JAI HIND COLLEGE
BASANTSING INSTITUTE OF SCIENCE
&
J.T.LALVANI COLLEGE OF COMMERCE
(AUTONOMOUS)

"A" Road, Churchgate, Mumbai - 400 020, India.

Affiliated to
University of Mumbai

Program: M.Sc. Chemistry

(Physical)

Course: Thermodynamics, Electrochemistry and Polymers

Semester III

Credit Based Semester and Grading System (CBSGS) with effect from the academic year 2022-23

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M.Sc. Thermodynamics, Electrochemistry and Polymers Syllabus

Semester III			
Course Code	**Course Title**	**Credits**	**Lectures/Week**
PSCHE1301	Thermodynamics, Electrochemistry and Polymers	04	04

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Semester III – Theory

Course: PSCHE1301	**Thermodynamics, Electrochemistry & Polymers (Credits: 04 Lectures/Week: 04)**	
	Statistical Thermodynamics, Electrochemistry& electrode processes, Polymer Chemistry& technology	
	Objectives: **1. To understand statistical thermodynamics.** **2. To acquaint theory and derivation of electrochemistry.** **3. To understand different characterization techniques of polymers.** **Outcomes:** **1. To describe the derivations and concept of statistical thermodynamics.** **2. To discuss the theory and derivation of electrochemistry.** **3. To identify different characterization techniques of polymers.**	
Unit I	**Statistical Mechanics** 1.1 **Thermodynamic probability:** Combinatorial problems, Strilling approximation, Le granges method, macro and microstates, ensembles, Boltzmann distribution law **[3L]** 1.2 **Partition Functions:**Translational, rotational, vibrational, electronic and nuclear partition functions, Expressions for the 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 monoatomic gas. Molecular partition function. **[7L]** 1.3 **Maxwell-Boltzmann, Bose Einstein & Fermi-Dirac Statistics[3L]** 1.4 **Debye and Einstein theory of specific heats of solids. [2L]**	**15L**
Unit II	**Electrochemistry: Introduction & Overview of Electrode Processes** 2.1 **Introduction:**Electrochemical Cells & Reactions, Faradic and Non-Faradic processes **[3L]** 2.2 **Non-Faradic processes and the nature of the Electrode-Solution interface:** The Ideal Polarized Electrode (IPE), Capacitance and Charge of an electrode, Brief description of the Electrical Double Layer, Double layer Capacitance and Charging Current in Electrochemical Measurements **[4L]** 2.3 **Faradic Processes and Factors Affecting Rates of Electrode**	**15L**

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	Reactions: Electrochemical cells- types & definition; Electrochemical experiment and variables in electrochemical cells; Factors affecting electrode reaction rate and current; electrochemical cells and cell resistance. **[4L]** 2.4 **Introduction to Mass Transfer Controlled reactions:** Modes of mass transfer; semiempirical treatment of Steady-state mass transfer, Semiempirical treatment of the transient response. **[4L]**	
Unit III	**Polymer Chemistry-I** 3.1 **Recapitulation:** Introduction to Polymer Science, fundamental terms, historical outline, classification; Molar mass- molecular weight averages, fractionation, molecular weight determination by GPC/SEC, end group analysis, viscometry, vapour phase osmometry, light scattering, ultracentrifugation and molecular weight distribution curves.**[5L]** 3.2 **Types of polymerizations:** Condensation, addition (cationic and anionic) and co-polymerization (with kinetics), chain transfer reaction. **[5L]** 3.3 **Polymers in Solid State:** Crystalline behaviour and thermal behaviour (glass transition and crystalline melting temperature) **[3L]** 3.4 **Properties of Polymers:** Thermal (Glass transition temperature and its determination), mechanical effects in polymers (deformation and fracture), Rheology (Viscoelasticity) and mechanical behaviour, surface tension, hardness, friction, abrasion, impact strength, tensile strength, solubility, elastomers (rubber elasticity), weatherability. **[2L]**	**15L**
Unit IV	**Polymer Chemistry-II** 4.1 **Identification and Characterization of Polymers:** Chemical Analysis- End group analysis; Physical Analysis by Spectral methods- IR, UV, Raman, NMR, X-ray diffraction; Microscopic methods- SEM, TEM; Thermal Analysis- TGA, DTA, DSC **[4L]** 4.2 **Techniques of polymerization:** Bulk polymerization, solution polymerization, precipitation polymerization, suspension polymerization, emulsion polymerization. **[1L]** 4.3 **Thermodynamics of polymer solutions:** Solubility parameter, thermodynamics of mixing, theta temperature. **[2L]**	**15L**

