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UNIVERSITY OF MYSORE

Estd. 1916

VishwavidyanilayaKaryasoudha
Crawford Hall, Mysuru- 570 005

No.AC2(S)/319/2023-24

Dated: 08.11.2023

Notification

Sub:- Revised Syllabus of M.Tech. in Material Science (PG) programme with effect from the Academic year 2023-24.

Ref:- 1. Decision of Board of Studies in of M.Tech. in Material Science (PG) held on 11-02-2023.
2. Decision of the Faculty of Science & Technology meeting held on 15-03-2023.
3. Decision of the Academic Council meeting held on 24-03-2023.

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The Board of Studies in M.Tech. in Material Science which met on 11-02-2023 has resolved to recommended and approved the revised syllabus of M.Tech. in Material Science (PG) Programme with effect from the academic year 2023-24.

The Faculty of Science & Technology and Academic Council at their meetings held on 15-03-2023 and 24-03-2023 respectively has also approved the above said revised syllabus. Hence, it is hereby notified.

The syllabus contents may be downloaded from the University Website i.e., www.uni-mysore.ac.in.

Registrar
Registrar
University of Mysore
Mysore

To;

1. The Registrar (Evaluation), University of Mysore, Mysuru.
2. The Chairman, BOS/DOS in M.Tech. in Material Science, Manasagangothri, Mysuru.
3. The Dean, Faculty of Science & Technology, DoS in Mathematics, MGM.
4. The Director, PMEB, Manasagangothri, Mysuru.
5. Director, College Development Council , Moulya Bhavan, Manasagangothri, Mysuru.
6. The Deputy Registrar/Assistant Registrar/Superintendent, Administrative Branch and Examination Branch, University of Mysore, Mysuru.
7. The PA to Vice-Chancellor/ Registrar/ Registrar (Evaluation), University of Mysore, Mysuru.
8. Office Copy.

2023-2024

UNIVERSITY OF MYSORE
MANASAGANGOTRI, MYSORE 570006

Course structure and revised syllabus

For

M.Tech Program in Materials Science

Course Structure and Syllabus:

M.Tech. Program in Materials Science

Admission Eligibility Qualification	**Degree after the Program**	**Hard Core credits (including project)**	**Soft core credits**	**Total credits**	**No. of Years**
B.Sc (Physics, chemistry, Geology, Polymer, Biochemistry, Biotechnology, Microbiology, Botany, Zoology, Environmental science, Sericulture, Computer science, Food Science, Mathematics, Statistics, Forensic Science)	M.Tech.	60	46-50	110	3 years
B.Sc (Physics, chemistry, Geology, Polymer, Biochemistry, Biotechnology, Microbiology, Botany, Zoology, Environmental science, Sericulture, Computer science, Food Science, Mathematics, Statistics, Forensic Science)	M.Sc. (optional exit)	50	22-26	76	2 years
B.E/ MBBS/ B.Tech/ B.Pharma/ BDS/ BSc(Ag)(any branch)	M.Tech.	52	12	64	2 years
M.Sc(Physics, chemistry, Geology, Polymer, Biochemistry, Biotechnology, Microbiology, Botany, Zoology, Environmental science, Sericulture, Computer science, Food Science, Mathematics, Statistics, Forensic Science, Nanotechnology)	M.Tech.	52	12	64	2 years

Terms and Conditions:

Total number of seats: 30
Admission is purely based on all India basis.
Admission is purely based on the marks obtained in the entrance exam.
(Syllabus will be specified by the board of studies. The question paper for entrance examination contains four parts each containing Physics, chemistry, Mathematics and Biology. Out of which the candidate can opt for any two parts.)
Other admission regulations are as per the CBCS regulations of University of Mysore 2010.
Project internship can be pursued in any reputed lab or industry or institution in India or abroad.
Odd semester will be during August/September to December/Jan
Even semester will be during Feb/March to June/July. Valuation process is continuous and internal.
This course is essentially an M.Tech Program like any other M.Tech Programs and provision for open electives is not created explicitly. However, if any candidate is interested, he/she can avail the benefit of registration for extra credits to take up open electives.
As and when the new soft core papers are approved by the BOS, the advantage is extended to the students in the higher semester as well along with the incoming students.

Scheme of Evaluation

Each student shall be evaluated continuously by means of tests and/or assignments. There will be two tests: C1 in the eighth week and C2 in the sixteenth week of the semester. A final examination C3 will be held around eighteenth week.

The C1 and C2 tests will be for 25 marks each and C3 will be for 50 marks. If marks scored in C1+C2 is less than 30%, the student is not allowed to take C3. If the attendance is less than 75% the student is not allowed to take C3.

C1 and C2 tests will be for 1 hour duration. C3 examination will be for 2 hrs duration. Practical tests/examinations will be for 4 hours respectively.

Make up Examination and Re-Appearances for C3 Examination

If a student scores less than 30% in C3, he can take the make-up examination before one month after the announcement of the results with prior information to the department.

If he/she again fails to clear the examination, such students can Re-register for that paper/papers in the department and attend the classes with the regular students of odd and even semesters respectively. This is allowed up to VIII semesters minus the IV semesters of the course (double the duration of the course)

Note: While Re-registering, make sure that per semester with re registration shall not exceed a total of 24 credits for the odd and even semesters.

Hard core courses for M.Tech. Materials Science program.

CODE	Paper title	Core	Credits			
			Lecture	Tutorial	Practical	Total
MSH-1	Introduction to Materials (I-Sem)	Hard	3	1	0	4
MSH-2	Thermodynamics and Statistical Mechanics (I-Sem)	Hard	3	1	0	4
MSH-3	Materials Preparation Techniques (II-Sem)	Hard	3	1	0	4
MSH-4	Methods of Materials Characterization (II-Sem)	Hard	3	1	0	4
MSH-5	Spectroscopic Techniques for Materials (II-Sem)	Hard	3	1	0	4
MSH-6	Physics and Chemistry of Materials (III-Sem)	Hard	3	1	0	4
MSH-7	Materials and Environmental Effects (III-Sem)	Hard	3	1	0	4
MSH-8	Characterisation lab-1	Hard	0	1	3	4
MSH-9	Characterisation lab-2	Hard	0	1	3	4
MSH-10	Characterisation lab-3	Hard	0	1	3	4
MSH-11	Characterisation lab-4	Hard	0	1	3	4
MSH-12	Characterisation lab-5	Hard	0	1	3	4
MSH-13	Minor Project	Hard	0	1	5	6
MSH-14	Major Project (Only for M.Tech. exit)	Hard	0	2	8	10
		Total : (M.Tech-exit) (For B.E. background)				56
		For B.Sc., background				64

Soft core courses for M.Tech. Materials Science program

Code	Paper title	Core	Credits			
			Lecture	Tutorial	Practical	Total
MSS-1	Structure, Property and Functions of Materials	Soft	3	1	0	4
MSS-2	Basics of Chemistry	Soft	3	1	0	4
MSS-3	Nanoscale Devices	Soft	3	1	0	4
MSS-4	Nanochemistry	Soft	3	1	0	4
MSS-5	Carbon Nanotubes	Soft	3	1	0	4
MSS-6	Materials for Aerospace Applications	Soft	3	1	0	4
MSS-7	Composite Materials	Soft	3	1	0	4
MSS-8	Polymer Science and Cell Biology	Soft	3	1	0	4
MSS-9	Metals and Alloys	Soft	3	1	0	4
MSS-10	Nano-biotechnology in Health Care	Soft	3	1	0	4
MSS-11	Nano-photonics	Soft	3	1	0	4
MSS-12	Thermodynamic Modelling of Systems	Soft	3	1	0	4
MSS-13	Basics of Engineering Drawing and Graphics	Soft	3	1	0	4
MSS-14	Ceramics Science and Technology	Soft	2	2	0	4
MSS-15	Materials for Renewable Energy and Storage	Soft	3	1	0	4
MSS-16	Basics of Nanotechnology	Soft	3	1	0	4
MSS-17	Enterprise Architecture	Soft	3	1	0	4
MSS-18	Chemical Engineering	Soft	3	1	0	4
MSS-19	Advanced X-ray Diffraction Studies	Soft	3	1	0	4
MSS-20	Analytical and Inorganic Chemistry	Soft	3	1	0	4

MSS-21	Semiconductor Optoelectronics	Soft	3	1	0	4
		Total soft credits available to choose				84

MSH-1: Introduction to Materials: 4 Credits (Hard core) Total: 48 hrs

Unit-I: Materials through ages

Introduction to Material Science, The Relationship of Science and Technology, How is Basic Science Linked to Everyday Materials , A Short History of Materials Science, Classification of Materials, Advanced Materials, Modern Materials' Needs. Materials through ages - Palaeolithic to Modern period. Bulk, fine and Nanomaterials, Crystalline - Functional materials, Smart Materials, Centrosymmetric and Non-centrosymmetric materials, Amorphous, Glasses, Metals, Alloys, Semiconductors - types of semiconductors, Opto-electronic, Polymers, Ceramics, Bio-materials Polymer, Blends, Composites.

12 hours

Unit-II: Crystal Structure

The Structure of Crystalline Solids, Crystallographic Directions, Crystallographic Planes, Linear and Planar, Densities, Concepts of space lattice, Unit Cells and miller indices, Seve crystal system and various crystal forms. Metallic, Crystal Structures Density Computations, Polymorphism and Allotropy, derivation of 32 Crystal Systems, Point Coordinates, Close-Packed Crystal Structures, Crystalline and Noncrystalline Materials, Single Crystals, Polycrystalline Materials. **12 hours**

Unit-III: Crystal Diffraction and Reciprocal Lattice (Qualitative)

Bragg's Law, Laue Equations, Reciprocal Lattice, Braggs Condition, Brillouin Zones,Atomic Scattering, Geometrical Structure Factor, Experimental X-Ray Diffraction, Methods of Crystal Structure, Laue Method, Rotary Crystal Method, Powder Method or Debye- Scherrer Method, Weber-Feckner Method. **12 hours**

Unit-IV:Fundamental concepts of Bonding

Atomic Structure and Interatomic Bonding,Ionic bonding, covalent Bonding, Metallic Bonding, Van Der Wall Bonding. Atomic and Ionic radii, Pauling - Ahrens radii of common atom and ions.Spheres in closest packing Cubic closest packing, Hexagonal closest packing, Body centered cubic packing.Voids in closest packing. Imperfections in crystals - Crystal defects,point, line, surface /volume defects.

