Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Basic Science Board)
As per 2017 Regulation

Group - 1		
Sl No	**Course Code**	**Course Name**
1	16PHY01	Mathematical Physics
2	16CHE01	Inorganic Chemistry-I
3	16CHE02	Inorganic Chemistry-II
4	16MAT01	Ordinary and Partial differential equations
5	16MAT02	Integral Transforms & Calculus of Variations

Group - 2		
Sl No	**Course Code**	**Course Name**
1	16PHY02	Classical Mechanics and Statistical Mechanics
2	16CHE03	Organic Chemistry-I
3	16CHE04	Organic Chemistry-II
4	16MAT03	Complex analysis
5	16MAT04	Computer Fundamentals and Programming in C

Group - 3		
Sl No	**Course Code**	**Course Name**
1	16PHY03	Quantum Mechanics
2	16PHY04	Atomic, Nuclear and Molecular Physics
3	16CHE05	Physical Chemistry-I
4	16CHE06	Physical Chemistry-II
5	16MAT05	Probability and Stochastic process
6	16MAT06	Operation Research

Group - 4		
Sl No	**Course Code**	**Course Name**
1	16PHY05	Solid State Physics, Nano Science and Technology
2	16PHY06	Material Science
3	16CHE07	Analytical Chemistry & Allied Subjects-I
4	16CHE08	Analytical Chemistry & Allied Subjects-II
5	16MAT07	Advanced Fluid Mechanics and Magneto hydrodynamics
6	16MAT08	Advanced Graph theory

Group - 5		
Sl No	**Course Code**	**Course Name**
1	16PHY07	Physics of Liquid Crystals and Polymer Science
2	16PHY08	Fluorescence Spectroscopy and X-ray Crystallography
3	16CHE09	Analytical Chemistry & Allied Subjects-III
4	16MAT09	Advanced Numerical Methods

Group - 6		
Sl No	**Course Code**	**Course Name**
1	16PHY09	Laser Physics and Biophysics
2	16PHY10	Electronics and Instrumentation
3	16CHE10	Analytical Chemistry & Allied Subjects-IV
4	16MAT10	Linear Algebra

1	**(Group-1):16PHY01**	**Mathematical Physics**
Exam Hours: 3 hours		**Exam Marks(Maximum):100**

Module-1

Differential equations

Partial differential equations: Classifications, systems of surfaces and characteristics, examples of hyperbolic, parabola and elliptic equations, method of direct integration, method of separation of variables

Special differential equations

Power series method for ordinary differential equations, Legendre's differential equation: Legendre polynomials and their properties, Generating functions, Recurrence Formulae, orthogonality of Legendre's polynomial. Bessel's differential equation: Bessel's polynomial - generating functions, Recurrence Formulae, orthogonal properties of Bessel's polynomials. Laguerre's equation, its solution and properties. Hermite differential equation: Hermite polynomials, generating functions, recurrence relation.

Module-2

Laplace transforms

Laplace transforms: Linearity property, first and second translation property of LT, Derivatives of Laplace transforms, Laplace transform of integrals, Initial and Final value theorems, Transform of Dirac delta function, periodic function and derivatives. Methods for finding LT: direct and series expansion method, Method of differential equation. Inverse Laplace transforms: Linearity property, first and second translation property, Convolution property, Solution of linear differential equations

Module-3

Fourier series and integrals

Fourier series definition and expansion of a function, Fourier's theorem. Cosine and sine series. Change of interval. Complex form of Fourier series. Fourier integral. Extension to many variables. Fourier transform. Transform of impulse function. Constant unit step function and periodic function

Module-4

Group Theory

Groups, subgroups, classes. Homomorphism and isomorphism. Group representation. Reducible and irreducible representations. Character of a representation, character tables. Construction of representations. Representations of groups and quantum mechanics. Lie groups. The three dimensional rotation group SO(3). The special unitary groups SU(2) and SU(3). The irreducible representations of SU(2). Representations of SO(3) from those of SU(2) Some applications of group theory in physics

Module-5

Numerical Techniques

Numerical Methods. Solutions of algebraic and transcendental equations: Bisection, iterative and Newton-Raphson methods. Interpolation: Newton's and Lagrange's methods.Curve fitting: Method of least squares. Differentiation: Newton's formula. Integration: Trapezoidal rule, Simpson's 1/3 and 3/8 rules. Eigen values and eigen vectors of a matrix. Solutions of ordinary differential equations: Euler's modified method and Runge-Kutta methods.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Mathematical Physics	B D Gupta	Vikas Publishing House Pvt. Ltd.	3rd Edition, 2006.
2	Mathematical Physics	Satya Prakash,	S Chand and Sons, New Delhi.	4th Ed-2007
3	Mathematical Physics	B S Rajput	Pragati Prakasam	17th Ed-2004.
4	Advanced Engineering mathematics	Erwin Kreyszig	Wiley Eastern	7th Ed- 1993
5	Mathematical Methods for Physics	G Arfken	Elsevier	4th Ed, 1992
6	Numerical Methods	E. Balagruswamy	TMH	3rd Ed, 2001

2. (Group-1): 16CHE01	**Inorganic Chemistry-I**
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Chemistry of Transition Elements: General characteristic properties of transition elements, co-ordination chemistry of transition metal ions, stereochemistry of coordination compounds, ligand field theory, splitting of d orbitals in low symmetry environments, Jahn- Teller effect, Interpretation of electronic spectra including charge transfer spectra, spectro chemical series, nephelauxetic series, metal clusters, sandwich compounds, metal carbonyls.

Module-2

Bioinorganic Chemistry: Role of metal ions in biological processes, structure and properties of metalloproteins in electron transport processes, cytochromes, ferrodoxins and iorn sulphur proteins, ion transport across membranes, Biological nitrogen fixation, PSI,PS – II, Oxygen uptake proteins.

Module-3

Electronic, Electric and Optical Behaviour of Inorganic Materials: Metals, Insulators and Semiconductors, Electronic structure of solid, band theory, band structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, doping of semiconductors and conduction mechanism, the bandgap, temperature dependence of conductivity, carrier density and carrier mobility in semiconductors, synthesis and purification of semi conducting materials, single crystal growth, zone refining, fractional crystallization, semiconductor devices, rectifier transistors, optical devices, photoconductors, photovoltaic cells, solar batteries.

Module-4

Reaction Kinetics of Coordination Compounds: Introduction, electron transfer reactions: Outer-sphere reactions, the Marcus theory, ligand-bridged inner sphere reactions doubly bridged inner-sphere transfer, one electron and two electrons transfers, non-complementary reactions. Ligand exchange via electron exchange. Mechanisms of ligand substitution reactions-general considerations, substitution reactions of square planar and octahedral complexes. Base-catalyzed hydrolysis of cobalt (III) ammine complexes.

Module-5

Quantum Mechanics and its applications: MO-VB Theory: Born-Oppenheimer approximation, Hydrogen Molecule ion. LCAO-Mo and VB treatments of hydrogen molecule. Electron Density, forces and their role in chemical bonding. Hybridization and valence MO's of H_2O, NH_3 and CH_4. Huckel pi-electro theory and its applications to Ethylene, Butadiene and Benzene. Idea of Self- consistent field method.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Concise Inorganic Chemistry	J. D. Lee	Elbs with Chapman and	5th Edition, 1996.
2	Solid State Chemistry	A. H. Hanney	A. H. Publications	1st Edition,
3	Biological aspects of Inorganic Chemistry	Cullen Dolphin and James	Wiley Publications	1st Edition,
4	An Introduction to Bioinorganic Chemistry	Williams	Thomas Publisher	1st Edition,
5	Bioinorganic Chemistry	I Bertini	University Science Books	1st Edition, 1994
6	Electronic Processes in Materials	L. V. Azoroff,	Mc Craw Hill	1st Edition, 1963
7	Principles of Bioinorganic Chemistry	S. J. Lippard,	University Science	1st Edition,
8	Coordination chemistry	S.F.A. Kettle	Thomas Nelson and Sons Ltd., London	1st Edition, 1969
9	Physical Inorganic Chemistry - A Coordination Chemistry Approach	S.F.A.Kettle	Spektrum, Oxford	1st Edition, 1996
10	Quantum Chemistry	R.K.Prasad	New Age	4th Edition, 2010
11	Quantum Mechanics	Chatwal & Anand	Himalya Publishing House	1st Edition, 2012
12	Introductory Quantum Chemistry	A.K.Chandra	Tata MacGraw-Hill	1st Edition, 1994

3. (Group-1):16CHE02 Inorganic Chemistry-II

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Uses of Inorganic Reagents in Inorganic Analysis: General discussion and uses of some inorganic reagents: Potassium bromate ($KBrO_3$), potassium iodate (KIO_3), ammonium vanadate (NH_4VO_3), ceric suphate [$Ce(SO_4)_2$], ethylenediamine tetra acetic acid (EDTA).

Module-2

Uses of Organic Reagents in Inorganic Analysis: Cupferron, DMG, dithiozone,aluminon, oxine, dithiooxamide, α-benzoinoxime, α-nitro-β-naphthol, α-nitroso-β-naphthol, diphenylcarbazone, diphenylcarbazide, anthranilic acid, tannin, pyragallol, benzidine, salicylaldoxime, o-phenanthroline.

Module-3

Inorganic Polymers: Classification, types of Inorganic polymers, Chemistry of followingpolymers a) Silicones b) phosphonitric halides c) condensed phosphates d) coordinated polymers e)silicates f) Isopoly & heteropoly acids

Module-4

Ionic Conductors: Types of ionic conductors, mechanism of ionic conduction, interstitialjumps, vacancy mechanism, diffusion, super ionic conductors, phase transition & mechanism of conduction in super ionic conductors, examples and applications of ionic conductors.

Electronic Properties of Materials: Organic semiconductors, examples, properties and application. Superconductivity, superconductivity in metals, alloys and ceramics materials (mixed oxides) BCS theory, Meissner effect, type I & II superconductors, application

Module-5

Supra Molecular Chemistry: Definition of supra molecular chemistry. Nature of binding interactions in supramolecular structures: ion-ion, ion-dipole, dipole-dipole, H-bonding, cation-p, anion-p, p-p, and van der Waals interactions.Synthesis and structure of crown ethers, lariat ethers, podands, cryptands, spherands, calixarenes, cyclodextrins, cyclophanes, cryptophanes, carcerands and hemicarcerands.,Host-Guest interactions, pre-organization and complimentarity, lock and key analogy. Binding of cationic, anionic, ion pair and neutral guest

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Vogel's Text Book of Quantitative Inorganic Analysis	Vogel	ELBS	4th Edition, 2010
2	Quantum Chemistry	R.K.Prasad	New Age	4th Edition, 2010

3	Inorganic Polymers	Mark J.F., Allock H.R	West, Prentice hall	1st Edition, 1981
4	Inorganic Polymers	Ring N.H	Academic Press N.Y.	1st Edition, 1978
5	Preparative Methods in Solis State Chemistry	Hagenmuller	Elsevier	1st Edition, 2012
6	The Structure and Properties of Materials (Electronic Properties)	LohnWulff	WilyEastern	Vol. IV, 1966
7	Electronic Processes in Materials	L.V. Azoroof and J.J. Brophy	MacGraw Hills	1st Edition, 1963
8	Supra Molecular Chemistry-Concepts and Perspectives	J.-M. Lehn	Wiley-VCH	1st Edition, 1995
9	Supra Molecular Chemistry	P. D. Beer, P. A. Gale, D. K. Smith	Oxford University Press	1st Edition, 1999
10	Supra Molecular Chemistry	J. W. Steed and J. L. Atwood	Wiley	1st Edition, 2000

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4. (Group-1):16MAT01	**Ordinary and Partial differential equations**
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Series Solution of Linear Differential Equations

Power series solutions about an ordinary point, Singular points, Frobenious method, Bessel's and Legendre's equations, Bessel functions, Legendre polynomials, Laguerrefunctions.

