Department of Microbiology

B.Sc. (Chemistry)

Eligibility crteria: Bachelor of Science (B.Sc.)

Sr.No	Course	Required Qualifications
1	B.Sc. Microbiology	12th Pass with PCB
2	B.Sc. Chemistry	12th Pass with PCB/PCM
3	B.Sc. Physics	12th Pass with PCB/PCM
4	B.Sc. Mathematics	12th Pass with PCM

Sr.No	Major	Minor
1	Microbiology	Chemistry
2	Chemistry	Microbiology: G-1 /Physics: G-2
3	Physics	Mathematics/Chemistry
4	Mathematics	Physics

GUJARAT VIDYAPITH: AHMEDABAD
Faculty of Science
Department of Microbiology
Program Structure For B.Sc. Chemistry (3-years UG)
Effective from June 2024*
Summary

Broad Category of Course	**Sem-1**	**Sem-2**	**Sem-3**	**Sem-4**	**Sem-5**	**Sem-6**	**Total**	**Required**
Major (Core)	3+2= **05**	3+2= **05**	3+3= **06**	3 3 06 + 2(P) = 08	3 3 3 =9+5(P) =14	3+2=05 3+2=05 3+2=05 3+2=05 20	**60**	**60**
DSE (Discipline Specific Elective)	**-**	**-**	**-**	**-**	**2** **14+2= 16**	**-**		
Minor	3+2= **05**	3+2= **05**	3+3= **06**	3 3 **06 +2(P)= 08**	**-**	**-**	**24**	**24**
Multidisciplinary	**03**	**03**	**03**	**-**	**-**	**-**	**09**	**09**
Ability Enhancement course	**02**	**02**	**02**	**02**	**-**	**-**	**08**	**08**
Skill Enhancement Course	**03**	**03**	**03**	**-**	**-**	**-**	**09**	**09**
Value added Courses	**02**	**02**	**-**	**02**	**-**	**-**	**06**	**06-08**
Internship/In-house	**-**	**-**	**-**	**-**	**04**		**04**	**02-04**
Total	**20**	**20**	**20**	**20**	**20**	**20**	**120**	**120**

GUJARAT VIDYAPITH: AHMEDABAD
Faculty of Science
Department of Microbiology
Program Structure For B.Sc Chemistry (Semester I to VI) Effective from June 2024

Availability of time for direct teaching in each semester = 15weeks = **517.5 hours** (15weeks × 34.5 hours)
Monday to Friday (excluding prayer and recess)= 30 hours (6 hours × 5 days)
Saturday (excluding prayer and recess) = 4.5 hours
Therefore 1week = 34.5 hours

B.Sc.Semester-1							
Sr. No.	**Broad Category of Course**	**Subject Name**	**Semester**	**Hours**		**Credits**	
				Theory	**Practical**	**Theory**	**Practical**
1	Major (Core)	Chemistry	First	45	60	3	2
2	Minor	G1:Microbiology G2:Physics	First	45	60	3	2
3	Multidisciplinary		First	45	-	3	-
4	Ability Enhancement course		First	30	-	2	-
5	Value added Courses		First	30	-	2	-
6	Skill Enhancement Course		First	-	90	-	3
Total				**195**	**210**	**13**	**07**

Available Total Credits= 20 Total required hours per semester=405
Total available hours per semester=517.5 hours
Available hours per week= 34.5 hours
Calculation of required hours per week
13 credits for theory=**13 hours**
07 credits for practicals=**14 hours**
Total required hours per week=27.0 hours, Extra hours =7.5 hours (we can arrange tutorial class, remedial class, library class and other co-curricular activities during these hours).

B.Sc.Semester-2							
Sr. no	**Broad Category of Course**	**Subject Name**	**Semester**	**Hours**		**Credits**	
				Theory	**Practical**	**Theory**	**Practical**
1	Major(Core)	Chemistry	Second	45	60	3	2
2	Minor	G1:Microbiology G2:Physics	Second	45	60	3	2
3	Multidisciplinary		Second	45	-	3	-
4	Ability Enhancement course		Second	30	-	2	-
5	Value added Courses		Second	30	-	2	-
6	Skill Enhancement Course		Second	-	90	-	3
Total				**195**	**210**	**13**	**07**

Available Total Credits= 20 Total required hours per semester=405
Total available hours per semester=517.5 hours
Available hours per week= 34.5 hours
Calculation of required hours per week
13 credits for theory=**13 hours**
07 credits for practicals=**14 hours**
Total required hours per week=27.0 hours, Extra hours =7.5 hours (we can arrange tutorial class, remedial class, library class and other co-curricular activities during these hours).

UG Certificate: Students who opt to exit after completion of the first year and have secured 40 credits will be awarded a UG certificate **if, in addition, they complete one vocational course or internship / Apprenticeship of 4 credits during the summer vacation of the first year**. These students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.

B.Sc.Semester-3							
Sr. No.	**Broad Category of Course**	**Subject Name**	**Semester**	**Hours**		**Credits**	
				Theory	**Practical**	**Theory**	**Practical**
1	Major (Core)	Chemistry	Third	45	90	3	3
2	Minor	G1:Microbiology G2:Physics	Third	45	90	3	3
3	Multidisciplinary		Third	45	-	3	-
4	Ability Enhancement course		Third	30	-	2	-
5	Skill Enhancement Course		Third	-	90	-	3
Total				**165**	**270**	**11**	**9**

Available Total Credits= 20 Total required hours per semester=435
Total available hours per semester=517.5 hours
Available hours per week= 34.5 hours
Calculation of required hours per week
11 credits for theory=**11 hours**
9 credits for practicals=**18 hours**
Total required hours per week= 29 hours
Extra hours =5.5 hours (we can arrange tutorial class, remedial class, library class and other co-curricular activities during these hours).

B.Sc.Semester-4							
Sr. No.	**Broad Category of Course**	**Subject Name**	**Semester**	**Hours**		**Credits**	
				Theory	**Practical**	**Theory**	**Practical**
1	Major (Core)	Chemistry	Fourth	45	-	3	-
2	Major (Core)	Chemistry	Fourth	45	-	3	-
3	Major (Core)	Chemistry	Fourth	-	60	-	2
4	Minor	G1:Microbiology G2:Physics	Fourth	45	-	3	-
5	Minor	G1:Microbiology G2:Physics	Fourth	45	-	3	-
6	Minor	G1:Microbiology G2:Physics	Fourth	-	60	-	2
7	Ability Enhancement course		Fourth	30	-	2	-
8	Value added Courses		Fourth	30	-	2	-
Total				**240**	**120**	**16**	**4**

Available Total Credits= 20 Total required hours per semester= 360
Total available hours per semester=517.5 hours
Available hours per week= 34.5 hours
Calculation of required hours per week
16 credits for theory=**16 hours**
4 credits for practicals=**8 hours**
Total required hours per week=24 hours
Extra hours =10.5 hours (we can arrange tutorial class, remedial class, library class and other co-curricular activities during these hours).

UG Diploma: Students who opt to exit after completion of the second year and have secured 80 credits will be awarded the UG diploma **if, in addition, they complete one vocational course or internship / Apprenticeship of 4 credits during the summer vacation of the second year.** These students are allowed to re-enter within a period of three years and complete the degree programme within the maximum period of seven years.

B.Sc.Semester-5							
Sr. no	**Broad Category of Course**	**Subject Name**	**Semester**	**Hours**		**Credits**	
				Theory	**Practical**	**Theory**	**Practical**
1	Major(Core)	Chemistry	Fifth	45	-	3	-
2	Major(Core)	Chemistry	Fifth	45	-	3	-
3	Major(Core)	Chemistry	Fifth	45	-	3	-
4	Major(Core)	Chemistry	Fifth	-	150	-	5
5	Major (DSE)	Chemistry	Fifth	30	-	2	-
6	Internship	Internship/ 20 days Workshop (Own Institute)	Fifth	-	120	-	4
Total				**165**	**270**	**11**	**09**

Available Total Credits= 20.0 Total required hours per semester=435
Total available hours per semester=517.5 hours
Available hours per week= 34.5 hours
Calculation of required hours per week
11 credits for theory=**11 hours**
9 credits for practicals=**18 hours**
Total required hours per week=29 hours
Extra hours =5.5 hours (we can arrange tutorial class, remedial class, library class and other co-curricular activities during these hours).

B.Sc.Semester-6							
Sr. no	**Broad Category of Course**	**Subject Name**	**Semester**	**Hours**		**Credits**	
				Theory	**Practical**	**Theory**	**Practical**
1	Major (Core)	Chemistry	Sixth	45	60	3	2
2	Major (Core)	Chemistry	Sixth	45	60	3	2
3	Major (Core)	Chemistry	Sixth	45	60	3	2
4	Major (Core)	Chemistry	Sixth	45	60	3	2
Total				**180**	**240**	**12**	**8**

Available Total Credits= 20.0 Total required hours per semester=420
Total available hours per semester=517.5 hours
Available hours per week= 34.5 hours
Calculation of required hours per week
12 credits for theory=**12 hours**
8 credits for practicals=**16 hours**
Total required hours per week=28 hours
Extra hours =6.5 hours (we can arrange tutorial class, remedial class, library class and other co-curricular activities during these hours).

PROGRAMME OUTCOMES (POs) FOR BACHELOR OF SCIENCE (B.Sc.)

Our program prepares graduates to achieve the followingPOs within three years of graduation.

POs	Integrated Justification
PO1: Discipline-Specific Knowledge	The program develops a strong foundation in scientific principles through interdisciplinary learning, enabling students to apply Natural Sciences and Mathematics to real-world problems. It builds core competencies that prepare graduates for higher education and professional careers.
PO2: Problem Analysis	Graduates develop critical thinking and analytical skills by integrating knowledge from Natural Sciences and Mathematics. They apply scientific methodologies and quantitative techniques to independently solve complex issues.
PO3: Experimental Skills	Students gain hands-on experience in designing, conducting, and analyzing experiments using modern scientific tools. This fosters accuracy, reproducibility, and practical application across various domains.
PO4: Environment and Sustainability	The curriculum promotes ecological awareness and sustainable practices. By linking Natural Sciences with global environmental issues, students develop a scientific approach to sustainability and social responsibility.
PO5: Ethics and Values	Graduates uphold Gandhian values, professional ethics, and integrity. The program fosters responsible application of scientific knowledge within ethical frameworks, encouraging social accountability.
PO6: Communication	Students acquire strong oral and written communication skills, enabling them to articulate scientific concepts, write technical reports, and engage in interdisciplinary dialogue effectively.
PO7: Modern Tool Usage	The program familiarizes students with advanced scientific instruments, IT tools, and analytical software. Graduates can ethically and effectively apply these tools across research and industry sectors.
PO8: Teamwork and Leadership	Graduates are prepared to contribute meaningfully to multidisciplinary teams, demonstrating leadership and collaboration in diverse scientific and professional environments.
PO9: Lifelong Learning	The program instills motivation for lifelong learning and adaptability. Students are equipped to independently explore and incorporate new knowledge and skills in a rapidly changing world.

PO10: Project Management	Graduates develop organizational and economic skills essential for managing scientific research projects and investigations. The curriculum emphasizes planning, execution, and evaluation of scientific work.
PO11: Innovation and Entrepreneurship	The program fosters creative thinking, problem-solving, and entrepreneurial mindset. Students are encouraged to develop innovative scientific solutions with societal impact.
PO12: Societal Contribution	Graduates understand the role of science in society and apply their knowledge for the public good. Emphasis is placed on rural development, informed public discourse, and Gandhian ideals of service and self-reliance.

PROGRAMME SPECIFIC OUTCOMES (PSOs) FOR BACHELOR OF SCIENCE (B.Sc.-Chemistry)

After successful completion of "Three Year Degree Program" in Chemistry, a student will be able to:

PSO Number	Programme Specific Outcomes (PSOs)	Justification
PSO1	Acquire foundational knowledge in key branches of chemistry—such as inorganic, organic, physical, analytical, and industrial—to solve problems, interpret chemical data, assess processes, and develop innovative, interdisciplinary solutions.	This PSO supports the development of discipline-specific knowledge (PO1) and problem analysis (PO2) while fostering an understanding of microbial roles in environmental sustainability (PO4).
PSO2	Develop and apply practical lab skills in techniques like titration, chromatography, spectroscopy, synthesis, and analysis; interpret results, assess method reliability, and refine protocols for improved outcomes.	This PSO is grounded in experimental skills (PO3), enhances familiarity with modern tools (PO7), and prepares students for basic project management (PO10) in scientific settings.
PSO3	Integrate core chemistry concepts with microbiology, physics, math, and environmental science to interpret phenomena, analyze complex problems, and develop innovative, real-world solutions through a multidisciplinary approach.	This outcome aligns with ethics and values (PO5), communication (PO6), teamwork (PO8), lifelong learning (PO9), and societal contribution (PO12) by fostering responsible citizenship and public health awareness.

CO Attainment Matrix

Benchmark (Target attainment) is 60% for all Cos for all courses of B.Sc. Program

Attainment Criteria	Level	Description
≥ 60% students scored ≥ Benchmark	Level 3	**High Attainment** – Most students achieved the expected outcome.
50–59% students scored ≥ Benchmark	Level 2	**Moderate Attainment** – Outcome partially achieved.
40–49% students scored ≥ Benchmark	Level 1	**Low Attainment** – Minimal outcome achieved.
< 40% students scored ≥ Benchmark	Level 0	**Not Attained** – Remedial action required

B.Sc. (Chemistry) Semester-1	BCHE-101: Physical Chemistry	MAJOR

Credit - 3, Teaching Hours - 45

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: interpret ionic equilibrium in terms of acid-base reactions, pH scale, hydrolysis of salt, and buffer systems.

