



1.1.3

List of Employability/ Entrepreneurship/ Skill Development Courses with Course Contents

Colour Codes		
Name of the Subjects	Yellow	
Employability Contents	Green	
Entrepreneurship Contents	Light Blue	
Skill Development Contents	Pink	



**List of Courses Focus on Employability/ Entrepreneurship/
Skill Development**

Department : Chemistry

Programme Name : B. Sc.

Academic Year : 2022-23

List of Courses Focus on Employability/ Entrepreneurship/Skill Development

Sr. No.	Course Code	Name of the Course
01.	CYUALT1	Inorganic Chemistry Practical-I
02.	CYUALT2	Organic Chemistry Practical-I
03.	CYUALG1	Generic Elective Practical-I
04.	CYUATC1	Value added courses
05.	CYUBLT1	Physical Chemistry Practical-I
06.	CYUBTT2	Organic Chemistry-II
07.	CYUBLT2	Organic Chemistry Practical-II
08.	CYUBLG1	Generic Elective Practical-II
09.	CYUBTC1	Value added courses
10.	CYUCLT1	Physical Chemistry Practical-II
11.	CYUCTT2	Organic Chemistry-III
12.	CYUCLT2	Organic Chemistry Practical-III
13.	CYUCLT3	Spectroscopy Practical
14.	CYUCLG1	Generic Elective- Practical-III
15.	CYUCTC1	Value added Courses
16.	CYUDLT1	Physical Chemistry practical-III
17.	CYUDLT2	Inorganic Chemistry practical-II
18.	CYUDLG1	Generic Elective- Practical-IV



19.	CYUDTC1	Value added Courses
20.	CBT-11	Organic Chemistry- IV
21.	CBT-11	Organic Chemistry- IV Practical
22.	CBL-12	Physical Chemistry-V: Practical
23.	DSE-I-THEORY	DSE-1 : Theory
24.	DSE-1-LAB	DSE-1: Practical
25.	DSE-2-THEORY	DSE-2 : Theory
26.	DSE-2-LAB	DSE-2: Practical
27.	CBL-13	Inorganic Chemistry-IV: Practical
28.	CBT-I4	Organic Chemistry-V
29.	CBL-I4	Organic Chemistry-V: Practical
30.	DSE-3-THEORY	DSE-3 : Theory
31.	DSE-3-THEORY	DSE-3 : Theory Practical
32.	DSE-4-PROJECT	Dissertation/ Project work followed by seminar

अध्यक्ष/Head
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Scheme and Syllabus

Semester wise Theory Papers and Practical

B.Sc. Hon's (Chemistry): LOCF 2021-2022

Department of Chemistry, School of Physical Sciences

Course Opted	Course Code	Name of the course	Credit	Hour/ week	Internal Assess	End Sem Exam
Semester I						
CC-I Theory	CYUATT1	Inorganic Chemistry-I	3	3	30	70
CC-I Practical	CYUALT1	Inorganic Chemistry Practical-I	2	4	30	70
CC-II Theory	CYUATT2	Organic Chemistry-I	3	3	30	70
CC-II Practical	CYUALT2	Organic Chemistry Practical-I	2	4	30	70
AEC-I Theory	CYUATA1	Select one from the Pool of AEC Courses offered	2	2	30	70
SEC-I Theory	CYUATL1	Select one from the Pool of SEC Courses offered	2	2	30	70
GEC-I Theory	CYUATG1	1A Physics-I, 1B Mathematics-I, 1C Zoology-I, 1D Botany-I, 1E Anthropology-I, 1F Biotechnology-I, 1G Forensic Science-I	3	3	30	70
GEC-I Practical	CYUALG1	Generic Elective- Practical-I	2	4	30	70
Additional Credit Course I	CYUATC1	Select one from the Pool of Value added Courses offered				
TOTAL			19	25	240	560
Semester II						
CC-III Theory	CYUBTT1	Physical Chemistry-I	3	3	30	70
CC-III Practical	CYUBLT1	Physical Chemistry Practical-I	2	4	30	70
CC-IV Theory	CYUBTT2	Organic Chemistry-II	3	3	30	70
CC-IV Practical	CYUBLT2	Organic Chemistry Practical-II	2	4	30	70
AEC-II Theory	CYUBTA1	Select one from the Pool of AEC Courses offered	2	2	30	70
SEC-II Theory	CYUBTL1	Select one from the Pool of SEC Courses offered	2	2	30	70
GEC-II Theory	CYUBTG1	2A Physics-I, 2B Mathematics-I, 2C Zoology-I, 2D Botany-I, 2E Anthropology-I, 2F Biotechnology-I, 2G Forensic Science-I	3	3	30	70
GEC-II Practical	CYUBLG1	Generic Elective- Practical-II	2	4	30	70
Additional Credit Course II	CYUBTC1	Select one from the Pool of Value added Courses offered				
Total			19	25	240	560
Semester III						
CC-V Theory	CYUCTT1	Physical Chemistry-II	3	3	30	70
CC-V Practical	CYUCLT1	Physical Chemistry Practical-II	2	4	30	70
CC-VI Theory	CYUCTT2	Organic Chemistry-III	3	3	30	70
CC-VI Practical	CYUCLT2	Organic Chemistry Practical-III	2	4	30	70
CC-VII Theory	CYUCTT3	Molecular Spectroscopy & Photochemistry	3	3	30	70
CC-VII Practical	CYUCLT3	Spectroscopy Practical	2	4	30	70
AEC-III Theory	CYUCTA1	Select one from the Pool of AEC Courses offered	2	2	30	70
GEC-III Theory	CYUCTG1	3A Physics-I, 3B Mathematics-I, 3C Zoology-I, 3D Botany-I, 3E Anthropology-I, 3F Biotechnology-I, 3G Forensic Science-I	3	3	30	70
GEC-III Practical	CYUCLG1	Generic Elective- Practical-III	2	4	30	70
Additional Credit Course III	CYUCTC1	Select one from the Pool of Value added Courses offered				
Total			22	30	270	630
Semester IV						
CC-VIII Theory	CYUDTT1	Physical Chemistry-III	3	3	30	70
CC-VIII Practical	CYUDLT1	Physical Chemistry practical-III	2	4	30	70
CC-IX Theory	CYUDTT2	Inorganic Chemistry-II	3	3	30	70
CC-IX Practical	CYUDLT2	Inorganic Chemistry practical-II	2	4	30	70
CC-X Theory	CYUDTT3	Introduction to Quantum Chemistry	3	3	30	70
CC-X Practical	CYUDLT3	Quantum Chemistry Practical	2	4	30	70



AEC-IV Theory	CYUDTA1	Select one from the Pool of AEC Courses offered	2	2	30	70
GEC-IV Theory	CYUDTG1	4A Physics-I, 4B Mathematics-I, 4C Zoology-I, 4D Botany-1, 4E Anthropology-1, 4F Biotechnology-1, 4G Forensic Science-1	3	3	30	70
GEC-IV Practical	CYUDLG1	Generic Elective- Practical-IV	2	4	30	70
Additional Credit Course IV	CYUDTC1	Select one from the Pool of Value added Courses offered				
Total			22	30	270	630
Summer Internship*	CYUDLF1		6*	90	30	70

CBCS

SUMMER Internship: 15 days		Swayam Swachhta / NSS / Industrial/ others		2	100
V	Core-11	CBT-11	Organic Chemistry IV	4	4
	Core -11 Practical	CBL-11	Organic Chemistry IV: Practical	2	4

