Shri Vile Parle Kelavani Mandal's

MITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE & AMRUTBEN JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS (AUTONOMOUS)

NAAC Reaccredited 'A' grade, CGPA: 3.57 (February 2016),

Granted under RUSA, FIST-DST & -Star College Scheme of DBT, Government of India,

Best College (2016-17), University of Mumbai

Affiliated to the

UNIVERSITY OF MUMBAI

Program: M. Sc. Physical Chemistry

Course: Polymer, Surface and Photo chemistry

Semester- III

Choice Based Credit System (CBCS) with effect from the Academic year 2020-21

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the MSc Physical Chemistry, the learners should be enriched with knowledge and be able to-

PSO1: Understand Polymerization techniques, polymer technologies, methods for analysis of polymeric materials, properties of polymers in solid state and in solution.
PSO2: Explore physical chemistry of biomolecules.
PSO3: Understand the concept of statistical mechanics and nuclear chemistry
PSO4: Explain the mechanism of photochemical reactions.
PSO5: Comprehend various aspect of material chemistry and their applications
PSO6: Use and interpret atomic and molecular spectroscopy.
PSO7: Perceive various aspects of nanotechnology and their applications
PSO8: Understand principle and applications of laser technology
PSO9: Recognize the applications of advanced analytical techniques for characterization
PSO10: Understand various terms and process of research.

Preamble

Students should have basic understanding in topics like Polymer Chemistry, Adsorption and Surface Chemistry, Photo Chemistry

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

a) Details of Continuous Assessment (CA)
25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	Written Test	15 marks
Component 2 (CA-2)	Assignment	10 marks

b) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	**Description**	**Marks**	**Total Marks**
Q1	Attempt Any three of the following. (3 out of 4 from Module 1)	5 X 3	15
Q2	Attempt Any three of the following. (3 out of 4 from Module 2)	5 X 3	15
Q3	Attempt Any three of the following. (3 out of 4 from Module 3)	5 X 3	15
Q4	Attempt Any three of the following. (3 out of 4 from Module 4)	5 X 3	15
Q5	Attempt Any five of the following. (5 out of 8 from Module 1 to 4)	3 X 5	15
		Total Marks	**75**

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HOD Approved by Vice –Principal Approved by Principal

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: MSc (Physical Chemistry)				**Semester : III**	
Course: Polymer, Surface and Photo chemistry				**Course Code:PSMACHP301**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	4	Nil	4+2	15+10	75

Learning Objectives:

The course provides the understanding of basics of classification of polymers, methods of determination of molecular weights of polymers and types of polymerization with kinetics. Further, it helps the students to know the modern applications of surface chemistry: Surface active agents, Micelles and emulsions. The students will be introduced to the Photochemical principles and reactions, photophysical process in electronically excited molecules. The students will be allowed to explore the applications of fluorescence phenomena such as Fluorescence sensing with mechanism, uses of novel fluorophores, radiative decay engineering and DNA technology.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Different ways of classification of polymers, how to determine the molecular weight of a polymer and various types of polymerizations.

CO2: The applications of surface-active agents, micelles, emulsions.

CO3: Principle of photochemical reaction with examples including natural and synthetic routes as well as photo physical processes in electronically excited molecules

CO4: Get acquainted with the applications of fluorescence phenomena such as fluorescence sensing with mechanism, uses of novel fluorophores, radiative decay engineering and DNA technology.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Polymer Chemistry I**	15
2	**Modern Applications of surface Chemistry**	15
3	**Photochemistry- I**	15
4	**Application of fluorescence Phenomenon**	15
	Total	**60**

PRACTICALS	

Unit	**Topic**	**No. of Hours/Credits**
Module 1	**Polymer Chemistry I**	**15**
	1.1 Introduction: Polymer Science, fundamental terms, historical outline, classification based on: the origin (natural, semi-synthetic, synthetic etc.),the structure (linear, branched, network, hyper branched, dendrimer, ladder, cross linked, IPN),the type of atom in the main chain (homochain, heterochain), the formation (condensation, addition), homopolymers, copolymers (random, alternate, block, graft),the behavior on application of heat (thermoplastic and thermosetting), the form and application (plastics, fibre, elastomers and resins). **(5L)** **1.2 Molar Mass**: Molecular weight averages, fractionation, molecular weight determination by GPC/SEC,end group analysis, viscometry, vapour phase osmometry, gradient elution, and molecular weight distribution curve**. (5L)** **1.3 Types of polymerization**: condensation, addition (cationic and anionic) and copolymerization (with kinetics), chain transfer reactions. **(5L)**	
Module 2	**Modern Applications of Surface Chemistry**	**15**
	2.1 Surface active agents and micelle **2.1.1. Surface active agents** and their classification, hydrophile-lipophile balance **(2L)** **2.1.2. Micellization**: shape and structure of micelles , hydrophobic interaction, critical Micelles concentration (cmc), factors affecting cmc of surfactants, counter ion binding to micelles, micelle catalysis, reverse micelles.**(4L)**	

	2.1.3. Emulsions: Solubilization, micro emulsions, characterization of micro emulsions (**2L)** **2.2 Hydrogen storage by Adsorption:** **2.2.1 Hydrogen storage**: fundamentals physisorption, temperature and pressure influence,chemisorption,adsorptionenergy,'Electrochemical'adsorption. **(3L)** **2.2.2. Practical adsorption**: storage of hydrogen with carbon materials, activated carbon, graphite graphene, carbon nano structures, fullerene. Carbon nano fibres(CNF) and graphite nano fibers electrochemical storage of hydrogen in carbon materials. **(4L)**	
Module 3	**Photo Chemistry- I**	**15**
	3.1 Photochemical principles: Environmental effect on absorption and emission spectra, properties of excited states, excited state acidity constants, dipole moments and redox properties, Importance of photochemistry, origin of life. **(4L)** **3.2 Photo physical processes in electronically excited molecules:** Types of photo physical pathways, types of radiation less transitions, fluorescence emission, fluorescence and structure. Triplet state and phosphorescence emission, delayed fluorescence–e type and p-type delayed fluorescence. **(6L)** **3.3 Photochemical reactions:** Ketones, olefins conjugated olefins and aromatic compounds, photosynthesis.**(5L)**	
Module 4	**Applications of Fluorescence Phenomena**	**15**
	4.1 Fluorescence sensing: Mechanism of sensing; sensing techniques based on Coalitional quenching, energy transfer, electron transfer; examples of pH sensors glucose sensors and protein sensors. **(5L)** **4.2 Novel fluorophores**: Quantum dots, lanthanides and long-lifetime Metal- ligand complexes. **(5L)** **4.3 Radioactive decay engineering**: metal enhanced fluorescence	

	(3L) **DNA technology:** sequencing. **(2L)**	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

PRACTICAL I

1. To determine the mean ionic activity coefficient of zinc chloride by emf method.
2. To construct the phase diagram for a two component system forming a simple eutectic.
3. To study the phase rule system for three pair partially miscible solution.
4. To determine the equilibrium constant for the reaction

$CaSO_{4(s)} + 2Ag^{+1}_{(aq)} = Ag_2SO_{4(s)} + Ca^{+2}_{(aq)}$

To determine the partial molar volume of ethanol.

Suggested Readings

Text Books:

Unit I and Unit II:

1. Ludovico, Cademartiri and Geoffrey A.Ozin, Concepts of Nanochemistry, Wiley– VCH Verlag GmbH & co, 2009
2. C. Bréchignac, P. Houdy, Marcel Lahmani, Nanomaterials and Nanochemistry, Springer,2007
3. C.N.R.Rao, AchimMüller, Anthony K. Cheetham, Nanomaterials Chemistry,
4. John Wiley & Sons, 2007
5. Geoffrey A. Ozin, André C. Arsenault, Ludovico Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry (Great Britain) 2, illustrated, Royal Society of Chemistry, 2009

Unit III:

1. AtkinsP.W, Physical Chemistry, Oxford University Press, 6thedition, 1998.
2. John M. Seddon & Julian D. Gale, Thermodynamics and statistical mechanics, Tutorial Chemistry Text series, Vol 10, Royal society of Chemistry, 2001.
3. Silbey R J &Alberty R A, Physical Chemistry, 3rd edition, John Wiley and sons, Inc.2002.
4. Laidler K.J. and Meiser J.H., Physical Chemistry, 2ndedition, CBS publishers &distributors, 1999.

