. Pahari,S *Physical Chemistry Vol I &II* New Central Book Agency (P) Ltd.
13. Puri,Sharma,Pathiana *Principles of Physical Chemistry* Vishal Publishing Co.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(3rd Semester)

Course No.: **CHEMISTRY-C-303-LAB**

(Physical Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

A. Any two experiments of the following

i. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
ii. Distribution of acetic/ benzoic acid between water and cyclohexane.

iii. Study the kinetics of the following reactions.
a. Integrated rate method:
i. Acid hydrolysis of methyl acetate with hydrochloric acid.
ii. Saponification of ethyl acetate.
b. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

Adsorption:

Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid/oxalic acid on activated charcoal.

Marks - 10×2=20

B.Viva Voce: **Marks - 4**

Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Hour

SEMESTER-IV

CBCS: B. Sc. (Honours) with CHEMISTRY
CORE COURSE

CHEMISTRY
(Honours)
(4th Semester)
Course No.: **CHEMISTRY-C-401**
(Inorganic Chemistry)
Contact Hours: 60
Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To develop a vivid knowledge on coordination chemistry and its application extended to biological system.

Expected Learner Outcome: Students will gain an understanding of ---

i. Predicting metal ion present in biological systems
ii. Use of chelating agents in medicine.
iii. Quantitative aspect of ligand field and MO theory, stability of various oxidation states and emf of transition elements

Unit I: Coordination Chemistry

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes. Labile and inert complexes.
Werner's theory, valance bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10Dq (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10Dq (Δo, Δt). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

26 Lectures, Marks - 25

Unit II: Transition Elements

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer and Bsworth diagrams). Difference between the first, second and third transition series.
Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excuding their metallurgy)

18 Lectures, Marks - 16

Unit III: Lanthanoids and Actinoids

Electronic configuration, oxidation states, colour, spectral and magnetic properties,
Lanthanide contraction, separation of lanthanides (ion-exchange method only)

6 Lectures, Marks - 5

Unit IV: Bioinorganic Chemistry

Metal ion present in biological systems, classification of elements according to their action in biological system. Geo chemical effect on distribution of metals. Sodium/ K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, use of chelating agents in medicine.
Iron and its application in bio-systems, Haemoglobin, storage and transfer of iron.

10 Lectures, Marks - 10

Reference Books:

1. Purcell, K.F. & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977
2. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall,1993
3. Cotton, F.A. & Wilkinson,G, *Advanced Inorganic Chemistry*, 5th Ed. Wiley-VCH,1999
4. Greenwood, N.N. & Earnshaw A., *Chemistry of Elements*, Butterworth-Heinemann,1977
5. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed., Pearson, 2010
6. Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).
7. R. Sarkar. General Inorganic Chemistry (Part-2), New Central Book Agency(P) Ltd.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(4th Semester)

Course No.: **CHEMISTRY-C-401-LAB**

(Inorganic Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

A. Gravimetric Analysis: (any one) **Marks - 10**

i. Estimation of nickel(ii) using Dimethylglyoxime
ii. Estimation of copper as CuSCN
iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$

B. Inorganic Preparation: (any one) **Marks - 6**

i. Tetraamminecopper(II) sulphate
ii. Tetraamminecarbonatocobalt(III) ion
iii. Potassium tris(oxalate)ferrate(III)

C. **Chromatography of metal ions**:

Principles involved in chromatographic seperations.Paper chromatographic separation of following metals **(any one**) **Marks - 4**

i. Ni(II) and Co(II)
ii. Fe(III) and Al(III)

D. Viva-voce **Marks - 4**

Reference Book:

1. Mendham, J., A.I.Vogel's *Quantitative Analysis* 6th Ed., Pearson, 2009

CBCS: B. Sc. (Honours) with CHEMISTRY
CORE COURSE

CHEMISTRY
(Honours)
(4th Semester)
Course No.: **CHEMISTRY-C-402**
(Organic Chemistry)
Contact Hours: 60
Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To develop the knowledge on the preparation and properties of different classes nitrogen containing compounds. Emphasis is given to heterocyclic compounds of both synthetic and natural origin .

Expected Learner Outcome: Students will gain an understanding of

i. Reaction for preparation of Heterocyclic compounds, polynuclear hydrocarbons
ii. Reaction and mechanism of substitution in heterocyclic compounds.
iii. Methods of structure elucidation of terpenoids

Unit I: Nitrogen Containing Functional Groups

Preparation and important reactions of nitro and compounds, nitriles and isonitriles

Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

Diazonium Salts: Preparation and their synthetic applications. Diazomethane & Diazoacetic Ester with synthetic application.

16 Lectures, Marks - 14

Unit II: Polynuclear Aromatic Hydrocarbons

Preparation and structure elucidation & Reactions of Polynuclear hydrocarbons : naphthalene phenanthrene and anthracene , and important derivatives of naphthalene and anthracene;.

12 Lectures, Marks - 12

Unit III:
Heterocyclic Compound-I

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene,
Derivatives of furan: Furfural and furoic acid.

Heterocyclic Compound-II

Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner- Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction

20 Lectures, Marks - 18

Unit IV: Alkaloids
Natural occurrence, General structural features, Isolation and their physiological action

Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine**.**

6 Lectures, Marks - 6

Unit V: Terpenes
Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α-terpineol.

6 Lectures, Marks - 6

Reference Books:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* John Wiley & Sons (1976).
5. Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.
6. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.
7. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University Press.
8. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan (2010).

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(4th Semester)

Course No.: **CHEMISTRY-C-402-LAB**

(Organic Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time :-6 hours

1. Detection of elements (N, S and Halogens). **Marks - 3**

2. Functional group test for nitro, amine and amide groups. **Marks - 3**

3. Qualitative analysis of unknown organic compounds (alcohols, carboxylic acids, phenols and carbonyl compounds) **Marks - 14**

4. Viva - voce **Marks - 4**

Reference Books

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)

2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)

3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).

4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

CBCS: B. Sc. (Honours) with CHEMISTRY
CORE COURSE

CHEMISTRY
(Honours)
(4th Semester)
Course No.: **CHEMISTRY-C-403**
(Physical Chemistry)
Contact Hours: 60
Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To develop the basic knowledge on electrochemistry, various laws governing electro chemical process and their application.

Expected Learner Outcome: Students will gain an understanding of ---

i. Quantitative aspects of Faraday's laws of electrolysis
ii. Application of conductance measurement
iii. Electrical and magnetic properties of atoms and molecules

Unit I: Conductance

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

20 Lectures, Marks - 22

Unit II: Electrochemistry

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.

Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

28 Lectures, Marks - 22

Unit III: Electrical & Magnetic Properties of Atoms and Molecules

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

12 Lectures, Marks - 12

Reference Books:

1. Atkins, P.W & Paula, J.D. *Physical Chemistry*, 9th Ed., Oxford University Press (2011).
2. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004).
3. Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP (2009).
4. Barrow, G. M., *Physical Chemistry 5th Ed.,* Tata McGraw Hill: New Delhi (2006).
5. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
6. Rogers, D. W. *Concise Physical Chemistry* Wiley (2010).
7. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. *Physical Chemistry 4th Ed.,* John Wiley & Sons, Inc. (2005).
8. Negi,A.S; Anand,S.C. *A Text book of Physical Chemistry* New Age International Publishers
9. Puri,Sharma,Pathiana *Principles of Physical Chemistry* Vishal Publishing Co.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(4th Semester)

Course No.: **CHEMISTRY-C-403-LAB**

(Physical Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

Group A : Conductometry **Marks - 10**

I. Determination of cell constant

II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

III. Perform the following conductometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base
   iii. Mixture of strong acid and weak acid vs. strong base
   iv. Strong acid vs. weak base

Group-B : Potentiometry **Marks - 10**

I Perform the following potentiometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base
   iii. Dibasic acid vs. strong base
   iv. Potassium dichromate vs. Mohr's salt

Viva-voce **Marks - 2×2=4**

Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Hours

SEMESTER-V

CBCS: B. Sc. (Honours) with CHEMISTRY
CORE COURSE

CHEMISTRY
(Honours)
(5th Semester)
Course No.: **CHEMISTRY-C-501**
(Organic Chemistry)
Contact Hours: 60
Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To acquire knowledge in organic synthesis, retro synthesis, and to understand biochemistry.

Expected Learner Outcome: Students will gain an understanding of ---

i. The chemical basis for biological phenomena and cellular structure.
ii. The chemical properties of amino acids co factors and sugar.
iii. Enzyme kinetics, chemical logic of metabolism
iv. Health, disease and modern medicine are all rooted in biological chemistry.

Unit I: Nucleic Acids
Components of nucleic acids, Nucleosides and nucleotides;
Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.
Structure of DNA (Watson & Model) and RNA, Genetic Code Biological role of DNA and RNA, Replication,Transcription and Translation (elementary idea only)

9 Lectures, Marks - 8

Unit II: Amino Acids, Peptides and Proteins

Amino acids, Peptides and their classification.α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pK_a values, isoelectric point and

Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

16 Lectures, Marks - 10

Unit III: Enzymes
Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes.
Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

8 Lectures, Marks - 10

Unit IV: Lipids

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

8 Lectures, Marks - 8

Unit V: Disconnection approach in Organic Synthesis

Elementary idea about disconnection, Synthon and Synthetic equivalent, Functionall group interconversion (FGI), Functional group addition (FGA)., simple examples off retrosynthesis of C-C bond formation (Corey House, Grignard, aldol condensation).. Retrosynthesis of monofunctionalised and Bi-functionalized (1,1 and 1,2) compounds.

10 Lectures, Marks - 10

Unit VI: Pharmaceutical Compounds: Structure and Importance

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials:

Antacids : Ranitidine; Antibacterial : Providone—Iodine Solution,
Synthesis and mode of action of Suphanilamides and other Sulphadrugs (sulphapyridine, sulphathiazole)

Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol,
Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C.