	Core -12	CBT-12	Physical Chemistry-V	4	4	
	Core -12 Practical	CBL-12	Physical Chemistry-V: Practical	2	4	
	Discipline Specific Elective (DSE-1)	DSE-1-THEORY	DSE-I : Theory	4	4	
	DSE-1 - Practical	DSE-1-LAB	DSE-I: Practical	2	4	
	Discipline Specific Elective (DSE-2)	DSE-2-THEORY	DSE-II : Theory	4	4	
	DSE-2 - Practical	DSE-2-LAB	DSE-II: Practical	2	4	
			TOTAL	24	32	
	VI	Core-13	CBT-13	Inorganic Chemistry IV	4	4
		Core -13 Practical	CBL-13	Inorganic Chemistry IV: Practical	2	4
		Core -14	CBT-14	Organic Chemistry V	4	4
Core -14 Practical		CBL-14	Organic Chemistry V: Practical	2	4	
Discipline Specific Elective (DSE-3)		DSE-3-THEORY	DSE-III : Theory	4	4	
DSE-3 - Practical		DSE-3-LAB	DSE-III: Practical	2	4	
Discipline Specific Elective (DSE-4) + DSE-4 - Practical		DSE-4-Project	Dissertation/ Project work followed by seminar	4+2=6	8	
Or Dissertation/ Project work followed by seminar				5+1=6		
			TOTAL	24	32	
			TOTAL CREDITS	152 + 4 (SI)		

As per UGC CBCS guidelines, University / departments have liberty to offer GE and SEC courses offered by one department to students of other departments. The No. of GE course is four. One GE course is compulsory in first 4 semesters each.
Minimum One Skill Enhancement course shall be proposed by each department. (4 credits) [4 L or 2L + 2P or 1L + 3P or 3L + 1T] 1P = 2 hours



CHEMISTRY-DSE I-IV (ELECTIVES)

CHEMISTRY-DSE-I:	ANALYTICAL METHODS IN CHEMISTRY
CHEMISTRY-DSE-II:	BIOCHEMISTRY
CHEMISTRY-DSE-III:	NOVEL INORGANIC SOLIDS
CHEMISTRY-DSE-IV:	POLYMER CHEMISTRY
CHEMISTRY-DSE-V:	APPLICATIONS OF COMPUTERS IN CHEMISTRY
CHEMISTRY-DSE-VI:	RESEARCH METHODOLOGY FOR CHEMISTRY
CHEMISTRY-DSE-VII:	GREEN CHEMISTRY

SKILL ENHANCEMENT COURSE (ANY TWO) (CREDIT: 02 EACH)

SEC-1:	BASIC ANALYTICAL CHEMISTRY
SEC-2:	INTELLECTUAL PROPERTY RIGHTS (IPR)
SEC-3:	GREEN METHODS IN CHEMISTRY
SEC-4:	PHARMACEUTICAL CHEMISTRY
SEC-5:	CHEMISTRY OF COSMETICS & PERFUMES
SEC-6:	PESTICIDE CHEMISTRY

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Inorganic Chemistry-I (Practical)

(A) Titrimetric Analysis

- (i) Calibration and use of apparatus.
- (ii) Preparation of solutions of different Molarity/Normality of titrants.
- (iii) Use of primary and secondary standard solutions.

(B) Acid-Base Titrations

- (i) Estimation of carbonate and hydroxide present together in mixture.
- (ii) Estimation of carbonate and bicarbonate present together in mixture.
- (iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

- (i) Estimation of Fe(II) and oxalic acid using standardized KMnO_4 solution.
- (ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
- (iii) Estimation of Fe(II) with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* Sixth Edition, Pearson, 2009.
2. Svehala G. and Sivasankar I. B, Vogel's *Qualitative Inorganic Analysis*, Pearson, India, 2012.

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Organic Chemistry-I (Practical)

1. Checking the calibration of the thermometer.
2. Purification of organic compounds by crystallization using the following solvents:
a. Water b. Alcohol c. Alcohol-Water
3. Determination of the melting points of given organic compounds and unknown organic compounds (using Kjeldahl method and electrically heated melting point apparatus).
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)
6. Chromatography
 - a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
Separation of a mixture of two sugars by ascending paper chromatography
 - b. Separation of a mixture of *o*- and *p*-nitrophenol or *o*- and *p*-aminophenol by thin layer chromatography (TLC).
 - c. chromatography

Recommended Books/Reference:

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

Note: Experiments may be added/deleted subject to availability of time and facilities

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GE PRACTICAL – I (Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons)

(30Hours)

Section – A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO_4 .
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO_4 .
4. Estimation of Fe (II) ions by titrating it with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $\text{Na}_2\text{S}_2\text{O}_3$.

Section – B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)
 - (a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
 - (b) Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

- Textbook of Practical Organic Chemistry, A.I. Vogel, Prentice Hall, 5th edition.
- Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.
- Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
- Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011

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Syllabus on Polymer Chemistry (Certificate Course)

Credits: 02

30 Lectures

Unit I

Introduction: Background, Nomenclature, Classifications, Examples and Applications, Principles of Polymerization

Unit II

Synthesis of Polymers: Step-Growth Polymerization, Radical Chain Polymerization, Controlled Radical Polymerization, Copolymerization Ionic Chain Polymerization, Coordination Polymerization, Ring-Opening Polymerization, Polymerization techniques.

Unit III

Characterization of Polymers: Determination of Molecular Weight, Frictional Properties of Polymers in Solution, Hydrodynamic Size, DSC, TGA and SEM.

Unit IV

Polymer Properties: Crystallinity in polymers, Glass transition temperature, Rheological properties, Mechanical, Optical, Electrical, Surface and Other Industrially Relevant Properties Degradation of polymers.

Unit V

Some industrially important Polymer reactions, Polymer Processing: Polymer additives, compounding and processing techniques

21. Books recommended:

1. F. W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Wiley-Interscience, New York.
2. G. Odian, P. W. Atkins, Physical Chemistry, 6th Edition, Oxford University Press, New York.
3. G. Odian, Principles of Polymerization, 3rd edition (1991) John Wiley, Singapore
4. P. Bahadur and N.V. Sastry, Principle of Polymer Sciences, Narosa Publishing House, New Delhi (2002)
5. V.R. Gowarikar, N.V. Vishwanathan, J. Shreedhar, Polymer Sciences, Wiley Eastern, New Delhi

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Physical Chemistry-I (Practical)

1. **Surface tension measurements.**
 - a. Determine the surface tension by (i) drop number (ii) drop weight method.
 - b. Study the variation of surface tension of detergent solutions with concentration.
2. **Viscosity measurements using Ostwald's viscometer.**
 - a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
 - b. Viscosity of sucrose solution with the concentration of solute.
3. **pH metry**
 - a. Effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
 - b. Preparation of buffer solutions of different pH
 - i. Sodium acetate-acetic acid
 - ii. Ammonium chloride-ammonium hydroxide
 - c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
 - d. Determination of dissociation constant of a weak acid.

21

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended text books/references:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.*; W.H. Freeman & Co.: New York (2003).
4. Athawale V. D. and Mathur P. *Experimental Physical Chemistry*, New Age International (2001)

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Organic Chemistry-II (Practical)

1. Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.
2. Organic preparations:
 - i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β -naphthol, vanillin, salicylic acid) by any one method: (Using conventional method and Using green chemistry approach)
 - ii. Benzoylation of one of the amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and one of the phenols (β -naphthol, resorcinol, *p*-cresol) by Schotten-Baumann reaction.
 - iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).
 - iv. Bromination (anyone)
 - a. Acetanilide by conventional methods
 - b. Acetanilide using green approach (Bromate-bromide method)
 - v. Nitration: (anyone)
 - a. Acetanilide/nitrobenzene by conventional method
 - b. Salicylic acid by green approach (using ceric ammonium nitrate).
 - vi. Selective reduction of *meta*-dinitrobenzene to *meta*-nitroaniline.
 - vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.
 - viii. Hydrolysis of amides and esters.
 - ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
 - x. *S*-Benzylisothiuronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).

- xi. Aldol condensation with either conventional or green method.
- xii. Benzil-Benzilic acid rearrangement.

Collected solid samples may be used for recrystallization, melting point and TLC.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

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



GE PRACTICAL – II(Kinetic Theory of Gases, Chemical Energetics, Equilibria & Functional Group Organic Chemistry)

(30Hours)

Section – A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3 , NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of H .

