UNIVERSITY OF MUMBAI
No. UG/166 of 2016-17

CIRCULAR:-

A reference is invited to the Syllabi relating to the B.Sc. degree course , **vide** this office Circular No. UG/128 of 2011, dated 13th June, 2011 and the Principals of affiliated Colleges in Science are hereby informed that the recommendation made by the Ad-hoc Board of Studies in Chemistry at its meeting held on 7th July, 2016 has been accepted by the Academic Council meeting held on 14th July, 2016 **vide** item No. 4.12 and that in accordance therewith, the revised syllabus as per the Choice Based Credit System for F.Y. B.Sc. programme in Chemistry (Sem. I & II), which are available on the University's web site (www.mu.ac.in) and that the same has been brought into force with effect from the academic year 2016-17.

(Dr.M.A.Khan)
REGISTRAR

MUMBAI – 400 032
19 November, 2016

To,

The Principals of the affiliated Colleges in Science.

A.C/4.12/14.07.2016

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No. UG/166 -A of 2016 MUMBAI-400 032 19 November, 2016

Copy forwarded with Compliments for information to:-

1) The Co-ordinator, Faculties of Science,
2) The Chairman, Board of Studies in Chemistry,
3) The Professor-cum-Director, Institute of Distance & Open Learning (IDOL)
4) The Director, Board of College and University Development,
5) The Co-Ordinator, University Computerization Centre,
6) The Controller of Examinations.

(Dr.M.A.Khan)
REGISTRAR

PTO..

AC_____

Item No._____

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of Course	Chemistry
2	Eligibility for Admission	12th of all recognised Board
3	Passing marks	
4	Ordinances/Regulations (if any)	
5	No. of Semesters	Two
6	Level	U.G.
7	Pattern	Semester
8	Status	New
9	To be implemented from Academic year	2016-2017

Date: **Signature:**

Name of BOS Chairperson: **Professor A.V.Karnik**

Draft of the proposed syllabus for CBCS

F. Y. B. Sc. Chemistry

For the subject of chemistry there shall be two papers for 45 lectures each comprising of three units of 15 L each.

Semester-I

1. Paper-I / II (General Chemistry) Unit-I will be for Physical Chemistry
2. Paper-I / II Unit-II will be for Inorganic Chemistry and
3. Paper- I / II Unit-III will be for Organic Chemistry.

Semester-II

1. Paper-I /II (General Chemistry) Unit-I will be for Physical Chemistry
2. Paper-I / II Unit-II will be for Inorganic Chemistry and
3. Paper-I / II Unit-III will be for Organic Chemistry.

Choice Based Credit System F.Y.B.Sc. Chemistry Syllabus

To be implemented from the Academic year 2016-2017

SEMESTER I

Course Code	Unit	Topics	Credits	L / Week
USCH101	I	Chemical Thermodynamics Chemical calculations	2	1
	II	Atomic structure, Periodic Table and periodicity		1
	III	Basics of Organic Chemistry: Classification and Nomenclature of Organic Compounds Bonding and Structure of organic compounds Fundamentals of organic reaction mechanism		1
USCH102	I	Chemical Kinetics Liquid state	2	1
	II	Comparative chemistry of Main Group Elements		1
	III	Stereochemistry I		1
USCHP1		Chemistry Practicals	2	6

SEMESTER II

Course Code	UNIT	Topics	Credits	L /Week
USCH201	I	Gaseous state Chemical Equilibrium and thermodynamic parameters	2	1
	II	Concept of Qualitative Analysis Acid Base Theories		1
	III	Chemistry of Aliphatic Hydrocarbons		1
USCH202	I	Ionic equilibria, Molecular Spectroscopy Solid State Chemistry	2	1
	II	Chemical bond and Reactivity Oxidation Reduction Chemistry		1
	III	Stereochemistry II: Cycloalkanes and Conformational Analysis Aromatic hydrocarbons		1
USCHP2		Chemistry Practicals	2	6

Semester I
Paper I
Unit-I

1.1 Chemical Thermodynamics: (10L)

Thermodynamic terms: System, surrounding, boundaries, open, closed and isolated system, intensive and extensive properties, state functions and path functions, zeroth law of thermodynamics

First law of thermodynamics: concept of heat (q), work (w), internal energy (U), statement of first law, enthalpy, relation between heat capacities, sign conventions, calculations of heat (q), work (w), internal energy (U), and enthalpy (H) (Numericals expected)

Thermochemistry: Heats of reactions, standard states, enthalpy of formation of molecules, enthalpy of combustion and its applications, calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equation (Numericals expected)

1.2 Chemical Calculations: (5L)

Expressing concentration of solutions: Normality, molality, molarity, formality, mole fractions, weight ratio, volume ratio, weight to volume ratio, ppm, ppb, millimoles, milliequivalents (Numericals expected)

