RAMAKRISHNA MISSION VIDYAMANDIRA

BELURMATH, HOWRAH, WEST BENGAL

DEPARTMENT OF INDUSTRIAL CHEMISTRY

PROGRAMME OFFERED :M.Sc. APPLIED CHEMISTRY

PROGRAMME CODE :APC

DURATION :4 SEMESTERS

TOTAL CREDIT :80

FULL SYLLABUS WITH COURSE OUTCOME

VALID & ONGOING AS ON 30TH JUNE, 2019

Following is the credit distribution for M.Sc. Applied Chemistry Programme:

	Credit	Credit	Credit	Credit	Total Credit
	SEM 1	SEM 2	SEM 3	SEM 4	
SUB	19	19	19	19	**76**
ICSH	1	1	2	--	**4**
	20	**20**	**21**	**19**	**80**

Following is the Grade Point distribution:

% of Marks	Descriptor	Grade	Grade Point
85 - 100	OUTSTANDING	**O**	**10**
70 - 84.99	EXCELLENT	**A+**	**9**
60 - 69.99	VERY GOOD	**A**	**8**
55 - 59.99	GOOD	**B+**	**7**
50 - 54.99	ABOVE AVERAGE	**B**	**6**
40 - 49.99	AVERAGE	**C**	**5**
LESS THAN 40	FAILED	**F**	**0**

Note 1 : M.Sc. Applied Chemistry Programme offers different project related electives amongst the following broad spectrum courses.

1. Materials Science including nano materials
2. Polymer Science
3. Physical Chemistry
4. Organic Chemistry
5. Inorganic Chemistry

However students after choosing the area will be required to do the project either in the institution or any other industry or institute for the full 4th semester duration.

Note 2. M.Sc. Applied Chemistry Programme students must take following course :
Value-Oriented Course (Indian Cultural and Spiritual Heritage) : 4 Credit

Note 3 : Total Credit to be earned by a student to complete M.Sc. Applied Chemistry Programme : 80 Credit

Note 4 : Mark sheet after each semester will be given both with SGPA and detailed marks obtained by the examinee.

Note 5 : Similarly Mark sheet after the final semester will be given with CGPA and detailed marks obtained by the examinee.

Calculation of SGPA = (Total Credit X Total Grade Point = Total Credit Point);
Total Credit Points/ Total Credits

Calculation of CGPA = (Total SGPA X Total Credits in each Sem.) / Total Credits earned in all the semesters

	M.Sc. Applied Chemistry					
	4 Semester Course					
	Course Structure					
Sl No	Name of the Course	Semester	Course Code	Credit	Marks	Course outcome

1	Inorganic Chemistry	1	APC- P-1T	4	50	• Students will acquire an idea about the Band theory of metals, bonding in metal complexes, orbital contribution to magnetic moment, antiferromagnetism and ferromagnetism in complexes, bioinorganic chemistry, and organometallic compounds.
2	Organic Chemistry	1	APC- P-2T	4	50	• Development of the concept of catalytic hydrogenation and dehydrogenation, synthon and synthetic equivalent, synthesis of bifunctional compounds, UV, IR, NMR, Mass Spectroscopy.
3	Physical Chemistry	1	APC- P-3T	4	50	• This course will provide a comprehensive idea about the Rotational & Vibrational spectroscopy, photochemistry, surface chemistry and electrical properties.
4	Analytical Chemistry	1	APC- P-4T	4	50	• Students will gain an idea about the chromatography, different kinds of titrations methods, Instrumental method of analysis
5	Physical Chemistry	1	APC- P-5P	4	50	• Students will be able to use appropriate laboratory skills and instrumentation technique to solve the labotory problems.
6	Engineering Mathematics-I	2	APC- P-6T	4	50	• Students will acquire an idea about the system of linear equations, symmetric, skew-symmetric and orthogonal matrices, Functions of single variable, limit, continuity and differentiability, Analytic functions,

						Cauchy-Riemann equations, Application in solving potential problems.
7	Materials Science & Engineering-I	2	APC- P-7T	4	50	•: Development of the concept of lattice, lattice energy. symmetry, crystal class, crystal system, unit cell, diffusion, Perfect and imperfect crystals.
8	Polymer Science & Technology I	2	APC- P-8T	4	50	• This course will provide an idea about the Monomer, high Polymer, Polymerization methods: addition and condensation & their kinetics, cationic and anionic polymerization & their kinetics, Synthesis, Properties and Applications, Polymer Characterization.
9	Thermodynamics of Materials andQuantum mechanics	2	APC- P-9T	4	50	• Development of the concept of first, second and third laws of thermodynamics, thermodynamics of interfaces, Postulates of Quantum Mechanics, Solutions of the one and three dimensional Schrödinger equation
10	Computational Laboratory-I	2	APC- P-10P **New Course vide Dated 03.07.2014**	4	50	• Development of the concept of basic features of the Programming Language, MATLAB/OCTAVE/C Programming.
11	Engineering Mathematics-II	3	APC- P-11T	4	50	• Students will acquire an idea about the Gradient, divergence and curl, vector identities, first order equation (linear and nonlinear), and second order linear differential equations with variable coefficients, probability and statistics, numerical

						methods.
12	Materials Science & Engineering II	3	APC- P-12T	4	50	• Development of the concept of Stress-strain, thermal properties, energy band diagram for materials, magnetic materials- ferro, antiferro and ferrimagnetism, para, dia magnetism & corrosion resistance of metals.
13	Polymer Science & Technology II	3	APC- P-13T	4	50	•This course will provide an idea about the Polymer blends, long and short fibre reinforced composites, rheological parameter, Polymer compounding, Polymer Processing & testing of polymer.
14	Industrial & Environmental Pollution Management and Industrial Process Safety	3	APC-IEPM P1T	4	50	• During these course students will be develop their knowledge about the industrial pollution, water pollution, Solid waste management & material safety.
15	Nano-Science & Technology	3	APC-NSTP1T	4		• Students will acquire an idea about the super alloys, shape memory alloys, carbon nanostructure & structural analysis of nano materials
16	Materials synthesis & Characterization	3	APC- P-14P	4	50	• Students will acquire an idea about the synthesis approach and characterizations tools of nano materials.
17	Project Stage-I (Term paper focus on project & Seminar) Project Stage-II (Dissertation & Viva-voce)	4	APC- P-15P	20	250	•During this course students will be able to define the problems clearly and solve in a scientific way.

