DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY, RANCHI

UNIVERSITY DEPARTMENT OF CHEMISTRY

B. Sc.(H) Programme in

Nanoscience and Nanotechnology
(Based on CBCS Pattern)

Guideline and syllabus for three years B.Sc.(H) Programme in

Nanoscience and Nanotechnology

2018-21 onwards

APPROVED BY

THE BOARD OF STUDIES
NANOSCIENCE AND NANOTECHNOLOGY

UNIVERSITY DEPARTMENT OF CHEMISTRY
DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY, RANCHI

BOARD OF STUDIES
NANOSCIENCE AND NANOTECHNOLOGY
UNIVERSITY DEPARTMENT OF CHEMISTRY

FOREWORD

A Meeting of the BOARD OF STUDIES was held in the UNIVERSITY DEPARTMENT OF CHEMISTRY, DSPM UNIVERSITY, RANCHI on 25.04.2018. All Members participated in the syllabus approval meeting. The Draft Syllabus for B.Sc.(H) Programme in Nanoscience and Nanotechnology was approved. It will be placed before the ACADEMIC COUNCIL of DSPM UNIVERSITY for final approval.

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   CUJ, Ranchi

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   CUJ, Ranchi

3. **Dr. N. K. Roy** — **Faculty Member**
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   DSPMU, Ranchi

4. **Dr. A. K. Acharya** — **Faculty Member**
   Assistant Professor
   University Department of Chemistry,
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5. **Dr. Rajeev Ranjan** — **Faculty Member**
   Assistant Professor
   & Course Co-ordinator
   University Department of Chemistry,
   DSPMU, Ranchi

6. **Dr. Poonam Bhardwaj** — **Faculty Member**
   Assistant Professor
   University Department of Chemistry,
   DSPMU, Ranchi

7. **Dr. Khurshid Akhtar** — **Chairperson & HOD**
   Head
   University Department of Chemistry,
   DSPMU, Ranchi

FOREWORD

In the UNIVERSITY DEPARTMENT OF CHEMISTRY, DSPM UNIVERSITY, the members of the Department Council participated in the syllabus preparation meetings held on 27.03.2028 and 28.03.2018. Keeping in view the aims of the Model Curriculum in developing interdisciplinary skills in students and linking Nanoscience and Nanotechnology studies with professional development of students, the teachers of different branches of science, namely Inorganic chemistry, Organic chemistry and Physical chemistry had joint sessions and arrived at a Draft Syllabus in Nanoscience and Nanotechnology for Six semesters B.Sc.(H) course. The Draft Syllabus was then approved by the Department Council in a meeting held on 25.04.2018 and placed before the BOARD OF STUDIES of B.Sc.(H) Programme in Nanoscience and Nanotechnology, DSPM UNIVERSITY for approval.

1. **Dr. N. K. Roy** — **Faculty Member**
   Assistant Professor
   University Department of Chemistry,
   DSPMU, Ranchi

2. **Dr. A. K. Acharya** — **Faculty Member**
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3. **Dr. Rajeev Ranjan** — **Faculty Member**
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   Head
   University Department of Chemistry
   DSPM University, Ranchi

B. Sc.(H) Nanoscience and Nanotechnology
(CBCS Pattern)

This course provides a broad overview of Nanoscience and Nanotechnology. The course structure is technology-centric where students basically learn technology and are taught necessary basic subjects for that purpose.

Objectives of the course:

The objectives of B.Sc.(H) in Nanoscience and Nanotechnology course are
- To provide an intensive and in-depth learning to the students.
- Beyond simulating, learning, understanding the techniques, the course also addresses the underlying recurring problems of disciplines in today scientific and changing business world.
- To develop awareness and knowledge of current scientific and research organization's requirement.
- Build up knowledge through varied subjects and training methodology in students.
- To train the students to take up wide variety of roles like researchers, scientists, consultants, entrepreneurs, academicians, industry leaders and policy makers.

Advantages of the course:

Nanoscience and Nanotechnology has tremendous job potential in,
- Scientific Research Organizations.
- Universities in India and abroad.
- Hospitals and Healthcare sector.
- Trading,
- Industrial job,
- Entrepreneurship,
- Consultancy organizations in pharmaceuticals, Electronics, Energy, Material Science, Medical, Defense, Agriculture, Environment Protection etc.

Eligibility: A Candidate possessing 10+2 (Science) / I.Sc. degree with Chemistry / Physics / Botany / Zoology shall be eligible for admission into B.Sc.(H) course in Nanoscience and Nanotechnology.
Admission: Merit list based on entrance exam / percentage of marks obtained in10+2 (Science) / I.Sc.

Duration: The duration for this program is of 3 years with semester pattern (06 Semesters)
Medium of Instruction: English

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DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY, RANCHI
UNIVERSITY DEPARTMENT OF CHEMISTRY

B. Sc. (H) Programme in Nanoscience and Nanotechnology
(Based on CBCS)

SEM	COURSE	COURSE NAME	Distribution of Marks			
			END SEM	MID SEM	PRACTICAL	TOTAL
I	AECC-I	EC-I/ ES-I	-	-	-	100
	CC-I + CC-I(P)	Basic Inorganic Chemistry	60	15	25	100
	CC-II+ CC-II(P)	Basic Physical Chemistry	60	15	25	100
	GE-1+ GE-1(P)/(T)	GE-1	As per concerned Department's syllabus			100
II	AECC-II	EC-II/ ES-II	-	-	-	100
	CC-III+ CC-III(P)	Basic Organic Chemistry	60	15	25	100
	CC-IV+ CC-IV(P)	Solid State Chemistry	60	15	25	100
	GE-2+ GE-2(P)/(T)	GE-2	As per concerned Department's syllabus			100
III	CC-V+ CC-V(P)	Physical Properties of Nanomaterials	60	15	25	100
	CC-VI+ CC-VI(P)	Chemical Properties of Nanomaterials	60	15	25	100
	CC-VII+ CC-VII(P)	Basics of Nanoscience and Technology	60	15	25	100
	SEC-1	SEC-1	-	-	-	-
	GE-3+ GE-3(P)/(T)	GE-3	As per concerned Department's syllabus			100
IV	CC-VIII+ CC- VIII(P)	General Characteristics of Nanomaterials	60	15	25	100
	CC-IX+ CC-IX(P)	Nanomaterials - Structure and Fabrication	60	15	25	100
	CC-X+ CC-X(P)	Nanostructures in Biological Systems	60	15	25	100
	SEC-2	SEC-2	-	-	-	-
	GE-4+ GE-4(P)/(T)	GE-4	As per concerned Department's syllabus			100
V	CC-XI+ CC-XI	Nanocomposites	60	15	25	100
	CC-XII+ CC-XII(P)	Nanomaterials for Energy and Environment	60	15	25	100
	DSE-1+ DSE-1(P)	DSE-1	60	15	25	100
	DSE-2+ DSE-2(P)	DSE-2	60	15	25	100
VI	CC-XIII+ CC-XIII(P)	Carbon and Nanoforms of Carbon	60	15	25	100
	CC-XIV+ CC-XIV(P)	Characterization of Nanomaterials	60	15	25	100
	DSE-3+ DSE-3(P)	DSE-3	60	15	25	100
	DSE-4+ DSE-4(P)	DSE-4	60	15	25	100

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Core Courses (CC) :

1. CC I : Basic Inorganic Chemistry (4 + 4)
2. CC II : Basic Physical Chemistry (4 + 4)
3. CC III : Basic Organic Chemistry (4 + 4)
4. CC IV : Solid State Chemistry (4 + 4)
5. CC V : Physical Properties of Nanomaterials (4 + 4)
6. CC VI : Chemical Properties of Nanomaterials (4 + 4)
7. CC VII : Basics of Nanoscience and Technology (4 + 4)
8. CC VIII : General Characteristics of Nanomaterials (4 + 4)
9. CC IX : Nanomaterials - Structure and Fabrication (4 + 4)
10. CC X : Nanostructures in Biological Systems (4 + 4)
11. CC XI : Nanocomposites (4 + 4)
12. CC XII : Nanomaterials for Energy and Environment (4 + 4)
13. CC XIII : Carbon and Nanoforms of Carbon (4 + 4)
14. CC XIV : Characterization of Nanomaterials (4 + 4)

Discipline Specific Elective Papers: (4 papers to be selected)

1. Nanomachines (4) + Lab (4)
2. Green Manufacturing Technology (4) + Lab (4)
3. Fundamentals of Bio-Nanotechnology (4) + Lab (4)
4. Nanotoxicology (4) + Lab (4)
5. Spectroscopy (4) + Lab (4)
6. Synthesis and Applications of Nanomaterials (4) + Lab (4)
7. Nano-Electronics (4) + Lab (4)
8. Nanopharmaceuticals (4) + Lab (4)

Note: Universities may include more options or delete some from this list.

