The Kelkar Education Trust's
Vinayak Ganesh Vaze College of Arts, Science & Commerce

(AUTONOMOUS)
College with Potential for Excellence

Mithaghar Road, Mulund (East), Mumbai-400081, India
Phones :022-21631421, 221631423, 221631004 Fax : 022-221634262,
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Syllabus for Program S. Y. B. Sc.

Chemistry Major & Minor

Syllabus as per Choice Based Credit System (NEP-2020)

(June 2026 Onwards)

Submitted by

Department of Chemistry
KET's Vinayak Ganesh Vaze College of Arts, Science and Commerce (Autonomous)
Mithagar Road, Mulund (East) Mumbai-400081. Maharashtra, India.
Tel: 022-21631004, Fax: 022-21634262
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❖ **Syllabus as per Choice Based Credit System (NEP 2020)**

Syllabus

Subject: Chemistry

Sr. No.	Heading	Particulars
1	Title of Programme	**Second Year B.Sc. Chemistry: Semester III and IV**
2	Eligibility for Admission	The First Year B.Sc. examination of this University with Chemistry as a Major or Minor subject or any other University recognized as equivalent thereto.
3	Passing marks	Minimum D Grade or equivalent minimum marks for passing at the Graduation level.
4	Ordinances/Regulations (if any)	---
5	No. of Years/Semesters	One year/Two semester
6	Level	U.G. Part-II : Level- 5.0
7	Pattern	Semester- CBCS
8	Status	Revised
9	To be implemented from Academic year	2026-2027

Date: 28th March 2026 **Signature:**

BOS Chairperson: Prof. (Dr.) Suresh S. Shendage

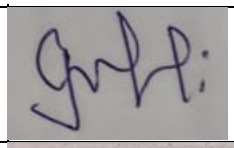
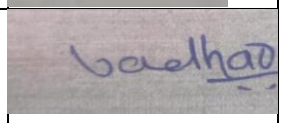
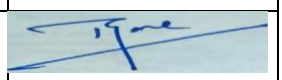
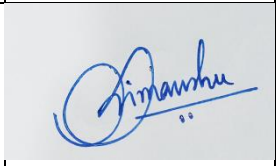
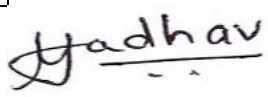
Preamble

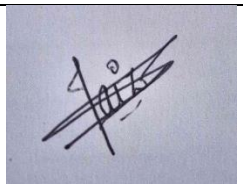
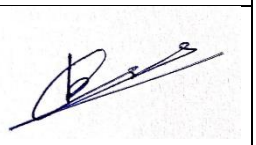
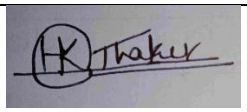
The Board of studies in Second Year Chemistry headed by Prof (Dr.) Suresh Shendage, the Chairman, Department of Chemistry, Vinayak Ganesh Vaze College of Arts, Science and Commerce (Autonomous), Mithagar Road, Mulund (East) Mumbai, University of Mumbai had the thorough discussions on the syllabus of III and IV semester Chemistry for B. Sc. Chemistry courses using the syllabus provided by the NEP Chemistry syllabus drafting Committee. This syllabus has to be accepted for the academic year 2026-27. The Core committee consisting of the faculty members of the Chemistry department with specializations in Analytical, Physical, Inorganic and Organic Chemistry which comprising the BOS and also additional faculty members from other Colleges of University of Mumbai have made effective joint brainstorming discussions and arrived at a Syllabus in Chemistry for III and IV semesters on 10th March 2026. The final syllabus incorporating all the suggestions was finally approved by the members of the Board of Studies in Chemistry (UG) on 28th March 2026. The following Faculty Members of the Core Committee were involved in the preparation of the Chemistry Syllabus.

1. Prof. (Dr.) Suresh Shendage (Head, Dean, Science, and Nodal Office NEP and ABC)
2. Dr. Ashok Awale
3. Dr. Paresh More
4. Dr. Himanshu Gupta
5. Mr. Gahininath Jadhav
6. Ms. Faiza Sayyed
7. Ms. Chirantani Sananse
8. Mr. Hitesh Thakur

Sd/-
Prof. (Dr.) Suresh Shendage
Chairman
BOS in Chemistry

BOS Members Present:

Name	Designation	Representation	
Prof. Suresh S. Shendage	Professor & Head, Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E), Mumbai-400081	Chairman	
Prof. B. D. Aghav	Professor of Chemistry Changu Kana Thakur A.C.S. College, New Panvel (Autonomous	Vice-Chancellor's Nominee	
Prof. Atul Chaskar	Professor of Chemistry, Institute of Chemical Technology Matunga Mumbai.	Subject Expert (From Other University)	
Dr. Tanaji Jadhav	Senior Research Scientist, Piramal pharma, Limited, Rabale Ghansoli- 400701	Industry Expert	
Mr. Shivaji Jadhav	Technical Manager-IAS, Indoco Remedies Limited Rabale, Navi Mumbai.	Industry Expert	
Dr. Nitin Mirgane	Associate professor, Deaprtment of Chemistry, SIES College Sion Mumbai	Subject Expert From Outside college	
Mr. Aditya Khanna	Assitant Professor, Department of Chemistry, Satish Pradhan Dnyanasadhana College, Thane	Meritorious Alumni	
Dr. Ashok Awale	Associate Professor Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	
Dr. Paresh More	Associate Professor , Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	
Dr. Himanshu Gupta	Assistant Professor, Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	
Mr. Gahininath Jadhav	Assistant Professor, Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	

Ms. Faiza Sayyed	Assistant Professor, Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	
Ms. Chirantani Sananse	(Assistant Professor, Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	
Mr. Hitesh Thakur	Assistant Professor, Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	

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❖ Syllabus as per Choice Based Credit System (NEP-2020)

Name of the Programme	❖ **S. Y. B. Sc. Chemistry : CBCS (NEP-2020)**	
The S. Y. B. Sc. in Chemistry course is a one Year Full Time Course consisting of two semesters, to be known as Semester III and Semester IV. Each semester consists of one major course and one minor course along with other courses- OE, VSC/SEC, AEC, VEC,FP,CEP and CC		
1. Course Code (Semester-III)	General Chemistry-III	VSCH200
	General Chemistry-IV	VSCH201
	Fundamentals of Analytical Chemistry-I	VSCH202
Course Code (Semester-IV)	General Chemistry-V	VSCH250
	General Chemistry-VI	VSCH251
	Fundamentals of Analytical Chemistry-II	VSCH252
2. Course Title (Semester-III)	General Chemistry - III : Paper - I	
	General Chemistry-IV : Paper - II	
	Fundamentals of Analytical Chemistry-I : Paper - III	
Course Title (Semester-IV)	General Chemistry – V : Paper - I	
	General Chemistry-VI : Paper - II	
	Fundamentals of Analytical Chemistry-II : Paper - III	
	General Chemistry-V	VSCH250
	General Chemistry-VI	VSCH251
	Fundamentals of Analytical Chemistry-II	VSCH252
3. Semester wise Course Contents	Copy of the detailed syllabus Enclosed	
4. References and additional references	Enclosed in the Syllabus	
5. No. of Credits per Semester	22	
6. No. of lectures per Unit	10 Hrs.	
7. No. of lectures per week	12	

8. No. of Tutorial per week	--
9. Scheme of Examination	Semester End Exam: **60 marks** (4 Questions of 15 marks each)
	Internal Assessment : **40 marks**
	Class Test : 15 marks
	Project/ Assignment : 15 marks
	Class Participation : 10 marks
10. Special notes, if any	No
11. Eligibility, if any	As laid down in the College Admission brochure / website
12. Fee Structure	As per College Fee Structure specifications
13. Special Ordinances / Resolutions, if any	No

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Programme Structure and Course Credit Scheme:

Semester	Major		Minor	OE	VSC/SEC	AEC,VEC,IKS	OJT, FP,CEP,CC, RP	Total
	Mandatory	Elective						
III	8 Credit (6L+2P) (Three Paper)	-	4 Credit (2L+2P) (One Paper)	2 Credit (2L) (One Paper)	2 Credit VSC (2P) Practical	AEC - 2 Credit (One Paper)	FP (2 Credits) - CC (2 Credits)	22
IV	8 Credit (6L+2P) (Three Paper)	-	2 Credit (2L) (One Paper)	2 Credit (2L) (One Paper)	2 Credit SEC (2P) Practical	AEC - 2 Credit (One Paper)	CEP (2 Credit) + CC (4 Credit)	**22**
TOTAL	16	NA	6	4	4	4	2+6	**44**

Programme: S. Y. B. Sc.