M.Sc. Applied Chemistry

4 Semester Course

Mapping of Employability etc

Sl No	Name of the Course	Semester	Course Code	Activities With Direct Bearing on Employability/Enterpreneurship/ Skill Development
1	Inorganic Chemistry	1	APC- P-1T	Students may develop their skill on basic electrical and magnetic applications which is being used in chemical and biochemical industries and also in research area based on those properties.
2	Organic Chemistry	1	APC- P-2T	It may be very helpful for the students to get employed in the "Research & Development" section of any chemical industries and also the skill to handling of basic instruments on research purpose wiil be developed.
3	Physical Chemistry	1	APC- P-3T	Skill upon sprectrochemical analysis of chemical compounds can be grwon for the students in this field.
4	Analytical Chemistry	1	APC- P-4T	Employment in "Chmeical Testing laboratory" and "Research and Development" section of any respective industry can be achieved by the students.
5	Physical Chemistry	1	APC- P-5P	Skill on basic instrumentation and testing of chemicals may be improved, providing the scope of emplobility in chemical based industries.
6	Engineering Mathematics-I	2	APC- P-6T	It will be fruitful for the students to solve mathematical problems arising during research work in laboratory section of the respective industries.
7	Materials Science & Engineering-I	2	APC- P-7T	The skill to identify Crystalic or amophous nature of industriral chemical compounds can be developed by the means of this course.

8	Polymer Science & Technology I	2	APC- P-8T	Students can find emloyability directly in the polymer based industries like Plastic, Rubber, Paint and adhesive .
9	Thermodynamics of Materials andQuantum mechanics	2	APC- P-9T **New Course vide Dated 26.10.2017**	It may be benificial for the students to apply their skill into the field of thermochemistry applied in the different aspect of industries.
10	Computational Laboratory-I	2	APC- P-10P	Skill to develop computer programing which will help to have employability in non core sofware companies.
11	Engineering Mathematics-II	3	APC- P-11T	It'll be productive for the understudies to unravel numerical issues emerging amid inquire about work in research facility segment of the individual businesses.
12	Materials Science & Engineering II	3	APC- P-12T	The expertise to observe the mechnical behaviours of industriral chemical products can be created by the implies of this course.
13	Polymer Science & Technology II	3	APC- P-13T	Understudies can discover emloyability specifically withi n the polymer based businesses like Plastic, Elastic, Paint and cement .
14	Industrial & Environmental Pollution Management and Industrial Process Safety	3	APC-IEPMP14T **New Course vide Dated 26.10.2017**	Amid these course students will be create their informative skill around the mechanical contamination, water contamination, Strong squander administration & f abric safety.
15	Nano-Science & Technology	3	APC-NSTP14T **New Course vide Dated 26.10.2017**	People will find employment in the industries based on materials science concepts like super combinations, shape memory amalgams, carbon nanostructure & nano materials.

16	Materials synthesis & Characterization	3	APC- P-14P	Understudies will obtain a skill of blend of both approach and characterization of nano materials which will provide him the capability to do work in R & D section of industries.
17	Project Stage-I (Term paper focus on project & Seminar) Project Stage-II (Dissertation & Viva-voce)	4	APC- P-15P	It may be exceptionally accommodating for the students to induce utilized within the "Research & Development" area of any chemical businesses conjointly the expertise to taking care of of essential disobedient on inquire about reason wiil be developed.

Applied Chemistry: 1st Semester

Detailed Syllabus

Course Code: APC- P-1T

[INORGANIC CHEMISTRY (Theory)] Full marks -50

*[**Course outcome:** Students will acquire an idea about the Band theory of metals, bonding in metal complexes, orbital contribution to magnetic moment, antiferromagnetism and ferromagnetism in complexes, bioinorganic chemistry, and organometallic compounds.]*

UNIT-I **[Marks 13]**

A) Metallic bonding- Band theory of metals. Brillouin zone, forbidden zone, Hume-Rothery rules and conductivity, semiconductors. Intrinsic and Extrinsic semiconductors, Hopping mechanism of semiconductivity. Superconductivity- Barden Cooper- Schrieffer (BCS) theory of superconductivity and phonons. Metal-metal multiple bonding and metal clusters. Nb-Ta Clusters, Mo-Ta clusters.

B) Bonding in metal complexes :valence bond theory and its limitations, ligand field theory, splitting of d- orbitals in different ligand fields. ligand field stabilization energy and its calculations, thermodynamic effects of LFSE, factors affecting splitting parameter, spectrochemical series, Jahn-Teller effect, σ and π bonding in complexes, MO diagram of complexes with and without π bonds, effect of π interaction on the stability of bond, nephelauxeticseries.Term symbol for d- ions, characteristics of d-d transition, selection rules for d-d transition, Orgel diagram, Tanabe-Sugano diagrams, band width, effect of Jahn-Teller distortion and spin-orbit coupling on spetra, electronic spetra of complex ions, calculation of Dq and B from spectral bands, charge transfer spectra.