Any one group from below mentioned Group-A and Group-B :

Semester-V

GROUP-A
DSE-1: Nanomachines (4) + Lab (4)
DSE-2: Green Manufacturing Technology (4) + Lab (4)
OR

GROUP-B
DSE-1: Fundamentals of Bio-Nanotechnology (4) + Lab (4)
DSE-2: Nanotoxicology (4) + Lab (4)

Semester-VI

GROUP-A
DSE-3: Spectroscopy (4) + Lab (4)
DSE-4: Synthesis and Applications of Nanomaterials (4) + Lab (4)
OR

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GROUP-B
DSE-3: Nano-Electronics (4) + Lab (4)
DSE-4: Nanopharmaceuticals (4) + Lab (4)

Skill Enhancement Courses (02 papers) (Credit: 02 each) - SEC1 to SEC2

1. Intellectual Property Rights and Technology
2. Social Implications of Nanotechnology

Note: Universities may include more options or delete some from this list

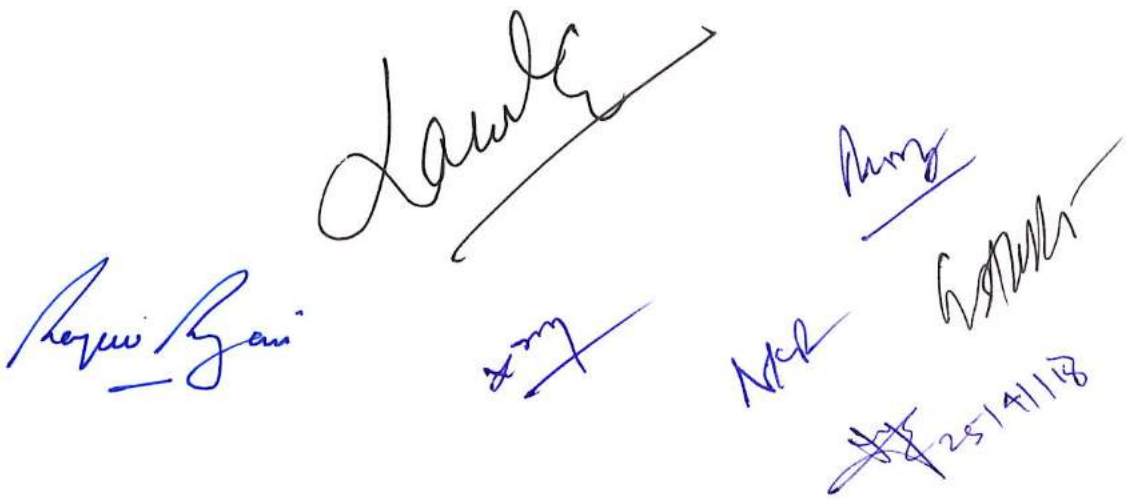
SEC-1 : Intellectual Property Rights and Technology
SEC-2 : Social Implications of Nanotechnology

Other Discipline (Four papers of any one discipline) - GE 1 to GE 4

1. Mathematics (5) + Tut (1)
2. Physics (4) + Lab (4)
3. Botany (4) + Lab (4)
4. Zoology (4) + Lab (4)

Any other discipline of importance

Important:
1. *University can add/delete some experiments of similar nature in the Laboratory papers.*
2. *University can add to the list of reference books given at the end of each paper.*



Course Structure
Details of courses under B.Sc. (Honours)

Course	*Credits	
	Theory+ Practical	Theory + Tutorial
I. Core Course		
(14 Papers)	14×4= 56	14×5=70
Core Course Practical / Tutorial*		
(14 Papers)	14×2=28	14×1=14
II. Elective Course		
(8 Papers)		
A.1. Discipline Specific Elective	4×4=16	4×5=20
(4 Papers)		
A.2. Discipline Specific Elective		
Practical/Tutorial*	4×2=8	4×1=4
(4 Papers)		
B.1. Generic Elective/ Interdisciplinary	4×4=16	4×5=20
(4 Papers)		
B.2. Generic Elective		
Practical/ Tutorial*	4×2=8	4×1=4
(4 Papers)		
III. Ability Enhancement Courses		
1. Ability Enhancement Compulsory		
(2 Papers of 2 credit each)	2×2=4	2×2=4
Environmental Science		
English/MIL Communication		
2. Ability Enhancement Elective		
(Skill Based) (Minimum 2)	2×2=4	2×2=4
(2 Papers of 2 credit each)		
Total credit	140	140

*Wherever there is a practical there will be no tutorial and vice-versa.

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GENERAL GUIDELINES

1. B.Sc. (H) Course in Nanoscience and Nanotechnology shall be of three years duration.

2. There shall be semester wise examination.

3. There shall be six semester (06) in three years, Semester-I and Semester-II in first year (1st year), Semester-III and Semester-IV in the second year (2nd year) and Semester-V and Semester-VI in the third year (3rd year).

4. There shall be FOURTEEN (14) Compulsory Core Papers and FOUR (04) Discipline Specific Elective Papers.

5. There shall be TWO (02) Ability Enhancement Compulsory Papers and TWO (02) Skill Enhancement Compulsory Papers.

6. For both Semester-V and Semester-VI, there shall be TWO GROUP of DSE PAPERS, out of which student has to elect ONE GROUP.

GROUP OF OPTIONAL DSE PAPERS:

Semester-V

GROUP-A
DSE-1: Nanomachines (4) + Lab (4)
DSE-2: Green Manufacturing Technology (4) + Lab (4)
OR

GROUP-B
DSE-1: Fundamentals of Bio-Nanotechnology (4) + Lab (4)
DSE-2: Nanotoxicology (4) + Lab (4)

Semester-VI

GROUP-A
DSE-3: Spectroscopy (4) + Lab (4)
DSE-4: Synthesis and Applications of Nanomaterials (4) + Lab (4)
OR

GROUP-B
DSE-3: Nano-Electronics (4) + Lab (4)
DSE-4: Nanopharmaceuticals (4) + Lab (4)

7. Each theory paper in each END SEMESTER EXAMINATION shall carry SIXTY (60) as FULL MARKS.

8. There shall be MID SEMESTER EXAMINATION/ INTERNAL EVALUATION in the middle of each Semester carrying FIFTEEN (15) as FULL MARKS.

9. There shall be total EIGHT (08) questions in each End-Semester Theory Examinations. Examinees are required to answer any FIVE (05) questions out of EIGHT (08).

10. The duration of End-Semester Examination shall be of THREE (03) HOURS in each Theory Paper of each Semester.

11. The duration of End-Semester Examination shall be of THREE (03) HOURS in each Combined Practical Paper/Practical Paper.

B.Sc. (H) IN NANOSCIENCE AND NANOTECHNOLOGY
(CORE COURSE)

Semester - I

Core Course - I (CC-I)
Basic Inorganic Chemistry
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I Atomic Structure: **(15 Lectures)**

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Shapes of s, p, d and f orbitals. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations.

Unit-II Periodic properties of Elements: **(15 Lectures)**

s, p, d, f block elements, the long form of periodic table. Discussion of the following properties of the elements, with reference to s & p-block: Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table, Atomic radii, Ionic and crystal radii, Covalent radii, Ionization enthalpy, Electron gain enthalpy, Electronegativity.

Unit-III Chemical Bonding: **(30 Lectures)**

(i) Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation, lattice energy. Born-Haber cycle and its application.
(ii) Covalent bond: Basic idea of Valence Bond theory. Resonance and resonance energy, Molecular orbital diagrams of diatomic molecules and their ions. VSEPR theory: shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules. Ionic character in covalent compounds
(iii) Metallic Bond: Basic idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

Reference Books:

- Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
- Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
- Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.

• Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

Core Course - I (Practical)
CC - I (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

(A) Titrimetric Analysis
(i) Calibration and use of apparatus
(ii) Preparation of solutions of different Molarity/Normality of titrants
(B) Acid-Base Titrations
(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.
(C) Oxidation-Reduction Titrimetry
(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - II (CC-II)
Basic Physical Chemistry
(Credits: Theory-04, Practical-02)

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I Kinetic Molecular Model of a Gas: **(15 Lectures)**

Postulates and derivation of the kinetic gas equation, collision frequency, collision diameter, mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, variation of viscosity with temperature and pressure.

Unit-II Behaviour of Real Gases: **(15 Lectures)**

Deviations from ideal gas behaviour, compressibility factor Z, its variation with pressure for different gases. Causes of deviation from ideal behaviour. vander Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici), virial equation of state, van der Waals equation expressed in virial form and calculation of Boyle temperature.

Unit-III Liquid State: **(15 Lectures)**

Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids. Qualitative discussion of structure of water.

Unit-IV Solid State: **(15 Lectures)**

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices, X-ray diffraction, Bragg's law, Defects in crystals.

Reference Books:

- Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press (2006).
- Ball, D. W. Physical Chemistry Thomson Press, India (2007).
- Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
- Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).

Core Course - II (Practical)
CC - II (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

1. Surface tension measurements.
   a. Determine the surface tension by (i) drop number (ii) drop weight method.
2. Viscosity measurement using Ostwald's viscometer.
   a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Semester - II

Core Course - III (CC-III)
Basic Organic Chemistry
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures
Full Marks: 15+60
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I Stereochemistry: **(10 Lectures)**

Isomerism, Geometrical isomerism: cis–trans and syn-anti isomerism, E/Z notations with Cahn Ingold and Prelog (CIP) rules for determining absolute configuration.
Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Distereoisomers, Meso structures, Racemic mixture.