5. B. K. Agarwal and M. Eisner, Statistical Mechanics,(1988) Wiley Eastern, New Delhi.

6. D. A. McQuarrie, Statistical mechanics (1976) Harper and Row Publishers, New *York.*

Unit IV:

1. G.Friedlander,J.W. Kennedy. Nuclear and Radio chemistry. John Wiley and sons,, 1981.
2. H. J. Arnikar, Essentials of Nuclear Chemistry. Wiley Eastern Ltd. 1989.

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UNIVERSITY OF MUMBAI

Program: M. Sc. Physical Chemistry

Course: : Nano chemistry, Statistical mechanics & Nuclear chemistry

Semester- III

Choice Based Credit System (CBCS) with effect from the Academic year 2020-21

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the MSc Physical Chemistry, the learners should be enriched with knowledge and be able to-

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PSO6: Use and interpret atomic and molecular spectroscopy.
PSO7: Perceive various aspects of nanotechnology and their applications
PSO8: Understand principle and applications of laser technology
PSO9: Recognize the applications of advanced analytical techniques for characterization
PSO10: Understand various terms and process of research.

Preamble

Students should have basic understanding in topics like Nuclear Chemistry, Nanotechnology and Thermodynamics.

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

c) Details of Continuous Assessment (CA)
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Continuous Assessment	Details	Marks
Component 1 (CA-1)	Written Test	15 marks
Component 2 (CA-2)	Assignment	10 marks

d) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	**Description**	**Marks**	**Total Marks**
Q1	Attempt Any three of the following. (3 out of 4 from Module 1)	5 X 3	15
Q2	Attempt Any three of the following. (3 out of 4 from Module 2)	5 X 3	15
Q3	Attempt Any three of the following. (3 out of 4 from Module 3)	5 X 3	15
Q4	Attempt Any three of the following. (3 out of 4 from Module 4)	5 X 3	15
Q5	Attempt Any five of the following. (5 out of 8 from Module 1 to 4)	3 X 5	15
		Total Marks	**75**

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Program: MSc (Physical Chemistry)				**Semester : III**	
Course : Nano chemistry, Statistical mechanics & Nuclear chemistry				**Course Code:PSMACHP302**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	4	Nil	4+2	15+10	75

Learning Objectives:

The students will be provided the knowledge of nano chemistry of gold, cadmium selenide, silica and poly dimethyl siloxane. In Statistical Mechanics, the students will be introduced to thermodynamic probability, partition functions, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics as well as to Debye and Einstein theory of specific heats of solids. The students will be introduced to different charged particle accelerators, nuclear forces, nuclear models and applications of nuclear radiations including radio-immune assay.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: The students will be able to correlate the variation in optical and magnetic properties of gold, cadmium, selenium, silica and poly dimethyl siloxane nano particles with their sizes and shapes.

CO2: They would be able to get to know how are diagnoses and treatments of diseases done using nano particles as well as what are the safety measures and ethics to be followed while using nano particles.

CO3: In statistical mechanics, the students get the introduction of thermodynamic probability, partition function as well as Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics and further they would get to know Debye and Einstein theory of specific heats of solids.

CO4: The students would get to know the construction and functioning of different accelerators. They would be acquainted with the characteristics of nuclear forces and nuclear models, further they would get the introduction of different applications of nuclear radiations and radioimmunoassay

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Nano chemistry of gold, cadmium selenide**	15

2	**Nano chemistry of Silica and poly dimethyl siloxane**	15
3	**Statistical mechanics**	15
4	**Nuclear Chemistry**	15
	Total	**60**
PRACTICALS		

Module	**Topic**	**No. of Hours/Credits**
Module 1	**Nano chemistry of gold, cadmium selenide.**	**15**
	1.1 Variation of optical and magnetic properties of non-material with size, shape, surface characteristics and impurities **(4L)** **1.2** Relationship between size and shape of nano materials **(3L)** **1.3** Nano architecture: self-assembly and template methods **(3L)** **1.4** Diagnosis and treatment of diseases using nano particles **(3L)** **1.5** Safety and ethics of use of nano particles **(2L)**	
Module 2	**Nano chemistry of silica and poly dimethyl siloxane:**	**15**
	2.1 Variation of optical and magnetic properties of nano materials with size, shape, surface characteristics and impurities **(4L)** **2.2** Relationship between size and shape of nanomaterials. **(3L)** **2.3** Nano architecture: self-assembly and template methods. **(4L)** **2.4** Diagnosis and treatment of diseases using nanoparticles **(4L)**	
Module 3	**Statistical Mechanics**	**15**
	3.1Thermodynamic probability: Combinatral problems, Strilling approximation, Lagrange's method, macro and micro states, ensembles, Boltzmann distribution law. **(3L)** **3.2 Partition functions:** Translational, rotational, vibrational, electronic and nuclear partition functions, Expressions for thermodynamic functions in terms of partition function-Internal energy, heat capacity, the Helmholtz and Gibbs functions, Enthalpy, entropy and equilibrium constants. Sackur –Tetrode equation for the entropy of a mono atomic gas. Molecular partition function.**(7L)**	

	3.3 Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. **(3L)** **3.4** Debye and Einstein theory of specific heats of solids. **(2L)**	
Module 4	**Nuclear Chemistry**	**15**
	4.1Charged particle accelerator- linear accelerator, cyclotron, Betatron, Synchro-cyclotron, synchrotron. **(4L)** **4.2Nuclearforces**- characteristicsandMesonfieldtheoryofnuclearforces **(2L)** **4.3Nuclear Models**- Liquid drop model, Fermi Gas Model, Shell Model, Collective Model, Optical Model. **(4L)** **4.4Applications of Nuclear radiations**-geological applications of radioactivity, age of minerals and rocks, age of earth and solar system, medical, industrial and agricultural applications of radiochemistry, positron emission tomography, Radioimmune assay.**(5L)**	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

PRACTICAL II

1. To determine the mean ionic activity coefficient of zinc chloride by emf method.
2. To construct the phase diagram for a two component system forming a simple eutectic.
3. To study the phase rule system for three pair partially miscible solution.
4. To determine the equilibrium constant for the reaction

   $CaSO_{4(s)} + 2Ag^{+1}_{(aq)} = Ag_2SO_{4(s)} + Ca^{+2}_{(aq)}$
5. To determine the partial molar volume of ethanol.

Suggested Readings

Text Books:

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5. Geoffrey A. Ozin, André C. Arsenault, Ludovico Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry (Great Britain) 2, illustrated, Royal Society of Chemistry, 2009

Unit III:

7. AtkinsP.W, Physical Chemistry, Oxford University Press, 6thedition, 1998.
8. John M. Seddon & Julian D. Gale, Thermodynamics and statistical mechanics, Tutorial Chemistry Text series, Vol 10, Royal society of Chemistry, 2001.
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Program: M. Sc. Physical Chemistry

Course: Atomic and Molecular Structure and Spectroscopy

Semester- III

Choice Based Credit System (CBCS) with effect from the Academic year 2020-21

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the MSc Physical Chemistry, the learners should be enriched with knowledge and be able to-

PSO1: Understand Polymerization techniques, polymer technologies, methods for analysis of polymeric materials, properties of polymers in solid state and in solution.
PSO2: Explore physical chemistry of biomolecules.
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PSO4: Explain the mechanism of photochemical reactions.
PSO5: Comprehend various aspect of material chemistry and their applications
PSO6: Use and interpret atomic and molecular spectroscopy.
PSO7: Perceive various aspects of nanotechnology and their applications
PSO8: Understand principle and applications of laser technology
PSO9: Recognize the applications of advanced analytical techniques for characterization
PSO10: Understand various terms and process of research.

Preamble

Students should have basic understanding ofatomic structure and spectroscopy.

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

e) Details of Continuous Assessment (CA)

25% of the total marks per course:

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Component 2 (CA-2)	Assignment	10 marks

f) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

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Question Number	**Description**	**Marks**	**Total Marks**
Q1	Attempt Any three of the following. (3 out of 4 from Module 1)	5 X 3	15
Q2	Attempt Any three of the following. (3 out of 4 from Module 2)	5 X 3	15
Q3	Attempt Any three of the following. (3 out of 4 from Module 3)	5 X 3	15
Q4	Attempt Any three of the following. (3 out of 4 from Module 4)	5 X 3	15
Q5	Attempt Any five of the following. (5 out of 8 from Module 1 to 4)	3 X 5	15
		Total Marks	**75**

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SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: MSc (Physical Chemistry)				**Semester : III**	
Course :Atomic and Molecular Structure and Spectroscopy				**Course Code:PSMACHP303**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	4	Nil	4+2	15+10	75

Learning Objectives:

To introduce the students with thorough understanding of the basic principles behind the theories of atomic structure of multi-electron atoms and molecular structure, and their manifestation in understanding atomic and molecular spectroscopy.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: The student would know, in detail, the theories and their applications to the ground state of helium atom as well as to multi-electron systems.