Semester	Course	Course Title	Course Code	Credits
III	Major	Course 1: General Chemistry -III	VSCH200	2
		Course 2: General Chemistry -IV	VSCH201	2
	Major/Minor (NOTE: Course 3 is common for Major and Minor)	Course 3: Fundamentals of Analytical Chemistry-I	VSCH202	2
	Minor	Other than Chemistry (Physics /Botany /Zoology)	NA	2
	Major(practical)	Major (Practical)	VSCH203	2
	Minor (practical)	Minor (practical)	VSCH206	2
	Open Elective (OE)	1. History of Bollywood: Origin and Evolution	VHB232	2
		2. Understanding Mental Health and Illness	VUM233	2
	Vocational skill Courses (VSC)	Chemical and Instrumental Analysis	VSCH204	2
	Ability Enhancement Courses (AEC) (Student will select any one from AEC Courses)	1. मराठी भाषेतील संवाद कौशल्ये (Dept. of Marathi)	VCS235	2
		2. ह5ंदी भाषा कौशल (Dept. of Hindi)	VHL234	
	Field Project	Field Project related to major will be offered	VSCH207	2
	Co-curricular Courses (Student will select any one from Co-curricular Courses)	Community Engagement Activities	VCE237	2
		Cultural Activities	VCA236	2
		National Service Scheme (NSS)	VNS238	2
		Sports Activities	VSA239	2
		Yoga	VYG240	2
	Total Credits			**22**

IV	Major	Course 1: General Chemistry –V	VSCH250	2
		Course 2: General Chemistry –VI	VSCH251	2
	Major/Minor (NOTE: Course 3 is common for Major and Minor)	Course 3: Fundamentals of Analytical Chemistry-II	VSCH252	2
	Minor	Other than Chemistry (Physics /Botany /Zoology)	NA	2
	Major(practical)	Major (Practical)	VSCH253	2
	Minor (practical)	Minor (practical)	-	-
	Open Elective (OE)	History of Bollywood: Legacy and Influence	VHB282	2
		2. Psychology of Well-being (Psychology Dept.)	VPW283	
	Skill Enhancement Courses (SEC)	Analytical Chemistry, Tools and Techniques	VSCH254	2
	Ability Enhancement Courses (AEC) (Student will select any one from AEC Courses)	1. मराठी भाषेतील लेखन कौशल्ये(Dept. of Marathi)	VWS285	2
		2. व्याव5ाररक लेखन कौशल (DEPT.OF HINDI)	VVL284	2
	Community Engagement Programme (CEP)	CEP Related to Major will be offered	VSCH256	2
	Co-curricular Courses (Student will select any TWO Co-curricular Courses)	1.Community Engagement Activities	VCE287	2
		2. Cultural Activities	VCA286	2
		3.National Service Scheme (NSS)	VNS288	2
		4.Sports Activities	VSA289	2
		5.Yoga	VYG290	2
	Total Credits			**22**

❖ Semester-wise Details of Chemistry Course

Semester - III									
Teaching Scheme (Hrs/Week)				**Continuous Internal Assessment (CIA) 40 marks**			**End Semester Examination Marks**		**Total**
Course	**L Hrs**	**P Hrs**	**Credit**	**CIA-1**	**CIA-2**	**CIA-3**	**Theory**	**Practical**	
Major P-I	02	---	2.0	15	15	10	60	-	100
Major P-II	02	---	2.0	15	15	10	60	-	100
Major P-III	02	---	2.0	15	15	10	60	-	100
Minor	02	---	2.0	15	15	10	60	-	100
Major (Practical)	----	4	2.0	--	---	---	---	100	100
Minor (Practical)		4	2.0	---	-----	---	-	100	100
VSC	-----	4	2.0	---	--	---	----	100	100
OE	02	---	2.0	15	15	10	60	---	100
AEC	02	----	2.0	15	35	----	NA	NA	50
FP	----	4	2.0	Report	Presentations	----	----	------	50
CC	-----	4	2.0	15	15	20	----	----	50
Total	12	20	22	---	----	---	----	-----	850

CIA-II : Assignment/Project

CIA-III : APICID &A

Max. Time, End Semester Exam (Theory) : 2 .00 Hrs.

Semester - IV

Teaching Scheme (Hrs/Week)				Continuous Internal Assessment (CIA) 40 marks			End Semester Examination Marks		Total
Course	**L Hrs**	**P Hrs**	**Credit**	**CIA-1**	**CIA-2**	**CIA-3**	**Theory**	**Practical**	
Major P-I	02	---	2.0	15	15	10	60	-	100
Major P-II	02	---	2.0	15	15	10	60	-	100
Major P-III	02	---	2.0	15	15	10	60	-	100
Minor	02	---	2.0	15	15	10	60	-	100
Major (Practical)	----	4	2.0	--	---	---	---	100	100
Minor (Practical)	NA	NA	NA	---	-----	---	NA	NA	NA
SEC	-----	4	2.0	---	--	---	----	100	100
OE	02	---	2.0	15	15	10	60	---	100
AEC	02	----	2.0	15	35	----	NA	NA	50
CEP	----	4	2.0	Report	Presentations	----	----	------	50
CC-I	-----	4	2.0	15	15	20	----	----	50
CC-II	-----	4	2.0	15	15	20	----	----	50
Total	12	20	22	---	----	---	----	-----	900

CIA-II: Assignment/Project

CIA-III: APICID &A

Max. Time, End Semester Exam (Theory) : 2 .00 Hrs.

- L - Lectures
- T - Tutorials
- P - Practical
- C - Credits

Programme Educational Objectives

PEO1	This course forms the basis of science and comprises of the subjects like, Physical Chemistry, Inorganic Chemistry, Organic Chemistry and Analytical Chemistry along with the skill-based courses like VSC and OJT/FP.
PEO2	Achievement of fundamentals of chemistry in a foundational level to the current knowledge
PEO3	Development of perceptive research skills at a level required to pursue higher education and placement after graduation.
PEO4	Understanding of experimentation, observation and data analysis suitable for any Chemistry based industry
PEO5	Familiarity with available instrumentation in the Institute laboratory and Industry for conducting specific scientific research
PEO6	To empower the students to exercise their abilities with great concern for the environment and society with moral and ethical values and contribute towards the development of the nation.

Programme Outcomes

Upon successful completion of the B.Sc. (Chemistry) course from Vaze College affiliated to Mumbai University, graduates can expect the following outcomes:

PO1	To equip students with the comprehension of concepts, principles, theories and practical applications of Organic, Inorganic, Analytical and Physical Chemistry.
PO2	Students will have a broad foundation in the core subjects of their choice with critical thinking resulting in scientific reasoning, problem solving and analytical skills
PO3	Utilize modern laboratory techniques and instruments to conduct experiments, analyse data, and interpret results accurately.
PO4	Learners achieved skill from different experimental performance; provide them good opportunities for industrial Placement.
PO5	To facilitate the students in pursuing their higher studies in chemistry, to boost their career and employment options and to apply chemistry in their everyday life
PO6	Students develop the ability to effectively communicate scientific information in written and oral formats.

