AC 27/2/13

Item no. 4.120

UNIVERSITY OF MUMBAI

Syllabus for Sem III and IV

Program: M.Sc.(PSCHI)

Course: Inorganic Chemistry

Credit based semester and grading system with effect from the academic year 2013-2014

SEMESTER III

Course Code	UNIT	TOPICS	Credits	L/Week
PSCHI301	I	**1. Solid State Chemistry-I** **1.1 Descriptive Crystal Chemistry** (15 Lectures) **(a) Simple structures** Structures of **AB** type compounds (PbO and CuO), **AB_2** type (β cristobalite, CaC_2 and Cs_2O), **A_2B_3** type (Cr_2O_3 and Bi_2O_3), AB_3 (ReO_3, Li_3N), **ABO_3** type, relation between ReO_3 and perovskite $BaTiO_3$ and its polymorphmic forms, Oxide bronzes, ilmenite structure, **AB_2O_4** type, normal, inverse, and random spinel structures. **(b)Linked Polyhedra** (i) Corner sharing: tetrahedral structure (Silicates) and octahedral structure (ReO_3) and rotation of ReO_3 resulting in VF_3, RhF_3 and calcite type structures. (ii) Edge sharing: tetrahedral structures (SiS_2) and octahedral structures (BiI_3 and $AlCl_3$). pyrochlores, octahedral tunnel structures and lamellar structures	4	1
	II	**1.2 Imperfection in crystals and Non-Stoichiometry (15 Lectures)** **(a) Point defects**: Point defects in metals and ionic Crystal – Frenkel defect and Schottky defect. Thermodynamics formation of these defects (mathematical derivation to find defect concentration and numerical problems expected); Defects in non-Stoiochiometric compounds, colour centres.		1

		(b) Line defects: Edge and Screw Dislocations. Mechanical Properties and Reactivity of Solids. **(c) Surface Defects**: Grain Boundary and Stacking Fault. Dislocation and Grain Boundaries, Vacancies and Interstitial Space in Non-Stoichiometric Crystals, Defect Clusters, Interchangeable Atoms and Extended Atom Defects.		
	III	**1.3 Inorganic Materials-I: Preparations (15 Lectures)** **(a) Methods of Synthesis**: Chemical Method, High Pressure Method, Arc Technique and Skull Method (with examples). **(b) Different methods for single crystal growth:** (i) Crystal Growth from Melt–: Bridgman and Stockbargar, Czochralski and Vernuil methods. (ii) Crystal growth from liquid solution: Flux growth and temperature gradient methods (iii) Crystal growth from vapor phase: – Epitaxial growth methods. **(c) Thin film preparation**: Physical and Chemical methods. **(d) Solid Solutions:** Formation of Substitutional, Interstitial and Complex Solid Solutions; Mechanistic Approach; Study of Solid solutions by X-ray Powder Diffraction and Density Measurement.		1
	IV	**1.4 Inorganic Materials: Properties-I (15 Lectures)** **(a) Diffusion in Solids**: Fick's Laws of		1

		Diffusion (numerical problems expected); Kirkendal Effect; Diffusion and Ionic Conductivity; Applications of Diffusion in Carburizing and non-Carburizing Processes in Steel Making. **(b) Solid state reactions**: General principles and factors influencing reactions of solids, Reactivity of solids. **(c) Liquid Crystals**: Introduction and classification of thermotropic liquid crystals, Polymorphism in liquid crystal, Properties and applications of liquid crystals. **(d) Optical properties:** Color Centres and Birefringence; Luminescent and Phosphor Materials; Coordinate Model; Phosphor Model; Anti Stokes Phosphor; Ruby Laser; Neodymium Laser.		
PSCHI302	I	**2 Coordination Chemistry (15 Lectures)** **2.1 Non-Heme Proteins** Coordination geometry of the metal ion and functions. Zn in biological systems: Carbonic anhydrase, protolytic enzymes, e.g. carboxy peptidase, Zinc finger. Role of metal ions in biological electron transfer processes Copper containing proteins and enzymes. Less common ions in biology e.g. Co, Ni, V Metallothionines Biomineralization.	4	1
	II	**2.2 Inorganic Photochemistry and Stability Constants (15 Lectures)** (a) Inorganic Photochemistry: (i) Luminescence: Fluorescence and		1

