Academic Council 25/05/2011
Item No. 4.53

UNIVERSITY OF MUMBAI

Syllabus for the F.Y.B.Sc.
Program: B.Sc.
Course : Chemistry

(Credit Based Semester and Grading System with effect from the academic year 2011–2012)

F.Y.B.Sc. Chemistry Syllabus
Restructured for Credit Based and Grading System
To be implemented from the Academic year 2011-2012

SEMESTER I

Course Code	Unit	Topics	Credits	L / Week
USCH101	I	Study Of States Of Matter	2	1
	II	Scope And Importance Of Inorganic Chemistry Periodic Table Concepts Of Qualitative Analysis		1
	III	Bonding And Structure Of Organic Compounds Nomenclature Of Organic Compounds		1
USCH102	I	Thermodynamics Presentation Of Experimental Data	2	1
	II	Chemical Bonding And Molecular Structure		1
	III	Mechanism Of Organic Reactions Alkanes And Cycloalkanes		1
USCHP1			2	6

SEMESTER II

Course Code	UNIT	Topics	Credits	L /Week
USCH201	I	Chemical Kinetics Photochemistry	2	1
	II	Chemistry of Coordination Compounds, Comparative Chemistry of Group 13 Elements		1
	III	Stereochemistry Of Organic Compounds Alkenes, Cycloalkenes, Alkadienes, and Alkynes		1
USCH202	I	Chemical Calculations Introduction To Molecular Spectroscopy	2	1
	II	Basic Bio Inorganic Chemistry Environmental Chemistry Comparative Chemistry Of Group 14 Elements		1
	III	Aromaticity and Aromatic Hydrocarbons Reactions Of Aliphatic Organic Compounds and their Interconversions		1
USCHP2			2	6

F.Y.B.Sc. Chemistry Syllabus modified for Credit System
To be implemented from the Academic year 2011-2012

Semester I

Course Code	Credits	
USCH101	**2 Credits (45 lectures)**	
Unit I : **Study of States Of Matter :-** **Gases :** Introduction, ideality and kinetic theory of gases (only postulates), gas laws, Maxwell's distribution of velocities (graph & qualitative discussion), real gases, compressibility factor, Boyle temperature, van der Waals equation of state, critical phenomena, liquefaction of gases based on Joule Thomson effect. **Liquids**: Introduction, study of viscosity and its determination using Ostwald's viscometer, study of surface tension and its determination using Stalagmometer. **Solid** : Introduction, amorphous and crystalline solids, crystallography, Crystal systems, concept of space lattice and unit cell.		**15 Lectures**
Unit II **1) Scope and Importance of Inorganic Chemistry,** **2) Periodic Table and periodicity of properties :** Long form of periodic table, Atomic and ionic radii; Lionization of atoms: (formation of cations and anions), Effective nuclear charges and its calculation using Slater's rules; Electronegetivity and its determination by Pauling's, and Mulliken's methods (numerical problems expected); Polarizability (Fajan's rules) **3) Concepts of Qualitative Analysis :** Types of qualitative analysis, Factors affecting precipitation equlibria (solubility product) in qualitative analysis (Numerical problems expected), Common ion effect; pH Complexation; Ionic strength ; (uncommon ion effect), Oxidation states (Examples to illustrate the abovementioned factors may be selected form the schemes for qualitative analysis in the laboratory work)		**15 Lectures**
Unit III 1) **Bonding and Structure of Organic Compounds** 1.1 Allotropy of carbon: Structure and properties of diamond, graphite, fullerenes, carbon nanotubes. 1.2 Hybridization: sp^3, sp^2, sp hybridization of carbon and nitrogen; sp^3 and sp^2 hybridizations of oxygen in Organic compounds. 1.3 Overlap of atomic orbitals: Overlaps of atomic orbitals to form o and II bonds, shapes of organic molecules. 1.4 Electronic effects in organic molecules: Polarization or Inductive effect – Nature; polarity of a covalent bond, dipole moment and its effect on properties of molecules, such as m.p./b.p., solubility; Polarizability		**15 Lectures**

effect; Delocalized bonds – Resonance, drawing of resonance structures of different conjugated systems, resonance energy and stability of conjugated systems; Hyperconjugation.

1.5 Bonds weaker than a convalent bond: Hydrogen bond – nature, effect of on m.p./b.p., solubility in water; van der Waals forces.