Programme Specific Outcomes

PSO1	Gain the knowledge of Chemistry through theory and practical.
PSO2	To understand various laws, concepts, formulae and develop problem solving skills in Chemistry.
PSO3	Get to know and understand the topics of three different branches of chemistry, viz. organic, inorganic and physical chemistry in a more detailed and broader way.
PSO4	To explain nomenclature, stereochemistry, structures, reactivity, and mechanism of the chemical reactions.
PSO5	Create an intellectual curiosity and ability to think in a scientific manner and get sensitized to social and environmental realities.
PSO6	Apply laboratory skills, carry out experiments, record observations and inferences and analyze the results.
PSO7	Understand good laboratory practices and safety.

S. Y. B. Sc. Chemistry: Choice Based Credit System

Semester- III

PAPER-I

Course Name: General Chemistry – III (30 Lectures)			**Course Code** VSCH200
Periods per week (1 period 60 minutes)			**02**
Credits			**02**
Evaluation System		**Hrs**	**Marks**
	Theory Examination	**-**	**60**
	Theory Internal	**-**	**40**

Learning Objectives (LOs):

1. **Understand and apply thermodynamic functions** such as Helmholtz and Gibbs free energies, their variations, and their relevance to chemical reactions and open systems.
2. **Interpret and solve numerical problems** related to the Van't Hoff isotherm, Gibbs-Helmholtz equation, and chemical potential, including the use of Gibb's Duhem equation.
3. **Comprehend the principles of electrolytic and electronic conductance**, analyze variation of conductance with concentration, and apply Kohlrausch's law in practical and theoretical contexts.
4. **Analyze types of chemical bonding**, including ionic, covalent, and molecular orbital approaches, and apply rules such as radius ratio, Born-Haber cycle, and hybridization concepts.
5. **Examine nucleophilic substitution reactions** in alkyl and aryl halides, compare mechanisms (SN1, SN2, SNAr, etc.), and evaluate the factors influencing their reactivity and stereochemistry.
6. **Understand the structure, properties, and reactions of alcohols and phenols**, including hydrogen bonding, acidity, and methods of preparation.

Course Outcomes (COs):

CO1: Analyze and interpret the changes in Gibbs and Helmholtz free energies for chemical systems and use thermodynamic relationships to predict spontaneity and equilibrium.

CO2: Apply electrochemical principles and Kohlrausch's law to calculate molar conductance, dissociation constants, and solubility products using experimental and theoretical data.

CO3: Evaluate the bonding in molecules using Valence Bond Theory, Molecular Orbital Theory, and hybridization concepts to explain structure and magnetic behavior of diatomic species.

CO4: Demonstrate the mechanism and stereochemical outcomes of nucleophilic substitution in alkyl and aryl halides and explain the properties and reactivity of alcohols and phenols.

	CONTENT	
Unit		**No. of Hours**
Unit - I	**1. Chemical Thermodynamics-II** 1.1 Free Energy Function: Helmholtz free energy, variation of Helmholtz free energy with volume and temperature, Gibb's free energy, Variation of Gibb's free energy with pressure and temperature, Gibb's free energy change for chemical reaction. 1.2 Gibb's Helmholtz equation, Van't Hoff reaction isotherm and Van't Hoff reaction, isochore. (Numericals expected). 1.3 Thermodynamics of Open System: Partial Molal Properties, Chemical Potential and its variation with Pressure and Temperature, Gibb's Duhem equation. **2. Electrochemistry** 2.1 Electronic and electrolytic conductors, conductance, specific conductance, equivalent conductance, molar conductance, determination of molar conductance, variation of molar conductance with concentration for strong and weak electrolytes, concept of limiting molar conductance. **2.2 Kohlrausch law of independent migration of ions** Applications of Kohlrausch's law: Determination of limiting molar conductance of a weak electrolyte, Determination of dissociation constant of a weak acid, Determination of solubility product of a sparingly soluble salt (Numericals expected) 2.3 Transference number and factors affecting transport number.	**05** **05**
Unit – II	**Chemical Bonding** **2.1 Non directional Bonding** Ionic Bond, Conditions for the Formation of Ionic bond 2.1.2 Types of Ionic Crystals 2.1.3 Radius Ratio Rules 2.1.4 Lattice Energy, Born-Lande Equation and Kapustinski Equation 2.1.5 Born-Haber Cycle and its Application **2.2 Directional Bonding - Orbital Approach** 2.2.1. Covalent Bonding: Valence Bond Theory- basic tenets 2.2.2. Interaction between two hydrogen atoms and Potential energy diagram of the resultant system 2.2.3. Corrections applied to the system of formation of Hydrogen molecule 2.2.4. Resonance and concept of Formal charge, Rules for writing resonance structures 2.2.5. Bonding in polyatomic species, need for hybridization and types of hybrid orbitals - sp, sp^2, sp^3, sp^2d, sp^3d, sp^2d^2, sp^3d^3 **2.3 Molecular Orbital Theory** 2.3.1. Comparing atomic orbitals and Molecular orbitals 2.3.2. Linear combination of atomic orbitals to give molecular orbitals LCAO-MO approach 2.3.3. Molecular orbital diagram H_2, He_2, diatomic molecules of second period elements and their ions, calculate bond order and predict magnetic property. (Problems and Numericals expected wherever possible)	**03** **04** **03**

Unit - III	**Organic Chemistry** **3.1 Reactions and reactivity in alkyl and aryl halides** 3.1.1 Alkyl halides: Nucleophilic substitution reactions: SN_1, SN_2, Neighboring Group participation (NGP), SN_i and SN_i mechanisms with stereochemical aspects and factors affecting nucleophilic substitution reactions-nature of substrate, solvent, nucleophilic reagent and leaving group. 3.1.2 Aryl halides: Reactivity of aryl halides towards nucleophilic substitution reactions. Nucleophilic aromatic substitution (SNAr) addition-elimination mechanism and benzyne mechanism. **3.2 Alcohols and Phenols** 3.2.1 Alcohols: Nomenclature, Preparation: Hydration of alkenes, hydrolysis of alkyl halides, reduction of aldehydes and ketones, using Grignard reagent. 3.2.1 Properties: Hydrogen bonding, types and effect of hydrogen bonding on different properties. Acidity of alcohols, Reactions of alcohols. 3.2.2 Phenols: Preparation, physical properties and acidic character, factors affecting acidity of phenols Reactions of phenols.	**04** **06**

❖ **References:**

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. J.D.Lee, Concise Inorganic Chemistry, 4th edition,ELBS.
4. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press (1999) page.
5. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity.
6. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
7. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

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S. Y. B. Sc. Chemistry: Choice Based Credit System

Semester- III

PAPER-II

Course Name: General Chemistry – IV (30 Lectures)			**Course Code:** VSCH201
Periods per week (1 period 60 minutes)			**02**
Credits			**02**
Evaluation System		**Hrs**	**Marks**
	Theory Examination	**-**	**60**
	Theory Internal	**-**	**40**

Learning Objectives (LOs):

1. **Classify and explain various complex chemical reactions** such as reversible, consecutive, and parallel reactions, and understand the mechanisms of thermal chain reactions.
2. **Apply kinetic concepts** like the Arrhenius equation to determine the effect of temperature on reaction rates and calculate activation energy using numerical problems.
3. **Compare collision theory and activated complex theory**, understanding their qualitative application to bimolecular reactions.
4. **Differentiate between ideal and non-ideal solutions** using Raoult's law, understand critical solution temperature, and apply Nernst distribution law for practical applications like solvent extraction and steam distillation.
5. **Explain the structure, bonding, and reactivity of boron compounds** (e.g., BH_3, BF_3, diborane), and discuss the chemistry of silicon and germanium, including their compounds and methods of extraction.
6. **Understand the preparation, properties, and reactivity of carbonyl compounds and epoxides**, focusing on nucleophilic addition mechanisms, keto-enol tautomerism, and epoxide ring-opening reactions under various conditions.