12 hours

References

1. Murugesan R, Modern Physics, S. Chand & Company, 9/e.Rev. Edn. 2003, EN8305SC011.
2. Arthur Beiser, Modern Physics, Addison Wesley Longman Publishing Co (January 1968) ISBN-10: 0201005158
3. Leonid Azaroff, An Introduction to Solids, McGraw-Hill Companies; New edition (1984)
4. Charles Kittel, Introduction to Solid State Physics, John Wiley & Sons, UK 7th Edition (1995)
5. Donald E. Sands, Introduction to Crystallography, Dover Publications, (1994).
6. Darrell Irvine and Nicola Marzari, Fundamentals of Materials Science, MIT Open Course Ware Publications (2005).

MSH-2: Thermodynamics and Phase Equilibria 4 Credits (Hard core) Total: 48 hrs

Unit-I: Kinetic Theory and Gas Laws

Kinetic Theory of Matter, Different States of Matter, Concept of Ideal or Perfect Gas, Kinetic Theory of Gases, Expression for the Pressure of a Gas, Kinetic interpretation of Temperature.

12 hours

Unit-II: Equation of State

Derivation of Gas Equation, Derivation of Gas Laws, Avogadro's Hypothesis, Graham's Law of Diffusion of Gases, Degree of Freedom & Maxwell's Law of Equipartition of Energy, Mean Free Path, Van-der Waals Equation of State, Critical Constants, Corresponding States, Critical Coefficient. **12 hours**

Unit-III: Phase equilibrium

Basic concepts of phase, components, Degrees of freedom. Concept of equilibrium and equilibrium constant, Phase rule and its application to One, two and three component systems with examples. concept of levers rule and its application to phase diagrams. solid solution - complete and partial solid solution. miscibility and immiscibility. **12 hours**

Unit-IV: Laws of Thermodynamics

Basic concepts and conventions, system and surrounding, Macroscopic physical properties, Time dependent and time independent processes, First law of thermodynamics – expressions for heat and work, Enthalpy, Heat capacity, heats of formations and heats of reactions. Second law of thermodynamics, types of disorders and concept of Entropy and derivation of expressions of entropy.Gibbs free energy, derivation of expression of free energy as function of P and T, Clapyeron equation, partial molar quantities, chemical potential, fugacity and activity. Application of thermodynamics for phase equilibrium studies.

12 hours

References

1. Richard E. Sonntag and Claus Borgnakke, Introduction to Engineering Thermodynamics, Wiley; 2 edition (March 3, 2006), ISBN-10: 0471737593.
2. Ken A. Dill and Sarina Bromberg, Molecular Driving Forces: Statistical Thermodynamics in Chemistry and Biology Garland Science. (Taylor & Francis Group), 2003.
3. Statistical Mechanics by SL Gupta and V Kumar (2011) Pragati Prakashan, India

MSH-3: Materials Preparation Techniques 4 credits (Hard core) Total 48 hours

Unit-I

Solid state routes; Nucleation; Role of impurities; Mechanical mixing; Grinding; Solid solution techniques. Top-Down reactions. Rate of crystallization. High temperature processes – heating, annealing, sintering treatment; Sputtering, Spin Coating.

12 hours

Unit -II

Evaporation; precipitation; Solution growth; Nucleation; Rate of crystallization; Superstaturation; Top seeded solution growth; sol-gel techniques; high temperature solution; Hydrothermal; Solvothermal methods; Ammonothermal method; Glycothermal; Melt methods- super cooling, Czechorlskii methods; Skull melting.

12 hours

Unit -III

Vapour phase methods - Thin films, epitaxial growth, substrates selection, career gases, metastable growth of materials. Chemical Vapour Deposition - Principles, apparatus, examples of CVD growth of thin films, advantages and disadvantages; Chemical Vapour Transportation; Molecular Beam Epitaxy, Liquid Phase Epitaxy, Vapour growth of Nitrides. Metal-organic Vapour phase epitaxy. Plasma Energetics; Laser ablation.

12 hours

Unit -IV

Biological synthesis, Biomimetic method,bacterial synthesis of nanoparticles; Electrochemistry - solvent selection, apparatus, deposition, growth of thin films, coatings, examples; Multi-energy processing - Mechanochemical; Sonochemical; Photochemical; Biochemical, Microbial, Organic synthesis. Growth of organic crystals.

12 hours

References:

1. Springer Handbook of Crystal Growth; Eds: G. Dhanraj, K. Byrappa, V. Prasad, M. Dudley, Springer Verlag (2010)
2. Springer Handbook of Nanotechnology; Eds: Bharath Bhushan, Springer Verlag, 2nd Edition (2009).
3. Handbook of Crystal Growth, K. Byrappa and T. Ohachi, Springer-Verlag (2003).
4. Growth of Single Crystals, R.A. Laudise, Prentice-Hall (1973).
5. Growth and Characterization of Technologically Important Crystals, By: K. Byrappa, R. Fornari, T. Ohachi, H. Klapper, Allied Sciences, New Delhi (2003).

MSH-4: Methods of Materials Characterization 4 credits (Hard core) Total: 48 hrs

Unit-I

Thermal analysis; TGA; DTA; DSC; Basic principle. Differences between DTA and DSC. Instrumentation-power compensated DSC, heat flux measurement in DSC. Applications testing the purity and characterizations of various materials (Polymeric, Pharmaceutical, Agricultural materials) Thermo mechanical analysis, Dynamic mechanical analysis, dilatometry; (Thermal expansion) Principles and applications.

12 hours

Unit-II

Microscopic techniques, Phase Contrast Microscopy – Principles, types, hot stage microscopy,Electron imaging techniques; Scanning Electron Microscopy; principle, instrumentation, measurement and analysis; Tunnelling Electron Microscopy; principle, instrumentation, measurement and analysis, Field Emission SEM; Scanning Tunnelling Microscopy; Atomic Force Microscopy; principle, instrumentation, measurement and analysis; Scanning Probe Microscopy; High Resolution TEM; principle, instrumentation, measurement and analysis, High Resolution SEM; principle, instrumentation, measurement and analysis. **12 hours**

Unit-III

Particle size measurement; Basic principle of particle analysis, equivalent sphere model,D[1,0], D[3,2] and D[4,3] representations, conversion between length and volume/mass means, mean, median and mode statistics; Methods of measurement of particle size, XRD, optical and laser scattering techniques; surface area and porosity;

definition and meaning, measurement using BET method , adsorption isotherms, DC polarization, AC impedance measurements. **12 hours**

Unit-IV

Photoluminescence, principle of working, instrumentation and measurement; demonstration of band gap measurement using PL spectrometer; Positron Annihilation Lifetime Spectroscopy; Basics of positron annihilation, the sources of positrons, three methods of positron annihilation techniques; lifetime, Doppler broadening and angular correlation methods, Application of lifetime spectroscopy for the fee volume determination in polymers and polymer nanocomposites. Non-linear electro-optical properties of materials, mechanical properties, tensile strength, micro hardness; zeta potential. **12 hours**

References

1. Sam Zhang, Lin Li and Ashok Kumar, Materials Characterization Techniques, CRC Press, (2008)
2. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Wiley & Sons (2008)
3. Elton N. Kaufmann, Characterization of Materials, Vol.1, Wiley & Sons (2003)
4. R.A. Laudise, Growth of Single Crystals, Prentice Hall, (1973)
5. G. Dhanaraj, K. Byrappa, V. Prasad and M. Dudley (Eds.), Springer Handbook of Crystal Growth, Springer-Verlag (2010)
6. Peter E.J. Flewitt and R.K. Wild, Physical Methods of Materials Characterization, 2nd Edition, Taylor & Francis (2003)

MSH-5: Spectroscopic Techniques for Materials 4 credits (Hard core) Total: 48 hours

Unit I

UV-Visible spectroscopy: Modes of electronic excitations, simple chromophoric groups–systems of extended conjugation, aromatic systems. Types of auxochromes–functions of auxochromes, absorption and intensity shift. Types of transition probability, types of absorption bonds, solvent effects and choice of solvent. Effect of polarity on various type of bonds, Woodwards empherical rules for predicting the wavelength of maximum absorption: - Olefins, conjugated dienes, cyclic trienes and polyenes, α,β-unsaturated aldehydes and ketones, benzene and substituted benzene rings.

IR spectroscopy: Principles, Hook's law, characteristic group frequencies and skeletal frequencies. Finger print region. Identification of functional groups: Alkenes, alkynes, aromatics, carbonyl compounds (aldehydes and ketones, esters and lactones), halogen compounds, sulphur and phosphorous compounds, amides, lactams, amino acids, and imines. Factors affecting group frequencies and band shapes, conjugation, resonance and inductance, hydrogen bonding and ring strain, tautomerism, cis-trans isomerism. Applications of IR spectra to co-ordinatation compounds, organotransition metal complexes (N,N-dimethyl acetamides, urea, DMSO, NO_3^-, SO_4^{--}, NO_2^-) **12 hours**

Unit II

Nuclear magnetic resonance spectroscopy: General introduction and defination, magnetic properties of nuclei (magnetic moment, g factor) and theory of nuclear resonance. Larmor precession frequency, resonance condition and relaxation processes.

Chemical shift: Standards employed in NMR, factors affecting chemical shift, electronegativity, shielding and deshielding mechanism, Vander waals deshielding, H-bonding, diamagnetic and paramagnetic anisotropics. Spin-spin coupling, chemical shift values and correlation for protons bonded to carbon and other nuclei. Instrumentation and sample handling.

Equivalence and magnetic equivalence proton exchange reactions, effects of chiral center, complex spin-spin interaction, stereochemistry, hindered rotation, Karplus curve-variation of coupling constants with dihedral angles. Simplification of complex spectra: isotopic substitution, increasing magnetic field strength, double resonance, spin decoupling, constant shift reagents, solvent effect, Fourier-transfer technique, variable temperature profile, nuclear overhauser effect (NOE). **12 hours**

Unit III

Mass spectrometry: Principles, instrumentation, different methods of ionization, EI, CI, FD and FAB, ion separators: single focusing separator with magnetic diffraction, focusing analyzer, time-of–flight separator and quadrupole analyzer. Mass spectra: molecular ion, base peak, meta-stable peak, nitrogen rule and McLafforty rearrangement. Mass spectral fragmentation of organic compounds and common functional groups: normal and branched alkanes, alkenes, cycloalkanes, benzene and its derivatives, alcohols, phenols, aldehydes and ketones, carboxylic acids, and their derivatives, amines, nitrocompounds. Determination of molecular formula by accurate molecular weight and isotopic abundance methods. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

LC-MS, LC-MS/MS, GC-MS: Principles and applications

Composite problems involving the applications of UV, IR, and 1H -NMR and mass spectroscopic techniques. **12 hours**

Unit IV

Electron Spin Resonance Spectroscopy: Basic principles, hyperfine couplings, the ‘g’ values, factors affecting ‘g’ values, isotropic and anisotropic hyperfine coupling constants, Zero Field splitting and Kramer’s degeneracy. Measurement techniques and Applications to simple inorganic and organic free radicals and to inorganic complexes.