CO2: describe the relationship between physical properties and molecular structure

CO3: recognize the catalytic processes and adsorption phenomena

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	3	2	–	–	2	2	–	–	–	–	–	2.40	3	2	2	2.33
CO2	3	2	–	–	–	2	1	–	–	–	–	–	2.00	3	1	3	2.33
CO3	2	3	3	1	–	–	2	–	–	–	–	–	2.17	2	2	3	2.33
PO Avg	2.67	2.67	2.5	1.0	–	2.0	1.67	–	–	–	–	–		2.67	1.67	2.67	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1. Constructivism
2. Social Constructivism
3. Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	Ionic equilibrium	15 Hrs

1.1 Degree of ionization **(1hour)**

1.2 Ostwald dilution law and its limitations **(1hour)**

1.3 pH scale **(2hours)**

- Definition of pH and importance of pH scale
- Relation between pH and concentration of H^+ in solution
- pH range of acidic, basic solution
- Introduction about pOH, relation between pH and pOH, ionic product of water (K_w)

1.4 Hydrolysis of salts (from weak acid [HA] and strong base [BOH]) including derivation of

- $K_h = \frac{[HA][OH^-]}{[A^-]}$ **(2hours)**
- $K_h = \frac{K_w}{K_a}$

	• $h = \sqrt{\frac{K_h}{C}}$ • $pH = \frac{1}{2}[pK_w + pK_a + \log C]$ 1.5 Hydrolysis of salts (from weak base [BOH] and strong acid [HA]) including derivation of • $K_h = \frac{[BOH][H^+]}{[B^+]}$ **(2hours)** • $K_h = \frac{K_w}{K_b}$ • $h = \sqrt{\frac{K_h}{C}}$ • $pH = \frac{1}{2}[pK_w - pK_b - \log C]$ 1.6 Hydrolysis of salts (from weak acid [HA] and weak base [BOH]) including derivation of • $K_h = \frac{[HA][BOH]}{[A^-][B^+]}$ **(2hours)** • $K_h = \frac{K_w}{K_a \times K_b}$ • $h = \sqrt{K_h}$ • $pH = \frac{1}{2}[pK_w + pK_a - pK_b]$ 1.7 Buffer solutions **(2hours)** - Properties of buffer solutions - Buffer capacity and buffer limit of buffer solution - pH of buffer formed from weak acid and its salt including derivation of Henderson-Hasselbach equation - pOH of buffer formed from weak base and its salt including derivation of Henderson-Hasselbach equation - Action of buffer solutions in adjustment of pH during addition of acid or Base - Buffer standards -Importance of buffer solutions 1.8 Numericals based on topics 1.3 to 1.7 **(3hours)**	
	References: 1. Puri, B. R., Sharma, L. R., & Pathania, M. S. (2022). Principles of Physical Chemistry (48th ed.). Vishal Publishing Co. 2. Mahan, B. H., & Meyers, R. J. (2020). University Chemistry (5th ed.). Pearson Education. 3. Atkins, P., & de Paula, J. (2018). Physical Chemistry (11th ed.). Oxford University Press. 4. Bahl, A., Bahl, B. S., & Tuli, G. D. (2023). Essentials of Physical Chemistry (28th rev. ed.). S. Chand & Company Ltd. 5. Kotz, J. C., & Treichel, P. (1999). Chemistry and chemical reactivity (4th ed.). Saunders College Publishing. 6. Skoog, D. A., West, D. M., & Holler, F. J. (1996). Fundamentals of analytical chemistry (7th ed.). Saunders College Publishing. 7. Harris, D. C. (2003). Quantitative chemical analysis (6th ed.). W. H. Freeman and Company.	

UNIT 2	Physical properties and molecular structure	15 Hrs
	2.1 Additive and constitutive properties **(1hour)** 2.2 Molar volume: **(2hours)** - Additivity of molar volume - Calculation of approximate molar volumes of given compound 2.3 Surface tension: **(2hours)** -Definition, unit - Derivation of formula of relative surface tension of liquid - Use of stalagmometer in determination of relative surface tension of liquid - Numericals 2.4 Parachor:**(2hours)** -Relation between parachor, surface tension and molarvolume -Calculation of approximate parachor of given compound -Application of parachor - Numericals 2.5 Viscosity: **(2hours)** - Definition, unit -Derivation of formula of relative viscosity of liquid - Use of Ostwal's viscometer in determination of relative viscosity of given liquid - Numericals 2.6 Molar refraction: **(2hours)** - Definition and applications - Molar refraction of mixture - Measurement of refraction index by Abbe refractometer - Numerical 2.7 Optical activity: **(2hours)** -Definition, measurement by polarimeter - d / (+) / dextro, l /(-) / levo concept - Numericals 2.8 Dipole moment, its measurement and its application **(2hours)**	
	References 1. Atkins, P., de Paula, J., & Keeler, J. (2022). Atkins' physical chemistry (12th ed.). Oxford University Press. 2. Kapoor, K. L. (2023). A textbook of physical chemistry (Vol. 1–5). Macmillan India. 3. Athawale, V. D., & Mathur, P. (2022). Experimental physical chemistry. New Age International Publishers.	
UNIT 3	**(A)Catalysis**	**8Hrs**
	3(A).1 Definition of catalyst and catalysis**(1 hour)** 3(A).2 Types of catalyst:POsitive catalyst, negative catalyst and auto catalyst**(1 hour)** 3(A).3 Catalytic reaction: homogeneous catalytic reaction and Heterogeneous catalytic reaction**(1 hour)** 3(A).4 Characteristics of catalyst**(1 hour)**	

	3(A).5 Action of finely divided catalyst**(1 hour)** 3(A).6 Catalytic promoters or activators**(1 hour)** 3(A).7 Catalytic poisons or anticatalysts**(1 hour)** 3(A).8 Enzyme catalyst: definition and characteristics**(1 hour)**	
	(B) Adsorption	**7 Hrs**
	3(B).1 Definition of adsorption, absorption,POsitive adsorption, negative adsorption, absorbate, desorption**(1 hour)** 3(B).2 Types of adsorption (physical adsorption, chemical adsorption)**(2 hours)** 3(B).3 Adsorption of gases by solids**(1 hour)** 3(B).4 Freudlich and langmuir adsoption isotherm(derivation) **(2 hours)** 3(B).5 Application of adsorption**(1 hour)**	
	References: 1. McQuarrie, D. A., & Simon, J. D. (2023). Physical chemistry: A molecular approach. University Science Books. 2. Raj, G. (2024). Advanced physical chemistry . Goel Publishing House. 3. Viswanathan, B., Sivasanker, S., & Ramaswamy, A. V. (2011). Catalysis: Principles and applications (Reprint ed.). Narosa Publishing House.	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-1	BCHE-101P: Physical Chemistry Practical	MAJOR

Credit - 2, Teaching Hours - 60

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: prepare chemical solutions accurately

CO2: analyze physical properties of liquids and ability to determine catalytic and adsorption activity

Mapping Matrix of POs, PSOs and COs

COs	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	3	–	–	2	2	–	–	–	–	–	2.40	2	3	2	2.33
CO2	3	3	3	1	–	–	2	–	–	–	–	–	2.00	3	2	2	2.33
PO Avg	3.0	2.5	3.0	1.0	–	2.0	2.0	–	–	–	–	–		2.50	2.50	2.00	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3. Behaviorism

Teaching Methods and Tools

- Experimentation
- Hands on Training

Experiments

(A)	**Solution preparation**	**24 Hrs**
	(1) General introduction ,Percentage solution: %v/v, %w/v **(4 hours)** (2)Preparation and standardization of sodium hydroxide solution (approximately 0.1 N) **(4 hours)** (3)To determine normality of given HCl/HNO_3 solution using standard sodium hydroxide Solution**(4 hours)** (4) Preparation and standardization of hydrochloric acid solution (approximately 0.1 N) **(4 hours)** (5) To determine normality of given NaOH/KOH solution using standard hydrochloric acid solution**(4 hours)** (6) Preparation of molar and normal solution of H_2SO_4 and Na_2CO_3 **(4 hours)**	
(B)	**Experiments of Physical chemistry**	**28 Hrs**
	(1) To measure the density of a given liquid by R.D. bottle **(4 hours)** (2) To determine the relative surface tension of a liquid with respect to water at room temperature by Stalagmometer**(4 hours)** (3) To determine the surface tension of methyl alcohol, ethylalcohol and n-hexane at room temperature and calculate the atomic	

	parachors of carbon, hydrogen and oxygen**(8 hours)** (4) To determine the relative viscosity of a liquid with respect to water at room temperature by Ostwald's viscometer**(4 hours)** (5) To determine the composition of a given mixture consisting of two miscible liquids, A and B by viscosity measurement **(4 hours)** (6) To determine the refractive index of a given liquid and find its specific and molar refractivities**(4 hours)**	
(C)	**Catalysis and Adsorption**	**8Hrs**
	(1) To determine the relative strength between HCl and H_2SO_4 by studying hydrolysis of methyl acetate. **(4 hours)** (2) To study the adsorption of an organic acid by Animal Charcoal. (Acetic acid /Oxalic acid) **(4 hours)**	
	References 1. Ahluwalia, V. K., & Sharma, S. (2022). Practical chemistry: For B.Sc. students (Latest ed.). University Press. 2. Patil, R. S., & Sawant, R. M. (2023). Laboratory manual of analytical chemistry (2nd ed.). Himalaya Publishing House. 3.Furniss, B. S., Hannaford, A. J., Smith, P. W. G., & Tatchell, A. R. (2021). Vogel's textbook of practical organic chemistry (5th ed., Reprint). Pearson Education.	

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination
External Assessment (60%)	Term End Practical examination

B.Sc. (Chemistry) Semester-2	BCHE-201: Inorganic Chemistry	MAJOR

Credit - 3, Teaching Hours - 45

Course Outcomes (COs)

After studying this course, the student will be able to….
CO1: relate the elements and their periodic relationships
CO2: express occurrence, chemical and physical properties of s, p, d and f-block elements
CO3: recognize the importance of chemical elements and their diverse applications

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	2	–	–	2	1	–	–	–	–	–	2.00	3	1	2	2.00
CO2	3	3	2	1	–	–	2	–	–	–	–	–	2.20	3	1	2	2.00
CO3	3	2	2	2	1	–	2	1	–	–	–	2	2.00	3	1	3	2.33
PO Avg	3.0	2.33	2.0	1.5	1.0	2.0	1.67	1.0	–	–	–	2.0		3.0	1.0	2.33	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	(A) s- Block Elements (Alkali and Alkaline earth metals)	10 Hrs
	<u>Group-1: Alkali metals</u> 1(A).1 General introduction, electronic configuration, occurrence**(1 hour)** 1(A).2 Anomalous properties of the Lithium **(0.5 hour)** 1(A).3 Diagonal Relationship between Lithium and Magnesium **(0.5 hour)** 1(A).4 Trends in the variation of properties (such as ionization enthalpy, atomic and ionic radii) **(1 hour)** 1(A).5 Trends in chemical reactivity with oxygen, water, hydrogen and halogens **(1 hour)** 1(A).6 Biological importance of sodium and potassium **(0.5 hour)** 1(A).7 Uses of Alkali metals **(0.5 hour)** **<u>Group-2: Alkaline earth metal</u>** 1(A).8 General introduction, electronic configuration, occurrence **(1 hour)** 1(A).9 Anomalous properties of the Beryllium **(0.5 hour)**	

	1(A).10 Diagonal Relationship between Beryllium and Aluminium **(0.5 hour)** 1(A).11 Trends in the variation of properties (such as ionization enthalpy, atomic and ionic radii) **(1 hour)** 1(A).12 Trends in chemical reactivity with oxygen, water, hydrogen and halogens **(1 hour)** 1(A).13 Biological importance of Mg and Ca **(0.5 hour)** 1(A).14 Uses of Alkaline earth metals **(0.5 hour)**	
	(B)d-Block Elements Transition Elements (First, second and third Transition Series	**5 Hrs**
	1(B).1 General introduction, electronic configuration **(1 hour)** 1(B).2 Physical properties of transition metals **(0.5 hour)** 1(B).3Variation in Atomic and Ionic Sizes of Transition Metals **(1 hour)** 1(B).4 Ionisation Enthalpies of Transition Metals **(0.5 hour)** 1(B).5 Oxidation states of Transition Metals **(0.5 hour)** 1(B).6 Magnetic Properties of Transition Metals **(0.5 hour)** 1(B).7 Formation of coloured ions **(0.5 hour)** 1(B).8 Catalytic properties of Transition Metals **(0.5 hour)**	
	References 1. Shriver, D. F., & Atkins, P. W. (2024). Inorganic Chemistry (7th ed.). Oxford University Press. 2.Tandon, O. P. (2023). Inorganic Chemistry (6th ed.). S. Chand Publishing. 3.Gerloch, M., & Constable, E. C. (2025). Transition Metal Chemistry: The Valence Shell in d-Block Chemistry. Wiley. 4.Cotton, F. A., Wilkinson, G., & Gaus, P. L. (2022). Basic Inorganic Chemistry (3rd Indian Adapted ed.). Wiley. 5.Lee, J. D. (2018). Concise Inorganic Chemistry (5th ed.). Wiley India Pvt. Ltd. 6.Weller, M. T., Overton, T. L., Rourke, J. P., Armstrong, F. A., & Atkins, P. W. (2018). Inorganic Chemistry (7th ed.). Oxford University Press.	
UNIT 2	**p-Block Elements**	**15 Hrs**
	2.1 General Introduction to p-Block Elements **(0.5 hour)** **<u>Group 13 elements : Boron Family</u>** 2.2 General introduction, electronic configuration, occurrence **(0.5 hour)** 2.3 Anomalous properties of the Boron **(0.5 hour)** 2.4 Trends in the variation of properties (such as ionization enthalpy, atomic and ionic radii, electronegativity) **(0.5 hour)** 2.5 Physical properties and chemical reactivity (with air, acids, alkalies and halogens) **(0.5 hour)** 2.6 Uses of boron, aluminium and their compounds **(0.5 hour)** **<u>Group 14 elements : Carbon Family</u>** 2.7 General introduction, electronic configuration, occurrence **(0.5 hour)** 2.8 Anomalous properties of the carbon **(0.5 hour)** 2.9 Trends in the variation of properties (such as ionization enthalpy, atomic and ionic radii, electronegativity) **(0.5 hour)** 2.10 Physical properties and chemical reactivity (with oxygen, water and halogens) **(0.5 hour)** 2.11 Allotropes of carbon (Diamond, Graphite and Fullerenes) and Uses of carbon **(0.5 hour)** **<u>Group 15 elements : Nitrogen Family</u>** 2.12 General introduction, electronic configuration, occurrence **(0.5 hour)**	