8 Lectures, Marks - 10

Reference Books:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VIth Edition. W.H.Freeman and Co.
2. Nelson, D.L., Cox, M.M. and Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper'sIllustrated Biochemistry. XXVIII edition. Lange Medical Bookselectrophoresis;/ McGraw-Hil

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(5th Semester)

Course No.: **CHEMISTRY-C-501-LAB**

(Organic Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

Any Two **Marks 10+10 =20**

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.
8. Isolation and characterization of DNA from onion/ cauliflower/peas.

Viva-voce **Marks - 4**

Reference Books:

1. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
2. Arthur, I. V. *Quantitative Organic Analysis,* Pearson.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY

(Honours)

(5th Semester)

Course No.: **CHEMISTRY-C-502**

(Physical Chemistry)

Contact Hours: 60

Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To make the students familiar with the various aspects of photo chemistry and quantum chemistry.

Expected Learner Outcome: Students will gain an understanding of

i. The difference between classical and quantum mechanics
ii. Qualitative treatment of hydrogen atom and hydrogen like ions.
iii. How to interpret spectra
iv. Role of photochemical reaction in biochemical processes

Unit I: Quantum Chemistry

Background of quantum mechanics, Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.
Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.
Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

24 Lectures, Marks-22

Unit II: Molecular Spectroscopy

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

24 Lectures, Marks-22

Unit III: Photochemistry

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

12 Lectures, Marks-12

Reference Books:

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
3. House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
4. Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
5. Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press (2015).
6. Sen,B.K. Quantum Chemistry including Spectroscopy Kalyani Publishers

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(5th Semester)

Course No.: **CHEMISTRY-C-502-LAB**

(Physical Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

Group A: UV/Visible spectroscopy **Marks-10**

I. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).

II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.

III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Group B: Colorimetry **Marks-10**

I. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration

II. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.

III. Study the kinetics of iodination of propanone in acidic medium.

IV. Determine the amount of iron present in a sample using 1,10-phenathroline.

V. Determine the dissociation constant of an indicator (phenolphthalein/ methyl red).

VI. Determine phosphate concentration in a soft drink

VII. Analysis of the given vibration-rotation spectrum of HCl(g)

Viva Voce **Marks-4**

Reference Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing Hour

SEMESTER-VI

CBCS: B. Sc. (Honours) with CHEMISTRY
CORE COURSE

CHEMISTRY
(Honours)
(6th Semester)
Course No.: **CHEMISTRY-C-601**
(Inorganic Chemistry)
Contact Hours: 60
Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To make familiar with various aspects of knowledge on organometalic chemistry, its application and Inorganic Reaction Mechanism.

Expected Learner Outcome: Students will gain an understanding of

i. Basic principles involved in analysis of anions, cations solubility product , common ion effect etc
ii. Inorganic reaction mechanism
iii. Use of Wilkinson's catalyst in industrial process of hydrozenation of alkene, gas synthesis by metel carbonyl
iv. Hapacity of organic ligands, 18 electron rule, Zeise's salt etc

Unit I: Theoretical Principles in Qualitative Analysis (H_2S Scheme)
Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions(fluoride, borate,oxalate and phosphate) and need to remove them after Group II**.**

10 Lectures, Marks-10

Unit II: Organometallic compounds
Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands.
Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe,Co and Ni using VBT. π-acceptor behavior of CO(MO diagram of CO to be discussed), synergic effect and use of IR data to eplain extent of back bonding.
Zeise's salt: preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.
Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium(dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerization of ethane (Ziegler-Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

22 Lectures, Marks - 20

Unit III: Reaction Kinetics and Mechanism

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans-effect, theories of trans-effect, mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and kinetic stability, kinetics of octahedral substitution, ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

18 Lectures, Marks - 16

Unit IV: Catalysis by Organometallic Compounds

Study of the following industrial processes and their mechanism

1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic Gasoline (Fisher Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes

10 Lectures, Marks - 10

Reference Books:

1. Vogel, A. I. Qualitative Inorganic Analysis, Longman, 1972.
2. Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Ed., Prentice Hall.
3. Cotton, F. A. G.; Wilkinson & Gaus, P. L. Basic Inorganic Chemistry 3rd Ed.; Wiley India,
4. Huheey, J. E.; Keiter, E. A. & Keiter, R. L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
5. Sharpe, A. G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005
6. Douglas, B. E.; McDaniel, D. H. & Alexander, J. J. Concepts and Models in Inorganic Chemistry 3rd Ed., John Wiley and Sons, NY, 1994.
7. Greenwood, N. N. & Earnshaw, A. Chemistry of the Elements, Elsevier 2nd Ed, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
8. Lee, J. D. Concise Inorganic Chemistry 5th Ed., John Wiley and sons 2008.
9. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
10. Shriver, D. D. & P. Atkins, Inorganic Chemistry 2nd Ed., Oxford University Press, 1994.
11. Basolo, F. & Person, R. Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed., John Wiley & Sons Inc; NY.
12. Purcell, K. F. & Kotz, J. C., Inorganic Chemistry, W. B. Saunders Co. 1977
13. Miessler, G. L. & Donald, A. Tarr, Inorganic Chemistry 4th Ed., Pearson, 2010.
14. Collman, James P. et al. Principles and Applications of Organotransition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.
15. Crabtree, Robert H. The Organometallic Chemistry of the Transition Metals. New York, NY: John Wiley, 2000.
16. E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
17. P.C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
18. B.K. Sharma: Industrial Chemistry, Goel Publishing House, Meerut.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(6th Semester)

Course No.: **CHEMISTRY-C-601-LAB**

(Inorganic Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

A. Qualitative Inorganic Analysis: **Marks - 4×5 = 20**

Qualitative analysis of mixtures containing 2 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

NO_2^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$,

PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+},

Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}

Mixtures should preferably contain one interfering anion, or insoluble component e.g., $BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3 or combination of anions e.g. CO_3^{2-} and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, B^- rand I^-, NO_3^- and Br^-, NO_3^- and I^-.

Spot tests should be done whenever possible.

B. **Viva - voce** **Marks 4**

Reference Books:

1. Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla.
2. Marr & Rockett Inorganic Preparations.

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY

(Honours)

(6th Semester)

Course No.: **CHEMISTRY-C-602**

(Organic Chemistry)

Contact Hours: 60

Full Marks = 70 **[**End Semester Exam (56) + Internal Assessment (14)]

Objective of the Course: To acquaint students on application of Spectroscopy (UV – visible, IR and NMR), carbohydrates, dyes and polymers.

Expected Learner Outcome: Students will gain an understanding of :

i. Application of UV, IR, NMR spectroscopy, mass spectra in organic molecules
ii. Biological importance of carbohydrates
iii. Biodegradable polymer, colour and constitution of dyes and applications of different dyes.

Unit I: Organic Spectroscopy

General principles Introduction to absorption and emission spectroscopy.

UV Spectroscopy: Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λmax for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpetation of NMR spectra of simple compounds.

Mass spectrometry: Basic principles

Applications of IR, UV, NMR and Mass for identification of simple organic molecules.

24 Lectures, Marks - 26

Unit II: Carbohydrates

Occurrence, classification and their biological importance.
Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Assecnding and descending in monosaccharide; Interconversions of aldoses and ketoses; Killiani- Fischer synthesis and Ruff degradation;

16 Lectures, Marks - 10

Unit III: Dyes

Classification, Colour and constitution; **Mordant and Vat Dyes**; Chemistry of dyeing; Synthesis and applications of: **Azo dyes** – Methyl Orange and Congo Red (mechanism of Diazo Coupling); **Triphenyl Methane Dyes** -Malachite Green, Rosaniline and Crystal Violet; **Phthalein Dyes** – Phenolphthalein and Fluorescein; **Natural dyes** –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

8 Lectures, Marks - 10

Unit IV: Polymers

Introduction and classification of polymers;

Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene);

Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Biodegradable polymers with examples.

12 Lectures, Marks - 10

Reference Books:

1. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.
2. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Billmeyer, F. W. *Textbook of Polymer Science*, John Wiley & Sons, Inc.
4. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. *Polymer Science*, New Age International (P) Ltd. Pub.
5. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.
7. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University Press.
8. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Prakashan (2010).
9. Kemp, W. *Organic Spectroscopy*, Palgrave

CBCS: B. Sc. (Honours) with CHEMISTRY

CORE COURSE

CHEMISTRY PRACTICAL

(Honours)

(6th Semester)

Course No.: **CHEMISTRY-C-602-LAB**

(Organic Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc. **Marks - 14**

Any one- **Marks - 6**

2. Extraction of caffeine from tea leaves.
3. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
4. Identification of simple organic compounds by IR spectroscopy and NMR Spectroscopy (Spectra to be provided).

5. Viva-voce **Marks - 4**

Reference Books:

1. Vogel, A.I. *Quantitative Organic Analysis,* Part 3, Pearson (2012).

2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)

3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)

4. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).

5. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

CBCS: B. Sc. (Honours) with CHEMISTRY
Discipline Specific Elective (DSE) Course

CHEMISTRY
(Honours)
(5th Semester)
Course No.: **CHEMISTRY-DSE-501**

(Analytical Methods in Chemistry)

Contact Hours: 60

Full Marks = 70 [End Semester Exam (56) Internal Assessment (14)**]**

Objective of the Course: To develop a strong knowledge on spectroscopy, qualitative and quantitative aspects of analysis and thermal analysis.