CO2: The students would be able to correlate the atomic structure and various atomic spectral observations.

CO3: The students would be able to apply the principles and/or theories and/or models to get the theoretical basis for the formation of simple tri, tetra and penta-atomic molecules.

CO4: The students would be able to correlate the molecular structure and various spectral observations in molecular and Raman spectroscopy as well as electronic spectra of molecules.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Atomic structure**	15
2	**Atomic spectroscopy**	15
3	**Molecular structure**	15
4	**Molecular spectroscopy**	15
	Total	**60**
PRACTICALS		

Unit	**Topic**	**No. of Hours/Credits**

Module 1	**Atomic structure**	**15**
	1.1 Introduction to approximate methods in Quantum Mechanics- Variation Theorem, linear and nonlinear variation functions, Perturbation Theory, Non degenerate Perturbation Theory, first order wave function correction, first order and second order energy correction. Application of variation and perturbation theory to ground state of Helium Atom. **(9L)** **1.2.Multi –electron atoms:** Anti symmetry and Pauli principle, Slater determinants, Hartree. –Fock and configuration interaction wave functions, Slater type orbitals, Gaussian orbitals, orbitals plots, Basis sets. Density functional theory**.** **(6L)**	
Module 2	**Atomic spectroscopy**	**15**
	2.1. Angular momentum, orbital and spin, total angular momentum, total angular momentum(J) of many electron atoms, Russell Saunders(L-S) coupling and J-J coupling **(4L)** 2.2. Term symbols, term symbols for multi electron atoms like He, Li, Be, B etc **(4L)** 2.3. Exchange of interactions and multiplicity of states. **(2L)** 2.4. Anomalous Zeeman Effect and Paschen Back effect. **(2L)** 2.5. Atomic spectra and selection rules, energy level diagram of atomic sodium. **(3L)**	
Module 3	**Molecular Structure**	**15**
	3.1 The Born–Oppenheimer approximation **(1L)** **3.2** LCAO method-molecular orbital formation **(1L)** **3.3** Calculation of energy of hydrogen molecule ion using Valence bond method, Heitler-London treatment and Improvements in Heitler-London treatment **(5L)** **3.4** Electronic structure of polyatomic molecules: Valence bond method for BeH_2, H_2O, NH_3,BH_3,CH_4. Huckel molecular orbital's Theory for–ethylene, Allyl system, cyclopropenyl system. and cyclobutadiene. **(8L)**	
Module 4	**Molecular spectroscopy**	**15**
	4.1Rotational spectroscopy: Einstein coefficients, classificationof polyatomic	

	Molecules spherical top, symmetric top and asymmetric top molecules, rotational spectra of polyatomic molecules Stark modulated microwave spectrometer**. (3L)** **4.2 Raman Spectroscopy:** Classical theory of molecular polarizability, pure rotational, vibrational and vibration-rotation spectra of diatomic and polyatomic molecules polarization and depolarization of Raman lines correlation between IR and Raman spectroscopy instrumentation. **(5L)** **4.3 Electronic Spectra of molecules:** Term symbols for linear molecules, selection rules characteristics of electronic transitions-Franck-Condon principle, types of electronic transitions-d-d, vibronic, charge transfer, π-π^*,n-π^*transitions, fate of electronically excited states, fluorescence ,phosphorescence, dissociation and pre-dissociation. **(7L)**	

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PRACTICAL III

1. Determination of the energy of activation and other thermodynamic parameters of activation for the acid catalyzed hydrolysis of methyl acetate.
2. To determine the proton ligand stability constant of an organic acid and metal ligand stability constant of its complex by pH measurement.
3. To determine the molar conductance of a weak electrolyte at infinite dilution hence to determine its dissociation constant.
4. To titrate potassium ferrocyanide with zinc sulphate and hence to determine the formula of the complex.
5. To determine the E^0 of the quinhydrone electrode.
6. To determine the formula of the zinc(II)ferrocyanide complex by titration of Zn(II) sulphate with potassiumferrocyanide.
7. To estimate the amount of hydrochloric acid and acetic acid in a mixture by titration with an alkali using a pH meter.
8. To determine hydrolysis constant and degree of hydrolysis of ammonium chloride and hence to estimate the dissociation constant of the base.

Suggested Readings

Text Books:

Unit I, II and III:

1. Laidlerand Miser, Physical Chemistry,2nd edition, CBS publishers, New Delhi. (chapters11-14)
2. SilbeyandAlberty,Physical Chemistry,3rd edition, John Wiley andsons, 2000.(Part two quantum chemistry)
3. Atkins P. W, Physical Chemistry, Oxford University Press, 6thedition, 1998.
4. William Kemp, Organic spectroscopy, 3rdEdition, ELBS, 1996.
5. I.N.LevineQuantumChemistry,5Delhi.
6. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, (1998) Viva Books, New Delhi.
7. J.N.Murrell, S. F. A. Kettle and J. M. Tedder, Valence Theory, 2 (1965), John Viley, New York.

A. K. Chandra, Introductory Quantum Chemistry, 4 McGraw Hill, New Delhi

8. D. A. McQuarrie, Quantum Chemistry, Viva Books Private Limited, New Delhi, first Indian ed., 2003.
9. R. K. Prasad, Quantum Chemistry, 3rd Ed., New Age International Publishers, 2006.
10. James E. House, Fundamentals of Quantum Chemistry, Second Ed., Academic Press, 2005.
11. T. A. Little field and N. Thorley, Atomic and Nuclear Physics – An Introduction, Van Nostrand, 1979.

Unit IV:

1. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Ed., Tata-McGraw-Hill, 1994.
2. M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers, 2001.
3. H. S. Randhawa, Modern Molecular Spectroscopy, McMillan India Ltd., 2003
4. G. Aruldas, Molecular Structure and Spectroscopy, Prentice-Hall of India, 2001.

List of Books for further reading:

1. R. Drago, Physical Methods for Chemists, Saunders, Philadelphia, 1992.
2. B. P. Straughanand S. Walker (Eds.), Spectroscopy–Vol1-3, Chapman and Hall, NewYork, 1976.
3. R. K. Harris, Nuclear Magnetic Resonance Spectroscopy, Pitman, London, 1983.
4. Donald L. Pavia, Gary M. Lampman and George S. Kriz, Introduction to Spectroscopy, 3rd ed., Thomson, Brooks/Cole, 2001.
5. John P. Lowe, Quantum Chemistry, 3rded., Academic Press, NewYork, 2006.
6. R. Anantharaman, Fundamentals of Quantum Chemistry, McMillan India Limited, 2001.
7. MahendraR. Awode, Quantum Chemistry, S. Chand and Co. Ltd., New Delhi, 2002.
8. David O. Hayward, Quantum Mechanics for Chemists, Royal Society for Chemistry, 2002.
9. Jack Simons, An Introduction to Theoretical Chemistry, Cambridge University Press, 2003.
10. Victor M. S. Gil, Orbitals in Chemistry, A Modern Guide to Students, Cambridge University Press, 2000.
11. K. Chandra, Introduction to Quantum Chemistry, 4th Ed., Tata-McGraw-Hill,1994.
12. S .N. Datta, Lectures on Chemical Bonding and Quantum Chemistry, Prism Books Pvt. Ltd., 1998.
13. F.A.Cotton, Chemical Applications of Group Theory, 3rdEd., John Wiley and Sons (Asia) Pte. Ltm, 1999.
14. D. C. Harris and M. D. Bertolucci, Symmetry and Spectroscopy, Oxford University.