4.4 **Polymer Technology: [4L]**

(i) Polymer auxiliaries, elasticizers, heat stabilizers, colorants, flame retardants, fillers, reinforcements
(ii) Elastomers: Introduction, processing, rubber types, vulcanization, properties, reclaiming.
(iii) Fibers: Introduction, production, fiber spinning, textile fibers, industrial fibers, recycling.
(iv) Film sheets: Introduction and processing techniques (injection and blow moulding extrusion), Recycling of plastics

4.5 **Speciality Polymers:** Polyelectrolytes, ionomers, conducting polymers, solid polymer electrolytes (SPE_, electroluminescent polymers, block copolymers, polymer colloids, thermoplastic elastomers (TPE), polyblends, polymer composites, Inter penetrating network (IPN) polymers, thermally stable polymers, liquid crystalline polymers, telechelic polymers, polymer microgels, biomedical polymers, polymeric supports for solid phase synthesis, polymers in combating environmental pollution, polymers as chemical reagents. **[3L]**

4.6 **Polymer degradation and stabilization:** Oxidative, thermal, radiation, biodegradation. **[1L]**

Standard References:

Unit I

1. Atkins P.W., Physical Chemistry, Oxford University Press, 6th Edition, 1998
2. McQuarrie D.A., Statistical Mechanics, Harper and Row Publishers, 1976, New York
3. Puri B.R., Pathania M.S., Sharma L.R., Principles of Physical Chemistry, 47th Edition, 2020, Vishal Publishing Co.

Unit II

4. Bard A.J., Faulkner L.R., Electrochemical Methods: Fundamentals and Applications, 2nd Edition, Wiley 2000
5. Bagotsky V.S., Fundamentals of Electrochemistry, 2nd Edition, Wiley-Interscience, 2006

Unit III& IV

6. Bahadur P., Sastry N.V., Principles of Polymer Science, 2nd Edition, Narosa Publishing House, 2005.
7. Carraher C.E. Jr., Carraher's Polymer Chemistry, 8th Edition, CRC Press, New York, 2010
8. Joel R., Fried, Polymer Science and Technology, Prentice-Hall of India Pvt. Ltd. 2000

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Additional References:

9. Seddon J.M., Gale J.D., Thermodynamics and Statistical Mechanics, Tutorial Chemistry Texts series, Vol. 10, Royal Society of Chemistry, 2001
10. Silbey R.J., Alberty R.A., Physical Chemistry, 3rd Edition, John Wiley and Sons, Inc. 2002
11. Laidler K.J., Meiser J.H., Physical Chemistry, 2nd Edition, CBS publishers and distributors 1999
12. Agarwal B.K., Eisner M., Statistical Mechanics 1988, Wiley Eastern, New Delhi
13. Lingane J.J., Electroanalytical Chemistry, 2nd Edition, Interscience publishers, Inc., New York (1958)
14. Bard A.J., Electro-analytical Chemistry, Marcel Dekkre Inc., New York
15. Noel M., Vasu K.J., Cyclic Voltammetry and Frontiers of Electrochemistry, IBH, New Delhi, 1990
16. Gowarikar V.R., Viswanathan H.V., Sreedhar J., Polymer Science, New Age International Pvt. Ltd. New Delhi, 1990.
17. Billmeyer F.W. Jr., Text Book of Polymer Science, 3rd Edition, John Wily and Sons, 1984.
18. Alhuwalia V.K., Mishra A., Polymer Science, A Text book, Ane Books Pvt. Ltd, 2008
19. Sinha R., Outline of Polymer Technology Manufacture of Polymers, Prentice hall of India Pvt. Ltd. 2000
20. Davis F.J., Polymer Chemistry, Oxford University Press, 2000.
21. Walton D., Lotimer P., Oxford University Press, 2000
22. Young R., Introduction to Polymers, Chapman & Hall, reprint, 1989.
23. Jain V., Organic Polymer Chemistry, IVY Publishing House, 2003
24. Singh A., Polymer Chemistry, Campus Book International, 2003

Evaluation Scheme

- **Continuous Assessment (CA) – 40 Marks**
  - Knowledge and Application based: Objective test of 20 Marks
  - Skill based (20 marks): Learner will be assessed on relevant skills pertaining to the course content of a particular paper which could involve but not limited to
    - Oral Presentations on relevant topics
    - Review writing/Worksheets etc.
- **Semester End Examination (SEE)- 60 Marks**

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Program: M.Sc. Chemistry

(Physical)

Course: Practical Coursework I

Semester III

Credit Based Semester and Grading System (CBSGS) with effect from the academic year 2022-23

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M.Sc. Practical Coursework I Syllabus

Semester III			
Course Code	**Course Title**	**Credits**	**Lectures/Week**
PSCHEP1301	Practical Coursework I	02	02

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Semester III – Practical

Course: PSCHEP1301	Practical Coursework I (Credits: 02, Practical/Week: 02)

PSCHEP1301: Practical Coursework I

Objectives: To equip the students with practical skills in instrumental & non-instrumental methods of analysis.