Unit II

2.1 Atomic structure: (10L)

(Qualitative treatment only; it is expected that the learner knows the mathematical statements and understands their physical significance after completing this topic. No derivations of the mathematical equations required)

a) Historical perspectives of the atomic structure; Rutherford's Atomic Model, Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Structure of hydrogen atom.
b) Hydrogenic atoms:
    1. Simple principles of quantum mechanics;
    2. Atomic orbitals
        i) Hydrogenic energy levels
        ii) Shells, subshells and orbitals
        iii) Electron spin
        iv) Radial shapes of orbitals
        v) Radial distribution function
        vi) Angular shapes of orbitals.

3. Many Electron Atoms
    i) Penetration and shielding
    ii) Effective nuclear charge
4. Aufbau principle

2.2: Periodic Table and periodicity : (5L)

Long form of Periodic Table; Classification for elements as main group, transition and inner transition elements; Periodicity in the following properties : Atomic and ionic size; electron gain enthalpy; ionization enthalpy, effective nuclear charge (Slater's rule); electronegativity ; Pauling, Mulliken and Alred Rochow electronegativities (Numerical problems expected, wherever applicable.)

Unit III

3. Basics of Organic Chemistry

3.1 Classification and Nomenclature of Organic Compounds: (5L)

Review of basic rules of IUPAC nomenclature. Nomenclature of mono and bi-functional aliphatic compounds on the basis of priority order of the following classes of compounds: alkanes, alkenes, alkynes, haloalkanes, alcohols, ethers, aldehydes, ketones, carboxylic acids, carboxylic acid derivatives (acid halides, esters, anhydrides, amides), nitro compounds, nitriles and amines; including their cyclic analogues.

3.2 Bonding and Structure of organic compounds: (4L)

Hybridization: $sp^{3,}$ $sp^{2,}$ sp hybridization of carbon and nitrogen; sp^3 and sp^2 hybridizations of oxygen in Organic compounds (alcohol, ether, aldehyde, ketone, carboxylic acid, ester, cyanide, amine and amide)
Overlap of atomic orbitals: Overlaps of atomic orbitals to form sigma and pi bonds, shapes of organic molecules.
Shapes of molecules; Influence of hybridization on bond properties (as applicable to ethane, ethene, ethyne)
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3.3 Fundamentals of organic reaction mechanism: (6L)

Electronic Effects: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strengths.
Bond fission: Homolytic and Heterolytic fission with suitable examples. Electrophiles and Nucleophiles; Nucleophilicity and basicity;
Types (primary, secondary, tertiary, allyl, benzyl), shape and their relative stability of reactive intermediates: Carbocations, Carbanions and Free radicals.

Introduction to types of organic reactions: Addition, Elimination and Substitution reaction. (With one example of each)

Semester I

Paper II

Unit I

1.1 Chemical Kinetics: (8L)

Rate of reaction, rate constant, measurement of reaction rates, order and molecularity of reaction, integrated rate equation of first and second order reactions (with equal initial concentration of reactants) (Numericals expected)

Determination of order of reaction by (a) Integration method (b) Graphical method (c) Ostwald's isolation method (d) Half time method (Numericals expected)

1.2 Liquid State: (7L)

Surface tension: Introduction, methods of determination of surface tension by drop number method (Numericals expected)

Viscosity: Introduction, coefficient of viscosity, relative viscosity, specific viscosity, reduced viscosity, determination of viscosity by Ostwald viscometer (Numericals expected)

Refractive index: Introduction, molar refraction and polarizability, determination of refractive index by Abbe's refractometer (Numericals expected)

Liquid crystals: Introduction, classification and structure of thermotropic phases (Nematic, smectic and cholesteric phases), applications of liquid crystals

Unit-II

2.0 Comparative chemistry of Main Group Elements: (15L)

Metallic and non-metallic nature, oxidation states, electronegativity, anomalous behaviour of second period elements, allotropy, catenation, diagonal relationship. Comparative chemistry of carbides, nitrides, oxides and hydroxides of group I and group II elements. Some important compounds- $NaHCO_3$, Na_2CO_3, NaCl, NaOH, CaO, $CaCO_3$; oxides of carbon, oxides and oxyacids of sulphur and nitrogen with respect to environmental aspects.

Unit III

3. Stereochemistry I: (15L)

Fischer Projection, Newman and Sawhorse Projection formulae (of erythro, threo isomers of tartaric acid and 2,3 dichlorobutane) and their interconversions ;
Geometrical isomerism in alkene and cycloalkanes: cis–trans and syn-anti isomerism E/Z notations with C.I.P rules.
Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two similar and dissimilar chiral-centres, Distereoisomers, meso structures, racemic mixture and resolution (methods of resolution not expected). Relative and absolute configuration: D/L and R/S designations.
Conformation analysis of alkanes (ethane, propane and n-butane); Relative stability with energy diagrams.