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Ionic Equilibria

pH measurements

- Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
- Preparation of buffer solutions:
 - Sodium acetate-acetic acid
 - Ammonium chloride-ammonium hydroxide

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

Section – B: Organic Chemistry

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

II

- Criteria of Purity: Determination of melting and boiling points.
- Purification of organic compounds by crystallization (from water and alcohol) and distillation.
- Preparations: Mechanism of various reactions involved to be discussed.
Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
 - Bromination of Phenol/Aniline
 - Benzoylation of amines/phenols
 - Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone

Reference Books

- A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
- F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry*, Universities Press
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011

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Semester	Course	Name of the course	Credits=02
I-VI	VAC-4	COSMETIC FORMULATION	Theory+ Practical

Total Credit: 02

Total hours: 30

Course Objective:

This course is intended to provide a comprehensive survey of ingredients fundamental to the cosmetic industry. The course will emphasize current trends in the selection of cosmetic ingredients. The chemistry and technology of cosmetic raw materials will be related to their behavioral properties as utilized in the construction of stable functional systems. In this way, it is intended to generate a better understanding of the contributions of ingredients to the performance of finished product formulations. Emphasis will be placed on recognizing and dealing with problem areas associated with the use of various ingredients. Safety considerations and other pertinent matters which can influence ingredient selection will be included in these discussions.

Course Content:

UNIT - I: Classification of raw materials and raw materials used in the cosmetic industry for the manufacture of finished products. Method of sampling, Indian Standard specification laid down for sampling and testing of various cosmetics in finished form by the bureau of Indian standards. Factors affecting stability of a formulation, ICH guidelines, Methods of stabilizations and Methods of stability testing. Concept of development of stability indicating analytical methods.

UNIT - II: Determination of physical and chemical constants such as extractive values, moisture content, alcohol content, volatile oil content, ash values, bitterness values, foreign matters, and physical constants applicable to the lipid containing drugs.

UNIT III: Brief introduction of the following cosmetic preparation and a detailed study on their quality control: Shampoo, Tooth paste, skin powder, skin creams, hair creams, nail polish, after shave lotion, bath and toiletries, lipstick and hair dyes, perfumes, depilatories.

UNIT- IV: Packaging of cosmetics –Filling of solids, semisolids & liquids. Materials used for cosmetic packaging Rules & regulations and legal provisions for packaging & labeling.

UNIT-V: Experiments: Nano-Formulation of Gels, Shampoos, Hair-conditioners; Color cosmetics

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

UNIT VII: Dilute solutions

6 Lectures

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Recommended Books/References

- 1 Atkins P. and De Paula, J. *Physical Chemistry* Tenth Ed., OUP, 2014.
- 2 Castellan, G. W. *Physical Chemistry* 4th Ed., Narosa, 2004.
- 3 Engel, T. and Reid, P. *Physical Chemistry* 3rd Ed., Prentice Hall, 2012.
- 4 McQuarrie, D. A. and Simon, J. D. *Molecular Thermodynamics* Viva Books, 2004.
- 5 Roy, B. N. *Fundamentals of Classical and Statistical Thermodynamics* Wiley, 2001
- 6 *Commonly Asked Questions in Thermodynamics*. CRC Press, 2011.
- 7 Levine, I. N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill, 2010. 8 Metz, C.R. *2000 solved problems in chemistry*, Schaum Series, 2006.

Physical Chemistry-II (Practical)

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
2. Study the equilibrium of at least one of the following reactions by the distribution method:
 - (i) $I_2(aq) + I^- \rightarrow I_3^-(aq)$
 - (ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$
3. Study the kinetics of the following reactions.
 - a. Acid hydrolysis of methyl acetate with hydrochloric acid.
 - b. Saponification of ethylacetate.

Adsorption

Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid and selected organic dye(s) on activated charcoal.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand, New Delhi, 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry*, Eighth Edition, McGraw-Hill (2003).
3. Halpern, A. M. and McBane, G. C. *Experimental Physical Chemistry*, Third Edition, W. H. Freeman (2003).



Semester	Course	Name of the course	Credits
III	CC 6	Organic Chemistry-III	Theory:3 Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Nitrogen containing functional groups and their reactions.
- Familiarization with polynuclear hydrocarbons and their reactions.
- Heterocyclic compounds and their reactions.
- Alkaloids and Terpenes
- Understanding reactions and reaction mechanism of nitrogen containing functional groups.
- Understanding the reactions and mechanisms of diazonium compounds.
- Understanding the structure and their mechanism of reactions of selected polynuclear hydrocarbons.
- Understanding the structure, mechanism of reactions of selected heterocyclic compounds.
- Classification, structure, mechanism of reactions of few selected alkaloids and terpenes.

Organic Chemistry-III (Theory)

UNIT I: Nitrogen Containing Functional Groups

8 Lectures

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

UNIT II: Polynuclear Hydrocarbons

8 Lectures

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

UNIT III: Heterocyclic Compounds

12

Lectures

Classification and nomenclature, Structure, aromaticity in 5-membered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan: Furfural and furoic acid.

UNIT IV: Alkaloids

6 Lectures

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of

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Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

UNIT V: Terpenes

6 Lectures

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and α -terpineol.

Recommended Text Books/references:

1. Morrison, R. T., Boyd, R. N., Bhatteejee, S.K., Organic Chemistry, 7th Edn., Pearson.
2. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, John Wiley & Sons (1976).
3. Solomons, T.W., Fryhle Craig, *Organic Chemistry*, John Wiley & Sons, Inc(2009).
4. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
5. Kalsi, P. S. *Organic reactions and their mechanisms*, New Age Science(2010).
6. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press Inc., New York(2001).
7. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan(2010).
8. Bansal R. K. *Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms*, New Age, Third Edition (1999).
9. Clayden J., Greeves N., Warren S., Organic Chemistry, (2nd Ed.), (2012), Oxford University Press.

Organic Chemistry-III (Practical)

1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.
2. Identification of functional groups of simple organic compounds by IR spectroscopy and NMR spectroscopy
3. Preparation of methylorange.
4. Extraction of caffeine from tea leaves.
5. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars using simple lab procedures.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

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



edition).

5. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi(2006).

Molecular Spectroscopy & Photochemistry (Practical)

- (i) Determination of indicator constant-colorimetry.
- (ii) Verification of Beer's Law - Determination of concentration of solution by colorimetry.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested books/reference books:

1. Practicals in physical chemistry – a modern approach, P.S.Sindhu, Macmillan,
2. Experiments in Physical Chemistry, J.M.Wilson, R.J.Newcomb, A.R.Denaro, 2nd Edn., Elsevier.

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- R. Sarkar (Part-I & II), General & Inorganic Chemistry, Central.
- R. L. Dutta (Part-I & II), Inorganic Chemistry, The New Book Stall.
- J. D. Lee: *A New Concise Inorganic Chemistry*, E.L.B.S.
- F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley.
- D. F. Shriver and P. W. Atkins: *Inorganic Chemistry*, Oxford University Press.
- Gary Wulfsberg: *Inorganic Chemistry*, Viva Books Pvt. Ltd.

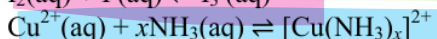
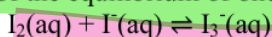
GE PRACTICAL – III (Solid, Solutions, Phase Equilibrium, Chemical Kinetics, Conductance & Periodic Properties and Chemistry of s-, p-, and d- block elements)

(30 Hours)

Section – A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions by the distribution method:



Phase equilibria

- Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
 - Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
 - Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.
- (I) Surface tension measurement (use of organic solvents excluded).
- Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
 - Study of the variation of surface tension of a detergent solution with concentration.
- (II) Viscosity measurement (use of organic solvents excluded).
- Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
 - Study of the variation of viscosity of an aqueous solution with concentration of solute.

(III) Chemical Kinetics

Study the kinetics of the following reactions.