Outcomes: Learner is expected to acquire laboratory skills in calibration and use of instruments for chemical analysis and also design experiments for instrumental and non-instrumental assays.

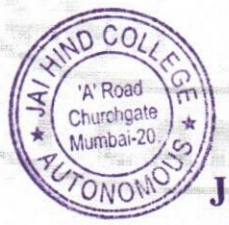
1. To titrate potassium ferrocyanide with zinc sulphate and hence to determine the formula of zinc ferrocyanide. (Conductometrically)
2. To determine the E° of quinhydrone electrode potentiometrically.
3. To determine the degree of hydrolysis of ammonium chloride and hence to determine the dissociation constant of the base. (pH metrically)
4. To determine the energy of activation and other thermodynamic parameters of activation for the acid catalyzed hydrolysis of methyl acetate.
5. To determine the molar mass of a non-volatile solute by cryoscopy method.
6. To determine the chain linkage in poly(vinyl alcohol) from viscosity measurements.

REFERENCES:

1. Athawale V.D., Mathur P., Experimental Physical Chemistry, New Age International Publishers, 2017.
2. Vishwanathan B., Raghavan P.S., Practical Physical Chemistry, Viva Books Private Limited, 2005
3. James A.M., Prichard F.E., Practical Physical Chemistry, 3rd Edition, Longman, 1974
4. Lewitt B.P., Findlay's Practical Physical Chemistry, 9th Edition, 1973
5. Brennan C.D., Tipper C.F.H., A Laboratory Manual of Experiments in Physical Chemistry, McGraw Hill 1967
6. Daniel F. & Others, Experimental Physical Chemistry, 1965, Kogakasha Co Ltd. Tokyo
7. Jeffery G.H., Bassett J., Mendham J., Denney R.C., Vogel's Textbook of Quantitative Chemical Analysis, 5th Edition, Longman Scientific & Technical John Wiley & Sons Inc., New York, 1989
8. Woolins J.D., Inorganic Experiments, VCH, Weinheim, 1994
9. Palmer W.G., Experimental Inorganic Chemistry, CUP Archive 1954
10. Raj G., Advanced Practical Inorganic Chemistry, Krishna Prakashan Media (P) Ltd, 2013
11. Daniel F. & Others, Experimental Physical Chemistry, 1965, Kogakasha Co Ltd. Tokyo

Evaluation Scheme

- **Semester End Examination (SEE)- 50 Marks**



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Program: M.Sc. Chemistry

(Physical)

Course: Atomic Molecular Structure and Spectroscopy

Semester III

Credit Based Semester and Grading System (CBSGS) with effect from the academic year 2022-23

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M.Sc. Atomic Molecular Structure and Spectroscopy Syllabus

Semester III			
Course Code	**Course Title**	**Credits**	**Lectures/Week**
PSCHE1302	Atomic, Molecular Structure and Spectroscopy	04	04

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Semester III – Theory

Course: PSCHE1302	**Atomic, Molecular Structure & Spectroscopy (Credits: 04 Lectures/Week: 04)**	
	Atomic structure, atomic spectroscopy; Molecular structure and molecular spectroscopy	
	Objectives: **1. To understand advantages of approximation methods for solving complex problems.** **2. To explain bonding in simple molecules with Valence bond theory, Molecular orbital theory** **3. To understand the principles and theories of rotational, vibrational Raman, ESR, Mossbauer and NQR spectroscopy.** **Outcomes:** **1. To apply approximation methods for solving complex problems.** **2. To describe bonding in simple molecules using MOT and VBT.** **3. To interpret rotational, vibrational Raman, ESR, Mossbauer and NQR spectra of different molecules.**	
Unit I	**Atomic Structure & Spectroscopy:** 1.1 **Introduction to approximate methods in Quantum Mechanics & Multi-electron atoms [9L]** (i) Variation Theorem, linear and nonlinear variation functions. **[2L]** (ii) Perturbation Theory, non-degenerate perturbation theory, first order wave function correction, first order and second order energy correction. **[3L]** (iii) Application of variation and perturbation theory to ground state of Helium atom. **[2L]** (iv) Multi-electron atoms: Antisymmetry and Pauli principle, Slater determinants, Hartree-Fock and configuration interaction wave functions. **[2L]** 1.2 **Atomic Spectroscopy [6L]** (i) Term symbols for multi electron atoms like He, Li, Be, B etc. **[2L]** (ii) Exchange of interactions and multiplicity of states. **[2L]** (iii) Anomalous Zeeman Effect and Paschen Back effect. **[2L]**	**15L**
Unit II	**Molecular Structure & Electronic Spectroscopy:** 2.1 **Theory of Chemical Bonding in diatomic molecules:** Born-Oppenheimer approximation.**[1L]**	**15L**