Unit-II Aliphatic Hydrocarbons **(20 Lectures)**

Chemistry of alkanes: Classification of carbon atoms in alkanes, Isomerism in alkanes, Methods of formation of alkanes- Wurtz Reaction, Wurtz-Fittig Reaction, Kolbe Reaction, Corey-House Reaction and Decarboxylation of carboxylic acids. Free radical substitutions: Halogenation – orientation, reactivity and selectivity.
Chemistry of alkenes and Alkynes: Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti-Markownikoff addition), Mechanism of Oxymercuration-demercuration, Hydroboration-oxidation, Ozonolysis, Reduction (catalytic).

Unit-III Aromatic Hydrocarbons **(15 Lectures)**

Aromaticity: Hückel's rule, aromatic/anti-aromatic/non-aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples.
Electrophilic aromatic substitution: Halogenation, Nitration, Sulphonation and Friedel-Craft's alkylation.

Unit-IV Organic Polymers **(15 Lectures)**

Brief introduction to preparation, structure, properties and application of the following polymers: Polyolefins, Polystyrene, Polyvinyl chloride, Polyvinyl acetate, Acrylic polymers, Fluoro polymers, Polyamides. Phenol-formaldehyde resins (Bakelite, Novalac), Urea-formaldehyde resins, Polyurethanes, Polydienes, Polycarbonates, Conducting Polymers (polyacetylene, polyaniline, polypyrrole, polythiophene).

Reference Books:

• Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.
• Kalsi, P. S. Stereochemistry, Conformation and Mechanism; New Age International, 2005.

Core Course - III (Practical)
CC - III (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

1. Purification of organic compounds by crystallization using the following solvents:
   a. Water
   b. Alcohol
   c. Alcohol-Water
2. Determination of the melting points of above compounds and unknown organic compounds
3. Determination of boiling point of liquid compounds.
4. Chromatography:
   a. Separation of a mixture of two amino acids by paper chromatography
   b. Separation of a mixture of o-and p-nitrophenol by thin layer chromatography (TLC)

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - IV (CC-IV)
Solid State Chemistry
(Credits: Theory-04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I Physical Properties of Materials **(10 Lectures)**

Size effect on thermal, electrical, electronic, mechanical, optical and magnetic properties of nanomaterials, surface area and aspect ratio, band gap energy, quantum confinement, size effect.

Unit-II Chemical Properties of Materials **(10 Lectures)**

Photochemistry and Electrochemistry of nanomaterials, Ionic properties of nanomaterials, Nanocatalysis, Nanoscale heat transfer, Electron transport in transition metals and semiconducting nanostructures.

Unit-III Ionic Crystals **(10 Lectures)**

Ionic crystals and their structures, radius ratio rule, effect of polarization on crystals. Covalent structure type- Sphalerite & Wurtzite, Geometry of simple crystal AB type: NaCl and CsCl, reasons for preference for a particular structure in above AB type of compounds. AB_2 type: Fluorite, Rutile structures. Li_2O, Na_2O, $CdCl_2$, CdI_2 structures. Defects in Solids: Point defects, Line defects and Plane defects.

Unit-IV Chemical Thermodynamics **(20 Lectures)**

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.
First law: Concept of heat-q, work-w, internal energy-U and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases under isothermal and adiabatic conditions. Second Law: Statement of the second law of thermodynamics, concept of entropy. Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

Unit-V Thermochemistry **(10 Lectures)**

Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.

Reference Books :

- Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
- Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
- Levine, I .N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010).
- Metz, C.R. 2000 solved problems in chemistry, Schaum Series (2006)

Core Course - IV (Practical)
CC - IV (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

Thermochemistry

1. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
2. Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Calculation of the enthalpy of ionization of ethanoic acid.
4. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
5. Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Semester-III

Core Course - V (CC-V)
Physical Properties of Nanomaterials

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I : Crystal Structures **(12 Lectures)**

Crystalline state of solids, unit cells and space lattices, crystal structures, crystal planes and directions, Miller indices, diffraction of X-rays by crystal, Bragg's equation, correction to Bragg's equation, reciprocal lattice, crystal defects, point, line and surface defects.

Unit-II : Semiconductors and Their Properties **(12 Lectures)**

Band model of semiconductors, intrinsic and extrinsic semiconductors, Fermi level, variation of conductivity and mobility with temperature, law of mass action. Hall Effect, Hall coefficients for intrinsic and extrinsic semiconductors, Hall effect devices.

Unit-III: Quantum Theory of Nanomaterials **(12 Lectures)**

Development of quantum theory of nanomaterials: Application of block functions in nanomaterials. Quantum dots: (a) Semiconductor quantum dots, (b) Introduction to lasers (c) Quantum dot lasers (d) Quantum cascade lasers and (e) Quantum dot optical memory.

Unit-IV: Properties of Ferroelectric and Piezoelectric Material **(12 Lectures)**

Static dielectric constant, electronic, ionic and orientation polarizations - Internal or local fields in solid and liquids. Lorentz field in cubic materials, Clausius-Mosotti equation, complex dielectric constant, determination of dipole moment for polar substances, dielectric losses, frequency dependence of electronic, ionic, orientation polarisabilities, optical absorption, luminescence, Thallium activated alkali halides, electro luminescence.

Unit-V: Size Dependent Properties of Nanomaterials **(12 Lectures)**

Elucidation of the structure: chemistry and properties of Nano-structured materials. Variation in properties of micro and Nanomaterials. Length scale involved and effect on properties: mechanical, electronic, optical, magnetic and thermal properties.

Reference Books:

1. C. Kittle. Introduction to Solid State Physics
2. S.O. Pillai Solid State Physics
3. A.J. Decker, Solid State Physics
4. Richard L. Liboff, Borns M. Smirnov, Physics of Atoms & Ions, Springer
5. Linus Pauling, E. Brignt Wilson Corrier, Introduction to Quantum Mechanics Dover Publication
6. Edward L. Wolf, Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Wiley-VCH (2006).

Core Course - V (Practical)
CC - V (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Determination of Young's modulus of a given material
2. Determination of Rigidity modulus of a sample
3. Determination of dispersive power of a prism
4. Study of attenuation and propagation characteristics of optical fiber cable
5. Calibration of voltmeter / ammeter using galvanometer
6. Construction & study of IC regulation properties of a given power supply
7. Study of electrical characteristics of a solar cell

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - VI (CC-VI)
Chemical Properties of Nanomaterials

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I: Multi-Electron Atom and Molecules **(15 Lectures)**

Structure of atoms, Ionic compounds, Nature of light, Line spectra and Bohr Atom, Matter of Waves, Quantum number in Hydrogen atom, Energy level of multi-electron atom, Electrons in multi-electron atoms. Periodic table and electronic structures, Sizes of atoms and ions, Ionization Energy, Electron affinity.

Unit-II: Chemical Bonds, Molecular Structure and Bonding Theories **(15 Lectures)**

Lewis symbols, Ionic bonding, Covalent bonding, Formal charges & resonance in Lewis structure, Molecules that do not satisfy the octet rule, Bond energies. Valence shell electron pair repulsion model, Polarity of molecules, Valence bond theory, Multiple bonds, Molecular orbitals: Homonuclear Diatomic Molecules, Heteronulear Diatomic Molecules.

Unit-III: Fundamentals of Nanotechnology **(15 Lectures)**

Introduction to Nanoscience and Nanotechnology, Nanoscale material, implications for Physics, Chemistry, Engineering & Biology, and Motivation for Nanotechnology study. History & development of Nanoscience and Nanotechnology with the emphasis on history of Nano-metals, Chalcogenides and Boron Nitrite and Carbon Nanomaterials

Unit-IV: Structures and Classification of Nanomaterials **(15 Lectures)**

Nano-structures: various types of nano-structures and nano-crystals. Classification: of bulk Nano-structured materials, 0D, 1D, 2D structures. Size Effects, Fraction of Surfaces, Surface Energy and Surface Stress, Effect on the Lattice Parameter, Phonon Density of States, Nano-particles, Quantum dots, Nano-wires, Ultra-thin films, Multi-layered materials.

Reference Books:

1. C. Bre´chignac P. Houdy M. Lahmani, Nanomaterials and Nanochemistry, Springer Berlin Heidelberg, Germany (2006).
2. Kenneth J. Klabunde, Nanscale materials in chemistry□, Wiley Interscience Publications (2001).
3. Hans Lautenshlager, Emulsions□, Kosmetik International, (2002).
4. Roque Hidalgo-Alvarez, Structure and Functional properties of Colloids□, CRC Press, (2009). 5. Richard J. Fann, Chemistry and Technology of Surfactants□, Wiley-Blackwell, (2006)

Core Course - VI (Practical)
CC - VI (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Estimation of copper in copper ore
2. Estimation of nickel in steel
3. Estimation of iron by potentiometry.
4. Determination of Na / K in water sample by Flame photometry (Demonstration)

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - VII (CC-VII)
Basics of Nanoscience and Technology

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I : Background to Nanotechnology **(12 Lectures)**

Scientific revolution: Atomic structures, Molecular and atomic size, Bohr radius, Emergence of Nanotechnology, Challenges in Nanotechnology, Carbon age: New form of carbon (from Graphene sheet to CNT).