	2.13 Anomalous properties of the Nitrogen **(0.5 hour)** 2.14 Trends in the variation of properties (such as ionization enthalpy, atomic and ionic radii, electronegativity) **(0.5 hour)** 2.15 Physical properties and chemical reactivity (with hydrogen, oxygen, halogens and metals) **(0.5 hour)** 2.16 Uses of nitrogen and allotropes of Phosphorus (White, Red and Black) **(0.5 hour)** **Group 16 elements : Oxygen Family** 2.17 General introduction, electronic configuration, occurrence **(0.5 hour)** 2.18 Anomalous properties of the Oxygen **(0.5 hour)** 2.19 Trends in the variation of properties (such as ionization enthalpy, electron gain enthalpy, atomic and ionic radii, electronegativity) **(0.5 hour)** 2.20 Physical properties and chemical reactivity (with hydrogen, oxygen and halogens) **(0.5 hour)** 2.21 Allotropes of Sulphur (Rhombic, Monoclinic) **(0.5 hour)** 2.22 Uses of oxygen, ozone, sulphur dioxide and sulphuric acid **(0.5 hour)** **Group 17 elements : Halogen Family** 2.23 General introduction, electronic configuration, occurrence **(0.5 hour)** 2.24 Anomalous properties of the Fluorine **(0.5 hour)** 2.25 Trends in the variation of properties (such as ionization enthalpy, electron gain enthalpy, atomic and ionic radii, electronegativity) **(0.5 hour)** 2.26 Physical properties and chemical reactivity (with hydrogen, oxygen, metals and other halogens) **(0.5 hour)** **Group 18 elements : Noble gas Family** 2.27 General introduction, electronic configuration, occurrence **(0.5 hour)** 2.28 Trends in the variation of properties (such as ionization enthalpy, electron gain enthalpy, atomic and ionic radii) **(0.5 hour)** 2.29 Physical properties and chemical reactivity**(0.5 hour)** 2.30 Uses of noble gases**(0.5 hour)**	
	References 1. Elias, A. (2024). Chemistry of the p-Block Elements: Syntheses, Reactions, and Applications (1st ed.). Universities Press. 2. Housecroft, C. E., & Sharpe, A. G. (2023).Inorganic Chemistry (5th ed.). Pearson. 3. Shriver, D. F., & Atkins, P. W. (2024). Inorganic Chemistry (7th ed.). Oxford University Press. **4.** Warren, S. C., & Walsh, P. J. (2024). Modern p-Block Chemistry (1st ed.). Wiley.	
UNIT 3	**(A) The lanthanide series**	**6Hrs**
	3(A).1 Electronic configuration**(1 hour)** 3(A).2 Oxidation states**(1hour)** 3(A).3 Magnetic properties**(1 hour)** 3(A).4 Colour and absorption spectra of lanthanide ions**(1 hour)** 3(A).5 Lanthanide contraction**(1 hour)** 3(A).6 Separation and purification of lanthanides :Ion exchange and solvent extraction methods**(1 hour)**	

	(B) The Actinide series	**9 Hrs**
	3(B).1 Electronic configuration**(1 hour)** 3(B).2 Oxidation states **(1 hour)** 3(B).3 Magnetic properties **(1 hour)** 3(B).4 Colour and absorption spectra of actinide ions **(1 hour)** 3(B).5 Actinide contraction **(1 hour)** 3(B).6 Nuclear synthesis of trans uranic elements **(1 hour)** 3(B).7 Chain reaction **(1 hour)** 3(B).8 Importance of uranium **(1 hour)** 3(B).9 Comparison with lanthanides **(1 hour)**	
	References 1. Cotton, S. (2024). Lanthanide and Actinide Chemistry (2nd ed.). John Wiley & Sons. 2. Shriver, D. F., & Atkins, P. W. (2024). Inorganic Chemistry (7th ed.). Oxford University Press. 3. Housecroft, C. E., & Sharpe, A. G. (2023). Inorganic Chemistry (5th ed.). Pearson. 4. Rai, B. K., Bretana, A., Morrison, G., Greer, R., Gofryk, K., & zur Loye, H.-C. (2024). Crystal Structure and Magnetism of Actinide Oxides: A Review. arXiv. https://arxiv.org/abs/2403.01634	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-2	BCHE-201P: Inorganic Chemistry Practical	MAJOR

Credit - 2, Teaching Hours - 60

Course Outcomes (COs)

After studying this course, the student will be able to….
CO1: identify ions in inorganic mixtures by dry tests
CO2: identify ions in inorganic mixtures by wet tests

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	3	–	–	1	2	–	–	–	–	–	2.2	2	3	1	2
CO2	3	3	3	–	–	1	2	–	–	–	–	–	2.4	2	3	1	2
PO Avg	3.0	2.5	3.0	–	–	1.0	2.0	–	–	–	–	–		2	3	1	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3. Behaviorism

Teaching Methods and Tools

- Experimentation
- Hands on Training

Experiments

Qualitative analysis of inorganic mixture — **60 Hrs**

Semi-micro method of analysis of mixture of powders containing four radicals excluding soluble PO_4^{3-}, arsenite, arsenate and borate.Mixture may be partly soluble in water and wholly soluble in an acid

Candidate should perform the analysis of following ions

Na^+, K^+, NH_4^+, Mg^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Fe^{2+}, Fe^{3+} , Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Hg^{2+}, Pb^{2+}, Cu^{2+}, Sn^{2+}, Ag^+ and S^{2-}, SO_3^{2-}, SO_4^{2-}, CO_3^{2-}, Cl^-, Br^-, I^-, NO_3^-, NO_2^-

References

1. Kesavan, M. P. (2025). Inorganic Semi-Micro Qualitative Analysis. LAP Lambert Academic Publishing.
2. Mukherjee, G. N. (2008). Semi-Micro Qualitative Inorganic Analysis. University of Calcutta Press.
3. Vogel, A. I., & Svehla, G. (1979). Text-book of Macro and Semi-Micro Qualitative Inorganic Analysis (5th ed.). Longman.

Assessment Method

Internal/Online Assessment (40%)	Internal Practical Examination
External Assessment (60%)	Term End Practical examination

B.Sc. (Chemistry) Semester-3	BCHE-301: Organic Chemistry	MAJOR

Credit - 3, Teaching Hours - 45

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: state the concepts of stereochemistry and the mechanism of electrophilic substitution reactions

CO2: describe the chemistry underlying the synthesis and behavior of amino acids, peptides, and proteins.

CO3: identify aromatic and antiaromatic systems using delocalization and resonance criteria.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	3	–	–	2	2	–	–	–	–	–	2.40	3	1	2	2.00
CO2	3	2	2	–	–	1	2	–	–	–	–	–	2.00	3	2	2	2.33
CO3	3	3	2	1	–	–	1	–	–	–	–	–	2.00	3	1	2	2.00
PO Avg	3.0	2.33	2.33	1.0	–	1.5	1.67	–	–	–	–	–					

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	(A): Stereochemistry	8 Hrs
	1(A).1 Definition of stereochemistry and stereoisomerism **(0.5hour)** 1(A).2 Configurational isomers: cis-trans isomers (for acyclic and cyclic compounds) **(0.5hour)** 1(A).3 E-Z nomenclature **(1hour)** 1(A).4 Chirality **(1hour)** 1(A).5 Configurational isomers: isomers with one and more than one chiral centre (Lactic acid, Tartaric acid, 2,3-dibromopentane, 3-chloro-2-butanol) – enantiomers, diastereomers, mesocompounds**(2hours)** 1(A).6 R-S nomenclature (one and more than one chiral centre) **(2hours)** 1(A).7 Conformational analysis of ethane and n-butane only **(1hour)**	

	References 1. Clayden, J., Greeves, N., Warren, S., & Wothers, P. (2012). Organic chemistry (2nd ed.). Oxford University Press. 2. Eliel, E. L., & Wilen, S. H. (1994). Stereochemistry of organic compounds (Rev. ed.). Wiley. 3. Bruice, P. Y. (2024). Organic Chemistry (9th ed.). Pearson. 4. Morrison, R. T., & Boyd, R. N. (2010). Organic Chemistry (7th ed.). Pearson Education India.	
	(B): Aromatic substitution reaction	**7 Hrs**
	1(B).1 Introduction about electrophilic and nucleophilic substitution reactions **(1hour)** 1(B).2 Electrophilic reagent / electrophilic substitution reaction **(0.5hour)** 1(B).3 Mechanism of nitration, sulphonation, halogenation, friedal craft alkylation, friedal craft acylation **(2hours)** 1(B).4 Classification of substituents groups **(0.5hour)** 1(B).5 Theory of orientation of second group in monosubstituted benzene [first substituent is activating / deactivating group] **(1hour)** 1(B).6 Orientation of third group in disubstituted benzenes **(0.5hour)** 1(B).7 Conversion [reactions form] based on above topics **(1.5hours)**	
	References 1. Coppola, B. P. (2023). Structure and Reactivity: An Introduction to Organic Chemistry (2nd printing). Van-Griner Learning. 2 .McMurry, J. E. (2022). Organic Chemistry (9th ed.). OpenStax. https://openstax.org/details/books/organic-chemistry 3.Bruice, P. Y. (2024). Organic Chemistry (9th ed.). Pearson. 4. Morrison, R. T., & Boyd, R. N. (2010). Organic Chemistry (7th ed.). Pearson Education India	
UNIT 2	**Aminoacids,Peptides and Protein**	**15 Hrs**
	2.1 General structure of aminoacids **(1hour)** 2.2 Classification and nomenclature of amino acids**(1hour)** 2.3 Configuration of amino acids: D and L notation **(1hour)** 2.4 Preparation of amino acids: Amination of α-haloacids, Gabriel phthalamide synthesis, strecker synthesis **(2hours)** 2.5 Zwitter ion (dipolar ion) **(1hour)** 2.6 Isoelectric point of amino acids **(1hour)** 2.7 Reaction of amino acid with ninhydrine (not structural reaction) **(1hour)** 2.8 Peptide linkage (dipeptides, tripeptides, polypeptides) **(1hour)** 2.9 Geometry of peptide linkages **(1hour)** 2.10 Determination of structure of peptides **(2hours)** - N-terminal residue analysis (DNFB method, Phenyl isothiocynate method) - C-terminal residue analysis(by thiohydantoin and with carboxypeptidase enzyme) 2.11Work out the sequence of amino acid residues from given peptides **(1hour)** 2.12 The strategy of peptide synthesis (Benzyloxycarbonyl method)**(1hour)** 2.13Overview of primary, secondary,tertiary and quternary structure of proteins**(1hour)**	

	References 1.Ahluwalia, V. K., Kumar, L. S., & Kumar, S. (2022).Chemistry of natural products: amino acids, peptides, proteins and enzymes. Springer. 2. Barrett, G. C., & Elmore, D. T. (2012). Amino acids and peptides: chemistry and analytical methods. Cambridge University Press. 3.Garrett, R. H., & Grisham, C. M. (2024). Biochemistry (7th ed.). Cengage Learning. 4..Bruice, P. Y. (2024). Organic Chemistry (9th ed.). Pearson. 5.. Morrison, R. T., & Boyd, R. N. (2010). Organic Chemistry (7th ed.). Pearson Education India 6. Carey, F. A., Giuliano, R. M., Allison, N., & Bane, S. (2023). Organic chemistry(12th International Student ed.). McGraw-Hill Education.	
UNIT 3	**Electron delocalization, Resonance and Aromaticity**	**15 Hrs**
	3.1 Delocalization electron and resonance **(1 hour)** 3.2 How to draw resonance contributors: rules for drawing resonance contributors (**3 hours)** 3.3 The resonance hybrid **(2 hours)** 3.4 Resonance energy **(1 hour)** 3.5 Stability of allylic and benzylic cations **(2 hours)** 3.6 Stability of allylic and benzylic radicals **(2 hours)** 3.7 Criteria for aromaticity **(1hours)** 3.8 Aromaticity **(2 hours)** 3.9 Antiaromaticity **(1 hour)**	
	References 1. Bruice, P. Y. (2024). Organic chemistry (9th ed.). Pearson. 2.Clayden, J., Greeves, N., Warren, S., & Wothers, P. (2012). Organic chemistry (2nd ed.). Oxford University Press. 3.McMurry, J. (2023). Organic Chemistry (10th ed.). OpenStax. https://openstax.org/details/books/organic-chemistry	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-3	BCHE-301P: Organic Chemistry Practical	MAJOR

Credit -3, Teaching Hours - 90

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: demonstrate proficiency in performing qualitative analysis of organic compounds using standard laboratory techniques.

CO2: apply appropriate methods and safety protocols to synthesize organic compounds effectively in a laboratory setting.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	3	–	–	2	2	–	–	–	–	–	2.40	2	3	1	3
CO2	3	3	3	1	–	–	2	–	–	–	–	–	2.00	2	3	2	2.33
PO Avg	3.0	2.5	3.0	1.0	–	2.0	2.0	–	–	–	–	–		2	3	1.5	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3. Behaviorism

Teaching Methods and Tools

- Experimentation
- Hands on Training

Experiments

(A) Preparation of organic compounds and its confirmation by function group test and M.P (with mole ratio calculation)	**30 Hrs**
(1) Oxidation: Benzoic acid from benzaldehyde by $KMnO_4$ (2) Nitration: p-nitroacetanilide from acetanilide (3) Nitration: 1,3-dinitrobenzene from nitrobenzene	
(B)Qualitative analysis of organic compounds	**60 Hrs**

Candidates are expected to perform the following tests for the organic compounds

(1) Nature of compound: acidic, basic, phenolic, neutral based on solubility tests
(2) Presence of elements: Lassaigne's test (C, H, N,S,X)
(3) Identification of functional groups:

-COOH	>C=O
-OH (alcoholic)	$-NH_2$
-OH (phenolic)	$-NO_2$
-CHO	$-CONH_2$
-CH	-X

(4) B.P. / M.P. (5)Identification of compound

List of organic compounds for qualitative analysis

Compounds	Acidic	Basic	Phenolic	Neutral
C, H, O elements	Tartaric acid		Phenol	Methanol

	Citric acid Phthalic acid Benzoic acid Oxalic acid Succinic acid	-	α-Naphthol β-Naphthol Resorcinol	Ethanol Benzaldehyde Acetone Acetophenone Benzene Toluene Naphthalene	
C, H, O, N elements	Anthranilic acid p-Nitrobenzoic acid	Aniline o-Nitroaniline m-Nitroaniline p-Nitroaniline α-Naphthylamine	o-Nitrophenol p-Nitrophenol	Acetamide Benzamide Nitrobenzene Urea	
C, H, O, N, S elements	-	-	-	Thiourea	
C, H, O, X elements	-	-	-	Chloroform Carbontetrachloride Chlorobenzene Bromobenzene	

References

1. Vogel, A. I., Tatchell, A. R., Furniss, B. S., Hannaford, A. J., & Smith, P. W. G. (1996). Vogel's Textbook of Practical Organic Chemistry (5th ed.). Prentice Hall PTR.
2. ..García-Isac-García, J., Dobado, J. A., Calvo-Flores, F. G., & Martínez-García, H. (2015). Experimental Organic Chemistry: Laboratory Manual (3rd ed.). Academic Press.
3. Liskin, D., Brunke, K., & Carney, J. (2023). Organic Chemistry Laboratory Manual (5th ed.). Kendall Hunt Higher Education.
3. Singh, S. K. (2017). Lab manual of qualitative and quantitative analysis. Manakin Press.