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	2.2 **Molecular Orbital Theory:** LCAO Approximation, LCAO-MO wave function of Hydrogen molecule ion (H_2^+); Ground state electronic energy, LCAO coefficients and orthonormal Mos, Electron density and bonding in H_2^+, Physical Representation & symmetry in σ & σ* MOs; GS of H_2 molecule, Graphical representation, shortcomings of simple MO theory**[4L]** 2.3 **Valence Bond Theory:** Hydrogen molecule ion, Heitler and London theory for H_2 molecule, wave function, evaluation of Energy E_+, Stability of the bond, electron density distribution, Antisymmetry of wave function, shortcomings of Heitler-London Treatment, resonance **[4L]** 2.4 **Comparison of VB and MO theories[1L]** 2.5 **Electronic spectra of molecules:** Molecular 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. **[5L]**	
Unit III	**Molecular Spectroscopy I** 3.1 **Rotational Spectroscopy:** Recapitulation- rotational spectrum of diatomic molecule, rigid rotor, selection rule& nature of spectrum, Einstein coefficients, classification of polyatomic molecules, rotational spectra of polyatomic molecules, Stark modulated microwave spectrometer.**[5L]** 3.2 **Infrared spectroscopy:** Vibrational motion, degree of freedom, vibrational spectrum of diatomic molecule and simple harmonic oscillator, selection rule and nature of spectrum; Anharmonic oscillator, Rotational-vibrational spectrum, breakdown of Born-Oppenheimer approximation, combinational differences, vibrations of polyatomic molecules, rotational fine structure of vibrational spectrum of polyatomic molecules. IR absorption bands of metal-donor atom, effect of complexation on the IR spectrum of ligands like NH_3, CN^-, CO, olefins (C=C) and $C_2O_4^{2-}$**[5L]** 3.3 **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]**	**15L**

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Unit IV	**Molecular Spectroscopy II** 4.1 **Electron Spin Resonance:** Fundamentals- g Values; fine, hyperfine and superhyperfine structures; anisotropy & spin polarization; line widths; experimental considerations- sample, spectrometer & instrumentation; Applications- single electron & multielectron systems.**[6L]** 4.2 **Mossbauer Spectroscopy:** Basic principles; spectrum and its parameters; experimental considerations- sample, temperature and instrumentation (sources and absorber; motion devices, detection, reference substances and calibration); isomer shift, quadrupole splitting, magnetic interaction, additive model; Applications- low and high spin Fe(II) and Fe(III) compounds and complexes; tin-119 and Iodine-127, Iodine-129 **[6L]** 4.3 **Nuclear Quadrupole Resonance:** Fundamentals- origin of EFG, asymmetry parameter, effects of magnetic field; experimental considerations; Applications- halogens, Group V elements, Transition metals; Nuclear Quadrupole Resonance Spectroscopy- ENDOR, ELDOR, EWDOR**[3L]**	**15L**

Standard References:

Unit I& II

1. Prasad R.K., Quantum Chemistry, 3rd Edition, New Age International Publishers, 2006
2. Levine I.N., Quantum Chemistry, 5th Delhi Edition (2000), Pearson Educ. Inc.,
3. McQuarrie D.A., Quantum Chemistry, 2nd Edition, University Science Books, California
4. Puri B.R., Pathania M.S., Sharma L.R., Principles of Physical Chemistry, 47th Edition, 2020, Vishal Publishing Co.

Unit III&IV

5. Banwell C.N., McCash E.M., Fundamentals of Molecular Spectroscopy, 4th Edition, Tata-McGraw-Hill, 1994
6. Gupta M.L., Atomic and Molecular Spectroscopy, New Age International Publishers, 2001
7. Parish R.V., NMR, NQR, EPR and Mossbauer spectroscopy in Inorganic Chemistry, Publisher E. Horwood (1990)
8. Rao C.N.R., Chemical Applications of Infrared Spectroscopy, Academic Press N.Y. (1963)

Additional References:

9. Laidler and Miser, Physical Chemistry, 2nd Edition, CBS publishers, New Delhi
10. Silbey and Alberty, Physical Chemistry, 3rd Edition, John Wiley and Sons, 2000.
11. Atkins P.W., Physical Chemistry, Oxford University Press, 6th Edition, 1998.
12. McQuarrie D.A., Simon J.D., Physical Chemistry: A Molecular Approach, (1998) Viva Books, New Delhi
13. Murrell J.N., Kettleand S.F.A., Tedder J.M., Valence Theory, 2nd Edition (1965),

