



SHIVAJI UNIVERSITY, KOLHAPUR - 416004,  
MAHARASHTRA

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शिवाजी विद्यापीठ, लिहापूर - ४१६००४, महाराष्ट्र

दूरध्वनी - ईपीएबीएक्स - २६०९०००, अभ्यासमंडळे विभाग दूरध्वनी विभाग २३१-२६०९०९३/९४



SU/BOS/Science/ ४४

Date: 25/ 11/ 2022

To,  
The Principal,  
All Affiliated Concerned Science Colleges/Institutions  
Shivaji University, Kolhapur.

**Subject: Minor Change in Syllabi of M.Sc. Part -I Chemistry, Applied, industrial, Organic, Inorganic, Physical and Analytical, Chemistry, (NEP-2020) degree Programme under the Faculty of Science and Technology as per National Education Policy 2020.**

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the Minor Change in syllabi of M.Sc. Part -I Chemistry, Applied, industrial, Organic, Inorganic, Physical and Analytical, Chemistry, under the Faculty of Science and Technology.

Sr. No.	Faculty of Science and Technology	Programme/ Course
1	Chemistry and Chemical Engineering	M.Sc. Part -I Chemistry, Applied, industrial, Organic, Inorganic, Physical and Analytical , Chemistry,

This Course Syllabi shall be implemented from the Second term of Academic Year 2022-2023 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website [www.unishivaji.ac.in](http://www.unishivaji.ac.in) (students Online Syllabus)

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Yours faithfully,

By Registrar

Copy to:

1	The Dean, Faculty of Science & Technology	7	Appointment Section
2	Director, Board of Examinations and Evaluation	8	P.G.Seminar Section
3	The Chairman, Respective Board of Studies	9	Computer Centre
4	B.Sc. Exam	10	Affiliation Section (U.G.)
5	Eligibility Section	11	Affiliation Section (P.G.)
6	O.E. I Section	12	P.G.Admission Section



**SHIVAJI UNIVERSITY,  
KOLHAPUR**

**DEPARTMENT OF CHEMISTRY**

**M. SC. CHEMISTRY/APPLIED  
CHEMISTRY/INDUSTRIAL CHEMISTRY  
REVISED SYLLABUS**

**(AS PER NATIONAL EDUCATION POLICY 2020)**

**FROM JULY 2022**

**SHIVAJI UNIVERSITY, KOLHAPUR DEPARTMENT  
OF CHEMISTRY**

**Revised Syllabus for the Master of Science in Chemistry  
(National Education Policy 2020)**

**Applicable from academic year 2022 – 2023 (July 2022)**

1. **Title:** M. Sc. Chemistry, Shivaji University, Kolhapur Revised Syllabus as per NEP 2020.
2. **Faculty:** Faculty of Science and Technology.
3. **Year of Implementation:** For M. Sc. I (Semester I and Semester II): From July 2022 and for M. Sc. II (Semester III and Semester IV): From July 2023.
4. **Programme Outcomes (POs):**
  1. Demonstrate, solve and an understanding of major concepts in all disciplines of chemistry.
  2. Solve the problem and also think methodically, independently and draw a logical conclusion.
  3. Employ critical thinking and the scientific knowledge to design, carry out, record and analyze the results of chemical reactions.
  4. Create an awareness of the impact of chemistry on the environment, society, and development outside the scientific community.
  5. Find out the green route for chemical reaction for sustainable development.
  6. To inculcate the scientific temperament in the students and outside the scientific community.
  7. Use modern techniques, decent equipments and various Chemistry software's

**Programme Specific Outcomes (PSOs):**

1. Critical thinking and the Analytical mind, students develop for the in depth knowledge in advanced-level Chemistry
2. The relevance of extension of Chemistry in the social context for solving social issues
3. Analytical or Experimental Skills make the students capable of doing higher level research works in the emerging fields of chemistry
4. Students will gain a thorough Knowledge in the subject to be able to work in projects at different research as well as academic institutions.
5. Students will become familiar with the different branches of chemistry like analytical, organic, inorganic, physical, environmental, polymer and biochemistry. They will also learn to apply appropriate techniques for the qualitative and quantitative analysis of chemicals in laboratories and in industries.

6. Employability Skills shall enable the students to find jobs in core chemistry and other related fields

7. Entrepreneurial Skills shall empower the students to start their own industries / business in core-chemistry fields

5. The entire course of M. Sc. (Chemistry) will be of **four Semesters** spread over two years.

6. Pattern of Examination: The Examinations will be conducted **semester wise for theory and Practical Examinations annually.**

7. **Fee structure:** As per Shivaji University guidelines.

8. **Eligibility criteria for Admission:** B. Sc. in Chemistry.

a. A student shall be held eligible for admission to the M. Sc. Course in Chemistry who has passed the B. Sc. examination with Chemistry as a principal subject from Shivaji University, Kolhapur and also has passed the entrance examination conducted by the University.

b. A student from other university shall be eligible who qualifies entrance examination of Shivaji University and scores minimum 55% (B<sup>+</sup>) marks in the subject at the B. Sc. with Chemistry as a principal subject or with Chemistry at B. Sc. III level.

c. While preparing merit list the performance at B. Sc. III level and entrance examination will be given equal weightage (50:50).

d. While preparing merit list for other university students, only the marks of entrance examination will be considered.

9. **Medium of Instruction:** English

10. **Structure of course:**

Total No. of Semester: 4

(Two semesters per year) Total No. of Papers: 16

Total No. of Practical course: 16

No. of papers (theory) per semester: 04

No. of practicals course per semester: 04

Maximum marks per paper (practical): 50

Distribution of Marks – Internal evaluation: 20

External evaluation: 80

(Semester exam.)

Total Marks for M.Sc. Degree

Theory Papers: 1600

Practical course: 800

Total: 2400

Total CGPA Credit : 96

Total Non-CGPA: 08

❖ The University department and University affiliated colleges centers offers following

specializations at M. Sc. II (Semester III and IV):

- i) Physical Chemistry
- ii) Inorganic Chemistry
- iii) Organic Chemistry
- iv) Analytical Chemistry
- v) Applied Chemistry (Only at University Department)
- vi) Industrial Chemistry (Only at University Department)

#### **11. Scheme of Teaching and Examination:**

(Applicable to University Department and University affiliated colleges centers)

- a. Each unit in theory course shall comprise 15 lectures, each of 60 minutes' duration and there shall be four lectures per theory course per week.
- b. Entire course of M. Sc. Chemistry will be of **2400** marks. Every Semester will be of 600 marks [400 marks for theory (four courses) and 200 marks for practical].
- c. Examination of each **theory course** shall be of **100 marks** (80 university examination + 20 internal assessment). University examination of 80 marks (3 hours' duration) will be conducted at the end of each Semester. Internal assessment of 20 marks will be done before the semester examination during each semester.
- d. Examination of each practical course shall be of 50 marks.
- e. Question papers will be set in the view of the entire syllabus and preferably covering each unit of the syllabus

#### **12. Standard of Passing:**

There will be separate passing for theory courses and practical courses. Minimum 40% marks will be required for passing separately for theory and practical courses.

#### **13. Nature of Question paper and scheme of marking:**

- Theory question paper: Maximum marks -80
- Total No. of question – 7
- All questions are of equal marks. Out of these seven questions five questions are to be attempted.
- Question No.1 is compulsory and objective/short answer type. Total number of bits is 16 with one mark each.
- Total marks – 16 (which cover multiple choices, fill in the blanks, definition, true or false). These questions will be answered along with other questions in the same answer book.
- Remaining 6 question are divided into two sections, namely section-I and section – II. Four questions are to be attempted from these two section such that not more than two questions from any of the section. Both sections are to be written in the same answer book.