Unit-II : Nucleation **(12 Lectures)**

Influence of nucleation rate on the size of the crystals, macroscopic to microscopic crystals and nanocrystals, large surface to volume ratio, top-down and bottom-up approaches, self assembly process, grain boundary volume in nanocrystals, defects in nanocrystals, surface effects on the properties.

Unit-III : Types of Nanostructures **(12 Lectures)**

Definition of a Nano system, Types of Nanocrystals: One Dimensional (1D), Two Dimensional (2D), Three Dimensional (3D) nanostructured materials, Quantum dots, Quantum wire, Quantum core/shell structures.

Unit-IV : Nanomaterials and properties **(12 Lectures)**

Carbon Nanotubes (CNT), Metals (Au, Ag), Metal oxides (TiO_2, CeO_2, ZnO), Semiconductors (Si, Ge, CdS, ZnSe) Ceramics and Composites, Dilute magnetic semiconductor, Biological system, DNA and RNA, Lipids, Size dependent properties, Mechanical, Physical and Chemical properties.

Unit-V : Applications of Nanomaterials **(12 Lectures)**

Molecular electronics and nanoelectronics, Quantum electronic devices, CNT based transistor and Field Emission Display, Biological applications, Biochemical sensor, Membrane based water purification.

References books:

1. M. Wilson, K. Kannangara, G Smith, M. Simmons, B. Raguse, Nanotechnology: Basic science and Emerging technologies, Overseas Press India Pvt Ltd, New Delhi, First Edition, 2005.
2. C.N.R.Rao, A.Muller, A.K.Cheetham (Eds), The chemistry of nanomaterials: Synthesis,

properties and applications, Wiley VCH Verlag Gmbh&Co, Weinheim, 2004.
3. Kenneth J. Klabunde (Eds), Nanoscale Materials Science, John Wiley & Sons, InC, 2001.
4. C.S.S.R.Kumar, J.Hormes, C.Leuschner, Nanofabrication towards biomedical applications, Wiley -VCH Verlag GmbH & Co, Weinheim, 2004.
5. W. Rainer, Nano Electronics and information Technology, Wiley, 2003. 6. K.E.Drexler, Nano systems, Wiley, 1992. 7. G.Cao, Naostructures and Nanomaterials: Synthesis, properties and applications, Imperical College Press, 2004.

Core Course – VII (Practical)
CC - VII (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Curve fitting - straight line fit, exponential and power- law fit
2. Non-linear curve fitting: Polynomial, Gaussian and Lorentzian
3. Determination of dielectric constant-LCR bridge
4. Determination of Band gap of semiconductors
5. Resistivity measurement of a thin film
6. Determination of molecular weight of polymer by viscosity average method

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Semester-IV

Core Course - VIII (CC-VIII)
General Characteristics of Nanomaterials

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I: Fundamental Properties of Nanomaterials **(15 Lectures)**

Size dependent properties: Surface to volume ratio (SVR), Size Effects on Structure and Morphology of Nanoparticles, Size and Confinement Effects, Fraction of Surface Atoms, Specific Surface Energy, Surface Stress, Effect on the Lattice Parameter, Effect on the Phonon Density of States, Nanoparticles Morphology, Equilibrium Shape of a Macroscopic Crystal, Equilibrium Shape of Nanometric Crystals. Some Physical forces do not apply at the nano-scale: Gravitational force and friction.

Unit-II: Optical Properties of Nanomaterials **(15 Lectures)**

Fluorescence. Thermoluminescence and Photoluminescence of nanoparticles. Optical properties of quantum dots: Excitons, weakly and tightly bound excitons, excitons in molecular crystals and nano-structures. Non-linear Optics: non-linear optical susceptibility second and third order optical susceptibilities. Multiple photon excitation. Simulated Raman scattering. Stimulated Brillion scattering. Non-linear optical properties of nanomaterials.

Unit-III: Magnetic Properties of Nanomaterials **(15 Lectures)**

Magnetic domains, interactions in magnetic materials, random anisotropy, particle size and magnetic behavior, interaction between particles, nanodisks, nanorings and nanowires. Magnetic Moment in clusters/nanoparticles, magnetic order, coercivity, magnetocrystalline anisotropy, thermal activation and Superparamagneticeffects .

Unit-IV: Other Properties of Nanomaterials **(15 Lectures)**

Electronics and optoelectronics: Quantum confinement of superlattices and quantum wells, dielectric constant of nanocompounds, doping of a nanoparticle, excitonic binding and recombination energies, capacitance in a nanoparticle, diffusion in nanocrystalline materials, nanocrystalline ceramics, super-plasticity phenomena, reactivity of nanoparticles

Reference books:

1. Hari Singh Nalwa, Handbook of Nano structured Materials and Nanotechnology Electrical PropertiesVol.3

2. Hari Singh Nalwa Handbook of Nano structured Materials and Nanotechnology Optical PropertiesVol.4
3. Paras N Prasad, Nano-photonics, Wiley IEEE
4. Sergey Edward Lyshevski, Lyshevski Edward Lyshevski, Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engineering CRC Press
5. M. Gentili et al.(edits), Nanolithography, Springer

Core Course - VIII (Practical)
CC - VIII (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Study of attenuation and propagation characteristics of optical fiber cable
2. Calibration of voltmeter / ammeter using galvanometer
3. Construction & study of IC regulation properties of a given power supply
4. Study of electrical characteristics of a solar cell

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - IX (CC-IX)
Nanomaterials - Structure and Fabrication

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I: Physical Methods of Synthesis of Nanomaterials (15 Lectures)

Synthesis of Nano-structured materials : Principle and relative merits of each techniques for production of Nano-structures including ultra-thin films and multilayer by: (a) Laser Ablation technique, (b) Arc Discharge technique and (c) Mechanical Milling.

Unit-II: Physico-Chemical Methods of Synthesis of Nanomaterials (15 Lectures)

Fundamentals of synthesis of nanoparticles by Physico-chemical methods such as (a) CVD (Chemical Vapor Deposition) / MOCVD technique, (b) Plasma/Sputtering/Hot-Wire Plasma Enhanced CVD method, (c) Molecular Bean Epitaxy (d) Atomic Layer Epitaxy and (f) Self assembly technique.

Unit-III: Chemical Methods of Synthesis of Nanomaterials (20 Lectures)

Chemical methods of synthesis and applicability of the methods
(a) Solution growth techniques of 1D-2D nano structures: Synthesis of metallic, semiconducting and oxide nanoparticles, homo- and hetero- nucleation growth methods, (b) Template-based synthesis (electrochemical, electrophoretic, melt and solution, CVD) , (c) Gas Phase Synthesis of Nanopowders: Vapor (or solution)-liquid-solid (VLS or SLS) growth-the Need for Gas/vapor State Processing (d) Self assembly technique (e) Sol-gel method and (g) Spray pyrolysis.
Fundamentals of nucleation growth: Controlling Nucleation and Growth Size, Control of the Nanometric State, Aggregation-Stability of Colloidal Dispersions, Spontaneous Condensation of Nanoparticles: Homogeneous Nucleation.

Unit-IV: Biogenic Methods of Synthesis of Nanomaterials (10 Lectures)

Properties of living organisms such as to combat deleterious effect of heavy metals in high concentrations, resistance against metals by Modulation of their transport, Sequestration and intracellular compartmentation into detoxified complexes, Biogenic synthesis by (i) bacteria, (ii) fungi, (iii) algae and (iv) plants.

Reference Books:

1. Edelestein A.S and Cammarata RC, Nano materials synthesis, properties and applications:
2. Michael Kohler, Wolfgang Fritzsche, Michael Kohler, Wolfgang Fritzsche, Nanotechnology- An Introduction to Nano structuring Techniques Wiley (Practical)

3. Brian Robinson, Self-Assembly, IOS Press
4. Tai Ran-Hsu, MEMS and Microsystems, Design, Manufacture and Nanoscale Engineering, John Wiley & Sons, 2008.
5. M. Gentili, C. Giovannella, S. Selci, Nanolithography: A Borderland between STM, EB, IB and X-Ray Lithographies (NATO ASI Series), Kluwer Academic Publishers, 1994.
6. Nicholas A. Kotov, Nanoparticle Assemblies and Superstructures□, CRC, (2006).
7. Guozhong Cao, Nanostructures & Nanomaterials Synthesis, Properties G; Z, Applications, World Scientific Publishing Pvy. Ltd., Singapore 2004
8. Zheng Cui, Nanofabrication, Principles, Capabilities and Limits, Springer Science + business media, New York (2008).

Core Course – IX (Practical)
CC - IX (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Synthesis of micelles and inverse micelles.
2. Synthesis of dendrimers.
3. Preparation of thiolated silver nanoparticles
4. Synthesis of Gold Nanoparticles by chemical and biogenic methods

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - X (CC-X)
Nanostructures in Biological Systems

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I Cell Biology **(12 Lectures)**

Eukaryotic and Prokaryotic cells-Structure and functions, Principle of membrane organization. Cytoskeletal proteins, Types of cell division-mitosis and meiosis, Cell cycle and its regulation. Screening of microbes using nanofluidic chips.

Unit-II Nucleic Acids **(12 Lectures)**

Genome structure and organization in prokaryotes and eukaryotes. Structure and function of nucleic acids. Replication, transcription and translation-mechanism, enzymology and regulation. Central Dogma of life. Two case studies on DNA nanotechnology.