Module-2

Existence and Uniqueness Theory

Existence and uniqueness theory for ordinary differential equations, Eigen value problem,

Module-3

Classification of Second Order PDE: Canonical forms, adjoint operators, Riemann's method. Elliptic Differential Equations**:**
DerivationofLaplaceandPoissonequation,Boundaryvalueproblems,someimportantmathematicaltools, properties of harmonic functions, separation of variables, Dirichlet problem for rectangle and circle, Neumann problem for rectangle and circle, Mixed boundary

Module-4

Parabolic Differential Equations:

Occurrence, boundary condition, elementary solutions, separation of variables, solution in cylindrical and spherical coordinate systems.Hyperbolic Differential Equations

Occurrence,derivationofonedimensionalwaveequation,solutionofonedimensionalcanonicalreduction, initial value problem, D'Alembert's solution, vibrating string – variable separable method, boundary and initial value problem for two dimensional wave

Module-5

Transform Methods: Laplace transform of Bessel functions, solution of diffusion equations and wave equations by Laplace and Fourier Transform method. Fourier transform for Laplace equation

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Differential Equations with applications and Historical Notes	G.F. Simmons	CRC Press	3rd Ed.,2017
2	ElementsofOrdinarydifferentialequationsandSpecialfunctions	A.Chakrabarty	New Age International	2nd Revised Ed., 1996
3	IntroductiontoPartialDifferentialEquations	K.SankaraRao	PHI	3rd Ed.,2011
4	Ordinary and Partial differential Equations	M.D.Raisinghania	S.Chand Co	18th Ed.,2018
5	Ordinary and Partial differential Equations	Nita H.Shah	PHI	2nd Ed.,2015

5. (Group-1):16MAT02 Integral Transforms & Calculus of Variations

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Laplace Transform: Transform of Elementary Functions, Transform of Derivatives, Inverse Transform, Convolution Theorem, Applications to Ordinary and Partial Differential Equations.

Module-2

Fourier Transform: Sine and Cosine Transform, Inverse Fourier Transform, Application to Ordinary and Partial Differential Equations.

Module-3

Calculus of Variations: Functionals, Linear Functionals, Fundamental Lemma of Calculus of Variations Simple Variational Problems, The Variation of Functional, the Extermum of Functional, Necessary Condition for Extreme, Euler's Equation, Euler's Equation of Several Variables

Module-4

Invariance of Euler's Equation. Motivating Problems of Calculus of Variation including Shortest Distance, Minimum Surface of Revolution, Brachistochrone Problem, Isoperimetric Problem, Geodesics.

Module-5

The Fixed End Point Problem for 'n' Unknown Functions, Variational Problems in Parametric form, Generalization of Euler's Equation to (i) 'n' Dependent Functions (ii) Higher Order Derivatives. Variational Problems with Subsidiary Conditions, Derivation of the Basic Formula, End Points lying on Two Given Curves or Surfaces.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Integral Transforms and their Applications	L.Debnath & Dambaru Bhatta	CRC Press	3rd Ed., 2015
2	The Use of Integral Transform	I. N. Sneddon	McGraw Hill	2nd Ed., 1972
3	Operational Mathematics	R. Churchill,	McGraw Hill	3rd Ed., 1972
4	Calculus of Variations with Applications to Physics and Engineering	Robert Weinstock	Franklin Classics	1st Ed., 2018

5	Calculus of Variations	I.M.Gelfand & S. V. Fomin	Dover Publications	1st Ed., 2000

1. (Group-2):16PHY02	**Classical Mechanics and Statistical Mechanics**
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Newtonian mechanics and Lagrangian formulation

Single and many particle systems - Conservation laws of linear momentum, angular momentum and energy. Application of Newtonian mechanics: Two-body central force field motion, Kepler's laws of planetary motion. Scattering in a central force field; Scattering cross-section;

Constraints in motion. Generalised co-ordinates, Virtual work and D'Alembert's principle. Lagrangian equations of motion. Symmetry and cyclic co-ordinates. Hamilton variational principle, Lagrangian equations of motion from variational principle. Simple applications

Module-2

Hamiltonian formalism ,Relativistic mechanics, Continuum mechanics

Hamilton's equations of motion - from Legendre transformations and the variational principle. Simple applications. Canonical transformations. Poisson brackets - Canonical equations of motion in Poisson bracket notation. Hamilton-Jacobi equations.

Relativistic mechanics: Four-dimensional formulation-four-vectors, four-velocity, four-

Module-3

Microcanonical, Canonical and Grandcanonical ensembles

Microcanonical distribution function, Two level system in microcanonical ensemble, Gibbs paradox and correct formula for entropy, The canonical distribution function. Contact with thermodynamics - Two level system in canonical ensemble, Partition function and free energy of an ideal gas, Distribution of molecular velocities.

Equipartition and Virial theorems, The grand partition function, Relation between grand canonical and canonical partition functions.

Module-4

Bose-Einstein, Fermi-Dirac and Maxwell-Boltzmann Distributions

Bose-Einstein and Fermi-Dirac distributions, Thermodynamic quantities, Fluctuations in different ensembles, Bose and Fermi distributions in microcanonical ensemble - Maxwell-Boltzmann distribution law for microstates in a classical gas - Physical interpretation of the classical limit, Derivation of Boltzmann equation for change of states without and with collisions, Boltzmann equation for quantum statistics, Equilibrium distribution in Boltzmann equation.

Module-5

Thermodynamics, Microstates and Macrostates

Basic postulates of thermodynamics, Fundamental relations and definition of intensive variables, Intensive variables in the entropic formulation, Intensive variables in the entropic formulation - Equations of state, Euler relation, densities - Gibbs-Duhem relation for entropy - Thermodynamic potentials and extensivity properties, Maxwell relations, Energy differential and thermodynamic potentials of systems in external magnetic field – Thermodynamic relations, Microstates and macrostates, Ideal gas, Microstate and macrostate in classical systems, Microstate and macrostates, in quantum systems. Density of states

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Classical Mechanics	H Goldsteinhon safko	PEARSON	3rd Ed-2000
2	Introduction to Classical Mechanics	R G Takawale and P S Puranik	TMH	1st Ed-1979
3	Classical Mechanics	N C Rana and P S Joag	TMH	2nd Ed-1991
4	An Introductory Course of Statistical Mechanics,	Palash B. Pal	Narosa Publishing House, New Delh	3rd Ed-2008
5	Elements of Statistical Mechanics	Kamal Singh & S. P. Singh,	S. Chand & Company, New Delhi,	4th Ed- 1992
6	Statistical Mechanics an Elementary	Avijit Lahiri,	University Press, Hyderabad,	4th Ed-2002

2. (Group-2): 16CHE03 Organic Chemistry-I

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Substitution Reactions – Kinetics, mechanism and stereo chemical factor affecting the rate ofSN1, SN2, SRN^{i}, SN^{i}, $SN^{1'}$, $SN^{2'}$, SN^{1i}, reactions, Neighbouring group participation. Electrophilic substitution reactions – Kinetics, me chanism and stereo chemical factor affecting the rate of SE1& SE2.

Module-2

Aromatic Electrophilic Substitution Reactions: Mechanism of nitration, halogenation,sulphonation, Friedel-Crafts alkylation and acylation, Mannich reaction, chloromethylation, VilsmeierHaack reaction, Diazonium coupling, Gattermann–Koch reaction, Mercuration reaction.

Aromatic Nucleophilic Substitution Reactions: SN1, SN2 and benzyne mechanism, Buchererreaction, von Richter reaction.

Module-3

Addition Reactions: Addition to C-C multiple bonds involving electrophiles, nucleophiles andfree radicals. Markownikoff's rule and antiMarkownikoff's rule, Hydroboration. Typical additions to carbonyl compounds: Addition of hydride, water, alcohol, thioalcohol, bisulphite, HCN, Grignard reagents and amino compounds to carbonyl compounds.

Module-4

Aldol and Related Reactions: Keto-enoltautomerism, mechanism and synthetic applications of aldol condensations, Claisen reaction, Schmidt reaction, Perkin reaction, Knoevenogel, benzoin, Stobbe and Darzen'sglysidic ester condensation, Cannizaro reaction, Tishchenko reaction, Michael addition, Robinson's annulation reactions. Mechanism of ester formation and their hydrolysis, formation and hydrolysis of amides, decarboxylation mechanisms.

Module-5

Elimination Reactions: Mechanism and stereochemistry of eliminations – E1, E2,E1cb mechanism, cis-elimination, Hofmann and Saytzeff eliminations, competition between elimination and substitution, Chugaev reaction. Rearrangement reactions: Inter and Intra molecular.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books				
1	Organic Chemistry, Vol. I & II	I. L. Finar	ELBS Longmann	4th Edition
2	Advanced Organic Chemistry	J. March	Wiley Interscience	4th Edition 1994
3	Mechanism and Structure in Organic Chemistry	E. S. Gould	Halt, Rinhart & Winston, New York	1st Edition, 1964
4	Advanced Organic Chemistry – Part A & B	F. A. Carey and Sundberg	Plenum Press, New York	3rd Edition, 1990
5	Comprehensive Organic Synthesis	B. M. Trost and I. Fleming series	Pergamon Press, New York	Volume 4, 1991
6	A Guide Book to Mechanism in Organic Chemistry	Petersykes	Longmans , Green And Co	2nd Edition 1965
7	Advanced General Organic Chemistry	S. K. Ghosh	Book and Alleied (P) Ltd	Volume 1 & 2,
8	Organic Reaction Mechanism	R. K. Bansal	Wiley Eastern Limited, New Delhi	1st Edition, 1993

3. (Group-2):16CHE04	**Organic Chemistry-II**
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Ultra Violet Spectroscopy: Nature of electronic excitations, origin of UV band structure, principles of absorption spectroscopy. Designation of UV absorption bands: Electronic transitions, bands, chromophores, auxochromes, red and blue shifts, transition probability. Instrumentation, substituent and solvent effects. UV spectral study of alkenes, dienes, polyenes, carbonyl and aromatic compounds.