1.6 Structure of common functional groups: Geometry and electronic structure in order to understand their reactivity.

2) Nomenclature of organic compounds

2.1 Functional groups and types of organic compounds, basic rules of IUPAC nomenclature.

2.2 Nomenclature of mono- and bi-functional compounds on the basis of priority order, pof the following classes of compounds: alkanes, alkenes, alkynes, haloalkanes, alcohols, ethers, aldehydes, ketones, carboxyclic ascids, carboxylic acid derivaties (acid halides, esters, anhydrides, amides), nitro compounds, nitriles and amines; including their cyclic analogues.

2.3 Nomenclature of aromatic compounds: mono-, di-, and poly-substituted benzenes, with not more than two functional groups. Monosubstituted fused polycyclic arenas – naphthalence, anthracene, and phenanthrene.

Course Code	Credits	
USCH102	**2 Credits (45 lectures)**	
Unit I : Thermodynamics : First law of thermodynamics, internal energy, enthalpy, isothermal and adiabatic processes, P-V-T relation for adiabatic process, second law of thermodynamics, need for the law,, Carnot's cycle, mechanical efficiency, concept of entropy, physical significance of entropy, entropy changes accompanying change of state and transtition, Helmholtz and Gibb's free energies, relation between them, criteria of spontaneity. **Presentation Of Experimental Data :** i) Graphical representation of experimental data: equation of straight line, slope and intercept and their significance. (with relevant examples) ii) Significant figures: concept, rules and examples		**15 Lectures**
Unit II : Chemical Bonding and molecular structure Ionic Bond: Formation of ionic bond, lattice energy, salvation energy, Bord-Haber cycle and Kapustinski's equation (Numerical Problems expected) Covalent Bond:- Lewis electron dot structures; single and multiple bonding, coordinate bond Valence Bond theory :- Sigma and pi-bonding, Theory of hybridization, with respect to equivalence of contributing atomic orbital in following examples: CH_4, NH_3 and H_2O, Energetics of hybridization:sp, sp^2, sp^3 , Types of hybridization:sp, sp^2, sp^3, with illustrations like $BeCl_2$, BF_3, $SiCl_4$ Shapes of Chemical species on the basis of V.S.E.P.R. Theory:- like NH_3, ClF_3, BrF_5, ICl_2^{-1}, TeF_5^{-1}, PX_3 (X=halides),		**15 Lectures**
Unit III : 1. **Mechanism of Organic Reactions** 1.1 Bondbreaking processes: Representation of electronic movement by curved arrows, Homolytic and heterolytic fissions, Assigning of formal charge to given atom. 1.2 Formation, Structure an stability of carbocations, carbanions and carbon radicals. 1.3 Types of reagents: Electrophiles and nucleophiles; Acids and bases: Lowry-Bronsted and Lewis concepts, carbon acids; Classifications of reactions on the basis of mechanisms. 1.4 Study of mechanisms: (a) S_N1 and S_N2 reactions – Effect of structure of substrate, leaving group, solvent, nucleophile. (b) aldol reaction – Base catalysed simple and crossed aldol reactions of aldehydes and ketones. **2. Alkanes and Cycloalkanes** 2.1 Omtrpdictopm: applications of alkanes and cycloaikanes, general formula, lack of reactivity in alkanes. Concept of angle strain–stability and reactivity of cycloalkanes up to 6 C atoms. 2.2 Sources: Petroleum oil – Composition, refining, cracking – thermal and hydrothermal, thermodynamics in the process, reformation; Natural gas – importance of methane. 2.3 Physical properties 2.4 Chemical properties: Combustion–alkanes as fuel, heat of combustion, octance number concept, anticknocking agents, fuel related issues–depletion of feedstocks, pollution; Isomerization; Free radical halogenation–mechanism, thermodynamics, factors affecting product distribution, reactivity-selectivity principle.		**15 Lectures**

Course Code	Credits
USCHP1	**2 Credits**

Practicals in Physical Chemistry

1. Study of the acid catalysed hydrolysis of methyl acetate. (rate constant to be evaluated graphically and from calculations)
2. Study of the base catalysed hydrolysis (saponification) of ethyl acetate. (rate constant to be evaluated graphically and from calculations)
3. To determine the strength of commercial sample of hydrochloric / acetic acid. (Standard solution of succinic acid to be prepared, NaOH solutions to be supplied.)
4. Ostwald's viscometer-To determine the viscosity of the given liquid.