Mössbauer spectroscopy: The Mössbauer effect, chemical isomer shifts, quadrupole interactions, measurement techniques and spectrum display, application to the study of Fe^{2+} and Fe^{3+} compounds, Sn^{2+} and Sn^{4+} compounds(nature of M-L bond, coordination number and structure), detection of oxidation states and inequivalent Mössbauer atoms.

Photoelectron spectroscopy (PES): Brief theoy, principle of working, instrumentation and data acquisition analysis. **12 hours**

REFERENCES:

1. Organic Spectroscopy-3rd Ed.-W.Kemp(Pagrave Publishers, New York), 1991.
2. Spectrometric Identification of Organic Compounds - Silverstein,Bassler & Monnill (Wiley) 1981.
3. Spectroscopy of Organic Compounds-3rd Ed.-P.S.Kalsi (New Age, New Delhi) 2000.
4. E.A.V.Ebsworth, D.W.H.Ranklin and S.Cradock: Structural Methods in Inorganic Chemistry, Blackwell Scientific, 1991.
5. J. A. Iggo: NMR Spectroscopy in Inorganic Chemistry, Oxford University Press, 1999. 6.

C. N. R .Rao and J. R. Ferraro: Spectroscopy in Inorganic Chemistry, Vol I & II (Academic) 1970

7. Spectroscopy, B. P. Straughan and S. Salker, John Wiley and Sons Inc., New Yourk,

Vol.2, 1976.
8. Application of Absorption Spectroscopy of Organic Compounds, John R. Dyer, Prentice/Hall of India Private Limited, New Delhi, 1974.
9. Organic Spectroscopy, V. R. Dani, Tata MeGraw-Hall Publishing Company Limited, New Delhi. 1995.
10. Interpretation of Carbon-13 NMR Spectra, F.W. Wehrli and T. Wirthin, Heyden, London, 1976.
11. NMR spectroscopy-Powai

MSH-6: Physics and Chemistry of Materials 4 credits (Hard core) Total: 48 hrs

Unit-I

Electromagnetic spectrum, application of accelerators for materials,Fermi energy in metals and semiconductors, Specific heat of solids, Conductivity and susceptibility of solids, Energy gap of semiconductors, Hall effect in metals and semiconductors, Quantum theory of metals, Quantized Hall effect. **12 hours**

Unit-II

Physical properties of materials Conductivity, density, refractive index, tensile strength, microstructure of bulk, small and nanoscale materials. Optical, Magnetic, Electronic, Semiconducting, Superconducting, Thermal, Electro-optic, Thermo-optic, Superionic, insulating properties of materials. **12 hours**

Unit-III

Statistical analysis of Analytical Data, measures of central tendency -Averages and moving averages, Measurements of dispersion, Moments ,skewness and kurtosis.Frequency distribution and Measures of central tendency using grouped data correlation and regression analysis error estimation and curve fitting. Tests of significance / hypothesis, t-test, f-test and χ^2test. Probability theory. **12 hours**

Unit-IV

Introduction to MX (NaCl, CsCl, ZnS) and MX2 (fluorite, rutile-crystobalite and cadmium iodide) types. The perovskite and spinel structures. Thermodynamics of ionic crystal formation. Lattice energy, Born-Haber cycle, Born-Lande equation. Applications of lattice energetics. Ionic radii, factors affecting the ionic radii, radius ratio rules. Electron deficient compounds:Diborane and its reactions, higher boranes, polyhedral boranes (preparations, properties, structure and bonding). Wade's rules, carboranes and metallocarboranes.

References

1. Pillai, Solid State Physics, Narosa Publication, India (2007)
2. J.I. Gersten and F.W. Smith, The Physics and Chemistry of Materials, Wiley & Sons (2001)
3. A. Navrotsky, Physics and Chemistry of Earth Materials, 6th Edition, (1995) Cambridge Series.

MSH-7: Materials and Environmental effects 4 Credit (Hard core) Total: 48 hrs

Unit-I

Corrosion– introduction, Electrochemistry of corrosion, Definitions and types, Forms of corrosion, Corrosion rates, Predictions of corrosion rates, corrosion environments, Passivity of environmental effect, Corrosion of metallic, ceramic, polymeric materials, Thermodynamic principles of corrosion, Electrochemical cells-Definitions and principles, General corrosion diagrams, Swelling and dissolution, Bond rupture, Weathering. Methods of corrosion prevention and control – Design, coatings and inhibition. **12 hours**

Unit-II

Electrochemical methods to Measure Corrosion: DC Polarization, linear polarization method, AC Impedance; Experimental measurement of corrosion Quantification of corrosion Environmentally Induced Cracking, Corrosion Fatigue, Hydrogen Induced Cracking. **12 hours**

Unit-III

Atmospheric Corrosion, Oxidation in Gaseous Environments, Ellingham Diagrams, Role of Protective Scale, Corrosion Prevention methods.Corrosion prevention by painting, phosphating and anodic (passivation) and cathodic protection.

12 hours

Unit-IV

Environmental effects from the chemical processes industries, infrastructure and transportation industry, Environmental protection and sustainable development, Energy saving materials, safety management. **12 hours**

References

1. D. A. Jones: Principles and Prevention of Corrosion, Macmillan Publ. Co. (1996).
2. C. Scully: The Fundamental of Corrosion, 2nd ed., Pergamon Press: E. E.Stansbury and R. A. Buchanan, Fundamentals of Electrochemical Corrosion, ASM International (2000)
3. M.G. Fontana: Corrosion Engineering, 3rd. Ed., McGraw Hill. (1986)
4. J. M. West: Electrodeposition and Corrosion Control, J. Wiley W. Revie (ed.): Corrosion Handbook, Electrochemical Society Series, John Wiley and Sons (2000).
5. W. Revie (ed.): Corrosion Handbook, Electrochemical Society Series, John Wiley and Sons, 2000: Metals Handbook, Vol. 13: Corrosion, ASM International

MSS-1: Properties of Materials 4 credits (Soft core) Total: 48 hrs

Unit-I: General Properties of Materials

Solid Solutions and Alloys: Phase Transitions: Overview of Crystal Structures: Structure - Property Relations: Neumann's Law: Thermal Properties: Optical Properties: Electrical Properties: Dielectric Properties: Magnetic Properties: Mechanical Properties.

12 hours

Unit-II: Polymers

Importance of polymers. Fundamentals of polymers-Monomers the repeat units, degree of polymerization. Linear, branched and network polymers. Classification of polymers. Polymerization-condensation, addition, free radical, ionic, co-ordination polymerization and ring opening polymerization. Molecular weight and Polydispersion. Average molecular weight concepts-number weight and viscosity average molecular weight. Practical significance of molecular weight. Size of polymer molecules. **12 hours**

Unit-III: Earths Materials

Basic components of earths Materials, Minerals & rocks- Physical properties of Minerals – density, specific gravity. Silicate structure, Description and classification of minerals – Oxides, Hydroxides Carbonates, Sulphides. and silicates. Solid solutions exsolution , polymorphism and isomorphism, Description of important rock types and ore minerals.

12 hours

Unit-IV: Biomaterials :

Carbohydrates, Nucleic acids, **membranes and cell wall** Protein, antibodies, Enzymes, Nucleotides, immobilization, functionalization methods for biomaterials (Antibody/enzyme/protein), encapsulation methods, Biodegradable polymers Bio-compatibility criteria, Toxicity evaluation (Inflammation, hypersensitivity, carcinogenesis). Application of biomaterials.

12 hours

References

1. R.E.Newnham, Properties of Materials: Anisotropy, Symmetry, Structure, Oxford University Press.
2. Buddy Ratner. Biomaterials Science. Second edition. Orlando, Academic Press, 2000;
3. Jonathan Black. Biological performance of materials: fundamentals of biocompatibility New York, Marcel Dekker, 1999
4. Joon Park and Joseph Bronzino. Biomaterials: Principles and Applications. Fort Lauderadale FL, CRC Press, 2003.
5. Ferry : Viscoelasticity properties of polymers
6. Aklonies,et al., An introduction of Viscoelasticity in polymers
7. Research and Development on Biosensors for food Analysis in India In: Advances in Biosensors M.S. Thakur and N.G. Karanth, 2003, Oxford University, Press, 2003.
8. From Bioimaging to Biosensors – Noble Metal Nanoparticles in Biodetection, by Lai-kwan Chau (National Chung Cheng University, Taiwan), Huan-Tsung Chang (National Taiwan University, Taiwan)
9. Advances in Biosensors, Volume 1, Reinhard Rennerberg and A.P.F. Turner, 1991.
10. Nanoparticles and Biophotonics as Efficient Tools in Resonance Energy Transfer-Based Biosensing for Monitoring Food Toxins and Pesticides, M. S. Thakur, Rajeev Ranjan, Aaydha C. Vinayak, Kunhitlu S. Abhijith, and Richa Sharma. Advances in Applied Nanotechnology for Agriculture, Chapter 4, 2013, pp 55-84, ACS Symposium Series, Volume 1143.

MSS-2 : Basics of Chemistry

Unit I:

Elements of quantum mechanics: Wave mechanical concept of the atom, dual nature of electron, derivation of de-Broglie's equation. Heisenberg's uncertainty principle and its significance. Schrodinger wave equation-explanation of the terms therein (no derivation) Eigen values and functions, significance of ψ and ψ^2. Quantum numbers and their significance. Shapes of s, p and d orbitals. Effective nuclear charge, screening effect-based on Slater's rules (problems to be worked out). General energy level diagram of multi electron atom (up to n=4). Pauli's exclusion principle, Hund's rule, (n+1) rule, Aufbau principle.

Periodic Table and Periodicity: Classification of elements into s, p, d, and f-blocks, cause of periodicity. Detailed discussion of the following periodic properties of elements with examples: Atomic radius, Ionization enthalpy, Electron gain enthalpy and Electronegativity**.**

Chemical bonding: Ionic bond, Covalent bond, Coordinate bond, metallic bonding and hydrogen bonding. **12 hours**

Unit II:

Hybridization: Tetravalency of carbon, sp^3, sp^2 and sp – hybridization (in brief). Bond length, bond angle, bond energy, localized and delocalized chemical bonds – resonance and hyperconjugation effects.

Types of organic reactions: Definition with examples of addition, substitution, elimination, isomerisation, oxidation, reduction, condensation and rearrangement reactions.