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination
External Assessment (60%)	Term End Practical examination

B.Sc. (Chemistry) Semester-4	BCHE-401: Organic Chemistry	MAJOR

Credit - 3, Teaching Hours - 45

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: interpret ionic equilibrium in terms of acid-base reactions, pH scale, hydrolysis of salt, and buffer systems.

CO2: describe the relationship between physical properties and molecular structure

CO3: recognize the catalytic processes and adsorption phenomena

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	3	–	–	2	2	–	–	–	–	–	2.40	3	2	2	2.33
CO2	3	2	2	–	–	2	1	–	–	–	–	–	2.00	3	1	3	2.33
CO3	3	3	2	1	–	–	1	–	–	–	–	–	2.00	3	2	2	2.33
PO Avg	3.0	2.33	2.33	1.0	–	2.0	1.33	–	–	–	–	–		3	1.67	2.33	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	Heterocyclic compounds	15 Hrs
	1.1 Introduction **(1hour)** 1.2 Nomenclature of heterocycles: **(3hours)** -systematic nomenclature system for naming three to ten membered monocyclic hetero cycles of various unsaturation containing one or more hetero atoms -system of nomenclature is based on the trivial and semitrivial names of heterocycles [Pyrrole, Furan, Thiophene, Selenophene, Pyrazole, Imidazole, Isoxazole, Pyridine, Pyridazine, Pyrimidine, Pyrazine, Pyrene, Indole, Isoindole, Purine, Quinoline, Isoquinoline] -nomenclature systems for fused heterocycles **Five membered heterocyclic compounds [Pyrrole, Furan, Thiophene]** 1.3 Source of pyrrole, furan and thiophene**(1hour)** 1.4 Aromaticity and orbital structure of pyrrole,furan and thiophene**(1hour)** 1.5 Preparation of pyrrole,furan and thiophene**(1hour)**	

	1.6 Orientation of electrophilic substitution in pyrrole,furan and thiophene **(1hour)** 1.7 Relative reactivity toward electrophilic aromatic substitution in pyrrole, furan, thiophene and benzene**(1hour)** **Six membered heterocyclic compounds [Pyridine]** 1.8 Source of pyridine compound **(1hour)** 1.9 Aromaticity and orbital structure of pyridine **(1hour)** 1.10 Basicity of pyridine including comparison with basicity of pyrroleand aliphatic amine **(1hour)** 1.11 Orientation of electrophilic and nucleophilic substitution in pyridine **(2hours)** 1.12 Relative reactivity toward electrophilic aromatic substitution in benzene, pyridine **(1hour)**	
	References 1..Bruice, P. Y. (2024). Organic Chemistry (9th ed.). Pearson. 2. Morrison, R. T., & Boyd, R. N. (2010). Organic Chemistry (7th ed.). Pearson Education IndiaClayden, 3. J., Greeves, N., & Warren, S. (2012). Organic chemistry (2nd ed.). Oxford University Press. 4.Joule, J. A., Mills, K., & Smith, G. (2010). Handbook of heterocyclic chemistry (3rd ed.). Elsevier. 5.Pugh, A. (2021). Heterocyclic chemistry (1st ed.). University Press.	
UNIT 2	**Carbohydrates**	**15 Hrs**
	2.1 Definition and classification **(0.5hour)** 2.2 Nomenclature **(0.5hour)** 2.3 D and L notation **(0.5hour)** 2.4 Configuration of aldose and ketose containing three through six carbon atoms **(2hours)** 2.5 General properties of monosaccharide (Glucose and Fructose): colour, taste, physical state, solubility **(0.5hour)** 2.6 Chemical properties of monosaccharide (Glucose and Fructose): acetylation, oxidation, reduction, cynohydrin formation, oxime formation, osazone formation **(2.5hours)** 2.7 Epimers, epimers of D-glucose, conversion of an aldohexose into its C-2 epimer (mannose) **(1hour)** 2.8 Methods of interconversion of sugars **(2hours)** - Lengthening the carbon chain of aldoses (The Kiliani Fischer synthesis: aldohexose from aldopentose) - Shortening the carbon chain of aldoses (The Ruff degradation: aldopentose from aldohexose) 2.9 Configuation of (+) glucose: The Fischer proof **(2hours)** 2.10 Cyclic structure of glucose **(2hours)** 2.11Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.**(1.5hour)**	
	References 1..Bruice, P. Y. (2024). Organic Chemistry (9th ed.). Pearson. 2. Morrison, R. T., & Boyd, R. N. (2010). Organic Chemistry (7th ed.). Pearson Education IndiaClayden, 3.Robyt, J. F. (1997). Essentials of carbohydrate chemistry (3rd ed.). Springer. https://doi.org/10.1007/978-1-4612-1622-3 4.Sinnott, M. L. (2016). Carbohydrate chemistry and biochemistry: Structure and mechanism (2nd ed.). Royal Society of Chemistry.	

UNIT 3	Chemical Reactivity and Molecular Structure (Acid-Base Properties)	15 Hrs
	3.1 Theories of acids and bases **(1hour)** 3.2 pK_a scale: relation between ionization constant K_a (pK_a) , K_b (pK_b) with strength of organic acids and bases**(2hours)** 3.3 Inductive effect and strength of organic acids/ bases**(2hours)** 3.4 Effect of resonance on strength of acids and bases **(3hours)** 3.5 Effect of hybridization on acidity and basicity of organic acids/ bases **(2hours)** 3.6 Role of steric effect on strength of organic acids/bases **(2hours)** 3.7 Effect of hydrogen bond on strength of organic acids**(2hours)** 3.8 Keto-enol tautomerism**(1hour)**	
	References 1. Smith, M. B. (2022). Organic chemistry: An acid–base approach (3rd ed.). CRC Press. 2. Solomons, T. W. G., Fryhle, C. B., & Snyder, S. A. (2022). Organic chemistry (13th ed.). Wiley. 3.Morrison, R. T., & Boyd, R. N. (2010). Organic Chemistry (7th ed.). Pearson Education India.	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-4	BCHE-402: Analytical Chemistry	MAJOR

Credit - 3, Teaching Hours - 45

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1:demonstrate foundational knowledge of Analytical Chemistry and its significance in chemical analysis.

CO2: explain the principles and procedures of acid-base and complexometric titrations.

CO3: apply statistical tools for the evaluation and interpretation of analytical data.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	3	–	1	2	2	–	–	–	–	–	2.17	3	2	2	2.33
CO2	3	2	3	–	–	1	2	–	–	–	–	–	2.20	3	3	2	2.67
CO3	3	3	2	–	–	2	3	–	2	–	–	–	2.50	2	2	3	2.33
PO Avg	3.0	2.33	2.67	–	1.0	1.67	2.33	–	2.0	–	–	–		2.67	2.33	2.33	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	(A)Introduction of analytical chemistry	7 Hrs
	1(A).1 Role of analytical chemistry **(1hour)** 1(A).2 Classification of analytical methods: chemical and instrumental methods **(1hour)** 1(A).3 Advantages and limitations of chemical and instrumental methods **(3hours)** 1(A).4 Literatures of analytical chemistry **(1hour)** 1(A).5 Safety in analytical / chemistry laboratory **(1hour)**	
	References 1.Christian, G. D., Dasgupta, P. K., & Schug, K. A. (2020). Analytical chemistry (7th ed.). Wiley. 2.Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2021). Fundamentals of Analytical Chemistry (10th ed.). Cengage Learning	
	(B)Complexometric titrations	**8 Hrs**
	1(B).1 Introduction **(0.5hour)** 1(B).2Classification of ligands **(0.5hour)**	

	1(B).3 Structure and acidic properties of EDTA **(0.5hour)** 1(B).4 Complexes and formation constant: How stable are complexes? **(1hour)** 1(B).5 Effect of pH on EDTA equilibria**(1hour)** 1(B).6 Types of EDTA titrations: direct titration, back titration, substitution titration **(1hour)** 1(B).7 Indicators for EDTA titrations / metal ion indicators **(2hours)** - working mechanism - Preliminary information of metal ion indicators- Murexide, Eriochrome black T, xylenol orange 1(B).8 Masking and demasking agents **(1.5hours)**	
	References 1.Christian, G. D., Dasgupta, P. K., & Schug, K. A. (2020). Analytical chemistry (7th ed.). Wiley. 2.Harris, D. C. (2015). Quantitative chemical analysis (9th ed.). W. H. Freeman. 3.Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2021). Fundamentals of analytical chemistry (10th ed.). Cengage Learning.	
UNIT 2	**Acid-base titrations**	**15 Hrs**
	2.1 Introduction **(1hour)** 2.2 Neutralization of strong acid with a strong base by pH metry**(2hours)** 2.3 Neutralization of weak acid with a strong base by pH metry**(2hours)** 2.4 Neutralization of weak base with a strong acid by pH metry**(2hours)** 2.5 Titration of mixture of strong acid and weak acid / base by pH metry**(1hour)** 2.6 Comparative study of different nature of curves for 2.2 to 2.5 **(1hour)** 2.7 Acid-base indicators: definition, theory and Henderson-Hasselbach equation **(1hour)** 2.8 Application of acid-base titrations **(2hours)** -Reagents for neutralization titrations: preparation and standardization of acids / bases -The determination of inorganic substances (ammonium salts, nitrates and nitrites, carbonates and carbonate mixtures) -The determination of organic functional groups (carboxylic and sulphonic acid groups, amine groups, ester groups, hydroxyl groups (Phenolic), carbonyl groups) 2.9 Numerical based on 2.2 to 2.4, 2.7 **(3hours)**	
	References 1.Christian, G. D., Dasgupta, P. K., & Schug, K. A. (2020). Analytical chemistry (7th ed.). Wiley. 2.Harris, D. C. (2015). Quantitative chemical analysis (9th ed.). W. H. Freeman. 3.Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2021). Fundamentals of analytical chemistry (10th ed.). Cengage Learning	
UNIT 3	**Statistics for analytical data**	**15 Hrs**
	3.1 Limitation of analytical data **(0.5hour)** 3.2 Accuracy and precision **(0.5hour)** 3.3 Measurement of central tendency: mean, median and mode **(1hour)** 3.4 Way of expressing accuracy: absolute error, relative error **(0.5hour)** 3.5 Way of expressing precision: range, deviation, average deviation, relative average deviation, standard deviation, coefficient of variation, variance **(1hour)** 3.6 Types of error in chemical analysis: systematic errors [instrumental	

	error, errors of method, operative errors, personal errors] and random errors **(2hours)** 3.7 The effect of systematic errors on analytical results: constant errors and proportional errors **(1hour)** 3.8 Minimization of errors **(0.5hour)** 3.9 Significant figure and computations **(1hour)** 3.10 Confidence interval **(0.5hour)** 3.11 Student's t-test: Are there difference in the methods? **(1hour)** -when accepted value is known -comparison of the means of two samples 3.12 F-test: comparison of precision of two sets of data **(1hour)** 3.13 Rejection of a result: the Q-test **(0.5hour)** 3.14 Correlation coefficient: **(0.5hour)** - Pearson correlation coefficient 3.15 Linear regression **(0.5hour)** 3.16 Numerical based on all topics **(3hours)**	
	References 1.Christian, G. D., Dasgupta, P. K., & Schug, K. A. (2020). Analytical Chemistry (7th ed.). Wiley. 2.Harris, D. C. (2015). Quantitative Chemical Analysis (9th ed.). W. H. Freeman. 3. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2021). 4. Fundamentals of Analytical Chemistry (10th ed.). Cengage Learning. 5. .Vogel′s Text Book of Quantitative Chemical Analysis (fifth edition), Longman Scientific and Technical Publish Group, England, pp. 125-149(1991) 6.Day, R. A., Jr., & Underwood, A. L. (2015). Quantitative analysis (6th ed.). Pearson Education India.	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-4	BCHE-403P: Organic and Analytical Chemistry Practical	MAJOR

Credit - 2, Teaching Hours -60

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: Perform systematic separation and qualitative analysis of components in organic mixtures using standard laboratory techniques..

CO2: Execute EDTA titrations and pH-metric titrations with accuracy and adherence to analytical protocols.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	2	2	3	-	-	-	2	-	-	2	-	1	2.00	2	3	1	2.00
CO2	2	2	3	-	-	-	3	-	-	2	-	-	2.33	3	3	2	2.67
PO Avg														2.50	3.00	1.50	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3. Behaviorism

Teaching Methods and Tools

- Experimentation
- Hands on Training

Experiments

(A) Qualitative analysis of organic mixture	28 Hrs

Separation of two components from the mixture of organic compounds using semi-micro method, identification of compounds by lassaigne's test, functional group test, melting point / boiling point test

(1) Acids: Benzoic acid, Salicylicacid, Cinnamic acid, Phthalic acid , Anthranilic acid, Oxalic acid , Tartaric acid, p-nitrobenzoic acid
(2) Phenols: α-Naphthol, β-Naphthol, o-Nitrophenol, p-Nitrophenol, Resorcinol
(3) Amines: p-Toludine, o-Nitroaniline, m- Nitroaniline, p- Nitroaniline
(4) Neutral: Urea, Thiourea, Acetamide, Benzamide, Acetanilide, Glucose, Naphthalene

(B)EDTA titrations and pH metry titrations	32Hrs

(1) Determination of nickel: direct titration **(4 hours)**
(2) Determination of aluminium: back titration **(4 hours)**
(3) Determination of calcium: substitution titration **(4 hours)**
(4) Preparation of buffer solution from buffer tablets/various chemical mixtures **(4 hours)**
(5) Titration of HCl using standard solution of NaOH by pH metrically**(4 hours)**
(6) Titration of NaOH using standard solution of HCl by pH metrically**(4 hours)**
(7) Titration of CH_3COOH using standard solution of NaOH by pH metrically**(4 hours)**
(8) Titration of HCl + CH_3COOH using standard solution of NaOH by pH metrically

(4 hours)	

References

1. Vogel, A. I., Tatchell, A. R., Furniss, B. S., Hannaford, A. J., & Smith, P. W. G. (1996). Vogel's Textbook of Practical Organic Chemistry (5th ed.). Prentice Hall PTR.