Shri Vile Parle Kelavani Mandal's

[ITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE & AMRUTBE JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS (AUTONOMOUS)

NAAC Reaccredited 'A' grade, CGPA: 3.57 (February 2016),

Granted under RUSA, FIST-DST & -Star College Scheme of DBT, Government of India,

Best College (2016-17), University of Mumbai

Affiliated to the

UNIVERSITY OF MUMBAI

Program: M. Sc. Physical Chemistry

Course:Advanced Instrumental techniques

Semester- III

Choice Based Credit System (CBCS) with effect from the Academic year 2020-21

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the MSc Physical Chemistry, the learners should be enriched with knowledge and be able to-

PSO1: Understand Polymerization techniques, polymer technologies, methods for analysis of polymeric materials, properties of polymers in solid state and in solution.
PSO2: Explore physical chemistry of biomolecules.
PSO3: Understand the concept of statistical mechanics and nuclear chemistry
PSO4: Explain the mechanism of photochemical reactions.
PSO5: Comprehend various aspect of material chemistry and their applications
PSO6: Use and interpret atomic and molecular spectroscopy.
PSO7: Perceive various aspects of nanotechnology and their applications
PSO8: Understand principle and applications of laser technology
PSO9: Recognize the applications of advanced analytical techniques for characterization
PSO10: Understand various terms and process of research.

Preamble

Students should have basic knowledge of spectroscopic techniques, Chromatographic techniques and electroanalytical techniques.

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

g) Details of Continuous Assessment (CA)

25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	Written Test	15 marks
Component 2 (CA-2)	Assignment	10 marks

h) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	Description	Marks	Total Marks
Q1	Attempt Any three of the following. (3 out of 4 from Module 1)	5 X 3	15
Q2	Attempt Any three of the following. (3 out of 4 from Module 2)	5 X 3	15
Q3	Attempt Any three of the following. (3 out of 4 from Module 3)	5 X 3	15
Q4	Attempt Any three of the following. (3 out of 4 from Module 4)	5 X 3	15
Q5	Attempt Any five of the following. (5 out of 8 from Module 1 to 4)	3 X 5	15
		Total Marks	**75**

Signature Signature Signature

HOD Approved by Vice –Principal Approved by Principal

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: MSc (Physical Chemistry)				**Semester : III**	
Course : Advanced Instrumental techniques				**Course Code:PSMACHP304**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	4	Nil	4+2	15+10	75

Learning Objectives:

The students will be introduced to electron spectroscopy, electron microscopy, thermal methods and some electroanalytical methods with reference to the principle, instrumentation and applications. They would be introduced to the significance of interface in hyphenated techniques.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: The students would know the principles, instrumentations and applications of electron spectroscopy (ESCA, AUGER, UPS), electron microscopy (SEM, STEM, AFM) thermal techniques (TG, DTA, DSC and enthalpimetric methods) and electroanalytical methods.

CO2: They would be able to appreciate the need of hyphenation, inter-facing devices and applications of the following: GC-MS, GC-IR, MS-MS, HPLC- MS, ICP-MS.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Electron Spectroscopy and Microscopy**	15
2	**Thermal methods**	15
3	**Hyphenated techniques**	15
4	**Electro-analytical methods**	15
	Total	**60**
PRACTICALS		

Module	**Topic**	**No. of Hours/Credits**
Module 1	**Electron Spectroscopy and Microscopy**	**15**
	1.1 Electron Spectroscopy: principles, instrumentation and applications of the following ESCA (XPS), AUGER, UPS. **(9L)**	

	1.2 Electron Microscopy: principles, instrumentation and applications of the following: Scanning Probe Microscopes, Scanning Electron Microscope(SEM), Scanning Tunneling electron Microscope(STEM) and Atomic Force Microscope (AFM) **(6L)**	
Module 2	**Thermal Methods**	**15**
	2.1Thermogravimetry (TG): Principle and Instrumentation, factors affecting thermogravimetric curves, Interpretation of thermo gravimetric curves. applications of thermo gravimetry **(4L)** **2.2 Differential thermal analysis (DTA) and Differential scanning calorimetry (DSC):** Principle and instrumentation, heat flux and power compensated DSC,Interpretation of DTA and DSC curves applications of DTA and DSC. **(5L)** **2.3 Enthalpimetric methods (2L)** **2.4 Thermometric titrations:** principle instrumentation and application **(2L)** **2.5 Evolved gas analysis (EGA):** Principle and applications. **(2L)**	
Module 3	**Hyphenated Techniques**	**15**
	3.1 Introduction, need for hyphenation, possible hyphenation. **(2L)** **3.2** Interfacing devices and applications of the following: GC-MS, GC-IR, MS-MS, HPLC- MS, ICP-MS, spectro-electrochemistry and radio-chromatography. **(13L)**	
Module 4	**Electro-analytical Methods.**	**15**
	4.1Over view of electrode process: Electro-capillary curve and electro-capillary maximum potential. **(2L)** **4.2 Microelectrodes:** mercury electrodes: Stationary mercury drop electrode (SMDE).Hanging mercury drop electrode (HMDE), Mercury film electrode (MFE), Carbon paste electrode and chemically modified electrodes. **(3L)** **4.3Introduction to three electrode system:** modern polarography and voltammetry necessity and development of new voltammetric techniques and their comparison with classical DC polarography. **(3L)**	

	4.4Voltammetric methods: Sampled DC polarography (TAST), Linear sweep voltammetry (LSV),Cyclic voltammetry (CV),diagnostic criteria of cyclic voltammetry **(7L)**	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

PRACTICAL IV

1. To determine the molar mass of a nonvolatile solute by cryoscopic method.
2. To determine the ionization constant of bromophenol blue
3. To study complex formation between nickel(II) with o-phenanthroline.
4. To determine the rate constant and the order of the reaction between persulphate and iodide ions.
5. To determine the amount of the strong acid, weak acid and salt in a given mixture conductometrically.
6. To determine pK_{In} of an indicator spectrophotometrically.

Suggested Readings

Text Books:

Unit I and II:

1. Skoog D. A, West D. M., Fundamentals of Analytical Chemistry, Thomson AsiaPvtltd.,8th Ed,(2004)
2. Skoog, Holler, Nieman, Principles of Instrumental Analysis, Thomson Asia Pvt ltd., 5th Ed (2003)
3. Sharma B K, Instrumental Methods of Chemical Analysis, Goel Publishing House.
4. Wendlandt, Thermal Methods, W. W. John Wiley, (1986).
5. Willard Merrit and Settle, Instrumental Methods of Analysis.
6. Douglas A. Skoog, Holler & Crouch, Instrumental analysis India edition CENGAGE Learning (Eighth Indian Reprint 2011)
7. Robert D.Braun. Introduction to Instrumental Analysis (IndianReprint2006)
8. J. W. Dodd, K. Tonge, Thermal Methods. Analytical Chemistry, open Learning.
9. Pavia, Lapman, kriz, introduction to Spectroscopy, Thomson Pub.
10. H. Straw, & K. Walker, Spectroscopy Vol.I& II, Science Paper backs.
11. M. Mahindersingh, Analytical chemistry, Instrumental techniques, Dominant Pub. Delhi.
12. F. W. Fiefield, & D. Kealey, Principles and Practice of Analytical Chemistry, Blackwell Pub.
13. G. W. Ewing, Instrumental methods of Chemical analysis, Mac-Graw-Hill.

Unit III:

1. R.P.W.Scott,TandemTechniques,WileyIndiaPvt.Ltd.Reprint2009
2. J.Barker, Analytical chemistry for open learning, Mass spectrometry, Wiiley India ED.

Unit IV:

1. A. J. Bardand, L. R. Faulkner, Electrochemical Methods, 2nd Ed. John Wiley and Sons, Asia Pvt. Ltd, (2004)

2. J. J. Lingane, Electro-analytical Chemistry, 2nd Ed, Interscience Publishers, Inc., New York (1958)

3. A. M. Bond, Modern Polarographic Methods in Analytical Chemistry, Marcel Dekker Publishers, Inc., NewYork, (1980)

4. A. J. Bard(Ed), Electro-analytical Chemistry, Marcel Dekker Inc., NewYork (A series of volumes).

5. Donald T. Sawyer, A.S Obkowiak and J. L. Roberts, Jr. Electrochemistry for Chemists,2nd Ed., John Wiley and Sons, Inc., NewYork, (1995).