Module-2

Infrared Spectroscopy: Introduction, modes of stretching and bending. Dispersive and FT-IRspectrometers. Sampling techniques. Fundamental vibrations, overtones, Group frequencies, factors affecting group frequencies; Conjugation, inductive, resonance, steric effects. Identification of the following organic compounds by IR: Alkanes, Alkenes, Alkynes, Aromatic compounds, Aldehydes, Ketones, Alcohols, Thiols, Acids, Acid chlorides, Amides, Amines, Esters, halides, nitro compounds.

Module-3

Proton Magnetic Resonance Spectroscopy: Introduction- Magnetic properties of nuclei-Resonance condition. Field Frequency diagram. Precession of Nuclei, Relaxation- CW and PFT-methods-Instrumentation and Sample handling. Chemical shift- Mechanism of shielding and deshielding- in Alkanes, Alkyl halides, Alkenes, Aromatic compounds, Carbonyl compounds and Annulenes. Chemical shifts of different types of organic compounds.

Module-4

Mass Spectroscopy: Introduction, instrumentation, methods of ionization: EI, CI, DI and ESI. Mass anaylsis. Fragmentation: principles, odd and EE ions, molecular ion and base peak, Nitrogen rule, metastable ions. Isotope effects in chloro and bromo compounds. Stevenson rule.

Module-5

Fragmentation: i) Normal and Branched Alkanes. ii) Alkenes. iii) Benzene and its derivatives, iv) Alcohols. v) Aldehydes. vi) Ketones. vii) Acids. viii) Esters. ix) Ethers. x) Amines. xi) Nitro compounds. xii) Halo compounds. xii) Peptides.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books				
1	Introduction to Spectroscopy	D.L.Pavia, G.M. Lampman and G.S.Kriz	Saunders Golden Sunburst Series London	1st Edition, 1979
2	Spectroscopic Identification of Organic Compounds	R.M.Silverstein and F.X.Webster	Wiley and Sons, India Ltd	6th Edition, 2006
3	Organic Spectroscopy	William Kemp	Palgrave publishers	3rd Edition, 2002
4	Organic Structural Spectroscopy	J. B. Lamber, H.F.Shurvell, D.A.Lightner, R.G.Cooks.	Prentice Hall Publishers, Jersey	1st Edition, 1998
5	Organic Spectroscopy	D.W.Brown, A.J.Floyd and M.Sainsbury	John Wiley and Sons	1st Edition, 1988
6	Applications of Absorption Spectroscopy of Organic Compounds	J.R Dyer	Prentice Hall Publishers, New Delhi	1st Edition, 1969
7	Interpretation of Mass Spectra	McLafferty	University Science Books, California.	4th Edition 1993
8	Organic Spectroscopy	V.R. Dani	Tata McGra w-Hill, Ltd	1st Edition,
9	Spectroscopy of Organic Compounds	P.S. Kalsi	New Age International	6th Edition, 2007
10	Organic Spectroscopy	Jag Mohan	Narosa Publishing House	2nd Edition, 2001

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4. (Group-2):16MAT03 Complex Analysis 22

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Complex Integration

Complex line integrals, simply and multiply connected regions, Cauchy's theorem and its consequences, Cauchy's integral formula, Morera's theorem, Liouville's theorem.

Module-2

Taylor's series and Laurent series

Taylor's theorem, Taylor series, Laurent's series, classification of singularities, Entire

Module-3

Residues and Evaluation of Integrals

Residues, calculation of residues, Residue theorem, contour integration-evaluation of

Module-4

Conformal Mapping

Transformation or mapping, Jacobian of transformation, Conformal mapping, Riemann's mapping theorem, fixed and invariant points of transformation, Translation, rotation, strtching and inversion. Bilinear transformation, The Schwarz – Christoffel

Module-5

Complex Analysis and Potential Theory

Electrostatic fields, applications of conformal mapping, heat problems and fluid flow,

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Complex Analysis	L.V.Ahlfors	McGraw Hill	3rd Ed.,2013
2	Real and Complex Analysis	Walter Rudin	McGraw Hill	3rd Ed.,1987
3	Complex Analysis	Serge Lang	Springer	4th Ed.,1999
4	The Elements of Complex Analysis	B.Choudhary	John Wiley & Sons	2nd Ed.,1993

5	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Ed.,2016

5. (Group-2):16MAT04	**Computer Fundamentals and Programming in C**
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

An overview of functioning of a computer system, Components of a computer system, I/O and auxiliary storage devices ,machine and high level languages, assembler, compiler and interpreters, flow charts and pseudo codes, Basic concepts of operatingsystem.

Module-2

Introduction to C Essentials – Programs development, Functions. Anatomy of a Function. Variables and Constants Expressions. Assignment Statements, Scalar Data types – Declarations, Different Types of integers. Different kinds of Integer Constants, Floating point type Initialization, mixing types.

Module-3

Explicit conversions – Enumeration Types, The void data type, Type definitions. Operators and expression in C-Precedence and associativity, Control flow statements Conditional branching, the switch statement, looping, nested loops, the break and continue statement, the go to statement, infiniteloops.

Module-4

Arrays and multidimensional arrays. Storage classes-fixed vs. automatic duration scope, global variable the register specifier, Functions –user defined and library function, Introduction to pointers, structures and unions.

Module-5

Introduction to C++: Declaration & Definition of Variables, Data Types, Operators, OOPS Fundamentals: OOPS Versus procedural programming, OOPS terminology, Data abstraction, Data hiding, Encapsulation, Class, Object, Inheritance, Polymorphism.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Programming with C (Schaum's OutlineSeries)	B.Gottifred and J.Chabra	Mc-Graw Hill	3rd Ed., 2017
2	Fundamentals of Computers	V. Rajaraman	PHI	6th Ed., 2015
3	Programming in C++	E.Balaguruswamy	Tata-McGraw Hill	4th Ed., 2010
4	The C Programmed language (ANSI	B.W. Kernigham & D.M. Ritchie	PHI	2nd Ed., 2009

5	Programming in C	V.Guptha, S.S.Bhatia & A.Bansal	Kalyani Publishers	3rd Ed., 2014

1.	**(Group-3):16PHY03**	**Quantum Mechanics**

for simple cases: j = ½, j = ½ and j = 1, j = ½ .

$_1$ 2 1 2

Identical particles and spin: Indistinguishability of identical particles. Symmetry ofwave function and spin. Bosons and Fermions. Pauli exclusion principle. Singlet and triplet states of He atom and exchange integral Spin angular momentum, Pauli matrices.

Angular momentum: Definition, eigenvalues and eigenvectors, matrix representation, orbital angular momentum. Addition of angular momenta, Clebsch-Gordon coefficients

for simple cases: j = ½, j = ½ and j = 1, j = ½ .

Module-5

Symmetry principles: Symmetry and conservation laws, symmetry and degeneracy.Space-time symmetries, Displacement in space- conservation of linear momentum, Displacement in time, conservation of energy, Rotation in space, conservation of angular momentum, Space inversion,parity. Time reversal invariance.

Relativistic wave equations: Schrodinger's relativistic equation: free particle,electromagnetic potentials, separation of equations, energy level in a coulomb field.

Dirac's relativistic equation: free particle equation, Dirac matrices, free particle solutions, charge and current densities. Electromagnetic potentials. Dirac's equation for central field: spin angular momentum, approximate reduction, spin orbit energy. Separation of the equation. The Hydrogen atom,

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Concepts of Modern Physics	Arthur Beiser:	McGraw Hill Edu Pvt Ltd	7th Ed-2017
2	Quantum Mechanics	L. I. Schiff	McGraw-Hill	4th Ed-2014

3	Quantum Mechanics	F. Schwabl	Springer	4th Ed- 2007
4	Quantum Mechanics:	V. K. Thankappan	J. Wiley	2nd Ed-1993
5	Quantum Mechanics	B. K. Agarwal and Hari Prakash	PHI	3rd Ed-1996
6	Text book of Quantum Mechanics	P. M. Mathews and K. Venkateshan	Mc Graw-Hill	2nd Ed-2010

2.	**(Group-3):16PHY04**	**Atomic, Nuclear and Molecular Physics**
Exam Hours: 3 hours		**Exam Marks(Maximum):100**

Module-1

One electron System: Quantum states of one electron atoms, atomic orbitals, hydrogenspectrum. Spectra of alkali elements, spin-orbit interaction and fine structure in alkali spectra.

Two electron Systems: LS-coupling, equivalent and non-equivalent electrons, spectralterms, Pauli exclusion principle, coupling schemes for two electrons, interaction energies for LS coupling, fine structure splitting for sp electron configuration, Lande interval rule. jj-coupling- spectral terms, interaction energies for jj-coupling, fine structure splitting for sp electron configuration. Qualitative consideration of selection andintensity rules for LS and jj-coupling. Hyperfine structure for one and two electrons and Lande interval rule.

Module-2

Weak magnetic field effects: Normal and anamolous Zeeman effect, magnetic momentof a bound electron and Lande g-factor, magnetic interaction energy, selection rules, Zeeman pattern for principal series doublet, intensity rules. Zeeman effect for two electrons-magnetic moment of the atom and g-factors, expression for magnetic interaction energy, selection rules, Zeeman pattern transitions for diffuse-series singlet, intensity rules.

Strong magnetic field and Electric field effects: Paschen-Back effect, expression fortotal energy shift, transitions for principal series doublet. Qualitative treatment of Paschen-Back effect and complete Paschen- Back effect for two electrons. Isotope structure. Stark effect-first and second order

Module-3

Microwave, Infra-red spectra , UV-Visible spectra

Types of molecules- linear, symmetric top, asymmetric top and spherical top molecules. Theory of rotational spectra for rigid and non-rigid rotator diatomic molecules, energy levels, intensity of rotational lines. Microwave spectrometer and applications. Vibrational energy of diatomic molecule as simple harmonic and anharmonic oscillators, Morse potential energy curve, energy levels and vibrational spectra. Diatomic molecule as a vibrating-rotator, vibration-rotation spectra-P,Q,R branches. IR- spectrometer and applications. Electronic spectra of diatomic molecules, Born-Oppenheimer approximation, vibrational coarse structure- band progressions and sequences, Frank-Condon principle-intensity of vibrational-electronic spectra, dissociation energy and dissociation products. Rotational fine structure of electronic-vibration transitions, determination of vibrational and rotational constants. Molecular orbital. Classification of electronic states and multiplet structure, selection rules for electronic transitions and simple electronic transitions. UV-Visible absorption and fluorescence spectrophotometers and

Module-4

Properties of Nucleus: Nuclear constitution. The notion of nuclear radius and itsstimation from Rutherford's scattering experiment; the coulomb potential inside the nucleus and the mirror nuclei. The nomenclature of nuclei, and nucleon quantum numbers. Nuclear spin and magnetic dipole moment. Nuclear electric moments and shape of the nucleus.