- Initial rate method: Iodide-persulphate reaction
- Integrated rate method:
 - Acid hydrolysis of methyl acetate with hydrochloric acid.
 - Saponification of ethyl acetate.
 - Compare the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetate

Conductance

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

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c) Perform the following conductometric titrations:

- i. Strong acid vs. strong base
- ii. Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:

- a) Strong acid vs. strong base
- b) Weak acid vs. strong base
- c) Potassium dichromate vs. Mohr's salt

Section – B: Inorganic Chemistry

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

Cations : NH_4^+ , Pb^{2+} , Ag^+ , Bi^{3+} , Cu^{2+} , Cd^{2+} , Sn^{2+} , Fe^{3+} , Al^{3+} , Co^{2+} , Cr^{3+} , Ni^{2+} , Mn^{2+} , Zn^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , K^+ , Anions : CO_3^{2-} , S^{2-} , SO_3^{2-} , $S_2O_3^{2-}$, NO_3^- , NO_2^- , Cl^- , Br^- , I^- , SO_4^{2-} , PO_4^{3-} , BO_3^{3-} , $C_2O_4^{2-}$, F^-

(Spot tests should be carried out wherever feasible)

Reference Books:

- B.D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.
- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011
- V. K. Ahluwalia, S. Dhingra & A. Gulati, College Practical Chemistry, University Press, Delhi.



CERTIFICATE COURSES/VALUE ADDED COURSES

Semester	Course	Name of the course	Credits=02
I-VI	VAC-3	Fuel Chemistry	Theory+ Practical

1. Department: Chemistry
2. Name of the Course: Certificate Course in Fuel Chemistry
Nature of Course(Certificate/ Value Added):Certificate
3. Mode of Course: Hybrid Mode (Online + Offline)
Online / Offline / Physical
4. Number of Seats: 20
5. Eligibility Criteria for Admission: 12th Pass, Ongoing B Sc in any discipline with Chemistry as a paper.

6. Introduction and relevance of Course:

In the present scenario energy are first and foremost requirement for the socio-economic development of the society and nation as well which is also recognized by United Nations (UN) as one of the very important and inevitable common goals for the sustainable development goals (SDGs). This course will enable the scientific knowledge, skill and hands-on experience about the most non-renewable energy sources fossil fuels (coal, petroleum, and natural gas) to meet out the energy demand of the country. This will assist them to be industry ready to contribute effectively in the field of coal, petroleum chemistry and technology. In the Bilaspur city the regional research centre of CSIR-Central Institute of Mining and Fuel Research (CIMFR) is located where they recruit the project assistant and project fellow having the knowledge and experience on fuel chemistry, therefore, this course will provide job opportunities too.

7. Objectives of the course: The course will have the following objectives

- To know about the sources of energies.
- To study the fuel as the main source of energy particularly fossil fuels.
- To know the chemical compositions of different fuels
- To study Domestic and industrial applications of coal.
- To understand about petroleum and petrochemical industry.
- Various prospects of lubricants

8. Learning outcome of the course:

- Understand both conventional based fuels, and alternative & renewable fuels.



- Understand the chemistry that underpins coal and petroleum fuel science and technology.
 - They will understand the refining processes used to produce fuels and lubricants and will know how differences in chemical composition affect properties of fuels and their usage in different applications.
 - Understand the fuel product specifications, various test methods used to qualify different types of fuels as well as characterization methods.
 - They will get experimental experience on fossil fuels like coal, petroleum, and natural gas)
 - Students can get job opportunities in various projects of CSIR-Central Institute of Mining and Fuel Research (CIMFR).
9. Number of lectures: 2 hour per week (02 Credit)
10. Number of practical's (if any): 2 hour per week (01 Credit)
11. List of experiments (If any)-
- Determination of flash point & fire point of given fuel sample.
 - Determination of viscosity index, cloud point, pour point of given fuel sample.
 - Determination of calorific value of given fuel sample/coal sample using bomb calorimeter. Proximate analysis of given coal sample.
 - Determination of the iodine number of oil.
 - Determination of the saponification number of oil.

12. Syllabus:

Credits: 02

30 Lectures

Unit 1

Review of energy sources (renewable and non-renewable). Energy from natural sources (i.e. solar and renewable forms), from fossil fuels and from nuclear fission. Classification of fuels and their calorific value. Solid, liquid and gaseous fuels, ultimate and proximate analysis of solid fuel

Unit II

Coal as Fuel: Determination of calorific value of solid, liquid and gaseous fuels, Flash point and fire point. Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar based chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Unit III

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different types

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of petroleum products and their applications Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Unit IV

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

13. Suggestive Readings:

- Industrial Chemistry by Stocchi, E. Vol-I, Ellis Horwood Ltd. UK (1990).
- Engineering Chemistry by Jain, P.C. & Jain, M. Dhanpat Rai & Sons, Delhi.
- A Text Book of Engineering Chemistry S. S. Dara S Chand & Company
- Industrial Chemistry by Sharma, B.K. & Gaur, H. Goel Publishing House, Meerut (1996).
- Chemistry of Fossil Fuels and Biofuels by Harold Schobert, Cambridge University Press 2013.
- The Chemistry and Technology of Coal by James G. Speight, CRC Press Boca Raton (2012)
- Water for Energy and Fuel Production, Yatish T. Shah, CRC Press Boca Raton (2014)
- Process Chemistry of Coal Utilization: Impacts of Coal Quality and Operating Conditions by Stephen Niksa, Elsevier 2019
- Chemistry of Coal Conversion by Richard H. Schlosberg Springer (1985).
- The Chemistry and Technology of Petroleum by James G. Speight CRC, Boca Raton (2014).
- Lubricants and Lubrication by Wilfried Dresel, Wiley (2017).

14. Course Coordinator (Name & Designation)

Dr S S Thakur, Assistant Professor

Prof G, K Patra, Professor

15. Evaluation Criteria:

Components	Class Test	Hands on Experiment	End Semester	Total
Weightage (%)	20	20	60	100

16. Infra Structure requirements (if any): Basic laboratory with small instrument like flash and fire point apparatus, Bomb Calorimeter, viscometer, consumables chemicals etc.

17. Financial Requirement (if any): Rs. 50,000/- for instrument and chemicals

18. Proposed fee for the Course (if any): 5000/- (or as per direction of the university)

19. Budgetary provisions : 50, 000/-

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

UNIT-IV: Surface chemistry

10 Lectures

Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langmuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution.

Recommended books/References:

1. Atkins P. W. and De Paula J., *Physical Chemistry*, (tenth edition) Oxford University Press, 2014.
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa, 2004.
3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books, 2004.
4. Engel, T. & Reid, P. *Physical Chemistry* Third Edition, Prentice-Hall, 2012.
5. Zundhal, S.S. *Chemistry concepts and applications* Cengage India, 2011
6. Ball, D. W. *Physical Chemistry* Cengage India, 2012.
7. Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP, 2009.
8. Levine, I. N. *Physical Chemistry 6th Ed.*, Tata McGraw-Hill, 2011.
9. Metz, C. R. *Physical Chemistry 2nd Ed.*, Tata McGraw-Hill, 2009.

Physical Chemistry-III (Practical)

Conductometry

1. Determination of cell constant
2. Equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Conductometric titrations of: (i) Strong acid Vs. strong base, (ii) Weak acid vs. strong base, (iii) Mixture of strong acid and weak acid vs. strong base.

Potentiometry

Potentiometric titrations of: (i) Strong acid vs. strong base, (ii) Weak acid vs. strong base (iii) Dibasic acid vs. strong base, (iv) Potassium dichromate vs. Mohr's salt.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommend books/References:

1. Khosla, B. D.; Garg, V. C. and Gulati, A. *Senior Practical Physical Chemistry*, R. Chand New Delhi, 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry* Eighth Edition; McGraw-Hill: New York, 2003.
3. Halpern, A. M. and McBane, G. C. *Experimental Physical Chemistry 3rd Ed.*; W.H. Freeman & Co.: New York, 2003.



Recommended books/references:

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

Inorganic Chemistry-II (Practical)

(A) Iodo / Iodimetric Titrations

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

(B) Inorganic preparations

- (i) Cuprous Chloride, Cu_2Cl_2
- (ii) Preparation of Aluminium potassium sulphate (Potash alum) or Chrome alum.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended books/references:

Mendham, J., A. I. *Vogel's Quantitative Chemical Analysis* Sixth Edition Pearson, 2009.