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John Wiley, New York Edition
14. Chandra A.K., Introductory Quantum Chemistry, Tata McGraw Hill, New Delhi Edition (1994)
15. House J.E., Fundamentals of Quantum Chemistry, 2nd Edition, Academic Press, 2005
16. Littlefield T.A., Thorley N., Atomic and Nuclear Physics- An Introduction, Van Nostrand, 1979.
17. Randhawa H.S., Modern Molecular Spectroscopy, McMillan India Ltd. 2003
18. Aruldas G., Molecular Structure and Spectroscopy, Prentice-Hall of India, 2001
19. Hollas J.M., Modern Spectroscopy, 4th Edition, John Wiley and Sons, 2004
20. Straughan B.P., Walker S., (Eds.) Spectroscopy- Vol 1-3, Chapman and Hall, New York, 1976
21. Pavia D.L., Lampman G.M., Kriz G.S., Introduction to Spectroscopy, 3rd Edition, Thomson, Brooks, Cole, 2001

Evaluation Scheme

- **Continuous Assessment (CA) – 40 Marks**
  - Knowledge and Application based: Objective test of 20 Marks
  - Skill based (20 marks): Learner will be assessed on relevant skills pertaining to the course content of a particular paper which could involve but not limited to
    - Oral Presentations on relevant topics
    - Review writing/Worksheets etc.
- **Semester End Examination (SEE)- 60 Marks**

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Program: M.Sc. Chemistry

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Course: Practical Coursework II

Semester III

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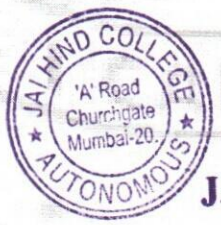
M.Sc. Practical Coursework II Syllabus

Semester III			
Course Code	**Course Title**	**Credits**	**Lectures/Week**
PSCHEP1302	Practical Coursework II	02	02



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Course: PSCHEP1302	Practical Coursework II (Credits: 02, Practicals/Week: 02)

PSCHEP1302: Practical Coursework II

Objectives: To equip the students with practical skills in synthesis and characterisation of coordination compounds

Outcomes: Learner will acquire laboratory skills in the synthesis of coordination complexes and its characterization using instrumental methods.

1. Solvent Extraction:
   a) Separation of Co and Ni using n-butyl alcohol and estimation of Co
   b) Separation of Fe and Mo using isoamyl alcohol and estimation of Fe
2. Preparation of Co(α-nitroso-β-napthol)$_3$
3. Preparation of Trans-bis(glycinato)Cu(II)
4. Determination of CFSE values of hexa-aqua complexes of Ti^{3+} and Cr^{3+}
5. Determination of Racah parameters for complex $[Ni(H_2O)_6]^{2+}$ & $[Ni(en)_3]^{2+}$
6. Synthesis of Ag Nanoparticles using tricitrate method and calculate the band gap using UV-Vis spectroscopy.
7. Synthesis of ZnO nanoparticles using chemical route and calculate the particle size by UV-Visible spectroscopy.

REFERENCES:

1. Athawale V.D., Mathur P., Experimental Physical Chemistry, New Age International Publishers, 2017.
2. Vishwanathan B., Raghavan P.S., Practical Physical Chemistry, Viva Books Private Limited, 2005
3. James A.M., Prichard F.E., Practical Physical Chemistry, 3rd Edition, Longman, 1974
4. Lewitt B.P., Findlay's Practical Physical Chemistry, 9th Edition, 1973
5. Brennan C.D., Tipper C.F.H., A Laboratory Manual of Experiments in Physical Chemistry, McGraw Hill 1967
6. Daniel F. & Others, Experimental Physical Chemistry, 1965, Kogakasha Co Ltd. Tokyo
7. Jeffery G.H., Bassett J., Mendham J., Denney R.C., Vogel's Textbook of Quantitative Chemical Analysis, 5th Edition, Longman Scientific & Technical John Wiley & Sons Inc., New York, 1989
8. Woolins J.D., Inorganic Experiments, VCH, Weinheim, 1994
9. Palmer W.G., Experimental Inorganic Chemistry, CUP Archive 1954
10. Raj G., Advanced Practical Inorganic Chemistry, Krishna

	Prakashan Media (P) Ltd, 2013 11. Daniel F. & Others, Experimental Physical Chemistry, 1965, Kogakasha Co Ltd. Tokyo

Evaluation Scheme

- **Semester End Examination (SEE)- 50 Marks**

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Program: M.Sc. Chemistry

(Physical)

Course: Nano chemistry and Nanotechnology

Semester III

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M.Sc. Nano chemistry and Nanotechnology Syllabus

Semester III			
Course Code	**Course Title**	**Credits**	**Lectures/Week**
PSCHE1303	Nano chemistry and Nanotechnology	04	04