#### **14. Equivalence according with Titles and contents of papers:**

<b>Old Paper</b>	<b>New Paper</b>
Organic Chemistry- I (CH.1.2)	Organic Chemistry- I (CH.1.2)
Physical Chemistry- I (CH.1.3)	Physical Chemistry- I (CH.1.3)
Analytical Chemistry - I (CH.1.4)	Analytical Chemistry - I (CH.1.4)
Inorganic Chemistry- II (CH.2.1)	Inorganic Chemistry- II (CH.2.1)
Organic Chemistry- II (CH. 2.2)	Organic Chemistry- II (CH. 2.2)
Physical Chemistry- II (CH.2.3)	Physical Chemistry- II (CH.2.3)
Analytical Chemistry – II (CH.2.4)	Analytical Chemistry – II (CH.2.4)
Organic Chemistry- I (CH.1.2)	Organic Chemistry- I (CH.1.2)

**15. Special instruction if any: Passing in Non CGPA courses is mandatory**

1. . Detailed titles of papers:

**M. Sc. I, Semester I:**

	Course No.	CourseCode	Course Name	Credits			
CGPA	<b>M. Sc. I, Semester I: Core Course Chemistry Theory</b>						
	Paper I	CH.1.1/APCH1.1/IND1.1	Inorganic Chemistry.-I	4	16	24	
	Paper II	CH.1.2/APCH1.2/IND1.2	Organic Chemistry.-I	4			
	Paper III	CH1.3/APCH1.3/IND1.3	Physical Chemistry.-I	4			
	Paper IV	CH.1.4/APCH1.4/IND1.4	Analytical Chemistry.-I	4			
	<b>M. Sc. I, Semester I: Core Course Chemistry Practical</b>						
	Practical I	CHP.1.1/APCHP1.1/INDP1.1	Inorganic Chemistry.Practical-I	2	8		
	Practical II	CHP.1.2/APCHP1.2/INDP1.2	Organic Chemistry.Practical-I	2			
	Practical III	CHP.1.3/APCHP1.3/INDP1.3	Physical Chemistry Practical -I	2			
	Practical IV	CHP.1.4/APCHP1.4/INDP1.4	Analytical Chemistry Practical-I	2			
Non CGPA		AEC-I	Communicative English-I	2	2		2

**M. Sc. I, Semester II**

	Course No.	CourseCode	Course Name	Credits			
CGPA	<b>M. Sc. I, Semester II: Core Course Chemistry Theory</b>						
	Paper-V	CH.2.1/APCH.2.1/IND.2.1	Inorganic Chemistry.-II	4	16	24	
	Paper-VI	CH.2.2/APCH.2.2/IND.2.2	Organic Chemistry.-II	4			
	Paper-VII	CH.2.3/APCH.2.3/IND.2.3	Physical Chemistry.-II	4			
	Paper-VIII	CH.2.4/APCH.2.4/IND.2.4	Analytical Chemistry.-II	4			
	<b>M. Sc. I, Semester II: Core Course Chemistry Practical</b>						
	Practical V	CHP.2.1/ACHP.2.1/INDP.2.1	Inorganic Chemistry.Practical -II	2	8		
	Practical VI	CHP.2.2/ACHP.2.2/INDP.2.2	Organic Chemistry.Practical-II	2			
	Practical VII	CHP.2.3/ACHP.2.3/INDP.2.3	Physical Chemistry.Practical-II	2			
	Practical VIII	CHP.2.4/ACHP.2.4/INDP.2.4	Analytical Chemistry.Practical-II	2			
Non CGPA		SEC-I	Fundamental of Information Technology:Information Security	2	2		2

➤ The syllabus for AEC-I and SEC-I courses is available on university website link:  
<http://www.unishivaji.ac.in/syllabusnew/On-Campus-Science>

**SEMESTER – I (DURATION 6 MONTHS)**

	Sr. No.	Course Code	Teaching Scheme			Examination Scheme					
			Theory and Practical			University Assessment (UA)			Internal Assessment (IA)		
			Lecture (Per week)	Hours (Per week)	Credit	Maximum Marks	Minimum Marks	Exam Hours	Maximum Marks	Minimum Marks	Exam Hours
CGPA	1	CH.1.1/APCH.1.1/IND1.1	4	4	4	80	32	3	20	8	1
	2	CH.1.2/APCH.1.2/IND1.2	4	4	4	80	32	3	20	8	1
	3	CH.1.3/APCH.1.3/IND1.3	4	4	4	80	32	3	20	8	1
	4	CH.1.4/APCH.1.4/IND1.4	4	4	4	80	32	3	20	8	1
	5	CHP.1.1/APCHP.1.1/INDP.1.1	8	8	4	100	40	--	--	--	*
	6	CHP.1.2/APCHP.1.2/INDP.1.2	8	8	4	100	40	-	-	-	
<b>Total (A)</b>			--	--	24	520	--	--	80	--	--
Non-CGPA	1	SEC-1	2	2	2	--	--	--	50	20	2
<b>SEMESTER – II (DURATION 6 MONTHS)</b>											
CGPA	1	CH.2.1/APCH.2.1/IND.2.1	4	4	4	80	32	3	20	8	1
	2	CH.2.2/APCH.2.2/IND.2.2	4	4	4	80	32	3	20	8	1
	3	CH.2.3/APCH.2.3/IND.2.3	4	4	4	80	32	3	20	8	1
	4	CH.2.4/APCH.2.4/IND.2.4	4	4	4	80	32	3	20	8	1
	5	CHP.2.1/APCHP.2.1/INDP.2.1	8	8	4	100	40	--	--	--	*
	6	CHP.2.2/APCHP.2.2/INDP.2.2	8	8	4	100	40	-	-	-	
<b>Total (B)</b>			--	--	24	520	--	--	80	--	--
Non-CGPA	1	SEC-2	2	2	2	--	--	--	50	20	2
<b>Grand Total (A+B)</b>			--	--	48	1040	--	--	160	--	--



## M. Sc. Part – I (Semester – I)

### Paper- I. Inorganic Chemistry – I(CH.1.1/ APCH.1.1/IND.1.1)

**UNIT-I: 15L**

#### **Chemistry of transition elements**

General characteristic and properties of transition elements, Coordination chemistry of transition metal ions, Stereochemistry of coordination compounds, Crystal field theory for tetrahedral, octahedral, square pyramidal and square planar complexes, Splitting of d- orbital's, Crystal field stabilization energy (CFSE), Factors affecting the crystal field parameters, Strong and weak field complexes, Spectrochemical series, Jahn-Teller effect, Interpretation of electronic spectra including d-d and charge transfer spectra, Nephelauxetic series

**UNIT-II: 15L**

#### **Transition metal carbonyls and related compounds**

Introduction, Preparation, structure, physical and chemical properties of metal carbonyls, Anionic and cationic carbonyl complexes, Lewis base derivatives of carbonyls, Carbonyl hydrides, Carbonyl halides, Miscellaneous derivatives of metal carbonyls, Nitrosyl complexes of transition metals, complexes of molecular nitrogen, Cyanide complexes of transition metals.

**UNIT-III: 15L**

#### **Organometallic Chemistry**

Synthesis, bonding, structure and reactivity of organometallic compounds, Classification of organometallic compounds based on hapticity and polarity of M-C bond, Nomenclature and general characters, 18 electron rule-applications and exceptions, Reactions of organometallic compounds: Oxidative addition, reductive elimination, Insertion and elimination, Organometallics in homogeneous catalysis: Hydrogenation, hydroformylation, isomerisation and polymerization.

**UNIT-IV: 15L**

#### **A) Metal-ligand Equilibrium in solution 8L**

Thermodynamic vs. kinetic stability, Stability constant, Stepwise and overall stability constants with their relation, Trends in stepwise stability constant, Factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, Chelate effect, Ternary complexes and factors affecting their stabilities, Stability of metal complexes of crown ethers, Determination of stability constants by spectrophotometric methods (Job's and Mole/slope ratio for composition), Bjerrum's PH metric method.