Stereochemistry: Introduction, definition, elements of symmetry (plane, centre, simple axes and alternative axes), asymmetry and dissymmetry, Chirality, designation of configuration – R-S notation. Optical activity – explanation – cause of optical activity (non-super impossibility). Enantiomers and diastereomers optical isomerism in tartaric acid and biphenyls, racemisation, resolution, methods of resolution (Chemical and biochemical methods) Walden inversion, asymmetric synthesis (partial and absolute).

Geometrical isomerism: Definition with example, designation of cis-trans and E-Z notations with examples. Geometrical isomerization of aldoximes and ketoximes,

12 hours

Unit III

Colligative Properties: Concept of vapour pressure, variation of vapour pressure with temperature. Definition of boiling point and freezing point, effect of dissolution of solute on the vapour pressure of the solvent. Lowering of vapour pressure. Raoult's law – relation between relative lowering of vapour pressure and molar mass (to be derived). Determination of relative molar mass of solute by dynamic method. Elevation of boiling point and its relation to lowering of vapour pressure and molar mass (to be derived). Ebullioscopic constant of the solvent and its relation to the boiling point (only equation). Determination of molar mass of the solute by Walker-Lumsden method. Depression in freezing point and its relation to lowering of vapour pressure and molar mass (to be derived). Cryoscopic constant and its relation to the melting point (equation). Determination of molar mass of a non-volatile solute by Beckmann's method (problems to be worked out).

Semi permeable membrane – natural and artificial, preparation of copper ferrocyanide membrane by Morse-Frazer method. Definition of osmosis, osmotic pressure (mention application), determination of osmotic pressure by Berkley-Hartley's method, laws of osmotic pressure analogy with gas laws, determination of molar mass from osmotic pressure measurements (relation to be derived), isotonic solutions, plasmolysis. **12 hours**

Unit IV

Indicator – Definitions, types (acid-base, redox, adsorption indicators), examples for each type. Theory of indicators – Oswald's theory and Quinonoid theory – indicator constant – action of phenolphthalein and methyl orange in acid-base solutions – pH titration curves for strong acid vs strong base, weak acid vs strong base, weak base vs strong acid, choice of indicators in these types of titrations – color change and pH range. Universal indicator – definition.

Chromatography: i. Paper: introduction to ascending, descending and circular, R_f value and it's applications; ii. **TLC:** Introduction and applications; iii. **Column Chromatography:** Introduction, principle and experimental details and applications; iv. **Gas Chromatography:** Introduction, apparatus, programmed temperature gas chromatography, quantitative analysis of GLC and v. **HPLC:** Introduction, schematic diagram of instrumentation and application.

12 hours

Reference:

1. Basic Inorganic Chemistry – 3rd edition. F.A. Cotton, G. Wilkinson and P.L. Gaus, John Wiley and Sons (2002).

2. Inorganic Chemistry, 3rd edition. James E. Huheey, Harper and Row Publishers (1983).
3. Inorganic Chemistry, 3rd edition. G.L. Miessler and D.A. Tarr, Pearson Education (2004).
4. Inorganic Chemistry, 2nd edition. D.F. Shriver, P.W. Atkins and C.H. Langford, Oxford University Press (1994).
5. H. Pine, Hendrickson, Cram and Hammond, Organic Chemistry, Mc Graw Hill, New York, 1987.
6. I.L. Finar, Organic Chemistry, ELBS Longmann, Vol. I & II, 1984.
7. R.K. Bansal, Organic Reaction Mechanism, Wiley Eastern Limited, New Delhi, 1993.
8. J. March, Advanced Organic Chemistry, Wiley Interscience, 1994.
9. Physical Chemistry by P.W. Atkins, ELBS, 5th edition, Oxford University Press(1995).
10. Text Book of Physical Chemistry by Samuel Glasstone, MacMillan Indian Ltd., 2nd edition (1974).
11. Elements of Physical Chemistry by Lewis and Glasstone.
12. Fundamentals of physical chemistry – Maron and Lando (Collier Macmillan) 1974.

MSS-3: Nanoscale Devices 4 credits (Soft core) Total: 48 hrs

Unit - I Processing

Silicon Processing methods- Cleaning / Etching- Oxidation- Gettering- Doping-Epitaxy-Sputtering-Chemical Vapor Deposition (CVD), Plasma Enhanced CVD- Reactive Ion Etching (RIE)- Moore's law-Design rules for 45nm, 32nm, and beyond- Semiconductor device roadmap- Silicon -insultaor technology- Gate of high -K dielectrics

12 hours

Unit –II Fabrication

Thermal manufacturing - Rapid Thermal Processing and beyond: Applications in Semiconductor Processing of Complimentary Metal Oxide Semiconductor. Memory devices – Volatile and Non-volatile memory. The material challenge of Ultra thin body (UTB) - metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) for technology. Insulated-gate field-effect transistor (IGFET). 3D inter-connect technology.

12 hours

Unit -IIILithographic Techniques

Top down approach to nanolithography-Immersion lithography- Optical lithography, UV photolithography- Phase lithography- Including Plasma X-ray sources- E-Beam Lithography-Focused Ion beams- Photoresist. Soft lithography for nanofilms and nanoscale patterning. Lithographic techniques and surface chemistry for the fabrication of PEG-passivated protein microarrays. **12 hours**

Unit -IV Fabrication of Nanostructures

Si-Ge-Si-C , Diamond,-Synthesis- Defects and properties on the nanoscale-Bottom up approach- Chemical self assembly- Properties of nanoparticles, Nanoclusters, Nanotubes, Nanowires, Nanoflowers, and Nanodots. Invention jet prints nanostructures with self-assembling material. Surfaces, Interfaces and Thin films. Fabrication of nanostructures using polymer brushes. Top down fabrication of nanostructures. Template assisted nanostructure growth. Nanostructured Films on Silicon Surfaces, Deposition, Characterization and Application of Nanocrystalline Diamond Films, Boron Nitride films. **12 hours**

References:

1) Mark J Jackson, Micro and Nanomanufacturing , Springer; First Edition, (2006) ISBN-10:038725744
2) Dieter K, Schroder, Semiconductor Material and Device Characterization, Wiley-IEEE Press, 3rd Edition, (2006) ISBN-10:0471739065
3) L. B. Freund and S Suresh, Thin film materials: Stress, Defect formation and surface Evolution, Cambridge University Press, (2004) ISBN-10:0521822815
4) Zheng Cui, Micro-nanofabrication: Technologies and Applications, Springer First Edition (2006), ISBN-10:3540289224
5) R. Kassing, P. Petkov, W. Kulish, C. Popov., Functional Properties of Nanostructured Materials. Springer (ISBN: 978-1-4020-4595-0 (Print) 978-1-4020-4594-3 (Online)

MSS-4: Nanochemistry 4 Credits (Soft core) Total: 48 hrs

Unit-I Fundamentals of molecular self-assembly

The nanoscale and colloidal systems-Fundamentals of Surface and interfacial chemistry-Suraface tension and Wettability-Insoluble monolayers-Surface Chemistry and monolayers-Electrostatic interactions in self assembling systems-Self-Assemble of amphiphiles-Monolayers-Micelles and microemulsions-the Structure and properties of Micelles.

12 hours

Unit-II Nanomaterials

Defining nanodimensional materials-Sice effects in Nanomaterials-Application and technology development-Supramolecular machines-Fundamentals of energy transfer and photon motion manipulation-Solar energy harvesting-Fundamentals of electron motion manipulation-Electron pumping and molecular wires-General methos available for the synthesis of nanomaterials-Manipulation o Nanopartices-Nanofabrication-Methods- Bottom up methods- Photolithography-Scanning probe methods-Soft lithography

12 hours

Unit-III Dendrimersand their applications

PPI and PAMAM dendrimers, Synthesis-Generation 1 and Generation 2, Application in Drug tergetting. **12 hours**

Unit-IV Functionalization and applications of Nanomaterials

Chemical functionalization - Recent advances in Thiol-Au and Silane Chemistry- Layer-by-Layer synthesis of multilayer assemblies Applications - Quantum dots - nanocores and applications. Detailed description of the fabrication of functinalised Gold Nanocores and their application in cancer therapy.**12 hours**

References

1. The chemistry of nanomaterials Volume 1, Synthesis, Properties and Applications: Edited by CNR Rao, A Muller, A K Cheetham; (2005) John-Wiley and Sons, Inc, ISBN:3-527- 30686-2
2. The chemistry of nanomaterials Volume 2, Synthesis, Properties and Applications: Edited by CNR Rao, A Muller, A K Cheetham; (2005) John-Wiley and Sons, Inc, ISBN:3-527- 30686-2

MSS-5: Carbon Nanotubes 4 Credits (Soft core) Total: 48 hrs

Unit-I Introduction and Morphology

Carbon allotropes , Fullerenes, Discovery of carbon nanotubes, Single and double walled carbon nanotubes, Bundled Nanotubes. The structure of carbon nanotubes: From a Graphene Sheet to a Nanotube - Archiral and Chiral Nanotubes, theoretical discussion, experimental studies, ZigZag and Armchair Nanotubes - Eulers Theorem in Cylindrical and Defective Nanotubes. **12 Hours**

Unit-II Production Techniques of Nanotubes

Carbon nanotube production: Arc discharge, Laser ablation, Chemical vapour deposition, Hydrothermal, Miscellaneous synthesis methods. Growth mechanism of Multi/Singlewalled nanotubes by arc discharge and Chemical vapour deposition method. Role of Metal Catalyst, High- Pressure CO Conversion (HIPCO), Experimental Puzzles of MWNT - Aspect Ratio-Perfection-chemical inertness. Purification and processing of MWCNTs and SWCNTs, separation of metallic and semiconducting SWCNTs**.** **12 Hours**

Unit- III Electrochemical properties and functionalization of Nanotubes

Electronic properties of SWCNTs, Electrode potentials versus work functions, electrochemistry of Carbon nanotubes, cyclic voltammetric investigations of SWCNTs, Standard redox potentials of SWCNTs. Physical properties: theoretical and experimental predictions of mechanical properties, optical properties of nanotubes, raman spectroscopy. Covalent functionalization: Chemical functionalization, Defect group functionalization, Direct sidewall functionalization. Noncovalent functionalization: with small aromatic molecules, heterocyclic polyaromatic systems, polymers, surfactants and ionic liquids. **12 Hours**