Expected Learner Outcome: Students will gain an understanding of

i. The principles and applications of modern chemical instrumentation, experimental design and data analysis.
ii. The composition of written laboratory reports that summarize experimental procedures and the accurately present and interprete data
iii. Qualitative and quantitave aspect of solvent extraction, chromatographic method of analysis -TLC & HPLC

Unit I: Qualitative and quantitative aspects of analysis

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals**.**

5 Lectures, Marks - 4

Unit II: UV-Visible and IR Spectrometry

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques.

Structural illustration through interpretation of data, effect and importance of isotope substitution.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

25 Lectures, Marks - 25

Unit III: Thermal Methods of analysis:

Theory of thermo-gravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

5 Lectures, Marks - 4

Unit IV:Electro-analytical methods

Classification of electro-analytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points.Techniques used for the determination of pKa values.

10 Lectures, Marks - 8

Unit V: Separation techniques

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions.

Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aueous solution, extraction of organic species from the aqueous and non-aqueous media.
Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: TLC and HPLC.

15 Lectures, Marks - 15

Reference Books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed., John Wiley & Sons, New York, 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W. H. Freeman, 2001.
5. Khopkar, S. M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D. A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.
7. Mikes, O. & Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.

8. Ditts, R.V. Analytical Chemistry - Methods of separation.
9. Skoog, Douglas A., West, Donald M., Holler, F. James and Crouch, Stanley R., Fundamentals of Analytical Chemistry, 9th Edition.

CBCS: B. Sc. (Honours) with CHEMISTRY

Discipline Specific Elective (DSE) Course

CHEMISTRY

(Honours)

(5th Semester)

Course No.: **CHEMISTRY-DSE-501-PRACT.**

Analytical Methods in Chemistry

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

A. ***Any 2 (two) experiments to be set in examination*** **Marks - 10×2=20**

i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, Cr^{3+}, Ag^{+}, Hg_2^{2+}, and Pb^{2+}

ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.

iii) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their R_f values.

iv) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

v) Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

vi) Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

vii) Analysis of soil: determination of pH of soil, total soluble salt, estimation of calcium, magnesium, phosphate, nitrate

viii) Separation of metal ions from their binary mixture.

ix) Separation of amino acids from organic acids by ion exchange chromatography.

x) Determination of dissolved oxygen in water.

xi) Determination of chemical oxygen demand (COD).

xii) Determination of Biological oxygen demand (BOD).

B. Viva - voce **Marks - 4**

Reference Books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G. H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.

CBCS: B. Sc. (Honours) with CHEMISTRY

Discipline Specific Elective (DSE) Course

CHEMISTRY

(Honours)

(5th Semester)

Course No.: **CHEMISTRY-DSE-502**

(Green Chemistry)

Contact Hours: 60

Full Marks = 70 [End Semester Exam (56) Internal Assessment (14)**]**

Objective of the Course: To develop the basis knowledge of green chemistry and its future trends.

Expected Learner Outcome: Students will gain an understanding of

i. concept of green chemistry
ii. Use of safer chemicals
iii. Concept of atom economy
iv. Use of green solvent
v. Use of green chemistry in our day to day life

Unit I: Introduction to Green Chemistry

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry.
Limitations? Obstacles in the persuit of the goals of Green Chemistry.

4 Lectures, Marks - 4

Unit II: Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following

i) Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy,Calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.
ii) Prevention/ minimization of hazardous/ toxic products reducing toxicity
iii) Green solvents- supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents.
iv) Energy reuirements for reactions- alternative sources of energy: use of microwaves and ultrasonic energy.
v) Selection of starting materials; avoidance of unnecessary derivatization- careful use of blocking/ protecting groups.
vi) Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis.

vii)Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD " What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.
viii)Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

30 Lectures, Marks - 27

Unit III: Examples of Green Synthesis/ Reactions and some real world cases

Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)
Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents, Diels-Alder reaction and Decarboxylation.
Ultrasound assisted reactions: sonochemical Simmons- Smith Reaction (Ultrasonic alternative to Iodine)
Surfactants for carbon dioxide- replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning garments.
Designing of Environmentally safe marine antifoulant.
Rightfit pigments: synthetic azopigments to replace toxic organic and inorganic pigments.
An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.
Healthier Fats and Oil by Greeen Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils.
Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting.

16 Lectures, Marks - 15

Unit IV: Future Trends in Green Chemistry:

Oxidation reagents and catalysts; Biominimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C^2S^3); Green chemistry in sustainable development.

10 Lectures, Marks - 10

Reference Books:

1. V. K. Ahluwalia & M. R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers (2005).
2. P. T. Anastas & J. K. Warner: Oxford Green Theory and Practical, University Press (1998).
3. A. S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).
4. M. C. Cann & M. E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
5. M. A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002).

CBCS: B. Sc. (Honours) with CHEMISTRY

Discipline Specific Elective (DSE) Course

CHEMISTRY

(Honours)

(5th Semester)

Course No.: **CHEMISTRY-DSE-502-LAB**

(Green Chemistry)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

A. ***Any 2 (two) experiments to be set in examination*** **Marks - 10×2=20**

a. Safer Starting Materials

The Vitamin C clock reaction using Vitamin C tablets, tincture of iodine, hydrogen peroxide and liquid laundry starch – study of effect of concentration on clock reaction

b. Using Renewable Resources

Preparation of biodiesel from vegetable oil.

c. Avoiding Waste

Principle of atom economy.

Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.

Preparation of acetanilide from aniline using acetic acid in presence of zinc dust.

The other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.

d. Green Reactions

Reaction between furan and maleic acid in water and at room temperature rather than in benzene and reflux.

Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).

Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

B. Viva – voce **Marks - 4**

Reference Books:

1. Anastas, P. T & Warner, J. C. Green Chemistry: Theory and Practice, Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M. A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC (2002).

3. Ryan, M. A. Introduction to Green Chemistry, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
4. Sharma, R. K.; Sidhwani, I. T. & Chaudhari, M. K. I. K. Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi. Bangalore CISBN 978-93-81141-55-7 (2013). 56
5. Cann, M. C. & Connelly, M. E. Real world cases in Green Chemistry, American Chemical Society (2008).
6. Cann, M. C. & Thomas, P. Real world cases in Green Chemistry, American Chemical Society (2008).
7. Pavia, D. L. Lamponan, G. H. & Kriz, G. S. W B Introduction to organic laboratory.

CBCS: B. Sc. (Honours) with CHEMISTRY
Discipline Specific Elective (DSE) Course

CHEMISTRY
(Honours)
(5th Semester)
Course No.: **CHEMISTRY-DSE-503**

(Research Methodology for Chemistry)

Contact Hours: 75

Credit-6 [Theory-5, Tutorial-1]

Full Marks = 100 [End Semester Exam (80) Internal Assessment (20)**]**

Objective of the Course: To demonstrate a familiarity with literature survey methods of scientific research, chemical safety and ethical handling of chemicals and data analysis.

Expected Learner Outcome: Students will gain an understanding of

i. Literature survey
ii. Writing scientific paper
iii. Chemical safety and ethical handling of chemicals
iv. Statistical methods of data analysis, hypothesis testing etc

Unit I: Literature Survey

Print: *Sources of information*: Primary, secondary and tertiary sources:; Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Seilstein, subject Index, Substance Indexx, Author Index, Formula Index and other indices with examples.

Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles< Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, Chem Industry, Wiki-databases, Chemspiders, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources: The internet and world Wide Web. Internet resources for Chemistry. Finding and citing published information.

20 Lectures, Marks - 23

Unit II: Methods of Scientific Research and Writing Scientific Papers:

Reporting practical and Project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation.

Writing Scientific Papers—justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.

20 Lectures, Marks - 22

Unit III: Chemical Safety and Ethical Handling of Chemicals

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above and below atmospheric--- safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

12 Lectures, Marks - 12

Unit IV: Data Analysis

The Investigate Approach: Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments.

Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Chemometrices. Analysis of variance (ANOVA), correlation and regression, Curve fittings, Fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, r and its abuse. Basic aspects of multiple linear regression analysis.

13 Lectures, Marks - 13

Unit V: Electronics

Basic fundamentals of electronic circuits and their components used in circuits of common instruments like spectrophotometers, typical circuits involving operational amplifiers for electrochemical instruments. Elementary aspects of digital electronics.

10 Lectures, Marks - 10

Reference Books:

1. Dean, J. R. , Jones, A.M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) *Practical skills in chemistry.* 2nd Ed. Pretice Hall, Harlow
2. Hibbert, D. B. & Gooding, J. J. (2006) *Data analysis for chemistry*. Oxford University Press.
3. Topping, J. (1984) *Errors of observation and their treatment*. $th Ed., Chapman Hall, London.
4. Harris, D. C. *Quantitative Chemical Analysis*. 6th Ed., Freeman (2007) Chapters 3-5.
5. Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis.* Cambridge Univ. (2001) 487 pages
6. *Chemical safety matters*- IUPAC – IPCS, Cambridge Univ. Press, 1992
7. *OSU safety manual* 1.01

CHEMISTRY
(Honours)
(5th Semester)
Course No.: **CHEMISTRY-DSE-504**
(Elementary Computational Chemistry)

Contact Hours: 75

Full Marks = 100 [End Semester Exam (80) Internal Assessment (20)**]**

Objective of the Course: To demonstrate an advanced understanding of computational chemistry.

Expected Learner Outcome: Students will gain an understanding of

a) Model of computer, BASIC,FORTAN, role of computers in chemistry

b) writing simple programs in BASIC language

c) molecular modelling

Unit I

Introduction to computer hardware and software: Model of a computer, Basic idea of algorithm, Input devices, output devices, storage devices, Memory, Central processing Unit, I/O unit, Elementary ideas about operating system (Windows and Linux), Programming languages: BASIC and FORTRAN, Role of Computers in Chemistry.