#### **B) Nuclear and radiochemistry 7L**

Nuclear stability and nuclear binding energy, Radioactivity and radioactive decay Radioactive equilibrium, Classification of nuclear reactions, Nuclear reaction cross section, Nuclear fission, Nuclear fusion, Applications of radioactivity in agriculture, medical field, and industry.

#### **RECOMMENDED BOOKS**

1. A. F. Wells, Structural Inorganic Chemistry – 5th edition (1984)
2. J. H. Huheey, Inorganic Chemistry-Principles, structure and reactivity, Harper and Row Publisher, Inc. New York (1972)

3. J. D. Lee, Concise Inorganic Chemistry, Elbs with Chapman and Hall, London
4. A. R. West, Plenum, Solid State Chemistry and its applications
5. H. J. Emeleus and A. G. Sharpe, Modern Inorganic Chemistry
6. A. R. West, Basic Solid State Chemistry, 2nd edition
7. M. C. Day and J. Selbin, Theoretical Inorganic Chemistry, Reinhold, EWAP
8. A. H. Hanney, Solid State Chemistry, A. H. Publications
9. O. A. Phiops, Metals and Metabolism
10. Cullen Dolphin and James, Biological aspects of Inorganic Chemistry
11. Williams, An Introduction to Bioinorganic Chemistry
12. M. N. Hughes, Inorganic Chemistry of Biological Processes
13. Ochi, Bioinorganic Chemistry
14. F. A. Cotton, R. G. Wilkinson. Advanced Inorganic chemistry
15. Willam L. Jooly, Modern Inorganic Chemistry
16. Manas Chanda, Atomic Structure and Chemical bonding
17. N. N. Greenwood and A. Earnshaw, Chemistry of elements,. Pergamon
18. S. J. Lippard, J.M . Berg, Principles of bioinorganic Chemistry, University Science Books
19. G. L. Eichhron, Inorganic Biochemistry, Vol I and II, Elsevier
20. Progress Inorganic Chemistry , Vol 18 and 38, J. J. Loppard, Wiley
21. Fundamental Concepts of Inorganic Chemistry (Vol I to VII), A.K. Das and M. Das, CBS Publishers.
22. Inorganic Chemistry, P. Atkins, T. Overtone, J. Rourke, M. Weller, F. Armstrong, 5th Eds., Oxoford University Press.
23. Inorganic Chemistry, H.E. House, Elsevier Publishers.

### **Inorganic Chemistry Practical Course( CHP.1.1/APCHP.1.1/INDP.1.1)**

#### **Semester-I, Inorganic Chemistry Practicals**

- A) Ore Analysis  
Determination of Silica and Manganese in pyrolusite Determination of iron from hematite.
- B) Alloy Analysis  
Determination of tin & lead from solder Determination of copper and nickel from monel metal
- C) Preparations and purity (Any four)
  - ✓ Potassium trioxalatochromate(III) trihydrate
  - ✓ cis-potassium dioxalatoaquachromate(III)
  - ✓ Potassium hexathiocyanatochromate(III)
  - ✓ Bis(dimethylglyoximate)nickel(II)
  - ✓ Carbonatotetramminocobalt(III) nitrate
  - ✓ Hexamminocobaltic(III) chloride
- D) Determination of concentration of phosphates in water samples colorimetrically

## RECOMMENDED BOOKS

1. A text book of Quantitative Inorganic Analysis – A. I. Vogel
2. Experimental Inorganic Chemistry - W. G. Palmer
3. The analysis of minerals and ores of the rarer elements – W. R. Schoeller and A.R. Powell, Charles, Griffin and Company Limited.
4. Experimental Inorganic/Physical Chemistry – M.A. Malti, Horwood Series in Chemical Science, Horwood Publishing Chinchster.

## Paper – II, Organic Chemistry-I(CH.1.2/APCH.1.2/IND.1.2)

### UNIT-I

15L

#### A) Reaction Mechanism: Structure and Reactivity

8L

Types of reactions, strength of acids and bases. Generation, structure, stability and reactivity of carbenes, arynes, nitrenes and effect of structure on reactivity, resonance and field, steric effects. Thermodynamic and Kinetic requirements, Introduction to Kinetic and Thermodynamic control reaction.

#### B) Aliphatic Nucleophilic substitutions

7L

The SN<sub>2</sub>, SN<sub>1</sub> and SN<sub>i</sub> reactions with respects to mechanism and stereochemistry. Nucleophilic substitutions at an allylic, aliphatic trigonal, benzylic, and vinylic carbons. Reactivity effect of substrate structure, effect of attacking nucleophiles, leaving groups and reaction medium. SN reactions at bridge head carbon, competition between SN<sub>1</sub> and SN<sub>2</sub>, Ambident nucleophiles, Neighbouring Group Participation.

### UNIT-II

15L

#### A) Introduction to aromaticity in Benzenoid and non – Benzenoid compounds.7L

Three, four and five membered systems. tropone, tropolone, tropylium salts.

#### B I] Aromatic Electrophilic Substitutions

8L

Introduction, the arenium ion mechanism, orientation and reactivity in Nitration, Sulphonation, Friedel-Crafts and Halogenation in aromatic systems, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in their ring systems. Diazo-coupling, Vilsmeier- Haak reaction, Von Richter rearrangement

#### II] Nucleophilic aromatic substitution reactions SN<sub>1</sub>, SN<sub>2</sub>.

### UNIT-III

15L

#### A) Elimination Reactions

5L

The E1, E2 and E1cB mechanisms. Orientation in Elimination reactions. Hofman versus Saytzeff elimination, Reactivity: effects of substrate structures, attacking base, the leaving group, the nature of medium on elimination reactions. Pyrolytic elimination reactions

### **B. Study of following reactions**

**10L**

Mechanism of condensation reaction involving enolates, Benzoin, Stobbe, Robinson annulation, Simon-Smith, Vlhmann, Mc-Murry, Dakin, prins, Wurtz-Fittig reaction, Hunsdiecker reaction, Pummerer, , Rupe, Gabriel-Colman, Corey-Chaykovsky reaction, Nef reaction, Passerini reaction, Baylis-Hilman reaction, Mitsunobu Reaction.

### **UNIT-IV**

**15L**

Stereochemistry: Concept of chirality Prochiral relationship, homotopic, enantiotopic and diastereotopic groups and faces. Racemic modifications and their resolution, R and S nomenclature. Conformational analysis : Cyclohexane derivatives, stability and reactivity, Conformational analysis of disubstituted cyclohexanes. Introduction of optical activity in the absence of chiral carbon (spiranes and allenes)

### **RECOMMENDED BOOKS**

1. A guide book to mechanism in Organic chemistry (Orient-Longmans)- Peter Sykes
2. Organic Reaction Mechanism (Benjamin) R. Breslow
3. Mechanism and Structure in Organic chemistry (Holt Reinh.)E. S. Gould.
4. Organic Chemistry(McGraw-Hill)Hendrikson, Cram and Hammond.
5. Basic principles of Organic Chemistry (Benjamin) J. D. Roberts and M. C. Caserio.
6. Reactive Intermediates in Organic Chemistry (John Wiley)N. S. Issacs.
7. Stereochemistry of Carbon compounds. (McGraw-Hill)E.L. Eliel
8. Organic Stereochemistry (McGraw-Hill) by Hallas.
9. Organic Reaction Mechanism (McGraw-Hill) R. K. Bansal.
10. Organic Chemistry- R. T. Morrison and R. N. Boyd,(Prentice Hall.)
11. Modern Organic Reactions(Benjamin) H. O. House.
12. Principle of organic synthesis- R.O.C. Norman and J. M. Coxon.(ELBS)
13. Reaction Mechanism in Organic Chemistry- S. M. Mukharji and S. P. Singh.
14. Stereochemistry of Organic compounds D. Nasipuri.
15. Advanced Organic Chemistry (McGraw-Hill) J. March.
16. Introduction to stereochemistry(Benjamin) K. Mislow.
17. Stereochemistry by P. S. Kalsi (New Age International)
18. Organic chemistry- Jonathan clayden.