C) Magnetic properties of metal complexes : Type of magnetism shown by complexes, Gouy method of susceptibility measurement, spin only value, orbital contribution to magnetic moment, antiferromagnetism and ferromagnesitm in complexes, TIP, application of magnetic measurements to structure determination of transition metal complexes.

Unit- II **[Marks 12]**

A) Supra molecular Chemistry:

a) General Definition :
b) Distinguish between Super molecules and Supra molecules
c) Nature of supra molecular interactions- Effect of ligand, Effect of metal ions, Effect of Counter ions and effect of solvents.

d) Designing of Supra molecules

e) Applications

i) Drug Delivery

ii) Separation of mixtures

iii) Molecular Sensors

iv) Molecular Switches

v) In Biology

vi) Drug Designing

B) Chemistry of Explosive: Classification, Nature of reaction, Overoxidised and under oxidised explosives, suitable combination of explosives, deternation velocity, redox activity in reaction to explosive actions.

C) Basic idea of nano chemistry

a) General definition, nano effect

b) Synthesis of nanoparticle

c) Characterisation and applications

UNIT -III [Marks = 13]

Bioinorganic Chemistry: Metalloporphyrins---Porphyrin ring system. Chlorophyll---synthetic model for photosynthesis, cytochromes. Biological importance of iron, availability and transport of iron,hemoglobin and myglobin--- transport of oxygen, synthetic oxygen carrier, iron in enzymes, Redoxmetalloenzymes: copper containing redox enzymes and zinc containing redox enzymes.

Chelation therapy: chelating agents as drugs, metal chelates as drugs, metal complexes as anticancer drugs. Metal toxicity.Metal dependent diseases—metal deficiency and metal execess. Alzheimer's disease, Wilson's disease, menkes disease, parkinson's disease, minamata disease, itaiitai disease, silicosis.

UNIT -IV: [Marks = 12]

Organometallic Compounds: Metal carbonyls---synthesis, structure and bonding in mononuclear and polynuclear carbonyls with and without bridging, metal carbonyl

hydrides and metal carbonyl clusters. LNCC and HNCC. Complexes with linear π donor ligands: olefins, acetylenes, dienes and allylcomplexes.Hapto nomenclature, Complexes with cyclic donors---cyclopentadiene, benzene.Sandwitch complexes- structure and bonding.Oxidative addition and reductive elimination reactions, insertion and extrusion reactions.Cyclometallationreaction.Catalysis by organometallic compounds---hydrogenation, hydroformylation and polymerisation reactions. (Wilkilson's catalyst, Ziegler-Natta catalyst & Synthetic gasoline should be included among various examples) and various others applications.

Course Code: APC- P-2T

[Organic Chemistry (Theory)] Marks – 50

*[**Course outcome:** Development of the concept of catalytic hydrogenation and dehydrogenation, synthon and synthetic equivalent, synthesis of bifunctional compounds, UV, IR, NMR, Mass Spectroscopy.]*

Unit-I: Organic Synthesis (Marks = 20)

(a) Chemistry of Mg, Li, Cu and Si and their application to organic synthesis.

(b) Reduction: catalytic hydrogenation and dehydrogenation, dissolving metal reduction, metal hydride reduction of carbonyl compounds and other functional groups, hydroboration and use of alkyl borane.

(c) Carbanions in synthesis, disconnection approach, concept of synthon and synthetic equivalent, synthesis of bifunctional compounds, illogical electrophiles and nucleophiles protecting groups, unpolung, Robinson annulation reaction.

(d) Oxidation: oxidation with Cr and Mn compounds, oxidation of alcohol, carbonyl compounds, C=C, C-H bonds in organic molecules, pyridiniumchlorochromate (PCC), oxidation with peracids and other peroxides, cleavage of glycols.

Unit-II Organic Spectroscopy: (UV, IR, NMR, Mass) (Marks 15)

(a) UV Spectra: Electronic transition, relative position of λ_{max} value of the chromophoric groups considering conjujation effect, steric effect, effect of Ph, etc.

(b) IR Spectra: Modes of molecular vibration, Hook's law, force constant, characteristic stretching frequencies of O-H, N-H, C-H, C-D, C=C, C=N C=O, C≡N C≡C. Factors affecting the stretching frequencies (H-bonding). electronic factors, mass effect, bond multiplicity, ring-size, solvent effect.

(c) NMR Spectra: NMR active nuclei, principle of proton magnetic resonance, equivalent and non equivalent protons, chemical shift, shielding and deshielding of proton, upfield and downfield NMR peack area. Application of NMR in determination of structure.

(d) Mass spectroscopy: Basic principal, fragmentation Process, fragmentation associated with the functional groups. Application of MS in structure elucidation

Unit-IIIBio molecules & Natural Products (Marks 15)

(a) Amino acids, peptides and proteins: Synthesis of α-amino acids (Gabriel, strecker, azlactone, malonic ester methodologies) isoelectric point, ninhydrin reaction. Resolution of amino acids.Peptide synthesis including Merrifield synthesis, structure determination of peptide, C-terminal and N-terminal unit determination, determination of amino acid sequence. Proteins: classification, structure (primary and secondary structure only):

(b) Carbohydrates: Monosaccharides- classification, osazone formation, stepping up and stepping down of aldoses, inter conversion of aldoses to ketoses and vice-versa, ring structure of D-glucose and D-fructose, conformational aspects of D-glucose, anomeric effect, mutarotation. Disaccharide: structure of sucrose.

Reference Books:

1. Advance Organic Chemistry (Jerry March)

2. Organic Spectroscopy (William Kemp)

3. Organic Chemistry (J Clayden)

*[**Course outcome:** This course will provide a comprehensive idea about the Rotational & Vibrational spectroscopy, photochemistry, surface chemistry and electrical properties.]*

Unit- I: Molecular Spectroscopy& Photochemistry (Marks = 25)

A)Light-matter interaction, transition moment integral, selection rule, Spectroscopic arrangements.