Course Outcomes (COs):

CO1: Analyze the kinetics of complex reactions and apply kinetic and thermodynamic principles to predict reaction behavior, temperature effects, and reaction mechanisms.

CO2: Apply concepts of solution chemistry to interpret phase behavior, miscibility, and extractive techniques using Raoult's law and distribution law.

CO3: Evaluate the electronic structure, bonding, and chemical behavior of boron, silicon, and germanium compounds, including electron-deficient species.

CO4: Demonstrate understanding of preparation, structure, and reactivity of carbonyl compounds and epoxides, and explain their reactions with various nucleophiles using appropriate mechanistic pathways.

CONTENT		
Unit		**No. of Hours**
Unit - I	**1.1 Chemical Kinetics - II** 1.1.1. Types of Complex Chemical reactions: Reversible or opposing, consecutive parallel reactions (No derivations, only examples expected), 1.1.2 Thermal chain reactions: H and Br Reaction (only steps involved, no kinetic expression expected). 1.1.3. Effect of temperature on the rate of reaction, Arrhenius equation, Concept of energy of activation (E_a). (Numericals expected). 1.1.4. Theories of reaction rates: Collision theory and activated complex theory of bimolecular reactions. Comparison between the two theories. (Qualitative treatment only) **1.2 Solutions** 1.2.1 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. 1.2.2 Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids with respect to Phenol - Water, Triethanolamine – Water and Nicotine – Water systems 1.2.3 Immiscibility of liquids - Principle of Steam distillation. Nernst distribution law and its applications, solvent extraction. (Numericals expected).	**06** **04**
Unit – II	**2.1 Chemistry of Boron** 2.1.1. Electron deficient compounds- BH_3, BF_3, BCl_3 with respect to Lewis acidity and applications. 2.1.2. Preparation of simple boranes like diborane and tetraborane. 2.1.3. Structure and bonding in diborane and tetraborane ($2e^-$ 3c bonds). 2.1.4. Synthesis of Borax. **2.2 Chemistry of Silicon and Germanium** 2.2.1 Silicon compounds: Occurrence, Structure and inertness of SiO_2 2.2.2. Preparation and structure of $SiCl_4$. 2.2.3. Occurrence and extraction of Germanium. 2.2.4 Preparation of extra pure Silicon and Germanium.	**05** **05**

Unit – III	**3.1 Carbonyl Compounds** 3.1.1. Structure, general methods of preparation; Oxidation of primary and secondary alcohols using PCC, hydration of alkynes, action of Grignard reagent on esters, Rosenmund reduction, Gattermann – Koch formylation and Friedel Craft acylation of arenes 3.1.2. General mechanism of nucleophilic addition, and acid catalyzed nucleophilic addition reactions. 3.1.3. Reactions of aldehydes and ketones with NaHSO3, HCN, RMgX, alcohol, amine, phenyl hydrazine, 2,4-Dinitrophenyl hydrazine, $LiAlH_4$ and $NaBH_4$. 3.1.4. Keto-enol tautomerism: Mechanism of acid and Base catalyzed enolization 3.1.6. Synthesis of enamines; alkylation and acylation of enamines. **3.2 Epoxides** 3.2.1. Nomenclature and methods of preparation. 3.2.2. Reactions of epoxides: reactivity, ring opening reactions by nucleophiles (a) In acidic conditions: hydrolysis, reaction with halogen halide, alcohol, hydrogen cyanide. (b) In neutral or basic conditions: ammonia, amines, Grignard reagents, alkoxides.	**06** **04**

❖ **References:**

1. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt.Ltd., New Delhi (2009).
2. B. S. Bahl and G. D. Tuli 'Essentials of Physical Chemistry,' S.Chand and Company(Pvt) Ltd, New Delhi.
3. J.D.Lee, Concise Inorganic Chemistry, 4th edition,ELBS.
4. R Gopalan, Universities Press India Pvt.Ltd. Inorganic Chemistry for Undergraduates.
5. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd.
6. Pub. Graham Solomons, T.W. Organic Chemistry, John Wiley &Sons, Inc.

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S. Y. B. Sc. Chemistry: Choice Based Credit System

Semester- III

PAPER– III

Course Name: Fundamentals of Analytical Chemistry-I (30 lectures)			**Course Code** VSCH202
Periods per week (1 period 60 minutes)			**02**
Credits			**02**
Evaluation System		**Hrs**	**Marks**
	Theory Examination	**-**	**60**
	Theory Internal	**-**	**40**

Learning Objectives (LOs):

1. **Explain the scope and significance of analytical chemistry**, distinguish between classical and instrumental methods, and understand their applications in chemical analysis.
2. **Understand analytical terminology and classification of analysis**, based on the type of information required and sample size (macro, semi-micro, micro).
3. **Recognize the importance of sampling**, define related terms, describe various sampling techniques, and explain their impact on analytical accuracy.
4. **Describe the principles and curves of precipitation and complexometric titrations**, including Volhard's, Mohr's methods, and the use of EDTA, along with the concept of adsorption indicators.
5. **Identify components and working of analytical instruments** through block diagrams and explain analyte-stimulus-response relationships in various instrumental techniques (optical, electrochemical, thermal).
6. **Apply spectrophotometric and photometric principles** for qualitative and quantitative analysis, construct calibration curves, and interpret photometric titration data.

Course Outcomes (COs):

CO1: Classify and apply different analytical methods and sampling techniques based on the nature of analysis and understand their role in obtaining reliable analytical results.

CO2: Perform and interpret classical titrimetric techniques, including precipitation and complexometric titrations, and evaluate their accuracy and limitations.

CO3: Illustrate the working principles of instrumental techniques using block diagrams, and distinguish between various interaction types (optical, electrochemical, thermal).

CO4: Use UV-visible spectrophotometry for qualitative and quantitative analysis, interpret instrumentation data, and apply the photometric titration method for compound estimation.

CONTENT		
Unit		**No. of Hours**
Unit - I	**1.1 Introduction to Analytical Chemistry and Sampling** 1.1.1 Classical and Non-Classical Methods of Analysis; their types and Importance **1.2 Role of Analytical Chemistry** 1.2.1 Language of analytical chemistry: important terms and their significance in Analytical Chemistry. 1.2.2 Purpose of Chemical Analysis; Analysis Based (i) On the nature of information required: (Proximate, Partial, Trace, Complete Analysis) and (ii) On the size of the sample used (Macro, Semi-micro and Microanalysis). **1.3 Sampling** 1.2 Significance of Sampling in Analytical Chemistry 1.2.1 Terms involved in Sampling 1.2.2 Types of Sampling 1.2.3 Sampling techniques	**06** **04**
Unit – II	**Titrimetry** 2.1 **Precipitation Titration** 2.1.1 Introduction 2.1.2 Construction of the titration curve 2.1.3 Volhard's Method 2.1.4 Mohar's Method 2.1.5 Theory of Adsorption indicator 2.2 **Complexometric Titrations** 2.2.1 Introduction, construction of titration curve 2.2.2 Use of EDTA as titrant and its standardization, absolute and conditional formation constants of metal EDTA complexes, Selectivity of EDTA as a titrant. Factors enhancing selectivity with examples. Advantages and limitations of EDTA as a titrant.	**05** **05**
Unit – III	**Instrumental Methods - I** 3.1 Basic Concepts in Instrumental methods, Relation between the Analyte, Stimulus and measurement of change in the observable property. 3.2 Block Diagram of an Analytical instrument. 3.3 Types of Analytical Instrumental methods based on: a. Optical interactions (E.g., Spectrometry: UV-visible, Polarimetry). b. Electrochemical interactions (E.g., Potentiometry, Conductometry). c. Thermal interactions (E.g., Thermogravimetry).	**03**