### **Semester-I, Organic Chemistry Practical Course( CHP.1.1/APCHP.1.1/INDP.1.1)**

#### **ORGANIC CHEMISTRY PRACTICALS**

##### **A) Preparations**

(One stage preparations involving various types of reactions and confirmation of product by TLC)

1. Coumarin Synthesis- 7-OH-4-methyl coumarin from Resorcinol and EAA.
2. Knoevenagel condensation reaction-Reaction of aldehyde and malononitrile.

3. Preparation of Hydrantoin.
4. Synthesis of triazoles- Reaction of aldehyde and thiosemicarbazide.
5. Preparation of benzimidazole from OPD,
6. Preparation of Orange II
7. Fischer Indole Synthesis- Reaction of phenyl hydrazine and cyclohexanone. (Any suitable Expt. may be added)

B) Estimations:

1. Estimation of Unsaturation.
2. Estimation of formalin.
3. Colorimetric Estimation of Dyes.
4. Estimation of Amino acids.
5. Estimation of Glycine.  
(Any suitable Expt. may be added.)

### RECOMMENDED BOOKS

1. A text book of practical organic chemistry- A. I. Vogel.
2. Practical organic chemistry- Mann and Saunders.
3. A handbook of quantitative and qualitative analysis- H. T. Clarke.
4. Organic Synthesis Collective Volumes by Blat.
5. Practical Med. Chem.- Dr. K. N. Jayveera, Dr. S. Subramanyam, Dr. K. Yogananda Reddy.

### Paper – III, Physical Chemistry-I (CH.1.3/APCH.1.3/IND.1.3)

#### UNIT-I: THERMODYNAMICS

15L

Introduction, revision of basic concepts: Entropy and third law of thermodynamics. Methods of determining the practical absolute entropies. Entropies of phase transition. Maxwell relations and its applications, thermodynamic equation of state.

Ideal and non-ideal solutions, Thermodynamics of nonelectrolyte solutions. Raoult's law. Duhem-Margules equation and its applications to vapor pressure curves (Binary liquid mixture). Gibbs-Duhem equation and its applications to study of partial molar quantities. chemical potential, variation of chemical potential with temperature & pressure. Henry's law. Excess and mixing thermodynamic properties. Equilibrium constants and general conditions of equilibrium in terms of thermodynamic potentials. Numerical Problems.

#### UNIT-II: STATISTICAL THERMODYNAMICS

15L

Probability and distribution, Stirling Approximation, Weights and configurations, the most probable configuration, Ensembles, ensemble average and time average of property. Statistical equilibrium, thermodynamic probability, Maxwell-Boltzmann (MB) distribution law.

Partition function and its significance. Rotational, translational, vibrational and electronic partition functions. Relationship between partition function and thermodynamic properties.

thermodynamic probability and entropy: Boltzmann – Planck equation, Partition function and third law of thermodynamics, Application to monoatomic gases - Sackur tetrode equation, applications to diatomic molecules, Statistical expression for equilibrium constant, Limitations of Maxwell-Boltzmann statistics, Numerical Problems.

### **UNIT-III: COLLOIDS AND SURFACE PHENOMENA**

**15L**

Colloidal Systems-Sols, Lyophilic and lyophobic sols, properties of sols, coagulation. Sols of surface active reagents, surface tension and surfactants, electrical phenomena at interfaces including electrokinetic effects, micelles, reverse micelles, solubilization. Thermodynamics of micellisation, critical micelle concentration, factors affecting critical micelle concentration (cmc), experimental methods of cmc determination, Micellar catalysis.

Adsorption, adsorption isotherms, methods for determining surface structure and composition, BET equation, surface area determination, Gibbs adsorption equation and its verification. Application of photoelectron spectroscopy, ESCA and Auger spectroscopy to the study of surfaces. Numerical Problems.

### **UNIT-IV**

**15L**

#### **MACROMOLECULES**

Macromolecules: Mechanism of polymerization, molecular weight of a polymer (Number and mass average ) viscosity average molecular weight, numerical problems. Degree of polymerization and molecular weight, practical significance of polymer molecular weight, methods of determining molecular weights (Osmometry, viscometry, light scattering, diffusion and ultracentrifugation)

Chemistry of polymerization: Ceiling temperature, Free radical polymerization (Initiation, propagation and termination ), kinetics of free radical polymerization, step growth polymerization (Polycondensation), molecular weight distribution, kinetics of step polymerization, cationic and anionic polymerization. Electronically conducting polymers, thermodynamics of polymer solutions: Flory-Huggins Theory. Glass transition temperature and molecular weight, factors influencing Glass transition temperature, determination of glass transition temperature

#### **RECOMMENDED BOOKS**

1. Physical Chemistry – P. W. Atkins, Oxford University press, 8th edition, 2006.
2. Text book of Physical Chemistry – S. Glasstone.
3. Principles of Physical Chemistry – Marron and Pruton.
4. Physical Chemistry – G. M. Barrow, Tata-McGraw Hill, Vth edition, 2003.
5. Thermodynamics for Chemists – S. Glasstone, D. Van Nostrand , 1965.
6. Thermodynamics: A Core Course- R. C. Srivastava, S. K. Saha and A. K. Jain, Prentice-Hall of India, IInd edition, 2004.
7. Elements of statistical thermodynamics - L. K. Nash, 2nd Ed. Addison Wesley 1974.
8. Theoretical Chemistry: An introduction to quantum mechanics, statistical mechanics, and molecular spectra for chemists - S. Glasstone, D. Van Nostrand Company, Inc., 1944.

9. An Introduction to Statistical Thermodynamics – T.L. Hill, Addison-Wesley. 1960.
10. Statistical Mechanics – Donald A. McQuarrie, 2000.
11. Physical chemistry of surfaces – A. W. Adamson, 4th Ed. John Wiley, 1982.
12. Introduction to Colloid and Surface Chemistry – D. Shaw, Butterworth Heinemann, 1992.
13. Surface Activity: Principles, Phenomena and Applications (Polymers, Interfaces and Biomaterials) – K. Tsujii, 1st Ed. Academic Press, 1998.
14. Physical Chemistry of macromolecules- D. D. Deshpande, Vishal Publications.
15. Polymer Chemistry- F. W. Billmeyer Jr, John-Wiley & Sons, 1971.

### **Semester-I, Physical Chemistry Practical Course( CHP.1.2/APCHP.1.2/INDP.1.2)**

#### **Physical Chemistry Practicals**

Students are expected to perform at least 8 experiments of three and half hours duration. Experiments are to be set up in the following techniques.

#### **Potentiometry:**

1. Determination of solubility and solubility product of silver halides.
2. Determination of binary mixture of weak and strong acid.

#### **Conductometry:**

3. Determination of mixture of acids and relative strength of weak acids.
4. Determination of solubility of lead sulphate.
5. Determination of CMC and  $\Delta G$  of sodium dodecyl sulphate.

#### **Refractometry:**

6. Determination of molecular radius of molecule of organic compound.
7. Determination of concentration of sugar in unknown sample.

#### **Polarimetry:**

8. Kinetics of inversion of cane sugar in presence of strong acid.

#### **pH- metry:**

9. Determination of dissociation constant of dibasic acid.

#### **Chemical Kinetics:**

10. Kinetics of reaction between bromate and iodide.

#### **Adsorption:**

11. Study of adsorption of acetic acid on charcoal.

#### **Viscosity:**

12. Determination of molecular weight of polymers (New experiments may be also be added)

#### **Books recommended for Practicals:**

1. Findlay's Practical Chemistry – Revised by J.A. Kitchner (V edition)
2. Text Book of Quantitative inorganic analysis : A.I. Vogel.