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(8 Hours)

Reference Books:

- Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry* 6th Ed., Saunders College Publishing, Fort Worth (1992).
- Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.
- Vogel, A. I. *Vogel's Qualitative Inorganic Analysis* 7th Ed., Prentice Hall.
- Vogel, A. I. *Vogel's Quantitative Chemical Analysis* 6th Ed., Prentice Hall.
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- J. C. Kotz, P. M. Treichel & J. R. Townsend: *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
- B. H. Mahan: *University Chemistry* 3rd Ed. Narosa (1998).
- R. H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
- J. D. Lee: *A New Concise Inorganic Chemistry*, E.L.B.S.
- F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley.
- D. F. Shriver and P. W. Atkins: *Inorganic Chemistry*, Oxford University Press.
- R. L. Dutta (Part-I & II), *Inorganic Chemistry*, The New Book Stall.
- Gary Wulfsberg: *Inorganic Chemistry*, Viva Books Pvt. Ltd.
- S. Chand. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry* 7th Ed., W. H. Freeman.
- Berg, J. M., Tymoczko, J. L. & Stryer, L. *Biochemistry* 7th Ed., W. H. Freeman

GEPRACTICAL – IV (Electrochemistry, Chemical Kinetics, Coordination compounds, Organometallics and Molecules of life

(30 Hours)

Section – A: Analytical Chemistry

- Estimation of the amount of nickel present in a given solution as bis(dimethylglyoximate) nickel(II) or aluminium as oxinate in a given solution gravimetrically.
- Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
- Estimation of total hardness of a given sample of water by complexometric titration.
- To draw calibration curve (absorbance at λ_{max} vs. concentration) for various concentrations of a given coloured compound and estimate the concentration of the same in a given solution.
- Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+} -



- phenanthroline complex in solution by Job's method.
6. Determination of concentration of Na^+ and K^+ using Flame Photometry.

Section – B: Inorganic Chemistry

1. Separation of mixtures by chromatography: Measure the R_f value in each case. (Combination of two ions to be given)
Binary mixture of nickel and cobalt, copper and nickel, zinc and magnesium, iron and copper; aluminium and nickel.
2. Preparation of any two of the following complexes:
 - (a) tetraammine copper (II) sulphate
 - (b) tetraamminecarbonatocobalt (III) nitrate
 - (c) potassiumtrioxalatochromate (III)
 - (d) potassiumtrioxalatoferrate (III)
 - (e) sodiumhexanitritocobaltate (III)
 - (f) prussian blue

Section – C: Organic Chemistry

1. Determination of the concentration of glycine solution by formylation method.
2. Titration curve of glycine
3. Action of salivary amylase on starch
4. Effect of temperature on the action of salivary amylase on starch.
5. Determination of the saponification value of an oil/fat.
6. Determination of the iodine value of an oil/fat
7. Differentiation between a reducing/nonreducing sugar.
8. Extraction of DNA from onion/ cauliflower

Reference Books:

- Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry* 6th Ed., Saunders College Publishing, Fort Worth (1992).
- Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.
- Vogel, A. I. *Vogel's Qualitative Inorganic Analysis* 7th Ed., Prentice Hall.
- Vogel, A. I. *Vogel's Quantitative Chemical Analysis* 6th Ed., Prentice Hall.
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.
- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011
- V. K. Ahluwalia, S. Dhingra & A. Gulati, College Practical Chemistry, University Press, Delhi.

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Semester	Course	Name of the course	Credits=02
I-VI	VAC-1	EFFICIENT TECHNOLOGIES FOR FOOD PROCESSING AND SHELF LIFE EXTENSION	Theory+ Practical

1. Department: Chemistry
2. Name of the Course: Certificate Course in
3. Nature of Course: Certificate or Value Added Course: Certificate
4. Mode of Course: Online / Offline / Physical: Hybrid Mode (online + Offline 60:40 %)
5. Number of Seats: 20
6. Eligibility Criteria for Admission: 10+2 in any discipline.
7. **Introduction and relevance of Course:** Food processing which includes both fresh and packaged food involves handling of foods, preparation and storage through the subsequent stages so that the pathogens and toxic components present in food are destroyed and deactivated making the food safer and hygienic. Food preservation techniques combines science-based knowledge with technologies, to prevent spoilage and extend shelf-life and ensure consumers free of pathogenic microorganism food. Deterioration of food leads to loss of quality including color, texture, taste as well as nutritive value. By preserving food, food waste can be reduced, which is an important way to decrease production costs and increase the efficiency of food systems, improve food security and nutrition and contribute towards environmental sustainability. For instance, it can reduce the environmental impact of food production
8. **Objectives of the course:**
 - ✓ To impart knowledge in the area of food science and technology
 - ✓ To aware with the recent technologies used in food preservation and processing
 - ✓ To understand the quality control of different food items
 - ✓ To understand the importance of food safety and food management
1. **Learning outcome of the course:**
After completing this certificate course the learner will be able to:
 - ✓ understand the food processing and technology, its history, development and present status
 - ✓ explain the significance and basic concepts of the subject
 - ✓ aware of the skills required to be a professional food technologist
 - ✓ aware of the career opportunities available and educational
 - ✓ qualifications required for specific careers in the industry
 - ✓ know the scope for self employment as small, medium or large scale entrepreneurs.
10. Number of lectures (1 hour = 1 credit per week): 1 (01 hour)
11. Number of practical's (if any) (2 hours = 1 Credit per week) 1 (2 Hour)
12. List of experiments (If any)- attached with annexure I
13. Syllabus:

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Credits: 02

30 Lectures

Unit I

Introduction: Food Constituents & Functions, Quality and Safety Aspects of Food, Factors Affecting Quality during Processing and Storage, Role of Water in Food and its Shelf Life, Browning Reactions

Unit II

Technologies in Food Preservation: Principles of Food Preservation, Traditional Food Preservation Technologies, High Pressure Processing of Food, Membrane Technology, Food Irradiation, Hurdle Technology.

Unit III

Nanotechnology in Food Packing: Nano encapsulation, Nanoemulsions, Nanoparticles/active packaging, Nanoclays in packaging, Nanocomposites in packaging, Nanosensors at the packaging and processing plant, Nanosensors in plastic film packages/ Electronic tongue/ Intelligent packaging, Nanosensors, Nanofibres, Color changing labels: Nanococheles/nanodroplets, Nanofilms/ Nanolaminates

Unit IV

Food Quality enhancement and analysis: Rancidity, Natural Antioxidants, High Energy RTE Food Paste, Ozonation of Food Grains, Food Fortification: Iron Fortified Rice (IFR), Nutri Dal and Fortified Noodles, Hyper Spectral Imaging for Quality Analysis of Food Grains, Non-Destructive Methods for Analysis of Grain Quality, Detection of Spoilage in Grains using Biosensors.

Practical

- To study the effect of enzymatic browning in fruits and vegetables.
- To study different types of blanching of fruits and vegetables.
- Preservation of food by canning.
- To perform cut out analysis of canned product.
- Preservation of food by high concentration of sugar i.e. jam.
- Preservation of food by high concentration of salt/acid i.e. pickle.
- Preservation of food by addition of chemicals i.e. tomato ketchup.
- Preservation of food by drying in a cabinet drier.
- Preservation of fruits & vegetables by freezing.



CHEMISTRY-C XI: ORGANIC CHEMISTRY-IV (CBT-11)

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Methods of Determining Reaction Mechanism: Mechanism of bonds breaking and formation. Inter and intra-molecular migration of groups, crossover experiments, exchange with solvents, importance of reactive intermediates. Isotopic substitution in a molecule: primary and secondary kinetic isotope effects - their importance in mechanistic studies.

Chemistry of reaction intermediates: Preparation, reactions and stability of carbenes, nitrenes and arynes.

Molecular Rearrangements: Favorskii rearrangement, Demzov rearrangement. Beckmann, Hofmann, Lossen, Curtius and Wolff rearrangements, Baeyer-Villiger oxidation.