Nuclear Forces: General features of nuclear forces. Bound state of deuteron with squarewell potential, binding energy and size of deuteron. Deuteron electric and magnetic moments - evidence for non-central nature of nuclear forces. Yukawa's meson theory of nuclear forces.

Nuclear Reactions: Reaction scheme, types of reactions and conservation laws. Reaction kinematics, threshold energy and *Q*-value of nuclear reaction. Energetics of exoergic and endoergic reactions. Reaction probability and cross section. Bohr's compound nucleus theory of nuclear reactions.

Nuclear Models: The shell model; Evidence for magic numbers, energy level, scheme for nuclei with Infinite Square well potential and the ground state spins. The extreme single particle prediction of nuclear spin and magnetic dipole moments -Schmidt limits. The liquid drop model: Nuclear binding

Module-5

Nuclear Decays: Alpha decay: Quantum mechanical barrier penetration, Gammow's theory of alpha decay and alpha half-life systematics. Beta decay: Continuous beta spectrum, neutrino hypothesis, and Fermi's theory of beta decay, beta comparative half- life systematics. Gamma decay: Qualitative consideration of multipole character of gamma radiation and systematics of mean lives for gamma multipole transitions.

Interaction of Radiation with Matter: Interactions of charged particles with matter,ionisation energy loss, stopping power and range energy relations for charged particles. Interaction of gamma rays; photoelectric, Compton and pair production processes. Nuclear radiation detectors-G M counter and Scintillation detector.

Nuclear Energy: Fission process, fission chain reaction, four factor formula and controlled fission chain reactions, energetics of fission reactions, fission reactor. Fusion process, energetics of fusion reactions; Controlled thermonuclear reactions; Fusion reactor. Stellar nucleo synthesis.

Fundamental Interactions and Elementary Particles: Basic interactions and theircharacteristic

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.

- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Introduction to Atomic Spectra	H E White	McGraw Hill	1934 Ed
2	Fundamentals of Molecular Spectroscopy:	C N Banwell and E M McCash	McGraw Hill	4th Ed
3	Spectroscopy,Vols. 1, 2 and 3	B P Straughan and S Walker	Chapman and Hall	1990 Ed
4	Nuclear and Particle Physics	W.E. Burcham and M. Jobes	Addison Wesley,	1998 Ed
5	Nuclear Physics	R R Roy and B P Nigam	New Age International	2nd Ed
6	Introduction to Nuclear Physics	S B Patel	New Age International	2006 Ed

3.	**(Group-3):16CHE05**	**Physical Chemistry-I**
Exam Hours: 3 hours		**Exam Marks (Maximum):100**

Module-1

Chemical Kinetics- Methods of deriving rate laws- complex reactions- Rate expressionsfor opposing parallel and consecutive reactions involving unimolecular steps. Theories of reaction rates – collision theory- Steric factor - Activated complex theory- thermodynamic aspects- Unimolecuar reactions- Lindemann's theor y- Lindemann- Hinshelwood and RRKM theories. Reactions in solutions- Influence of solvent- Primary and secondary salt effects-Elementary account of linier free energy relationships – Hammet- Taft equation- Chain reactions – Rate laws of H_2-Br_2 , photochemical reaction of H_2-C_{l2} Decomposition of acetaldehyde and ethane – Rice – Herzfeld mechanism.

Module-2

Statistical Thermodynamics: Basic terms: Probability, cell, phase space, micro and macrostates, thermodynamic probability, statistical weight factor, statistical equilibrium, assembly, ensemble and its classification, Derivation of Boltzmann-Maxwell, Bose-Einstein and Fermi-Dirac statistics, partition function and derivations of translational, rotational, vibrational and electronic partition functions, thermodynamic functions such as internal energy, heat capacity, entropy, work function, pressure, heat content, etc.. Partition function and third law of thermodynamics, applications of partition function to mono atomic gases, diatomic molecules, equilibrium constant and equilibrium constants of metathetic reaction and

Module-3

Electronic Properties and Band Theory: Metals, insulators and semiconductors, electronicstructure of solids-band theory, band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super conductors. Optical properties- Optical reflectance, photoconduction. Magnetic Properties- Classification of materials: quantum theory of paramagnetic cooperative phenomena magnetic domains, hysteresis.

Module-4

Nuclear Chemistry: Nuclear properties, binding energies, nuclear force radii, angularmomentum in nuclear chemistry, spin magnetic and quantum moments, pairing energy, Square Well and Wood Saxon potentials.

Module-5

Nuclear Models: Fermi, Shell, Collective, nuclear reaction energetic, Q values and thresholds, barriers for charged particles, cross section, partial cross sections, elastic scattering, energy changes in fission and fusion, synthesis of some radioactive elements like Na, P, S, Y and Br, accelerators, use of radioactive isotopes as tracers.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.

- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Chemical Kinetics	KJ. Laidler	McGraw hill publications	1st Edition, 1976
2	The text book of physical chemistry	Samuel Glasstone	Mcmillan publications	1st Edition, 1974
3	Textbook of Physical Chemistry	Glasstone S	Affiliated East West Press	1st Edition, 2006
4	Thermodynamic for Chemists	GlasstoneS	Affiliated East West Press	1st Edition, 2006
5	Thermodynamics	Gurdeep and Rajesh	Goel Publishing House, Meerut	1st Edition, 2012
6	Physical Chemistry	Barrow G M	Mcgraw Hill Company	5th Edition, 1968
7	Nuclear Chemistry and Radio Activity	S Baluja	Saurashtra Universty, Rajkot	3rd Edition, 1968

4. (Group-3):16CHE06 Physical Chemistry-II

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Solid State Chemistry: Preparative methods Solid state reaction, chemical precursor method,co-Precipitation, sol-gel, metathesis, self-propagating high temperature synthesis, ion exchange reactions, intercalation deintercalation reactions; hydrothermal and template synthesis;

Module-2

High Pressure Synthesis Methods of Single Crystal Growth: Solution growth; Melt Growth-Bridgeman, Czochralski, Kyropoulus, Verneuil; Chemical Vapour Transport; Fused Salt Electrolysis; Hydrothermal method; Flux Growth.

Module-3

Crystal Structure: Crystalline and amorphous solids; crystal systems, point groups: methodsof characterizing crystal structure - Powder x-ray diffraction, electron and neutron diffraction; types of close packing - hcp and ccp, packing efficiency, radius ratios; polyhedral description of solids; structure types -NaCl, ZnS, Na_2O, $CdCl_2$, wurtzite, nickel arsenide, CsCl, CdI_2, rutile and Cs_2O, perovskite ABO_3, K_2NiF_4, spinels

Module-4

Electrode Kinetics: Metal/solution interface- Dependence of electrochemical reaction rate onover potential-current density for single step and multi-step processes-Influence of electrical double layer on rate constants. Activation and diffusion controlled processes- Marcus kinetics and quadratic dependence of Gibbs free energies-electron transfer processes involving organic and inorganic compounds. Different types of over potentials- polarization behavior-Mechanism of hydrogen evolution and oxygen reduction in acid and alkaline media-

Module-5

Quantum Mechanics: Solution of the Schrodinger equation for exactly solvable problemssuch as particle-in-a- box, particle-in-a-ring, harmonic oscillator and rigid rotor. Tunneling, one dimensional potential barriers and wells. Postulates of quantum mechanics, wave functions and probabilities, operators, matrix representations, commutation relationships. Hermitian operators, Commutators and results of measurements in Quantum Mechanics. Eigen functions and eigen values of operators and superposition principle.States as probability distributions and expectation values. The expansion of arbitrary states in terms of complete

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.

- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Solid State Chemistry and its Applications	R. West	John Wiley & Sons	2nd Edition, 1984
2	Solid State Chemistry - An Introduction	L. Smart and E. Moore	Chapman & Hall	1st Edition, 1993
3	Principles of the Solid State	H. V. Keer	Wiley Eastern Limited	1st Edition,
4	Chemical Kinetics and Dynamics	Jeffrey I Steinfeld, Joseph S. Francisco and William L. Hase	Prentice Hall	2nd Edition, 1998
5	Chemical Kinetics	Laidler, K. J	Benjamin-Cummings. Indian reprint - Pearson	3rd Edition, 2009
6	Electrode kinetics	W.J.Albery	Clarendon Press, Oxford	1st Edition,
7	Comprehensive Chemical Kinetics, Vol 26 Electrode Kinetics – Principles and Methodology	C.H. Banford and R.G. Compton	Elsevier science publishers	1st Edition, 1986
8	Quantum Chemistry	D. A. McQuarrie	University Science Books	1st Edition, 1983
9	Quantum Chemistry	I. N. Levine	Allyn and Bacon	3rd Edition, 1983
10	Quantum Chemistry	J. P. Lowe and K. A. Peterson	Academic Press	3rd Edition, 2006
11	Principles of Quantum Chemistry	R.K.Prasad	McgrwHill publications	3rd Edition, 2006

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Basic Science Board)
As per 2017 Regulation

5. (Group-3):16MAT05	**Probability and Stochastic process**
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Probability – Random experiments, sample paces, event, axioms, addition and multiplication rules, conditional probability, independent events, Baye'stheorem.

Module-2

Random variable, discrete probability distribution, continuous random variables, continuous probability distribution, Cumulative distribution function, expected value. Continuous and discrete Joint distribution, expectation, variance, standard deviation, covariance.

Module-3

Probabilitydistributions-Binomial, Poisson, Exponential, Normal, Hyper geometric relations, gamma distribution, Weibull distribution.

Module-4

Sampling Theory-Population and sample, sampling with and without replacement, sampling distribution of means, sample variance. Unbiased estimate, reliability, confidence intervals for mean, statistical hypothesis, testing of hypothesis, Type I and II errors, one tailed, two tailed tests, *t* – distribution, Chi square test for goodness of fit.

Module-5

Markov Chains: States and transitions, Transition probabilities, General two-state Markov chain, Powers of the transition matrix for the *m*-state chain, Gambler's ruin as a Markov chain, Classification of states, Classification of chains, problems.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Probability and Statistics (Schaum's outline series)	M.R. Spiegel, J. Schiller, & R.A. Srinivasan	McGraw-Hill	2nd Ed.,1985
2	Probability and Statistics for Engineers and Scientists	R.E, Walpole, R.H.Myres, S.L.Myres & K. Ye	Pearson	9th Ed., 2012
3	Probability and Stochastic Processes	D. Yates & David J.Goodman	John Wiley & Sons	2nd Ed., 2005
4	Higher Engineering Mathematics	B.S. Grewal	Khanna Publishers	44thEd., 2017

5	Probability and Statistics for Engineers and Scientists	Sheldon M.Ross	Academic Press	5th Ed., 2014

6. (Group-3):16MAT06	**Operations Research**
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Linear Programming

Formulation, Graphical method, Simplex Method, Two Phase method, Big M Method, Dual Simplex method.

Module-2

Assignment Models: Formulation, Hungarian Method, Travel Salesman problem.

Transportation Models: Mathematical Formulation, Matrix form, North west corner method, Vogel's method for Feasible solution, Stepping stone and Modified distribution method for Optimality test.