Practicals in Inorganic Chemistry

1. To study the effect of heat on a mixture of sodium carbonate and bicarbonate with respect to the calculation of
    a) Percentage composition of the mixture
    b) Atom efficiency of the reaction;
2. Inorganic preparations:
    i) Aluminum composition of the mixture
    ii) Sodium thisulphate;
3. Volumetric Analysis :-
    a) Determination of the number of electrons required in a chemical reaction between potassium oxalate and potassium permanganate tirimetrically (weighed sample of oxalic acid should be used)
    b) Determination of the strength of sodium carbonate and sodium bicarbonate by titration with standard acid solution using phenolphthalein and methyl orange as indicators;
    c) Determination of the volume strength of hydrogen peroxide solution, by titration with standard potassium permanganate solution.
4. Inorganic semi-micro qualitative analysis of sample containing two anions and any four cations from the groups given below:*

    **Group A) Pb^{2+} , Cu^{2+}, Fe^{3+}, Ni^{2+}, Zn^{2+}, Ca^{2+}, Mg^{2+}, $NH4^{1+}$,
    Group B) NH_4^{I+}, K^{1+}, AI^{3+}, Cd^{2+}, Mn^{2+}, Ba^{2+}, Co^{2+}, $Mg^{2+;}$
    Group C) K^{1+}, Fe^{3+}, Sr^{2+}, Cu^{2+}, Cr^{3+}, Ni^{2+}, AI^{3+}, Mg^{2-}

Anions: CO32-, SO42-, NO31-, Cl1-, Br1-, I1-, Complexitiesof anion not expected)

* Minimum two mixtures belonging to each group should be analyzed

** Sulphide in any from should not be used for precipitation of cations.

Semester II

Course Code	Credits
USCH201	**2 Credits (45 lectures)**

Unit I : CHEMICAL KINETICS — **15 Lectures**

Rate of reaction, definition of rate constant, measurement of reaction rates, order and molecularity, integrated rate equations for zero, first and second order reactions (for second order reactions only a=b to be considered), kinetic characteristics of first and second order reactions, pseudo first order reactions.
Methods of determining order of reaction by

a) Integration method b) graphical method
c) equi-fraction method d) Ostwald's isolation method.

Effect of temperature on rate of a reaction, temperature coefficient, Arrehenius equation.
Catalysis characteristics of catalysed reactions, classification & examples.

PHOTOCHEMISTRY

Laws of photochemistry, photon yield (quantum yield) and its determination, primary and secondary reactions, reasons for high and law quantum yield, study of photochemical reaction:
i) Reaction between hydrogen and chlorine, ii) dissociation of hydrogen iodine.
Photo sensitizers and photosensitized reactions, photochemical smog, ozone depletion, concept of flash photolysis.

Unit II — **15 Lectures**

1. Chemistry of Coordination compounds

- 1.1 Distinction between double salts and coordination compounds;
- 1.2 Effective atomic number rule
- 1.3 IUPAC nomenclature:
- 1.4 Terms involved in coordination chemistry;
- 1.5 Experimental evidences of coordinate bond formation;
- 1.6 Werner's theory of coordination compounds;
- 1.7 Isomerism in coordination compounds
  - 1.7.1 Ionisation isomerism;
  - 1.7.2 Hydrate isomerism;
  - 1.7.3 Linkage isomerism;
  - 1.7.4 Coordination position isomerism;
  - 1.7.5 Stereoisomerism-geometrical and optical isomerism, with special reference to coordination Number 4 and 6
- 1.8 Application of coordination compounds

2. Comparative chemistry of group 13 elements:-

- 2.1 Trends in metallic character, oxidation states, melting and boiling points I pair effect
- 2.2 Structures of electron deficient compounds with reference to boron hydrides;
- 2.3 Chemistry of aluminum compounds: halides, oxides and alkyls