Reagents and reactions in Organic Synthesis: Reducing agents: lithium aluminium hydride, sodium borohydride, Birch reduction. Oxidizing agents: Osmium tetroxide, Woodward & Prevost oxidation and m-Chloroperbenzoic acid. Hydroboration,

Ultra-Violet Spectroscopy: Electromagnetic radiation, UV Spectroscopy – Electronic transitions, auxochromes, chromophores, bathochromic and hypsochromic shift, Woodward-Fieser rule for calculating λ_{\max} for conjugated dienes and α,β -unsaturated aldehydes and ketones. Interpretation of UV spectra.

26

Agss

Infrared Spectroscopy: Vibration modes and bond stretching. Absorption of common functional groups, Factors affecting vibrational frequency, effects of Hydrogen bonding. Fingerprint region and interpretation of IR spectra.

Books Recommended

1. "Organic Chemistry", I. L. Finar, [Vol. I, 6th Edition (1973), Reprinted in 1980 & Vol. II, 5th Edition (1975), Reprinted in 1996], ELBS and Longman Ltd., New Delhi.
2. "A Guide Book to Mechanism in Organic Chemistry", P. Sykes, 6th Edition (1997), Orient Longman Ltd., New Delhi.
3. "Organic Chemistry", R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.
4. "Organic Chemistry", S. M. Mukherji, S. P. Singh, and R. P. Kapoor, 1st Edition (1985), 5th Reprint (1999), New Age International (P) Ltd. Publishers, New Delhi.
5. "Organic Chemistry", J. Clayden, N. Greeves, S. Warren, and E. Wothers, Oxford Univ. Press, Oxford (2001).
6. "Organic Chemistry", G. Solomon, Wiley India, Paper Back, 9th Edition.
7. "Modern Organic Chemistry", M. K. Jain and S. C. Sharma, Vishal Publishing CO. Jalandhar, India, 4th Edition (2012).



CHEMISTRY PRACTICAL-C XI ORGANIC CHEMISTRY IV LAB
(PSCHCR0511P)

60 Lectures

1. Functional group test for nitro, amine and amide groups.
2. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols, carbonyl compounds and esters)

Course Outcome:

After this course students will be able to identify functional groups such as nitro, amine and amide, alcohols, carboxylic acids, phenols, carbonyl compounds and esters *etc.*

Reference Books:

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

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

CHEMISTRY PRACTICAL-C XII PHYSICAL CHEMISTRY V LAB

(PSCHCR0512P)

60 Lectures

UV/Visible spectroscopy

- I. Study the 200-500 nm absorbance spectra of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1} , kJ mol^{-1} , cm^{-1} , eV).
- II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $\text{K}_2\text{Cr}_2\text{O}_7$.
- III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Colourimetry

- I. Verify Lambert-Beer's law and determine the concentration of $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ in a solution of unknown concentration
- II. Determine the concentrations of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ in a mixture.
- III. Study the kinetics of iodination of propanone in acidic medium.
- IV. Determine the amount of iron present in a sample using 1,10-phenanthroline.
- V. Determine the dissociation constant of an indicator (phenolphthalein).
- VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
- VII. Analysis of the given vibration-rotation spectrum of HCl(g)

Course Outcome:

After this course students will be able to record & analyze spectra of compounds by UV/Visible spectroscopy and estimation of solute by colorimetric method.

Reference Books

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

Handwritten signatures and names:
A. K. Singh, DSS, Cham Anand, S. K. Singh, DSS



CHEMISTRY PRACTICAL-C XIII INORGANIC CHEMISTRY-IV (PSCHCR0613P)

LAB 60 Lectures

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

CO_3^{2-} , NO_2^- , S^{2-} , SO_3^{2-} , $\text{S}_2\text{O}_3^{2-}$, CH_3COO^- , F^- , Cl^- , Br^- , I^- , NO_3^- , BO_3^{3-} , $\text{C}_2\text{O}_4^{2-}$, PO_4^{3-} , NH_4^+ , K^+ , Pb^{2+} , Cu^{2+} , Cd^{2+} , Bi^{3+} , Sn^{2+} , Sb^{3+} , Fe^{3+} , Al^{3+} , Cr^{3+} , Zn^{2+} , Mn^{2+} , Co^{2+} , Ni^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , Mg^{2+}

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

Spot tests should be done whenever possible.

- Measurement of 10 Dq by spectrophotometric method
- Verification of spectrochemical series.
- Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.
- Preparation of acetylacetonato complexes of $\text{Cu}^{2+}/\text{Fe}^{3+}$. Find the λ_{max} of the complex.
- Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Course Outcome:

After this course students will be able to analyze cations, anions & radicals, and preparations of inorganic compounds & their spectral analysis.

Reference Books

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

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CHEMISTRY-C XIV: ORGANIC CHEMISTRY-V (PSCHCR0614L)

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Carbohydrates:

Introduction, monosaccharides, glycoside bond formation, mutarotation. Reactions of aldoses and ketoses (oxidation and reductions). Killiani synthesis, Osazone formation. Glucose-structure (including cyclic structure), Fructose (reactions only). Degradation of monosaccharides: Ruff degradation.

Heterocyclic Compounds: Synthesis and chemistry of furan, thiophene, pyrrole, indole, pyridines, isoquinoline and quinoline.

Chemistry of Natural Products:

A study of the following compounds involving their isolation, structure elucidation and synthesis: Alkaloids- Hofmann exhaustive methylation, nicotine; Terpenes- Isoprene rule, citral.

Organic Synthesis via enolates: Preparation of DEM and EAA. Synthesis of mono/dicarboxylic acid, diketones, uracil, barbituric acid using DEM/EAA: Mukhayama Aldol reactions and Michael reactions.

Photochemistry: Principles of photochemistry, photochemical reactions of carbonyl compounds and olefins.

¹H NMR Spectroscopy: NMR phenomenon, precessional motion, Chemical shift, Shielding and deshielding effects, Spin-spin splitting, Coupling constant, Interpretation of NMR spectra.

Course Outcome:

After completion of the course, the learner can be able to understand:

- Chemistry of carbohydrates, heterocyclic compounds & Chemistry of Natural Products.
- Synthesis, structures and characterizations of organic compounds.
- NMR Spectroscopy.

Books Recommended

1. "Chemical Applications of Group Theory" F. Albert Cotton, 3rd Edition 1993, Wiley-India.
2. "Environmental Chemistry", A. K. De, 3rd Edition (1994), Wiley Eastern, New Delhi.
3. "Analytical Chemistry", G. D. Christian, 4th Edition (1986), John Wiley & Sons, New York.
4. "Principles of Instrumental Analysis", D.A. Skoog, 5th Edition (1998), Saunders College Publishing, Philadelphia, London, New York.
5. "Basic Concepts of Analytical Chemistry", S. M. Khopkar, 2nd Edition (1998), New Age International Publications, New Delhi.

Handwritten signatures and names:
Dr. H. H. S. (Signature)
DSS (Signature)
Cham Arora (Signature)
S. G. S. (Signature)
D. S. (Signature)



6. "Instrumental Methods of Analysis", H. H. Willard, L. L. Merritt, and J. A. Dean, 6th Edition (1986), CBS Publishers & Distributors, Shahdara, Delhi.
7. "Organic Chemistry", I. L. Finar, [Vol. 2, 6th Edition (1973), Reprinted in 1980 & Vol. II, 5th Edition (1975), Reprinted in 1996], ELBS and Longman Ltd., New Delhi.

CHEMISTRY PRACTICAL-C XIV: ORGANIC CHEMISTRY-V LAB
(PSCHCR0614P)

60 Lectures

1. Preparation of organic dyes.
2. Preparation of organic compounds

Course Outcome:

After this course students will be able to prepare organic dyes & compounds.

Reference Books:

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

PRACTICALS- DSE-I LAB: ANALYTICAL METHODS IN CHEMISTRY
(PSCHDS0501P)

60 Lectures

I. Separation Techniques

1. Chromatography:
 - (a) Separation of mixtures
 - (i) Paper chromatographic separation of Fe^{3+} , Al^{3+} , and Cr^{3+} .