Unit-III Amino Acids and Proteins **(12 Lectures)**

Structure and properties of amino acids. Peptide bond. Proteins-Classification and functions of proteins. Primary, secondary, super secondary, tertiary, quaternary structures and bonding interactions.Enzymes- properties, structure, assay and inhibition. Synzymes, ribozymes.

Unit-IV Carbohydrates and Lipids **(12 Lectures)**

Classification, Nomenclature, Structure, Function of carbohydrates and lipids. Membrane transport.

Unit-V Metabolism and Energy Production **(12 Lectures)**

Integrative Metabolism of biomolecules, Electron transport chain, oxidative phosphorylation, energy production.

References Books:

1. R. Cantor, P.R.Samuel, "Biophysical Chemistry", W.H., Freeman & Co., 1985.
2. Watson, James, T.Baker, S.Bell, A.Gann, M.Levine, and R.Losick. "Molecular Biology of the Gene", 5th ed., San Francisco: Addison-Wesley, 2000.
3. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell. 4th ed. New York: Garland Science, 2002.
4. Branden, Carl-Ivar, and John Tooze. Introduction to Protein Structure. 2nd ed. New York: Garland Pub., 1991.
5. Creighton, E, Thomas, "Proteins: Structures and Molecular Properties", 2nd Ed. New York:

W.H. Freeman, 1992.
6. B.Lewin, "Genes IX", International Edition. Sudbury: Jones & Bartlett, 2007.

Core Course - X (Practical)
CC - X (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

Chromatography:

1. Separation of a mixture of two amino acids by paper chromatography
2. Separation of a mixture of o-and p-nitrophenol by thin layer chromatography (TLC)

Or any other experiment carried out in the class.

Reference Books :

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

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - XI (CC-XI)
Nanocomposites

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I Basics of Nanocomposites **(12 Lectures)**

Properties, features and processing of nanocomposites. Sample Preparation and Characterization of Structure and Physical properties. Designing, stability and mechanical properties and applications of super hard nanocomposites.

Unit-II Metal Based Nanocomposites **(12 Lectures)**

Metal-metal nanocomposites, Metal-oxide/Metal-ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Glass-metal nanocomposites, its designing and fractal dimension analysis. Electrical property of fractal based nanocomposites. Core-Shell structured nanocomposites.

Unit-III Polymer Based Nanocomposites **(12 Lectures)**

Preparation and characterization of diblock-copolymer based nanocomposites, Polymer carbon nanotubes based composites, their mechanical properties and industrial possibilities.

Unit-IV Nanocomposite from Biomaterials **(12 Lectures)**

Natural nanocomposite systems, spider silk, bones, shells, organic-inorganic nanocomposite : Formation through self-assembly. Biomimetic synthesis of nanocomposite material, Use of synthetic nanocomposites for bone, teeth replacement.

Unit-V Nanocircuitry **(12 Lectures)**

Protein based nanocircuitry. DNA based nanocircuitry Nanocomposite membrane structures-Preparation and applications.

References Books:

1. Introduction to Nanocomposite Materials. Properties, Processing, Characterization- Thomas E. Twardowski. 2007. DEStech Publications. USA.
2. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun 2006.
3. Physical Properties of Carbon Nanotubes- R. Saito 1998.
4. Carbon Nanotubes (Carbon , Vol 33) - M. Endo, S. Iijima, M.S. Dresselhaus 1997.
5. The search for novel, superhard materials- Stan Veprįek (Review Article) JVST A, 1999

6. Electromagnetic and magnetic properties of multi component metal oxides, Philippe Talbot, Anne-Marie Konn, (Review Article) J. Appl. Phys, Vol 93, 2003
7. Diblock Copolymer, - Aviram (Review Article), Nature, 2002

Core Course - XI (Practical)
CC - XI (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

Polymer synthesis

1. Free radical solution polymerization of styrene (ST)/ Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
2. Preparation of nylon 66/6
3. Interfacial polymerization : preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
4. Redox polymerization of acrylamide
5. Precipitation polymerization of acrylonitrile
6. Preparation of urea-formaldehyde resin
7. Preparations of novalac resin/resold resin.

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course – XII (CC-XII)
Nanomaterials for Energy and Environment

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I Introduction (12 Lectures)

Sustainable energy, Materials for energy, Green house effect, CO_2 emission, Energy demand and challenges.

Unit-II Renewable Energy Technology (12 Lectures)

Development and implementation of renewable energy technologies. Nano, micro and meso scale phenomena and devices. Energy conversion, transport and storage. High efficiency Photovoltaic solar cells. High performance thermoelectric systems - Integration and performance of DSSC - Quantum dots based solar cells.

Unit-III Fuel Cells and Storage Technology (12 Lectures)

Micro-fuel cell technologies, integration and performance for micro-fuel cell systems, thin film and microfabrication methods, design methodologies, micro-fuel cell power sources, Supercapacitors, Specific energy- charging/discharging, EIS analysis.

Unit-IV Hydrogen Storage and Photocatalysis (12 Lectures)

Hydrogen storage methods, metal hydrides, size effects, hydrogen storage capacity, hydrogen reaction kinetics, gravimetric and volumetric storage capacities, hydriding / dehydriding kinetics, multiple catalytic effects, nanomaterials based photocatalyst design, kinetics of degradation.

Unit-V Nanoparticles for environmental remediation (12 Lectures)

Use of nanoparticles for environmental remediation and water treatment, Dendrimer: Role of dendrimer, single enzyme, nanoparticle and metalloprotein. Regulatory needs.

References Books:

1. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.
2. Hydrogen from Renewable Energy Sources by D. Infield 2004.
3. Fuel Storage on Board Hydrogen Storage in Carbon Nanostructures by R.A. Shatwell 1996.
4. Fuel cell technology handbook. Hoogers. CRC Press, 2003.
5. Handbook of fuel cells: Fuel cell technology and applications by Vielstich. Wiley, CRC Press, 2003.

Core Course - XII (Practical)
CC - XII (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Zinc selenide quantum dot preparation.
2. Synthesis of Iron Oxide Nanoparticle
3. Thin film preparation by spin coating technique.
4. Synthesis of Nickel metal nanoparticle by urea decomposition method
5. Synthesis of Zinc Oxide nanoparticle

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - XIII (CC-XIII)
Carbon and Nanoforms of Carbon

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I: Introduction to Carbon (10 Lectures)

Introduction to various forms of Carbon: Diamond, Diamond Like Carbon, Graphite, Carbon Fibers, Carbon Black and Activated Carbon. Active carbon fibers, coal derived carbons: Structure, properties and uses.

Unit-II: Nanoforms of Carbon (15 Lectures)

Structure and bonding in Carbon Nano-material: Arm-chair, Zigzag and chiral patterns. Theory of formation of different structures and growth process of CNT single walled carbon nanotubes and multi walled carbon nano tubes, graphite and diamond. Different types of carbon Nano-materials: CNT, CNF, CNB, their structure and properties. Properties of CNM and conventional Carbon materials: Physical, Chemical and Electronic properties.

Unit-III: Synthesis of Nano-Carbon (15 Lectures)

Methods of CNM synthesis: Arc-discharge, Chemical Vapor Deposition (CVD), Pulsed Laser deposition (PLD), Thermal Vapor Deposition of CNM thin films. Nano-catalysts for CNT synthesis, Preparation and purification of CNM. Synthesis of Nano-diamonds (amorphous Carbon).

Unit-IV: Nano Graphene and Carbon-dots (15 Lectures)

Nano-graphene: Structure, properties. Carbon dots: Structure and properties (optical, photocatalytic, chemical inertness and water solubility. Synthesis of carbon dots by: Chemical, electrochemical, combustion, thermal, hydrothermal and acidic oxidation of carbon precursors, pulsed laser irradiation, laser ablation of graphite, arc discharge, ultrasonic-/microwave assisted and biogenic methods.

Reference books:

1. Laurie Kelly, MeyyappanMeyyappen, Carbon Nano tubes: Science and Applications, CRC Press
2. R.A. Shatwell, Fuel Storage on Board Hydrogen Storage in Carbon Nanostructures - in Fuel cell technology handbook, CRC Press, 2003
3. Michael J. O'Connell, Carbon nanotubes: Properties and Applications□, CRC/Taylor & Francis, (2006).