10 Lectures, Marks - 12

Unit II

Introduction to BASIC language and its statements: REM, END, STOP, Numbers, Strings, Constants, Variables, Mathematical Operation, Value Assignment, Logical Operators, Loop (IF, ELSEIF, ENDIF, FOR, NEXT), Library Function, and Introductory Ideas to write simple programs applicable to Chemistry: Calculate the volume of an ideal gas and van der Waals gas for given Temperature and Pressure, pH of a solution for a given H^+ ion concentration, thermodynamic quantities of a monoatomic gas (Internal energy, heat capacity, entropy and free energy), Matrix algebra (addition and multiplication), Value of determinant

20 Lectures, Marks - 20

Unit III

Numerical Methods to find the Roots of an equation (Quadratic formula, iterative method, Newton-Raphson method, Binary bisection and Regula-Falsi), Numerical integration (Trapezoidal method and Simpson's rule), Least square fitting, Gauss-Siedal Method

20 Lectures, Marks - 22

Unit IV

Introduction to molecular modeling, concepts of coordinate systems (Cartesian and Z-matrix), potential energy surface, global and local minima. Force Field (Bond stretching, Angle bending, Non-bonded interactions), Basic idea about Monte Carlo and Molecular dynamics simulations, Metropolis, Verlet, Velocity-verlet and Leap-frog algorithm.

25 Lectures, Marks - 26

Textbooks:

1. A Textbook of Physical Chemistry, Volume 6, K. L. Kapoor, MacMillan.
2. Computational Chemistry, Errol Lewars, Kluwer Academic Publisher.
3. Fundamentals of Computers, V. Rajaraman and Neeharika Adabala, Prentice-Hall of India.

Reference Books:

1. Understanding Molecular Simulation, Daan Frenkel, Academic Press.
2. Introduction to Computational Chemistry, Frank Jensen, John-Wiley and Sons.

*If possible hands on sessions for simple programming may be arranged for the students.

CBCS: B. Sc. (Honours) with CHEMISTRY
Discipline Specific Elective (DSE) Course

CHEMISTRY
(Honours)
(6th Semester)
Course No.: **CHEMISTRY-DSE-601**

(Inorganic Materials of Industrial Importance)

Contact Hours: 60

Full Marks = 70 [End Semester Exam (56) Internal Assessment (14)**]**

Objective of the Course: To learn about fertilizers, surface coating, silicate industries, batteries etc.

Expected Learner Outcome: Students will gain an understanding of

i. Properties and the types of different glasses, ceramics and cements
ii. Different types and manufacture of fertilizers, composition of paint pigments.
iii. Working principle of different batteries, elements present in alloys, different types of steel etc.

Unit I: Silicate Industries

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

16 Lectures, Marks - 15

Unit II: Fertilizers

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

8 Lectures, Marks - 8

Unit III: Surface Coatings

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic

paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings, metal spraying and anodizing.

10 Lectures, Marks - 8

Unit IV: Batteries

Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

6 Lectures, Marks - 5

Unit V: Alloys

Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon, decarbonization, demanganization, desulphurization, dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

10 Lectures, Marks - 10

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut.

CBCS: B. Sc. (Honours) with CHEMISTRY

Discipline Specific Elective (DSE) Course

CHEMISTRY

(Honours)

(6th Semester)

Course No.: **CHEMISTRY-DSE-601-LAB**

(Inorganic Materials of Industrial Importance)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

A. ***Any 2 (two) experiment to be set in examination*** **Marks - 10x2=20**

a. Determination of free acidity in ammonium sulphate fertilizer.

b. Estimation of Calcium in Calcium ammonium nitrate fertilizer.

c. Estimation of phosphoric acid in superphosphate fertilizer.

d. Electroless metallic coatings on ceramic and plastic material.

e. Determination of composition of dolomite (by complexometric titration).

f. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.

g. Analysis of Cement.

h. Preparation of pigment (zinc oxide).

B. Viva – voce **Marks - 4**

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut.

CBCS: B. Sc. (Honours) with CHEMISTRY
Discipline Specific Elective (DSE) Course

CHEMISTRY
(Honours)
(6th Semester)
Course No.: **CHEMISTRY-DSE-602**

(Industrial Chemicals and Environment)

Contact Hours: 60

Full Marks = 70 [End Semester Exam (56) Internal Assessment (14)**]**

Objective of the Course: To impart knowledge about nuclear pollution, ecosystem, handling of industrial gases, semi conductor technology etc.

Expected Learner Outcome: Students will gain an understanding of

i. Stored and handle different types of industrial gases and chemicals
ii. Semiconductor technology
iii. The effect of hazardous chemicals, purification method of water and industrial waste management.

Unit I: Industrial Gases and Inorganic Chemicals

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: Oxygen, nitrogen, argon, neon,helium, hydrogen, acetylene, crbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

Inorganic materials: Manufacture, application, analysis, and hazards in handling of the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

10 Lectures, Marks - 10

Unit II: Industrial Metallurgy

Preparation of metals (ferrous and non ferrous) and ultrapure metals for semiconductor technology.

4 Lectures, Marks - 4

Unit III: Environment and its segments

Ecosystem, Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources,particle size and chemical nature. Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, major sources of air pollution.

Pollution by SO_2, CO_2, CO, NO_x, H_2S and other foul smeling gases, Methods of estimation of CO, NO_x, SO_x and control procedures.

Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone

Letion by oxides of nitrogen, chlorofluorocarbons and halogens, removal of sulphur from coal. Control of particulates.

Water pollution: Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems.

Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile. Tannery, diary, petroleum and petrochemicals, agro, fertilizers etc. Sludge disposal.

Industrial waste management, incineration of waste. Water treatment and purification (Reverse osmosis, electro dialysis, ion-exchange). Water quality parameters for waste watter, industrial water and domestic water.

30 Lectures, Marks - 30

Unit IV: Energy & Environment

Sources of energy: Coal, petrol and natural gas. Nuclear Fusion/ Fission, Solar energy, Hydrogen, Geothermal, Tidal and Hydel etc.

Nuclear pollution: Disposal of nuclear waste, nuclear disaster and its management.

10 Lectures, Marks - 8

Unit V: Biocataysis

Introduction to biocatalysis: Importance in " Green Chemistry" and " Chemical Industry"

6 Lectures, Marks - 4

Reference Books:

1. E. Stocchi: *Industrial Chemistry*, Vol-1, Ellis Horwood Ltd, UK.
2. R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi
3. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi
4. S.S.Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd, New Delhi
5. K.De, *Environmental Chemistry*: New Age International Pvt. Ltd., New Delhi
6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi
7. S.E. Manahan, *Environmental Chemistry*, CRC Press (2005)
8. G. T. Miller, *Environmental Science*, 11th Ed. Brooks/ Cole(2006)
9. A. Mishra, *Environmental Studies*. Selective and Scientific Books, New Delhi (2005)

CBCS: B. Sc. (Honours) with CHEMISTRY

Discipline Specific Elective (DSE) Course

CHEMISTRY

(Honours)

(6th Semester)

Course No.: **CHEMISTRY-DSE-602-LAB**

(Industrial Chemicals and Environment)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6hours

A. ***Any 2 (two) experiment to be set in examination*** **Marks - 10×2=20**

i) Determination of dissolved oxygen in water.

ii) Determination of Chemical Oxygen Demand (COD)

iii)Determination of Biological Oxygen Demand (BOD)

iv) Percentage of available chlorine in bleaching powder.

v)Estimation of total alkalinity of water samples (CO_3^{-2}, HCO_3^-) using double titration method.

vi) Measurement of dissolved CO_2

B. Viva-Voce **Marks - 4**

Reference Books:

1. E. Stocchi: *Industrial Chemistry*, Vol-1, Ellis Horwood Ltd, UK.
2. R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi
3. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi
4. S.S.Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd, New Delhi
5. K.De, *Environmental Chemistry*: New Age International Pvt. Ltd., New Delhi
6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi

CBCS: B. Sc. (Honours) with CHEMISTRY
Discipline Specific Elective (DSE) Course

CHEMISTRY
(Honours)
(6th Semester)
Course No.: **CHEMISTRY-DSE-603**

Dissertation

(*Project Work*)

Full Marks-100[Dissertation (80) Internal Assessment (20)]

(Credit-6)

Objective of the Course: To develop the written and verbal communication. To present information in a clear an effective manner, to write report in a scientific style and to solve scientific problems.

Expected Learner Outcome: Students will gain an understanding of: ---

i. Communication effectively, verbally and written for the purpose of conveying chemical information to both professional scientist and to the public.
ii. Availability of instrument for conducting specific, scientific research

In this paper students have to carry out project work (Laboratory experiments or Comprehensive Review work on a specified topic) either at their respective colleges or any other R&D laboratory and UGC recognized University under guidance of a faculty member. The student may start their project work during the semester break between fifth and sixth semester.

The area of work is to be decided by the advisor.

On completion of the project work students have to submit the work in the form of a dissertation followed by oral presentation in the presence of faculty member and an external expert.

[Mark Distribution for evaluation of the Project Work

A. Laboratory Experiment

1. Literature Review	5 Marks
2. Objectives	5 Marks
3. Experimental work	25 Marks
4. Results & Discussions	25 Marks
5. Presentation and Viva	20 Marks
6. IA	20 Marks

B. Comprehensive Review

1. Objective	5 Marks
2. Review	35 Marks

3. References 10 Marks
4. Future prospects 10 Marks
5. Presentation and Viva 20 Marks
6. IA 20 Marks

Note: Students are encouraged to carry out laboratory experiment individually (However in case of infrastructural issues a maximum of 4 students can perform experiments together). Comprehensive review must be carried out individually. Students are encouraged to submit Antiplagiarism certificate for the report/review.