2. Flaschka, H. A. (2013). EDTA Titrations: An Introduction to Theory and Practice (2nd ed.). Elsevier.

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination
External Assessment (60%)	Term End Practical examination

B.Sc. (Chemistry) Semester-5	BCHE-501: Organic Chemistry	MAJOR

Credit - 3, Teaching Hours - 45

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: explain the structure, synthesis, and reactivity of polynuclear aromatic hydrocarbons.

CO2: describe the structural features and biological significance of selected pharmaceutical compounds.

CO3: illustrate the synthesis and industrial applications of various classes of dyes.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	2	–	–	2	2	–	–	–	–	–	2.20	3	1	2	2.00
CO2	3	2	2	1	2	2	–	–	–	–	–	–	2.00	3	1	3	2.33
CO3	3	2	2	–	–	2	3	–	–	2	2	–	2.29	3	2	3	2.67
PO Avg	3.0	2.0	2.0	1.0	2.0	2.0	2.33	–	–	2.0	2.0	–		3	1.33	2.67	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	Polynuclear Aromatic Hydrocarbons	15 Hrs
	1.1 Polynuclear Aromatic Compounds, Fused ring aromatic compounds, Nomenclature of naphthalene derivatives **(2 hours)** 1.2 Structure of naphthalene, Reactions of naphthalene, Oxidation of naphthalene, Reduction of naphthalene, Dehydrogenation of hydroaromatic compounds(Aromatization) **(2 hours)** 1.3 Nitration and halogenation of naphthalene, Orientation of electrophilic substitution in naphthalene, Friedal–Craft acylation of naphthalene, Sulphonation of naphthalene **(2 hours)** 1.4 Orientation of electrophilic substitution in naphthalene derivatives, Synthesis of naphthalene derivatives by ring closure (Haworth method). **(2 hours)** 1.5 Nomenclature of anthracene and phenanthrene derivatives **(1 hour)** 1.6 Structure of anthracene and phenanthrene, Reactions of anthracene and phenanthrene **(2 hours)** 1.7 Preparation of anthracene derivative by ring closure. **(2 hours)** 1.8 Preparation of phenanthrene derivative by ring closure, Carcinogenic hydrocarbon. **(2 hours)**	

	References 1.Clayden, J., Greeves, N., & Warren, S. (2012). Organic Chemistry (2nd ed.). Oxford University Press. 2. Carey, F. A., & Sundberg, R. J. (2007). Advanced Organic Chemistry: Part A: Structure and Mechanisms (5th ed.). Springer. 3. Hayakawa, K. (2022). Polycyclic aromatic hydrocarbons. In H. Akimoto & H. Tanimoto (Eds.), Handbook of Air Quality and Climate Change (pp. 1–17). Springer. https://doi.org/10.1007/978-981-15-2527-8_22-1 4.Morrison, R. T., & Boyd, R. N. (2010). Organic chemistry (7th ed.). Pearson Education India. 5.Bahl, A., & Bahl, B. S. (2016). A textbook of organic chemistry (22nd ed.). S. Chand Publishing. 6.Mukherji, S. M., Singh, S. P. S., & Kapoor, R. P. (2018). Organic chemistry: Vol. II (2nd ed.). New Age International Publishers.	
UNIT 2	**Pharmaceutical Compounds: Structure and Importance**	**15 Hrs**
	Classification, structure and therapeutic uses of….. 2.1 Antipyretics: Paracetamol (with synthesis) **(3 hours)** 2.2 Analgesics: Ibuprofen (with synthesis) **(3 hours)** 2.3 Antimalarials: Chloroquine (with synthesis) **(3 hours)** 2.4 An elementary treatment of Antibiotics and detailed study of chloramphenicol**(3 hours)** 2.5 Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine) **(3 hours)**	
	References 1.Newman, D. J., & Cragg, G. M. (Eds.). (2024).Handbook of pharmaceutical natural products (3rd ed.). Wiley-VCH. 2.Patrick, G. L. (2023). An introduction to medicinal chemistry (7th ed.). Oxford University Press. 3. Rang, H. P., Dale, M. M., Ritter, J. M., Flower, R. J., & Henderson, G. (Eds.). (2020). Rang & Dale's Pharmacology (9th ed.). Elsevier. 4. Patrick, G. L. (2023). An introduction to medicinal chemistry (7th ed.). Oxford University Press. 5. Singh, H., & Kapoor, V. K. (2012). Medicinal and pharmaceutical chemistry (3rd ed., rpt. 2023). Vallabh Prakashan. 6. Roche, V. F., Lemke, T. L., & Williams, D. A. (2019). Foye's principles of medicinal chemistry (8th ed.). Lippincott Williams & Wilkins. 7. Block, J. H., & Beale, J. M., Jr. (Eds.). (2010). Wilson and Gisvold's textbook of organic, medicinal and pharmaceutical chemistry (12th ed.). Lippincott Williams & Wilkins. 8. Lednicer, D., & Mitscher, L. A. (2008). The organic chemistry of drug synthesis (Vol. 7). Wiley. 9. Sriram, D., & Yogeeswari, P. (2010). Medicinal chemistry (2nd ed.). Pearson Education India. 10. Abraham, D. J. (Ed.). (2020). Burger's medicinal chemistry: Drug discovery and development (8th ed., Vols. 1–8). Wiley. 11. Chatwal, G. R. (2010). Medicinal chemistry (Rev. ed.). Himalaya Publishing House.	

UNIT 3	Dyes	15 Hrs
	3.1 Classification, Colour and constitution **(1 hour)** 3.2 Mordant and Vat Dyes; Chemistry of dyeing **(2 hours)** **Synthesis and applications of….(3.3 to 3.5)** 3.3 Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling) **(3 hours)** 3.4 Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet **(3 hours)** 3.5 Phthalein Dyes – Phenolphthalein and Fluorescein **(3 hours)** 3.6 Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin **(2 hours)** 3.7 Edible Dyes with examples **(1 hour)**	
	References 1. Clayden, J., Greeves, N., Warren, S., & Wothers, P. (2012). Organic chemistry (2nd ed.). Oxford University Press. 2.Singh, J., Ali, S. M., & Singh, J. (2010). Natural product chemistry Pragati Prakashan. 3.Chatwal, G. R. (2009). Synthetic dyes (Rev. ed.). Himalaya Publishing House. 4.Hunger, K., Mischke, P., Rieper, W., & Raue, R. (2003). Azo dyes. In Ullmann's encyclopedia of industrial chemistry. Wiley-VCH. 5.Waring, D. R., & Hallas, G. (Eds.). (1990). The chemistry and application of dyes Plenum Press. 6.Zollinger, H. (2003). Color chemistry: Syntheses, properties, and applications of organic dyes and pigments (3rd ed.). Wiley-VCH.	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-5	BCHE-502: Inorganic Chemistry	MAJOR

Credit - 3, Teaching Hours - 45

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: demonstrate understanding of the physical properties and classifications of metals, semiconductors, and superconductors.

CO2: analyze the role of metal ions in biological systems through concepts of bioinorganic chemistry.

CO3: Explain the bonding, structure, and reactivity of organometallic compounds.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	2	–	–	2	3	–	–	–	–	–	2.40	3	1	2	2.00
CO2	3	2	2	2	2	–	–	–	–	–	–	–	2.20	3	1	3	2.33
CO3	3	2	3	–	–	2	2	–	–	–	2	–	2.33	3	2	2	2.33
PO Avg	3.0	2.0	2.33	2.0	2.0	2.0	2.5	–	–	–	2.0	–		3	1.33	2.33	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	Metals, Semiconductors and Superconductors	15 Hrs
	1.1 Introduction **(1 hour)** 1.2 Properties of metallic solids. **(2 hours)** 1,3 Theories of bonding in metal. **(3 hours)** i) Free electron theory. ii) Molecular orbital theory (Band theory). 1.4 Classification of solids as conductor, insulators and semiconductors on the basis of band theory. **(2 hours)** 1.5 Semiconductors, Types of semiconductors - intrinsic and extrinsic semiconductors. **(2 hours)** 1.6 Applications of semiconductors. **(2 hours)** 1.7 Superconductors : Ceramic superconductors - Preparation and structures of mixed oxide YBa2Cu3O7 – *x* **(2 hours)** 1.8 Applications of superconductors **(1 hour)**	

	References 1.Lee, J. D. (2018). Concise inorganic chemistry (5th ed.). Wiley-Blackwell. 2. Shriver, D. F., Atkins, P. W., & Langford, C. H. (2010). Shriver & Atkins' inorganic chemistry (5th ed.). Oxford University Press. 3. Cotton, F. A., Wilkinson, G., & Gaus, P. L. (2007). Basic inorganic chemistry (3rd ed.). Wiley. 4.Douglas, B. E., & McDaniel, D. H. (1994). Concepts and models of inorganic chemistry (3rd ed.). John Wiley & Sons.	
UNIT 2	**Bio-inorganic Chemistry**	**15 Hrs**
	2.1 Essentials and trace elements of life, ionophores and siderophores, 2.2 Membrane transport (active and passive transport process) 2.3 Sodium / potassium-pump. 2.4 Excess and deficiency of some trace metals. 2.5Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity 2.6 Deficiency of Fe, Ca and iodine and consequences 2.7 Use of chelating agents in medicine (chelation therapy), platinum complexes as anticancer drugs. 2.8 Active site structure and functions of haemoglobin, myoglobin and role of iron and globin chain in haemoglobin 2.9 Active site structure of chlorophyll and role of magnesium and phytyl group in chlorophyll 2.10 Role of Co in vitamin B_{12}. 2.11Metalloenzymes-Carbonicanhydrase, Carboxypeptidase, 2.12 Hemocyanin-active site structures and functions.	
	References 1. Das, A. K., Das, M., & Das, A. (2020). Bioinorganic chemistry (2nd ed.). Books & Allied Pvt. Ltd. 2. Roat-Malone, R. M. (2020). Bioinorganic chemistry: A short course (3rd ed.). Wiley-India. 3. Cotton, F. A., Wilkinson, G., & Gaus, P. L. (2007). Basic inorganic chemistry (3rd ed.). Wiley-India **4.** Roat-Malone, R. M. (2020). Bioinorganic chemistry: A short course (3rd ed.). Wiley-India..	
UNIT 3	**Organometallic Chemistry**	**15 Hrs**
	3.1 Definition and classification of organometallic compounds, concept of hapticity. 3.2 18 & 16 electron rule, electron counts scheme. 3.3 Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. 3.4 π-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and explanation of π -back bonding 3.5 Zeise's salt: Preparation and structure 3.6 Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation), **Study of the following catalytic processes and their mechanism:** 3.7 Alkene hydrogenation (Wilkinson's Catalyst) 3.8 Polymerisation of alkene (Ziegler–Natta Catalyst) 3.9 Hydroformylation (Co salts) 3.10 Wacker Process ($PdCl_2$) 3.11. Synthetic gasoline (Fischer Tropsch reaction)	

	References 1. Puri, B. R., Sharma, L. R., & Kalia, K. C. (2024). Principles of inorganic chemistry (33rd ed.). Vishal Publishing Co. 2.Nandi, M. (2022). Essentials of chemistry (1st ed.). New Age International Pvt. Ltd. 3. Powell, P. (1988). Principles of organometallic chemistry (2nd ed.). Chapman & Hall. 4. Lee, J. D. (2018). Concise inorganic chemistry (5th ed.). Wiley-Blackwell. 5. Huheey, J. E., Keiter, E. A., & Keiter, R. L. (1993). Inorganic chemistry: Principles of structure and reactivity (4th ed.). Prentice Hall.	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-5	BCHE-503: Physical Chemistry	MAJOR

Credit - 3, Teaching Hours - 45

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: apply thermochemical principles, electrochemical concepts, and nuclear chemistry to solve chemical problems.

CO2: understand the theoretical and practical aspects of electrochemical cells and electrode potentials.