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Semester III – Theory

Course: PSCHE1303	**Nanochemistry and Nanotechnology (Credits: 04 Lectures/Week: 04)**	
	Introduction to nanotechnology & synthesis, characterisation and applications of nanomaterials; environmental aspects of nanotechnology	
	Objectives: 1. To understand various chemical and physical methods for the synthesis of diverse types of nanomaterials (0D, 1D and 2D). 2. To establish various characterization techniques for nanomaterials 3. To introduce different application of nanotechnology in the field of energy. **Outcomes:** 1. To explain the synthesis of metal nanoparticles. 2. To assess physical properties of materials and make decision on their application in energy conversion devices. 3. To describe the principles of Scanning Electron Microscope (SEM) and its use in characterizing nanoparticles. 4. To identify application of nanotechnology in environmental science and biomedical field.	
Unit I	**Introduction to Nanomaterials and Nanotechnology** 1.1 **Introduction and Properties**: The science of Nano, classification, types, size effect and surface effects on properties, mechanical-physical-chemical properties (in brief). **[4L]** 1.2 **Synthesis of Nanomaterials: [7L]** i. Chemical methods (Recapitulation) ii. Bio-inspired synthesis: Green synthesis using plant extracts & microorganisms, self-assembly iii. Physical Methods: Template based self-assembly (SAM), Ball Milling, Vapor deposition and different types of epitaxial growth techniques, Laser Ablation, pulsed laser deposition, Magnetron sputtering- deposition progress and Lithography.	**15L**
Unit II	**Advanced Characterization of Nanomaterials** 2.1 **Preparation of environment:** Clean rooms- specifications and design, air and water purity, requirements for particular processes, Vibration free environments- facilities required; working practices, sample cleaning, chemical purification, chemical and biological contamination, safety issues, flammable and toxic hazards, biohazards.**[3L]**	**15L**

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	2.2 **Characterization techniques for nanomaterials:[12L]** i. Optical spectroscopy: UV-Vis, FTIR, photoluminescence and Raman spectroscopy. ii. X-ray diffraction technique (with reference to PXRD of SMOs, metal oxides and nanocomposites) iii. Electron microscopy: Scanning Electron Microscopy – EDAX, Transmission Electron Microscopy including high-resolution imaging & SAED, Confocal microscopy iv. Surface Analysis techniques- BET, AFM, SPM, SPOM, STM, ESCA, SIMS- Nanoindentation, Ellipsometer	
Unit III	**Applications of Nanomaterials** 3.1 **Sensors:** Sensors for Small molecules, volatile compounds, gases, biosensor, ion selective, humidity sensor, wearable sensor (materials based on SMOs, polymer nanocomposites, quantum dots) **[7L]** 3.2 **Fuel Cells, batteries & hydrogen storage:** Polymer membranes for fuel cells, Acid/alkaline fuel cells, design of fuel cells, principle, design and role of carbon based nanostructures in Li-ion batteries and Na-ion batteries; Hydrogen storage **[5L]** 3.3 **Other Applications:** Quantum dots for light emitting diodes, nanotube/nanowire-based field effect transistors; nanoparticles as catalysts; detection, diagnosis and mapping using nanomaterials. **[3L]**	**15L**
Unit IV	**Environmental Nanotechnology** 4.1 **Nanomaterials for environmental protection:** Nanotechnology for waste reduction and waste water treatment, water purification (nano porous polymers), Nanoengineering materials, nanodevices and nano systems for pollution prevention and improved energy efficiency **[6L]** 4.2 **Diagnosis and treatment of diseases using nanoparticles:** Cancer treatment and biomedical field. **[2L]** 4.3 **Environment related case studies on Nanomaterials:** Toxicity of nanoparticles, screening of nanomaterials for understanding potential effects to human health and the environment. Mapping of the environmental fate of nanomaterials. Relationships between key properties of nanomaterials and their environmental fate, transport, transformation, bio-distribution, toxicity, health impact, safety and ethics. **[7L]**	**15L**

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Standard References:

1. Kulkarni S.K., Nanotechnology: Principles and Practices, Capitol Publishing Company (2007)
2. Goyal R.K., Nanomaterials and Nanocomposites: Synthesis, Properties, Characterization Techniques and Applications, CRC press, Taylor and Francis (2018)
3. Rao C.N.R., Muller & Cheetham A.K., Eds. The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim (2004)
4. Vollath D., Nanomaterials- An Introduction to Synthesis, Properties and Applications Wiley-VCH, 2nd Edition (2013)
5. Environmental Chemistry for a Sustainable World, Volume 1: Nanotechnology and Health Risk Editors: Lichtfouse, Schwarzbauer, Robert

Evaluation Scheme

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    - Review writing/Worksheets etc.
- **Semester End Examination (SEE)- 60 Marks**