	3.4 Colorimetry & Spectrophotometry 3.4.4 Instrumentation for absorption spectroscopy: Colorimeters and Spectrophotometers. 3.4.5 Block Diagrams for Single beam and Colorimeter, and spectrophotometer (Principles, Construction and working-Details of Components expected i.e, source, Sample holder, Filters/Monochromators, Detectors such as Photomultiplier tube). **3.4.6 Applications of UV-Visible Spectrophotometry** a) Qualitative analysis such as Identification of functional groups in Organic compounds, Chromophores and Auxochrome, cis and trans isomers. b) Quantitative analysis by Calibration curve method **3.4.7 Photometric Titrations:** Principle, Instrumentation, Types of Photometric titration Curves with examples	**03** **02** **02**

❖ **References:**

1. Instrumental Analysis by Douglas A. Skoog, F. James Holler, Stanley R.Crouch.
2. Skoog et al. “Fundamentals of Analytical chemistry" Cengage Learning, Eight Edition, chapter 13, 14 and 15.
3. Instrumental Methods of Chemical Analysis by Gurdeep R. Chatwal, Sham K.Anand pp2.107-2.148.
4. Gary D. Christan,” Analytical Chemistry”, VIth Edition, Wiley StudentsEdition, Chapter No. 8,9,10.
5. Modern Analytical Chemistry, David Harvey (page numbers 232-265) 6. Fundamental of Analytical Chemistry by Douglas A. Skoog, West, F. James Holler, S. R. Crouch.

Practicals

(Major/Minor)

Semester: III

COURSE CODE: VSCH203 **CREDITS: 02**

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Learning Objectives

After completing this course, students will be able to:

LO1: Perform conductometric measurements to verify Ostwald's Dilution Law for weak acids.
LO2: Determine the Critical Solution Temperature (CST) of the Phenol–Water System and interpret phase diagrams.
LO3: Investigate reaction kinetics of Potassium Persulfate and Potassium Iodide to evaluate rate and order of reaction.
LO4: Determine EMF and calculate thermodynamic parameters ($\Delta G°$) of the Daniell Cell using techniques.
LO5: Apply quantitative analytical methods including gravimetric estimation ($BaSO_4$), complexometric titrations (Cu–EDTA, Mg–EDTA), and spectrophotometry using Beer–Lambert Law.
LO6: Execute organic synthesis and purification (glucosazone, acetanilide, m-dinitrobenzene, phthalic anhydride) and perform qualitative analysis of inorganic mixtures with emphasis on anion identification.

Course Outcomes (COs):

CO1: Develop understanding of fundamental physicochemical principles through conductometric, potentiometric, and kinetic experiments.
CO2: Apply analytical techniques such as gravimetry, titrimetry (EDTA), and spectrophotometry for quantitative chemical analysis.
CO3: Acquire practical skills in organic synthesis, purification, and qualitative analysis of inorganic mixtures.

CONTENT

Subject	Sr. No.	Experiment
Physical Chemistry	1	Conductometry To verify Ostwald's dilution law for weak acid conductometrically.
	2	Phase equilibria Phase equilibria: To determine the critical solution temperature (CST) of Phenol – Water system.
	3	Chemical kinetics :To investigate the reaction between $K_2S_2O_8$ and KI with equal initial concentrations of the reactants.
	4	Potentiometry: To determine the standard emf and standard free energy of Daniel cell.

Inorganic Chemistry	5	Gravimetric Estimations Barium as Barium sulphate.
	6	Qualitative analysis with anion complexity **(Minimum 5 mixtures to be analyzed)**
Organic Chemistry	7	Glucosazone from dextrose or fructose.
	8	m-Dinitrobenzene from nitrobenzene.
	9	Phthalic anhydride from phthalic acid by sublimation.
	10	Acetanilide from aniline.
Analytical Chemistry	11	Verify Beers Lambert's Law using KMnO4
	14	Estimation of Cu using EDTA Complexometrically
	15	Estimation of Mg using EDTA Complexometrically

References:

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).
3. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3rd Ed., W.H. Freeman and Co., New York (2003).
4. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001).
5. Practical Inorganic Chemistry by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972).
6. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
7. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
8. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
9. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
10. D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, Analytical Chemistry: An Introduction, 7th ed., Chapter 15, pp.345-381.
11. Some Experiments for B. Tech in Chemistry & Chemical Technology compiled by Prof. J. B. BARUAH, Mrs. Abhilasha Mohan Baruah and Mr. ParikshitGogoi.
12. D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, Analytical Chemistry: An Introduction, 7th ed., Chapter 15, pp.345-381.
13. A.I. Vogel. "Textbook of Quantitative Inorganic Analysis," Longman,London (I961).
14. R.V. Dilts. "Analytical Chemistry. Methods of Separation," van Nostrand,N.Y. (1974).

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S. Y. B. Sc. Chemistry: Choice Based Credit System			
Semester- III			
VSC			
Course Name: Chemical and Instrumental Analysis (60 Hrs)			**Course Code:** VSCH204
Practicals Per week :(1 Practical = 2Hrs.)			**02**
Credits			**02**
Evaluation System		**Hrs**	**Marks**
	Practical Examination	60	100

Learning Objectives (LOs)

After completing this course, students will be able to:

LO1: Determine solubility of sparingly soluble salts such as Lead Sulphate and Barium Sulphate using conductometric methods.

LO2: Measure pH and estimate the concentration of strong acids using pH-metry and evaluate buffer capacity of acidic and basic buffer systems.

LO3: Analyze water quality by determining alkalinity and total hardness using standard titrimetric procedures.

LO4: Perform gravimetric estimations including barium as Barium Chromate, iron as Ferric Oxide, and nickel as nickel–DMG complex.

LO5: Synthesize inorganic coordination compounds such as nickel dimethylglyoximate, bis(acetylacetonato)copper(II), and potassium trioxalatoferrate(III) using appropriate laboratory techniques.

LO6: Carry out organic synthesis of derivatives including cyclohexanone oxime, tribromoaniline, and p-bromoacetanilide, along with proper sampling of solids and liquids.

Course Outcomes (COs):

CO1: Understand and apply physicochemical techniques such as conductometry and pH-metry for determining solubility, acidity, buffer capacity, and water quality parameters.

CO2: Develop skills in quantitative analysis using gravimetric methods and hardness determination, along with proper sampling techniques for solids and liquids.

CO3: Gain proficiency in inorganic and organic synthesis, including preparation of coordination compounds and organic derivatives using standard and microscale techniques.

CONTENT

References:

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).
3. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3rd Ed., W.H. Freeman and Co., New York (2003).
4. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001)
5. Practical Inorganic Chemistry by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)
6. Mann, F. G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
7. Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
8. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
9. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
10. D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, Analytical Chemistry: An Introduction, 7th ed., Chapter 15, pp.345-381.
11. Some Experiments for B. Tech in Chemistry & Chemical Technology compiled by Prof. J. B. BARUAH, Mrs. Abhilasha Mohan Baruah and Mr. Parikshit Gogoi.
12. D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, Analytical Chemistry: An Introduction, 7th ed., Chapter 15, pp.345-381.
13. A.I. Vogel. “Textbook of Quantitative Inorganic Analysis,” Longman, London (I961).
14. R.V. Dilts. “Analytical Chemistry. Methods of Separation,” van Nostrand, N.Y. (1974).

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S. Y. B. Sc. Chemistry: Choice Based Credit System			
Semester- IV			
PAPER– I			
Course Name: General Chemistry-V (30 Lectures)			**Course Code:** VSCH250
Periods per week (1 period 60 minutes)			**02**
Credits			**02**
Evaluation System		**Hrs**	**Marks**
	Theory Examination	**-**	**60**
	Theory Internal	**-**	**40**

Learning Objectives (LOs)

1. **Understand and apply electrochemical conventions**, reversible and irreversible cells, and use the Nernst equation to calculate EMF, equilibrium constants, and pH.
2. **Apply thermodynamic principles** to determine ΔG, ΔH, and ΔS from EMF data and derive Clausius–Clapeyron equation for phase changes using appropriate numerical methods.
3. **Interpret phase diagrams** for one- and two-component systems (eutectic, congruent/incongruent melting points), and apply Gibbs Phase Rule to assess phase equilibria.
4. **Describe the general characteristics of 3d-transition metals**, including their variable oxidation states, complex formation, and catalytic activity.
5. **Explain the theories and applications of coordination compounds**, including Werner's theory, valence bond theory, types of isomerism, bonding nature, and real-world applications.
6. **Explore the structure, preparation, and reactivity** of carboxylic acids, their derivatives, and aromatic sulphonic acids, with a focus on nucleophilic acyl substitution and mechanistic insights.