		Phosphorescence of Transition and Inner Transition Elements. (ii) Prompt and Delayed Reactions (b) Stability Constants: (i) Methods for Determining Stability Constants of Coordination Compounds such as spectrophotometry, Conductometry, Potentiometry, and Polarography (Numerical Problems expected). (ii) Stability Constants of Mixed Ligand Complexes.		
	III	**2.3 Reactivity of Chemical Species (15 Lectures)** Reactivity Matrix of Lewis Acids and Bases (i) Acidity and Basicity Parameters (ii) Measures of hardness and Softness of Acids and Bases; (iii) Pauling and Drago-Wayland Equation (iv) Redox Reactions in Aqueous, Non-Aqueous and Solvent Free Media (v) Latimer Diagrams (vi) Pourbaix Diagrams (vii) Frost diagrams		1
	IV	**2.4 Synthesis, Structure and Bonding, and Stereochemistry (15 Lectures)** **(a) Synthesis of Coordination Compounds** (i) Addition Reactions, (ii) Substitution Reactions, (iii) Redox Reactions, (iv) Thermal Dissociation of Solid Complexes, (v) Reactions in Absence of Oxygen, (vi) Reactions of Coordination Compounds, (vii) Trans Effect **(b) Structure and Bonding**		1

		(i) Molecular Orbital Theory for Complexes with Coordination Number 4 and 5 for the central ion (sigma as well as Pi bonding) (ii) Angular Overlap Model **(c) Stereochemistry of Coordination Compounds** (i) Chirality and Fluxionality of Coordination Compounds with Higher Coordination Numbers. (ii) Geometries of Coordination Compounds of d^6 to d^9 metal ions.		
PSCHI303	I	**3. Instrumental Methods of Analysis** **3.1 Diffraction Methods-I (15 Lectures)** X-Ray Diffraction: Bragg Condition; Miller Indices; Laue Method; Bragg Method; Debye Scherrer Method of X-Ray Structural Analysis of Crystals	4	1
	II	**3.2 Diffraction Methods-II (15 Lectures)** (a) Electron Diffraction: Scattering of electrons, Scattering Intensity versus Scattering Angle, Weirl Measurement Technique, Elucidation of Structures of Simple gas Phase Molecules (b) Neutron Diffraction: Scattering of Neutrons: Scattering of neutrons by Solids and Liquids, Magnetic Scattering, Measurement Technique.		1
	III	**3.3 Electron Spin Resonance Spectroscopy (15 Lectures)** (a) Electron behaviour, interaction between electron spin and magnetic field. (b) Instrumentation : Source, Sample		1

		cavity. Magnet and Modulation coils, Microwave Bridge, Sensitivity. (c) Relaxation processes and Line width in ESR transitions: (i) ESR relaxation and chemical bonding. (ii) Interaction between nuclear spin and electron spin (hyperfine coupling) (iii) Spin polarization for atoms and transition metal ions, (iv) Spin-orbit coupling and significance of g-tensors, (v) Application to transition metal complexes (having one unpaired electron) including biologic al systems and to inorganic free radicals such as PH_4, F_2 and BH_3		
	IV	**3.4 Mossbauer Spectroscopy (15 Lectures)** (a) Introduction to Mossbauer Spectroscopy, Mossbauer theory and parameters. (b) Instrumentation: Drive mechanism, sources, detectors, absorber, cosine effect calibration of instrument, conditions for good spectrum. (c) Applications: Purity and characterization, detection of structurally different atoms, in polynuclear compounds, solid state decompositions, study of effect of temperature and pressure on Fe compound, bonding properties and structures.		1
PSCHI4304	I	**4. Applied Chemistry** **4.1 Safety in Chemistry Laboratories (15 Lectures)**	4	1