6. D. A. Skoog, F. J. Holler, J. A. Nieman, Principles of Instrumental analysis, 6th Ed.

7. R. D. Braun. Introduction to Instrumental Analysis, MacGrawhill, 1987.

8. H.A. Willard, L. L.Merritt, J. A. Dean & F. A. Settle, Instrumental methods of analysis, 5th Ed. CBS, 1986.

9. M. Noel, K. J. Vasu, Cyclic Voltammetry and Frontiers of electrochemistry, IBH, NewDelhi, 1990.

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Best College (2016-17), University of Mumbai

Affiliated to the

UNIVERSITY OF MUMBAI

Program: M. Sc. Physical Chemistry

Course: Polymer, Green, Biophysical and Applied Chemistry

Semester- IV

Choice Based Credit System (CBCS) with effect from the Academic year 2020-21

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the MSc Physical Chemistry, the learners should be enriched with knowledge and be able to-

PSO11: Understand Polymerization techniques, polymer technologies, methods for analysis of polymeric materials, properties of polymers in solid state and in solution.
PSO12: Explore physical chemistry of biomolecules.
PSO13: Understand the concept of statistical mechanics and nuclear chemistry
PSO14: Explain the mechanism of photochemical reactions.
PSO15: Comprehend various aspect of material chemistry and their applications
PSO16: Use and interpret atomic and molecular spectroscopy.
PSO17: Perceive various aspects of nanotechnology and their applications
PSO18: Understand principle and applications of laser technology
PSO19: Recognize the applications of advanced analytical techniques for characterization
PSO20: Understand various terms and process of research.

Preamble

Students should have basic understanding in topics like Polymer Chemistry, Green Chemistry, Biomolecules and their separation techniques, Photo Chemistry.

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

i) Details of Continuous Assessment (CA)

25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	Written Test	15 marks
Component 2 (CA-2)	Assignment	10 marks

j) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	**Description**	**Marks**	**Total Marks**
Q1	Attempt Any three of the following. (3 out of 4 from Module 1)	5 X 3	15
Q2	Attempt Any three of the following. (3 out of 4 from Module 2)	5 X 3	15
Q3	Attempt Any three of the following. (3 out of 4 from Module 3)	5 X 3	15
Q4	Attempt Any three of the following. (3 out of 4 from Module 4)	5 X 3	15
Q5	Attempt Any five of the following. (5 out of 8 from Module 1 to 4)	3 X 5	15
		Total Marks	**75**

Signature Signature Signature

HOD Approved by Vice –Principal Approved by Principal

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: MSc (Physical Chemistry)				**Semester: IV**	
Course: Polymer, Green, Biophysical and Applied Chemistry				**Course Code: PSMACHP-401**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	4	Nil	4+2	15+10	75

Learning Objectives:

To provide the basic knowledge on the different aspects of concept used in identification, characterization, properties and applications of polymer, elastomers, fibres, film sheets and additives etc. The course is aimed at providing the basics of green chemistry and various green routes of synthesis. They would be acquainted with stereo-chemical aspects of biomolecules and techniques to study them. They will be conversant with photophysical kinetics of bimolecular processes and alternative devices of energy storage.

Course Outcomes:

After completion of the course, learners would be able to:

CO5: Characterize polymers by employing chemical, spectral, thermal, surface characterization techniques and would be able to use techniques of polymerization.

CO6: Understand the roles of different additives used in polymer production; production of value added polymers with desired properties and applications as well as the recycling of polymers.

CO7: Judge the chirality and pH dependence of biomolecules; the assembly, functioning and applications of biosensors; the techniques used in separation of biomolecules.

CO8: Know the photophysical kinetics of bimolecular processes and alternative devices to trap solar energy.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Polymer Chemistry-II**	15
2	**Polymer Chemistry-III**	15
3	**Bio-physical Chemistry and Green Chemistry**	15
4	**Photochemistry-II: Kinetics and Applications**	15
	Total	**60**
PRACTICALS		

Unit	Topic	No. of Hours/Credits
Module 1	**Polymer Chemistry-II**	**15**
	1.1Polymers in solid state – Transitions (glass transition and crystalline melting temperature), crystalline behaviour, factors affecting crystallinity, polymer blends and Alloys. **(3L)** **1.2Identification and characterization of polymers**: Chemical analysis- End group analysis; Physical analysis by Spectral methods: IR, UV, Ramam, NMR, X-raydiffraction analysis, Microscopic methods: SEM, TEM, Thermal analysis-TGA, DTA, DSC.**(6L)** **1.3 Properties of polymers**: Thermal (glass transition temperature, and its determination),mechanical (deformation and fracture) effects in polymers, visco-elasticity surface (surface tension, hardness, friction, abrasion), physical (Impact strength, Tensile strength, solubility) of polymers, weather ability, rheology and mechanical models, mechanical behavior, Rubber-elasticity **(4L)** **1.4 Polymer degradation and stabilization**: Oxidative, thermal, radiation, Biodegradation **(2L)**	
Module 2	**Polymer Chemistry-III**	**15**
	2.1 Techniques of polymerization: Bulk polymerization, solution, polymerization, suspension, polymerization, emulsion polymerizations **(3L)** **2.2 Thermodynamics of polymer solutions**: Solubility parameter, thermodynamics of mixing**,** theta temperature **(2L)** **2.3 Polymer technology: (5L)** Polymer auxiliaries, plasticizers, heat Stabilizers, colorants, flame retardants. fillers, reinforcements, Elastomers: Introduction, Processing, Rubber Types, Vulcanization, Properties, Reclaiming. Fibers: Introduction, production, Fiber spinning, Textile fibers, Industrial fibers, recycling. Films sheets: Introduction and processing techniques (injection and blow Moulding extrusion), Recycling of plastics. **Properties and applications of some commercially important polymers**. Carbochain polymers- Polyolefins, ABS group, elastomers, vinyl polymers, acrylic polymers, heterochain polymers- polyethers, polycarbonates, polysaccharides, polyamides fluoro-polymers, Resins	

	(epoxy, alkyd, phenol-formaldehyde and urea-formaldehyde), Silicones, polyphosphazenes, sulphur containing polymers **(5L)**	
Module 3	**Bio-physical Chemistry and Green Chemistry**	**15**
	3.1 Introduction to Complex Biomolecules: Proteins, enzymes, DNA, RNA, polysaccharides and lipids. Chirality and pH dependence of biomolecules. **(2L)** **3.2 Biosensors**: Enzyme based, Electrochemical, immuno sensor, fluorescence, optical, Piezoelectric Biosensors **(2L**) **3.3 Electrophoresis (Technique for bio-molecular study):** Principle and factors affecting electro-phoretic mobility, zone electrophoresis– Paper electrophoresis, cellules acetate electrophoresis, Gel electrophoresis. Capillary Electrophoresis, Application of electrophoresis. **(4L)** **3.4 Green Chemistry:** Recapitulation of principles of green chemistry, Waste minimization techniques**. (1L)** **3.5** Catalysis and Green Chemistry: Phase transfer catalysts, biocatalyst, photo catalysis. **(2L)** **3.6** Organic solvents, solvent free system, supercritical fluid, ionic-liquid, their characteristics, use as catalyst and solvents. **(2L)** **3.7** Alternative energy sources for initiation and execution of chemical reaction:micro wave and sono-chemistry. **(2L)**	
Module 4	**Photochemistry-II: Kinetics and Applications**	**15**
	4.1: Photophysical Kinetics of bimolecular processes (10L) Mechanism of fluorescence quenching. Collisions in solutions Kinetics of collisional quenching and Stern-Volmer equation and deviations from Stern Volmer equation, Concentration dependence of quenching and excimer formation Quenching by added substances–charge transfer mechanism and energy transfer mechanism. **4.2: Solar Cells:** photovoltaic and photo galvanic cells; photo electrochemistry; Prospects of solar energy conversion and storage, organic solarcells.**(05L)**	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

PRACTICAL I

1. To determine the formula of the zinc(II) ammonia complex by partition method.
2. Determination of the transport no. of silver(I) ions by Hittorf's method.

Conductometry

1. To determine the composition of a mixture of hydrochloric acid, potassium

chloride and ammonium chloride by titration with sodium hydroxide and silver nitrate.

2. To determine ΔG, ΔHand ΔS of dissolution of a sparingly soluble salt by conductometry.

pH metry

1. To determine K1 and K2 of a dibasic acid by titration with a base.
2. To determine dissociation constant of p-nitro phenol.