Course Outcomes (COs)

CO1: Solve numerical problems related to EMF, electrode potentials, and thermodynamic properties using the Nernst equation and related electrochemical principles.

CO2: Analyze and interpret phase behavior of substances using phase diagrams, Gibbs Phase Rule, and thermodynamic laws applied to one- and two-component systems.

CO3: Describe the chemical behavior, electronic configuration, and coordination properties of 3d transition elements and coordination compounds using basic bonding theories and isomerism.

CO4: Illustrate the preparation, structure, acidity, and interconversion reactions of carboxylic acids, their derivatives, and sulfonic acids, emphasizing mechanistic and comparative aspects.

CONTENT		
Unit		**No. of Hours**
Unit - I	**1.1 Electrochemistry II** 1.1.1 Electrochemical conventions, Reversible and Irreversible cells. 1.1.2 Nernst equation and its importance, Types of electrodes, Standard electrode potential, Electrochemical series (Numericals expected). 1.1.3 Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from Emf data. (Numericals expected) 1.1.4 Calculation of equilibrium constant from EMF data. (Numericals expected) 1.1.5 pH determination using hydrogen electrode and quinhydrone electrode (Numericals expected) **1.2 Phase Equilibria** 1.2.1 Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. 1.2.2 Derivation of Clausius – Clapeyron equation and its importance in phase equilibria.(Numerical expected) 1.2.3 Phase diagrams of one-component systems (water and sulphur). 1.2.4 Two component systems involving eutectics, congruent and incongruent melting points (lead-silver system)	**06** **04**
Unit – II	**2.1 Comparative Chemistry of Transition Metals** 2.1.1 Definition, general characteristics of Transition elements 2.1.2 Chemistry of 3d transition elements with reference to: Variable oxidation states, colour, magnetic property ability to form complexes, colour, magnetic property, ability to form complexes, catalytic property **2.2 Coordination Chemistry** 2.2.1 Historical perspectives, Molecular compound – double salt, complex salt 2.2.2 Werner's theory of Coordination compounds 2.2.3 Basic terms complex ion, charge on the complex, ligand and their types Coordination number and Nomenclature 2.24 Effective atomic number Rule, Eighteen electron rule. 2.2.5 Isomerism(Structural, Stereo, Optical) of coordination compounds (CN=4,6). 2.2.6 Evidences for formation of coordination compounds 2.2.7 Applications of coordination compounds 2.2.8 Nature of the Metal-Ligand Bond i) Valence Bond Theory: Hybridization of the central metal orbitals sp^3, dsp^2/sp^2 d, sp^3d, sp^2d^2,$sp3d^3$. ii) Inner and Outer orbital complexes (suitable examples). iii) Electroneutrality principle and back bonding. 2.2.7 Limitations of ValenceBond Theory	**04** **06**

Unit-III	**3.1 Carboxylic Acids and their Derivatives** 3.1.1 Structure and physical properties, acidity of carboxylic acids, effects of substituents on acid strength of aliphatic and aromatic carboxylic acids. 3.1.2 General methods of preparation of carboxylic acids: oxidation of alcohols and alkyl benzene, carbonation of Grignard and hydrolysis of nitriles. 3.1.3 Reactions: Acidity, salt formation, decarboxylation, Reduction of Carboxylic acids with $LiAlH_4$, diborane, Hell-Volhard-Zelinsky reaction, Conversion of carboxylic acid to acid chlorides, esters, amides and acid anhydrides and their relative reactivity. 3.1.4 Acid derivatives: Mechanism of nucleophilic acyl substitution and acid-catalyzed nucleophilic acyl substitution. Interconversion of acid derivatives by nucleophilic acyl substitution. **3.2 Sulphonic acids** 3.2.1 Nomenclature, preparation of aromatic sulfonic acids by sulphonation of benzene (with mechanism), toluene and naphthalene. 3.2.2 Reactions: Acidity of arene sulfonic acid, Comparative acidity of carboxylic acid and sulfonic acids. Salt formation, sulphonation. Reaction with alcohol, Phosphorous pentachloride, IPSO substitution.	**06** **04**

References:

1. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
2. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
3. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co., New York (1985).
4. K. L. Kapoor A textbook of Physical chemistry.
5. J. D. Lee, Concise Inorganic Chemistry, 4^{th} edition, ELBS.
6. Inorganic Chemistry – Gary Wulfsberg, Viva Book, First Indian Edition 2002.
7. F. A Cotton and G. Wilkinson 'Basic Inorganic chemistry' John Wiley & Sons.
8. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education.
9. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.

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S. Y. B. Sc. Chemistry: Choice Based Credit System			
Semester- IV			
PAPER– II			
Course Name: General Chemistry-VI (30 Lectures)			**Course Code** VSCH251
Periods per week (1 period 60 minutes)			**02**
Credits			**02**
Evaluation System		**Hrs**	**Marks**
	Theory Examination	**-**	**60**
	Theory Internal	-	**40**

Learning Objectives (LOs):

1. **Understand the basic laws of crystallography**, unit cell types (SC, FCC, BCC), and calculate interplanar distance ratios; apply Bragg's law to analyze crystal structures using X-ray diffraction.
2. **Analyze the structure of ionic solids (e.g., NaCl, KCl)** and use X-ray diffraction data to determine Avogadro's number (numerical problems expected).
3. **Explain the principles and types of catalysis**, including acid-base catalysis, nanoparticle catalysis, and the effects of pH, particle size, and inhibitors on catalytic activity and selectivity.
4. **Describe the behavior of cations and anions in aqueous medium**, with respect to hydrolysis, hydration, acidity/basicity, and classification based on pKa, z^2/r ratio, and Latimer equation.
5. **Outline the steps and types of metallurgical processes**, including the extraction of copper, vanadium, and titanium using relevant physico-chemical principles and refining methods.
6. **Understand the structure, nomenclature, preparation, and reactivity** of amines and five-membered heterocyclic compounds (pyrrole, furan, thiophene), including aromaticity and electrophilic substitution reactions.

Course Outcomes (COs):

CO1: Apply crystallographic and X-ray diffraction principles to determine unit cell dimensions and crystal structures and solve related numerical problems.

CO2: Evaluate different types of catalysis and their mechanisms, including nanoparticle catalysis, with attention to kinetics, specificity, and environmental relevance.

CO3: Assess the acidity/basicity of ions in aqueous medium and correlate these properties to metal ion behavior using pKa, z^2/r ratios, and Latimer equations.

CO4: Demonstrate knowledge of the preparation, properties, and reactions of amines and heterocyclic compounds, and describe electrophilic substitution mechanisms in heterocycles.