Unit-IV Applications of Nanotubes

Catalytic: Macroscopic shaping of CNTs, specific metal support interaction, dispersion of the active phase, electrically and thermally conductive supports. Biomedicine: cell penetration, drug delivery, gene delivery, anticancer approaches, antioxidants properties, toxicity. Probes and Sensors: nanotube tips for atomic force microscopy, gas sensors, biosensors, physical sensors. Containers: mechanisms of nanotube filling, fullerene C_{60}, higher fullerenes, endohedral fullerenes, functionalized fullerenes, molecules without metal atoms, organometallic and coordination compounds, oxides and hydroxides, inorganic materials. Effect of Doping on conductivity - Harnessing Field Enhancement - Flat Panel Displays **12 hours**

References

1. Dirk M. Guldi and Nazario Martin, Carbon nanotubes and related structures
2. Peter J. F. Harris, Carbon nanotube science.
3. M.Endo, S.Iijima, M.S. Dresselhaus, Carbon Nanotubes, Pergamon; Ist Ed Edition (December 1st 1996), ISBN-10: 0080426824
4. Ado Jorio, Mildred S. Dresselhaus, and Gene Dresselhaus Carbon Nanotubes: Advanced Topics in the Synthesis, Structure, Properties and Applications, Springer; 1 edition (April 20,2001) ISBN-10: 3540410864

MSS-6: Materials for Aerospace Applications 4 credits (soft core) 48 hours

Unit I: **Introduction to aerospace materials**

The importance of aerospace materials, understanding aerospace materials, the main types of polymer based aerospace materials, advantages of polymer based materials, High performance like light weight and other important properties of materials for aerospace applications including modified structures on nano-scale materials. **12 hours**

Unit II: Polymers for aerospace structures

Aerospace applications of polymers, advantages and disadvantages of polymers for aerospace applications, Polymerization routes, Thermoset, Thermoplastics and elastomers, Structural adhesives, Mechanical properties, Polymer additives, Polymers for radar absorbing materials, Fracture toughness properties, Ductile/brittle fracture transition for polymers, Improving the fracture toughness of aerospace materials. **12 hours**

Unit III: Manufacturing of fibre-polymer composite materials

Fibre reinforcements for composites, Production of prepregs and fabrics ,Core materials for sandwich composites, Composites manufacturing using prepregs, Composites manufacturing by resin infusion, Machining of composites , Damage mechanics of composites. Fracture processes, Stress concentration effects in materials, Fracture mechanics, Application of fracture mechanics to aerospace materials. **12 hours**

Unit IV: Fibre-polymer composites for aerospace structures and engines

Types of composite materials, Aerospace applications of fibre-polymer composites, Advantages and problems with using fibre-polymer composites, Mechanics of continuous fibre composites, Sandwich composites, Environmental durability of composites Fatigue stress, Fatigue life (S-N) curves, Fatigue crack growth curves, Fatigue of fibre-polymer composites, Creep behaviour of materials, Creep of polymers and polymer composites, Designing Creep resistant materials. **12hours**

References:

1. Mechanics of Fibrous Composites, C.T. Herakovich, John Wiley & Sons, Inc., New York, 1998
2. Analysis and Performance of Fibre Composites, B.D. Agarwal and L.J. Broutman, John Wiley & Sons, Inc. New York.
3. Fundamentals of Modern Manufacturing, Materials, Processing, and Systems, 2nd edition, Mikell P. Grover, John Wiley & Sons, inc.
4. Structure and properties of engineering materials, fifth edition, Henkel and Pense, McGraw Hill, 2002
5. Mechanical Testing of Advanced Fibre Composites, J.M. Hodgkinson, Woodhead Publishing Limited, Cambridge, 2000.
6. ASTM standards.

MSS-7: Composite Materials 4 Credits (Soft core) Total: 48 hrs

Unit-I: Introduction: Definition, Reason for composites, classification of composites, Raw materials, classification, Chemistry, Properties and applications. Matrix: Thermoplastics-Raw materials, Physical and chemical properties, Thermal behaviour and mechanical properties, Thermosets-Epoxy; Curing reactions, Hardener, Gel time Viscosity Modifications, Prepreg making, Unsaturated polyester resin; catalyst, curing reaction, Viscosity modifier, Alkyd Resin, Vinly ester, polyimides, Physical and chemical properties, Thermal behaviour, Mechanical Properties and uses, Elastomeric composites. **12hours**

Unit-II: Reinforcements; Types, Properties, Uses of silica, Titanium dioxide, Talc, Mica, etc., Flake, Fibres -Structure, property and applications of natural and synthetic fibres, organic and inorganic fibres. Example: Glass, Carbon, Aramid, Nylon, Boron, Aluminium carbide, Silk, Jute, Sisal, Cotton, etc, Coupling agents. **12hours**

Unit-III: Processing : Thermoplastic, Thermosets, etc., Types of methods, Processing conditions advantages and disadvantages, Film forming, Lamination, Sandwich, etc., Hand Layup methods, compression and Transfer molding, Pressure and Vacuum bag process, Filament winding, Spin coating, Pultrusion, Reinforced RIM, Injection molding of Thermosets, SMC and DMC, Factors affecting the performance of Composites. Testing of Composites; Destructive and non-destructive tests, Tensile, Compression, Flexural, ILSS, Impact strength, HDT, Basic Concepts of fracture mechanism. **12 hours**

Unit-IV: Composite product design, Fundamentals, Definitions, Structure -Material -Design relationships, Design methodologies, Material Considerations, Application of Composites-Aerospace, Transport, marine, Structural, Chemical and Corrosion resistant products, sports, electrical, Electronic, Communication, Biomedical Applications, Repairs and maintenance, etc., Nanocomposites: -Types, preparation, characterization and applications.

12 hours

References

1. Handbook of Composites by G. Lubin, Van Nostrand, New York, 1982.
2. Polymers and Polymer Composites in Construction L.C. Holleway,1990
3. Engineering plastics and Composites by John C.Bittence,1990
4. Handbook of Plastics, Elastomers and Composites by Charles A Harper,1975
5. Designing with Reinforced Composites - Technology Performance, Economics Rosato, 2nd ED.1997
6. Delwane Composite design Encyclopedia (Vol 3 Processing and Fabrication / Technology_ Ed. Leif A. Carlssen. and Joahn W. Hillispie, Technomic Publishing Ah. Lancaster U.S.A.
7. Fibre Glass Reinforced Plastics Nicholas P.Cheremisinoff and Composites Paul N.Cheremmisinoff., Noyes publications,N.J. U.S.A (1995)
8. Composite applications The Future is now, Thomas J. Drozdr, (Eds), Published by Society of Manufacturing Engineers, Michigan,1989.
9. Polymer Layered Silicate and silica nano Composites, Y.C.Ke,P.stroeve and F.s.Wang, Elesvier,2005
10. Hand Book of Plastics Testing Technology Vishu Shah, John Wiley & Sons, Inc NY. (1998)

MSS-8: Polymer Science and Cell Biology 4 Credits (Soft core) Total: 48 hrs

Unit-I: Basic Polymer Science

Basic concepts: Classification of Polymers, Nomenclature of Polymers, Polymer synthesis and structure-chain structure and configuration - Amorphous polymer state-Conformation of polymer chain - Macromolecular dynamics - structure of crystalline polymers-polymers in the liquid crystalline state - Glass, Rubber - Transition behaviour, condensation including co-ordination, cationic, anionic, Ring opening Redox polymerization, Living Radical polymerization-Atom transfer radical polymerization. **12 hours**

Unit-II: Properties of polymers

Methods of measuring transitions in polymers - Cross linked polymers and rubber elasticity - Polymer Visco elasticity and Rheology, Mechanical Behaviour of polymers - Polymer surfaces and interface, Bulk, solution, precipitation polymerization, Suspensions,emulsion, melt polycondensation, Criteria of polymer solubility, solubility parameter, thermodynamics and phase equalibria of polymer solution, Fractionation of polymers by solubility.

12 hours

Unit-III: Cell Structure
Origin and overview of cells, prokaryotic and lukaryotic cells, subcellular organels, cells as experimental models, Chemistry of cells, molecular composition. Enzymes as biological catalysts. Metabolic energy, Biosynthesis of cell constituents.

Bio energetics and metabolism, cytoskeleton and cell movement, Cell signalling, Cell cycle, Cancer cells. **12 hours**

Unit-IV: Central Dogma of Life: Flow of genetic information, RNA and DNA as genetic materials. Organization and sequence of cellular genomes, DNA replication, RNA synthesis and Processing, Protein synthesis and processing protein sorting and transport. Recombinant DNA, detection of nucleic acids and proteins. **12 hours**

References

1. Leslie Howar Sperling, Introduction of physical polymer science, Wiley-Interscience; 4th Edition (2005) ISBN-10: 047170606X.
2. Geoffrey M Cooper, The cell- A molecular approach, Sinauer Associates Inc; 4 the Edition, (2006) ISBN-10: 0878932194

MSS-9: Metals and Alloys 4 Credits (Soft core) Total: 48 hrs

Unit- I Crystal defects in metals: Vacancy, interstitial, substitutional, free energy of mixing, dislocation (elementary concepts only), edge / screw dislocation, partial dislocation, stacking fault, dislocation lock, dislocation pile up, Hall Petch relation, grain boundary structure. **Diffusion:** Elementary concepts of phenomenological& atomistic approaches.
12 hours

Unit-II Solidification of binary alloys: Limits of solubility, isomorphous system, lever rule, constitutional super cooling, effect of non equilibrium cooling, eutectic, peritectic, eutectoid& peritectoid system, complex phase diagram, ternary diagram, composition triangle, ternary eutectic, vertical& horizontal sections, structure of cast metal, segregation& porosity, iron-carbon diagram, steel& cast iron. **Binary phase diagrams of common commercial alloys:** Cu-Ni, Au-Cu, Ni-Cr, Al-Si, Al-Zn, Al-Ag, Pb-Sn, Cu-Zn, Cu-Sn, Cu-Al, Ti-Al, Ti-V: interpretation of microstructure & properties. **12 hours**

Unit-III Cold working & Annealing: Recovery, recrystallization& grain growth, phenomenological& mechanistic approaches. **Precipitation from super-saturated terminal solid solution:** Thermodynamics& kinetics of precipitation, precipitation hardening. **Heat treatment of steel:** T-T-T diagram, Pearlitic, Martensitic& Bainitic transformation, effect of alloy elements on phase diagram& TTT diagram, CCT diagram, Annealing, normalizing, hardening& tempering, hardenability. **12 hours**

Unit–IV Application of physical metallurgy: Strengthening mechanism, strength vs. toughness (ductility), thermo mechanical processing, micro alloyed steel, ultra high strength steel, superalloy, control of texture. **12hours**

References:

1.Text book of Polymer Science – Fred W. Billmeyer, J.R. John Wiley & Son, New York.(1990)
2.Polymer Science – V.R. Gowarikar, N.V. Vishwanathan, Jayadev Shreedhar Wiley Eastern Ltd. New Dehli, India(1986)

3.Analysis of polymers – an introduction – T.R. Crompton. Smithers Rapra Technology Pvt Ltd., SY4 4NR, UK, 2008
4.Experimental methods in polymer chemistry – J.F. Rabek. John Wiley and Sons NY(1980)
5.Polymer Science, P.L. Nayak, Kalyani publishers, New Dehli.(2005)
6.Analysis and Characerisation of Polymers – Sukumar Maiti, Ansandhan Prakashan, Midnapur, India.(1978)

MSS-10: Nano-biotechnology 4 Credits (Soft core) Total: 48 hrs

Unit-I

Introduction on biocompatible nano-particles (Gold, silver, zinc, carbon, graphene and quantum dots), synthesis and applications. Nano-biosensors and Lab-on-chip devices for ultrasensitive diagnostics: Amperometric, potentiometric and potentiometric and flurometric biosensors (glucose biosensors, enzyme biosensors, screen printed electrodes). Affordables diagnostics. **12 hours**

Unit-II

Techniques involved in Nanoparticles application in diagnostics and characterization: Fluorescence resonance energy transfer (FRET), Surface energy transfer (SET), Raman light scattering, Surface Plasmon Resonance (SPR), Transmission electron microscopy, Scanning electron microscopy Atomic force microscopy, confocal microscopy, scanning tunneling microscopy, fluorescence spectroscopy. **12hours**

Unit-III

Micro-array (DNA and Protein array)-concepts and advantages of Microfluidic devices, Materials for manufacture of microfluidic devices, (Silicon and PDMS). Nanoparticles for Optical Imaging of Cancer, Nanogold in Cancer Therapy and Diagnosis, Nanotubes, Nanowires, Nanocantilevers and Nanorods in Cancer Treatment and Diagnosis. Carbon Nanotubes in Cancer Therapy and Diagnosis. **12hours**

Unit-IV

Introduction, Liposomes, dendrimers, Layer by layer deposition, self-assembled monolayers, In-vivo imaging. Nanobiotechnology for food health and environment.

12hours

References:

1. From Bioimaging to Bisensors – Noble Metal Nanoparticles in Biodetection, by Lai-kwan Chau (National Chung Cheng University, Taiwan), Huan-Tsung Chang (National Taiwan University, Taiwan)
2. Advances in Biosensors, Volume 1, Volume 1, Reinhard Renneberg and A.P.F. Tuner, 1991.
3. Nanoparticles and Biophotonics as Efficient Tools in Resonance Energy Transfer-Based Biosensing for Monitoring Food Toxins and Pesticides, M. S. Thakur, Rajeev Ranjan, Aaydha C. Vinayaka, Kunhitlu S. Abhijith, and Richa Sharma. Advanes in Applied Nanotechnology for Agriculture, Chapter 4, 2013, pp 55-84, ACS Symposium Series, Volume 1143.
4. Nanomaterials for Cancer Diagnosis, Challa S. S. R. Kumar (Editor), ISBN: 978-3-527-31387-7,448 pages, January 2007.

5. Microarray Technology and Its Applications, Uwe R. Muller, Dan V. Nicolau, Springer, 30-Mar-2006- Technology and Engineering.
6. Nanoparticulates as Drug Carriers edited by Vladimir P Torchilin (Northeastern University, USA), 2006, Imperial college press.

MSS-11: Nano-photonics 4 Credits (Soft core) Total: 48 hrs

Unit-I: Quantum confined materials

Quantum dots - Optial transitions absorption - interband transitins - quantum confinement - intraband transitions flurescence/luminescence - photoluminescence/flurescence optically excited emission electroluminescence emission. **12 hours**

Unit-II: Plasmonics

Internal reflection and evanescent waves - plasmons and surface plasmon resonance - Attenuated Total reflection - Grating SPR coupling - Optical wavegide SPR coupling - SPR dependencies and materials - plasmonics and nanoparticles. **12 hours**

Unit-III: New Approaches in Nanophotonics

Near filed optics - Aperture less near field optics - near field scanning optical miroscopy (NSOM or SNOM) - SNOM based detection of plasmonic energy transport - SNOM based visualization of waveguide structures - SNOM in nanolithography - SNOM based optical data storage and recovery. **12hours**

Unit-IV: Biophotonics

Interaction of light with cells-tissues - nonlinear optical processes with intense laser beams - photo induced effects in biological systems - generation of optical forces - optical trapping and manipulation of single molecules and cells in optical confinement - laser trapping and dissection for biological systems-single molecules biophysics - DNA protein interaction.

12 hours

References

1. H Masuhara, S Kawata and F Tokunga, Nanobiophotonics, Elsevier Science 2007.
2. BEA Sale and A C Teich, Fundamentals of photonics, John Wiley and Sons, NewYork 1993.
3. M Ohtsu, K Kobayashi, T Kawazoe and T Yatsui, Principals of Nanophotonics (Optics and Optoelectronics), University of Tokyo, Japan (2003).
4. P N Prasad, Introduction to Biophotonics, JohnWiley and Sons (2003)

MSS-12: Thermodynamic Modelling 4 Credits (Soft core) Total: 48 hrs

Unit-I

Entropy as a measure of unavailable energy. Entropy change during spontaneous process. Helmholtz and Gibbs free energies. Thermodynamic criteria of equilibrium and spontaneity. Variation of free energy with temperature and pressure. Maxwell’s relations, Van’t Hoff’s reaction isotherm and isochore, Gibbs-Helmholtz equation. Determination of free energy changes. Nernst heat theorem and Third law of thermodynamics-calculation of absolute entropies.Concepts of thermodynamics. Partial molar volume and its determination by density measurements. Order of reaction and determination. Energy activation and its determination. Assumptions of activated complex theory. Fast reactions with examples. Polymers and their classification. **12hours**

Unit-II

Crystallization kinetics. Basic concepts. Different methods Models for determining the crystallization kinetics for simple systems. In situ studies on crystallization kinetics.

12 hours

Unit-III

Thermodynamic equilibrium for simple to complex systems. Equilibrium reactions. Equilibrium and non-equilibrium phases. Estimation of solubility and stability. Dissociation constant. Activation coefficient. Speciation constant. Isoelectric points. Thermal stability and Chemical stability. **12 hours**

Unit-IV

Thermodynamic modeling basic concept. Thermodynamic variables. Equation of state for predicting partial molal standard state properties of the system species. Helgeson equation of state. Calculation of excess properties of ions. Simple models. Pitzer model, Setschenow model. Bromley Zemaitis model. Helgeson Kirkham Flowers (HKF) model. Theoretical Phase diagrams with examples. Yield diagrams. Commercial softwares - CALPHAD, ChemApp, SimuSage, OLI Systems - FactSage Interface, etc. **12 hours**

References

1. J. Thoma and B.O. Bouamama, Modelling and Simulation in Thermal and Chemical Engineering: A Bond Graph Approach, Springer (2000).
2. H. L. Lukas, Suzana G. Fries, Bo Sundman, Computational thermodynamics: the CALPHAD method, Cambridge University Press, UK (2007).
3. Jrgen Gmehling, Brbel Kolbe, Michael Kleiber, Jrgen Rarey, Chemical Thermodynamics: For Process Simulation, John Wiley & Sons (2012).
4. Advanced Course on Thermodynamic Models: Fundamentals & Computational Aspects, www.cere.dtu.dk, Department of Chemical and Biochemical Engineering - Sltofts Plads - Building 229 - DK2800 Kgs. Lyngby.

MSS-13: Basics of EngineeringDrawing and Graphics 4Credits (Soft Course)

Total: 48 hrs

Unit I : Principles of Graphics

Two dimensional geometrical construction Concept of section planes - Conic sections, involutes and cycloids - Representation of three dimensional objects - Principles of projections - standard codes of principles. **12hours**

Unit II: Orthographic Projections

Projections of points, straight line and planes - ' Auxiliary projections '- Projection and sectioning of solids -Intersection of surfaces - Development of surfaces. **12 hours**

Unit III: Pictorial Projections

Isometric projections - ' Perspectives '- Free hand sketching. Conversion of pictorial views of simple machine parts into orthographic views, conversion of orthographic views of simple machine parts into isometric views. **12 hours**

Unit IV: Computer Graphics

Hardware - Display Technology - Software - Introduction to drafting software

12 hours

References

1. Narayanan, K.L., and Kannaiah, P., " Engineering Graphics ", Tata McGraw-Hill Publishers Co., Ltd., 1992.
2. William M. Neumann and Robert F.Sproul, " Principles of Computer Graphics ",McGraw Hill, 1989.
3. Warren J. Luzzadder and John M. Duff, " Fundamentals of Engineering Drawing ",Prentice-Hall of India Private Ltd., Eastern Economy Edition, 1995.
4. Natarajan K.V., "A Text Book of Engineering Drawing", Private Publication, Madras, 1990.
5. Mathur, M. L. and Vaishwanar, R.S., "Engineering Drawing and Graphics", Jain Brothers, New Delhi, 1993.

Note:

1. Further details on Basics of engineering drawing and graphics are illustrated below since this is a new course introduced to enhance the industrial acceptability of the M.Tech Program.

MSS-14: Ceramics Science and Technology 4 Credits (Soft core) Total: 48 hrs

Unit I

Ceramics: Definition, scope, bonding and structure, crystal structure, defects, polymorphism, ceramics as a class of material, variations within ceramics; defect structures; chronological developments, structure of silicates; polymorphic transformations, raw materials.

Unit II

Conventional Ceramics: b) Refractories : Classification of Refractories, Modern trends and developments, Basic raw materials, Elementary idea of manufacturing process technology, Flow diagram of steps necessary for manufacture, basic properties and areas of application. c) Whitewares : Classification and type of Whitewares, Elementary idea of manufacturing process technology including body preparation, basic properties and application areas. d) Ceramic Coatings : Types of glazes and enamels, Elementary ideas on compositions, Process of enameling & glazing and their properties. e) Glass : Definition of glass, Basic concepts of glass structure, Batch materials and minor ingredients and their functions, Elementary concept of glass manufacturing process, Different types of glasses.Application of glasses. f) Cement & Concrete : Concept of hydraulic materials, Basic raw materials, Manufacturing process, Basic compositions of OPC. Compound formation,setting and hardening.Tests of cement and concrete. **12 hours**

Unit-III

Elementary ideas about the raw materials used in pottery, Heavy clayweres, Refractoriers, Glass, Cement, Industries. Raw materials clays and their classification, Quartz, Polymorphism of quartz, Feldspar and its classification, Talc, Steatite and Mica. Fabrication methods: Packing of Powders, Classification and scope of various fabrication methods. Dry and semi dry pressing. extrusion, Jiggering & jollying, Slip casting HP & HIP. Drying

&Firing of ceramics: Biscuit firing and glost firing, fast firing technology, action of heat on triaxial body, Elementary ideas of various furnaces used is ceramic industries.