CBCS: B. Sc. (Honours) with CHEMISTRY

Skill Enhancement Course (SEC)

CHEMISTRY

(Honours)

(3rd Semester)

Course No.: **CHEMISTRY-SEC-301**

Basic Analytical Chemistry

(Contact Hours-30; Credits: 02)

Full Marks = 50 [End Semester Exam (40) Internal Assessment (10)**]**

Unit I: Introduction

Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

3 Lectures, Marks - 4

Unit II: Analysis of soil

Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators

a. Determination of pH of soil samples.

b. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

5 Lectures, Marks - 6

Unit III: Analysis of water

Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

a. Determination of pH, acidity and alkalinity of a water sample.

b. Determination of dissolved oxygen (DO) of a water sample.

4 Lectures, Marks - 6

Unit IV: Analysis of food products

Nutritional value of foods, idea about food processing and food preservations and adulteration.

a. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.

b. Analysis of preservatives and colouring matter.

5 Lectures, Marks - 7

Unit V: Chromatography

Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.

a. Paper chromatographic separation of mixture of metal ion ($Fe^{3+}$and Al^{3+}).

b. To compare paint samples by TLC method.

5 Lectures, Marks - 7

Unit VI: Ion-exchange

Column, ion-exchange chromatography etc.

Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

4 Lectures, Marks - 5

Unit VII: Analysis of cosmetics

Major and minor constituents and their function

a. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.

b. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

4 Lectures, Marks - 5

Suggested Applications (Any one):

a. To study the use of phenolphthalein in trap cases.

b. To analyze arson accelerants.

c. To carry out analysis of gasoline.

Suggested Instrumental demonstrations:

a. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry

b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.

c. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drinks

Reference Books

1. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA,1988.
2. Skoog, D.A., Holler, F.J. & Crouch, S. *Principles of Instrumental Analysis*, Cengage Learning India Edition, 2007.
3. Skoog, D.A.; West, D.M. & Holler, F.J. *Analytical Chemistry: An Introduction 6th Ed.,* Saunders College Publishing, Fort Worth, Philadelphia (1994).
4. Harris, D. C. *Quantitative Chemical Analysis*, 9th ed. Macmillan Education, 2016.
5. Dean, J. A. *Analytical Chemistry Handbook*, McGraw Hill, 2004.
6. Day, R. A. & Underwood, A. L. *Quantitative Analysis*, Prentice Hall of India, 1992.
7. Freifelder, D.M. *Physical Biochemistry 2nd Ed.,* W.H. Freeman & Co., N.Y. USA (1982).
8. Cooper, T.G. *The Tools of Biochemistry,* John Wiley & Sons, N.Y. USA. 16 (1977).
9. Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7th Ed.,* Prentice Hall, 1996.
10. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
11. Robinson, J.W. *Undergraduate Instrumental Analysis 5th Ed.,* Marcel Dekker, Inc., NewYork (1995).
12. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.

CBCS: B. Sc. (Honours) with CHEMISTRY

Skill Enhancement Course (SEC)

CHEMISTRY

(Honours)

(4th Semester)

Course No.: **CHEMISTRY-SEC-401**

Fuel Chemistry

(Contact Hours-30 Lectures; Credits: 02)

Full Marks = 50 [End Semester Exam (40) Internal Assessment (10)**]**

Unit I:

Review of energy sources (renewable and non-renewable).
Classification of fuels and their calorific value.

4 Lectures, Marks - 4

Unit II:

Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals.

5 Lectures, Marks - 6

Unit III:

Petroleum and Petrochemical Industry: Composition of crude petroleum; Different types of petroleum products and their applications. Principle and process of fractional distillation, Cracking - Thermal and catalytic cracking; Qualitative treatment of non-petroleum fuels - LPG, CNG, LNG, bio-gas, fuels derived from biomass, fuel from waste; synthetic fuels - gaseous and liquids.

9 Lectures, Marks - 12

Unit IV:

Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

6 Lectures, Marks - 8

Unit V:

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting), Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants – viscosity index, cloud point, pore point.

6 Lectures, Marks - 10

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
2. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
3. B. K. Sharma: Industrial Chemistry, Goel Publishing House, Meerut.

CBCS: B. Sc. with Chemistry

Generic Elective

CHEMISTRY

(1st Semester)

Course No.: **CHEMISTRY-GE-101**

Atomic Structure, Bonding,
General Organic Chemistry and Aliphatic Hydrocarbons

(Contact Hours-60; Credits: 04)

Full Marks = 70 **[**End Semester Exam (56) Internal Assessment (14)]

Section A:- 28 Marks and Section B:- 28 Marks

Section A: Inorganic Chemistry

Unit I: Atomic Structure

Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (m_s).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

14 Lectures, Marks - 13

Unit II: Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

16 Lectures, Marks - 15

Section B: Organic Chemistry

Unit III: Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting *p*K values. Aromaticity: Benzenoids and Hückel's rule.

8 Lectures, Marks - 6

Unit IV: Stereochemistry

Conformation with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso Compounds. Threo and erythro; D and L; Cis-trans nomenclature; cIP Rules: R/S (for upto 2 chiral carbon atoms) and E/Z Nomenclature (for upto two C=C systems)

10 Lectures, Marks - 10

Unit V: Aliphatic Hydrocarbons

Alkanes: (Up to 5 Carbons):
Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent.
Reactions: Free radical Substitution: Halogenation.

Alkenes: (Up to 5 Carbons):
Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule).
Reactions: cis-addition (*alk*. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti Markownikoff's addition), Hydration, Ozonolysis.

Alkynes: (Up to 5 Carbons):
Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinaldihalides.
Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis and oxidation with hot alk. $KMnO_4$.

12 Lectures, Marks - 12

Reference Books:

1. J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
2. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
3. Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.
4. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
5. T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
6. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
7. E. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill.
8. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
9. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
10. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand

CBCS: B. Sc. with Chemistry

Generic Elective

CHEMISTRY

(1st Semester)

Course No.: **CHEMISTRY-GE-101-LAB**

(Contact Hours-60; Credits: 02)

Full Marks = 30 **[**End Semester Exam (24) Internal Assessment (6)]

Time- 6hours

1. *Section A: Inorganic Volumetric Analysis*: (*any one*) **Marks - 10**

i. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.

ii. Estimation of oxalic acid by titrating it with $KMnO_4$.

iii. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.

iv. Estimation of Fe (II) ions by titrating it with $KMnO_4$.

v. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

2. *Section B: Organic Chemistry*: (*any one*) **Marks - 10**

i. Detection of characterized element (N, S, Cl, Br, I) in an organic compound.

ii. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)

(a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography

(b) Identify and separate the sugars present in the given mixture by paper chromatography.

3. Viva - voce **Marks - 4**

Reference Books:

1. Vogel's Qualitative Inorganic Analysis, A. I. Vogel, Prentice Hall, 7th Ed.
2. Vogel's Quantitative Chemical Analysis, A. I. Vogel, Prentice Hall, 6th Ed.
3. Textbook of Practical Organic Chemistry, A. I. Vogel, Prentice Hall, 5th Ed.
4. Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960

CBCS: B. Sc. with Chemistry

Generic Elective

CHEMISTRY

(2nd Semester)

Course No.: **CHEMISTRY-GE-201**

Chemical Energetics, Equilibria and Functional Organic Chemistry

(Contact Hours-60; Credits: 04)

Full Marks = 70 **[**End Semester Exam (56) Internal Assessment (14)]

Section A:- 28 Marks and Section B:- 28 Marks

Section A: Physical Chemistry

Unit I: Chemical Energetics

Review of thermodynamics and the Laws of Thermodynamics.

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature– Kirchhoff's equation.

10 Lectures, Marks - 10

Unit II: Chemical Equilibrium

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^o, Le Chatelier's principle. Relationships between *Kp*, *Kc* and *Kx* for reactions involving ideal gases.

8 Lectures, Marks - 6

Unit III: Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

12 Lectures, Marks - 12

Section *B: Organic Chemistry*

Unit IV: Aromatic Hydrocarbons

Preparation: (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (up to 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

8 Lectures, Marks - 8

Unit V: Alkyl and Aryl Halides

Alkyl Halides: (Up to 5 Carbons): Types of Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.
Aryl Halides: *Preparation*: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. *Reactions* (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

8 Lectures, Marks - 8

Unit VI: Alcohols, Phenols and Ethers (Up to 5 Carbons)

Alcohols: Preparation: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, *alk*. $KMnO_4$, acidic dichromate, conc. HNO_3). Diols: (Up to 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case): Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Schotten – Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde): Preparation: from acid chlorides and from nitriles. Reactions – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's Reaction, Wittig Reaction, Benzoin Condensation. Clemensen Reduction and Wolff Kishner Reduction. Meerwein-Pondorff Verley Reduction.

14 Lectures, Marks – 12

Reference Books:

1. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
2. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
3. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
4. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
5. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
6. R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
7. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
8. Castellan, G. W. Physical Chemistry 4^{th} Ed. Narosa (2004).