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Affiliated to
University of Mumbai

Program: M.Sc. Chemistry

(Physical)

Course: Research Methodology

Semester III

Credit Based Semester and Grading System (CBSGS) with effect from the academic year 2022-23

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M.Sc. Research Methodology Syllabus

Semester III			
Course Code	**Course Title**	**Credits**	**Lectures/Week**
PSCHEP1303	Research Methodology	02	02

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Course: PSCHEP1303	Research Methodology (Credits: 02, Practical/Week: 02)
	Objectives: **1. To understand a general definition of research design.** **2. To familiar with how to write a good introduction to educational research study and the components that comprise such an introduction** **Outcomes:** **1. To identify a research problem stated in a study.** **2. To distinguish a purpose statement, a research question or hypothesis and aresearch objective.**
	PSCHEP1303: Research Methodology **Unit Ia: Research Methodology:** 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. **Unit Ib: Methods of scientific research and writing scientific papers:** 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. **Unit II: Teaching Aptitude:** Teaching: Concept, Objectives, Levels of teaching (Memory, Understanding and Reflective), Characteristics and basic requirements. 2. Learner's characteristics: Characteristics of adolescent and adult learners (Academic, Social, Emotional and Cognitive), Individual differences. 3. Factors affecting teaching related to: Teacher, Learner, Support material, Instructional facilities, Learning environment and Institution. 4. Methods of teaching in Institutions of higher learning: Teacher centred vs. Learner centred methods; Off-line vs. On-line methods (Swayam, Swayam Prabha, MOOCs etc.). 5. Teaching Support System: Traditional, Modern and ICT based. 6. Evaluation Systems: Elements and Types of evaluation, Evaluation in Choice Based Credit System in Higher education, Computer based testing, Innovations in evaluation systems. **Unit III: Communication:**

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	Communication: Meaning, types and characteristics of communication; Effective communication: Verbal and Non-verbal, Inter-Cultural and group communications, Classroom communication; Barriers to effective communication; Mass-Media and Society. **Unit IV: Mathematical Reasoning and Aptitude:** 1. Types of reasoning. 2. Number series, Letter series, Codes and Relationships. 3. Mathematical Aptitude (Fraction, Time & Distance, Ratio, Proportion and Percentage, Profit and Loss, Interest and Discounting, Averages etc.). **UnitV: Data Interpretation:** 1. Sources, acquisition and classification of Data. 2. Quantitative and Qualitative Data. 3. Graphical representation (Bar-chart, Histograms, Pie-chart, Table-chart and Line-chart) and mapping of Data. 4. Data Interpretation REFERENCES: 1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), Practical skills in Chemistry, 2 nd Ed., Prentice Hall, Harlow 2. Hibbert, D. B. & Gooding, J. J. (2006) Data Analysis for Chemistry Oxford University Press. 3. Topping, J., (1984) Errors of Observation and their Treatment 4th Ed., Chapman Hill, London. 4. Levie, R. De. (2001) How to use Excel in Analytical Chemistryand in general scientific data analysis Cambridge University Press.

Evaluation Scheme

- **Semester End Examination (SEE)- 50 Marks**

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Program: M.Sc. Chemistry

(Physical)

Course: Applications of Materials and Nuclear Chemistry

Semester III

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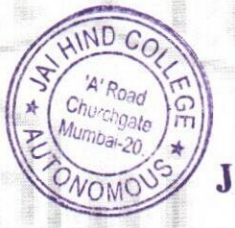
M.Sc. Application of Materials and Nuclear Chemistry Syllabus

Semester III			
Course Code	**Course Title**	**Credits**	**Lectures/Week**
PSCHE1304	Application of Materials and Nuclear Chemistry	04	04



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Semester III – Theory

Course: PSCHE1304	**Application of Materials & Nuclear Chemistry (Credits: 04 Lectures/Week: 04)**	
	Metals and alloys, mechanical properties of solid materials, applications of materials as lasers and super conductors & Nuclear chemistry	
	Objectives: **1.To understand advanced concept of Metals and alloys.** **2.To introduce the mechanical properties of solid materials.** **3.To introduce the concept, working and application of lasers.** **4.To discuss the concept and application of nuclear chemistry.** **Outcomes:** **1. To explain the growth of single crystal, defect and atomic diffusion in solids.** **2. To identify mechanical properties of solid materials.** **3. To classify different laser and its application in Chemistry.** **4. To describe the concept and application of nuclear chemistry.**	
Unit I	**Metals and alloys:** 1.1 Solidification of metals and alloys- homogenous and heterogenous 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]**	**15L**
Unit II	**Mechanical properties of Solid Materials:** 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. Hardness and hardness testing, plastic deformations of metals in single crystals, plastic deformation of polycrystalline metals, solid solution, strengthening of metals. **[5L]** 3. Fracture of metals-ductice and brittle fracture, toughness and impact testing, fatigue of metals, the creep test, creep-rupture test. **[5L]**	**15L**