4. Francois Leonard, The Physics of Carbon Nanotube Devices□, William Andrew Inc., (2009).
5. R. Saito and M. S. Drbselmus, Physical properties of Carbon Nanotubes, Imperial College Press, (1998)

Core Course - XIII (Practical)
CC - XIII (P)

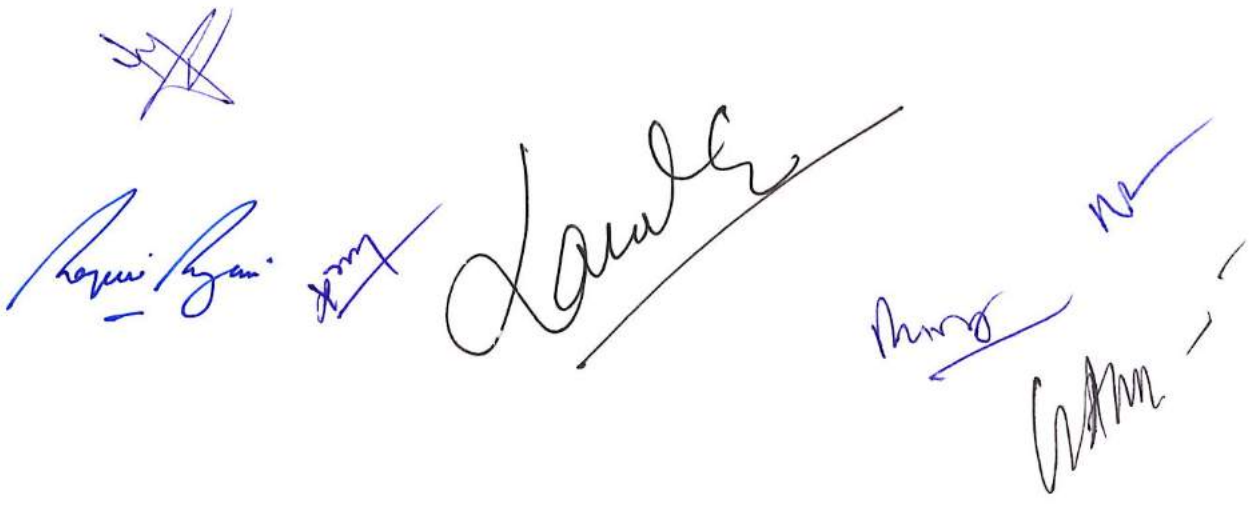
60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Synthesis quantum dot by chemical route
2. Synthesis of colloidal suspension of nanoparticles
3. Synthesis of CdS Nanoparticle
4. Purification of Nanomaterials by
   i. Physical method
   ii. Chemical method

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.



Core Course - XIV (CC-XIV)
Characterization of Nanomaterials

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I: Electron Microscopic Characterization of Nanomaterials (12 Lectures)

Fundamentals of the techniques-experimental approaches, sample preparation and data interpretation-applications/limitations of Microscopic equipments: SEM, EDAX, STM, TEM and AFM. SEM/TEM-high resolution imaging-defects in Nanomaterials.

Unit-II: Spectroscopic Characterization of Nanomaterials (12 Lectures)

Spectroscopy: Electron energy loss mechanisms, electron filtered imaging, prospects of scanning probe microscopes, optical spectroscopy of metal/semiconductor nanoparticles. Nano-lithographic technique and Surface area measurement technique. Analysis for evaluating optical absorption, Nonlinear Kerr effect, Photoluminescence and optical band gap analysis.

Unit-III: Mechanical, Thermal and Optical Properties of Nanomaterials (12 Lectures)

Fundamentals and need of characterization of Nano-materials: Identification of pertinent parameters amenable to characterization. Mechanical properties characterization: Young's Modulus, Poisson Ratio, Bulge Test and Surface Tension. Thermal and Optical effect characterization: Thermal conductivity, TGA and Thermal stability.

Unit-IV: Experimental Methods in XRD (12 Lectures)

Rotation, Oscillation, Weissenberg and Precession methods. Debye-Scherrer method (Powder method), Determination of lattice parameters from these methods. Experimental technique: Wierl equation, Radial-Distribution method.

Unit-V: Characterization of Quantum Structures (12 Lectures)

Quantum structures Particle diameter by HRTEM Photoluminescent properties, Excitation wavelength, Photoluminescence by Micro plate Reader Photostability, Quantum yield.

Reference books:

1. Zhong Lin Wang, Handbook of Nanophase and Nanomaterials (Vol 1 and II) Springer
2. C.R. Brundle, C.A. Evans Jr., and S. Wilson (eds), Encyclopedia of Materials Characterization, Butterworth Heinemann, Stoneham, Ma
3. J.C.Vickerman, Surface Analysis: The Principal Techniques, John Wiley and Sons
4. Roland Wiesendanger, Scanning Probe Microscopy and Spectroscopy: Methods and

Applications, Cambridge Univ press
5. T. Pradeep, Nano: The essentials, understanding Nanoscience and Nanotechnology, Tata McGraw Hill, 2007.

Core Course - XIV (Practical)
CC - XIV (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

LIST OF EXPERIMENTS

1. Analysis of absorption spectra of thin films of Nano-materials.
i. Transmission/absorption spectra in range of 300nm to 1500nm
ii. Determination of absorption coefficient for different wavelength
2. To calculate the absorption coefficient from UV-Vis spectrometer
3. Trace out the emission spectra for UV excited luminescent sample
4. To determine the particle size using UV spectra
5. To estimate the edge shift using UV
6. To identify the elements using atomic absorption spectra
7. To do imaging micron size particle using Optical Microscope
8. To measure the film's thickness by optical ellipsometer
9. To synthesis the nanomaterials using combustion method
10. To synthesis the nano biomaterials using wet chemical method

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-A
DSE - 1
Nanomachines

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I Nanomachines and Nanobarcodes **(15 Lectures)**

DNA nanomachines for molecular diagnostics, nanobarcodes technology, nanobarcode particle technology for SNP genotyping, Qdot nanobarcode for multiplexed gene expression profiling, biobarcode assay for proteins, single molecule barcoding system for DNA analysis, Nanoparticle based colorimetric DNA detection method.

Unit-I Biosensors for Molecular Diagnostics **(15 Lectures)**

Cantilevers as biosensors for molecular diagnostics, carbon nanotube, biosensors: FRET-based DNA nanosensors. Ion channel switch biosensor technology, electronic nanobiosensors, electrochemical nanobiosensors, quartz nanobalance biosensors, viral nanosensors, PEBBLE nanosensors, microneedle, mounted biosensors optical biosensors, nanowire (NW) biosensors , nanoscale erasable biodetectors.

Unit-III Nanomolecular Diagnostics **(15 Lectures)**

Introduction, nano diagnostics, rationale of nanotechnology for molecular diagnostics, nanoarrays for molecular diagnostics. NanoProTM System, Nanofluidic/Nanoarray devices to detect a single molecule of DNA, Self assembling protein nanoarrays, Fullerene photo detectors for chemiluminescence, detection on micro fluidic chips, protein microarray for detection of molecules with nanoparticles protein, nanobiochip, nanoparticles for molecular diagnostics, Gold nanoparticles.

Unit-IV Quantum Dots for Molecular Diagnostics **(15 Lectures)**

Quantum dots for molecular diagnostics, magnetic nanoparticles, use of nanocrystals in Immuno-chemistry, imaging applications of nanoparticles, study of chromosomes by AFM, Applications of nanopore-technology for molecular diagnostics DNA/Protein, nanoparticle conjugates.

GROUP-A
DSE - 1 Practical
DSE - 1 (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Synthesis of Gold Nanoparticles by biogenic methods
2. Synthesis of Silver Nanoparticles by biogenic methods
3. Use of enzymes as catalysts : Benzoin condensation using Thiamine Hydrochloride
4. Isolation of enzymes involved in biosynthesis of nanomaterials

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-A
DSE - 2
Green Manufacturing Technology

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I Sustainable Green Manufacturing **(15 Lectures)**

Sustainable green manufacturing, green manufacturing processes, requirements and risk, International green manufacturing standards and compliance. Green rapid prototyping and rapid manufacturing. Green flexible automation. Green collaboration processes. Alternative energy resources. Globally green manufacturing supply chains and logistic networks. Sustainable green manufacturing system.

Unit-II Waste Management **(15 Lectures)**

Sustainability and global conditions, Material and solid waste management, Energy management, chemical waste management and green chemistry, Climate change and air emissions, Origin of waste-water, water pollutants and their effects. Measurement of DO, BOD, COD and Pesticides as water pollutants. Supply-water and waste-water management.

Unit-III Industrial Ecology **(15 Lectures)**

Material flows in chemical manufacturing, Industrial parks, Assessing opportunities for waste exchanges and by product synergies, Life cycle concepts, Product shewardship and green engineering, Regulatory, social and business environment for green manufacturing. Green supply chains. Present state of green manufacturing.

Unit-IV Green Plastics and Nanocomposites **(15 Lectures)**

Introduction to commercial plastics and elastomers, Natural Rubber (NR), modified NR and blends, Polyesters from microbial and plant biofactories (polylactic acid and poly hyroxyalkanoates), Plastics from vegetable oils, Cellulose and starch based materials, Natural fillers, fibers, and clay nanocomposites, Biodegradability, life cycle assessment of using natural materials.

References books:

1. T. David Allen and David R. Shonnard, Green engineering, Prentice Hall NJ, (2002).
2. David Dornfeld, Green manufacturing fundamental and applications, Prentice hall (2002).
3. G. Sammy Shinga, Green electronics design and manufacturing, Prince publications (2008).
4. James clark, Green chemistry, Blackwell publishing (2008).
5. Paulo Davim, Sustainable Manufacturing, Wiley publications (2010).

6. Frank Kreith, George Tchobanoglous, Solid waste management, McGraw Hill (2002).
7. E. S. Stevens, Green plastics, Princeton university press (2002).
8. U. Robert Ayres, A Handbook of Industrial Ecology, Edward elgar publishing (2002).