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DSS (signature)
Cham Akash (signature)
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- (ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.
- (b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their R_f values.
- (c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. Solvent Extractions:

- (i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+} -DMG complex in chloroform, and determine its concentration by spectrophotometry.
- (ii) Solvent extraction of zirconium with amberliti LA-1, separation from a mixture of irons and gallium.
- 3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.
- 4. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.
- 5. Analysis of soil:
 - (i) Determination of pH of soil.
 - (ii) Total soluble salt
 - (iii) Estimation of calcium, magnesium, phosphate, nitrate
- 6. Ion exchange:
 - (i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
 - (ii) Separation of metal ions from their binary mixture.
 - (iii) Separation of amino acids from organic acids by ion exchange chromatography.

III Spectrophotometry

- 1. Determination of pK_a values of indicator using spectrophotometry.
- 2. Structural characterization of compounds by infrared spectroscopy.
- 3. Determination of dissolved oxygen in water.
- 4. Determination of chemical oxygen demand (COD).
- 5. Determination of Biological oxygen demand (BOD).
- 6. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Course Outcome:

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Cham Arora
S. G. S. S.
B. G. S.



After this course students will be able to separate compounds by chromatographic techniques & solvent extraction, analyze soil and use of spectrophotometry techniques.

Reference Books:

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

PRACTICALS- DSE-II LAB-I: BIOCHEMISTRY CHEMISTRY LAB (PSCHDS0502P)

Identification and estimation of the following:

1. Carbohydrates – qualitative and quantitative.
2. Lipids – qualitative.
3. Proteins – qualitative.
4. Isolation of protein.
5. Determination of protein by the Biuret reaction.

Course Outcome:

After this course students will be able identify and estimate carbohydrates, lipids & proteins.

Reference Books:

1. T.G. Cooper: Tool of Biochemistry.
2. Keith Wilson and John Walker: Practical Biochemistry.
3. Alan H Gowenlock: Varley's Practical Clinical Biochemistry.
4. Thomas M. Devlin: Textbook of Biochemistry.
5. Jeremy M. Berg, John L Tymoczko, Lubert Stryer: Biochemistry.
6. G. P. Talwar and M Srivastava: Textbook of Biochemistry and Human Biology.
7. A.L. Lehninger: Biochemistry. O. Mikes, R.A. Chalmers: Laboratory Handbook of Chromatographic Methods

Handwritten signatures and names:
A. H. Talwar, S. S. Srivastava, Cham Arora, S. S. Srivastava, S. S. Srivastava



5. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).

**CHEMISTRY PRACTICAL - DSE LAB-III: NOVEL INORGANIC SOLIDS
(PSCHDS0603P)**

60 Lectures

1. Study of optical activity of chiral molecules
2. Synthesis of polymers: like Nylon (6,6)
3. Synthesis of hydrogel by co-precipitation method.
4. Synthesis of metal/metal oxide nanoparticles.

Course Outcome:

After this course students will be able optical properties of chiral molecules and synthesize Nylon (6,6), hydrogel & metal oxide nanoparticles.

Reference Book:

- Fahan, *Materials Chemistry*, Springer (2004).

CHEMISTRY-DSE-IV: POLYMER CHEMISTRY (PSCHDS0604L)

(Credits: Theory-06, Practicals-02)

Theory: 60 Lectures

Introduction and history of polymeric materials:

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.

Functionality and its importance:

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Cham Akash *S. S. S.* *Dr. H. H. S.*



Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi-functional systems, Poly-functional systems.

Kinetics of Polymerization:

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

Crystallization and crystallinity:

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

Nature and structure of polymers-Structure Property relationships.

Determination of molecular weight of polymers (M_n , M_w , etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance.

Polydispersity index.

Glass transition temperature (T_g) and determination of T_g . Free volume theory, WLF equation, Factors affecting glass transition temperature (T_g).

Polymer Solution – Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory-Huggins theory, Lower and Upper critical solution temperatures.

Properties of Polymers (Physical, thermal, Flow & Mechanical Properties).

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes,

Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

Course Outcome:

After completion of the course, the learner can be able to understand:

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D. S. S.



- ☐ The mechanism of polymer material formation.
- ☐ Molecular weight and structure property relationship
- ☐ Polymerization procedure and Ziegler-Natta catalysis.
- ☐ Characterization of polymers

Reference Books:

- ☐ Seymour's Polymer Chemistry, Marcel Dekker, Inc.
- ☐ G. Odian: Principles of Polymerization, John Wiley.
- ☐ F.W. Billmeyer: Text Book of Polymer Science, John Wiley.
- ☐ P. Ghosh: Polymer Science & Technology, Tata McGraw-Hill.
- ☐ R.W. Lenz: Organic Chemistry of Synthetic High Polymers.

**CHEMISTRY PRACTICAL - DSE LAB: POLYMER CHEMISTRY
(PSCHDS0604P)**

60 Lectures

1. Polymer synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
 - a. Purification of monomer
 - b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bis-isobutyronitrile (AIBN)
2. Preparation of nylon 66/6
 1. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
 - a. Preparation of IPC
 - b. Purification of IPC
 - c. Interfacial polymerization
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resold resin.
7. Microscale Emulsion Polymerization of Poly(methylacrylate).

Polymer characterization

1. Determination of molecular weight by viscometry:
 - (a) Polyacrylamide-aq. NaNO₂ solution
 - (b) (Poly vinyl propylidene (PVP) in water

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Cham Akash *S. G. S.* *Pragn*



2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).
4. Testing of mechanical properties of polymers.
5. Determination of hydroxyl number of a polymer using colorimetric method.

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Instrumental Techniques
3. IR studies of polymers
4. DSC analysis of polymers
5. Preparation of polyacrylamide and its electrophoresis

Course Outcome:

After this course students will be able to synthesize, characterize & analyze different types of polymers.

Reference Books:

- Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed.
- Harry R. Allcock, Frederick W. Lampe and James E. Mark, Contemporary Polymer Chemistry, 3rd ed. Prentice-Hall (2003)
- Fred W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)
- Joel R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
- Petr Munk and Tejraj M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002)
- L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
- Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd ed. Oxford University Press (2005)
- Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

PRACTICAL-DSE V LAB: APPLICATIONS OF COMPUTERS IN CHEMISTRY (PSCHDS0605P)

60 Lectures

Computer programs based on numerical methods for:

1. Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).

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Dr. S.



3. Numerical integration (e.g. entropy/ enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values.
4. Matrix operations. Application of Gauss-Siedel method in colourimetry.
5. Simple exercises using molecular visualization software.

Course Outcome:

After this course students will be able to learn computer programs based on numerical methods.

Reference Books:

- McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books (2008).
- Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
- Steiner, E. The Chemical Maths Book Oxford University Press (1996).
- Yates, P. Chemical Calculations. 2nd Ed. CRC Press (2007).
- Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
- Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487 pages.
- Noggle, J. H. Physical Chemistry on a Microcomputer. Little Brown & Co. (1985).
- Venit, S.M. Programming in BASIC: Problem solving with structure and style. Jaico Publishing House: Delhi (1996).

**CHEMISTRY PRACTICAL - DSE - VII LAB: GREEN CHEMISTRY
(PSCHDS0607P)**

1. Safer starting materials

Preparation and characterization of nano particles of gold using tea leaves.

2. Using renewable resources

Preparation and characterization of biodiesel from vegetable oil/ waste cooking oil

3. Use of enzymes as catalysts

Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide

4. Alternative sources of energy

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

5. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Course Outcome:

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Dr. S. S.

Cham Akash

S. S. S. S.

Dr. S. S.



After this course students will be able to learn safer starting materials, using renewable resources, use of enzymes & alternate sources of energy.