3. Experimental Physical Chemistry : R. C. Das and B. Behera
4. Practical Physical Chemistry : B. Viswanathan and P.S. Raghavan
5. Experimental Physical Chemistry :V.D. Athawale and Parul Mathur.
6. Systematic Experimental Physical Chemistry :S.W. Rajbhoj and T.K. Chondhekar
7. Advanced practicals in physical chemistry-Datar and Doke
8. Practical Physical Chemistry- B. D. Khosla, V. C. Garg, A. Gulati

**Paper - IV Analytical Chemistry –I(CH.1.4/APCH.1.4/IND.1.4)**

**UNIT-I**

**15L**

**Basics of Analytical Chemistry, Errors, treatments and statistics**

Analytical Chemistry, Chemical analysis, instrumental methods, Analytical methods, Techniques of analysis, classification of analytical techniques, Classification of instrumental methods, factors affecting choice of analytical methods, interferences.

Types and sources of error, determinate and indeterminate errors, accuracy and precision Absolute and relative errors, Minimisation of errors, Significant figures, Mean, median and standard deviation, Least square method.

Sampling, Types of sampling, Techniques of sampling of gases, fluids, solids, and particulates. Good Laboratory Practices

**Problems.**

**UNIT-II**

**15L**

**Fundamentals of Quantitative Analysis**

Introduction, general terms in volumetric analysis, indicators, indicator theory, choice of indicators. Acid-base titrations, titration curves with example, Buffer solutions, acid-base equilibria in- polyprotic acids, amino acids, carbonates, bicarbonates, mixture of two acids.

Complexometric titrations-stability of complexes, metal-ion buffer, titrations involving unidentate and multidentate ligands.

Precipitation titrations and solubility equilibria, indicators, factors affecting solubility, applications of precipitation titrations.

Oxidation-reduction equilibria and applications, Nernst equation, titration curves, redox indicators, applications with respect to  $\text{KMnO}_4$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$ , Iodine, and Potassium bromate.

Gravimetric Analysis: Introduction, general terms used in gravimetry, steps in gravimetric analysis, conditions for precipitation, purity of the precipitate – Co-precipitation and Post-precipitation, precipitation from homogenous solution, organic precipitants. Advantages and disadvantages of gravimetric analysis. Determination of iron gravimetrically from iron ore, determination of lead gravimetrically from Galena ore, determination of Pb gravimetrically from type metal alloy.

**Problems.**



### UNIT-III

15L

#### Chromatographic methods

General principle, classification of chromatographic methods, migration rates of solutes, chromatographic behaviour of solutes, band broadening, column efficiency and resolution.

Thin layer chromatography, basic principle, coating materials, solvent-solvent system, analytical and preparative TLC, methods of detection, applications and advances in TLC including modern TLC techniques.

Column chromatography: Principle and theory, adsorption and partition methods, stationary and mobile phase, columns and preparation of the columns, solvent systems, normal phase, reverse phase, detection methods and applications. Possible hyphenations- Advantages and limitations.

Gas Chromatography: Basic Principle, Instrumentation, detectors, Applications, Advantage and disadvantages.

HPLC: Basic Principle, Instrumentation, detectors, applications, advantage and disadvantages.

Ion exchange chromatography: Introduction and basic principles, instrumentation, types of exchangers, synthesis of ion exchangers, mechanism of ion exchange, exchange theories, methodology, applications.

#### Problems.

### UNIT-IV

15L

#### Electro Analytical Techniques

Polarography: Introduction, Instrumentation, Ilkovic equation and its verification. Polarographic measurements, Dropping mercury electrode, Determination of half wave potential, qualitative and quantitative applications.

Amperometry: Basic principles, instrumentation, Amperometric titration curves, Amperometric indicators, procedure for Amperometric titrations, Evaluation of amperometry in research and analytical applications.

Voltametry: Voltammetric methods of analysis, basic principles, instrumentation, voltammetric measurements, voltammetric techniques, current in voltammetry, shape of voltammograms, quantitative and qualitative aspects of voltammetry, quantitative applications, characterization applications, Evaluation of CV in research and analytical applications.

#### Problems.

#### RECOMMENDED BOOKS

1. Analytical Chemistry: (J.W) G. D. Christain.
2. Instrumental Methods of analysis (CBS)- H.H . Willard, L.L. Merrit, J.A. Dean
3. Quantitative analysis, R.A. Day and A.L. Underwood, Prentice-Hall of India Pvt Ltd, New Delhi
4. Instrumental Methods of Analysis: Chatwal and Anand
5. Instrumental Methods of Inorganic Analysis (ELBS) : A.I. Vogel
6. Chemical Instrumentation: A Systematic approach- H.A. Strobel

7. Physical Chemistry – P.W. Atkins
8. Principal of Instrumental Analysis- D. Skoog and D. West
9. Treatise on Analytical Chemistry: Vol I to VII – I.M. Kolthoff
10. Instrumental methods of chemical analysis, H. Kaur
11. Principles of Instrumental analysis, Holler, Skoog, Crouch
12. Chromatographic methods- H. Kaur
13. Analytical Chemistry-Alka Gupta
14. Analytical Chemistry-H. Kaur
15. Advanced Practical Inorganic Chemistry, Gurdeep Raj

### **Semester-I, Analytical Chemistry Practical Course( CHP.1.2/APCHP.1.2/INDP.1.2)**

#### **Analytical Chemistry Practicals**

1. To verify Beer-Lambert's Law for potassium permanganate solution and hence to determine the molar extinction coefficient and unknown concentration of given sample Spectrophotometrically
2. To determine the iron potentiometrically by titrating with potassium dichromate
3. To determine the solubility of Calcium oxalate in presence of different concentration of KCl
4. To determine the solubility of Calcium oxalate in presence of different concentration of HCl
5. Analysis of pharmaceutical tablets for ibuprofen content
6. To verify the Beer-Lamberts Law and determine the concentration of given organic dye solution colorimetrically/spectrophotometrically.
7. To estimate the amount of D-glucose in given solution colorimetrically.
8. To determine the acid value of given oil
9. Determination of standard deviation from the results obtained by redox titration of iron solution against standard potassium dichromate solution
10. Determination of sodium from the fertilizer sample using cation exchange chromatography
11. Determination of calcium from given drug sample.
12. Determination of hardness, alkalinity and salinity of water sample
13. Separation and estimation of  $\text{Cd}^{2+}$  and  $\text{Zn}^{2+}$  by ion exchange chromatography for given  $\text{Cd}^{2+}$  and  $\text{Zn}^{2+}$  mixture.

(Any other experiments may be added)

#### **RECOMMENDED BOOKS**

1. Instrumental Methods of analysis- Willard, Merrit, Dean and Settle.
2. Spectroscopic identification of organic compounds- R.M. Silverstein and G.C. Bassler
3. Spectroscopic methods in organic chemistry- D.H. Williams and I. Fleming
4. Absorption spectroscopy of organic molecules- V.M. Parikh
5. Applications of spectroscopic techniques in Organic chemistry- P. S. Kalsi
6. A Text book of Qualitative Inorganic Analysis- A. I. Vogel
7. Physical Methods in Inorganic Chemistry (DWAP)- R. Drago
8. Fundamentals of Analytical Chemistry – D.A. Skoog and D. M. West (Holt Rinehart and Winston Inc.)
9. Principles of instrumental analysis, Holler, Skoog, Crouch. Cengage learning India Pvt. Ltd.
10. Instrumental methods of chemical analysis, H. Kaur, Pragati Prakashan.