Unit III	**Lasers and super conductors** 3.1 **Lasers in Chemistry [10L]** i. General principles of LASER action- Population inversion, cavity and mode characteristics, Q-switching, Mode locking **[2L]** ii. Practical lasers- solid state lasers- Ruby, neodymium, gas lasers- He, Ne, Ar, Kr, Carbon dioxide, Chemical and exciplex Lasers, Dye lasers, LED and Semiconductor Lasers. **[5L]** iii. Applications of Lasers in Chemistry: Spectroscopy at high photon fluxes, collimated beams, precision specified transitions, isotope separation, study of fast reactions using pulsed techniques. **[3L]** 3.2 **Superconducting solid matierals:** Band theory of electrical conductivity, Bardeen-Cooper-Schriffer Theory of super conductivity, the superconducting state, high critical temperature super conductors, magnetic properties of superconductors. **[5L]**	**15L**
Unit IV	**Nuclear Chemistry** 4.1 **Charged particle accelerator:** linear accelerator, cyclotron, Betatron, synchro-cyclotron, synchrotron **[4L]** 4.2 **Nuclear forces:** characteristics and Meson field theory of nuclear forces **[2L]** 4.3 **Nuclear Models:** liquid drop model, Fermi Gas model, Shell model, Collective model, Optical model **[4L]** 4.4 **Applications 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]**	**15L**

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Standard References:

Unit I& II

1. West A.R., Solid State Chemistry and its Applications, John Wiley and Sons (Asia) Pvt. Ltd.
2. Smart L.F., Moore F.A., Solid State Chemistry- An Introduction, 3rd Edition, Taylor and Francis, 2005
3. Smith W.F., Principles of Material Science and Engineering, 3rd edition, McGraw-Hill Inc. 1996
4. Keer H.V., Principles of the Solid State, first reprint, Wiley Eastern Limited, 1994
5. Principles of Material Science and Engineering, 3rd Edition, McGraw-Hill Inc. 1996

Unit III

6. Atkins P.W., Physical Chemistry, Oxford University Press, 6th Edition, 1998
7. McQuarrie D.A., Simon J.D., Physical Chemistry: A Molecular Approach, (1998) Viva Books, New Delhi

Unit IV

8. Friedlander G., Kennedy J.W., Nuclear and Radio Chemistry, 3rd Edition, John Wiley and Sons, 1981
9. Arnikar H.J., Essentials of Nuclear Chemistry, 2nd Edition, Wiley Eastern Ltd. 1989

Additional References:

10. Raghavan V., Materials Science and Engineering, 5th Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2004
11. William D., Callister Jr., Materials Science and Engineering: An Introduction, 5th Edition, John Wiley and Sons (Asia) Pvt. Ltd. 2001
12. Pillai S.O., Solid State Physics, 5th Edition, New Age International Publishers, 2002
13. Leonid V., Azaroff, Introduction to Solids, Tata McGraw Hill Publishing Co. Ltd. New Delhi, 1977
14. Dann S.E., Reactions and Charaterization of Solids, Royal Society of Chemistry, 2000
15. Rao C.N.R., Gopalakrishnan J., New Directions in Solid State Chemistry, 2nd Edition, Cambridge University Press, 1997
16. Hannay N.B., Solid State Chemistry, Prentice Hall of India, New Delhi, 1976.
17. AliOmer M., Elementary Solid State Physics, 5th Indian Reprint, Pearson Education Inc., 1999

Evaluation Scheme

- **Continuous Assessment (CA) – 40 Marks**
  - Knowledge and Application based: Objective test of 20 Marks
  - Skill based (20 marks): Learner will be assessed on relevant skills pertaining to the course content of a particular paper which could involve but not limited to

    Oral Presentations on relevant topics

    Review writing/Worksheets etc.
- **Semester End Examination (SEE)- 60 Marks**

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Course: Literature Review

Semester III

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M.Sc. Literature Review Syllabus

Semester III			
Course Code	**Course Title**	**Credits**	**Lectures/Week**
PSCHEP1304	**Literature Review**	**02**	**02**

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Semester III – Practical

Course: PSCHEP1304	Literature Review (Credits: 02, Practical/Week: 02)
	Objectives: **To understanding of the existing research and debates relevant to a parti topic or area of study, and to present that knowledge in the form of a wri report.** **Outcomes:** **To critically write review and conclude its finding.**
	PSCHEP1304: Literature Review Literature survey, review writing and presentation

Evaluation Scheme

- **Semester End Examination (SEE)- 50 Marks**

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