Reference Books:

1. Anastas, P.T and Warner, J.C. *Green Chemistry: Theory and Practice*, Oxford University Press, 1998
2. Kirchoff, M. and Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC, 2002
3. Ryan, M.A. *Introduction to Green Chemistry*, Tinneland; (Ed), American Chemical Society, Washington DC, 2002
4. Sharma, R.K.; Sidhwani, I.T. and Chaudhari, M.K. *Green Chemistry Experiments: A monograph*, I.K. International Publishing House Pvt Ltd. New Delhi, Bangalore ISBN 978-93-81141-55-7, 2013
5. Cann, M.C. and Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society, 2008
6. Cann, M. C. and Thomas, P. *Real world cases in Green Chemistry*, American Chemical Society, 2008
7. Lancaster, Mike *Green Chemistry: An introductory text. 2nd Ed.* RSC publishing, ISBN 978-1-84755-873-2
8. Pavia, D.L., Kriz, G.S., Lampman, G.M. and Engels, R.G. *Introduction to Organic Laboratory Techniques – a Microscale Approach 4th Ed.*, Brooks-Cole Laboratory Series for Organic Chemistry, 2006

SKILL ENHANCEMENT COURSE

SEC-1: BASIC ANALYTICAL CHEMISTRY

(Theory 02 Credits; Practicals 02 Credits)

Total 30 Lectures

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

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

- Determination of pH of soil samples.
- Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

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

- Determination of pH, acidity and alkalinity of a water sample.
- Determination of dissolved oxygen (DO) of a water sample.

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

- Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
- Analysis of preservatives and colouring matter.

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

- Paper chromatographic separation of mixture of metal ion (Fe^{3+} and Al^{3+}).
- To compare paint samples by TLC method.

Ion-exchange: Column, ion-exchange chromatography etc.

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

Analysis of cosmetics: Major and minor constituents and their function

- Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.
- Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

Suggested Applications (Any one):

- To study the use of phenolphthalein in trap cases.
- To analyze arson accelerants.
- To carry out analysis of gasoline.

Suggested Instrumental demonstrations:

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- Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.
- Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
- Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink.

Course Outcome:

After this course students will be able to understand analysis of soil, water, cosmetics & food products, chromatographic techniques.

Reference Books:

- Willard, H. H. *Instrumental Methods of Analysis*, CBS Publishers.
- Skoog & Lerry. *Instrumental Methods of Analysis*, Saunders College Publications, New York.
- Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry* 6th Ed., Saunders College Publishing, Fort Worth (1992).
- Harris, D. C. *Quantitative Chemical Analysis*, W. H. Freeman.
- Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.
- Day, R. A. & Underwood, A. L. *Quantitative Analysis*, Prentice Hall of India.
- Freifelder, D. *Physical Biochemistry* 2nd Ed., W.H. Freeman and Co., N.Y. USA (1982).
- Cooper, T.G. *The Tools of Biochemistry*, John Wiley and Sons, N.Y. USA. 16 (1977).
- Vogel, A. I. *Vogel's Qualitative Inorganic Analysis* 7th Ed., Prentice Hall.
- Vogel, A. I. *Vogel's Quantitative Chemical Analysis* 6th Ed., Prentice Hall.
- Robinson, J.W. *Undergraduate Instrumental Analysis* 5th Ed., Marcel Dekker, Inc., New York (1995).

SEC-3: GREEN METHODS IN CHEMISTRY

(Theory 02 Credits; Practicals 02 Credits)
Total 30 Lectures

Tools of Green chemistry, Twelve principles of Green Chemistry, with examples.

The following Real world Cases in Green Chemistry should be discussed:

- A green synthesis of ibuprofen which creates less waste and fewer byproducts (Atom economy).
- Surfactants for Carbon Dioxide – replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments.

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- 3 Environmentally safe antifoulant.
- 4 CO₂ as an environmentally friendly blowing agent for the polystyrene foam sheet packaging market.
- 5 Using a catalyst to improve the delignifying (bleaching) activity of hydrogen peroxide.
- 6 A new generation of environmentally advanced preservative: getting the chromium and arsenic out of pressure treated wood.
- 7 Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments.
- 8 Development of a fully recyclable carpet: cradle to cradle carpeting.

PRACTICALS

1. Preparation and characterization of biodiesel from vegetable oil.
2. Extraction of D-limonene from orange peel using liquid CO₂ prepared from dry ice.
3. Mechanochemical solvent free synthesis of azomethine.
4. Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II)

Course Outcome:

After completion of the course, the learner shall be able to understand:

- Green chemistry and its principles.
- Green synthesis and reactions.
- Green chemistry for sustainable solutions.
- Understanding design of chemical reactions/chemical synthesis using green chemistry principles.
- Atom economy and design of chemical reactions using the principle.
- Understanding the use of green chemistry principle and processes in laboratory reactions.

Reference Books:

1. Manahan S.E. (2005) Environmental Chemistry, CRC Press
2. Miller, G.T. (2006) Environmental Science 11th edition. Brooks/Cole
3. Mishra, A. (2005) Environmental Studies. Selective and Scientific Books, New

SEC-4: PHARMACEUTICAL CHEMISTRY

(Theory 02 Credits; Practicals 02 Credits)

Total 30 Lectures

Drugs & Pharmaceuticals

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, Ibuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents

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(Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glycerol trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Fermentation

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

Practicals

1. Preparation of Aspirin and its analysis.
2. Preparation of magnesium bisilicate (Antacid).

Course Outcome:

Students will be well versed with biologically active molecules, details of fermentation process & preparations of few drugs.

Reference Books:

- G.L. Patrick: Introduction to *Medicinal Chemistry*, Oxford University Press, UK.
- Hakishan, V.K. Kapoor: *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan, Pitampura, New Delhi.
- William O. Foye, Thomas L., Lemke, David A. William: *Principles of Medicinal Chemistry*, B.I. Waverly Pvt. Ltd. New Delhi.

SEC-5: CHEMISTRY OF COSMETICS & PERFUMES

(Theory 02 Credits; Practicals 02 Credits)
Total 30 Lectures

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

Practicals

1. Preparation of talcum powder.
2. Preparation of shampoo.
3. Preparation of enamels.
4. Preparation of hair remover.
5. Preparation of face cream.
6. Preparation of nail polish and nail polish remover.

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Course Outcome:

Students will be well versed with chemistry of cosmetics & perfumes & preparations of few cosmetic products.

Reference Books:

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

SEC-6: PESTICIDE CHEMISTRY

(Theory 02 Credits; Practicals 02 Credits)
Total 60 Lectures

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

Practicals

- 1 To calculate acidity/alkalinity in given sample of pesticide formulations as per BIS specifications.
- 2 Preparation of simple organophosphates, phosphonates and thiophosphates

Course Outcome:

Students will be well versed with chemistry of pesticides & preparations of few pesticides.

Reference Book:

- R. Cremlyn: *Pesticides*, John Wiley.

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Cham Akash *S. G. S.* *Shree*



Outcomes of teaching -learning:

Students will learn about the structure and characterizations of different types of materials such as Semiconductors, Organic and Non linear materials.

Books recommended:

1. A.R. West, *Solid State Chemistry and its Applications*, John Wiley & Sons, Singapore (1984)
2. C.N R. Rao and J. Gopalkrishnan, *New Directions in Solid State Chemistry*, Cambridge Univ. Press (1997).
3. T. V. Ramakrishnan and C.N. Rao, *Superconductivity Today*, Wiley Eastern Ltd., New Delhi (1992).
4. P. Ball, *Designing the Molecular World: Chemistry at the Frontier*, Princeton Univ. Press, (1994).

CMP-409: Projects

Credits : 6

Topic selection in consultation with the teacher; literature search from different reference books, scientific journals and using internet search; Bench work, typed write-up with proper tables, structures, figures and literature to be submitted; seminar lecture on this topic to be delivered in presence of all the teachers.

Teaching and Learning: The term courses also include a dissertation a research-based thesis project enhancing the students understanding.

Outcomes of learning:

- formulating and solving problems in the laboratory
- The principles and applications of modern chemical instrumentation, experimental design, and data analysis
- the underlying chemical and physical of instrumental methods of analysis, searching scientific journals and using internet search etc.
- how to work with others as part of a team to solve scientific problems
- how to communicate scientific information clearly and accurately, both in oral and in written forms
- the composition of written laboratory reports that summarize experimental procedures and the accurately present and interpret data