		(a) Good Laboratory Practices: Elements of Good Laboratory Practices; Standard Operating Procedures; Quality Assurance (b) Handling of Hazardous Materials (i) Toxic Materials (Various types of toxins and their effects on humans) (ii) Explosives and Inflammable Materials (iii) Types of fire extinguishers (iv) Bioactive materials. (c) Recycling and Waste Disposal Management in Chemical Laboratories. (d) Legal provisions regarding Chemical Laboratories. (e) Environment Protection Act, 1986.		
	II	**4.2 Manufacture and Applications of Inorganic Compounds-I (15 Lectures)** (i) Lime, Chlorine and Caustic soda, (ii) Ceramics and refractory materials (iii) Cement (iv) Inorganic explosives (mercury fulminate, Lead azide)		1
	III	**4.3 Manufacture and Applications of Inorganic Compounds-II (15 Lectures)** (i) Fertilizers and micronutrients (ii) Glass (iii) Paints and Pigments		1
	IV	**4.4 Metallurgy (15 Lectures)** Occurrence, extraction and metallurgy of Zirconium, Hafnium, Niobium, Tantalum Platinum and Palladium metals. Physical and chemical properties and applications		1

	of these metals, compounds of these metals, alloys and their uses.		
PSCHI3P	Practicals		
PSCHI3P1	**Analysis of ores/alloys** 1. Analysis of Brass alloy: (i) Cu content by iodometric method, (ii) Zn content by complexometric method. 2. Analysis of Mangelium alloy: (i) Al content by gravimetric method as basic succinate, (ii) Mg content by complexometric method. 3. Analysis of Bronze alloy: (i) Cu content by complexometric method, (ii) Sn content by gravimetric method. 4. Analysis of steel nickel alloy: (i) Ni content by homogeneous precipitation method.	2	4
PSCHI3P2	**Solvent Extraction** 1. Separation of Mn and Fe using isoamyl alcohol and estimation of Mn 2. Separation of Co and Ni using n-butyl alcohol and estimation of Co 3. Separation of U and Fe using 8-hydroxyquinoline in chloroform and estimation of U 4. Separation of Fe and Mo using isoamyl alcohol and estimation of Mo 5. Separation of Cu and Fe using n-butyl acetate and estimation of Cu	2	4
PSCHI3P3	**Inorganic Preparations** 1. Preparation of $Hg[Co(SCN)_4]$ 2. Preparation of $V(oxinate)_3$ 3. Preparation of Sn(IV) Iodide 4. Preparation of $Co(\alpha\text{-nitroso-}\beta\text{-naphthol})_3$ 5. Preparation of $Ni(salicylaldoxime)_2$ 6. Hexaamine cobalt (III) chloride **7.** Preparation of Trans-bis (glycinato) Cu(II)	2	4
PSCHI3P4	**Analysis of the following samples** 1. Calcium tablet for its calcium content by complexometric titration. 2. Bleaching powder for its available chlorine content by iodometric method. 3. Iron tablet for its iron content colorimetry by 1,10-phenonthroline method.	2	4

	4. Calcium tablet for its calcium content by complexometric titration. 5. Bleaching powder for its available chlorine content by iodometric method. 6. Iron tablet for its iron content colorimetry by 1,10-phenonthroline method. **7.** Nycil powder for its Zn content complexometrically.		