CONTENT		
Unit		**No. of Hours**
Unit - I	**1.1 Solid State** 1.1.1 Recapitulation of laws of crystallography and types of crystals. 1.1.2 Characteristics of simple cubic, face centered cubic and body centered cubic systems, interplanar distance in cubic lattice (Only expression for ratio of interplanar distances are expected). 1.1.3 Use of X-rays in the study of crystal structure, Bragg's equation (Derivation expected), X-rays diffraction method of studying crystal lattice structure, structure of NaCl and KCl. Determination of Avogadro's number (Numericals expected) **1.2 Catalysis** 1.2.1 Types of catalysis, catalytic activity, specificity and selectivity, inhibitors,Catalyst poisoning and deactivation. 1.2.2 Mechanisms and kinetics of acid-base catalyzed reactions, effect of pH. 1.2.3 Effect of particle size and efficiency of nanoparticles as catalyst.	**06** **04**
Unit – II	**2.1 Ions in aqueous medium** Acidity of Cations and Basicity of Anions 2.1.1 Hydration of cations; Hydrolysis of Cations predicting degree of hydrolysis of Cations- effect of charge and radius. 2.1.2 Latimer Equation. Relationship between pK_a, acidity and z^2/r ratio of metal ions graphical presentations. 2.1.3 Classification of cations on the basis of acidity. Category-Non acidic, 07 Moderately acidic, strongly acidic, very strongly acidic, with pK_a values range and with examples. 2.1.4 Hydration of Anions; Effect of charge and radius; Hydration of anion concept, diagram classification on the basis of basicity. **2.2 Metallurgy:** 2.2.1 Types of metallurgies. 2.2.2 General Steps of Metallurgy**:** Concentration of ore, calcinations, roasting, reduction and refining. 2.2.3 Metallurgy of copper: Occurrence, physico chemical principles, Extraction of copper from pyrites and refining by electrolysis. Extraction of titanium and vanadium.	**06** **04**

Unit-III	**3.1 Nitrogen containing compounds and heterocyclic compounds** **3.1.1 Amines:** Nomenclature, basicity, factors affecting basicity of aliphatic and aromatic amines; **3.1.2 Preparation:** Reduction of aromatic nitro compounds using catalytic hydrogenation, chemical reduction using Fe-HCI, Sn-HCl, Zn – aceticacid, reduction of nitriles, ammonolysis of halides, reductive amination Hofmann bromamide reaction (no mechanism) **3.1.3 Reactions:** Salt Formation, N-acylation, N-alkylation, Hofmann's exhaustive methylation (HEM), Hofmann- elimination reaction, reaction with nitrous acid, carbylamine reaction, Electrophilic substitution in aromatic amines: bromination, nitration and sulphonation. **3.1.4 Five membered Heterocyclic compounds:** Nomenclature, structure and aromaticity in five membered heterocyclic compound containing one heteroatom. Paal Knorr synthesis for furan, thiophene and pyrrole; reactivity of pyrrole, furan and thiophene towards electrophilic aromatic substitution reactions; General mechanism of Electrophilic aromatic substitution; Diels Alder reaction of furan; Basicity and acidity of pyrrole.	**04** **06**

References:

1. Solid state chemistry and its Applications by A. R. West, Wiley publications, Second edition 2015/16.
2. Solid state Chemistry-An Introduction' by L. Smart and E. Moore, CRC Press Taylor and Francis group, 3rd Edition 2005.
3. "Chemical Kinetics and Catalysis" by Masel R I January 1 2015.
4. Emeleus and Anderson, Modern Aspects of Inorganic Chemistry, page no. 435-463.
5. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
6. Comprehensive Organic Chemistry- The synthesis and reactions of Organic Compounds, Derek barton, W. David Ollis.
7. Mc Murry, J. E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

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S. Y. B. Sc. Chemistry: Choice Based Credit System

Semester- IV

PAPER– III

Course Name: Fundamentals of Analytical Chemistry - II (30 Lectures)			**Course Code** VSCH252
Periods per week (1 period 60 minutes)			**02**
Credits			**02**
Evaluation System		**Hrs**	**Marks**
	Theory Examination	**-**	**60**
	Theory Internal	-	**40**

Learning Objectives (LOs):

1. **Understand the importance and scope of analytical separations**, and recognize when separation is or isn't needed in chemical analysis.
2. **Classify and describe various separation techniques** based on solubility, electrical effects, volatility, retention in stationary phases, ion exchange, and gravity.
3. **Apply the principles of solvent extraction**, including Nernst distribution law, partition coefficient, and multi-step extraction techniques with numerical problem-solving.
4. **Explain the working principles of electroanalytical techniques**, including potentiometry, electrogravimetry, and conductometry with their instrumentation, applications, and limitations.
5. **Use potentiometric and conductometric titrations** to determine endpoints in acid-base neutralizations and interpret titration curves and electrode roles effectively.
6. **Apply statistical tools for data analysis**, including identification and correction of errors, calculation of central tendency and dispersion, and assessment using Gaussian distribution, confidence limits, and hypothesis testing.

Course Outcomes (COs):

CO1: Explain and apply suitable separation techniques such as chromatography, solvent extraction, ion exchange, and distillation in analytical procedures.

CO2: Utilize electroanalytical instruments like potentiometers, conductivity meters, and electrogravimetric setups for analysis and titration with proper understanding of principles and applications.

CO3: Solve problems related to solvent extraction efficiency, distribution ratios, and perform calculations for single and multistep extraction techniques.

CO4: Interpret experimental data using statistical analysis methods by calculating accuracy, precision, standard deviation, and applying tests like t-test, F-test, and Q-test to validate analytical results.

CONTENT		
Unit		**No. of Hours**
Unit - I	**Separation Techniques in Analytical Chemistry** **1.1** An Introduction to Analytical Separations and its importance in analysis. **1.2** Estimation of an analyte without effecting separation. **1.3 Types of separation methods** 1.3.1 Based on Solubilities (Precipitation, filtration Crystallization) 1.3.2 Based on Electrical Effects-Electrophoresis 1.3.3 Based on retention capacity of a Stationary Phase-Chromatography; 1.3.4 Based on distribution in two immiscible phases 1.3.5 Based on capacity to exchange with a resin-Ion Exchange; 1.3.6 Based on Gravity-Centrifugation 1.3.7 Based on volatility-Distillation **1.4 Solvent extraction** 1.4.1 Introduction, Nernst distribution Law, Distribution Ratio, Partition Coefficient. 1.4.2 Conditions of extraction: Equilibration time, Solvent volumes, temperature, pH. 1.4.3 Single step and multi - step extraction, percentage extraction for single step and multistep extraction. Separation factor. 1.4.4 Batch and continuous extraction (Numericals Expected).	**06** **04**
Unit – II	**Instrumental Methods – II** Instruments based on the electrochemical properties of the analytes **2.1 Potentiometry** 2.1.1 Principle 2.1.2 Role of Reference and indicator electrodes 2.1.3 Applications in Neutralization reactions with reference to the titration of a Strong acid against a Strong Base (using quinhydrone electrode) Graphical methods for detection of endpoints **2.2 Electrogravimetry** 2.2.1 Introduction, principle, 2.2.2 Instrumentation 2.2.3 Factors affecting the nature of the deposit 2.2.4 Applications. **2.3 Conductometry** 2.3.1 Principle 2.3.2 Conductivity cell its construction and care 2.3.3 Applications in Neutralization Titrimetry with respect to i) Strong Acid-Strong Base ii) Strong Acid-Weak Base iii) Strong Base-weak Acid iv. Weak Acid- Weak Base. 2.3.4 Advantages & limitations of conductometric titrations.	 **03** **03** **04**

Unit-III	**Statistical Treatment of Analytical Data-I** **3.1 Results of Analysis** 3.1.1 Errors in Analysis and their types 3.1.2 Precision and Accuracy in Analysis 3.1.3 Corrections for Determinate Errors (Problems including Numerical expected wherever required. **3.2 Nature of Indeterminate Errors** 3.2.1 The true and acceptable value of a result of analysis 3.2.2 Measures of central tendency: mean, median. mode, average 3.2.3 Measures of dispersion: Absolute deviation, relative deviation, relative average deviation, standard deviation, (s, sigma) variance, coefficient of variation. **3.3 Distribution of random errors** 3.3.1 Gaussian distribution curve. 3.3.2 Equation and salient features of Gaussian distribution curve. 3.3.3 Concept of Confidence limits and confidence interval and its computation using Population standard deviation, Student's test, Range 3.3.4 Criteria for rejection of doubtful result 2.5 d rule, 4.0 d rule, Q test 3.3.5 Test of Significance Null hypothesis, F-test (variance ratio test)	**02** **04** **04**