CBCS: B. Sc. with Chemistry

Generic Elective

CHEMISTRY

(2nd Semester)

Course No.: **CHEMISTRY-GE-201-LAB**

(Contact Hours-60; Credits: 02)

Full Marks = 30 **[**End Semester Exam (24) Internal Assessment (6)]

Time- 6hours

1. *Section A: Physical Chemistry*: (*any one*) ***M*arks - 10**

Thermochemistry and Ionic equilibria

i. Determination of heat capacity of calorimeter for different volumes.

ii. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

iii. Determination of enthalpy of ionization of acetic acid.

iv. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).

v. Determination of enthalpy of hydration of copper sulphate.

vi. Study of the solubility of benzoic acid in water and determination of ΔH.

vii. *Measurement of pH* of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.

ix. *Preparation of buffer solutions*:

(*a*) Sodium acetate-acetic acid or,

(*b*) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

2. *Section B: Organic Chemistry*: (**either** *i. + iii.* **or** *ii. + iii.*) **Marks - 3+7=*10***

i. *Purification* of organic compounds by crystallization (from water and alcohol) and distillation.

ii. *Criteria of Purity*: Determination of melting and boiling points.

iii. *Preparations*: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline

(b) Benzoylation of amines/phenols

(c) Oxime and 2, 4-dinitrophenylhydrazone of aldehyde/ketone

3. Viva - voce **Marks - 4**

Reference Book:

1. A. I. Vogel: Textbook of Practical Organic Chemistry, 5th Ed. Prentice-Hall.
2. F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
3. B. D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

CBCS: B. Sc. with Chemistry

Generic Elective

CHEMISTRY

(3rd Semester)

Course No.: **CHEMISTRY-GE-301**

Solutions, Phase Equilibrium, Conductance, Electrochemistry and Functional Group Organic Chemistry-II

(Contact Hours-60; Credits: 04)

Full Marks = 70 **[**End Semester Exam (56) Internal Assessment (14)]

Section A:- 28 Marks and Section B:- 28 Marks

Section A: Physical Chemistry

Unit I: Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Distillation of solutions. Azeotropes.

Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

8 Lectures, Marks - 8

Unit II: Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic deviation. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead –silver, $FeCl_3$-H_2O and Na-K only)

8 Lectures, Marks - 6

Unit III: Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch's law of independent migration of ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

6 Lectures, Marks - 6

Unit IV: **Electrochemistry**

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data.

Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge.

P^H determination using hydrogen electrode and quinhydrone electrode.

8 Lectures, Marks - 8

Section B: Organic Chemistry

Unit V: Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic): Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlard - Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (upto 5 carbons) Preparation: Acid chlorides, anhydrides, Esters and Amides from acids and their interconversion.

Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin Condensation.

6 Lectures, Marks - 6

Unit VI: Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Up to 5 carbons): Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes

6 Lectures, Marks - 6

Unit VII: Carbohydrates

Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides.

8 Lectures, Marks - 8

Unit VIII: Amino Acids, Peptides and Proteins

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

10 Lectures, Marks - 8

Reference Books:

1. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
2. G. W. Castellan: Physical Chemistry 4th Ed. Narosa (2004).
3. J. C. Kotz, P. M. Treichel, J. R. Townsend, General Chemistry, Cengage
4. Learning India Pvt. Ltd.: New Delhi (2009).
5. B. H. Mahan: University Chemistry, 3rd Edn. Narosa (1998).
6. R. H. Petrucci, General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).
7. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
10. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
11. Berg, J. M., Tymoczko, J. L. & Stryer, L. Biochemistry 7th Ed., W. H. Freeman.

CBCS: B. Sc. with Chemistry

Generic Elective

CHEMISTRY

(3rd Semester)

Course No.: **CHEMISTRY-GE-301-LAB**

(Contact Hours-60; Credits: 02)

Full Marks = 30 **[**End Semester Exam (24) Internal Assessment (6)]

Time- 6hours

1. *Section A: Physical Chemistry*: (*any one*) **Marks - 10**

Phase Equilibria and conductance

i. Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.

ii. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.

iii. Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

iv. Determination of cell constant

v. Perform the following conductometric titrations:

- ***a.*** Strong acid vs. strong base or,
- ***b.*** Weak acid vs. strong base

2. *Section B: Organic Chemistry*: (*any one*) **Marks - 10**

Systematic Qualitative Organic Analysis of Organic Compounds possessing mono-functional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

3. Viva – voce **Marks - 4**

Reference Books:

1. A. I. Vogel: Textbook of Practical Organic Chemistry, Prentice Hall, 5th Ed.
2. F. G. Mann & B. C. Saunders: Practical Organic Chemistry, Orient Longman, 1960.
3. B. D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.
4. Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

CBCS: B. Sc. with Chemistry

Generic Elective

CHEMISTRY

(4th Semester)

Course No.: **CHEMISTRY-GE-401**

Transition metals, Coordination Chemistry,
States of Matter and Chemical Kinetics

(Contact Hours-60; Credits: 04)

Full Marks = 70 **[**End Semester Exam (56) Internal Assessment (14)]

Section A:- 28 Marks and Section B:- 28 Marks

Section A: Inorganic Chemistry

Unit I: *Transition Series* Elements (*3d* series)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

12 Lectures, Marks - 10

Unit II: *Coordination Chemistry*

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT.

IUPAC (2005) system of nomenclature.

8 Lectures, Marks - 8

Unit III: Crystal Field Theory

Crystal Field Theory (CFT): Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for Oh and Td complexes, Tetragonal distortion of octahedral geometry.

Jahn-Teller distortion, Square planar coordination.

10 Lectures, Marks - 10

Section B: Physical Chemistry

Unit IV: Kinetic Theory of Gases

Gases: Kinetic Theory of Gases: Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation.

Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO_2. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision number and mean free path of molecules. Viscosity of gases, effect of temperature/pressure on coefficient of viscosity (qualitative treatment only).

8 Lectures, Marks - 8

Unit V: Liquids

Liquids: Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)

6 Lectures, Marks - 6

Unit VI: Solids

Solids: Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. Bragg's law. Structures of NaCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

8 Lectures, Marks - 6

Unit VII: Chemical Kinetics

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions. Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

8 Lectures, Marks - 8

Reference Books:

1. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
2. G. W. Castellan: Physical Chemistry 4^{th} Edn. Narosa (2004).

3. B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
4. J. D. Lee: A New Concise Inorganic Chemistry, ELBS.
5. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
6. D. F. Shriver and P. W. Atkins: Inorganic Chemistry, OUP.
7. Gary Wulfsberg: Inorganic Chemistry, Viva Books Pvt. Ltd.

CBCS: B. Sc. with Chemistry

Generic Elective

CHEMISTRY

(4th Semester)

Course No.: **CHEMISTRY-GE-401-LAB**

(Contact Hours-60; Credits: 02)

Full Marks = 30 **[**End Semester Exam (24) Internal Assessment (6)]

Time- 6hours

1. *Section A: Inorganic Chemistry*: (*any one*) **Marks - 2½×4=10**

A. Semi-micro qualitative analysis using H_2S of mixtures- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following::

Cations: Pb^{2+}, Ag^{2+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, NH_4^{+}.

Anions: CO_3^{2-}, NO^{2-}, NO^{3-}, SO_4^{2-}, Cl^{-}, Br^{-}, I^{-}, BO_3^{3}, PO_4^{3-}.

Spot tests should be done whenever possible.

2. *Section B: Physical Chemistry*: (*any one*) ***M*arks - 10**

I. Surface tension measurement (*use of organic solvents excluded*).
Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

II. Viscosity measurement (*use of organic solvents excluded*).
Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

3. Viva-voce **Marks - 4**

Reference Books:

1. A. I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Ed.
2. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

CBCS
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B. Sc. with
CHEMISTRY

CBCS: B. Sc. with Chemistry

Discipline Specific Core (DSC) Course

CHEMISTRY

(1st Semester)

Course No.: **CHEMISTRY-DSC-101**

Atomic Structure, Bonding,
General Organic Chemistry and Aliphatic Hydrocarbons

(Contact Hours-60; Credits: 04)

Full Marks = 70 **[**End Semester Exam (56) Internal Assessment (14)]

Section A:- 28 Marks and Section B:- 28 Marks

Section A: Inorganic Chemistry

Unit I: Atomic Structure

Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wave functions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (m_s).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

14 Lectures, Marks - 13

Unit II: Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

16 Lectures, Marks - 15

Section B: Organic Chemistry

Unit III: Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting *p*K values. Aromaticity: Benzenoids and Hückel's rule.

8 Lectures, Marks - 6

Unit IV: Stereochemistry

Conformation with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso Compounds. Threo and erythro; D and L; Cis-trans nomenclature; cIP Rules: R/S (for upto 2 chiral carbon atoms) and E/Z Nomenclature (for upto two C=C systems)

10 Lectures, Marks - 10

Unit V: Aliphatic Hydrocarbons

Alkanes: (Up to 5 Carbons):
Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent.
Reactions: Free radical Substitution: Halogenation.

Alkenes: (Up to 5 Carbons):
Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule).
Reactions: cis-addition (*alk*. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti Markownikoff's addition), Hydration, Ozonolysis.

Alkynes: (Up to 5 Carbons):
Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinaldihalides.
Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis and oxidation with hot alk. $KMnO_4$.

12 Lectures, Marks - 12

Reference Books:

1. J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
2. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
3. Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.
4. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
5. T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
6. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
7. E. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill.
8. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
9. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
10. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand

CBCS: B. Sc. with Chemistry

Discipline Specific Core (DSC) Course

CHEMISTRY

(1st Semester)

Course No.: **CHEMISTRY-DSC-101-LAB**

(Contact Hours-60; Credits: 02)

Full Marks = 30 **[**End Semester Exam (24) Internal Assessment (6)]

Time- 6hours

1. *Section A: Inorganic Volumetric Analysis*: (*any one*) **Marks - 10**

i. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.

ii. Estimation of oxalic acid by titrating it with $KMnO_4$.

iii. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.

iv. Estimation of Fe (II) ions by titrating it with $KMnO_4$.

v. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

2. *Section B: Organic Chemistry*: (*any one*) **Marks - 10**

i. Detection of characterized element (N, S, Cl, Br, I) in an organic compound.

ii. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)

(a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography

(b) Identify and separate the sugars present in the given mixture by paper chromatography.