SEMESTER IV

Course Code	UNIT	TOPICS	Credits	L / Week
PSCHI401	I	**1 Solid state chemistry-II** **1.1 Inorganic Materials- Properties-II (15 Lectures)** Electrical properties of solids: (i) Conductivity: Solid Electrolytes; Fast Ion Conductors; Mechanism of Conductivity; Hopping Conduction. (ii) Other Electrical Properties: Thomson and Seebeck Effects; Thermocouples and their Applications; Hall Effect; Dielectric, Ferroelectric, Piezoelectric and Pyrroelectric Materials and their Inter-relationships and Applications	4	1
	II	**1.2 Inorganic Materials-Properties-III (15 Lectures)** (a) Magnetic Properties: Structure and Properties of Metals and Alloys; Transition Metal Oxides; Spinels; Ilmenites; Perovskite and Magneto plumbites. (b) Thermal Properties: Introduction, Heat Capacitiy and its Temperature Dependance; Thermal Expansion of Metals; Ceramics and		1

		Polymers and Thermal Stresses.		
	III	**1.3 Applications of group theory- electronic structures (15 Lectures)** (a) Molecular Orbital Theory of Inorganic Compounds, Transformation Properties of Atomic Orbitals; sigma and pi- molecular orbitals for AB, AB_2, AB_3 molecules; (b) Molecular orbitals for inorganic cage and cluster compounds such as B_6H_6, metal sandwich compounds such as ferrocene and dibenzene chromium.		1
	IV	**1.4 Application of Group Theory-Spectral properties (15 Lectures)** (a) Ligand Field Theory: Electronic structures of Free Atoms and Ions; Splitting of Levels and Terms in a Chemical Environment; Construction of Energy Level Diagrams; (b) Correlation Diagrams for d^2 ions in octahedral and tetrahedral ligand field; Method of Descending Symmetry; Hole Formalism. (c) Molecular Vibrations: The Symmetry of Normal Vibrations; Determining the Symmetry Types of the Normal Modes; Selection Rules for Fundamental Vibrational Transitions and Interpretation of IR and Raman Spectra		1
PSCHI402	I	**2 Organometallics and main group chemistry (15 Lectures)** **2.1 Organometallic Chemistry** (a) Organometallic Chemistry of *f*- block Elements, (b) Metal-Metal Bonding and Metal Clusters, (c) Electron Count and Structures of Clusters,, (d) Isolobal Analogy and Structures.,	4	1

		(e) Organo Palladium and Organo Platinum Compounds: Synthesis and Applications.		
	II	**2.2 Applications of Organometallic Compounds (15 Lectures)** (a) Catalysis-Homogenous and Heterogenous Catalysis: Comparison, Fundamental Reaction Steps. (b) Organometallics as Catalysts in Organic Reactions: (i) Hydrogenation, (ii) Assymetric Hydrogenation, (iii) Hydroamination. (c) Organometallic compounds in medicine and agriculture and their biological and environmental Aspects		1
	III	**2.3 Inorganic cluster and cage compounds (15 Lectures)** (i) Introduction, (ii) Bonding in boranes, (iii) Heteroboranes, (iv) Carboranes, (v) cluster compounds, (vi) electron precise compounds and their relation to clusters.		1
	IV	**2.4 Inorganic ring and chain compounds (15 Lectures)** (a) Silicates, polysilicates and aluminosilicates, (b) Phosphazenes, phosphazene polymers (c) Polyanionic and polycationic compounds		1
PSCHI403	I	**3 Instrumental methods of analysis-I** **3.1 Spectroscopy (15 Lectures)** **(a) Vibrational Spectroscopy:** (i) Symmetry and shapes of AB_2, AB_3, AB_4,, AB_5 and AB_6 molecules. (ii) Mode of bonding of ambidentate ligands. (iii) Applications of vibrational and Raman spectroscopy for the study of active sites of metalloproteins.	4	1