Unit III	**15 Lectures**
Stereochemistry of Organic Compounds 1.1 Isomerism – Types of isomerism : Structural isomerism (chain, position and functional) and Stereoisomerism. 1.2 **Chirality :** Configuration, chirality and enantiomers, stereogenic/chiral centre, asymmetric carbon atom, Representation of configuration by "flying wedge formula" and projection formulate – Fischer, Newman and Sawhorse. The interconversion of the formulae. 1.3 Stereochemistry of carbon compounds with one,and two similar and dissimilar asymmetric carbon atoms; enantioners, diastereomers, and racemic mixtures and their properties, threo, erythro and meso-isomers. 1.4 Diastereomerism (Geometrical isomerism) due to restricted rotation around cabon-carbon double bond. 1.5 Conformation: Conformations of ethane. Difference between configuration and conformation. **2. Alkenes, Cycloalkenes, Alkadiences, and Alkynes** 2.1 Introduction: Concept of elements of unsaturation; applications of alkenes, cuclolkenes, alkadiences and alkynes. Olefin polymerization, heat of hydrogenation and stability. 2.2 Preparation of alkenes and cycloalkenes (up to 6 carbon atoms): Dehydration of alcohols, Dehydrohalogenation of haloalkenes – E1 and E2 mechanisms. 2.3 Reaction of alkenes and cycloalkenes (up to 6 carbon atoms): Hydrogenation, epoxidation, permanganate oxidation, ozonolysis, halogenations, addition of HX – Markovnikov's and anti – Markovnikov's additions (with mechanisms) formation of halohydrins, hydroboration- oxidation 2.4 Alkadienes: Types of alkadienes and their stabilities – cumulated, isolated, conjugated; Reactions of conjugated dienes – 1,2 – and 1,4-additions, Diels-Alder reaction. 2.5 Preparation of alkenes: Dehydrohalogenation of vicinal dihalides and haloalkenes, from metal carbides. 2.6 Reaction of alkynes: Hydration, Addition of HX, selective hydrogenation to cis –and trans-alkenes, acidity of terminal alkynes, preparation of metal acetylides and their alkylation.	

Course Code	Credits	
USCH202	**2 Credits (45 lectures)**	
Unit I : **Chemical Calculations:-** Methods of expressing concentration of solutions-molarity, normality, molality, mole fraction, formality, dilution of solutions, interconversion between different concentration units, concept of milliequivalents, millimols, ppm and ppb. Primary and secondary standards, preparation of standard solutions, calculation of concentration of commercial samples of acids and bases like Use of computers in chemical calculations. **Introduction To Molecular Spectroscopy** Nature of electromagnetic radiation, interaction of emr with matter-absorption, emission, florescence and scattering, Energy types and energy levels of for atoms and molecules. Types of spectroscopy, regions of electromagnetic spectrum and different types of spectroscopy. General applications of different spectroscopic techniques. (qualitative discussion-information to be given in tabular format)		**15 Lectures**
Unit II : **1. Basic Bioinorganic Chemistry-** Introduction, essential and non-essential elements in biological systems; role of metal ions such as Na, K, Fe, and Cu in biological systems; **2. Environmental Chemistry –** 2.1 Study of various gaseous pollutants such as oxides of nitrogen, carbon and sulphur with respect to i) sources of emission; ii) fate; iii) health hazards and iv) control measures; 2.2 Green House effect, Ozone layer depletion, and its consequences 3. **Comparative Chemistry of group-14 elements:-** 3.1 Trends in metallic character, oxidation states, melting and boiling points inert pair effect; 3.2 Catenation and allotropy with special reference to carbon (to include study of fullerenes): 3.3 Chemistry of silicon with special reference to methods of purification zone refining and single crystal method 3.4 Introduction of silicones with reference to methods of preparation and their uses.		**15 Lectures**
Unit III: 1. Aromaticity and Aromatic Hydrocarbons 1.1 Aromaticity: Characteristic properties of aromatics compounds, Hucker's rule, aromaticity and antiaromaticity, resonance energy. 1.2 Aromatic hydrocarbons: (a) Benzenoid hydrocarbons; benzene, naphthalene, antnracene, phenanthrene. (b) Nonbenzenoid icons: Cyclopropenium, cyclopentadienide, cycloheptatrienium cation 1.3 Antiaromatic hydrocarbons: Cycloburadiene, structure of 2. Reactions of aliphatic organic compounds and their interconversions 2.1 Reactions of Alkyl halides with : Aqueous Alkali, Alcoholic alkali (dehydrohalogeneation) Potassium cyanide, acid. Conversion of alkyl		**15 Lectures**