Rotational spectroscopy of diatomic molecules: rigid rotor model, selection rules, spectrum, characteristicfeatures of spectral lines (spacing and intensity). Determination of bond length , effect of isotopic substitution.

Vibrational spectroscopy of diatomic molecules: SHO model, selection rule, spectra; anharmonicity and its consequences on energy levels, overtones, hot bands, Raman Effect. Characteristic features and condition of Raman activity with suitable illustraitons. Rotational and vibrational Raman spectra. Rule of mutual exclusion with examples.

Potential energy curves (diatomic molecules), Decay of excited states by radiative and non-radiative paths. Fluorescence and phosphorescence, Jablonsky diagram.

B) Stark-Einstein law of photochemical equivalence and Lambert-Beer's law; quantum yield and its measurement for a photochemical process, actinometry. Photosensitized reactions.Kinetics of HI decomposition, H2-Br2 reaction, dimerisation of anthracene.

UNIT -II: Surface Dynamics and Electrical Properties (Marks = 25)

A) Special features of interfaces compared to bulk. Surface dynamics: Physical and chemical adsorption.Freundlich and Langmuir adsorption isotherms; multilayer adsorption and BET isotherm (no derivation). Gibbs adsorption isotherm and surface excess.Heterogenous catalysis (single reactant), MicellizationProcess – Definition and properties of Micelle.

B)Polarizability of atoms and molecules, dielectric constant and polarisation, molar polarisation for polar and non-polar molecules. Clausius-Mosotti equation and Debye equation and their application.Dipolemoments and determination of dipole moments.

C) Simple Butler - Volmer equation, Tafel equation, Exchange current from low and high field approx, Ilkovic equation, Generalised B-V equation, Evaluation of kinetic parameters, Transfer co-

efficient, Mechanism of charge transfer across electrode solution interface, Fundamental of electroplating, corrosion, passivating, Batteries, fuel cell and electrocatalysis

Reference Books:

1. Fundamentals of Molecular Spectroscopy (C.N. Bawell)

2. Physical Chemistry (G W Castellan)

3. A Text Book on Physical Chemistry Vol 2 (K L Kapoor)

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Course Code: APC- P-4T

[Analytical Chemistry (Theory)] Full marks - 50

*[**Course outcome:** Students will gain an idea about the chromatography, different kinds of titrations methods, Instrumental method of analysis.]*

Unit-I

A) Primary and secondary standard substances in acid base, redox , complex metric argento metric(precipitation) titrations.

B) Principle and application of redox estimation (titrimetric, using $KMnO_4$, $K_2Cr_2O_7$, $Na_2S_2O_3$ (iodometry) / Iodimetry, Estimation of Vitamin C.

C)Principle of Complexometric titration, EDTA titration, Metal ion indictors (with structures), masking agents and demasking agents , Role of buffer in complexometry, Estimation of Cu^{2+} - Zn^{2+}; Fe^{3+}-Al^{3+}; Ca^{2+}-Mg^{2+} , complexometrically.

D) Principles of argentometric titration, requirements ,Estimation of Cl- using adsorption indicatior , Mercurometry.

E) Principles of estimation of i) Dolomite , II) Pyrolusite, III) Portland cement , iV) Basic slag ,V) Brass , VI) Steel , VII) Chalcopyrites , VIII) Type metals ,

F) Principle of Gravimetric estimations , requirements ,co-precipitations , post precipitations, gravimetric estimation of Cl^- , Al^{3+} , Zn^{2+}, Ni^{2+}, SiO_2, PO_4^{3-},

Unit-II

A) Errors in chemical analysis

B)Accuracy , Precision , absolute errors , and relative errors, systematic error and random errors,

C) Standard deviations, Gausse curve for distribution, confidence limit.

Unit III

A) Principle of determination of BOD, COD, DO, TDS of water samples,

B) Detection and estimation of Hg^{2+} , Cd^{2+} , As^{3+}, Pb^{2+} , NO_3^-, NO_2^-, F^- in water sample as also as trace amounts

C) Detection and estimation of CO, NO, SO_2, H_2S and SPM

Unit -IV

1. **Chromatography :** Theory, Practice and application of chromatography , HPLC, TLC, GLC and GSC

2. Instrumental method of analysis

a**)** Thermal methods of analysis and thermometric titrations: TGA /DTA , DSC , Thermometric titrations , Principles, methods, apparatus and applications

b)Atomic absorption spectroscopy and Atomic emission spectroscopyBasic principles and applications of AAS and AES.

c) Mossbauer spectroscopy (specially Fe and Sn)

d) Raman spectroscopy, Microwave spectrometry

e) ESR spectroscopy, Phosphorescence spectrometry

Unit-V

1. **Electroanalytical chemistry:**
    a) Polarography, A.C Polarography
    b) Cyclic voltammetry
    c) Amperometry and coulometry
    d) Electrogravimetry and application theory of corrosion and their prevention by electrochemical means.
    e) Spectroelectrochemistry, OTE,OTTLE

2. **Bio-analytical Chemistry:**
    a) Forensic science and forensic medicine
    b) Adulterated chemicals
    c) Explosive and pattern recognition
    d) Narcotic drugs
    e) Toxicology- Measurement of Drug toxicity and food toxicity
    f) Scrology and DNA figure printing
    g) Radio immune assay for hormones
    h) Bio-sensors

ReferenceBooks :

1. Fundamentals of analytical chemistry (Skoog, Douglas &Donald M.)
2. Insatant notes Analytical Chemistry (D kealey& J Haines)