CO3: describe the principles and applications of nuclear reactions in chemistry.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	3	2	–	–	–	2	–	–	–	2	–	2.40	3	2	2	2.33
CO2	3	2	3	–	–	2	3	–	–	–	–	–	2.60	3	3	1	2.33
CO3	3	2	–	2	2	–	–	–	–	–	–	2	2.20	3	2	2	2.33
PO Avg	3.0	2.3	2.5	2.0	2.0	2.0	2.5	–	–	–	2.0	2.0		3.00	2.33	1.67	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	Thermodynamics	15 Hrs

First Law of Thermodynamics

1.1Terminology of Thermodynamics, Work and Heat, Internal Energy and First Law of Thermodynamics **(1hour)**

1.2Measurements of ΔE and ΔH, Hess's Law and its applications, Heat Capacity and Temperature dependence of ΔH **(1hour)**

1.3 Numerical Problems. **(1hour)**

Entropy And Second Law Of Thermodynamics

1.4Limitation of first law, spontaneous or irreversible process, cyclic process, Carnot cycle, Carnot theorem **(2hours)**

1.5 Entropy the new state function, the concept of entropy, entropy change in isothermal expansion of an ideal gas**(2hours)**

1.6 Entropy change in reversible and irreversible change, the entropy change accompanying phase change**(2hours)**

1.7 Calculation of entropy of an ideal gas with change in P, V and T**(1hour)**

	1.8 Entropy of mixing of an ideal gas, physical significance of entropy **(2hours)** 1.9 Work and free energy function, variation of free energy change with T and P **(1hour)** 1.10 Numerical **(1hour)** **Third law of thermodynamics** 1.11 Third law of thermodynamics**(1hour)**	
	References 1.Atkins, P., & de Paula, J. (2022). Atkins' physical chemistry (12th ed.). Oxford University Press. 2. Ball, D. W. (2021). Physical chemistry (3rd ed.). Cengage Learning. 3. Silbey, R. J., Alberty, R. A., & Bawendi, M. G. (2020). Physical chemistry (5th ed.). Wiley. 4. Levine, I. N. (2020). Physical chemistry (7th ed.). Pearson Education. 5. McQuarrie, D. A., & Simon, J. D. (2021). Physical chemistry: A molecular approach. University Science Books.	
UNIT 2	**Electrochemistry**	**15 Hrs**
	2.1 Chemical cells, reversible and irreversible cells with examples 2.2 Electromotive force of a cell and its measurement, Nernst equation; 2.3 Standard electrode (reduction) potential and its application to different kinds of half-cells 2.4 Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone and glass electrodes. 2.5 Concentration cells with and without transference, liquid junction potential; 2.6 Determination of activity coefficients and transference numbers. 2.7 Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).	
	References 1..Atkins, P.W & Paula, J.D. *Physical Chemistry*, 9th Ed., Oxford University Press (2011). 2. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004). 3. Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP (2009). 4. Barrow, G. M., *Physical Chemistry 5th Ed.,* Tata McGraw Hill: New Delhi (2006). 5. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012). 6. Rogers, D. W. *Concise Physical Chemistry* Wiley (2010). 7. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. *Physical Chemistry 4th Ed.,* John Wiley & Sons, Inc. (2005).	
UNIT 3	**Nuclear Chemistry**	**15 Hrs**
	3.1Radioactivity, Types of radiations, Properties of radiations **(1 hour)** 3.2 Detection and measurementof radioactivity (Cloud Chamber, Ionisation Chamber, Geiger-Muller Counter, Scintillation Counter, Film Badges) **(2 hours)** 3.3 Types of radioactive decay, Rate of radioactive decay, Half-life **(2 hours)** 3.4 How to write nuclear equations**(1 hour)** 3.5 Radioactive dating**(1 hour)** 3.6 Mass defect, Nuclear binding energy, Neutron-proton ratio and nuclear stability **(2 hours)**	

	3.7 Nuclear fission process(Nuclear chain reaction) **(2 hours)** 3.8 Nuclear energy, Nuclear reactor, The atomic bomb **(2 hours)** 3.9 Nuclear fusion process, hydrogen bomb and fusion as a source of energy in 21st century **(2 hours)**	
	References 1.Arnikar, H. J. (1996). *Essentials of nuclear chemistry* (4th ed.). New Age International Pvt. Ltd 2.Bahl, B. S., Tuli, G. D., & Bahl, A. (2006). *Essentials of physical chemistry*. S. Chand. 3.Stoker, H. S. (2021). *Introduction to chemical principles* (11th ed.). Pearson.4.Choppin, G. R., Liljenzin, J. O., Rydberg, J., & Ekberg, C. (2021). Radiochemistry and nuclear chemistry (4th ed.). Academic Press. 5.Meyer, G. J. (2022). Nuclear chemistry (2nd ed.). De Gruyter.6.Friedlander, G., Kennedy, J. W., Macias, E. S., & Miller, J. M. (2020). Nuclear and radiochemistry (4th ed.). Wiley-VCH.	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-5	BCHE-504P: Chemistry Practical	MAJOR

Credit - 5, Teaching Hours - 150

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: identify cations and anions in a given inorganic mixture containing six radicals using systematic qualitative analysis.

CO2: estimate selected organic compounds using standard volumetric and gravimetric techniques.

CO3: synthesize coordination compounds and interpret their chemical properties through experimental techniques.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	3	–	–	–	2	–	–	–	–	–	2.5	2	3	1	2.00
CO2	3	3	3	–	–	2	3	–	–	–	–	–	2.8	2	3	1	2.00
CO3	3	3	3	2	–	–	2	–	–	–	2	–	2.5	3	3	2	2.67
PO Avg	3.0	2.7	3.0	2.0	–	2.0	2.3	–	–	–	2.0	–		2.33	3.00	1.33	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3. Behaviorism

Teaching Methods and Tools

- Experimentation
- Hands on Training

Experiments

(A) Qualitative analysis of inorganic mixture — 80 Hrs

Qualitative analysis of Inorganic mixture containing six radicals only.
The following radicals are suggested:Na^+, K^+, NH_4^+, Mg^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Fe^{2+}, Fe^{3+} , Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Hg^{2+}, Pb^{2+}, Cu^{2+}, Sn^{2+}, Ag^+ and S^{2-}, SO_3^{2-}, SO_4^{2-}, CO_3^{2-}, Cl^-, Br^-, I^-, NO_3^-, NO_2^-

(B) Estimation — 16 Hrs

1. Estimation of glucose
2. Estimation of Oxalic acid by standardized NaOH
3. Estimation of vinegar by using standardized NaOH
4. Estimation of glycine by formal titration method (Soronsen's Method)

(C)Preparation of coordination compounds: — 54 Hrs

1.Tris(thiourea)copper(I)sulphate,
2.Tetra ammine copper(II) sulphate,
3.Potash alum/ Chrome alum
4.Bis(dimethylglyoximinato)nickel(II),
5.Tris(acetylacetanoto)iron(III),
6.Potassium tri(oxalate)chromate(III)

References

1. Vogel's Qualitative Inorganic Analysis, 7th edition revised by Svehla, Pearson Education Pvt. Ltd (2004).
2. Nordman, J. (2023). Qualitative testing and inorganic chemistry. Legare Street Press.
3. Alhasan, H. S., & Alahmadi, N. (2021). Principles of qualitative inorganic analysis: Precipitation, separation and identification of cations. Bentham Books.
4. Berry, A. J. (2016). Qualitative inorganic analysis (1st ed.). Cambridge University Press.
5. Harris, D. C. (2015). Quantitative chemical analysis (9th ed.). W. H. Freeman.
6. Kealey, D., & Haines, P. J. (2016). Analytical chemistry: Principles and techniques (2nd ed.). CRC Press.
7. Li, N., Hefferren, J. J., & Li, K. (2013). Quantitative chemical analysis. World Scientific.
8. Vogel, A. I., Jeffery, G. H., Mendham, J., & Denney, R. C. (2019). Vogel's textbook of quantitative chemical analysis (6th ed.). Pearson Education.
9. Buss, J. (Ed.). (2020). Inorganic Syntheses: Volume XVIII. University of Michigan Press.

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-5	DSE-501: Fuel Chemistry	MAJOR

Credit - 2, Teaching Hours - 30

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: explain the chemical composition, classification, and industrial significance of coal.

CO2:describe the origin, refining processes, and major applications of petroleum and petrochemicals

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	–	2	–	1	2	–	–	–	–	2	2.00	3	2	1	2.00
CO2	3	3	–	3	–	2	2	–	–	–	2	2	2.43	3	2	2	2.33
PO Avg	3.0	2.5	–	2.5	–	1.5	2.0	–	–	–	2.0	2		3.0	2.0	1.5	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	Coal	15 Hrs
	1.1 Review of energy sources (renewable and non-renewable). **(1 hour)** 1.2 Classification of fuels and their calorific value. **(2 hours)** 1.3 Uses of coal (fuel and nonfuel) in various industries, its composition **(2 hours)** 1.4 Carbonization of coal. **(2 hours)** 1.5 Coal gas, producer gas and water gas—composition and uses. **(2 hours)** 1.6 Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke **(2 hours)** 1.7 Coal gasification (Hydro gasification and Catalytic gasification) **(2 hours)** 1.8 Coal liquefaction and Solvent Refining. **(2 hours)**	
	References 1. Stocchi, E. (1990). Industrial chemistry (Vol. 1). Ellis Horwood Ltd. 2. Jain, P. C., & Jain, M. (2023). Engineering chemistry (17th ed.). Dhanpat Rai Publishing Company. 3. Sharma, B. K. (2013). Industrial chemistry (17th ed.). Goel Publishing House..	
UNIT 2	**Petroleum and Petrochemical**	**15 Hrs**

	2.1 Composition of crude petroleum **(1 hour)** 2.2 Refining and different types of petroleum products and their applications. **(2 hours)** 2.3 Fractional Distillation (Principle and process) **(2 hours)** 2.4 Cracking (Thermal and catalytic cracking)**(1 hour)** 2.5 Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass) **(3 hours)** 2.6 fuel from waste **(2 hours)** 2.7 synthetic fuels (gaseous and liquids) **(2 hours)** 2.8 clean fuels **(2 hours)**	
	References 4. Stocchi, E. (1990). Industrial chemistry (Vol. 1). Ellis Horwood Ltd. 5. Jain, P. C., & Jain, M. (2023). Engineering chemistry (17th ed.). Dhanpat Rai Publishing Company. 6. Sharma, B. K. (2013). Industrial chemistry (17th ed.). Goel Publishing House..	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-5	DSE-502: Polymer Chemistry	MAJOR (Optional)

Credit - 2, Teaching Hours - 30

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: summarize the historical development and classification of polymeric materials.

CO2: analyze the kinetics of polymerization and determine the molecular weights of polymers using appropriate techniques.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	–	2	1	2	2	–	–	–	–	2	2.00	3	1	2	2.00
CO2	3	3	3	–	–	2	3	1	2	1	2	–	2.33	2	3	2	2.33
PO Avg	3.0	2.5	3.0	2.0	1.0	2.0	2.5	1.0	2.0	1.0	2.0	2.0		2.5	2.0	2.0	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	Introduction and history of polymeric materials	15 Hrs
	1.1 Different schemes of classification of polymers **(1 hour)** 1.2 Polymer nomenclature **(1 hour)** 1.3 Molecular forces and chemical bonding in polymers **(2 hours)** 1.4 Texture of Polymers **(1 hour)** 1.5 Criteria for synthetic polymer formation **(2 hours)** 1.6 Classification of polymerization processes **(2 hours)** 1.7 Relationships between functionality **(2 hours)** 1.8 Extent of reaction and degree of polymerization. **(2 hours)** 1.9 Bifunctional systems **(1 hour)** 1.10 Poly-functional systems **(1 hour)**	
	References 1. Seymour, R.B. & Carraher, C.E. Polymer Chemistry: An Introduction, Marcel Dekker, Inc. New York, (1981). 2. Ghosh P., Polymer science & Technology, Tata-McGraw-Hill Education(1991).	
UNIT 2	**Kinetics of Polymerization and molecular weight of polymers**	**15 Hrs**
	2.1 Mechanism and kinetics of…… 2.1.1 Step growth **(1 hour)**	

	2.1.2 Radical chain growth **(1 hour)** 2.1.3 Ionic chain (both cationic and anionic) **(1 hour)** 2.1.4 Coordination polymerizations **(1 hour)** 2.1.5 Copolymerization **(1 hour)** 2.2 Polymerization techniques. **(2 hours)** 2.3 Determination of molecular weight of polymers (Mn, Mw, etc) by ….. 2.3.1End group analysis **(1 hour)** 2.3.2 Viscometry **(1 hour)** 2.3.3 Light scattering and osmotic pressure methods **(2 hours)** 2.4 Molecular weight distribution and its significance **(2 hours)** 2.5 Polydispersity index. **(2 hours)**	
	References 1. Seymour, R.B. & Carraher, C.E. Polymer Chemistry: An Introduction, Marcel Dekker, Inc. New York, (1981). **2.** Ghosh P., Polymer science & Technology, Tata-McGraw-Hill Education(1991).	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-5	DSE-503: Inorganic Materials of Industrial Importance	MAJOR (Optional)

Credit - 2, Teaching Hours - 30

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: demonstrate understanding of raw materials, manufacturing processes, and uses of silicate-based industries.

CO2: explain the types, components, and functioning of batteries and the role of fertilizers in agriculture.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	–	2	–	2	2	–	–	–	1	2	2.00	3	2	2	2.33
CO2	3	3	2	2	–	2	2	–	–	–	1	2	2.13	3	2	3	2.67
PO Avg	3.0	2.5	2.0	2.0	–	2.0	2.0	–	–	–	1.0	2.0		3.0	2.0	2.5	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	Silicate Industries	15 Hrs

Glass

1.1Glassy state and its properties **(1 hour)**
1.2 classification (silicate and non-silicate glasses) **(1 hour)**
1.3 Manufacture and processing of glass. **(1 hour)**
1.4 Composition and properties of the following types of glasses: **(4 hours)**
(a)Soda lime glass
(b) lead glass,
(c) armoured glass
(d) safety glass
(e) borosilicate glass
(f)fluorosilicate
(g)coloured glass
(h) photosensitive glass.

Ceramics

1.5Important clays , feldspar, ceramic, their types and manufacture **(1 hour)**
1.6 High technology ceramics and their applications **(1 hour)**
1.7 Superconducting and semiconducting oxides **(1hour)**
1.8 Fullerenes, carbon nanotubes and carbon fibre. **(1 hour)**

	Cements 1.9Classification of cement **(1hour)** 1.10 Ingredients and their role **(1hour)** 1.11 Manufacture of cement and the setting process**(1 hour)** 1.12 Quick setting cement **(1 hour)**	
	References 1. Kingery, W. D., Bowen, H. K., & Uhlmann, D. R. (1976). Introduction to Ceramics (2nd ed.). Wiley. 2. Felder, R. M., Rousseau, R. W., & Bullard, L. G. (2020). Elementary Principles of Chemical Processes (4th ed.). John Wiley & Sons..	
UNIT 2	**(A)Batteries:**	**10 Hrs**
	2(A).1 Primary and secondary batteries **(1 hour)** 2(A).2 battery components and their role **(1 hour)** 2(A).3 Characteristics of Battery. **(1 hour)** 2(A).4 Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. **(4 hours)** 2(A).5 Fuel cells **(1 hour)** 2(A).6 Solar cell **(1 hour)** 2(A).7 Polymer cell **(1 hour)**	
	References 1. Kent, J. A. (Ed.). (2012). Riegel's handbook of industrial chemistry (9th ed.). Springer Science & Business Media. 2. Jain, P. C., & Jain, M. (2023). Engineering chemistry (17th ed.). Dhanpat Rai Publishing Company.	
	(B) Fertilizers	**5 Hrs**
	2(B).1 Types of fertilizers. **(1 hour)** 2(B).2 Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate. **(4 hours)**	
	References 1. Felder, R. M., Rousseau, R. W., & Bullard, L. G. (2020). Elementary Principles of Chemical Processes (4th ed.). John Wiley & Sons. **2.** Kent, J. A. (Ed.). (2012). Riegel's handbook of industrial chemistry (9th ed.). Springer Science & Business Media.	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-6	BCHE-601: Organic Spectroscopy	MAJOR

Credit - 3, Teaching Hours - 45

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: predict λ_{max} of conjugated systems and distinguish cis-trans isomers using UV-Visible spectroscopy.