**M. Sc. Part – I (Semester – II)**

**Paper- V. Inorganic Chemistry – II (CH.2.1/APCH.2.1/IND.2.1)**

**UNIT-I**

**15L**

Chemistry of Non-transition Elements and their compounds

General discussion on the properties of the non-transition elements, Polymorphism in carbon, phosphorous and sulphur, Synthesis, properties and structure of boranes, carboranes, silicates, carbides, phosphazenes, sulphur-nitrogen compounds, peroxy compounds of boron, carbon, sulphur, structure and bonding in oxyacids of nitrogen, phosphorous, sulphur and halogens, interhalogens, pseudohalides

**UNIT-II**

**15L**

**A) Stereochemistry and bonding in Main group compounds**

**8L**

Hybridization and structure of molecules, VSEPR Theory,  $p\pi-p\pi$  and  $p\pi-d\pi$  bonds, Bent rule, Walsh Diagram, Back bonding, Some simple reactions of covalently bonded molecules (atomic inversion, Berry Pseudorotation, Nucleophilic displacement, free radical reaction).

**B) Non-aqueous solvents**

**7L**

Classification of solvents, Characteristics of solvents, Types of reactions in solvents, Physical and chemical properties of the non-aqueous solvents such as liquid ammonia, sulphur dioxide, dinitrogen tetroxide, anhydrous sulphuric acid and molten salts.

**UNIT-III**

**15L**

**Chemistry of f-block elements (Lanthanides and Actinides)**

Occurrence, properties of the f-block elements, colour, oxidation state, Spectral and magnetic properties of lanthanides and actinides, lanthanide contraction, Use of lanthanide compounds as shift reagents, compounds of lanthanides, Photoluminescence properties of lanthanide compounds, Modern methods of separation of lanthanides and actinides, Applications of lanthanide and actinide compounds in Industries.

**UNIT-IV**

**15L**

**A) Solid state chemistry**

**8L**

Crystal structure, Crystal types, Crystal defects, Electronic structure of solids, Band theory, Theory of Metals, Semiconductors and Insulators, Superconductivity, optical and magnetic properties, Solid state reactions, AB [Nickel arsenide (NiAs)],  $AB_2$  [fluorite ( $CaF_2$ ) and anifluorite], layer structure [cadmium chloride and iodide ( $CdCl_2$  &  $CdI_2$ )]

**B) Bioinorganic Chemistry**

**7L**

Role of metal ions in biological processes, structure and properties of metalloproteins, porphyrines, metalloenzymes, oxygen transport, electron transfer reactions, cytochromes, ferredoxins and iron sulphur proteins, ion transport across membranes, Nitrogen fixation-nitrogenase, metal complexes in medicines.

## RECOMMENDED BOOKS:

1. A. F. Wells, Structural Inorganic Chemistry – 5th edition (1984)
2. J. H. Huheey, Inorganic Chemistry - Principles, structure and reactivity, Harper and Row Publisher, Inc. New York (1972)
3. J. D. Lee, Concise inorganic Chemistry, Elbs with Chapman and Hall, London
4. M. C. Day and J. Selbin, Theoretical Inorganic Chemistry, Reinhold, EWAP
5. Jones , Elementary coordination Chemistry
6. Martell, Coordination Chemistry
7. T. S. Swain and D. S. T. Black, organometallic Chemistry
8. John Wulff, structure and properties of materials, vol – 4, electronic properties, Wiley Eastern
9. L. V. Azoroff, J. J. Brophy, Electronic processes in materials, Mc Craw Hill
10. F. A. Cotton, R. G. Wilkinson. Advanced Inorganic chemistry
11. Willam L. Jooly, Modern Inorganic Chemistry
12. Manas Chanda, Atomic Structure and Chemical bonding
13. P. L. Pauson, Organometallic Chemistry
14. H. S. Sisler, Chemistry in non – aqueous solvents, Reinhold Publishing Corporation, USA,  
4th edition (1965)
15. H. J. Arnikar, Essentials of Nuclear Chemistry
16. Friedlander, Kennedy and Miller, Nuclear and Radiochemistry.
17. Fundamental Concepts of Inorganic Chemistry (Vol I to VII), A.K. Das and M. Das, CBS Publishers.
18. Inorganic Chemistry, P. Atkins, T. Overtone, J. Rourke, M. Weller, F. Armstrong, 5th Eds.,  
Oxford University Press.
19. Inorganic Chemistry, H.E. House, Elsevier Publishers.

## Semester-II, Inorganic Chemistry Practical Course ( CHP.2.1/APCHP.2.1/INDP.2.1)

### Inorganic Chemistry Practicals

- A) Ore Analysis  
Determination of calcium and magnesium from Dolomite Determination of copper and iron from chalcopyrite
- B) Alloy Analysis  
Determination of copper and zinc from brass alloy.  
Determination of iron & chromium from steel.
- C) Preparations and purity (Any four)
- ✓ Tris(acetylacetonato)cobalt(III) trihydrate
  - ✓ Pentaquachlorochromium(III) chloride
  - ✓ Hexathioureaplumbus(II) nitrate
  - ✓ Bis(acetylacetonato)copper(II)
  - ✓ Diaquabis(ethylenediamine)copper(II) iodide

- ✓ Copper ferrite  
D) Separation of  $\text{Fe}^{2+}$   $\text{Cu}^{2+}$   $\text{Ni}^{2+}$  by anion exchange

### RECOMMENDED BOOKS

- 1 A text book of Quantitative Inorganic Analysis – A. I. Vogel
- 2 Experimental Inorganic Chemistry- W. G. Palmer
- 3 The analysis of minerals and ores of the rarer elements – W. R. Schoeller
- 4 A. R. Powell, Charles, Griffin and Company Limited

### Paper-VI. Organic Chemistry-II (CH.2.2/APCH.2.2/IND.2.2)

#### UNIT-I

15L

##### A) Study of following rearrangements

5L

Curtius, Lossen, Witting, Neber, Ortaon, Hofmann-Martius and Demjanov reaction.

##### B) Photochemistry

10L

Effect of light intensity on the rate of photochemical reactions. Types of photochemical reactions, photochemistry of alkynes, intramolecular reactions of the olefinic bonds, geometrical isomerism, cyclisation reactions, rearrangements of 1,4 and 1,5-dienes, photochemistry of carbonyl compounds, intramolecular reactions of carbonyl compounds saturated cyclic and acyclic  $\alpha$ ,  $\beta$ -unsaturated compounds, cyclohexadienones, intermolecular cycloaddition reactions, dimerisation and oxitane formation, photochemistry of aromatic compounds, photo fries reactions of anilides, photo fries rearrangements. Singlet molecular oxygen reactions.

#### UNIT-II

15L

##### A) Hydroboration

4L

Various hydroborating agents their mechanism and synthetic applications *viz* 9-borabicyclo-[3.3.1]nonane (9-BBN), thexylborane, H B diisoamylborane. (Sia<sub>2</sub>BH) BH<sub>3</sub>•SMe<sub>2</sub>. (BMS), Borane as reducing agent.

##### B) Enamins

4L

Formation, reactivity and synthetic applications of enamines

##### C) Oxidation

7L

Applications of oxidizing agents like chromium trioxide, manganese dioxide, Woodward-Prevost hydroxylation, Chloranil, hydrogen peroxide. Swern oxidation. PCC(Corey's reagent), PDC(Cornforth reagent), Baeyer-Villiger oxidation.

#### UNIT-III

15L

##### A) Reductions

9L

Study of following reductions- Catalytic hydrogenation using homogeneous and heterogeneous catalysts. Study of following reducing reagents and reactions: Wolff-Kishner, Birch, Sodium cyano borohydride, Sodium in alcohol, Fe in HCl, Adam's catalyst, Lindlar catalyst, TBTH.