Course Code: APC- P-5P

Physical Chemistry (PRACTICAL) MARKS – 50

*[**Course outcome:** Students will be able to use appropriate laboratory skills and instrumentation technique to solve the labotory problems.]*

1. Potentio Metric Experiment – Determination of E^0 of redox electrode system – Mohr's salt vs. potassium dichromate

2. Conductometric experiment – conductometric titration of a mixture of HCl and AcOH or oxalic acid.

3. pH-metric experiment – determination of pK's of polybasic acid (oxalic acid)

4. Viscometry experiment – determination of iso-electric point by viscosity measurement. Determination of molarmass of a polymer by viscosity measurements

5. Polarimetric experiment – kinetics study of muta rotation of optically active compound

6. Analytical Experiment – a) Determination of solubility product of salts ; b) determination of composition of complexes – Cu^{2+} and ammonia complex ; c) Study of binary phase system (phenol – water) and ternary phase system (AcOH-water-$CHCl_3$)

Applied Chemistry: 2nd Semester

Detailed Syllabus

Course Code: APC- P-6T

[Engineering Mathematics -I (Theory)] Full marks - 50

*[**Course outcome:** Students will acquire an idea about the system of linear equations, symmetric, skew-symmetric and orthogonal matrices, Functions of single variable, limit, continuity and differentiability, Analytic functions, Cauchy-Riemann equations, Application in solving potential problems.]*

Unit-I: Linear Algebra: Algebra of matrices, inverse, rank, system of linear equations, symmetric, skew-symmetric and orthogonal matrices. Hermitian, skew-Hermitian and unitary matrices.Eigenvalues and eigenvectors, diagonalisation of matrices, Cayley-Hamilton Theorem**.**

Unit-II: Calculus: Functions of single variable, limit, continuity and differentiability, Mean value theorems, indeterminate forms and L'Hospital rule, Maxima and minima, Traylor's series, fundamental and mean value theorems of integral calculus. Evaluation of definite and improper integrals, Beta and Gamma functions, Functions of two variables, limit, continuity, partial derivatives, Euler's theorem for homogeneous functions, total derivatives, maxima and minima, Lagrange method of multipliers, double and triple integrals and their applications, sequence and series, test for convergence, power series.

Unit-III: Complex Variable: Analytic functions, Cauchy-Riemann equations, Application in solving potential problems, Line integral, Cauchy's integral theorem and integral formula (without proof), Residue theorem (without proof) and its applications.

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Course Code: APC- P-7T

Revision vide Dated 26.10.2017

[Material Science & Engineering -I (Theory)] Full marks - 50

*[**Course outcome:** Development of the concept of lattice, lattice energy. symmetry, crystal class, crystal system, unit cell, diffusion, Perfect and imperfect crystals.]*

Unit-I: Introduction

Brief history of emergence of Material science, Engineering materials, modern day groups - metals & alloys, ceramics, polymers, composites, other approaches of grouping; Property areas of engineering materials; inter relations and inter dependence of Material science, Material Technology and Material Engineering.

Unit-II : Structure & Diffusion

A. Crystallography: Structure of ionic solids: AB type and AB_2 type. Concepts of lattice, lattice energy. symmetry, crystal class, crystal system, unit cell; identifications of crystal planes, directions and positions.

B. Packing of spheres and packing in crystals: Close packing and its properties, packing efficiencies and voids, constraints in close packing and chemical bond types.

C. Imperfections in crystals: Crystal defects: Perfect and imperfect crystals; point, line and plane defects. Schottky and Frenkeldefects.Colourcentres in alkali halide crystals.

D. Non- crystalline structures: Short and long range order, glass, polymer and others, general property differences with crystalline materials. Linear and three dimensional network structures for non-crystalline materials.

E. Diffusion: Fick's laws and application of diffusion in sintering, doping of semiconductors and surface hardening of metals.

Unit-III: Brief idea of Metals and Alloys, Ceramics, Polymers and Composites

A. Metals & alloys :Solid solutions, solubility limit, phase rule, binary phase diagrams, intermediate phases,intermetallic compounds, iron-iron carbide phase diagram, heat treatment of steels,cold, hot working of metals, recovery, recrystallization and grain growth. Microstrcture,properties and applications of ferrous and non-ferrous alloys.

B.Ceramics: Structure, properties, processing and applications of traditional and advanced ceramics.

*C. Polymer:*Classification, polymerization, structure and properties, additives for polymer products, processing and applications.

*D. Composites:*Properties and applications of various composites.

Course Code: APC- P-8T

Revision vide Dated 26.10.2017

[Polymer Science and Technology-I (Theory)]Full marks -50

*[**Course outcome:** This course will provide an idea about the Monomer, high Polymer, Polymerization methods: addition and condensation & their kinetics, cationic and anionic polymerization & their kinetics, Synthesis, Properties and Applications, Polymer Characterization.]*

Unit-I: Chemistry of high Polymer

Monomer , functionality , degree of polymerization, Carother's equation, classification of polymers, glass transition, melting transition , criteria for rubberiness, Polymerization methods: addition and condensation & their kinetics, cationic and anionic polymerization &their kinetics, stereo-regular ploymerization , coploymerization , monomer reactivity ratios and its significance , Kinetics, types of copolymerization, Polymerization techniques: bulk , solution, suspension, emulsion.

Unit-II: Synthesis, Properties and Applications

Thermosetting Polymers : Phenol-formaldehyde resin, Urea-formaldehyde and Melamine-formaldehyde resins , Epoxy resin. Unsaturated polyester,Alkyds.