cyanide further to primary amine and carboxylic acid, Ammonia, Sliver salt of carboxylic acid, Sodium Alkoxide, Formation of Grignard Reagent, Wurtz reaction. 2.2 Reactions of Alcohols with : Sodium Metal, HX, PCI3, PCI5, SOCI2, Dehydration, Oxidation of primary, secondary and tertiary alcohols. 2.3 Reactions of Aldehydes and Ketones: 2.3.1 Addition to carbonyl compounds : - i) HCN ii) Grignard Reagent. Condensation reaction with hydroxylamine. 2.3.2 Aldol Condensation. 2.3.3 Reduction of Aldehydes and Ketones:- i) Catalutic Reduction ii) Clemenson's Reduction. iii) Reduction with LiAIH4 and NaBH4, iv) Wolff-Kishner reduction. 2.3.4 Haloform Reaction. 2.4 Reactions of Acids, Esters and Amides: 2.4.1 Acids: Salt formation, Anhydride formation, Amide formation, Acid halide formation, Ester formation, Formation of alkenes. 2.4.2 Hdrolysis of Esters with acids and alkalies, Reaction of esters with Grignard Reagent, Hydrolysis of amides, Reduction of amides, Hoffmann bromanide reaction. 2.5 Reactions of Amines: 2.5.1 Formation of amines from – nitrolkanes, oximes 2.5.2 Acetylation of amines with acetic anhydride and acetyl chloride. Action of nitrous acid on primary, secondary and tertiary amines. Methylation of primary, secondary and tertiary amines, yielding quaternary ammonium salts; Hoffmann elimination.	

Note : Each reaction should be studied with respect to compounds with us to six carbon atoms. Based on these and the reactions of alkanes, alkenes and alkynes, multistep synthesis of compounds having one functional group are expected; the number of carbon atoms in each being not more than six. No mechanisms are expected.

Course Code	Credits
USCHP2	**2 Credits**

(1) Purification of solid compounds by crystallization from water: Quantity of compound – about 1 g; Quality and quantity of the crystallized compound to be given credit (minimum 6 compounds to be given).

(2) Determination of m.p. and b.p. of pure compounds and mixed melting point technique (minimum 6 compounds)

(3) Characterization of Organic Compound (by microscale techniques)

(a) An organic compound belonging to any of the following classes and containing only one functional group to be characterized through the following tests.

(b) Tests: Preliminary observations, solubility profile, elemental analysis, functional group identification, m.p./b.p

(c) Types of compounds: Carboxylic acids, phenols, aldehydes and ketones, alcohols, esters, amines, amides, aromatic nitro compounds, halhydrocarbons, hydrocarbons.

(d) Quantity of compound to be given: About 1.0g/2.0ml

(e) At least one compound from each type should be given for practice, and a total of minimum 12 compounds should be characterized during the course.

(f) It is expected that affordable compounds from different types be given to the students for characterization, without keeping any specific list of compounds in focus, so that the students are expected to be confident in the methods of analysis of any unknown compound.

Note : The theory behind the experiments is expected at the time of viva.

Scheme of Examination:

The performance of the learners shall be evaluated into two parts. The learner's performance shall be assessed by Internal Assessment with 40% marks in the first part & by conducting the Semester End Examinations with 60% marks in the second part.

The Course having Practical training will have Practical Examination for 50 marks at the end of Semester, out of which 30 marks for the Practical task assigned at the time of examination. The 20 marks are allotted as Internal Assessment.

The allocation of marks for the Internal Assessment and Semester End Examinations are as shown below:-

Internal Assessment: It is defined as the assessment of the learners on the basis of continuous evaluation as envisaged in the Credit based system by way of participation of learners in various academic and correlated activities in the given semester of the progamme.

Semester End Assessment : It is defined as the assessment of the learners on the basis of Performance in the semester end Theory/ written/ Practical examination.

Modality of Assessment :

Internal Assessment - 40% **40 marks.**

a) Theory **40 marks**

Sr No	Evaluation type	Marks
1	Two Assignments/Case study/Project	20
2	One class Test (multiple choice questions objective)	10
3	Active participation in routine class instructional deliveries(case studies/ seminars//presentation)	05
4	Overall conduct as a responsible student, manners, skill in articulation, leadership qualities demonstrated through organizing co-curricular activities, etc.	05

b) Practicals **20 marks**

Sr No	Evaluation type	Marks
1	Two best practicals	10
2	Journal	05
3	Viva	05

B) External examination - 60 %

Semester End Theory Assessment - 60% **60 marks**

i. Duration - These examinations shall be of two hours duration.

ii. Theory question paper pattern :-

1. There shall be four questions each of 15 marks. On each unit there will be one question & fourth one will be based on entire syllabus.
2. All questions shall be compulsory with internal choice within the questions. Each question will be of 20 to 23 marks with options.
3. Questions may be sub divided into sub questions a, b, c, d & e only & the allocation of marks depends on the weightage of the topic.

Practical External Assessment **30 marks**