Module-3

Game theory

Basic definition, Saddle points, Principles of Dominance, Games without Saddle point,

Module-4

Queuing Theory

Introduction, types of Queuing models, Kendal's notations, Single channel and multiple

Module-5

CPM and PERT

Basic definitions, Network components, Rules for Network construction, Critical path method,

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Operations Research	S D Sharma	Kedarnath Ramnath & Co	Latest Ed., 2017
2	Operations Research	H.A.Taha	Pearson	8th Ed., 2007
3	Operations Research	P.Ramamurthy	New Age International	2nd Ed., 2007
4	Operations Research	H.A.Eiselt & C.L.Sandblom	Springer	6th Ed., 2010

5	Optimization in Operations Research	R.L.Rardin	Pearson	2nd Ed., 2007

1. (Group-4):16PHY05	**Solid State Physics, Nano Science and Technology**
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Crystal structure: Crystal systems, Crystal classes, Bravais lattice. Unit cell: Wigner-Seitz cell, equivalent positions in a unit cell. Notations of planes and directions. Atomic packing: packing fraction, Co-ordination number. Examples of simple crystal structures: NaCl, ZnS and diamond. Symmetry operations, point groups and space groups.

X-ray diffraction: X-ray diffraction, Bragg law. Laue equations. Atomic form factorand Structure factor. Concept of reciprocal lattice and Ewald's construction. Experimental diffraction methods: Laue, Rotating crystal method and Powder method.

Crystal binding: Types of binding. Van der Waals-London interaction, Repulsive interaction. Modelung constant. Born's theory for lattice energy in ionic crystals and comparison with experimental results. Ideas of metallic binding, Hydrogen bonded crystals.

Lattice vibrations: Vibrations of monoatomic lattices. First Brillouin zone.Quantization of lattice vibrations - Concept of Phonon, Phonon momentum. Specific heat of lattice (qualitative).

Module-2

Energy bands in solids: Formation of energy bands. Free electron model: free electronsin one and three dimensional potential wells, electrical conductivity, heat capacity, paramagnetism, Fermi-Dirac distribution, density of states, concept of Fermi energy. Kronig-Penny model. Nearly Free Electron Model (qualitative). Tight Binding model (qualitative).

Defects in solids: Point defects: Schottky and Frenkel defects and their equilibrium concentrations. Line defects: Dislocations, multiplication of dislocations (Frank-Read mechanism). Plane defects: grain boundary and stacking faults.

Semiconductors: Intrinsic and extrinsic semiconductors, concept of majority andminority carriers. Statistics of electrons and holes, electrical conductivity. Hall effect. Experimental determinations of resistivity of semiconductor by four probe method.

Superconductors: Superconductivity, Zero resistance,. Meissner effect, Critical field,Classification

Module-3

Introduction: Origin of Nanotechnology, Nano materials, Types of nonmaterials,Surface area to volume ration, Quantum confinement effect, band theory of nonmaterials. Physical and chemical properties of nonmaterials.

Synthesis of nanomaterials: Bottom-up approach and Top-down approach with examples. Physical methods: Inert gas condensation, Arc Discharge, RF-plasma, plasma arc technique, electric explosion of wires, lasers ablation, laser pyrolysis, ball milling, molecular beam epitaxial, electro deposition. Sol-gel technique, Combustion synthesis, ultrasonic precipitation process, chemical vapour deposition.

Characterization of Nanomaterials

Structural characterization techniques: X-Ray Photoelectron Spectroscopy(XPS), X-Raytopography, Energy Dispersive X-Ray Analysis(EDAX), Principles and applications of X- Ray Diffraction: Small angle X-Ray Diffraction and Wide angle X-Ray Diffraction; Electron Diffraction, Electro probe microanalysis (EPMA), Ion beam techniques: RBS.

Surface characterization Techniques: Scanning electron microscopy (SEM), Transmission electronmicroscopy, Basic principles and applications of scanning probe techniques (SPM), Atomic force microscopy, and scanning tunneling microscopy.

Spectroscopic techniques: UV-Visible spectroscopy, Infrared (IR) & Fourier Transform infrared (FTIR) Spectroscopy, Raman Spectroscopy techniques: Photo luminescence Spectroscopy.

Module-4

Carbon nanostructures: Allotropes of Carbon, Graphene, Properties of Graphene,Applications of graphene, Fullerenes, Fullerene synthesis and purification, Properties of fullerenes. Carbon nanotubes, Structure, Types of Carbon nanotubes, Synthesis of Carbon nanotubes, Purification of Carbon nanotubes, Properties of Carbon nanotubes, Applications of Carbon nanotubes.

Inorganic nanostructures: Overview of relevant semiconductor physics - Quantumconfinement in semiconductor nanostructures - The electronic density of states - Fabrication techniques - Physical processes in semiconductor nanostructures - The characterisation of semiconductor nanostructures, Applications of semiconductor nanostructures.

Module-5

Nanotechnology and Society

Introduction to Societal Implications of Nanoscience and Nanotechnology, Nanotechnology Goals: Knowledge and scientific understanding of nature, Industrial manufacturing, materials and products, Medicine and the human body, Sustainability: Agriculture, water, energy, materials and clean environment, Space exploration, National security, Moving into the market.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each

module.

- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Elementary Solid State Physics: Principles and applications	M. A. Omar	Addison-	3rd Ed
2	Introduction to Solid State Physics	C. Kittel	Wiley Eastern	8th Ed
3	Solid State Physics	A. J. Dekkar	Macmillan India Limited	2014Ed
4	Semiconductor Physics,	P. S. Kire	MIR	1975 Ed
5	Solid State Physics	S. O. Pillai	New Age Publisher	2018 Ed
6	Nano: The Essentials: Understanding Nanoscience and Nanotecnology	T. Pradeep	Tata McGraw-Hill	2008 Ed

2. (Group-4):16PHY06	**Material Science**
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Engineering Materials: Materials science and engineering, Classification, Levels of structure, Structure-property relationship in materials.

Structure of Solids: The crystalline and Non-crystalline states, Covalent solids, Metals and alloys, Ionic solids, The structure of silica and silicates

Crystal growth: Crystal growth from melt: Bridgemann technique, Crystal pulling byCzochralski's method, Growth from solutions, Hydrothermal method, Gel method, Zone refining method of purification.

Crystal imperfections: Point imperfections, Dislocation, Edge and Screw dislocation,Concept of Burger vector and Burger circuit, Surface imperfections, Colour centres in ionic solids.

Module-2

Solid Phases and Phase diagrams: Single and multiphase solids, Solid solutions and Hume-Rothery rules, Intermediate phase, The intermetallic and interstitial compounds,Properties of alloys: solid solutions and two component alloy systems; Phase diagram, Gibbs phase rule, Lever rule; First, second and third order phase transitions with examples; Some typical phase diagrams: Pb-Sn and Fe-Fe_2O_3; Eutectic, eutectoid, peritectic and peritectoid systems.

Phase transformation: Time scale for phase changes; Nucleation and growth, nucleation kinetics; Growth and overall transformation kinetics, Applications: transformation in steel; Precipitation processes, solidification and crystallization; Glass transition, recovery, recrystallization and grain growth.

Diffusion in Solids: Theory of diffusion, Self-diffusion, Fick's law of diffusion, Kirkindal effect, Activation energy for diffusion, Applications of diffusion

Module-3

PROPERTIES OF NANOMATERIALS

Electrical and mechanical propertie Introduction, Energy Storage Basics, General Information: Electrical Energy Storage Devices and Impact of Nanomaterials, Batteries, Capacitors - Gold Standards (State of the Art) for Both Batteries and Capacitors - Electrochemical Properties of Nanoscale Materials- Aerogels and Structure-Directed Mesoporous and Macroporous Solids - Nanoparticles - Nanotubes, Nanowires, and Nanorolls. Nanoscale Mechanics - Introduction, Mechanical properties, Density Considered as an Example Property, The Elasticity of Nanomaterials, Elasticity of Bulk Nanomaterials, Plastic Deformation of Nanomaterials - The Physical Basis of Yield Strength, Crystals and Crystal Plasticity, From Crystal Plasticity to Polycrystal Plasticity

Module-4

Nanooptics : Absorption: direct and indirect bandgap transitions - Emission: photoluminescence and Raman Scattering, Emission: Chemiluminescence and Electroluminescence, Shape dependent optical properties, Optical absorption, Optical emission, Surface plasmon resonance (SPR) - Surface enhanced Raman scattering (SERS).

Nanocatalysis: Introduction, nanomaterials in catalysis, metals, recent progress, nanostructured adsorbant, metals, controlled pore size materials, pelletized nanocrystal, nanoparticles as new chemical reagents, metals, metal oxide reactions, nanocomposite polymers, fluids, inks and dyes, block co polymers and dendrimers, nano crystal super lattices.

Module-5

Nanomagnetism: Introduction, fundamental concepts, magnetic materials, dia, para and ferromagnetism - magnetic phenomena in ferromagnetic materials, magnetic anisotropy, magnetic domains, hysteresis small particle magnetism, single domain particles, coercivity of single domain particles, superparamagnetism, the coercivity of small particles - review of some issue in nanoscale magnetism.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Elements of Materials science and Engineering	L. H. Van Vlack	Addison Wesley	6th edition, 1989
2	Materials Science and Engineering	V. Raghvan	Printice Hall of India	5th edition, 2009
3	Materials Science and Processes	S. K. Hazra Chaudary	Indian Distr Co	3rd Ed-2009
4	Introduction to Solids	L. V. Azaroff	Tata McGraw Hill	New Ed-2017
5	Nanoscale materials in chemistry	Kenneth J. Klabunde	John Wiley & Sons	2nd Ed- 2009.
6	Optical properties and spectroscopy of nanomaterials	Jin Zhong Zhang	World Scientific	3rd Ed- 2009

3.	**(Group-4):16CHE07**	**Analytical Chemistry & Allied Subjects-I**
Exam Hours: 3 hours		**Exam Marks (Maximum):100**

Module-1

Statistical Treatment of Analytical Data and Sampling: Limitations of analyticalmethods. Classification of errors-systematic errors-sources, effects and their reduction. Random errors-sources and distribution. Accuracy and precision. Measures of central tendency and variability. Reliability of results-confidence interval. Comparision of results-Student's t-test, comparing the two means and standard deviations-F-test, t-test and paired t-test. Rejection of a result-Q-test.Number of replicate determinations. Control charts. Correlation and regression-correlation coefficient, linear regression, errors in slope and intercept, error in the estimate of concentration. Detection limits, Sampling and sample handling-representative sample, sample storage, sample pretreatment and sample preparation. Hazards in sampling. Quality in analytical laboratories-quality control and quality assurance, accreditation system.

Module-2

Flame Photometry: Introduction, Principle, flames andflame spectra vibration of emission intensity with flames, flame back ground, metallic spectra inflame, total consumption and premix burners, interferences, role of temperature on absorption.