❖ **References:**

1. 1.D.A. Skoog, D.M. West, F.J. Holler and CX.R. Crouch – Fundamentals of Analytical chemistry, 8th edition.
2. G.H. Morrison and H. Freiser, Solvent extraction in analytical chemistry.
3. P. G. Swell and B. Clarke, Chromatographic separations, Analytical chemistry by open Learning, John Wiley and sons, 1987.
4. Modern Analytical Chemistry, David Harvey (page numbers 596 -606).
5. Principles of Instrumental analysis, D. A. Skoog, 3rd edition, Saunders college publishing. Chapters: 20, 23 Page no: 600 - 605, 631, 704 - 711.
6. Vogel's Text book of quantitative inorganic analysis, 4th edition, ELBS/ Longman. Chapters: XIV, XV Page no: 566 - 601, 615 – 625.
7. Instrumental methods of analysis, B. K. Sharma, Goel publishing house. Miscellaneous methods: Chapters: 1, 3, 4 Page no: 1 - 14, 21 - 57.
8. Modern Analytical Chemistry, David Harvey (page numbers 53 -84).
9. Fundamentals of analytical chemistry – Skoog and West.

PRACTICALS

(MAJOR/MINOR)

SEMESTER: IV

COURSE CODE: VSCH253 **CREDITS: 02**

Learning Outcomes (LOs)

After completing this course, students will be able to:

LO1: Determine the concentration of Hydrochloric Acid and estimate Iron(II) ions using potentiometric titration with Potassium Dichromate.

LO2: Estimate the strength of acids using conductometric titration and interpret conductance changes during neutralization.

LO3: Compare the strengths of Hydrochloric Acid and Sulfuric Acid by studying kinetics of acid hydrolysis of Methyl Acetate.

LO4: Synthesize coordination compounds such as potassium diaqua bis(oxalato) cuprate(II), bis(ethylenediamine)copper(II) sulphate, sodium hexanitrocobaltate(III), and tris(ethylenediamine)nickel(II) complexes.

LO5: Prepare advanced inorganic complexes including tris(thiourea)copper(I) chloride using standard laboratory techniques.

LO6: Perform systematic qualitative analysis of organic compounds (mono- and bi-functional) through preliminary tests, solubility, element detection, functional group identification, and determination of physical constants with balanced chemical reactions.

Course Outcomes (COs):

CO1: Apply electroanalytical techniques such as potentiometry and conductometry for quantitative estimation of chemical species.

CO2: Understand reaction kinetics and compare acid strengths through experimental investigation of hydrolysis reactions.

CO3: Develop proficiency in inorganic synthesis and systematic qualitative analysis of organic compounds including functional group identification.

CONTENT

Subject	Sr. No.	Experiment
	Potentiometry	
Physical Chemistry	1	To determine the amount of HCl in the given sample potentiometrically.
	2	Estimation of Fe (II) in the given solution by titrating against K2Cr2O7 potentiometrically
	Conductometry	

	3	Estimation of given acid by conductometric titration with strong base
	4	**Chemical kinetics** To compare the strength of HCl and H2SO4 by studying kinetics of acid hydrolysis of methyl acetate
Inorganic Chemistry	5	Preparation of Potassium diaqua bis(oxalato) cuprate(II) from Copper sulphate pentahydrate & Potassium oxalate monohydrate
	6	Preparation of Bis ethylenediamine copper (II) sulphate from Copper sulphate & ethylene diamine.
	7	Preparation of Sodium Hexanitrocobaltate (III) from Cobalt(II) nitrate hexahydrate & Sodium Nitrate.
	8	Preparation of Tris (Ethylene diamine) Nickel (II)Thiosulphate from Nickel Chloride hexahydrate.
	9	Preparation of Tris(thiourea)copper(I)chloride from thiourea, copper turnings and hydrochloric acid.
Organic Chemistry	10	Qualitative Analysis of organic compounds including bi-functional groups on the basis of 1. Preliminary examination 2. Solubility profile. 3. Detection of elements C, H, (O), N, S, X. 4. Detection of functional groups 5. Determination of physical constants(M.P./B.P.) Solid or liquid Compounds containing not more than two functional groups from among the following classes may be given for analysis to be given: Carboxylic acids, phenol, carbohydrates, aldehydes, ketones, ester, amides, nitro, anilides, amines, alkyl and aryl halide. Students are expected to write balanced chemical reactions wherever necessary. **(Minimum 6 compounds to be analyzed)**

References:

1. Khosla B. D., Garg V. C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).

2. Garland C. W., Nibler J. W. and Shoemaker D. P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).

3. Halpern A. M. and McBane G. C., Experimental Physical Chemistry, 3rd Ed., W. H. Freeman and Co., New York (2003).

4. Athawale V. D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001)

5. Practical Inorganic Chemistry by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)

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

7. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)

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

9. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996
10. D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, Analytical Chemistry: An Introduction, 7th ed., Chapter 15, pp.345-381.
11. A.I. Vogel. "Textbook of Quantitative Inorganic Analysis," Longman, London (I961).
12. R.V. Dilts. "Analytical Chemistry. Methods of Separation," van Nostrand, N. Y. (1974).
13. Some Experiments for B. Tech in Chemistry & Chemical Technology compiled by Prof. J.B. BARUAH, Mrs. Abhilasha Mohan Baruah and Mr. Parikshit Gogoi.

S. Y. B. Sc. Chemistry: Choice Based Credit System			
Semester- IV			
SEC			
Course Name: Analytical Chemistry, Tools and Techniques (60 Hrs)			**Course Code:** VSCH254
Practicals Per week (2 Practical 2 Hrs. each)			**02**
Credits			**02**
Evaluation System		**Hrs**	**Marks**
	Practical Examination	60	100

Learning Outcomes (LOs)

After completion of the course, students will be able to:

LO1: Perform conductometric and pH-metric assays for estimation of analytes such as chloride using Silver Nitrate and phosphoric acid in cola samples.

LO2: Determine dissociation constant (pKa) of weak acids such as Acetic Acid using potentiometric (EMF) measurements.

LO3: Estimate metal ions like nickel using spectrophotometry with Dimethylglyoxime and calcium in talcum powder by complexometric titration.

LO4: Apply separation techniques including Thin Layer Chromatography (TLC), paper chromatography, and simple distillation for analysis of mixtures.

LO5: Analyze real-life samples such as water (acidity), butter (salt content), and iron tablets (Fe^{2+} purity) using appropriate analytical methods.

LO6: Process experimental data by calculating mean, median, and standard deviation and interpret results for accuracy and reliability.

Course Outcomes (COs):

CO1: Apply instrumental and analytical techniques such as conductometry, pH-metry, potentiometry, and spectrophotometry for quantitative analysis of real samples.

CO2: Develop skills in separation techniques, complexometric titrations, and analysis of commercial products and environmental samples.

CO3: Interpret analytical data using statistical tools and evaluate accuracy, precision, and purity of chemical substances.

CONTENT

References:

1. Chattopadhyay, K. and Mandal, M. *Analytical Chemistry skill enhancement course*,CBS Publishers & Distributors Pvt. Ltd. 2022
2. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
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5. Prof. Robert H. Hill Jr., David C. Finster Laboratory Safety for Chemistry Students, 2nd Edition Wiley ISBN: 978-1-119-02766-9 May 2016
6. D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, Analytical Chemistry: An Introduction, 7th ed., Chapter 15, pp.345-381.
7. A.I. Vogel. "Textbook of Quantitative Inorganic Analysis," Longman,London (I961).
8. R.V. Dilts. "Analytical Chemistry. Methods of Separation," van Nostrand,N.Y.(1974).
9. Some Experiments for B. Tech in Chemistry & Chemical Technology compiled by Prof. J.B.BARUAH, Mrs. Abhilasha Mohan Baruah and Mr. ParikshitGogoi.