Suggested Readings

Reference Books:

Unit I and II:

1. P. Bahadur and N. V. Sastry, Principles of Polymer Science, second edition, Narosa Publishing House,2005.
2. C. E. Carraher, Jr., Carraher's Polymer Chemistry, 8th edition, CRC Press, New York, 2010.
3. JoelR.Fried, Polymer Science and Technology, Prentice-HallofIndiaPvt.Ltd., 2000.
4. V.R.Gowarikar, H.V. Viswanathan and J. Sreedhar, Polymer Science. New Age International Pvt. Ltd., New Delhi, 1990.
5. F. W. Billmeyer Jr., Text Book of Polymer Science, 3rd edition, John Wiley and Sons, 1984.
6. V.K.Ahluwalia&A. Mishra, Polymer Science, A text book,Ane Books Pvt. Ltd, 2008.
7. R. Sinha, Outline of Polymer Technology manufacture of Polymers, Prentice Hall ofIndiaPvt.Ltd.2000
8. F.J.Davis, Polymer Chemistry, Oxford University Press, 2000.
9. D.Walton & P. lotimer, Polymer, Oxford University Press, 2000.
10. R.Ypung, Introduction to Polymers, Chapman&Hall, reprint, 1989.
11. V.Jain. Organic Polymer Chemistry, IVY Publishing House, 2003.
12. A.Singh, Polymer Chemistry, Campus Book International, 2003.

Books for further reading:

1. J. M. G. Cowie, Polymers: Chemistry and Physics of Modern Materials, 2nd ed. (firstIndianReprint2004), Replika Press Pvt. Ltd.
2. G.S.Misra, Introductory Polymer Chemistry, New Age International (P) Limited, Publishers, 1993.
3. L. H. Sperling, Introduction to Physical Polymer Science. 2nd Edition, John Wiley and Sons.Inc.
4. Hans-Georg Elias, An Introduction to polymer Science, VCH1997.
5. Charles E. Seymour, Jr., Seymour, Carraher's Polymer Chemistry, 6th ed. Marcel Dekker, Inc., 2003.
6. A. Ravve, Principles of Polymer

Unit III:

1. N Dash,A Text Book of Biophysical Chemistry, Macmillan India Ltd
2. Gurtu and Gurtu, Biophysical Chemistry, Pragati Prakashan.
3. R.P.Budhiraja,Separationchemistry,NewAgeInternational(P)Limited,Publisher
4. Avinash Upadhyay, Kakoti Upadhyay, Nirmalendu Nath. Biophysical Chemistry Principles and Techniques Himalaya
5. Susan R. Mikkelson, Eduardo Corton, Bio-analytical Chemistry, WileyInterscience.08Science,2nd ed., Kluwer Academic/Plenum Publishers, New York,2000.
6. Mike Lancaster, Green Chemistry an Introductory Text, Royal Society of Chemistry.
7. V.K. Ahluwalia, M. Kidwai, Kluwer Academic Publisher.

Unit IV:

1. K. K. Rohatgi Mukherjee. Fundamentals of Photochemistry. Reprint 2002. New Age International Publisher, 1978.

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Best College (2016-17), University of Mumbai

Affiliated to the

UNIVERSITY OF MUMBAI

Program: M. Sc. Physical Chemistry

Course: Material Science, network and irreversible thermodynamics

Semester- IV

Choice Based Credit System (CBCS) with effect from the Academic year 2020-21

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the MSc Physical Chemistry, the learners should be enriched with knowledge and be able to-

PSO1: Understand Polymerization techniques, polymer technologies, methods for analysis of polymeric materials, properties of polymers in solid state and in solution.
PSO2: Explore physical chemistry of biomolecules.
PSO3: Understand the concept of statistical mechanics and nuclear chemistry
PSO4: Explain the mechanism of photochemical reactions.
PSO5: Comprehend various aspect of material chemistry and their applications
PSO6: Use and interpret atomic and molecular spectroscopy.
PSO7: Perceive various aspects of nanotechnology and their applications
PSO8: Understand principle and applications of laser technology
PSO9: Recognize the applications of advanced analytical techniques for characterization
PSO10: Understand various terms and process of research.

Preamble

Students should have basic knowledge of metallurgy, solid state chemistry, spectroscopy and thermodynamics Law.

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

k) Details of Continuous Assessment (CA)

25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	Written Test	15 marks
Component 2 (CA-2)	Assignment	10 marks

l) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	**Description**	**Marks**	**Total Marks**
Q1	Attempt Any three of the following. (3 out of 4 from Module 1)	5 X 3	15
Q2	Attempt Any three of the following. (3 out of 4 from Module 2)	5 X 3	15
Q3	Attempt Any three of the following. (3 out of 4 from Module 3)	5 X 3	15
Q4	Attempt Any three of the following. (3 out of 4 from Module 4)	5 X 3	15
Q5	Attempt Any five of the following. (5 out of 8 from Module 1 to 4)	3 X 5	15
		Total Marks	**75**

Signature Signature Signature

HOD Approved by Vice –Principal Approved by Principal

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: MSc (Physical Chemistry)				**Semester : IV**	
Course : Material Science, network and irreversible thermodynamics				**Course Code: PSMACHP402**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	4	Nil	4+2	15+10	75

Learning Objectives:

To provide the understanding of various aspects such as solidification, diffusion processes, homogeneity, crystal growth, imperfections, defects in metals and alloys. The importance of the mechanical properties of solids and their manifestations. To make them know the principles and applications, especially in chemistry, of lasers and superconductors. To make them understand the features of non-equilibrium thermodynamics and the transport phenomenon across the membrane.

Course Outcomes:

After completion of the course, learners would be able to:

CO5: Judge processes in solids such as crystal growth, diffusion also they get to know the importance of imperfections and defects in solids in developing certain applications.

CO6: Employ different mechanical properties in developing varied applications.

CO7: Find applications of lasers and superconductors by knowing their principles

CO8: Understand features of non-equilibrium thermodynamics, entropy production in heat transfer process and transport phenomena across membranes.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Metals and alloys**:	15
2	**Mechanical properties of solid material**	15
3	**Lasers and super conductors**	15
4	**Non-equilibrium thermodynamics**	15
	Total	**60**
PRACTICALS		

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Module	Topic	No. of Hours/Credits
Module 1	**Metals and alloys**:	**15**
	1.1 Solidification of metals and alloys-homogeneous and heterogeneous nucleation, growth of crystals, growth of silicon single crystal. **(4L)** **1.2**Metallic solid solutions-substitutional and interstitial solid solutions. **(3L)** **1.3**Crystalline imperfections, point ,line and boundary defects **(4L)** **1.4** Atomic diffusions in solids-diffusion mechanisms, steady state and non-steady state diffusions,-impurity diffusion into silicon wafers for integrated circuits. (**4L)**	
Module 2	**Mechanical properties of solid material**	**15**
	2.1 Stress and strain in metals- Engineering stress and engineering strain, shear stress and shear strain, the tensile test and engineering stress -strain diagram, modulus of elasticity, yield strength. **(5L)** **2.2** Hardness and hardness testing, plastic deformations of metals in single crystals, plastic deformation of polycrystalline metals, solid solution strengthening of metals. **(5L)** **2.3** Fracture of metals-ductile and brittle fracture, toughness and impact testing, fatigue of metals, the creep test, creep-rupture test. **(5L)**	
Module 3	**Lasers and super conductors**	**15**
	3.1Lasers in chemistry **3.1.1General principles of LASER action**-Population Inversion, cavity and mode characteristics, Q switching, Mode locking.**(02L)** **3.1.2Practical lasers**-Solid state lasers-Ruby, neodymium, gas lasers-He-Ne, Ar, Kr, Carbon dioxide, Chemical and exciplex Lasers, Dye lasers LED and Semiconductor Lasers**. (05L)** **3.1.3Applications of Lasers in chemistry:** Spectroscopy at high photon fluxes, collimated beams, Precision specified transitions, Isotope separation, Study of fast reactions using pulsed techniques**. (3L)**	
Module 4	**Non-equilibrium thermodynamics**	**15**
	4.1 Features of non-equilibrium thermodynamics, second law of thermodynamics, uncompensated heat and its relation to thermodynamics function.**(2L)** **4.2** Entropy production and its rate. Entropy production in heat transfer process and during mixing of gases. Entropy production and efficiency of galvanic cell.**(4L)** **4.3** Onsagers theory: Reciprocal relation, principle of microscopic reversibility. Coupled and uncoupled reactions and their condition.**(5L)**	

	4.4 Transport phenomena across membranes. Electro kinetic effect and thermo mechanical effects.**(4L)**	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

PRACTICAL II

1. To construct the phase diagram for a two component system forming a compound
2. To determine the energy of activation and other thermodynamic parameters of activation for the reaction between persulphate and potassium iodide.
3. To determine the effect of ionic strength of a solution on the reaction between potassium persulphate and potassium iodide.
4. To study the order of the reaction between bromate and bromide.
5. To determine the van't Hoff's factor by cryoscopic method.
6. To determine the liquid junction potential with a concentration cell with and without transference.