Comodity and general purpose thermoplastics: Polyethylene, Polypropylene, Polystyrene, Polyvinyl Chloride, Polyesters, Acrylic, PUpolymers ,

Engineering Plastics : Nylon , Polycarbonate, Polybutylene Terephthalate ,Polysulfone, Polyphenylene oxide , Acrylonitrile butadiene styrene, Fluoropolymers.

Natural and synthetic rubbers: Recovery of NR hydrocarbon from latex , Styrene -Butadiene rubber, Polychloroprene Rubber , Nitrile rubber, Butyl rubber, Ethylene-propylene-DieneTerpolymer, Polysulphide rubber, Polyacrylic rubber, Silicone, Thermoplastic Elastomers.

Unit-III: Polymer Characterization

Solubility and swelling , concept of average molecular weight , determination of weight average , number average , viscosity average and Z-average molecular weights,

Polydispersity and molecular weight distribution in polymers, Gel permeation chromatographic technique, Polymer crystallinity ,Analysis of polymers using IR, XRD, thermal (DSC,TGA ,DMTA), microscopic (optical and electronic) techniques

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Course Code: APC- P-9T

[Thermodynamics of Materials & Quantum mechanics] Full marks -50

*[**Course outcome:** Development of the concept of first, second and third laws of thermodynamics, thermodynamics of interfaces, Postulates of Quantum Mechanics, Solutions of the one and three dimensional Schrödinger equation.]*

Group-A: Thermodynamics of Materials Marks 25

Thermodynamic systems and variables; First, second and third laws of thermodynamics; Statistical interpretation of entropy; Free energy functions and criteria for equilibrium;Thermodynamics of solutions; Ideal and non-ideal solutions;Partialand molar quantities; Quasi-chemical model and regular solutions; Polynomial expressions for excess Gibbs energy of mixing forbinary and higher order solutions; Multi-component dilute solutions and interaction parameters; Chemical reaction equilibrium, equilibrium constant; applications to

materials and metallurgical systems; Electrochemical systems, cell reactions and EMF, Formation and concentrations cells; Phase rule and binary phase diagrams; Free energy composition diagrams; Phase equilibrium calculations; Introduction to ternary phase diagrams; Thermodynamics of interfaces; Surface tension and surface energy; Absorption and adsorption; Gibbs Thompson effect

Group-B: Quantum mechanics Marks 25

Black-body radiation, Compton Effect, Wave-particle duality, Uncertainty principle, Acceptable Wave functions, Postulates of Quantum Mechanics, Solutions of the one and three dimensional Schroedinger equation for systems – free particle, particle in a box, particle in a finite well, linear harmonic oscillator (. Reflection and transmission by a potential step and by a rectangular barrier, Solution of Time independent Schrödinger equation at higher

dimensions and more complicated systems, Particle in a three dimensional box, linear harmonic oscillator and its solution, density of states, free electron theory of metals. The angular momentum problem. The spin half problem and properties of Pauli spin matrices, Approximate methods, Time independent and time dependent perturbation theory for non-degenerate and degenerate energy levels, the variational method, WKB approximation, adiabatic approximation, sudden approximation, Quantum computation ,Concept of quantum computation, Quantum Q-bits etc.

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Course Code: APC- P-10P

Computational Laboratory-I (Practical) Marks-50

*[**Course outcome:** Development of the concept of basic features of the Programming Language, MATLAB/OCTAVE/C Programming.]*

C Programming Laboratory: Problems should cover basic features of the Language and Numerical Laboratory:

Implementation of various Numerical problems using MATLAB/OCTAVE/C Programming.

Applied Chemistry: 3rd Semester

Detailed Syllabus

Course Code: APC- P-11T

Revision vide Dated 26.10.2017

[Engineering Mathematics -II (Theory)] Full marks – 50

*[**Course outcome:** Students will acquire an idea about the Gradient, divergence and curl, vector identities, first order equation (linear and nonlinear), and second order linear differential equations with variable coefficients, probability and statistics, numerical methods.]*

Unit-IV: Vector Calculus: Gradient, divergence and curl, vector identities, directional derivatives, applications. line, surface and volume integrals, stokes, Gauss and Green's theorems (without proofs) applications.

Unit-V:Ordinary Differential Equations: First order equation (linear and nonlinear), Second order linear differential equations with variable coefficients, Variation of parameters method, higher order linear differential equations with constant coefficients, power series solutions, Legendre polynomials and Bessel's functions of the first kind and their properties.

Unit-VI: Probability and Statistics: Definitions of probability and simple theorems, conditional probability, Bayes Theorem, random variables, discrete and continuous distributions, Binomial, Poisson, and normal distributions, correlation and linear regression.

Unit-VII: Numerical Methods: Solution of a system of linear equation by Gauss-Jordan and Gauss-Seidel Methods, Newton's interpolation formulae, solution of polynomial and a transcendental equation by Newton-Raphson method, numerical integration by trapezoidal rule, Simpson's rule, numerical solutions of first order differential equation by Euler's method and 4th order Runge-Kutta method

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Course Code: APC- P-12T

Revision vide Dated 03.07.2014

[Material Science & Engineering-II (Theory)] Full marks - 50

*[**Course outcome:** Development of the concept of Stress-strain, thermal properties, energy band diagram for materials, magnetic materials- ferro, antiferro and ferrimagnetism, para and diamagnetism, corrosion resistance of metals.]*

Unit- IV: Properties of Materials (Marks 25)

A. Mechanical: Stress-strain diagrams of metallic, ceramic and polymeric materials, modulus of elasticity, yield strength, tensile strength, toughness, elongation, plastic deformation, viscoelasticity, hardness, impact strength, creep, fatigue, ductile and brittle fracture.

B. Thermal: Thermal expansion, heat capacity and conductivity, lattice vibrations, phonon.

C. Electrical &Electronic: Concept of energy band diagram for materials - conductors, semiconductors and insulators, electrical conductivity effect of temperature on conductivity, intrinsic and extrinsic semiconductors.