12 hours

Unit-IV

Advanced ceramics: Bio-ceramics, Space ceramics, Automotive ceramics, Electronic ceramics, Superconducting ceramics, Elementary ideas of their preparation and applications.

12 hours

References

1. F.H Norton, Elements of Ceramics, Addison-Wesley Press (1974)
2. M.W. Barsoum, Fundamentals of Ceramics, McGraw-Hill (2003)
3. W.D Kingery, Introduction to Ceramics, Wiley & Sons (1976).
4. Lawrence H. Van Vlack, Physical Ceramics for Engineers, Addison-Wesley Publishing (1964).
5. F. Singer and S.J. Singer, Industrial Ceramics, Chapman & Hall, UK (1963)
6. Richerson D. W., 'Modern Ceramic Engineering - Properties Processing and Use in Design, 3rd Edition, CRC Press, 2006
7. Chiang Y.M., Birnie D. P., Kingery W.D., Physical Ceramics: Principles for Ceramic Science and Engineering, John Wiley, 1997
8. James E. Shelby., 'Introduction to Glass Science and Technology' 2nd Edition, The Royal Society of Chemistry Publications, 2005

MSS-15: Materials for Renewable Energy and Storage 4 Credits (Soft core)

Total: 48 hrs

Unit-I

Introduction to new generation of materials and nano-engineering of their structures for sustainable energy economy. Contribution to high performance renewable energy production, storage, conversion and usage. Solar grade glass; (a) properties-transparency, emissivity and reflectivity, (b) manufacturing- Flat glass for PV & CSP, tube glass for Evacuated Tube Receiver (ETR) and Collector (ETC). **12 hours**

Unit-II

Solar Photo Voltaic (PV) cells: Single and multi-crystalline silicon solar cells, amorphous silicon, thin film; Cd-Te, CIGS, CZTS, nano-, micro-, poly-Si. Transparent conducting coating, Multi-junction, solar PV concentrator, flexible solar cells, Emerging PV; dye sensitized, other organic, and quantum dot cells. Nano-engineered materials. **12 hours**

Unit-III

Materials for Concentrated Solar Power (CSP): Reflector materials; glass, metal, polymer and film. Receiver and collectors; absorptive coating and anti-reflective coating. Materials and shapes for thermal storage, Lithium ion Batteries. **12 hours**

Unit-IV

Fuel cells; materials and construction; PEM Fuel Cell(FC), AFC, PAFC, MCFC, SOFC. Catalysts for electro catalysis, fuel reformer and water splitting. **12 hours**

References

1. Vielstich, W., et al. (eds.) (2009). Handbook of fuel cells: advances in electrocatalysis, materials, diagnostics and durability. 6 vol. Hoboken: Wiley, 2009
2. Francis de Winter, Solar Collectors, Energy Storage, and Materials (Solar Heat Technologies), MIT Press, USA (1991)

3. David S. Ginley, David Cahen, Fundamentals of Materials for Energy and Environmental Sustainability, Cambridge University Press (2011)
4. Materials, Electronics, and Renewable Energy Part III Physics, Small lecture theatre, Cavendish Laboratory lecturers: David MacKay and Neil Greenham
5. Fuel Cell Handbook,
6. Introduction to Fuel Cell Technology

MSS-16: Basics of Nanotechnology 4 Credits (Soft core) Total: 48 hrs

Unit-I

Background and definition of nanotechnology, why nano? Lessons from nature, chemical approaches to nanostructure materials, Types of nanomaterials depending upon their properties electronic, semiconductors, superconductors, super ionic, magnetic, optic, opto-electronic, spintronics, lasers, photonics, ceramics, bio ceramics, biomedical, biosensors, bio imagers, photocatalysts, quantum dots. **12 hours**

Unit-II

Basic properties of materials and the instrumentation used to study these properties. Size effect of materials on properties. Quantization effect on the properties of materials with examples. Nanocomposites and their applications in modern technology. Carbon nanotubes and other nanotubes. Nanomaterials natural and synthetic. Nanocomposites and Nanohybrid materials. **12 hours**

Unit-III

Nanomaterials synthesis techniques nanoengineering of materials. Bottom up and Top down routes. Solution, Melt and Gas Processing of nanomaterials. Nature inspired processes. **12 hours**

Unit-IV

Nanomaterials characterization X-rays, Spectroscopic - infrared, UV-Vis, Laser Raman, Photoluminescence, Electron Microscopic techniques, Thermal analysis, surface characteristics, light scattering methods, gas adsorption, magnetic susceptibility, conductivity, band gap calculations. Nanotechnology in modern technology in relation to electronic, biological, consumer and domestic applications. Applied nanobiotechnology and nanobiomedical science drug delivery, drug targeting, biosensors, bioimaging, neutron capture therapy. **12 hours**

References

1. Bharath Bhusan, Springer Handbook of Nanotechnology, 3rd edition, Springer-Verlag (2009)
2. CNR Rao and T. Cheetham, Chemistry of Nanomaterials : Synthesis, Properties and Applications, Wiley & Sons (2005)
3. Hari Singh Nalwa, Encyclopedia of Nanotechnology, American Scientific Publishers (2004)
4. K. Byrappa and M. Yoshimura, Handbook of Hydrothermal Technology, 2nd edition, Elsevier (2012)
5. K. Byrappa and T. Adschiri, Hydrothermal Technology for Nanotechnology, Progress in Crystal Growth and Characteriation of Materials, Volume 53 (2007) pp.117-166.
6. K. Byrappa and M. Yoshimura (Editors): Special Edition of Journal of Materials Science, Volume 41, No.6 (2006).

7. K. Byrappa and T. Adschiri (Editors), Special Edition of Journal of Materials Science, Volume 43, No.7 (2008).
8. Charles P. Poole Jr. and Franks J. Qwens, Introduction to Nanotechnology, Wiley & sons (2003)

MSS-17: Enterprise Architecture 4 Credits (Soft core) Total: 48 hrs

Unit I:

1. What is Enterprise Architecture?
2. History of Architecture in the context of engineering discipline
3. History of Enterprise Architecture
4. Why Enterprise Architecture?
5. What are the various Enterprise Architecture Frameworks?
6. Why Zachman Framework an Ontology?

Unit II:

1. Growing enterprise opportunities
2. Enterprise Disorders & limitations of current approach
3. Zachman Framework & Primitive Models
4. Sample – Strategy Primitive model
5. Sample – Business process primitive models
6. Busting biggest myth about Enterprise Architecture
7. Summary

Unit III:

1. Case study1 Sample Problem–Application Rationalization arising out of Acquisition & Merger
2. Identify the cells responsible for the problem
3. Identify the primitives for each cell
4. Creating the composite models – 11 departments
5. Sample – Finance Department models, composites, relationship matrix, performance indicators
6. Composite Models & Traceability
7. Relationship Matrix, GAP Analysis & Application Maturity Index
8. Current status of Baseline Architecture v1.0
9. Timeline, Effort, Cost Estimations & Benefits

Unit IV:

1. Sample case 2 : Which cells are key to define the Disaster Recovery Plan
2. Sample case 3 - HR: Resource Request Process
3. Visual diagnosis for effective enterprise treatment
4. Use of Enterprise Architecture by Governments and Government Departments
5. Use of Enterprise Architecture in Telecom Industry
6. Use of Enterprise Architecture in Healthcare
7. Use of Enterprise Architecture in Banking & Finance
8. Use of Enterprise Architecture in Manufacturing

How to use Enterprise Architecture in managing Universities & Colleges

MSS 18: Chemical Engineering 4 credits (Soft core) Total:48 hours

Unit I:

Introduction, concepts of Unit operation and Unit Processes, Units and Dimensions, Dimensional Analysis.

12 hours

Unit II:

Mass Transfer: Molecular and convective mass transfer, mass transfer equations. Heat Transfer: Heat transfer by conduction, convection and radiation, heat transfer equations, Heat exchangers. Momentum Transfer: Fluid flow, pipes and tubes, fittings, valves and pumps, measurement of pressure and flow. **12 hours**

Unit III:

Size reduction, size separation, sedimentation, centrifugation, filtration, crystallization, Extraction, drying, evaporation, distillation. Sedimentation, Centrifugation, filtration, extraction, drying, evaporation, (Adsorption and partition) Techniques, Column thin layer and paper chromatography and their application. Criteria of purity-Melting and Boiling point. Surface tension, Viscosity. **12 hours**

Unit IV:

Reaction Engineering: Reaction kinetics, order of reaction, Batch, fed batch and continuous reactors, reactor design. Process Control: Proportional, integral, derivative and PID controllers, stability of controllers. Basics of Flow sheet, material balance, materials economics, safety analysis. **12 hours**

1. Badger Walter, L. and Banchero Julis, T., Introduction to Chemical Engineering, Tata McGraw Hill Pub. 1997.
2. McCabe, W.L., Smith, J.C. and Harriot, H.P., Unit Operations in Chemical Engineering, Mc Graw Hill, 2009
3. Jonson, C.D., Process Control and Instrumentation Technology, Prentic Hall India, 2003
4. Peters, Max S., and Timmerhaus, Klauss D., Plant Design and Economics for Chemical Engineers, Mc Graw Hill, 1991

MSS-19: Advanced X-ray Diffraction Studies 4 Credits (Hard core) Total: 48 hrs

Unit-I

Powder Diffraction Methods and calibration techniques: The modern Automated diffractometer: Applications of the Powder Method: Qualitative phase analysis: Crystallography and space group analysis: Indexing and lattice parameter determination, refinement and identification: Powder pattern calculation:Crystal structure determination - The Rietveld method. **12 hours**

Unit-II

Single Crystal Methods : Quantitative X-ray Diffraction: Interaction of X-rays with matter: absorption and EXAFS (time?): X-ray reflectometry analysis: Small Angle Scattering : Patterson Function: Pair correlation functions and linkage to structure function: Application to spherical, elliptical and needle shape inclusions". **12 hours**

Unit-III

Debyes function: Application to amorphous structures, nano-composites : Particle size and strain analysis line profile and Fourier techniques : Texture, Micro-texture and Residual stress "Pole figure in x-ray (single crystal and area detector).