Suggested Readings

Reference Books:

Unit I and II:

1**.** William F.Smith, Principles of Material Science and Engineering, 3rdedition, McGraw–HillInc.1996.

2. KeerH.V, Principles of the Solid State,firstreprint,WileyEastern Limited, 1994.

3. Principles of Material science and engineering, 3rdedition, McGraw–Hill Inc.1996.

List of Books for further reading:

1. A.R.West, Solid State Chemistry and its Applications, John Wiley and Sons (Asia) Pvt. Ltd.

2. L.E. Smart and E.A. Moore, Solid State Chemistry–AnIntroduction,3rdEd., TaylorandFrancis,2005.

3. V.Raghavan,Materials Science and Engineering, FifthEd., Prentice-Hallof India Pvt.Ltd., New Delhi, 22004.

4. William D.Callister,Jr., Materials Science and Engineering, An Introduction, Fifth Ed. ,John Wiley and sons(Asia) Pvt.Ltd.,2001.

5. S.O. Pillai, Solid State Physics, FifthEd.,New Age International Publishers, 2002.

6. Leonid V.Azaroff, Introduction to Solids, Tata-McGraw-HillPublishingCo.Ltd., NewDelhi, 1977.

7. SandraE.Dann, Reactions and Characterization of Solids, Royal Society of Chemistry, 2000.

8. C.N.R.Raoand J.Gopalakrishnan, New Direction sin Solid State Chemistry, Seconded. CambridgeUniversityPress, 1997.

9. N.B.Hannay, Solid State Chemistry, Prentice HallofIndia,NewDelhi, 1976.

10. M.AliOmer,ElementarySolidStatePhysics,5thIndianReprint,PearsonEducation, Inc., 1999.

Unit III:

Atkins P.W, Physical Chemistry, Oxford University Press, 6th edition, 1998.

Unit IV:

1.D.A.McQuarrieandJ.D.Simon,MolecularThermodynamics,VivaBooks,PrivateLimited,FirstIndia nEd., 2004.
2.D.A.McQuarrieandJ.D.Simon,PhysicalChemistry,aMolecularApproach,VivaBooksPrivateLimit ed,FirstSouth AsianEd., 1998.Chap.
3.E.D.Kaufmann,Advanced Concepts inPhysicalChemistry,McGraw-Hill, 1966.
4. RobertP.H.Gasser andW.GrahamRichards,AnIntroductiontoStatistical Thermodynamics,WorldScientificPublishingCo.Pte.Ltd., 1995.
5. C.KalidasandM.V.Sangaranarayan,Non-EquilibriumThermodynamics, Principles andApplications,McMillanIndiaLtd., 2002.

List of Books for further reading:

6.M.Dole,AnIntroductiontoStatisticalThermodynamics,Dover,NewYork, 1986.
7. W. Kauzmann, Thermodynamics and Statistics: with applications to gases, W.A.Benjamin,NewYork, 1967.
8. M. C. Gupta, Statistical Thermodynamics, 2nd. Ed., New Age International Publishers, NewDelhi, 1998.
9. S. Glasstone, Theoretical Chemistry, Affiliated East–West Press Pvt. Ltd., New Delhi,1973.
10. S. Glasstone, Thermodynamics for Chemists, Affiliated East–West Press Pvt. Ltd.,NewDelhi, 1964.
11.R. Hasse, Thermodynamics of Irreversible Processes, Addison Wesley, London,1969.
12. I.Prigogine,IntroductiontoThermodynamicsofIrreversibleProcesses,3rd ed., Interscience,NewYork,1967

Shri Vile Parle Kelavani Mandal's

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NAAC Reaccredited 'A' grade, CGPA: 3.57 (February 2016),

Granted under RUSA, FIST-DST & -Star College Scheme of DBT, Government of India,

Best College (2016-17), University of Mumbai

Affiliated to the

UNIVERSITY OF MUMBAI

Program: M. Sc. Physical Chemistry

Course: Symmetry and Spectroscopy

Semester- IV

Choice Based Credit System (CBCS) with effect from the Academic year 2020-21

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the MSc Physical Chemistry, the learners should be enriched with knowledge and be able to-

PSO1: Understand Polymerization techniques, polymer technologies, methods for analysis of polymeric materials, properties of polymers in solid state and in solution.
PSO2: Explore physical chemistry of biomolecules.
PSO3: Understand the concept of statistical mechanics and nuclear chemistry
PSO4: Explain the mechanism of photochemical reactions.
PSO5: Comprehend various aspect of material chemistry and their applications
PSO6: Use and interpret atomic and molecular spectroscopy.
PSO7: Perceive various aspects of nanotechnology and their applications
PSO8: Understand principle and applications of laser technology
PSO9: Recognize the applications of advanced analytical techniques for characterization
PSO10: Understand various terms and process of research.

Preamble

Students should have basic understanding of symmetry and spectroscopy.

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

m) Details of Continuous Assessment (CA)

25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	Written Test	15 marks
Component 2 (CA-2)	Assignment	10 marks

n) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	**Description**	**Marks**	**Total Marks**
Q1	Attempt Any three of the following. (3 out of 4 from Module 1)	5 X 3	15
Q2	Attempt Any three of the following. (3 out of 4 from Module 2)	5 X 3	15
Q3	Attempt Any three of the following. (3 out of 4 from Module 3)	5 X 3	15
Q4	Attempt Any three of the following. (3 out of 4 from Module 4)	5 X 3	15
Q5	Attempt Any five of the following. (5 out of 8 from Module 1 to 4)	3 X 5	15
		Total Marks	**75**

Signature Signature Signature

HOD Approved by Vice –Principal Approved by Principal

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: MSc (Physical Chemistry)				**Semester : IV**	
Course : Symmetry and Spectroscopy				**Course Code: PSMACHP-403**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	4	Nil	4+2	15+10	75

Learning Objectives:

To provide theoretical basis for various spectroscopic phenomenon. To provide the students the understanding of the principles, processes and applications od NMR-especially ^{13}C NMR, ESR, Mossbauer spectroscopy, and their application based modified techniques.

Course Outcomes:

After completion of the course, learners would be able to:

CO5: The students would be able to correlate the theoretical basis with the interpretation of spectra-especially with respect to bonding.

CO6: The students would be able to use application based modified techniques such as NMR-especially ^{13}C NMR,, ESR and Mossbauer spectroscopies

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Symmetry in Chemistry**	15
2	**N.M.R.Spectroscopy-I**	15
3	**ESR and Mossbauer Spectroscopy**	15
4	**13C N.M.R. Spectroscopy**	15
	Total	**60**
PRACTICALS		

Unit	**Topic**	**No. of Hours/Credits**
Module 1	**Symmetry in Chemistry**	**15**
	1.1 Recapitulation: point groups, character tables **(2L)**	