D. Dielectric: Capacitors, dielectrics, dielectric constant, frequency dependence, loss, ferroelectrics.

E. Magnetic: Origin of magnetism, magnetic materials- ferro, antiferro and ferrimagnetism, para and diamagnetism, magnetization- demagnetization, hysterisis, ferrites- soft and hard.

F. Optical: Materials and light- reflection, refraction, absorption and transmission, refractive index, its variations with material parameters, total internal reflection and principle of fibre communication.

G. Chemical (Environmental Stability): Oxidation of metals and kinetics, Aqueous corrosion: galvanic theory, principles and method of corrosion control.

Unit-V: Characterization of Materials&Elements of Advanced Topics (Marks 25)

Strength, hardness and toughness estimations, instrumental stress- strain plots and interpretations. Thermal analysis- thermo gravimetry, differential thermal analysis, differential scanning calorimetry, Ultraviolet-visible and Fourier transformed infrared

spectrometer.Steady-state and time-resolved spectroscopy, Optical microscope, Electron microscopy- scanning and transmission, x-ray diffraction and phase identification.

Materials: Smart materials, exhibiting ferroelectric, piezoelectric, optoelectric, semiconductingbehavior, lasers and optical fibers, photoconductivity and superconductivity, biomaterials, superalloys, shapememory alloys.

Nanomaterials- properties and applications of simple systems, carbon nanostructure.

Synthesis: Sol-gel technique, Hydrothermal and solvothermal, Ball milling, Chemical vapour deposition , Sputtering and green chemistry route.

*Characterization:*Atomic force microscopy, Scanning tunnelling microscopy, Field emission scanning electron microscopy, X-ray photoelectron spectroscopy.

Applications: Elements of material design, microstructure design, energy storage materials &device , Gas sensing, photocatalytic, Display technology.

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Course Code: APC- P-13T

Revision vide Dated 26.10.2017

[Polymer Science and Technology-II (Theory)] Full marks – 50

*[**Course outcome:** This course will provide an idea about the Polymer blends, long and short fibre reinforced composites, rheological parameter, Polymer compounding, Polymer Processing & testing of polymer.]*

Unit-IV: Polymer blends and composites

Different between blends and composites, their significances, Choice of Polymers for blending. blend miscibility-miscible and immiscible blends, thermodynamics, phase morphology, polymer alloys, polymer eutectics , plastic-plastic , rubber-plastic and rubber - rubber blends, FRP , particulate, long and short fibre reinforced composites.

Unit-V: Polymer Rheology

Flow of Newtonian and non-Newtonian fluids, different flow equations, dependence of shear modulus on temperature, molecular/segmental deformations at different zones and transitions. Measurements of rheological parameter by capillary rotating, parallel plate, cone-plate rheometer. Viscoelasticity-creep and stress relaxations, mechanical models, control of rheological characteristics through compounding, rubber curing in parallel plate viscometer, ODR and MDR

Unit-VI: Polymer Technology

Polymer compounding-need and significance, different compounding ingredients for rubber and plastics , crosslinking and vulcanization , vulcanization kinetics.

Unit - VII: Polymer Processing

Compression moulding, transfer moulding, injecting moulding, blow moulding, reaction injection moulding, extrusion, pultrusion, calendaring, rotational moulding, thermoforming, rubber processing in two-roll mill, Internal mixer.

Unit - VIII: Polymer testing

Mechanical- static and dynamic tensile, flexural, compressive, abrasion, endurance, fatigue, hardness, tears, resilience, impact, toughness. Conductivity- thermal and electrical, dielectric constant, dissipation factor, power factor, electric resistance, surface resistivity, volume resistivity, swelling, ageing resistance, environmental stress cracking resistance.

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Course Code: APC-IEPM P14T

Revision vide Dated 03.07.2014

Elective-1: [Industrial and environmental pollution management Industrial Process Safety] Full marks – 50

*[**Course outcome:** During these course students will be develop their knowledge about the industrial pollution, water pollution, Solid waste management & material safety.]*

Group- A: Industrial and environmental pollution management

Marks -25

1. Industrial & Environmental pollution - An overview

Pollution and pollutants-sources, types and consequences.Air and Water pollution, solid wastes.Imbalance in atmosphere, Hydrosphere and Lithosphere.Industrial Effluents. Industrial Episodes of hazards and pollution: Minamata, Love canal, Flixborough, Bhopal , Chernobyl.

Elements of hazards and toxicity, tixilogy. Some long term biosystem and ecosystem. Impacts' - Bio accumulation and Bio magnification, ecotoxicity, radiation hazards, Carcinogenics, Hormone Disruptor, Need for treatment, Reuse Recycling and Disposal

***2.* Water as Environmental Resources**: Hydrological cycle. Water quality, criteria of pollution suspended solids; physical chemical and biological; dissoloved solids-organics, Bio-degradable and Nonbiodegradable; Inorganic heavy metal and others.

Assement of water quality- sampling and analysis- Dissoloved oxygen(DO), Bio- chemical oxygen demand (BOD), Chemical oxygendemand(COD), Industrial methods for total organic carbon(TOC), Colorimetric and gas chromatographic methods; Analysis of toxic inorganic pollutants- as fluoride, Hg, Cd, Pb, Sb, Coliform test.

Drinking water standards (India and WHO), Industrial discharge Standards -Minimum National Standards (MINAS).

3. Waste water treatment methods: Physical chemical and biological , Primary, secondary and tertiary, Removal of Biodegradable Organics- Activated Sludge Methods , Fixed Film methods- Trickling Filter, Rotating Biological Contractor(RBC), Design criteria of Bio-

reactor, Pond Treatment and soil treatment systems. Bioremediation. Concepts of recycling and zero discharge industries.