		(b) NMR spectroscopy of Inorganic compounds (i) The contact and pseudo contact shifts (ii) Factors affecting nuclear relaxation (iii) NMR of metal nuclides with emphasis on ^{195}Pt and ^{119} Sn (iv) Measurements of paramagnetic susceptibilities of coordination compounds (v) Applications for biochemical shifts		
	II	**3.2 Microscopy of Surface Chemistry-I (15 Lectures)** Introduction to surface spectroscopy, Microscopy, problems of surface analysis, distinction of surface species, sputter etching and depth profile and chemical imaging, instrumentations, Ion Scattering Spectra (ISS), Secondary Ion Mass Spectroscopy (SIMS), Auger Emission Spectroscopy (AES),		1
	III	**3.3 Microscopy of Surface Chemistry-II (15 Lectures)** ESCA, Scanning Electron Microscopy (SEM), Atomic force microscopy (AFM) and transmission electron microscopy (TEM): Instrumentation and applications.		1
	IV	**3.4 Thermal Methods (15 Lectures)** (a) Introduction to principles and Instrumentation of thermoanlytical techniques including thermogravimetry (TG), differenctial thermal analysis (DTA), diiferential scanning calorimetry (DSC), thermomechanical analysis (TMA), simultaneous thermal analysis (STA) and evolved gas analysis (EGA). (b) Applications of thermal techniques for the acquisition of rate dependent kinetic parameters such as activation energy, pre-exponential factor, etc. for solid-solid polymorphic transformation		1

		and their relevance. (c) Determination of thermodynamic parameters such as heat capacity, standard enthalpy of formation of the compounds and Gibbs free energy change for the reaction employing thermoanalytical measurements. (d) Application of thermal techniques in materials science and industry		
PSCHI404	I	**4.1 Inorganic Materials (15 Lectures)** (a) Classification, manufacture and applications of (i) Inorganic fibers, and (ii) Inorganic fillers. Study of (i) Condensed phosphates, and (ii) Coordination polymers. **(b) Preparation, properties and uses of industrially important chemicals** – potassium permanganate, sodium thiosulphate, bleaching powder, hydrogen peroxide, potassium dichromate.	4	1
	II	**4.2 Nuclear Chemistry and Inorganic Pharmaceuticals (15 Lectures)** **(a) Nuclear Chemistry :** **Introduction to** of nuclear fuels and separation of fission products from spent fuel rods by PUREX process. Super heavy element:, discovery, preparation, position in the periodic table. **(b) Inorganic Pharmaceuticals :** Compounds of iron, calcium and lithium, gold antiarithritic drugs, anti-cancer drugs, radiopharmaceuticals containing Tc, Ga and Xe isotopes, contrast agents for X-ray and NMR imaging.		1
	III	**4.3 Advances in Nanomaterials: (15 Lectures)** **(a) Types of nanomaterials**, e.g. nanotubes, nanorods, solid spheres, core-shell nanoparticles, mesoporous materials; General preparative methods for various nanomaterials.		1

		(b) Some important properties of nanomaterials: optical properties of metal and semiconductor nanoparticles, magnetic properties. **(c) Some special nanomaterials:** Carbon nanotubes: Types, synthesis using various methods, growth mechanism, electronic structure; Porous silicon: Preparation and mechanism of porous silicon formation, Factors affecting porous structure, properties of porous silicon; Aerogels: Types of aerogels, Properties and applications of aerogels. **(d) Applications of nanomaterials in** electronics, energy, automobiles, sports and toys, textile, cosmetics, medicine, space and defense. Environmental effects of nanotechnology.		
	IV	**4.4 Some Selected Topics (15 Lectures)** i) Isopoly and Hetropoly acids, **ii)** Supramolecular chemistry **iii)** Inorganic pesticides, and iv) Intercalation compounds		1
PSCHI4P		Practicals		
PSCHI4P1		1. Analysis of galena ore: (ii) Pb content as $PbCrO_4$ by gravimetric method using 5% potassium chromate, (iii) Fe content by colorimetrically using 1, 10- phenonthroline. 2. Analysis of Zinc blend ore: a. Zn content by complexometric method, b. Fe content by colorimetric method (Azide method). 3. Analysis of Pyrolusite ore: a. Mn content by complexometric method, b. Acid insoluble residue by gravimetric method.	2	4
PSCHI4P2		**Coordination Chemistry** 1. Determination of Stability constant of $[Zn(NH_3)_4]^{2+}$ by potentiometry	2	4