3. Viva - voce **Marks - 4**

Reference Books:

1. Vogel's Qualitative Inorganic Analysis, A. I. Vogel, Prentice Hall, 7th Ed.
2. Vogel's Quantitative Chemical Analysis, A. I. Vogel, Prentice Hall, 6th Ed.
3. Textbook of Practical Organic Chemistry, A. I. Vogel, Prentice Hall, 5th Ed.
4. Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960

CBCS: B. Sc. with Chemistry

Discipline Specific Core (DSC) Course

CHEMISTRY

(2nd Semester)

Course No.: **CHEMISTRY-DSC-201**

Chemical Energetics, Equilibria and Functional Organic Chemistry

(Contact Hours-60; Credits: 04)

Full Marks = 70 **[**End Semester Exam (56) Internal Assessment (14)]

Section A:- 28 Marks and Section B:- 28 Marks

Section A: Physical Chemistry

Unit I: Chemical Energetics

Review of thermodynamics and the Laws of Thermodynamics.

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature– Kirchhoff's equation.

10 Lectures, Marks - 10

Unit II: Chemical Equilibrium

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^o, Le Chatelier's principle. Relationships between *Kp*, *Kc* and *Kx* for reactions involving ideal gases.

8 Lectures, Marks - 6

Unit III: Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

12 Lectures, Marks - 12

Section *B: Organic Chemistry*

Unit IV: Aromatic Hydrocarbons

Preparation: (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (up to 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

8 Lectures, Marks - 8

Unit V: Alkyl and Aryl Halides

Alkyl Halides: (Up to 5 Carbons): Types of Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Aryl Halides: *Preparation*: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. *Reactions* (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

8 Lectures, Marks - 8

Unit VI: Alcohols, Phenols and Ethers: (Up to 5 Carbons)

Alcohols: Preparation: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, *alk*. $KMnO_4$, acidic dichromate, conc. HNO_3). Diols: (Up to 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case): Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Schotten – Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde): Preparation: from acid chlorides and from nitriles. Reactions – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's Reaction, Wittig Reaction, Benzoin Condensation. Clemensen Reduction and Wolff Kishner Reduction. Meerwein-Pondorff Verley Reduction.

14 Lectures, Marks – 12

Reference Books:

1. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
2. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
3. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
4. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
5. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
6. R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
7. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
8. Castellan, G. W. Physical Chemistry 4^{th} Ed. Narosa (2004).

CBCS: B. Sc. with Chemistry

Discipline Specific Core (DSC) Course

CHEMISTRY

(2nd Semester)

Course No.: **CHEMISTRY-DSC-201-LAB**

(Contact Hours-60; Credits: 02)

Full Marks = 30 **[**End Semester Exam (24) Internal Assessment (6)]

Time- 6hours

1. *Section A: Physical Chemistry*: (*any one*) ***M*arks - 10**

Thermochemistry and Ionic equilibria

i. Determination of heat capacity of calorimeter for different volumes.

ii. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

iii. Determination of enthalpy of ionization of acetic acid.

iv. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).

v. Determination of enthalpy of hydration of copper sulphate.

vi. Study of the solubility of benzoic acid in water and determination of ΔH.

vii. *Measurement of pH* of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.

ix. *Preparation of buffer solutions*:

(*a*) Sodium acetate-acetic acid or,

(*b*) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

2. *Section B: Organic Chemistry*: (**either** *i. + iii.* **or** *ii. + iii.*) **Marks - 3+7 = *10***

i. *Purification* of organic compounds by crystallization (from water and alcohol) and distillation.

ii. *Criteria of Purity*: Determination of melting and boiling points.

iii. *Preparations*: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline

(b) Benzoylation of amines/phenols

(c) Oxime and 2, 4-dinitrophenylhydrazone of aldehyde/ketone

3. Viva - voce **Marks - 4**

Reference Book:

1. A. I. Vogel: Textbook of Practical Organic Chemistry, 5th Ed. Prentice-Hall.
2. F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
3. B. D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

CBCS: B. Sc. with Chemistry

Discipline Specific Core (DSC) Course

CHEMISTRY

(3rd Semester)

Course No.: **CHEMISTRY-DSC-301**

Solutions, Phase Equilibrium, Conductance, Electrochemistry and Functional Group Organic Chemistry-II

(Contact Hours-60; Credits: 04)

Full Marks = 70 **[**End Semester Exam (56) Internal Assessment (14)]

Section A:- 28 Marks and Section B:- 28 Marks

Section A: Physical Chemistry

Unit I: Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Distillation of solutions. Azeotropes.

Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

8 Lectures, Marks - 8

Unit II: Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic deviation. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead –silver, $FeCl_3$-H_2O and Na-K only)

8 Lectures, Marks - 6

Unit III: Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch's law of independent migration of ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

6 Lectures, Marks - 6

Unit IV: **Electrochemistry**

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data.

Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge.

P^H determination using hydrogen electrode and quinhydrone electrode.

8 Lectures, Marks - 8

Section B: Organic Chemistry

Unit V: Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic): Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlard - Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (upto 5 carbons) Preparation: Acid chlorides, anhydrides, Esters and Amides from acids and their interconversion.

Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin Condensation.

6 Lectures, Marks - 6

Unit VI: Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Up to 5 carbons): Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes

6 Lectures, Marks - 6

Unit VII: Carbohydrates

Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides.

8 Lectures, Marks - 8

Unit VIII: Amino Acids, Peptides and Proteins

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

10 Lectures, Marks - 8

Reference Books:

1. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
2. G. W. Castellan: Physical Chemistry 4th Ed. Narosa (2004).
3. J. C. Kotz, P. M. Treichel, J. R. Townsend, General Chemistry, Cengage
4. Learning India Pvt. Ltd.: New Delhi (2009).
5. B. H. Mahan: University Chemistry, 3rd Edn. Narosa (1998).
6. R. H. Petrucci, General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).
7. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
10. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
11. Berg, J. M., Tymoczko, J. L. & Stryer, L. Biochemistry 7th Ed., W. H. Freeman.

CBCS: B. Sc. with Chemistry

Discipline Specific Core (DSC) Course

CHEMISTRY

(3rd Semester)

Course No.: **CHEMISTRY-DSC-301-LAB**

(Contact Hours-60; Credits: 02)

Full Marks = 30 **[**End Semester Exam (24) Internal Assessment (6)]

Time- 6hours

1. ***Section A: Physical Chemistry*****: (*any one*)** **Marks - 10**

Phase Equilibria and conductance

i. Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.

ii. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.

iii. Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

iv. Determination of cell constant

v. Perform the following conductometric titrations:

- ***a.*** Strong acid vs. strong base or,
- ***b.*** Weak acid vs. strong base

2. ***Section B: Organic Chemistry*****: (*any one*)** **Marks - 10**

Systematic Qualitative Organic Analysis of Organic Compounds possessing mono-functional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

3. Viva – voce **Marks - 4**

Reference Books:

1. A. I. Vogel: Textbook of Practical Organic Chemistry, Prentice Hall, 5th Ed.
2. F. G. Mann & B. C. Saunders: Practical Organic Chemistry, Orient Longman, 1960.
3. B. D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.
4. Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

CBCS: B. Sc. with Chemistry

Discipline Specific Core (DSC) Course

CHEMISTRY

(4th Semester)

Course No.: **CHEMISTRY-DSC-401**

Transition metals, Coordination Chemistry,
States of Matter and Chemical Kinetics

(Contact Hours-60; Credits: 04)

Full Marks = 70 **[**End Semester Exam (56) Internal Assessment (14)]

Section A:- 28 Marks and Section B:- 28 Marks

Section A: Inorganic Chemistry

Unit I: *Transition Series* Elements (*3d* series)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

12 Lectures, Marks - 10

Unit II: *Coordination Chemistry*

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT.

IUPAC (2005) system of nomenclature.

8 Lectures, Marks - 8

Unit III: Crystal Field Theory

Crystal Field Theory (CFT): Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for Oh and Td complexes, Tetragonal distortion of octahedral geometry.

Jahn-Teller distortion, Square planar coordination.

10 Lectures, Marks - 10

Section B: Physical Chemistry

Unit IV: Kinetic Theory of Gases

Gases: Kinetic Theory of Gases: Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation.

Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO_2. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision number and mean free path of molecules. Viscosity of gases, effect of temperature/pressure on coefficient of viscosity (qualitative treatment only).

8 Lectures, Marks - 8

Unit V: Liquids

Liquids: Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)

6 Lectures, Marks - 6

Unit VI: Solids

Solids: Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. Bragg's law. Structures of NaCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

8 Lectures, Marks - 6

Unit VII: Chemical Kinetics

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions. Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

8 Lectures, Marks - 8

Reference Books:

1. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
2. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
3. B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
4. J. D. Lee: A New Concise Inorganic Chemistry, ELBS.
5. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
6. D. F. Shriver and P. W. Atkins: Inorganic Chemistry, OUP.
7. Gary Wulfsberg: Inorganic Chemistry, Viva Books Pvt. Ltd.

CBCS: B. Sc. with Chemistry

Discipline Specific Core (DSC) Course

CHEMISTRY

(4th Semester)

Course No.: **CHEMISTRY-DSC-401-LAB**

(Contact Hours-60; Credits: 02)

Full Marks = 30 **[**End Semester Exam (24) Internal Assessment (6)]

Time- 6hours

1. *Section A: Inorganic Chemistry*: (*any one*) **Marks - 2½×4 = 10**

A. Semi-micro qualitative analysis using H_2S of mixtures- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following::

Cations: Pb^{2+}, Ag^{2+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, NH_4^+.

Anions: CO_3^{2-}, NO_2^-, NO_3^-, SO_4^{2-}, Cl^-, Br^-, I^-, BO_3^{3-}, PO_4^{3-}.

Spot tests should be done whenever possible.