Module-3

Atomic Absorption Spectroscopy: Sources, hallow cathode lamp, line sources, comparative study of AAS and flame spectroscopy; applications of AAS and Flame photometry.

Module-4

Luminescence Spectroscopy (Molecular Luminescence): Introduction, Fluorescence andphosphorescence, excited states, deactivation processes, variable that affect fluorescence and phosphorescence. Relation between intensity and concentration, Instrumentation, Basic difference in the measurement of fluorescence and phosphorescence, general scope of application, comparison of flourimetry and phosphometry, Flourescent indicators, applications; flourimetric analysis of inorganic, organic, pharmaceutical and biological

Module-5

Electron Spin Resonance (ESR) Spectroscopy: Basic principle, interaction between electronspin and magnetic field; Origin of spectral lines; intensity, width and position of spectral lines; Relaxation process; multiplicity in ESR hyper fine splitting; g-value and factors affecting; Rules for interpretation of spectra; zero field splitting and Krammer's degeneracy, John-Teller's distortion, isotropic and Anisotropic coupling constants; Nuclear quadrapole coupling interaction; spin Hamiltonian, ESR spectra of radical containing a single set of equivalent protons-methyl, p-benzoquine anion, cyclopentadienyl, benzene, cycloheptatrienyl

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Analytical Chemistry	G.D. Christian	John Wiley & Sons, Inc, India	5th Edition., 2001
2	Quantitative Analysis	R.A. Day and A.L. Underwood	Prentice Hall, Inc. New Delhi	6th Edition., 1993
3	Vogel's Textbook of Quantitative Chemical Analysis	J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas	Pearson Education Pvt. Ltd., New Delhi	6th Edition, 3rd Indian Reprint.2003
4	Analytical Chemistry Principles	John H. Kennedy	Saunders College Publishing, California	2nd Edition, 1990
5	Introduction to Instrumental Analysis	R.D. Braun	McGraw-Hill Ryerson Limited.	1st Edition, 1987
6	Principles of Instrumental Analysis	Skoog, Hollar and Niemann	Harcourt Asian Pvt ltd India, New Delhi	5th Edition, 1998
7	Instrumental Methods of Analysis	Willard, Merit and Dean	Vaneica Y. Young, University of Florida Gainesville	7th Edition, 1998
8	Organic Spectroscopy	William Kemp	ELBS	3rd Edition, 1991
9	Organic Spectroscopy	Kalasi	Tata Mc. Graw Hill	1st Edition,

4	**(Group-4): 16CHE08**	**Analytical Chemistry & Allied Subjects-II**
Exam Hours: 3 hours		**Exam Marks(Maximum):100**

Module-1

Fundamentals of Chromatography: General description, definition, terms and parameters usedIn chromatography, classification of chromatographic methods, criteria for selection of stationary and mobile phase-nature of adsorbents, factors influencing the adsorbents, nature and types of mobile phases and stationary phases. Elution chromatography: Theories-plate theory; rate theory, band broadening-eddy diffusion, longitudinal diffusion and resistance to mass transfer, column efficiency-plate theory and rate theory approach, Van Deemter's equation and its modern version, optimization column performance, interrelationships-capacity factor, selectivity factor, column resolution, distribution constant and applications of conventional column chromatography, advantages and limitations.

Module-2

Paper Chromatography (PC): Definitions, theory and principle, techniques; one, two-dimensional and circular PC, mechanism of separation, structure of cellulose and types of paper, methodology preparation of sample, choice of solvents, location of spots and measurement of RF value, factors affecting RF values, advantages and applications.

Thin-Layer Chromatography (TLC): Definition, mechanism, efficiency of TL plates, Methodology selection of stationary and mobile phases-preparation of plates, spotting, development, identification and detection, reproducibility of RF values, comparison of TLC

Module-3

Gas Chromatography (GC): Principle, comparison of GSC and GLC, instrumentation columns packed and tubular, study of detectors-thermal conductivity, flame ionization, electron capture and mass spectrometry, factors affecting separation, applications.

High Pressure Liquid Chromatography (HPLC): Apparatus, pumps, column packing, characteristics of liquid chromatographic detectors - UV, IR, refractometer and fluorescence detectors, advantages and applications.

Ion - Exchange Chromatography (IEC): Definitions, requirements for ion -

Module-4

Exclusion Chromatography: Theory and principle of size exclusion chromatography, experimental techniques for gel-filtration chromatography (GFC) and gel-permeation chromatography (GPC), materials for packing-factors governing column efficiency, methodology and applications.

Module-5

Super Critical Fluid Chromatography: Properties of super critical fluids, instrumentation and operating variables, comparison of supercritical to other types of chromatography, applications.

Super Critical Fluid Extraction: Advantages of supercritical fluid extraction,

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Fundamental of Analytical Chemistry	D.A. Skoog, D.M. West,	Saunders College	8th Edition, 2005
2	Analytical Chemistry	G.D. Christian	John Wiley & Sons, Inc, India	5th Edition, 2001
3	Quantitative Analysis	R.A. Day and A.L. Underwood	Prentice Hall, Inc. New Delhi.	6th Edition., 1993
4	Vogel's Textbook of Quantitative Chemical Analysis	J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas	Pearson Education Pvt. Ltd., New Delhi	6th Edition, 3rd Indian Reprint.2003
5	Analytical Chemistry Principles	John H. Kennedy	Saunders College Publishing, California	2nd Edition, 1990

5. (Group-4):16MAT07Advanced Fluid Mechanics and Magneto hydrodynamics

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Real fluids and ideal fluids, velocity of fluid at a point, streamlines, pathlines, streamlines, velocity potential, vorticity vector, local and particle rate of change, equation of continuity, irrotational and rotational motion, acceleration of fluid, conditions at rigid boundary. Euler's equation of motion, Bernoulli's equation, axially symmetric flows, impulsive motion.

Module-2

Kelvin's Theorem of circulation, equation of vorticity. Three dimensional flows, sources, sinks and doublets, images in rigid planes, images in solid sphere. Stoke's stream function.

Module-3

Viscous Flows: Stress components, Stress and strain terror, Coefficient of viscosity and Laminar flow, Plane Poiseuille flows and Couette flow. Flow through tubes of uniform cross section in the form of circle, Ellipse, equilateral triangle, annulus, under constant pressure gradient, steady flow past a fixed sphere.

Dimensional analysis, Reynolds numbers, Prandtl's boundary layer, Boundary layer

Module-4

Non-Newtonian fluids, rheological classification , time dependent, thyrotrophic, viscoelastic fluids, constitution of blood, viscosity of blood, steady non- Newtonian fluid flows in circular tubes, Fahraeus- Lindqvist effect, Pulsative flow in circular rigid tube, flow through artery with stenosis, Peristaltic flow in a tube, long wave lengthapproximation.

Module-5

Basic equations of MHD including Faraday's laws and constitutive laws. Magnetic induction equation – Lorentz force – MHD approximations. Non-dimensional numbers – velocity, temperature and magnetic field boundary conditions. Hartmann flow – isothermal boundary conditions – temperature distribution in Hartmann flow – Hartmann couette flow. Classical MHD and Alfven's wave, Alfven's theorem, Frozen – n – phenomenon and equipartition of energy by Alfven'swaves.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	An Introduction to Fluid Mechanics	Batchelor, G. K.	Cambridge UniversityPres	Kindle Ed., 2000
2	Ideal and Incompressible Fluid Dynamics	M.E. O'Neill and F. Chorlton	Ellis Horwood	Digital Ed., 2007
3	Mathematical Models in Biology and Medicine	J.N.Kapur	Affiliated East-West	1st Ed., 1985
4	An Introduction to Magnetohydrodynamics	P.A.Davidson	Cambridge UniversityPres	2nd Ed.,
5	A Text Book of Fluid Mechanics	R.K.Bansal	Laxmi Publications	1st Ed., 2008

6. (Group-4):16MAT08Advanced Graph Theory

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Varieties of graphs, walks and connectedness, degrees, intersection graphs, operations on graphs. Cut points, bridges and blocks, block graphs and cutpoint graphs.

Trees - characterization of trees, centers and centroids, block cutpoint trees, independent cycles and cocycles, Matroids.

Module-2

Connectivity and line connectivity, Graphical variations of Menger's theorem, Partitions Eulerian and Hamiltonian graphs, Line graphs, properties and characterizations of line graphs, line graphs and transversability. Total graphs.

Module-3

Coverings and independence, critical points and lines, Planes and planar graphs, outerplanar graphs, Kurtowski's theorem.

Module-4

Colorability, the chromatic number, Five color theorem, Four color conjencture,The Heawood map coloring theorem, Uniquely colorable graphs, critical graphs. The adjacency matrix, incidence matrix, cycle matrix.

Module-5

Digraphs – digraphs and connectedness, directional dualty and acyclic digraphs, digraphs and matrices.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	GraphTheory	Reinhard Deistel	Springer	5th Ed., 2017
2	GraphTheorywithApplicationstoEngineeringandComputerScience	N.Deo	PHI	1st Ed., (5th Print), 2004
3	GraphTheory	F.Harary	AdditionWesleyReadingMA	1st Ed., 1969

4	GraphTheory	J.A.Bondy & U.S.R.Murthy	North-Holland	1st Ed.,(5th Print), 1982
5	GraphTheory and Applications	G.Appasami	Sarumathi Publications	1st Ed., 2016

1.	**(Group-5):16PHY07**	**Physics of Liquid Crystals and Polymer Science**
Exam Hours: 3 hours		**Exam Marks(Maximum):100**

Module-1

Liquid crystals: Introduction, classification of liquid crystals, thermotropic liquid crystals (rod like molecules), chirality in liquid crystals, nematic, cholestrric and smectic mesophases, polymorphism in thermotropic liquid crystals, polymer liquid crystals and their applications, distribution functions and order parameter, measurement of order parameters by X-ray diffraction.

Theories of phase transition: Nature of phase transitions and critical phenomena in liquid crystals, Mier-Saupe theory for nematic-isotropic and nematic-smectic A transitions, optical properties of cholesteric liquid crystals, the blue phases, pressure induced mesomorphism.

Continuum Theory: Continuum theory of the nematic state, liquid crystals in electricand magnetic fields, magnetic coherence length, Freedericksz transitions, field-induced cholesteric-nematic transition, continuum theory of smectic. A Phase, Reentrant phenomena in liquid crystals.

Module-2

Ferroelectric and discotic liquid crystals: Ferroelectric liquid crystals, applications of ferroelectric liquid crystals, discotic liquid crystals, he columnar liquid crystal, the discotic nematic phase. Lyotropic liquid crystals, constituents of lyotropic liquid crystals, structures of lyotropic liquid crystal phases, biological membranes.

Module-3

Identification of liquid crystal phases and liquid crystal technology: Identification of nematic, smectic and chiral liquid crystal phases by optical polarizing microscopy (Visual appearance and texture), Phase identification with Differential Scanning Calorimetry, liquid crystal display, the twisted nematic liquid crystal displays, liquid crystal displays using polymers, applications of liquid crystals.