**B) Protection of functional group** **6L**  
Principle of protection of alcohol, amine, carbonyl and carboxyl groups.

**UNIT-IV** **15L**

**A) Study of Organometallic compounds** **8L**  
Organo-lithium, Use of lithium dialkyl cuprate, their addition to carbonyl and unsaturated carbonyl compounds. Study of coupling reactions *viz* Heck, Suzuki, Stille, Nigeshi and Sonogashira coupling.

**B) Methodologies in organic synthesis** **7L**  
Ideas of syntheses and retrones, Functional group transformations and inter conversions of simple functionalities.

### RECOMMENDED BOOKS

1. Modern synthetic reactions-(Benjamin) H. O. House.
2. Reagents in organic synthesis-(John Wiley) Fieser and Fieser
3. Principles of organic synthesis-(Methuen) R. O. C. Norman
4. Hydroboration- S. C. Brown.
5. Advances in Organometallic Chemistry- (A.P.)F. C. A. Stone and R. West.
6. Organic Chemistry (Longman)Vol. I & Vol. II- Finar
7. Oxidation by-(Marcel Dekker) Augustin
8. Advanced Organic chemistry 2nd Ed. R R. Carey and R. J. Sundburg.
9. Tetrahedron reports in organic chemistry- Vol.1, No. 8.
10. Organic Synthesis-(Prentice Hall)R. E. Ireland.
11. Homogeneous Hydrogenation-(J. K.) B. R. James.
12. Comprehensive Organic Chemistry- (Pargamon) Barton and Ollis.
13. Organic reactions- various volumes- R. Adams.
14. Some modern methods of Organic synthesis-(Cambridge) W. Carruthares.
15. Organic chemistry- Jonathan clayden.

### Semester-II, Organic Chemistry Practical Course ( CHP.2.1/APCHP.2.1/INDP.2.1)

#### Organic Chemistry Practicals

1. Qualitative analysis:  
Separation and identification of the two component mixtures using Chemical and physical methods.
2. Thin layer chromatography (TLC).
3. Column chromatography and steam distillation techniques.
4. Determination of percentage of Keto-enol form.
5. Estimation of Ibuprofen.
6. Estimation of Aspirin.
7. Verify Beer-Lamberts Law by Colorimetric method.  
( Any other suitable experiments may be added).

## RECOMMENDED BOOKS

1. A text book of practical organic chemistry- A. I. Vogel.
2. Practical organic chemistry- Mann and Saunders.
3. A handbook of quantitative and qualitative analysis- H. T. Clarke.
4. Organic Synthesis Collective Volumes by Blat.

## Paper-VII. PHYSICAL CHEMISTRY – II (CH.2.3/APCH.2.3/IND.2.3)

### UNIT-I: QUANTUM CHEMISTRY 15L

Introduction: Wave particle duality of material and De Broglie's hypothesis, uncertainty principle, Schrodinger equation, wave function, conditions for acceptable wave functions and its interpretation, properties of wave functions, Operators and related theorems, algebra of operators, commutator, linear operators, Normalization and orthogonality, Eigen functions and Eigen values, postulate of quantum mechanics. Solutions of wave equation for a free particle and particle in a box problem, Transition dipole moment integral and selection rules, particle in a box application to electronic spectra of conjugated linear organic molecules.

Linear and angular momentum operators, eigen function and eigen values of angular momentum operator, Ladder operator, addition of angular momenta. Spin angular momenta, symmetric and antisymmetric wavefunctions, Pauli Exclusion Principle, spectroscopic term symbols.

### UNIT-II: PHOTOCHEMISTRY 15L

Absorption of light, laws of photochemistry, electronic structure of molecules, molecular orbital, electronically excited singlet states, designation based on multiplicity rule, construction of Jablonski diagram, electronic transition, Frank Condon principle, selection rules, intensity of absorption bands, nature of electronic spectra and primary process, photo- dissociation, pre-dissociation, Photo physical phenomena: photo-physical pathways of excited molecular system (radiative and non-radiative), prompt fluorescence, delayed fluorescence, and phosphorescence, fluorescence quenching: concentration quenching, collisional quenching, quenching by excimer and exciplex emission, fluorescence resonance energy transfer between photo-excited donor and acceptor systems. Stern-Volmer relation, critical energy transfer distances, energy transfer efficiency, examples and applications in chemical analysis. Photochemical reactions, photo-oxidation, photoreduction, photo- dimerization, photoisomerization and photosensitized reactions. Photochemistry of environment: Greenhouse effect.

### UNIT-III: ELECTROCHEMISTRY 15L

Activity and Activity coefficients: forms of activity coefficients and their interrelationship, Types of electrodes, Determination of activity coefficients of an electrolyte using concentration cells, instability constant of silver ammonia complex. Acid and alkaline storage batteries, Abnormal ionic conductance of hydroxyl and hydrogen ions.

Electrokinetic phenomena: Electrical double layer, theories of double layer-Helmholtz-Perrin theory, Gouy and Chapman theory, Stern theory. electro-capillary phenomena, electro- capillary curve. Electro-osmosis, electrophoreses. Streaming and Sedimentation potentials. Zeta potentials and its determination by electrophoresis, influence of ions on Zeta potential.

#### **UNIT-IV: CHEMICAL KINETICS**

**15L**

Introduction to basic concepts, Experimental methods of following kinetics of a reaction, chemical and physical (measurement of pressure, volume, EMF, conductance, diffusion current and absorbance) methods and examples. Steady state approximation and study of reaction between  $\text{NO}_2$  and  $\text{F}_2$ , decomposition of ozone, and nitrogen pentoxide. Ionic reaction: Primary and secondary salt effect,

Catalysis: Classification of catalysis, mathematical expression of autocatalytic reactions, Michaelis–Menten enzyme catalysis, Homogeneous catalysis: acid and base catalyzed reactions, Heterogeneous catalysis: Adsorption of gas on a surface and its kinetics, Catalyzed hydrogen-deuterium exchange reaction.

#### **RECOMMENDED BOOKS:**

1. Introductory Quantum Chemistry - A. K. Chandra. Tata McGraw-Hill. 1988.
2. Physical Chemistry: A molecular Approach – Donald A. McQuarrie and John D. Simon, Viva Books, New Delhi, 1998.
3. Quantum Chemistry – Donald A. McQuarrie, Viva Books, New Delhi, 2003.
4. Physical Chemistry – P. W. Atkins, Oxford University press, VIth edition, 1998.
5. Quantum Chemistry - W. Kauzmann, Academic press.
6. Theoretical Chemistry: An introduction to quantum mechanics, statistical mechanics, and molecular spectra for chemists - S. Glasstone, D. Van Nostrand Company, Inc., 1944.
7. Quantum Chemistry - R.K. Prasad, New Age International, New Delhi.
8. Physical Chemistry – R.S. Berry, S.A. Rice, J. Ross, 2nd Ed., Oxford University Press, New York, 2000.
9. Photochemistry – J. G. Calverts and J. N. Pitts, John-Wiley & Sons
10. Fundamentals of Photochemistry- K. K. Rohatgi-Mukharjii, Wiley Eastern
11. Introduction to Photochemistry-Wells
12. Photochemistry of solutions-C. A. Parker, Elsevier
13. An Introduction to Electrochemistry by S. Glasstone
14. Modern Electrochemistry Vol. I & II by J. O. M. Bockris and A.K.N. Reddy.
15. Electrolytic Solutions by R. A. Robinson and R. H. Strokes, 1959
16. Chemical Kinetics-K. J. Laidler, Pearson Education, 2004
17. Kinetics and Mechanism - A. A. Frost and R. G. Pearson.
18. Electrochemistry- S. Glasstone, D. Van Nostrand , 1965
19. Advanced Physical Chemistry- Gurdeep Raj, Goel Publishing House
20. Basic chemical Kinetics- G. L. Agarwal, Tata-McGraw Hill
21. Physical Chemistry – G. M. Barrow, Tata-McGraw Hill, Vth edition, 2003.