2. *Section B: Physical Chemistry*: (*any one*) **Marks - 10**

I. Surface tension measurement (*use of organic solvents excluded*).

Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

II. Viscosity measurement (*use of organic solvents excluded*).

Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

3. Viva-voce **Marks - 4**

Reference Books:

1. A. I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Ed.
2. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

CBCS: B. Sc. with Chemistry

Discipline Specific Elective (DSE) Course

CHEMISTRY

(5th Semester)

Course No.: **CHEMISTRY-DSE-501**

Analytical Methods in Chemistry

Contact Hours: 60

Full Marks = 70 [End Semester Exam (56) Internal Assessment (14)**]**

Unit I: Qualitative and quantitative aspects of analysis

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals**.**

5 Lectures, Marks - 4

Unit II: UV-Visible and IR Spectrometry

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques.

Structural illustration through interpretation of data, effect and importance of isotope substitution.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

25 Lectures, Marks - 25

Unit III: Thermal Methods of analysis:

Theory of thermo-gravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

5 Lectures, Marks - 4

Unit IV:Electro-analytical methods

Classification of electro-analytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points.Techniques used for the determination of pKa values.

10 Lectures, Marks - 8

Unit V: Separation techniques

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions.

Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aueous solution, extraction of organic species from the aqueous and non-aqueous media.

Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: TLC and HPLC.

15 Lectures, Marks - 15

Reference Books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed., John Wiley & Sons, New York, 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W. H. Freeman, 2001.
5. Khopkar, S. M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D. A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.
7. Mikes, O. & Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
8. Ditts, R.V. Analytical Chemistry – Methods of separation.
9. Skoog, Douglas A., West, Donald M., Holler, F. James and Crouch, Stanley R., Fundamentals of Analytical Chemistry, 9th Edition.

CBCS: B. Sc. with Chemistry

Discipline Specific Elective (DSE) Course

CHEMISTRY

(5th Semester)

Course No.: **CHEMISTRY-DSE-501-LAB**

Analytical Methods in Chemistry

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

A. ***Any 2 (two) experiments to be set in examination*** **Marks - 10×2=20**

i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, Cr^{3+}, Pb^{2+}, Hg_2^{2+}, and Ag^{+}

ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.

iii) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their R_f values.

iv) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

v) Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

vi) Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

vii) Analysis of soil: determination of pH of soil, total soluble salt, estimation of calcium, magnesium, phosphate, nitrate

viii) Separation of metal ions from their binary mixture.

ix) Separation of amino acids from organic acids by ion exchange chromatography.

x) Determination of dissolved oxygen in water.

xi) Determination of chemical oxygen demand (COD).

xii) Determination of Biological oxygen demand (BOD).

B. Viva – voce **Marks - 4**

Reference Books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G. H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.

CBCS: B. Sc. with CHEMISTRY

Discipline Specific Elective (DSE) Course

CHEMISTRY

(6th Semester)

Course No.: **CHEMISTRY-DSE-601**

(Inorganic Materials of Industrial Importance)

Contact Hours: 60

Full Marks = 70 [End Semester Exam (56) Internal Assessment (14)**]**

Unit I: Silicate Industries

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

16 Lectures, Marks - 15

Unit II: Fertilizers

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

8 Lectures, Marks - 8

Unit III: Surface Coatings

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings, metal spraying and anodizing.

10 Lectures, Marks - 8

Unit IV: Batteries

Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

6 Lectures, Marks - 5

Unit V: Alloys

Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon, decarbonization, demanganization,

desulphurization, dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

10 Lectures, Marks - 10

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut.

CBCS: B. Sc. with CHEMISTRY

Discipline Specific Elective (DSE) Course

CHEMISTRY

(6th Semester)

Course No.: **CHEMISTRY-DSE-601-LAB**

(Inorganic Materials of Industrial Importance)

Contact Hours: 60

Full Marks = 30 [End Semester Exam (24) Internal Assessment (6)**]**

Time: 6 hours

A. ***Any 2 (two) experiment to be set in examination*** **Marks - 10×2 = 20**

a. Determination of free acidity in ammonium sulphate fertilizer.

b. Estimation of Calcium in Calcium ammonium nitrate fertilizer.

c. Estimation of phosphoric acid in superphosphate fertilizer.

d. Electroless metallic coatings on ceramic and plastic material.

e. Determination of composition of dolomite (by complexometric titration).

f. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.

g. Analysis of Cement.

h. Preparation of pigment (zinc oxide).

B. Viva – voce **Marks - 4**

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut.

CBCS: B. Sc. with CHEMISTRY

Skill Enhancement Course (SEC)

CHEMISTRY

(3rd Semester)

Course No.: **CHEMISTRY-SEC-301**

Basic Analytical Chemistry

(Contact Hours-30 Lectures; Credits: 02)

Full Marks = 50 [End Semester Exam (40) Internal Assessment (10)**]**

Unit I: Introduction

Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

3 Lectures, Marks - 4

Unit II: Analysis of soil

Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators

a. Determination of pH of soil samples.

b. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

5 Lectures, Marks - 6

Unit III: Analysis of water

Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

a. Determination of pH, acidity and alkalinity of a water sample.

b. Determination of dissolved oxygen (DO) of a water sample.

4 Lectures, Marks - 6

Unit IV: Analysis of food products

Nutritional value of foods, idea about food processing and food preservations and adulteration.

a. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.

b. Analysis of preservatives and colouring matter.

5 Lectures, Marks - 7

Unit V: Chromatography

Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.

a. Paper chromatographic separation of mixture of metal ion ($Fe^{3+}$and Al^{3+}).

b. To compare paint samples by TLC method.

5 Lectures, Marks - 7

Unit VI: Ion-exchange

Column, ion-exchange chromatography etc.

Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

4 Lectures, Marks - 5

Unit VII: Analysis of cosmetics

Major and minor constituents and their function

a. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.

b. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

4 Lectures, Marks - 5

Suggested Applications (Any one):

a. To study the use of phenolphthalein in trap cases.

b. To analyze arson accelerants.

c. To carry out analysis of gasoline.

Suggested Instrumental demonstrations:

a. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry

b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.

c. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drinks

Reference Books

1. Willard, H.H, Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA,1988.
2. Skoog, D.A., Holler, F.J. & Crouch, S. *Principles of Instrumental Analysis*, Cengage Learning India Edition, 2007.
3. Skoog, D.A.; West, D.M. & Holler, F.J. *Analytical Chemistry: An Introduction 6th Ed.,* Saunders College Publishing, Fort Worth, Philadelphia (1994).
4. Harris, D. C. *Quantitative Chemical Analysis*, 9th ed. Macmillan Education, 2016.
2. Dean, J. A. *Analytical Chemistry Handbook*, McGraw Hill, 2004.
3. Day, R. A. & Underwood, A. L. *Quantitative Analysis*, Prentice Hall of India, 1992.
4. Freifelder, D.M. *Physical Biochemistry 2nd Ed.,* W.H. Freeman & Co., N.Y. USA (1982).
5. Cooper, T.G. *The Tools of Biochemistry,* John Wiley & Sons, N.Y. USA. 16 (1977).
6. Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7th Ed.*, Prentice Hall, 1996.
7. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
8. Robinson, J.W. *Undergraduate Instrumental Analysis 5th Ed.,* Marcel Dekker, Inc., NewYork (1995).
9. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.

CBCS: B. Sc. with CHEMISTRY

Skill Enhancement Course (SEC)

CHEMISTRY
(4th Semester)
Course No.: **CHEMISTRY-SEC-401**
Fuel Chemistry

(Contact Hours-30 Lectures; Credits: 02)

Full Marks = 50 [End Semester Exam (40) Internal Assessment (10)**]**

Unit I:

Review of energy sources (renewable and non-renewable).
Classification of fuels and their calorific value.

4 Lectures, Marks - 4

Unit II:

Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals.

5 Lectures, Marks - 6

Unit III:

Petroleum and Petrochemical Industry: Composition of crude petroleum; Different types of petroleum products and their applications. Principle and process of fractional distillation, Cracking – Thermal and catalytic cracking; Qualitative treatment of non-petroleum fuels- LPG, CNG, LNG, bio-gas, fuels derived from biomass, fuel from waste; synthetic fuels – gaseous and liquids.

9 Lectures, Marks - 12

Unit IV:

Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

6 Lectures, Marks - 8

Unit V:

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting), Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants – viscosity index, cloud point, pore point.

6 Lectures, Marks - 10

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
2. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
3. B. K. Sharma: Industrial Chemistry, Goel Publishing House, Meerut.

CHEMISTRY

(5th Semester)

Course No.: **CHEMISTRY-SEC-501**

Chemistry of Pesticides

(Contact Hours-30 Lectures; Credits: 02)

Full Marks = 50 [End Semester Exam (40) Internal Assessment (10)**]**

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

Practicals

1 To calculate acidity/alkalinity in given sample of pesticide.
2 Preparation of simple organophosphates

Reference Book:

1. R. Cremlyn: *Pesticides*, John Wiley.

CHEMISTRY

(6th Semester)

Course No.: **CHEMISTRY-SEC-601**

Pharmaceutical Chemistry

(Contact Hours-30 Lectures; Credits: 02)

Full Marks = 50 [End Semester Exam (40) Internal Assessment (10)**]**

Unit I: Drugs & Pharmaceuticals

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, lbuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam),Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

20 Lectures, Marks - 20

Unit II: Fermentation

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

10 Lectures, Marks - 10

Unit III: Practicals

1. Preparation of Paracetamol from p-aminophenol.

2. Preparation of magnesium bisilicate (Antacid).

Marks - 10

Reference Books:

1. G.L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK.
2. Hakishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.
3. William O. Foye, Thomas L., Lemke , David A. William: Principles of Medicinal Chemistry, B.I. Waverly Pvt. Ltd. New Delhi.