	1.2 Reduction formula, application of reduction formula to vibrational modes of water molecule**.(2L)** **1.3**Application in vibrational spectroscopy, selection rules for IR spectroscopy for molecules such as H_2O, CO_2,HF,H_2**(3L)** **1.4**Application to Raman spectra, selection rules, comparison of IR and Raman selection rules, general approach to vibrational spectroscopy.**(2L)** **1.5**Symmetry in chemical bonding: symmetry adapted linear combination of molecular orbitals, H_2^+,H_2, LiH, BeH_2,BH_3,CH_4,molecular orbital energy, and bond order.**(6L)**	
Module 2	**N.M.R.Spectroscopy-I**	**15**
	2.1 A review of one dimensional NMR spectroscopy.**(1L)** **2.2** Spin-relaxation. Nuclear Overhause-Effect(NOE) .polarization transfer.**(3L)** **2.3** Two-dimensional NMR.Correlated spectroscopy(COSY)**(3L)** **2.4** Nuclear Overhauser effect Spectroscopy(NOESY) **(2L)** **2.5** Hetero nuclear correlation Spectroscopy (HETCOR) **(2L)** **2.6** Solid-state NMR **(2L)** **2.7** Magnetic Resonance Imaging(MRI) **(2L)**	
Module 3	**ESR and Mossbauer Spectroscopy**	**15**
	3.1Electron spin Resonance Spectroscopy Basic principle, hyperfine splitting(isotropic systems); G-value and the factors affecting thereof; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy) Isotropic effects (the g-value and the hyper fine couplings); The EPR of triplet states; Structural applications to transition metal complexes**.** Fundamentals and hyperfine splitting, application to study of free radicals spin densities McConnell relationship Zero field splitting. **(10L)** 3.2Mossbauer Spectroscopy: Principles, Recoilless emission and absorption of γ-rays, experimental methods, isomer shift, hyperfine structure (quadrupole interaction), magnetic hyperfine interaction, applications. (5L)	
Module 4	**13C N.M.R. Spectroscopy**	**15**
	4.1 Elementary ideas, instrumental difficulties, FT technique advantages and disadvantages. Proton noise decoupling technique advantages and disadvantages, off-resonance technique. **(5L)** **4.2** Chemical shifts of solvents, factors affecting chemical shifts, analogy with 1HNMR.(**3L**) **4.3** Calculations of chemical shift of hydrocarbons, effect of substituent's on chemical shifts, different types of carbons (alkene, alkyne and allene). **(3L)** **4.4** Chemical shift of aromatic carbons and effect of substituent. **(2L)** **4.5** Chemical shifts of carbonyl, nitrile, and oxime carbons. **(2L)**	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

PRACTICAL III

Interpretation of spectra/data:

1. Interpretation of vibrational-rotational spectra of rigid and non-rigid diatomic molecules
2. Interpretation of electronic spectra of diatomic molecules.
3. Interpretation of electronic spectra ofsimple polyatomic molecules.
4. Interpretation of NMR, ESR spectra.
5. Interpretation of Mössbauer spectra.
6. Analysisof XRD pattern of cubic system

Interpretation of DTA, TG, and DTG curves

Suggested Readings

Reference Books:

Unit I:

1.K.Veera Reddy, Symmetry and Spectroscopy of molecules,2nded,newage International publishers.

2. U.C.Agarwala, HL Nigam,S. Agarwal,S.S.Kalra,Molecularsymmetryin Chemistryviagrouptheory, 2013,AneBooksPvt.ltd.

3. H.N.Dass,symmetryandgrouptheoryforchemists, 2004AsianBooksPvt.Ltd.

4. K.V.Raman,grouptheoryanditsapplicationstoChemistry, 1980, Tata Mac Graw hillPub.Co.Pvt.Ltd.

5. P/K.Bhattacharya,Groupthezoryand itschemicalapplications, 1999, Himalaya, Pub.House.

6. F.A.Cotton,ChemicalapplicationsofGroupTheory,WileyStudentEd., 2006,JohnWileyandSons,(Asia)Pvt.Ltd.

7. R.L.Carter,MolecularsymmetryandGrouptheory,WileyStudentEd.,1996,John WileyandSons,(Asia)Pvt.Ltd.

8. S.Swarnalakshmi,T.saroja,R.M.Ezhilarisi,AsimpleapproachtoGrouptheory inchemistry,2008,UniversitiesPress(India)Pvt.Ltd.

Unit II and III:

1. N.BanwellandE.M.McCash, Fundamentals of Molecular Spectroscopy, 4thEd., Tata-McGraw-Hill,1994.
2. M. L. Gupta, Atomic and Molecular Spectroscopy, New AgeInternationalPublishers, 2001.
3. H.S.Randhawa,ModernMolecularSpectroscopy,McMillanIndiaLtd.,2003
4. G.Aruldas, Molecular Structure and Spectroscopy,Prentice-HallofIndia,2001.
5. J.MichaelHollas, Modern Spectroscopy, 4thEd., John Wiley and Sons, 2004.

List of Books for further reading:

1. R.Drago,PhysicalMethodsforChemists,Saunders,Philadelphia, 1992.

2. B. P. Straughan and S. Walker (Eds.), Spectroscopy – Vol 1-3, Chapman and Hall,NewYork, 1976.
3. R. K. Harris, Nuclear Magnetic Resonance Spectroscopy, Pitman, London, 1983.
4. Donald L. Pavia, Gary M. Lampman and George S. Kriz, Introduction to Spectroscopy, 3rd., Thomson,Brooks/Cole,2001.

Unit IV:

1.A.E. Derome, Modern NMR Techniques for Chemistry Research, Pergamon, Oxford (1987)
2. J.K.M. Sanders and B.K. Hunter, Modern NMR Spectroscopy, Oxford University Press, Oxford.edition (1993),
3.R.K.Harris,NuclearMagneticResonanceSpectroscopy,(1986)Addison-Wesley, Long man Ltd., London
4. Organic spectroscopy by William Kemp, 3rd Edition, ELBS, 1996.

List of reference books for practical:

1. B.Vishwanathan and P.S. Raghavan, Practical Physical Chemistry, Viva BooksPrivateLimited, 2005.
2. A.M.JamesandF.E.Prichard,Practical Physical Chemistry, 3rded., Longman, 1974.
3. B.P. Lewitt(ed.),Findlay'sPracticalPhysicalChemistry,9thed.,1973.
4. C.D.Brennan and C.F.H.Tipper,ALaboratoryManualofExperimentsin PhysicalChemistry,McGraw-Hill, 1967.
5. F. Daniel & Others, Experimental Physical chemistry, 19665, KogakashaCoLtd.,Tokyo.

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Affiliated to the

UNIVERSITY OF MUMBAI

Program: M. Sc. Physical Chemistry

Course: Research methodology

Semester- IV

Choice Based Credit System (CBCS) with effect from the Academic year 2020-21

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the MSc Physical Chemistry, the learners should be enriched with knowledge and be able to-

PSO1: Understand Polymerization techniques, polymer technologies, methods for analysis of polymeric materials, properties of polymers in solid state and in solution.
PSO2: Explore physical chemistry of biomolecules.
PSO3: Understand the concept of statistical mechanics and nuclear chemistry
PSO4: Explain the mechanism of photochemical reactions.
PSO5: Comprehend various aspect of material chemistry and their applications
PSO6: Use and interpret atomic and molecular spectroscopy.
PSO7: Perceive various aspects of nanotechnology and their applications
PSO8: Understand principle and applications of laser technology
PSO9: Recognize the applications of advanced analytical techniques for characterization
PSO10: Understand various terms and process of research.

Preamble

This paper is to familiarize the students of chemistry at postgraduate level with the analytical methods used in Research.

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

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Q4	Attempt Any three of the following. (3 out of 4 from Module 4)	5 X 3	15
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		Total Marks	**75**

Signature Signature Signature

HOD Approved by Vice –Principal Approved by Principal

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: M. Sc. (Physical Chemistry)				**Semester : IV**	
Course : Research methodology				**Course code: PSMACHP404**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	4	Nil	4+2	15+10	75

Learning Objectives:

1.To familiarize the students with basic of research and the research process.

2. To enable the students in conducting research work and formulating research synopsis and report.

Course Outcomes:

After completion of the course, learners would be able to:

CO3: Develop understanding on various kinds of research, objectives of doing research, research process, research design and sampling

CO4: Get basic awareness of data analysis and hypothesis testing procedure.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Research Methodology**	15
2	**Data Analysis**	15
3	**Methods of Scientific Research and Writing Scientific papers**	15
4	**Chemical Safety & Ethical Handling of Chemicals**	15
	Total	**60**
PRACTICALS		

Module	**Topic**	**No. of Hours/Credits**
Module 1	**Research Methodology**	**15**
	Print: Primary, Secondary and Tertiary sources. Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, textbooks, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples. Digital:Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC	

	infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus. Information Technology and Library Resources: The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.	
Module 2	**Data Analysis**	**15**
	The Investigative Approach: Making and recording Measurements, SI units and their use, Scientific methods and design of experiments. Analysis and Presentation of Data: Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of multiple linear regression analysis.	
Module 3	**Methods of Scientific Research and Writing Scientific papers**	**15**
	Reporting practical and project work, writing literature surveys and reviews, organizing a poster display, giving an oral presentation. Writing Scientific Papers: Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism.	
Module 4	**Chemical Safety & Ethical Handling of Chemicals**	**15**
	Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressure, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

PRACTICAL IV

7. Research Project

Suggested Readings

Text Books:

Research Methodology by N.C. Kothari