GROUP-A
DSE - 2 Practical
DSE - 2 (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Determination of dissolved oxygen in water.
2. Percentage of available chlorine in bleaching powder.
3. Estimation of Ca and Mg in waste-water.
4. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
5. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-A
DSE - 3
Spectroscopy

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I : Ultraviolet and Visible Spectroscopy **(10 Lectures)**

Beer-Lambert law, Effect of solvent polarity on electronic transitions, Chromophores and Auxochromes, Absorption and Intensity shift, Distinction between cis and trans isomers. Ultraviolet and visible spectra of dienes and dienones.

Unit-II : Infrared Spectroscopy **(10 Lectures)**

Theory of IR spectroscopy, Instrumentation and sample handling. Characteristic vibrational frequencies, solvent effect on vibrations frequencies, overtones, combination bands and Fermi resonance. FTIR of solids and polymeric materials.

Unit-III: Nuclear Magnetic Resonance Spectroscopy **(10 Lectures)**

Basic principle of PMR Spectroscopy, chemical shift, spin-spin coupling and coupling constant, Pascal's triangle, reference compounds, nuclear shielding and deshielding phenomenon, chemical shift and factors influencing it: anisotropic effects, chemical exchange, effect of deuteration, solvent effects. Fourier transform technique.

Unit-IV: Mass Spectrometry **(10 Lectures)**

Basic principle of mass spectrometry, Introduction, ion production - EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Molecular ion peak, Metastable peak, McLafferty rearrangement. Nitrogen rule.

Unit-V: Electron Spin Resonance Spectroscopy **(10 Lectures)**

Hyperfine coupling, spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors, application to nanomaterials.

Unit-VI: Diffraction theory and Single crystal XRD **(10 Lectures)**

Bravais lattices, Miller indices, Laue method, Screw axes and glide planes, point groups, and space groups and nomenclature. Law of Interfacial angle. X-rays, Bragg's law, assignment of lines, diffraction pattern of a primitive cubic lattice, Scaterring factor and structure factor, Identification of unit cells from systematic absences in diffraction pattern.

GROUP-A
DSE - 3 Practical
DSE - 3 (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Determination of cation exchange method
2. Determination of total difference of solids
3. Synthesis of hydro-gel by co-precipitation method
4. Synthesis of silver and gold metal nanoparticles

Or any other experiment carried out in the class

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-A
DSE - 4
Synthesis and Applications of Nanomaterials

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I Bulk Synthesis **(12 Lectures)**

Top down and bottom up approaches, Mechanical alloying, mechanical ball milling, Mechano chemical process, Inert gas condensation technique, Arc plasma and laser ablation.

Unit-II Chemical Approaches **(12 Lectures)**

Sol gel processing-Solvothermal, hydrothermal, precipitation, Spray pyrolysis, Electro spraying and spin coating routes, Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films, micro emulsion polymerization-templated synthesis, pulsed electrochemical deposition.

Unit-III Physical Approaches **(12 Lectures)**

Vapor deposition and different types of epitaxial growth techniques (CVD, MOCVD, MBE, ALD)-pulsed laser deposition, Magnetron sputtering-lithography : Photo/UV/EB/FIB techniques, Dip pen nanolithography, Etching process : Dry and Wet etching, micro contact printing.

Unit-IV Nanoporous Materials **(12 Lectures)**

Zeolites, mesoporous materials, nanomembranes, carbon nanotubes and grapheme, core shell and hybrid nanocomposites.

Unit-V Application of Nanomaterials **(12 Lectures)**

Overview of nanomaterials, properties and their applications, nano-painting, nano-coating, nanomaterials for renewable energy, Molecular Electronics and Nano-electronics, Nano-robots, Biological Applicationsof nano-robots.

References Books:

1. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.
2. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002.
3. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001.

4. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties &Applications , Imperial College Press, 2004.
5. J.George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.

GROUP-A
DSE - 4 Practical
DSE - 4 (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Determination of cation exchange method
2. Determination of total difference of solids
3. Synthesis of hydro-gel by co-precipitation method
4. Synthesis of silver and gold metal nanoparticles

Or any other experiment carried out in the class

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-B
DSE - 1
Fundamentals of Bio-Nanotechnology

Theory: 60 Lectures
Full Marks: 60+15
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

Unit-I: Living System **(15 Lectures)**

Cell theory: origin and evolution of cells, Organization of cellular structures, prokaryotes and eukaryotes. Molecular composition of cells, Carbohydrates, Lipids, Nucleic acids, Proteins, Cell membranes, Membrane lipids. Cell wall and extra cellular matrix, cytoskeleton, cell membrane, Endocytosis, Cell-cell interactions. Cell cycle, Mitosis, Meiosis. Regulation of cell cycle-Molecular basis.

Unit-II: Suitability of living organisms as nano-factories **(15 Lectures)**

Overview of Nano-scale activities in bio-systems at organelle and molecular level. Cell as nano-factory; Cell organelle (Mitochondria- Plastids. Endoplasmic reticulum, Ribosome, Endosomes, Golgi, Lysosomes, Peroxysomes, Hydrogenosomes and Centrosomes. Nucleus: Nuclear envelope, Nucleolus, Chromosomes. Prokaryotic nucleoids (bacterial & plastid genomes). Membrane functions, Cell adhesions and cell junctions. Membrane transport, Neurotransmission, Transport across the membranes

Unit-III: DNA, Amino acids and Proteins **(15 Lectures)**

Introduction to DNA and DNA nanotechnology, Components of DNA: purine bases, pyrimidine bases, deoxyribose sugar, physical and chemical properties of DNA, Protein: introduction, biochemistry of proteins, cellular functions of proteins, introduction to protein based nanotechnology. Hydrophilic and hydrophobic amino acids, table of standard amino acid, abbreviations and side chain properties.

Unit-IV: Cell Signaling, Bioenergy-system and Bio-sensors **(15 Lectures)**

Cell signaling and cell transduction: Signaling molecules and their receptors, Functions of cell surface receptors, Pathways of intracellular signal transduction. Signal transduction and cytoskeleton, Regulation of programmed cell death. Innate immunity, adaptive immunity, cells of reticulo endothelial system, introduction to antigen presenting cells, Nature in the construction of Nano-scale biosensor devices and motors: chips, sensors and electronic circuits.

Reference books:

1. H. Baltimore, WH Freeman, Cell & Molecular Biology
2. Kimball T.W. , Cell Biology, Wesley Pub

3. Geoffrey M. Copper, The Cell A Molecular Approach□; 2nd Edition, ASM press, Sinauer Associates, Inc., Washington, (2000)
4. Harvey Lodish, Arnold Berk, S.L Zipursky, Paul Matsudaira, David Baltimore and James Daniell, Molecular Cell Biology□; 4th Ed., W.H Freeman and company, (2000).
5. E.D.P. De Robertis, and E.M.F De Robertis, Cell and Molecular Biology□. 8th Ed., Lippincott
Williams and Wilkins, (2001).
6. Alberts Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter, -Molecular Biology of The Cell", New York: Garland Science, (2002).
7. Janis Kuby, Immunology, W H Freeman, (2006).

GROUP-B
DSE - 1 Practical
DSE - 1 (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

Bio-nanotechnology Experiments (Any six practicals)
1. Isolation of DNA from various sources
2. Determination of Electrical conduction of DNA
3. Isolation and separation of cell organelles
4. 2D-Electrophoresis technique for separation of proteins
Or any other experiment carried out in the class.

GROUP-B
DSE - 2
Nanotoxicology

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I Introduction to Toxicology **(12 Lectures)**

Concept of Toxicology, Types of toxicity based on route of entry, nature of the toxin. Dose vs Toxicity Relationships. Toxicokinetics: ADME, LADMET hypothesis. Genotoxicity and carcinogenicity, Mechanisms and Tests. Organ toxicity: Respiratory, dermal, hepato, neuro and nephro.

Unit-II Nanotoxicology **(12 Lectures)**

Characteristics of Nanoparticles that determine Potential Toxicity. Bio-distribution of nanoparticles. Interation of Nanoparticles with Biomembrane and genes. Evaluation of Nanoparticle transfer using placental models. Nanomaterial toxicity-Pulmonary, dermal, hepato, neuro, ocular and nephro; Estimation of Nanoparticle Dose in Humans.

Unit-III Protocols in Toxicology Studies **(12 Lectures)**

Methods for toxicity assessment-Cyto, Geno, hepato, neuro, nephrotoxicity. Assessment of toxicokinetics. Assessment of oxidative stress and antioxidant status.

Unit-IV Animal Models **(12 Lectures)**

Types, species and strains of animals used in toxicity studies. Dosing profile for animal models. Studies on toxicology, pathology and metabolism in mouse and rat. Laws and Regulations Governing Animal Care and Use in Research.

Unit-V Risk Assessment and Execution **(12 Lectures)**

Risk assessment of Nanoparticle exposure. Prevention and control of nanopaticles exposure. Regulation and recommendations.

References Books:

1. John H. Duffus, Howard G. J. Worth, Fundamental Toxicology, The Royal Society of Chemistry 2006.
2. Nancy A. Monteiro-Riviere, C. Lang Tran., Nanotoxicology: Characterization, Dosing and Health Effects, Informa Healthcare publishers, 2007.