## Semester-II, Physical Chemistry Practical Course ( CHP.2.2/APCHP.2.2/IND.2.2)

### Physical Chemistry Practicals

Students are expected to perform at least 8 experiments of three and half-hours duration. Experiments are to be set up in the following techniques.

#### Potentiometry:

1. Determination formal redox potential of system ( $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ )
2. Determination of binary mixture of halides.
3. Dissociation constant of acetic acid.

#### Conductometry:

4. Titration of ternary acid mixture of acids.
5. Verification of Onsagar Equation for 1:1 type strong electrolyte.
6. Determination of  $\Delta G$ ,  $\Delta H$ ,  $\Delta S$  of silver benzoate by solubility product method.

#### Refractometry:

7. Determination of atomic refractions of H, C and Cl atoms.
8. Determination of composition of mixture of liquids.

#### Cryoscopy:

9. Determination of apparent weight and degree of dissociation a strong electrolyte

#### Chemical kinetics:

10. Kinetics of iodination of acetone in presence of strong acid

#### Phase Equilibrium:

11. To construct phase diagrams for ternary system.

#### Viscosity:

12. Determination of radius of sucrose molecules. (New experiments may be also be added)

### RECOMMENDED BOOKS

1. Findlay's Practical Chemistry – Revised by J.A. Kitchner (Vedition)
2. Text Book of Quantitative inorganic analysis : A.I. Vogel.
3. Experimental Physical Chemistry : By F. Daniels and J. Williams
4. Experimental Physical Chemistry : R.C Das and B.Behera
5. Practical Physical Chemistry : B. Viswanathan and P.S. Raghavan
6. Advanced practicals in physical chemistry-Datar and Doke
7. Practical Physical Chemistry- B. D. Khosla, V. C. Garg, A. Gulati

## Paper –VIII, Analytical Chemistry –II (CH.2.4/APCH.2.4/IND.2.4)

## UV-Vis and IR Molecular Spectroscopy

- a) Ultraviolet and visible spectrophotometry (UV-Vis) Introduction, Beer Lambert's law, instrumentation, calculation of absorption maxima of dienes, dienones and polyenes, applications.
- b) Infrared Spectroscopy (IR) Introduction, instrumentation, sampling technique, selection rules, types of bonds, absorption of common functional groups. Factors affecting frequencies, applications.
- c) Luminescence, Chemiluminescence, Fluorimetry and phosphorimetry: Instrumentation, Reporting spectra, applications and comparison.

**Problems:** Simple structural problems based on UV-Vis and IR

## UNIT-II

15L

### Advanced Analytical Tools

- a) Nuclear Magnetic Resonance (NMR) Magnetic and non magnetic nuclei, Larmor frequency, absorption of radio frequency. Instrumentation (FT-NMR). Sample preparation, chemical shift, anisotropic effect, spin spin coupling, coupling constant, applications to simple structural problems
- b) Mass spectrometry (MS), Basic principle, working of mass spectrometer, ionization, types of ionization and classification of MS based on ionization, analyzers (magnetic sector, quadrupole, ion-trap, time of flight, formation of different types of ions, McLafferty rearrangements, fragmentation of alkanes, alkyl aromatics, alcohols and ketones, simple applications.

**Problems:** Simple structural problems based on IR, UV, NMR and MS.

## UNIT-III

15L

### Thermal Analysis

Introduction to thermal analysis, types of thermal analysis, significance of thermal analysis in Analytical Chemistry, effect of heat on materials, chemical decomposition, phase transformation etc. and general thermal analysis applications, advantages and disadvantages.

- a) Thermogravimetry analysis (TGA), principle, instrumentation, working, types of TGA, factors influencing TGA, curve to show nature of decomposition reactions, the product and qualities of compounds expelled, TGA in controlled atmosphere, TGA curves, analysis, research and analytical implications of TGA.
- b) Differential thermal analysis (DTA) and differential scanning calorimetry (DSC), instrumentation, methodology, application and research implications. Thermometric titrations method and applications

**Problems:** Simple problems based on TG, DTA and DSC.

## UNIT-IV

15L

### Atomic Spectroscopy

- a) Atomic Absorption Spectroscopy Introduction, Principal, difference between AAS and FES, Advantages of AAS over FES, advantages and disadvantages of AAS, Instrumentation, Single and double beam AAS, detection limit and sensitivity, Interferences, applications. Graphite furnace atomic absorption spectroscopy, general description, advantages and disadvantages. Flame photometry, Cold Vapor Mercury, Hydride Generation, Spark emission, challenges and limitations.
- b) Inductively Coupled Plasma Spectroscopy Introduction, Nebulisation Torch, Plasma, Instrumentation, Interferences, and Applications.

**Problems:** Simple problems based on FES, AAS, GFAS, ICP

### RECOMMENDED BOOKS

1. Instrumental Methods of analysis- Willard, Merrit, Dean and Settle.
2. Spectroscopic identification of organic compounds- R.M. Silverstein and G.C. Bassler
3. Spectroscopic methods in organic chemistry- D.H. Williams and I. Fleming
4. Absorption spectroscopy of organic molecules- V.M. Parikh
5. Applications of spectroscopic techniques in Organic chemistry- P. S. Kalsi
6. A Text book of Qualitative Inorganic Analysis- A. I. Vogel
7. Physical Methods in Inorganic Chemistry (DWAP)- R. Drago
8. Fundamentals of Analytical Chemistry – D.A. Skoog and D. M. West (Holt Rinehart and Winston Inc.)
9. Principles of instrumental analysis, Holler, Skoog, Crouch. Cengage learning India Pvt. Ltd.
10. Instrumental methods of chemical analysis, H. Kaur, Pragati Prakashan.

### Semester-II, Analytical Chemistry Practical Course ( CHP.2.2/APCHP.2.2/INDP.2.2)

#### Analytical Chemistry Practicals

1. To estimate the amount of  $\text{NH}_4\text{Cl}$  colorimetrically using Nessler's Reagent.
2. To determine the solubility of  $\text{PbI}_2$  in presence of different concentration of  $\text{KNO}_3$
3. To determine the solubility of  $\text{PbI}_2$  in presence of different concentration of  $\text{KCl}$
4. Potentiometric estimation of bleaching powder.
5. Determination of capacity of cation exchanger
6. Determination of capacity of anion exchanger
7. Determination of turbidity of water sample using nephelometer
8. To determine the iron content from soap sample
9. Determination of sulphate by nephelometry/turbidimetry
10. Determination of isoniazid from pharmaceutical tablet
11. Determination of caffeine from tea powder
12. Determination of iron from iron tablet samples
13. Estimation of fatty acid from soap sample
14. (Any other experiments may be added)

### RECOMMENDED BOOKS

1. Instrumental Methods of analysis- Willard, Merrit, Dean and Settle.

2. Spectroscopic identification of organic compounds- R.M. Silverstein and G.C. Bassler
  3. Spectroscopic methods in organic chemistry- D.H. Williams and I. Fleming
  4. Absorption spectroscopy of organic molecules- V.M. Parikh
  5. Applications of spectroscopic techniques in Organic chemistry- P. S. Kalsi
  6. A Text book of Qualitative Inorganic Analysis- A. I. Vogel
  7. Physical Methods in Inorganic Chemistry (DWAP)- R. Drago
  8. Fundamentals of Analytical Chemistry – D.A. Skoog and D. M. West (Holt Rinehart and Winston Inc.)
  9. Principles of instrumental analysis, Holler, Skoog, Crouch. Cengage learning India Pvt. Ltd.
  10. Instrumental methods of chemical analysis, H. Kaur, Pragati Prakashan.
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