12 hours

Unit-IV

Electron Diffraction (Orientation Imaging Microscopy): Fourier Analysis of Distributions: Euler angle definition of orientation space: Orientation Distribution Function: Fourier analysis of Orientation Distribution Function and quantification of texture: Stress (residual stress analysis)

12 hours

References

1. R. Jenkins and R. L. Snyder, Introduction to X-ray Analysis Diffractometry, John Wiley and Sons (1996):
2. Jens Als-Nielsen and Des Mc Morrow, Elements of Modern X-ray Physics, 2nd Edition Wiley & Sons (2011)
3. D. L. Bish and J. E. Post ed., Modern Powder, Diffraction Reviews in Mineralogy Vol. 20, Mineralogical Society of America, (1989).:
4. John Mc. Cowley Diffraction Physics, Klug and Alexander, X-ray Diffraction Procedures, J. Wiley and Son, New York (1972)
5. B. D. Cullity, Elements of X-ray Diffraction, Addison Wesley Publishing Company, Reading, Mass. (1956)

MSS -20: Analytical and Inorganic Chemistry 4 credits (soft core) Total: 48 hours

Unit I: Statistical Treatment of Analytical Data:

Limitations of analytical methods. Classification of errors:- Systematic errors- Sources, effects and their reduction. Random errors - Sources and distribution. Accuracy and precision.Fundamentals of chromatography**:**General description- Definition, terms and parameters used in chromatography (RF- value, retention volume and time). Ion-exchange chromatography (ICH), The synthesis of novel cation (Amberlite TR-1204) and anion exchange resin materials and its application in ion exchange chromatographic separation of the components from the reaction mixture.Potentiometry and conductometry: Theory, principle of working and few applications. **12 hours**

Unit II: Physical Chemistry

Application of physical chemistry

Application of phase rule to two and three component systems. Concepts of entropy and free energy. Partial molar volume and its determination by density measurements. Symmetry elements and symmetry operations with examples of simple molecule materials. X-ray diffraction, Bragg equation and Miller indices. Order of a reaction and its determination. Energy of activation and its determination. Assumption of activated complex theory. Fast reactions with examples, polymers and their classification. Arrhenius theory of strong and weak electrolytes. Corrosion and its prevention. Law of photochemistry. Quantum yield and its determination. **12 hours**

Unit III: Photodegradation of Materials

Photocatalyst- ZnO, TiO_2, principle of photocatalyst, application of ZnO, TiO_2 in the photo degradation of various types, pesticides and in industrial effluents. Effect of photodegradation on chemical oxygen demand in drinking water and in industrial waste water.Photophysical properties of materials; Theory, instrumentation, and applications of fluorescence, characteristic of fluorescence, resonance fluorescence, sensitized fluorescence, quenching of fluorescence. Theory, principle, and applications of phosphorescence.

12 hours

Unit IV: Organic Chemistry

Importance of natural products and synthetic products of organic origin materials in industry, pharmaceutical, petroleum refinery and agricultural fields. Uses of Dyes, polymers (plastics) soaps and detergents in industry, drugs and cosmetics in pharmaceutical industries, waxes, coal tar from petroleum industry and pesticides, (insecticides, pesticides, herbicides, fumigacide etc.) **12 hours**

References:

1) Quantitative analysis. R.A.DAY and A.L. underwood 6th edition prentice hall, Inc1999
2) Principle of Instrumental analysis, D.A.skoog, F.J.Holler and T.A.Nieman, 5thedition. Thomson Asia pvt.Ltd. Singapore 1998
3) Analytical chemistry. G.D. christian 5th edition 2001, John-wiley and sons Inc. India
4) Chemical kinetics. KJ. Laidler
5) Chemical kinetics. Moore and pearson
6) Kinetics and Mechanism of Chemical Transformation by J. Rajaram and J.C. Kuriacose.
7) Advances in Photochemistry - Rohatgi Mukherjee
8) Principle and applications of Photochemistry – R.P. Wayne, Elsevier, New York, (1970).
9) Elements of physical chemistry – Glass stone and lewis
10) Encyclopedia of chemical technology – Kirck-othmer series
11) Inorganic chemistry – JE Huheey
12) Chemical Kinetics –L.K. Jain.
13) Physical chemistry by PW. Atkins, ELBS, 4th edition, Oxford University press (1990).

MSS-21: Semiconductor optoelectronics 4 credits (Soft Core) Total 48 hours

Unit-I: Review of Semiconductor Device Physics

Energy bands of solids, the E-k diagram, Density of states, Occupation probability, Fermi level and quasi Fermi levels, p-n junctions, Schottky junction and Ohmic contacts. Semiconductor optoelectronic materials, Bandgap modification, Heterostructures and Quantum Wells. **12 hours**

Unit –II: Interaction of photons with electrons and holes in a semiconductor

Rates of emission and absorption, Condition for amplification by stimulated emission, the laser amplifier.

Semiconductor Optical Amplifiers & Modulators:Semiconductor optical amplifiers (SOA), SOA characteristics and some applications, Quantum-confined Stark Effect and Electro-Absorption Modulators. **12 hours**

Unit –III: Semiconductor Photon Sources

Electroluminescence. The LED: Device structure, materials and characteristics. The Semiconductor Laser: Basic structure, theory and device characteristics; direct modulation.Quantum-well laser; DFB-, DBR- and vertical-cavity surface-emitting lasers (VCSEL); Laser diode arrays. Device packages and handling. **12 hours**

Unit-IV: Semiconductor Photodetectors

Types of photodetectors, Photoconductors, Single junction under illumination: photon and carrier-loss mechanisms, Noise in photodetection;Photodiodes, PIN diodes and APDs: structure, materials, characteristics, and device performance. Photo-transistors, solar cells, and CCDs. Optoelectronic integrated circuits – OEICs. **12 hours**

Reference

1.B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2nd Ed. (2007), Ch.16, 17, and 18.
2. P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).
3. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995)
4. G. Keiser, Optical Fiber Communications, McGraw-Hill Inc., 3rd Ed. (2000), Ch.4,6.
5. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communications, Oxford University Press, New York (2007), 6th Ed.
Ch.15-17.
6.J. M. Senior, Optical Fiber Communication: Principles and Practice, Prentice Hall of India, 2nd Ed.(1994), Ch.6-8.

List of experiments for Practical classes

I –Semester

MSH-7: Characterisation Lab-1 4 credits (Hard core) 48 hours

Experiments:

1) Crystal Models-Crystal symmetry-Basic forms, 7 crystal systems, Holhedral forms, axial ratio, axial angles, crystal faces indexing.
Important hemihedral and hemimorphic forms.
2) X-ray powder pattern method
3) UV-Visible spectrometer recording of a material and interpretation
4) (a)Microscopic identification of cells (live/ fixed) slides: plant cells, bacterial cells, fungal hypha and animal tissues. (b) Observing stages of cell cycle – onion root tip (c) Microbial cell culture techniques – bacterial and fungal(d) Gram staining
5) (a) Spread plate technique
(b)Streaking method
(c) Serial dilution of bacterial cultures (Ex:- isolation of bacteria from mud)
(d) Size determination of biomolecules using microscopic techniques.
6) Particle size determination by optical diffraction method.
7) Particle size determination by X-ray diffraction technique.
8) Thermistor-temperature variation.

<u>II –Semester</u>

MSH-8: Characterisation Lab-2 4 credits (Hard core) 48 hours

Experiments:

1) FTIR and ^{1}H NMR recording of a materials/organic/inorganic compounds and interpretation
2) Determination of the birefringence of the given sample using the Abbe Refractometer/Prism coupler.
3) Measurement of the band gap energy of the given semiconductor by the method of four probes
4) Determination of refractive index and thickness of polymer films using Metricon prism coupler
5) Cell density analysis hemocytometers
6) Cell size determination by micrometers
7) Free volume estimation of a polymer by positron annihilation lifetime spectroscopy
8) Measurement of AC impedance of the given composite and construction of Bode-Bode plot
9) Well diffusion method, Disk diffusion method, Antimicrobial activity of nanoparticlesusing.
10) Isolation of plasmid DNA from E.coli
11) Isolation of genomic DNA from E.coli
10) Transformation of cell – heat shock technique
11) Quantification of DNA purity analysis by nanodrop methodand spectrophotometric analysis

<u>III –Semester</u>

MSH-9: Characterisation Lab-3 4 credits (Hard core) 48 hours

Experiments:

1) Paramagnetic susceptibility of the given salts.
2) Hall effect in metals/semi conductors.
3) Crystallization
4) Distillation.
5) Fractional crystallization.
6) Synthesis of aspirin and antipyrine
7) Synthesis of liquid crystals.
8) Thin layer chromatography and column chromatography
9) Isolation of DNA from animal tissues
10) Isolation of DNA from plant tissues
11) Isolation of mRNA from animal tissues
12) Restriction enzyme digestion of desired gene.
13) Ligation of the gene of interest into a vector.
14) Seperation of DNA by AGE (Agarose gel electrophoresis)
15) SDS PAGE electrophoresis
16) Biological materials characterization by X-ray diffraction studies.

IV- Semester

MSH-10 Characterisation Lab.-4 4 credits (Hard core) 48 hours

Experiments (for B.Sc., students)

1) Preparation of simple materials: Crystals, glasses, polymers, and composites by hydrothermal, solvothermal, Flux, gel, melt and sol-gel techniques.
2) Synthesis of Au, Ag, Cu NPs by Chemical/Biological methods.
3) Preparation of materials exposed to microwave radiations.
4) Preparation of pellets of materials.
5) Fermi energy estimation of conductors/Semi conductors.
6) Morphological studies of prepared materials.
7) Morphological changes in materials due to irradiation.
8) Animal cell culture techniques – primary cell culture, sub-culturing.
9) Size determination of bio-materials using microscope and Zeta potential.
10) Protein adsorption in bio-materials.
11) Interpretation of Cell bio-material.

V-Semester

MSH-11 Characterisation Lab.-5 4 credits (Hard core) 48 hours

Characterization Lab-5 is For B.Sc, Students

1) Preparation of carbon nanoparticles and X-ray investigation
2) FTIR and UV-Visible studies of polymers (both natural and man-made)
3) Preparation of polymer film and x-ray investigation
4) X-ray studies of natural polymers like silk, cotton, hemp and jute
5) AFM Study of a polymer film/composite material/Nanomaterials
6) SEM study of a polymer film/composite material/Nanomaterials
7) Conductivity of a polymer film

PROJECT WORK

MSH-12: Minor project during III Semester for non B.Sc. students and in V semester for B.Sc. students. : 6 credits

MSH-13: Major project during IV semester for non-B.Sc. students and in VI Semester for B.Sc. students. : 10 credits

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