3. Lucio G. Costa, Ernest Hodgson, David A. Lawrence, Donald J. Reed,William F. Greenlee, Current Protocols in Toxicology, John Wiley & Sons, Inc. 2005.
4. Shayne C. Gad, 'Animal models in toxicology', Taylor & Francis Group, LLC 2007.

GROUP-B
DSE - 2 Practical
DSE - 2 (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Synthesis of Gold Nanoparticles by biogenic methods
2. Synthesis of Silver Nanoparticles by biogenic methods
3. Use of enzymes as catalysts : Benzoin condensation using Thiamine Hydrochloride
4. Isolation of enzymes involved in biosynthesis of nanomaterials

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-B
DSE - 3
Nano-Electronics

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I: Basics of Nano-Electronics **(15 Lectures)**

Introduction, Fundamentals of Nano-electronics and Nano-fabrication, Optical & electron beam lithography, Molecular beam lithography. MEMS and NEMS : Development of micro electronics-Region of Nanostructures. Silicon micromachining, semiconductors and insulators, Silicon MEMS fabrication technology, Single crystal reactive etching and metallization process. Non-silicon MEMS.

Unit-II: Electronics and Nano-optical Application **(15 Lectures)**

Single Electron Devices.; Optical amplifiers and Lasers; Application of LED in Emission of visible light; optic electronic device. Electron field emission and its application (Flat plate TV screen, laptop-screen and portable X-ray, Physics of organic LED, Photodiodes, FETs). Sensors: Principle, design, types of sensor & application of Nanotechnology.

Unit-III: Role of Nanotechnology in Harvesting Solar Energy **(15 Lectures)**

Introduction to Energy, different forms of energy & mode of harnessing. Carbon Solar cell: Physics of semiconductor, p:n junction, Schottky junction, preparation of p:n junction, photovoltaic module, types of photovoltaic cells, carbon homo/hetero junction solar cells and fabrication of a such cell.

Unit-IV: Applications of Nanotechnology in Energy **(15 Lectures)**

Hydrogen Fuel Cell: Thermodynamics of conversion of chemical energy into electrical energy, Basic design of fuel cell, comparison of fuel cell with battery, types of fuel cell and their merits and demerits. Hydrogen Storage: as liquid and gaseous form. Thermodynamics of storage of hydrogen by metal hydride, types of metal hydrides, hydrogen storage by carbon nanomaterials. Super capacitors: application of super capacitor in energy storage. Lithium batteries and application of carbon and nano-carbon in lithium batteries.

Reference books:

1. W.R. Fahrner, Nanotechnology and Nanoelectronics: Materials, Devices, Measurement Techniques, Springer, 2005.
2. K. Goser, P.Glosekotter&J.Dienstuhl, Nanoelectronic and Nanosystems From Transistors to

Molecular Quantum Devices, Springer, 2004.
3. S. E. Lyshevski, "MEMS and NEMS: Systems, Devices and Structures", CRC Press, 2002.
4. K.Goser, P.Glosekotter&J.Dienstuhl, Nanoelectronic and Nanosystems – From Transistors to Molecular Quantum Devices, Springer, 2004
5. Rainer Waser, Nanoelectronics and Information Technology: Advanced Electronic Materials Novel and Devices, Wiley VCH, 2005.
6. Branda Paz, "A Handbook on Nanoelectronics", Vedams books, 2008
7. V. Mitin, V. Kochelap, M. Stroscio, Introduction to Nanoelectronics, Cambridge University Press (2008).
8. Rainer Waser, Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, Wiley-VCH (2003).

GROUP-B
DSE - 3 Practical
DSE - 3 (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

1. Determination of dissolved oxygen in water.
2. Percentage of available chlorine in bleaching powder.
3. Estimation of Ca and Mg in waste-water.
4. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
5. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.

Or any other experiment carried out in the class.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-B
DSE - 4
Nanopharmaceuticals

Theory: 60 Lectures
Full Marks: 60+15
Time: 03 Hrs

Eight questions are to be set out of which five are to be answered.

Unit-I Nanopharmaceuticals **(20 Lectures)**

Introduction, Nanobiotechnology for drug discovery: Use of gold nanoparticles and quantum dots for drug discovery, cells targeting by nanoparticles with attached small molecules, nanoscale devices for drug discovery, Dendrimers as drugs, Fullerenes as drug candidates, Nanoscale delivery of therapeutics, Nanoparticle based drug delivery, Trojan Nanoparticles, Self-assembling nanoparticles, Nanospheres, Nanotubes, Nanocochleates, Nanomolecular valves for controlled drug release, Nanomotors for drug delivery.

Unit-II Role of Nanotechnology in Biological Therapies **(20 Lectures)**

Introduction, Development of nanomedicines, Nanoshells, Nanopores, Tectodendrimers. Nanotechnology in diagnostic application. Preformulation Studies: as tablets, capsules, suspension, creams, emulsion, injectables, ophthalmic and aerosols etc. Biomedical nanoparticles: Liposome's and dentrimers, Different types of drug loading, Drug release. Nanodiagnostics for integrating diagnostics with therapeutics.

Unit-III Application in Cancer Therapy and Nanomedicine **(20 Lectures)**

Introduction and rationale for nanotechnology in cancer therapy, Passive targeting of solid tumors: Pathophysiological principles, Physicochemical aspects of delivery systems, Active targeting strategies in cancer, Pharmacokinetics of nanocarrier, Multifunctional nanoparticles for cancer therapy, Neutron capture therapy of cancer, Nano-oncology, Nano-neurology, Nano-cardiology, Nano-orthopedics and Nano-ophthalmology.

References books:

1. Kewal K. Jain ,□ The Handbook of Nanomedicine □Humana Press, (2008).
2. Zhang, □Nanomedicine: A Systems Engineering Approach" 1st Ed., Pan Stanford Publishing, (2005).
3. Robert A. Freitas Jr., Nanomedicine Volume IIA: Biocompatibility□, Landes Bioscience Publishers, (2003).

GROUP-B
DSE - 4 Practical

DSE - 4 (P)

60 Lectures
Full Marks: 25
Time: 03 Hrs

One question is to be set.

Practicals:

1. Preparation of Cinnamic acid
2. Preparation of Acetanilide
3. Preparation of Aspirin and its analysis.
4. Preparation of Magnesium bisilicate (Antacid).

Or any other experiment carried out in the class.

Reference Books:

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

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Skill Enhancement Course
(Credit: 02 each) : SEC 1-2

SEC-1
Intellectual Property Rights and Technology
(Credits: 02)

Theory: 30 Lectures

Eight questions are to be set out of which five are to be answered.

Unit-I Basics of IP Law **(07 Lectures)**
Introduction, Background and concepts, Brief history of institutions, Investing in knowledge, Market failures in knowledge, Public sponsorship and prize, Basics of IP Law, Means of IP protection, Patents, Copyrights, IP and antitrust.

Unit-II Design of IP **(07 Lectures)**
Optimal design of IP, Scarce ideas vs. Non-scarce ideas, Policy levers in IP design, Required inventive steps, Optimal size of reward and structure, Entry cost regime, Horizontal competition regime, Economic effects of exemptions.

Unit-III Licensing and Joint Venture **(08 Lectures)**
Licensing, Joint ventures and competition policy, Licensing vs. product sale, Licensing for productive efficiency, New product innovation vs. cost reduction innovation, Mergers, Ex Ante: R&D Joint ventures, Ex Post: Patent pool, Collective rights management organization

Unit-IV Litigation and Enforcement **(08 Lectures)**
Litigation and enforcement, Remedies for infringement, Enforcement of IP by technical means, Limited sharing of copyrighted works, Technology transfer, Diffusion and adoption, Business strategies, System competition vs. standard competition

Reference Book :

1. Innovation and Incentives, Suzanne Scotchmer, MIT Press 2004.
2. Industrial Organization: Contemporary Theory & Practice, 3e, Pepall, D. J. Richards, and G. Norman, South-Western 2005.

SEC-2
Social Implications of Nanotechnology
(Credits: 02)

Theory: 30 Lectures

Eight questions are to be set out of which five are to be answered.

Unit-I Economic Impact of Nanotechnology **(10 Lectures)**

Socio-economic impact of nanoscale science, Managing the nanotechnology revolution : Consider the malcolm, Transcending Moore's law with molecular electronics and nanotechnology, Semiconductor scaling as a model for nanotechnology commercialization, Sustaining the impact of nanotechnology, Innovations for social research, Nanotechnology : Societal implications, Nanotechnology and social trends.

Unit-II Converging Technologies and Governance **(10 Lectures)**

Implications on Quality of Life, Management of Innovation for convergent technologies, The 'Integration/Penetration model', Social impacts of nanotechnology issues, Analogies for interdisciplinary research, Innovation, Legal risks and society.

Unit-III Ethics and Law **(10 Lectures)**

Ethical issues in nanoscience and nanotechnology, Ethics and law in a new frontier, An Exploration of patent matters associated with nanotechnology, Negotiations over quality of life in the nanotechnology initiative.

Reference Book

1. Mihail C. Roco and William Sims Bainbridge, "Nanotechnology: Societal Implications II – Individual Perspectives", Springer Publishers, Sponsored by National Science Foundation.