Semester II

Paper I

Unit-I

1.1 Gaseous State: (8L)

Ideal gas laws, kinetic theory of gases, Maxwell-Boltzmann's distribution of velocities (qualitative discussion), ideal gases, real gases, compressibility factor, Boyle's temperature (Numericals expected)

Deviation from ideal gas laws, reasons for deviation from ideal gas laws, Van der Waals equation of state, Joule-Thomson effect: qualitative discussion and experimentation, inversion temperature. (Numericals expected)

1.2 Chemical Equilibria and Thermodynamic Parameters: (7L)

Reversible and irreversible reactions, law of mass action, dynamic equilibria, equilibrium constant, (K_c and K_p), relationship between K_c and K_p, Le Chatelier's principle, factors affecting chemical equilibrium (Numericals expected)

Statement of second law of thermodynamics, concepts of entropy and free energy, spontaneity and physical significance of free energy, thermodynamic derivation of equilibrium constant (Numericals expected)

Unit II

2.1 Concept of Qualitative Analysis: (7L)

a) Testing of Gaseous Evolutes, Role of Papers impregnated with Reagents in qualitative analysis (with reference to papers impregnated with starch iodide, potassium dichromate, lead acetate, dimethylglyoxime and oxine reagents).

b) Precipitation equilibria, effect of common ions, uncommon ions, oxidation states, buffer action, complexing agents on precipitation of ionic compounds. (Balanced chemical equations and numerical problems expected.)

2.2 Acid Base Theories: (8L)

Arrhenius, Lowry- Bronsted, Lewis, Solvent – Solute concept of acids and bases, Hard and Soft acids and bases. Applications of HSAB
Applications of acid base chemistry in:

i) Understanding organic reactions like Friedel Craft's (acylation/alkylation) reaction
ii) Volumetric analysis with special reference to calculation of titration curve involving strong acid and strong base.

Unit III

3. Chemistry of Aliphatic Hydrocarbons

3.1 Carbon-Carbon sigma bonds: (3L)

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

3.2 Carbon-Carbon pi bonds: (12L)

Formation of alkenes and alkynes by elimination reactions: Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition),
Mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction(catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2-and 1, 4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination using N-bromosuccinimide and mechanism, e.g. propene, 1-butene, toluene, ethylbenzene.
Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

Semester II

Paper II

Unit I

1.1 Ionic Equilibria: (7L)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water, ionization of weak acids and bases, pH scale, common ion effect, dissociation constants of mono-, di- and triprotic acid (exact treatment for monoprotic acid)

Buffers: Introduction, types of buffers, derivation of Henderson equation for acidic and basic buffers, buffer action, buffer capacity (Numericals expected)

1.2 Molecular Spectroscopy: (4L)

Electromagnetic radiation, electromagnetic spectrum, Planck's equation, interaction of electromagnetic radiation with matter: Absorption, emission, scattering, flourescence, electronic, vibrational and rotational transitions, Beer-Lambert's law (Numericals expected)

1.3 Solid State Chemistry (4L)

Types of solids, crystal lattice, lattice points, unit cell, space lattice and lattice plane, laws of crystallography: Law of constancy of interfacial angle, law of symmetry and law of rational indices (Numericals expected)

Unit II

2.1: Chemical Bond and Reactivity: (7L)

Types of chemical bond, comparison between ionic and covalent bonds, polarizability (Fajan's Rule), shapes of molecules, Lewis dot structure, Sidgwick Powell Theory, basic VSEPR theory for AB_n type molecules with and without lone pair of electrons, isoelectronic principles, applications and limitations of VSEPR theory.

2.2: Oxidation Reduction Chemistry: (8L)

a) Reduction potentials
b) Redox potentials: half reactions; balancing redox equations.
c) Redox stability in water
    i) Latimer and Frost Diagrams
    ii) pH dependence of redox potentials.
d) Applications of redox chemistry
    i) Extraction of elements: (example: isolation of copper by auto reduction)
    ii) Redox reagents in Volumetric analysis: a) I_2; b) $KMnO_4$
    iii) Titration curves:i) single electron systems (example Ce(IV) against Fe(II)); and ii) Multi electron systems as in KMnO4 against Fe(II))

Unit III

3.1 Stereochemistry-II: Cycloalkanes and Conformational Analysis: (5L)

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy.

3.2Aromatic Hydrocarbons: (10L)

Aromaticity: Hückel's ruleanti-aromaticity, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft alkylation/acylation with their mechanism. , Hammond's postulate, Directing effects of the groups.