Module-4

POLYMER SCIENCE

Introduction and methods of synthesis: Macromolecular concepts, structural feature ofpolymers, correlation between structure and properties of various polymerization methods.

Industrial methods for polymer production & characterization techniques: Bulk,solution, suspension and emulsion polymerization techniques, interfacial, melt and solution polycondensation, some other miscellaneous techniques.

Concepts on chemical & physical properties: Chemical bonds, polymer solubility, chemical

Module-5

Rheology of polymers: Stress and strain, types of deformation, Newtonian and non-newtonian fluid, apparent viscosity, the power law, molecular hole concept, Weisenberg effect, melt fracture, ideal elastic behaviour, viscoelastic behaviour, plastic stress-strain behaviour, creep, toughness, measurement methods.

Microstructure of polymers and order in crystalline polymers: Microstructures basedon chemical and geometrical structures, properties related to structures, crystalline and non-crystalline polymers degree of crystallinity, factors affecting crystallinity and crystallisability, helix structure, spherulites

Transition temperatures & properties of polymers: Glass transition temperature,melting temperature, measurement methods, factors affecting transition temperatures as well as

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Liquid Crystals	S. Chandrasekhar	Cambridge Univ Press	2nd Ed -1996
2	Thermotropic Liquid Crystals	Vertogen and Jeu.	Springer Series	2nd Ed-1988
3	The Physics of Liquid Crystals	De Geenes and Prost	Claredon Press	2nd Ed-1995
4	Polymer Science and Tech. of Plastics	P. Ghosh	Mc Graw-Hill	3rd Ed-1990
5	Introduction to polymers	Young & Lovell	CRC Press	2nd Ed-1991
6	Plastic materials and processing	A. Brent strong	CRC Press	3rd Ed-2005

2. (Group-5):16PHY08	**Fluorescence Spectroscopy and X-ray Crystallography**
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Solvent and Environmental Effects on Fluorescence spectra

Stokes' shifts and solvent relaxation, general and specific solvent effects, other mechnisms for spectral shifts. Lippert equation, Derivation of Lippert equation, Applications of Lippert equation, Specific solvent effects. Temperature effects, Additional factors that affects the emission spectra - locally excited and internal charge transfer states, excites state intramolecular proton transfer, effects of viscosity, probe-probe interaction and effect of solvent mixtures.

Module-2

Fluorescence Quenching

Introduction, quenchers of fluorescence, Theory of collidal quenching, Derivation of Stern-Volmer equation, Interpretation of bimolecular quenching constants, theory of static quenching, Comparision between static and dynamic quenching. Combined dynamic and static quenching with examples. Deviation from the Stern-Volmer equantion - Quenching sphere of action. Derivation of the quenching sphere of action, Origin of the Smoluchowski equation.

Mechanisms and Dynamics of Fluorescence Quenching

Introduction, comparison of quenching and resonance energy transfer, distance dependence of resonance energy transfer and quenching, encounter complexes nd quenching efficiency, mechanisms of quenching: Intersystem crossing or heavy atom effect, electron exchange, photoinduced electron transfer. Transient effects in quenching,

Fluorescence Sensing

Optical Clinical Chemistry and spectral observable, spectral observable for fluorescence sensing, Mechanism of sensing, sensing collisional quenching - oxygen sensing, chloride sensors, energy transfer

Module-3

X-RAY CRYSTALLOGRAPHY

Crystal and Symmetry: Growth of single crystals, different methods, Optical properties, ferroelectric, piezoelectric, thermal properties of crystal, Crystal system- Bravais lattices- point group and space group, symmetry elements. Quasicrystals: definition, preparation, symmetry orientation order in quasicrystals, Quasi-periodic space tiling procedure.

Macromolecules: definition, examples of macromolecules or Bio-molecules-symmetry.

X-rays: Production, white radiation characteristics, radiation - absorption edge, filters - absorption by

Module-4

DIFFRACTION OF X-RAYS: Direct and reciprocal lattice, Ewald's sphere and Bragg's law, Spacing formula,Transformation equations, Interpretation of rotation photograph. Scattering of X-rays by a distribution of electron, structure factor, calculation of electron density function, Fourier synthesis, the crystal symmetry and x-ray diffraction pattern, Friedel's law and its break down. Electron and neutron diffraction, comparison with X-ray diffraction, significance of electron and neutron diffraction, characterization of quasicrystalline sample using electron diffraction.

The Laue method, The Powder method, rotation and Weissenberg methods, The Burger precession method.

Module-5

INTENSITY DATA COLLECTION, STRUCTURE SOLUTION AND REFINEMENT

The single crystal diffractometer method, intensity data collection, corrections to intensity data-Lorentz, polarization, spot shape and absorption effects, primary and secondary extinction effects, absolute scaling and temperature factors. Fourier techniques, Phase problem, Patterson function and its significance, Heavy atom methods, Isomorphous replacement method, anomalous scattering method, direct methods. Cyclic Fourier refinement, the difference Fourier refinement, correction for series termination effects, temperature correction, Least squares refinement. Derived results- bond lengths, bond angles, standard deviations in bond lengths and angles, comparison and averaging of bond

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Principles of Fluorescence Spectroscopy	Joseph R Lakowicz	Plenum Press, NewYork	1986
2	Fundamentals of Photochemistry	Rohtagi - Mukherjee K K	Wiley Eastern Ltd	1992
3	Photophysics of Aromatic Molecules	Birks J B	Wiley - Interscience, London	1970
4	X-ray Crystallography	Woolfson, M. M	Cambridge University Press	1978
5	Outline of crystallography for Biologists	David Blow	Oxford University press	2004
6	Introduction to Solids	Azaroff. L.V	McGraw-Hill	1960

3.	**(Group-5):16CHE09**	**Analytical Chemistry & Allied Subjects-III**
Exam Hours: 3 hours		**Exam Marks (Maximum):100**
Module-1		
X-ray Diffraction: Fundamentals of x-ray diffraction:X-Ray Fluorescence method: Principles-Characteristicsx-ray emission. Instrumentation x-ray tube, radioactive sources. Wavelength dispersive instruments. Energy dispersive instruments. Analytical Applications-Qualitative Analysis-Quantitative Analysis, Theory of x-ray diffraction, diffraction of x-rays by crystals, determination of crystal Structure (powder as well as single crystals), Instrumentation, determination of lattice parameters, x-ray intensity calculations and application of x-rays. **Neutron Diffraction**: Introduction to neutron diffraction, theory, Instrumentation andapplication.		
Module-2		
Mossbaur Spectroscopy : Introduction to Mossabaur effect, recoilless emission & absorption ofx-rays, Instrumentation, isomer shift, Quadra pole splitting and hyperfine interactions, application of Mossbaur effect to the investigations of compounds of iron and tin .		
Module-3		
Laser Based Techniques: Atomic fluorescent spectrometry (AFS), Resonant ionisationspectroscopy (RIS), Laser enhanced ionization (LEI). Principle – types of transition tuneable laser, Classification of medium pumping and controlling mechanisms, Instrumentation detailing of various gaseous, liquid and solid sources, cell, mono chromators,		
Module-4		
Atomic Emission Spectrometry (AES): Inductively coupled plasma – ICP / AES andFlame emission spectroscopy (FES). Sources – electrical discharge, dc/ac arcs, spark laser microprobe, qualitative and quantitative analysis, problems discussion		

Module-5

Imaging Techniques: Magnetic Resonance Imaging (MRI) - principle,instrumentation, magnetic resonance angiography, 1H-nmr of relevant diamagnetic and paramagnetic compounds, contrast agents and clinical applications.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Elements of x-ray diffraction	B.DCullity	Addison Wisley	1st Edition, 1967
2	Diffraction Method	Wormald	Oxford University, Press	1st Edition, 1973
3	Neutron Scattering in Chemistry	Baun, G. E. Butleworth,	London	1st Edition, 1971
4	Mossbaur Spectroscopy	Greenwood N.N., Gibbs T.C	Chapmann Hall	1st Edition, 1971
5	Chemical Application of Mossbaur Spectroscopy	Goldanski V.I &Harber R.H	Academic Press	1st Edition, 1968
6	Spectroscopy in Inorganic Compounds	CNR Rao & Ferraro G.R	Academic Press	1st Edition, 1970
7	Basic Principles of Spectroscopy	Cheney R.	Mac Grows Hill	1st Edition,
8	Thermal Method	Wendlandt, W.W. John	Wiley	1st Edition, 1986
9	Principles of Instrumental Analysis	Skoog	Sounders	3rd Edition, 1985
10	MRI : Basic principles and applications	B. M Dale, M. A . Brown and R. C. Semelka	Wiley Blackwell	5th Edition 1995

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Basic Science Board)
As per 2017 Regulation

4. (Group-5):16MAT09	**Advanced Numerical Methods**
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

High Speed Computation

Introduction, Computer arithmetic, Errors and computation in numerical techniques, General error formula and error in series approximations. Machine computation and computer software.

Transcendental and Polynomial Equations

Introduction, Newton-Raphson method, Secant and Regula falsi method , rate of convergence, Newton-McAuleymethodformultipleroots.Birge–Vietamethod,Bairstowmethod,Graffe'srootsquaringmethod.

Module-2

System of Linear Algebraic Equations and Eigen valueProblems

Introduction. Consistency, Rank of a matrix, Gaussian elimination, LU decomposition, Gauss-Seidel and Successive Over Relaxation methods, Tri-diagonal system of equations

Module-3

Interpolation and Approximation

Introduction, Lagrange and Newton Interpolations, Interpolating polynomials - piecewise polynomial interpolation, Spline's interpolation formula, Hermite Interpolation, Bivariate Interpolation, least square approximations. **Numerical integration:**Newton's cotes formula, Simpson's rules, Weddle's rule, Gaussian

Module-4

Ordinary Differential Equations: Boundary Value Problems

Initial Value and boundary value problems, Runge – Kutta's Method of order IV for 1^{st} and 2^{nd} order ordinary differential equations. System of equations predictor – corrector formulae. Shooting method and

Module-5

Partial Differential Equations

Finitedifferenceapproximationtoderivatives.Laplaceequation–Jacobi,Gauss-SeidelandSORmethods,ADI

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	NumericalMethodsforScientificandEngg.Computation	M.K.Jain,S.R.K.Iyengarand R.K. Jain	New Age International	6^{th} Ed.,2012

2	Numerical Methods for Engineers	S. C. Chapra and R. P. Canale	McGraw-Hill	7th Ed., 2015
3	Introductory Methods of Numerical Analysis	S. S. Sastry	PHI	4th Ed.,2011
4	Elements of Numerical Analysis	R.S.Gupta	Oxford Univ. Press	2nd Ed.,2015
5	Introduction to Numerical Analysis	F.B.Hilderbrand	Dover Publications	2nd Ed.,1987

1. (Group-6):16PHY09	**Laser Physics and Biophysics**
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Coherence: Coherence, spatial and temporal coherence, measurement of spatial andtemporal coherence, coherence time, coherence length, line width and monochromaticity; coherence time and line width via Fourier analysis, complex degree of coherence and fringe visibility in Young's double hole experiment.