CO2: identify functional groups by analyzing IR absorption patterns and related spectral effects.

CO3: interpret proton NMR spectra to determine structures of simple organic compounds

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	2	–	–	2	3	–	1	–	–	–	2.17	3	3	2	2.67
CO2	3	2	2	–	–	2	3	–	–	–	–	–	2.33	3	3	2	2.67
CO3	3	3	3	–	–	3	3	–	–	–	–	–	3.00	3	3	2	2.67
PO Avg	3.0	2.3	2.3	–	–	2.3	3.0	–	1.0	–	–	–		3.0	3.0	2.0	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	**UV Spectroscopy**	**15 Hrs**
	1.1 Types of electronic transitions, λ_{max} **(1 hour)** 1.2 Chromophores and Auxochromes **(2 hours)** 1.3 Bathochromic and Hypsochromic shifts, Intensity of absorption **(2 hours)** 1.4 Application of Woodward Rules for calculation of λmax for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular**(7 hours)** 1.5 Extended conjugated systems (aldehydes, ketones and dienes) **(2 hours)** 1.6 Distinction between cis and trans isomers. **(1 hour)**	
UNIT 2	**IR Spectroscopy**	**15 Hrs**
	2.1Fundamental and non-fundamental molecular vibrations **(2 hours)** 2.2 IR absorptionpositions of O, N and S containing functional groups **(3 hours)** 2.3 Effect of H-bonding, conjugation, resonance and ring size on IR absorptions **(3 hours)**	

	2.4 Fingerprint region and its significance **(2 hours)** 2.5 Application in functional group analysis**(5 hours)**	
	References 1. Kemp, W. (1993). *Organic spectroscopy* (3rd ed.). ELBS, Macmillan. 2. Morrison, R. T., Boyd, R. N., & Bhattacharjee, S. K. (2011). *Organic chemistry* (7th ed.). Pearson Education Inc. **3.** Sharma, Y. R. (2013). *Elementary organic spectroscopy: Principles and chemical applications* (5th ed.). S. Chand Publishing.	
UNIT 3	**NMR Spectroscopy**	**15 Hrs**
	3. 1 Basic principles of Proton Magnetic Resonance **(1 hour)** 3.2 chemical shift and factors influencing it **(2 hours)** 3.3 Spin – Spin coupling and coupling constant **(2 hours)** 3.4 Anisotropic effects in alkene, alkyne, aldehydes and aromatics **(2 hours)** 3.5 Interpetation of NMR spectra of simple compounds**(2 hours)** 3.6 Applications of IR, UV and NMR for identification of simple organic molecules **(6 hours)**	
	References 1. Kemp, W. (1986). *NMR in chemistry: A multinuclear introduction*. Macmillan. 2. Kemp, W. (1991). *Organic spectroscopy* (3rd ed.). Red Globe Press. 3. Morrison, R. T., & Boyd, R. N. (1992). *Organic chemistry* (6th ed.). Prentice Hall..	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-6	BCHE-601P: Organic Spectroscopy Practical	MAJOR

Credit - 2, Teaching Hours - 60

Course Outcomes (COs)

After studying this course, the student will be able to….
CO1: demonstrate the operation of UV, IR, and NMR instruments for organic compound analysis.
CO2: interpret IR and NMR spectra to identify simple organic compounds.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	2	2	3	–	–	2	3	–	–	–	–	–	2.33	3	3	2	2.67
CO2	2	3	3	–	–	2	3	–	–	–	–	–	2.50	3	3	2	2.67
PO Avg	2.0	2.5	3.0	–	–	2.0	3.0	–	–	–	–	–		3.0	3.0	2.0	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3. Behaviorism

Teaching Methods and Tools

- Experimentation
- Hands on Training

Experiments

(A) Demonstration of UV, IR and NMR instruments	**20 Hrs**
How to run instrument and how to analyze organic compound using UV, IR and NMR instruments will be demonstrated. (This experiment will be conducted by visit of sophisticated instrumentation laboratory.)	
(B) Identification of simple organic compounds	**40 Hrs**
Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).	

References

1. Kemp, W. (2022). *Organic spectroscopy* (3rd ed.). Bloomsbury Academic India.
2. Pavia, D. L., Lampman, G. M., Kriz, G. S., & Vyvyan, J. R. (2015). *Introduction to spectroscopy* (5th ed.). Cengage Learning.
3. Yadav, L. D. S. (2015). *Organic spectroscopy*. Springer.
4. Jagmohan. (2016). *Organic spectroscopy: Principles and applications* (2nd ed.). Narosa Publishing House.
5. Dewan, S. K. (2010). *Organic spectroscopy: NMR, IR, Mass, and UV*. CBS Publishers & Distributors.

Assessment Method

Internal/Online Assessment (40%)	Internal Practical Examination
External Assessment (60%)	Term End Practical examination

B.Sc. (Chemistry) Semester-6	BCHE-602: Physical Chemistry	MAJOR

Credit - 3, Teaching Hours - 45

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: apply photochemical laws to explain excited-state phenomena such as fluorescence and chemiluminescence.

CO2: identify molecular symmetry elements and apply group theory concepts to classify point groups.

CO3: apply rate laws and derive expressions for rate constants to study reaction kinetics and temperature dependence.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	2	–	–	2	2	–	1	–	–	–	3	3	2	2	2.33
CO2	3	3	–	–	–	2	2	–	2	–	–	–	3	3	1	2	2.00
CO3	3	3	2	–	–	2	–	–	2	–	–	–	3	3	2	2	2.33
PO Avg	3.0	2.7	2.0	–	–	2.0	2.0	–	1.7	–	–	–	3.0	3.0	1.67	2.0	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	Photochemistry	15 Hrs
	1.1 Introduction,Difference between thermal and photochemical processes. **(1 hour)** 2.2 Laws of photochemistry : Grotthus - Draper law, Lambert's law, Lambert Beer's law (with derivation), Stark - Einstein law. **(2 hours)** 2.3 Quantum yield, Reasons for high and low quantum yield. **(2 hours)** 2.4 Photosensitized reactions – Dissociation of H_2, Photosynthesis. **(2 hours)** 2.5 Photodimerisation of anthracene, decomposition of HI and HBr. **(2 hours)**	

	2.6 Jablonski diagram depicting various processes occurring in the excited state : Qualitative description of fluorescence and phosphorescence. **(2 hours)** 2.7 Chemiluminescence. **(1 hour)** 2.8 Numerical problems. **(3 hours)**	
	References 1. Rohatgi-Mukherjee, K. K. (2022). *Fundamentals of photochemistry*. New Age International Publishers. 2. Atkinson, D. (2022). *Photochemistry and photophysics*. States Academic Press. 3. Marazzi, M., & García Iriepa, C. (Eds.). (2023). *Theoretical and computational photochemistry: Fundamentals, methods, applications and synergy with experimental approaches*. Elsevier. 4. Scaiano, J. C. (2022). *Photochemistry essentials*. ACS In Focus. 5. Turro, N. J. (2009). *Modern molecular photochemistry*. University Science Books.	
UNIT 2	**Group Theory**	**15 Hrs**
	2.1 Symmetry and importance of symmetry aspects -Symmetry elements and various associated symmetry operations-Definitions and examples **(5 hours)** 2.2 Mathematical group – properties of a group – construction of group multiplication table (GMT) for H_2O and NH_3 – Abelian and non -Abelian groups-point groups- **(5 hours)** 2.3 Cnv, Cnh and Dnh- symmetry present with examples – matrix representation of symmetry operations E, Cn, σ, Sn and i. **(5 hours)**	
	References 1. Swarnalakshmi, S., Saroja, T., & Ezhilarasi, R. M. (2008). *A simple approach to group theory in chemistry*. Universities Press. **2.** Mukherjee, A. K., & Ghosh, B. C. (2018). *Group theory in chemistry: Bonding and molecular spectroscopy*. Orient BlackSwan. 3. Dogra, S. K. (2022). *Symmetry and group theory in chemistry*. Alpha Science International Ltd. 4. Vincent, A. (2013). *Molecular symmetry and group theory: A programmed introduction to chemical applications* (2nd ed.). Wiley. 5. Lesk, A. M. (2004). *Introduction to symmetry and group theory for chemists*. Springer. 6. Agarwala, U. C. (2023). *Molecular symmetry in chemistry via group theory*. Ane Books. 7. Raj, G., & Bhagi, A. (2010). *Group theory and symmetry in chemistry*. Krishna Prakashan Media.	
UNIT 3	**Chemical Kinetics**	**15 Hrs**
	3.1 The concept of reaction rates. **(1 hour)** 3.2 Effect of temperature, pressure, catalyst and other factors on reaction rates. **(1 hour)** 3.3 Order and molecularity of a reaction. **(1 hour)** 3.4 Derivation of first order rate constant **(2 hours)** 3.5 Derivation of Second order rate constant for (a=b) and (a ≠ b). **(3 hours)** 3.6 Derivation of Third order rate constant (a=b=c) **(2 hours)** 3.5 Half–life of a reaction. **(2 hours)** 3.6 General methods for determination of order of a reaction. **(2 hours)** 3.7 Concept of activation energy and its calculation from Arrhenius equation. **(1 hour)**	

References

1. Atkins, P., & de Paula, J. (2022). *Atkins' physical chemistry* (12th ed.). Oxford University Press.
2. Laidler, K. J. (2020). *Chemical kinetics* (3rd ed.). Pearson Education.
3. Houston, P. L. (2021). *Chemical kinetics and reaction dynamics* (2nd ed.). Dover Publications.
4. Espenson, J. H. (2019). *Chemical kinetics and reaction mechanisms* (2nd ed.). McGraw-Hill Education.
5. Frost, A. A., & Pearson, R. G. (2018). *Kinetics and mechanism* (3rd ed.). Wiley.
6. Barrow, G. M. (2007). *Physical chemistry* (6th ed.). Tata McGraw-Hill Education.
7. Castellan, G. W. (2004). *Physical chemistry* (3rd ed.). Narosa Publishing House.

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-6	BCHE-602P: Physical Chemistry Practical	MAJOR

Credit - 2, Teaching Hours - 60

Course Outcomes (COs)

After studying this course, the student will be able to….
CO1: Acquire practical skills in conducting chemical kinetics experiments.
CO2: Demonstrate understanding of photochemical reactions through laboratory experiments..

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	3	3	–	–	2	2	–	2	–	–	–	2.43	2	3	2	2.33
CO2	3	2	3	–	–	2	2	–	2	–	–	–	2.29	2	3	2	2.33
PO Avg	3.0	2.5	3.0	–	–	2.0	2.0	–	2.0	–	–	–		2.0	3.0	2.0	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3. Behaviorism

Teaching Methods and Tools

- Experimentation
- Hands on Training

Experiments

(A) Chemical Kinetics — 40 Hrs

1. The study of energy of activation of first order reaction i.e. hydrolysis of methyl acetate in presence of 0.5 N HCl / 0.5 N H_2SO_4.
2. The study of energy of activation of second order reaction i.e. reaction between $K_2S_2O_8$ and KI (Equal concentrations).
3. The study of energy of activation of second order reaction i.e. reaction between $K_2S_2O_8$ and KI (Unequal concentrations).
4. To study the hydrolysis of methyl acetate by using its two concentrations in presence of 0.5 N HCl and hence find velocity constant of the reaction.
5. To study the effect of addition of electrolyte (KCl) on the reaction between $K_2S_2O_8$ and KI (Equal concentrations).

(B) Photochemistry — 20 Hrs

Demonstration of photochemistry related experiments

References

1. Findlay, A. (1972). *Findlay's practical physical chemistry* (9th ed., B. P. Levitt, Ed.). Longman.
2. Yadav, J. B. (2015). *Advanced practical physical chemistry*. Goel Publishing House.
3. Khosla, B. D., Garg, V. C., & Gulati, A. (2018). *Senior practical physical chemistry* (18th ed.). R. Chand & Co
4. Rajbhoj, A. S., & Chandekar, S. B. (2016). *Systematic experimental physical chemistry*. Anjali Publication.

5. Nandkumari, K., Kothari, R., & Lavande, S. (2016). *Practical physical chemistry*.
6. Gurtu, J. N., & Gurtu, A. (2017). *Advanced physical chemistry* (4th ed.). Pragati Prakashan.

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination
External Assessment (60%)	Term End Practical examination

B.Sc. (Chemistry) Semester-6	BCHE-603: Nanotechnology and Greenchemistry	MAJOR

Credit - 3, Teaching Hours - 45

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: identify various types of nanomaterials, explain their synthesis methods, and discuss their environmental applications.

CO2: describe advanced characterization tools and interpret their role in analyzing nanomaterial properties.