Reference Books:

Unit I:

1. Atkins P.W. and Paula J.de, Atkin's Physical Chemistry, 10th Ed., Oxford University 12 Press (2014).
2. Ball D.W., Physical Chemistry, Thomson Press, India (2007).
3. Castellan G.W., Physical Chemistry, 4th Ed., Narosa (2004).
4. Mortimer R.G., Physical Chemistry, 3rd Ed., Elsevier: NOIDA, UP (2009).
5. Engel T. and Reid P., Physical Chemistry, 3rd Ed., Pearson (2013).
6. Peter A. and Paula J. de., Physical Chemistry, 10th Ed., Oxford University Press (2014).
7. McQuarrie D.A. and Simon J.D., Molecular Thermodynamics, Viva Books Pvt. Ltd.,New Delhi (2004).
8. Levine I.N., Physical Chemistry, 6th Ed., Tata Mc Graw Hill (2010).
9. Metz C.R., 2000 Solved Problems in Chemistry, Schaum Series (2006).
10. Mortimer R.G., Physical Chemistry, 3rd Ed., Elsevier: NOIDA, UP (2009).
11. Banwell C.N., Fundamentals of Molecular Spectroscopy, 4th Ed., Tata McGraw Hill (1994).
12. K.L. Kapoor, A Textbook of Physical Chemistry, Macmillan (2000).

Unit II:

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970
3. Atkins, P.W. & Paula, J. Physical Chemistry, 10^{th} Ed., Oxford University Press, 2014.
4. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
5. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.

Unit III:

1. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt Ltd. (Pearson Education).2012
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
4. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
6. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7^{th} Ed. Cengage Learning India Edition, 2013.

CHEMISTRY LAB:

Semester I

Unit I: Physical Chemistry

1. To prepare 0.1 N succinic acid and standardize the NaOH of two different concentrations
2. To determine the rate constant for the hydrolysis of ester using HCl as catalyst
3. To determine enthalpy of dissolution of salt (like KNO_3)

Unit II: Inorganic Chemistry

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1. Commercial analysis of (any two)
   a) Mineral acid
   b) Organic acid
   c) Salt of weak acid and strong base.

2. Titration using double indicator: analysis of solution of Na_2CO_3 and $NaHCO_3$.
3. Gravimetric analysis
   a) To determine the percent purity of sample of $BaSO_4$ containing NH_4Cl
   b) To determine the percent purity of ZnO containing $ZnCO_3$.

Unit III: Organic Chemistry

1. Purification of any two organic compounds by recrystallization selecting suitable solvent. (Provide 1g.).
   Learners are expected to report
   a) Solvent for recrystallization.
   b) Mass and the melting points of purified compound.

   Learners should calibrate thermometer before determining melting point.

2. Chromatography (Any one)
   a) Separation of a mixture of two sugars by ascending paper chromatography
   b) Separation of a mixture of o-and p-nitrophenols by thin layer chromatography (TLC)

Semester II
Chemistry Lab

Unit I: Physical Chemistry

1. To determine the rate constant for the saponification reaction between ethyl acetate and NaOH
2. To determine dissociation constant of weak acid (Ka) using Henderson's equation and the method of incomplete titration pHmetrically.
3. To verify Beer-Lambert's law, using $KMnO_4$ solution by colorimetric method.
4. To standardize commercial sample of HCl using borax and to write material safety data of the chemicals involved.

Unit II: Inorganic Chemistry

1. **Qualitative analysis: (at least 4 mixtures to be analyzed)**
   Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions.
   Cations (from amongst):
   Pb^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Cu^{2+}, Cd^{2+}, Fe^{2+}, Ni^{2+}, Mn^{2+}, Mg^{2+}, Al^{3+}, Cr^{3+}, K^{+},NH^{4+}
   Anions (From amongst):
   CO_3^{2-}, S^{2-}, SO_3^{2-}, NO_2^{-}, NO_3^{-}, Cl^{-}, Br^{-}, I^{-}, SO_4^{2-}, PO_4^{3-}
   (Scheme of analysis should avoid use of sulphide ion in any form for precipitation / separation of cations.)
2. **Redox Titration:** To determine the percentage of copper(II) present in a given sample by titration against a standard aqueous solution of sodium thiosulfate (iodometry titration)

Unit III: Organic Chemistry

Characterization of organic compound containing C, H, (O), N, S, X elements.
(minimum 6 compounds)

Reference Books

Unit I: Physical Chemistry

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).
3. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3rd Ed., W.H. Freeman and Co., New York (2003).
4. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001).

Unit II: Inorganic Chemistry

Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.

Unit III: Organic Chemistry

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996

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