Laser rate equations: Basic structure of a Laser, theory of laser oscillations, round-trip power gain and threshold condition. Rate equations for two, three and four level lasers; variation of laser power around threshold, optimum output coupling

Optical resonators: Plane-parallel resonator, spherical resonator, confocal resonator,unstable resonator, losses in optical resonator, quality factor *Q*.

Line broadening mechanisms and laser modes: Line shape broadening: Dopplerbroadening, collision broadening, natural radiative lifetime broadening, homogeneous and inhomogeneous broadening.

Laser modes: Longitudinal and transverse modes, experimental arrangement for mode selection. Gain saturation, gain saturation in homogeneously and inhomogeneously broadened lasers, hole burning.

Module-2

Single and multimode oscillations: Multimode oscillations, single-line and single-modeoscillation, frequency pulling, Lamb dip and laser frequency stabilization; ultimate line width of the laser (limit to monochromaticity), laser spiking in time-dependent condition.

***Q*-switching and mode locking techniques:** *Q*-switching, production of a giant pulse;methods of *Q*-switching: Mechanical shutters, electro-optical shutters, acousto-optic *Q*-switches, shutter using saturable dyes, peak-power emitted during the pulse, giant pulse dynamics.

Mode locking: Active and passive mode locking techniques, ultrashort laser pulses, Laser amplifiers.

Types of Lasers: Solid state Lasers: Nd:YAG and Nd:Glass lasers. Gas Lasers: Ionic Lasers: Ar^+ Laser,Metal vapour Lasers: He-Cd laser and copper vapour laser. Molecular Laser: CO_2 Laser

Module-3

Cell biophysics: Cell doctrine; General organisation and composition of the cells.

Bioenergetics: The biological energy cycle and the energy currency. Thermodynamicconcepts; Free energy of a system- Gibb's free energy function, Chemical potential and redox potentials. Energy conversion pathways-Kreb's cycle; respiratory chain, oxidative phosphorylation. Photosynthesis-photosynthetic apparatus; mechanisms of energytrapping and transfer; photophosporylation.

Membrane biophysics: Cell membranes- structure, function and models; Transport across membranes- passive and active processes; Chemiosmotic energy transduction- van't Hoff equation; Ionic equilibrium-electrochemical potential; Nernst's equation; Flow across membranes- membrane permeability.

Neurophysics: The nervous system. Synaptic transmission; information processing inneuronal

Module-4

Physiological biophysics

Physics of sensory organs- the transmission of information; Generator potentials. Visual receptor-mechanism of image formation; Auditory receptor- mechanism of sound perception; Mechanisms of chemical, somatic and visceral receptors. Mechanism of muscle contractility and motility. Temporal

Module-5

Biophysics of the immune system: The Immune system; cellular basis of immunalresponses; antibodies and antigens; Immunological memory.

Genetic engineering: Gene-Structure, expression and regulation; Genetic code andgenome organisation; Recombinant technology. Transgenic systems. Cybernetics-Genetic information and the brain; neural nets.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Optics	Ajoy Ghatak	Tata Mc-Graw-Hill	2 nd Ed-2017
2	Lasers: Theory and Applications	K. Thyagarajan and A. K. Ghatak	Mc-Millan India Ltd.	1st Ed-1981
3	Optical Electronics	Ajoy Ghatak and K. Thyagarajan	Cambridge Univ. Press	1st Ed-1989
4	Lasers and Non-Linear Optics	B. B. Laud,	New Age Intl	7th Ed-2016
5	Essentials of Biophysics	P Narayanan	New Age Intl	2nd Ed-2001

6	Molecular Cell Biology	H Lodish, A Berk, S L	Mc Graw-Hill	2nd Ed-2001

2. (Group-6):16PHY10	**Electronics and Instrumentation**
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Analog IC s and Applications: Integrated Circuits, microelectronics technology; IC packages relevant to BJT and MOS. Basic characteristics of operational amplifier: Offset error voltage and currents, inverting and non-inverting amplification using closed loop concept, input and outputimpedance. Adder and subtractor circuits, voltage to current convertor, current to voltage converter, analog integration and differentiation, analog computation, logarithmic and exponential amplifiers, comparators and voltage regulators. Waveform generators: RC- oscillator, Wein bridge oscillator, multivibrators, square and triangle wave generator, Schmitt trigger. Digital to analog convertor, analog to digital converters.

Module-2

Digital IC s and applications

Combinational digital system: Binary adders, arithmetic function, decoder-demultiplexer, data selector, multiplexer, encoder, read only memory(ROM), PROMs and EPROMs. Sequential circuits and systems: 1 bit memory, clocked flip-flops, S-R, J-K, T and D-type flip-flops, shift registers,

Module-3

Transducers: Electrical transducer types and their selection. Resistive Transducers: Strain Gauges-

resistance wire gauge and semiconductor gauge. Thermometer, Platinum resistance and thermistor. Inductive Transducer: Principle, variable reluctance type, differential output transducer,

Module-4

Piezoelectric transducer. Photoelectric transducerss: Photomultiplier tube, Photoconductive cell, Photovoltaic cell, semiconductor photo diode, phototransistor. Thermoelectric transducers: Resistance temperature detector (RTD), Thermocouples. Signal conditioning: Need, methods, instrumentation amplifier

Module-5

Physical methods of analysis: Thermal methods: Differential Thermal Analysis (DTA); Differential Scanning Calorimetry (DSC); Thermo gravimetric analyses (TGA). Electron microscopy: Scanning electron microscopy (SEM), Transmission electron microscopy (TEM). Scanning tunnelling electron microscopy (STEM). Magnetic Resonance Spectroscopy: NMR- principle, spectrometer, application. ESR- principle, spectrometer, applications. Vacuum Technique: Production by rotary and diffusion pumps, measurement by Pirani and Penning gauges.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.

- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Microprocessor Architecture, Programming and Applications	Ramesh S Gaonkar	TMH	5th Ed
2	Electronic Instrumentation	H. S. Kalsi,	TMH	1995
3	Instrumental method of Analysis	Willard, Merritt, Dean and Settle	CBS Publishers & Distributors	6th Ed
4	Electronic Fundamentals and	J D Ryder	Prentice Hall	2nd Ed
5	Instruments methods of Chemical analysis	Chatwal and Anand	Himalaya Publishing House	3rd Ed
6	Digital Principles and Application	Malvino and Leach	TMH	2nd Ed

3.	**(Group-6): 16CHE10**	**Analytical Chemistry & Allied Subjects-IV**
Exam Hours: 3 hours		**Exam Marks (Maximum):100**

Module-1

Nano Technology: Introduction to Nano-science; History and Scope, Interdisciplinary nature, Structure of nanomaterials, Quantum wells, quantum wires,quantum dots, fullerenes, graphite, carbon nanotubes, inorganic nano wires, nano particles, core - shell nano particles. Nano-optoelectronic materials and devices, medicine and pharmacology applications, thin-films, One Dimensional Nanostructures, Nano wires and nano rods, Spontaneous growth: Evaporation and condensation growth, vapor-liquid-solid growth, stress induced recrystallization.

Module-2

Template Based Synthesis: Electrochemical deposition, Electro-phoretic deposition. Two dimensional nano-structures, Fundamentals of film growth. Physical vapour Depostion (PVD): Ebvaporation molecular beam epitaxy (MBE), Sputtering, Comparison of Evaporation and sputtering. Chemical Vapour Deposition (CVD). Wet chemical synthesis methods: sol-gel, hydrothermal, co-precipitation and solution combustion methods.

Module-3

Nano-materials and Composites: Introduction, Nylon 6-clay hybrid (NCH) - Synthesis, Characterization; Epoxy nanocomposites, Epoxy layered silicate nanocomposites, Epoxy-nanocomposites based on other nanofillers, Ternary epoxy nanocomposite systems, Biodegradable polymer/layered silicate nanocomposites, Polymer/layered silicate nanocomposite technology, structure-property relationships, olypropylene layered silicate nanocomposites, Barrier properties of nanocomposites, Nanotubes, nanoparticles and inorganicorganic hybrid systems, Single-walled carbon nanotubes in epoxy, Fullerene/carbon nanotube (CNT) composites, Filled polymer nanocomposites containing functionalized

Module-4

Nanomagnetic Materials: Basics of ferromagnetism, Effect of bulk structuring of Magnetic properties, Dynamics of Nanomagnets, Nanopore containment of magnetic properties, Nano carbon ferromagnets, Giant Magnetoresistance, Colossal magnetoresistance, Applications in data storage, Feerofluids, Band structure in magnetic fields, Parallel and perpendicular field. Thin films, Atomic layer deposition (ALD), Electrochemical deposition (ECD), and Sol-Gel films.

Module-5

Characterization of Nano-Structured Materials: Principle, instrumentation and applications of Powder X-ray diffraction, Fourier transform infrared spectroscopy, Scanning electron microscopy, tunnelling electron microscopy, atomic-force microscopy, magnetic-force microscopy (MFM), scanning near-field optical microscopy (SNOM).

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Nanomaterials	AK Bandyopadhyay	Newage International (p) limited publishers	1st Edition, 2017
2	Nanomaterials	J Dutta and H Hofmann	AK Bandyopadhyay, Newage International (p) limited	1st Edition, 2011
3	Nanostructured materials processing, properties and applications	Carl C Koch	Jaico publishing house	1st Edition, 2006

4. (Group-6):16MAT10	**Linear Algebra**
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Vector Spaces: Definition and Examples, Subspaces, Bases and Dimensions, Linear Transformations, Quotient Spaces, Direct Sum.

Module-2

The matrix of Linear Transformation, Duality, Eigen values and Eigenvectors, The minimal Polynomial, Diagonalisability and Triangularization.

Module-3

Canonical and Bilinear Forms: Jordan Forms, The Rational Forms, Bilinear Forms : Definition and Examples, The matrix of a Bilinear Form, Orthogonality, Classification of Bilinear Forms.

Module-4

Inner Product Spaces : Inner Product Spaces, Orthogonality, Gram-Schmidt orthogonalization process, Adjoint of Linear Transformation, Unitary operators, Self Adjoints and Normal Operators.

Module-5

Symmetric Matrices and Quadratic forms: Diagonalization of symmetric matrices , quadratic form, constrained optimization, Singular value decomposition.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

1	Linear Algebra and its Applications	David C. Lay	Pearson Education (Asia) Pvt. Ltd.	3rd Ed.,2005
2	Linear Algebra	K.Hoffman and R.Kunze	Pearson Education	2nd Ed.,2004
3	Introduction to Linear Algebra	Gilbert Strang	Wellesley-Cambridge Press	5th Ed.,2016
4	Elementary Linear Algebra - Applications Version	H.Anton and C. Rorres	Wiley & Sons	11th Ed.,2014
5	Linear Algebra	Kuldeep Singh	Oxfor University Press	1stEd (Reprint)., 2015