	2. Determination of Stability constant of $[Ag(en)]^{+}$ by potentiometry 3. Determination of Stability constant of $[Fe(SCN)]^{2+}$ by slope ratio method 4. Determination of CFSE values of hexa-aqua complexes of Ti^{3+} and Cr^{3+}. 5. Determination of Racah parameters for complex $[Ni(H_2O)_6]^{2+}$ and $[Ni(en)_3]^{2+}$		
PSCHI4P3	**Analysis of the following samples** 1. Electral powder for Na/K content flame photometrically. 2. Fasting salt for chloride content conductometrically. 3. Sea water for percentage salinity by Volhard's method. 4. Soil for mixed oxide content by gravimetric method. 5. Fertilizer for potassium content by flame photometry.	2	4
PSCHI4P4	**Spectral interpretation**	2	4

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Scheme of examination for M. Sc Inorganic Chemistry Semester III and IV.
Internal Theory examination (40 Marks)

1. One seminar based on curriculum / publication of a research paper/ presentation of a research paper in seminar or conference (to be assessed by teacher of the institution teaching PG learners).
   A. Selection of the topic, introduction, write up, references- **15 marks.**
   B. Presentation **15 marks.**

2. Active participation in routine class instructional deliveries. **05 Marks**
3. Overall conduct as a responsible learner, communication and leadership qualities in organizing related academic activities. **05 Marks**

There will not be any internal assessment for practicals.

External Theory Examination (60 Marks)

Paper	Time allotted in hours	Maximum marks
PSCHI3P1/4P1	2.5	60
PSCHI3P2/4P2	2.5	60
PSCHI3P3/4P3	2.5	60
PSCHI3P4/4P4	2.5	60

It is recommended that a total of five questions be set, based on the syllabus with due weightage to the number of lectures allotted per topic. The candidates are expected to answer all five questions. Question 5 will be based on all four units and the remaining questions will be based on the units as indicated below :

	Semester- III	Semester-IV
Q.1	Unit-I	Unit-I
Q.2	Unit-II	Unit-II
Q.3	Unit-III	Unit-III
Q.4	Unit-IV	Unit-IV
Q.5	From all four units	From all four units

Semester End Practical Examination (50 Marks)

Laboratory Work	40 Marks
Journal	05 Marks
Viva	05 Marks

Practical

The practical examination will be held for two days as described below. The candidates will be examined practically and orally on each day.

Papers	Day	Experiment	Time duration (hours)	Maximum marks
Paper I	Day -1 M	1	3.5	50
Paper I	Day-1 E	1	3.5	50
Paper I	Day-II M	1	3.5	50
Paper I	Day-II E	1	3.5	50

1. Credit based semester and grading system with effect from the academic year 2013-2014.
2. As per the credit system directives each credit will correspond to 15 hours of lectures or 30 hours of practical work.
3. Each student is expected to take 4 credits per theory paper and 2 credits per practical per semester.
4. At the end of each semester each student will be examined both in the theory and in the practical.
5. For the award of first class, the candidate must obtain at least 50% marks in the theory papers at the Semester I, II, III and IV of the M. Sc. examination taken together, in addition to the marks prescribed for the first class and the other rules of passing in the concerned regulation of the standard of passing.
6. The candidate is expected to submit a journal certified by the Head of the Department / institution at the time of the practical examination.
7. A candidate will not be allowed to appear for the practical examination unless he / she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate.
8. Use of non-programmable calculator is allowed both at the theory and the practical examination.