4. Air composition and quality: Chemical and photochemical reactions in the atmosphere. Ozone formation and depletion, green house effect. Air pollution criteria: Particulates, SOx, NOx, CO, HC's (Hydrocarbons) and others, Dispersion modelling,Vehicular pollution. GHG's.Sampling and analysis of air pollutants.Controll of Air Pollution- Electrostatic precipitators (ESPs), Precipitators, collectors.Scrubbers.Vehicular pollution and control-Holistic approach.Real time analysis and monitoring of combustion and emission. Sound pollution and intensity levels, control.

5. Solid waste: Municipal, Industrial and electronic (E-wastes)-Extent, Constituents and managements. Isolation, Incineration, Landfill and other disposal options.Industrial sources of solids wastes and sludge.,minimization options.

6. Industrial process and pollution: Case studies-Acid , Alkali, Fertilizer, Cement, Sugar, Paper, Distillery, metallurgical, Polymer and Petrochemical, Power plants- Thermal and Nuclear.

7. Legal aspects-Indian Scenario: Major Provisions in Factory Act, Water (preventation and control of pollution) Act , Enviroment (Protection) Act, Manufacture, Storage and handling of hazardous chemicals rules, solid waste rules.

8. Management concepts and systems: Environmental Impact Assement (EIA), Energy and environment Audit. Polluters Pay Principle, Life cycle Assement(LCA), Sustainability concepts, Ecosystem approach of environmental management, Green chemistry principles and practices, ISO certification.

Group- B: Industrial Process Safety [Marks -25]

Introduction - Some well-known Process Industrial accident, like Flixborough, England, Bhopal, India, Seveso, Italy etc. – Description and major causes.

Chemical hazards - Toxicology and its effect on human being, i.e., biological organisms, how they enter the body, how they eliminated from body, Dose-response relationship, Threshold limit values.

Industrial hygiene – Identification, Material Safety Data Sheets, Evaluation and control.

Fires and Explosion – Defination, Flammability characteristics of liquids and vapours, Estimation of flammability limits, What causes fires and explosions - fuel, ignition sources, how they spread - its prevention like ventilation, sprinklers, fire extinguishers etc.

Detonation and deflagration, confined explosion, vapour cloud explosion, BLEVE.

Hazard identification and Risk assessment - HAZOP and safety review,

Risk assessment, Event and fault tree analysis, LOPA, Fire and Explosion Index.

Accident Evaluation, Emergency planning,

Basic idea of Inherently safer design.

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Course Code: APC-NSTP14T

Elective-2: Nano-Science & Technology Full Marks: 50

*[**Course outcome:** Students will acquire an idea about the super alloys, shape memory alloys, carbon nanostructure & structural analysis of nano materials.]*

Smart materials, exhibiting ferroelectric, piezoelectric, optoelectric, semiconductingbehavior, lasers and optical fibers, photoconductivity and superconductivity, biomaterials, superalloys, shapememory alloys.

Nanomaterials- properties and applications of simple systems, carbon nanostructure.

Synthesis: Sol-gel technique, Hydrothermal and solvothermal, Ball milling, Chemical vapour deposition , Sputtering and green chemistry route.

*Characterization:*Atomic force microscopy, X-ray diffraction (XRD); Fourier Transform Infrared (FTIR) spectrophotometer; Ultraviolet- Visible (UV/Vis) spectrophotometer; Raman spectroscopy; Scanning and Transmission electron microscope (SEM/TEM); Thermo gravimetric analysis (TGA); Spectrofluorophotometer ; Semiconductor characterization system.

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Course Code: APC- P-14P

[Materials synthesis & Characterisation (Practical)] Full Marks: 50

*[**Course outcome:** Students will acquire an idea about the synthesis approach and characterizations tools of nano materials.]*

Materials: Metal nanoparticles; Organometallic nanostructures; Doped and undoped binary and ternary oxidenanostructures ; Carbon nanostructures such as Carbon nanotube, Graphene; Conducting Polymer etc.

Synthesis technique: Sol-gel; Self-assembly; Hydrothermal &Solvothermal; Solid state reaction; Physical & Chemical vapour deposition; Spin coating.

Characterizations tools: X-ray diffraction (XRD); Fourier Transform Infrared (FTIR) spectrophotometer; Ultraviolet- Visible (UV/Vis) spectrophotometer; Raman spectroscopy; Scanning and Transmission electron microscope (SEM/TEM); Thermo gravimetric analysis (TGA); Spectrofluorophotometer ; Semiconductor characterization system.

Applied Chemistry: 4th Semester

Detailed Syllabus

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Course Code: APC- P-15P

Full Marks: 250

*[**Course outcome:** During this course students will be able to define the problems clearly and solve in a scientific way.]*

Project Stage-I (Term paper focus on project & Seminar)

Project Stage-II (Dissertation & Viva voce)

Any topic of the work may be selected from the subjects of the course-curricula and allied area. Students have to carry out the investigation work either at the college or in an industry having adequate R & D facilities or in an University laboratory, or in an National / reputed laboratory across the country (as will be arrange by the college) under the guidance of a scientist or a faculty member of the particular institute. In the case where investigation work is undertaken outside the college laboratory, a faculty member of the college will be co-guide of the project. The work will be based on literature review and practical work on the topic. On completion of the investigation work students have to submit the report of the work in the form of dissertation (three copies, at least two weeks before the date of examination) followed by seminar presentation in the presence of the faculty members, the members and the scientists of the laboratory where the students has performed the work and others interested. The work will be assessed by the internal examiners (including guide under whom the student has worked on the project) and an external expert appointed as examiner on the particular project.