CO3: apply green chemistry principles to design sustainable chemical processes using eco-friendly techniques.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	2	3	–	2	2	3	–	–	2	1	2	2	2.11	3	2	3	2.67
CO2	2	2	3	–	3	3	3	2	1	–	1	3	2.30	3	3	2	2.67
CO3	3	2	1	1	3	3	–	–	3	1	1	–	2.00	3	2	3	2.67
PO Avg	2.33	2.33	2.0	1.5	2.67	3.0	3.0	2.0	2.0	1.0	1.33	2.5					

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	Nanomaterials and nanotechnology	15 Hrs
	4.1Introduction **(1 hour)** 4.2 History of Nanomaterials **(2 hours)** - The Lycurgus cup - Michael Faraday's colloids - The story of the Damascus sword 4.3 Types of nanomaterials **(4 hours)** -One dimensional materials (Single or multi walled carbon nanotubes) - Two dimensional materials (nanofilms, nanosheets, Nanowalls) 4.4 Synthesis of nanomaterials **(4 hours)** -Top-down approach -Bottom-up approach 4.5 Environmental applications of nonmaterials **(4 hours)** -Nanomembranes in Drinking water treatment,	

	-Nanomembranes in Sea desalination. -Nanomaterial in microfuelcell, fuel Cell, hydrogen storage. -Nanosensors	
	References 1. Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, Guozhong Cao, Ying Wang,World Scientific (2011) 2. Poole, C. P. Jr. and Owens F. J. Introduction to nanotechnology, Wiley India, New Delhi. (2009). 3. C N R Rao, Nanoworld : An Introduction to Nanoscience Technology, Navakarnataka Publications Pvt Ltd (2014)	
UNIT 2	**Characterization techniques for Nanomaterials**	**15 Hrs**
	2.1 Particle size Analyser (Laser scattering) **(2 hours)** 2.2 Scanning Electron Microscopy (SEM) **(2 hours)** **2.3** Transmission Electron Microscopy (TEM) **(3 hours)** **2.4** Scanning Tunnel Microscopy (STM) **(2 hours)** 2.5 X-ray Diffraction (XRD) **(2 hours)** 2.6Auger Emission Spectroscopy**(2 hours)** 2.7 Electron Spectroscopy for Chemical analysis (ESCA) **(2 hours)**	
	References 1. Cao, G., & Wang, Y. (2011). *Nanostructures and nanomaterials: Synthesis, properties, and applications* (2nd ed.). World Scientific Publishing. 2. Poole, C. P., Jr., & Owens, F. J. (2003). *Introduction to nanotechnology*. Wiley-Interscience. 3. Rao, C. N. R. (2011). *Nanoworld: An introduction to nanoscience and technology* (1st ed.). Navakarnataka Publications Pvt Ltd. 4. Allen, T. (2003). *Particle size measurement* (5th ed.). Springer. 5. Goldstein, J. I., Newbury, D. E., Joy, D. C., Lyman, C. E., Echlin, P., Lifshin, E., Sawyer, L., & Michael, J. R. (2003). *Scanning electron microscopy and X-ray microanalysis* (3rd ed.). Springer. 6. Williams, D. B., & Carter, C. B. (2009). *Transmission electron microscopy: A textbook for materials science* (2nd ed.). Springer. 7. Chen, C. J. (1993). *Introduction to scanning tunneling microscopy*. Oxford University Press. **8.** Cullity, B. D., & Stock, S. R. (2001). *Elements of X-ray diffraction* (3rd ed.). Pearson Education.	
UNIT 3	**Green Chemistry**	**15 Hrs**
	3.1 Introduction **(1 hour)** 3.2 Basic principles (twelve) of green chemistry **(2 hours)** 3.3 Designing a green synthesis **(4 hours)** - Choice of starting materials - Choice of reagents - Choice of catalysts - Choice of solvents 3.4 Ultrasound assisted and Microwave assisted green synthesis **(2 hours)** 3.5 Biocatalysts in organic synthesis **(2 hours)** -Biochemical (Microbial) oxidations -Biochemical (Microbial) reductions 3.6Aqueous phase reactions **(2 hours)** -Diels-Alder reaction -Epoxidation -Reduction of carbon-carbon double bonds	

	- Synthesis of polycarbonates 3.7 Green chemistry in sustainable development **(2 hours)**	
	References 1. Clark, J. H., & Macquarrie, D. J. (2002). *Handbook of green chemistry and technology*. Wiley-Blackwell. 2. Anastas, P. T., & Warner, J. C. (2000). *Green chemistry: Theory and practice*. Oxford University Press. 3. Ahluwalia, V. K., & Kidwai, M. (2004). *New trends in green chemistry*. Kluwer Academic Publishers. 4. Manahan, S. E. (2011). *Green chemistry and the ten commandments of sustainability* (3rd ed.). ChemChar Research, Inc.	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-6	BCHE-603P: Nanotechnology and Greenchemistry Practical	MAJOR

Credit - 2, Teaching Hours - 60

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: apply green chemistry principles to synthesize organic and coordination compounds using eco-friendly reagents and methods.

CO2: develop hands-on skills to synthesize and characterize nanomaterials using plant-based and sol-gel techniques.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	2	3	3	2	2	–	2	–	3	3	2.45	3	2	3	2.67
CO2	3	2	3	2	2	–	3	2	3	–	2	3	2.55	3	3	3	3.00
PO Avg	3.0	2.0	2.5	2.5	2.5	2.0	2.5	2.0	2.5	–	2.5	3.0		3.0	2.50	3.0	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3. Behaviorism

Teaching Methods and Tools

- Experimentation
- Hands on Training

Experiments

(A) Greenchemistry — 40 Hrs

1. Preparation of acetanilide by using AcOH
2. Nitration of salicylic acid by green approach (using ceric ammonium nitrate)
3. Synthesis of azomethines from vanillin and 4-amino toluene
4. Preparation of Tris(acetylacetonato)manganese(III) by green method
5. Prepration of Tris(acetylacetonato)iron(III) by green method
6. Prepration of bis(acetylacetonato)copper(II) by green method
7.Preparation and use of green natural acid-base indicator

(B) Nanomaterials — 20 Hrs

1. Synthesis of plant based nano-materials and characterization **(15 hours)**
2. Sol gel method of synthesis of nano-material and characterization **(15 hours)**

References

1. Green Chemistry Task Force Committee, DST. (2011). *Monograph on green chemistry laboratory experiments*. Department of Science & Technology, Government of India. Link
2. Sharma, R. K., Sidhwani, I. T., & Chaudhuri, M. K. (2013). *Green chemistry experiments: A monograph*. I.K. International Publishing House.

<table>
<tr><td colspan="2">3. Cao, G., & Wang, Y. (2011). Nanostructures and nanomaterials: Synthesis, properties, and applications (2nd ed.). World Scientific Publishing. Link
4. Bandyopadhyay, A. K. (2010). Nano materials. New Age International Publishers.</td></tr>
<tr><td colspan="2">Assessment Method</td></tr>
<tr><td>Internal/Online Assessment (40%)</td><td>Internal Practical Examination</td></tr>
<tr><td>External Assessment (60%)</td><td>Term End Practical examination</td></tr>
</table>

B.Sc. (Chemistry) Semester-6	BCHE-604: Analytical Methods in Chemistry	MAJOR

Credit - 3, Teaching Hours - 45

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: apply principles of chromatography to separate and analyze chemical mixtures using techniques like TLC, paper, and column chromatography.

CO2: interpret pH metric, potentiometric, and conductometric titration data for determining equivalence points and pKa values.

CO3: demonstrate gravimetric procedures and perform quantitative calculations using classical precipitation methods.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	3	–	–	2	3	–	–	–	–	–	2.60	2	3	2	2.33
CO2	2	3	3	–	–	2	3	–	–	–	–	–	2.60	3	3	2	2.67
CO3	2	2	3	–	–	2	2	–	–	–	–	–	2.17	3	3	2	2.67
PO Avg	2.33	2.33	3.00	–	–	2.00	2.67	–	–	–	–	–		2.67	3.0	2.0	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3.Behaviorism

Teaching Methods and Tools

- Direct Teaching using Black board
- Presentations,
- Multimedia resources
- Diagrams and Layouts
- Group discussion and activity

UNIT 1	Introduction to separation techniques	15 Hrs
	1.1 Filtration, distillation and solvent extraction **(2hours)** 1.2 Chromatography: principle, classification of chromatographic methods **(2hours)** 1.3 Paper chromatography: principle, experimental technique **(2hours)** 1.4 Column chromatography: principle, experimental technique **(2hours)** 1.5 Thin layer chromatography: principle, experimental technique **(2hours)** 1.6 Ion exchange chromatography: principle, experimental technique **(1hour)** 1.7 Gas chromatography: principle, experimental technique **(2hours)** 1.8 Applications of chromatography in qualitative and quantitative analysis **(2hours)**	
	References 1. Rouessac, F., Rouessac, A., & Towey, J. (2022). *Chemical analysis:*	

	Modern instrumentation methods and techniques (3rd ed.). Wiley. 2. Harris, D. C., & Lucy, C. A. (2020). *Quantitative chemical analysis* (10th ed.). W. H. Freeman. 3. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). *Principles of instrumental analysis* (7th ed.). Cengage Learning. 4. Poole, C. F. (2019). *The essence of chromatography* (2nd ed.). Elsevier. 5. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2021). *Fundamentals of analytical chemistry* (10th ed.). Cengage Learning. 6. Gilbert, J. C., & Martin, S. F. (2015). *Experimental organic chemistry: A miniscale and microscale approach* (6th ed.). Cengage Learning	
UNIT 2	**Electroanalytical methods**	**15 Hrs**
	2.1 Classification of electroanalytical methods **(2hours)** 2.2 Basic principle of pH metric titrations **(2hours)** 2.3 Basic principle of potentiometric titrations **(3hours)** 2.4 Basic principle of conductometric titrations **(2hours)** 2.5 Techniques used for the determination of equivalence points.**(3hours)** 2.6 Techniques used for the determination of pK_a values.**(3hours)**	
	References 1. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2021). *Fundamentals of Analytical Chemistry* (10th ed.). Cengage Learning. 2. Harris, D. C. (2020). *Quantitative Chemical Analysis* (10th ed.). W. H. Freeman. **3.** Willard, H. H., Merritt, L. L., Dean, J. A., & Settle, F. A. (1988). *Instrumental methods of analysis* (7th ed.). Wadsworth Publishing Company.	
UNIT 3	**Gravimetric and Combustion analysis**	**15 Hrs**
	2.1 Introduction **(1hour)** 2.2 How to perform a successful gravimetric analysis? - Preparation of the solution **(1hour)** - Precipitation **(1hour)** - Digestion **(1hour)** - Filtration **(1hour)** - Washing **(1hour)** - Drying or igniting **(1hour)** -Weighing **(0.5hour)** - Calculation **(0.5hour)** 2.3Gravimetric calculation: How much analyte is there? **(1hour)** 2.4 Organic precipitants **(2hours)** [Definition, only name and structure of three organic precipitants(Dimethylglyoxime, 8-hydroxyquinoline, Quinaldic acid), advantages and disadvantages of organic precipitants] 2.5 Application of gravimetric analysis **(2hours)** 2.6 Numericals based on 2.3 **(2hours)**	
	References 1. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2021). *Fundamentals of analytical chemistry* (10th ed.). Cengage Learning. 2. Harris, D. C., & Lucy, C. A. (2022). *Quantitative chemical analysis* (11th ed.). W. H. Freeman. 3. Christian, G. D., & Dasgupta, P. K. (2014). *Analytical chemistry* (7th	

	ed.). Wiley. 4. Miller, J. N., & Miller, J. C. (2010). *Statistics and chemometrics for analytical chemistry* (6th ed.). Pearson Education. 5. Dean, J. A. (1995). *Analytical chemistry handbook* (2nd ed.). McGraw-Hill.	

Assessment Method	
Internal/Online Assessment (40%)	1. Written test (20 Marks) 2 .Quiz / Group Discussion (10 Marks) 3. Assignments / Seminar (10 Marks)
External Assessment (60%)	Term End Theory examination (Written test 60 Marks)

B.Sc. (Chemistry) Semester-6	BCHE-604P: Analytical Methods in Chemistry Practical	MAJOR

Credit - 2, Teaching Hours - 60

Course Outcomes (COs)

After studying this course, the student will be able to….

CO1: apply crystallization, distillation, and chromatography methods to purify and separate components in chemical mixtures.

CO2: use conductometric titrations and gravimetric techniques for accurate quantitative chemical analysis.

Mapping Matrix of POs, PSOs and COs

CO \ PO	POs												CO Avg	PSOs			CO Avg
	1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	
CO1	3	2	3	1	–	2	3	–	1	–	–	1	2.00	2	3	2	2.33
CO2	3	3	3	–	–	2	2	–	1	–	–	–	2.29	3	3	2	2.67
PO Avg	3.0	2.5	3.0	1.0	–	2.0	2.5	–	1.0	–	–	1.0		2.5	3.0	2.0	

(1-weak correlation; 2-medium correlation; 3-strong correlation)

Teaching Pedagogy

1.Constructivism
2.Social Constructivism
3. Behaviorism

Teaching Methods and Tools

- Experimentation
- Hands on Training

Experiments

(A) Separation techniques	**16 Hrs**

(1) Crystallizaton
- Concept of induction of crystallization
- Phthalic acid from hot water
- Acetanilide from boiling water
- Benzoic acid from water
- Naphthalene from ethanol

(4) Distillation
- Simple distillation of acetone-water mixture using water condenser
- Distillation of nitrobenzene and chlorobenzene using air condenser
- Separation of azeotropic mixture

(3) Chromatography**(Any three experiments)**
- To separate Pb^{2+}, Ag^{+} and Hg^{2+}ions present in a mixture by paper chromatography
- To separate Zn^{2+}, $Pb^{2+}$and Cd^{2+}ions present in a mixture by paper chromatography
- Separation of a mixture of phenylalanine and glycine, alanine and aspartic acid, leucine and glutamic acid by paper and thin layer chromatography
- Separation of drug mixture by TLC

(B) Electroanalytical methods	**12 Hrs**
Acid-base titrations by conductometrically (1) HCl→NaOH (2) NaOH→HCl (3) CH_3COOH →NaOH (4) HCl + CH_3COOH →NaOH	
(C) Gravimetric Analysis	**32 Hrs**
(1) Iron as ironoxide (2) Ni as Ni $(DMG)_2$ (3) Ba as $BaSO_4$ (4) Al as Al_2O_3	

References

1. Kenkel, J. (2013). *Analytical Chemistry for Technicians* (4th ed.). CRC Press.
2. Viswanathan, C., & Duraisamy, R. (2024). *Analytical Chemistry Lab Manual*. LAP LAMBERT Academic Publishing.
3. Mikes, O., & Chalmers, R. A. (1979). *Laboratory handbook of chromatographic and allied methods*. Ellis Horwood.

Assessment Method	
Internal/Online Assessment (40%)	Internal Practical Examination
External Assessment (60%)	Term End Practical examination