Academic Council Meeting No. and Date : 2 / April 30, 2021

Agenda Number : 4 **Resolution Number : 4.3 and 4.19**

Vidya Prasarak Mandal's
B. N. Bandodkar College of
Science (Autonomous), Thane

Syllabus for

Programme : Bachelor of Science

Specific Programme : Chemistry

[F.Y.B.Sc. (Chemistry)]

Revised under Autonomy

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Preamble

The B.Sc. (Chemistry) programme is aimed to make the students employable and impart industry oriented training. The main objectives of the course are:

- to develop an aptitude to engage in continuing professional development.
- to work effectively as a part of a team to achieve a common stated goal.
- to be capable of managing complex chemical projects with consideration of the human, financial and environmental factors.
- to think analytically, creatively and critically in developing robust, extensible and highly maintainable technological solutions to simple and complex problems.
- to apply their knowledge and skills to be employed and excel in chemical industrial work.
- to communicate effectively with a range of audiences both technical and non-technical.

The syllabus is aimed to achieve the objectives. The syllabus spanning three years covers the industry relevant courses. The students will be ready for the jobs available in different fields like:

- History of Indian chemical science
- Introduction to physical concepts use for the chemical systems
- Study of thermodynamics, chemical kinetics, molecular spectroscopy, solid state, etc.
- Detailed study of periodic table
- Introduction to aliphatic and aromatic compounds
- Study of stereochemistry
- Introduction to analytical chemistry
- Study of safety precaution use in chemical laboratory
- Be skillful in handling various glassware and instruments

Eligibility :

Passed 12th standard (HSC) of Maharashtra State Board / CBSE / ICSE board or equivalent.

Duration: 3 years

Mode of Conduct :

Laboratory practicals / Offline lectures / Online lectures

Program Specific Outcome

- Study of structure, properties, reaction and application of chemical systems.
- Study of safety precaution use in chemical laboratory.
- Select and apply current techniques, skills, and tools necessary in chemical laboratory.
- Study of basics of Physical chemistry, Inorganic chemistry, Organic chemistry and Analytical chemistry.

F.Y.B.Sc. (Chemistry)

Structure of Programme

Semester 1			
Course Code	**Course Title**	**No. of lectures**	**Credits**
BNBUSCH1T1	Chemistry Paper - I	**45**	**2**
BNBUSCH1T2	Chemistry Paper – II	**45**	**2**
BNBUSCH1P1	Chemistry Practical - I	**30**	**2**
Total		**120**	**6**

Semester 2			
Course Code	**Course Title**	**No. of lectures**	**Credits**
BNBUSCH 2T1	Chemistry Paper – I	**45**	**2**
BNBUSCH 2T2	Chemistry Paper – II	**45**	**2**
BNBUSCH 2P1	Chemistry Practical – II	**30**	**2**
Total		**120**	**6**

Semester I

Course Code	Course Title	Credits	No. of lectures
BNBUSCH1T1	**Chemistry Paper - I**	2	

Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to

- History of Indian chemical science.
- Classification of elements in periodic table.
- Basics of Organic Chemistry.
- Study of basics of atomic structure.

Unit I :	**HISTORY OF SCIENCE :** General history of Chemical science **Indian Pioneers in Chemical sciences :** 1. **Prof. C. N. R. Rao:** Area of research: Prof. C. N. R. Rao is a leading Indian scientist in the field of solid state and materials chemistry. His major are of research comprises transition metal oxides and other extended inorganic solids, inorganic-organic hybrid materials, nanomaterials and generation of hydrogen by photocatalysis. 2. **Acharya P. C. Ray:** Area of research: Acharya P. C. Ray established the first modern research in Chemistry and is regarded as the father of chemical science in India. He published around 150 research articles during his lifetime. He discovered the stable compound mercurous nitrite in 1896 and established Bengal chemical and pharmaceutical works Ltd, India's first pharmaceutical company in 1901. 3. **Prof. H. J. Arniker:** Area of research: Prof. H. J. Arniker was worked in the field of Radiochemistry and Allied sciences. He was applied Neutron activation analysis in the various fields of chemical science. 4. **Har Govind Khurana:** Area of research: The researcher shared the 1968 Nobel prize for Physiology or Medicine with Marshall W. Nirnberg and Robert W. Holley for research that showed how the order of nucleotides in nucleic acids, which carry genetic code of the cell, control the cell's synthesis of proteins. 5. **Dr. Yusuf Khwaja Hamid:** Area of research: Dr. Yusuf Khwaja Hamid is a Polish born Indian scientist, the chairman of Cipla, a generic pharmaceuticals company founded by his father Kwaja Abdul Hamied in 1935. He is also an elected fellow of the Indian National Science Academy. 6. **Dr. Asima Chatterjee:** Area of research: Dr. Asima Chatterjee was an Indian organic chemist noted for her work in the fields of organic chemistry and phytomedicine. Her most notable work includes research on vinca alkaloids, the development of anti-epileptic drugs and development of anti-malarial drugs. 7. **Prof. S. R. Gadre:** Area of research: Prof. S. R. Gadre is an Indian scientist working in computational quantum and theoretical chemistry. He has authored authors over 200 publications mostly in highly impact factors.	**15**
Unit II :	**Atomic Structure :** (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) 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.	**15**

	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 **Periodic Table and periodicity :** 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 :	**Basics of Organic Chemistry :** **Classification and Nomenclature of Organic Compounds :** 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. **Bonding and Structure of organic compounds :** Hybridization:sp3,sp2,sp hybridization of carbon and nitrogen;sp3 and sp2 hybridization sofoxygenin Organic compounds(alcohol, ether, aldehyde, ketone, carboxyli cacid, 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) **Fundamentals of organic reaction mechanism:** **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)	**15**

Course Code	Course Title	Credits	No. of lectures
BNBUSCH1T2	**Chemistry Paper - I**	2	

Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to

- Understand the various physical laws and rules which applied for chemical system
- Study of applications of chemical kinetics, thermodynamics, liquid state, etc.
- Study inorganic compounds
- Basics of stereochemistry

Unit I :	**Chemical Kinetics:** 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) **Liquid State: Surfacetension:** Introduction, methods of determination of surface etension by drop number method (Numerical's 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) **Liquidcrystals:** Introduction, classification and structure of thermotropic phases(Nematic, smectic and cholesteric phases), applications of liquid crystals. **Chemical Thermodynamics 1 :** 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 to fheat(q), work(w), internalenergy(U), statement of first law, enthalpy, relation between heat capacities, sign conventions, calculations of heat (q), work (w), internal energy (U), and enthalpy (H) (Numerical's expected)	**15**
Unit II :	**Comparative chemistry of Main Group Elements :** 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 oxy-acids of sulphur and nitrogen with respect to environmental aspects.	**15**
Unit III	**Stereochemistry I:** Fischer Projection, Newman and Sawhorse Projection formulae (of erythro, threoisomers 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.	**15**

Course Code	Course Title	Credits	No. of lectures
BNBUSCH1P1	**Chemistry Practical**	**2**	

Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to

- Be skillful in handling various glassware and instruments.
- Actively participate in chemical laboratories.
- Study of commercial analysis of various organic and inorganic compounds.
- Learned basics of chemical analysis.

Practical 1	**Unit I: Physical Chemistry**	**30**
a.	To prepare 0.1 N succinic acid and standardize the NaOH of two different concentrations	
b.	To determine the rate constant for the hydrolysis of ester using HCl ascatalyst	
c.	To determine enthalpy of dissolution of salt (likeKNO3)	
Practical 2	**Unit II: Inorganic Chemistry**	
a.	Commercial analysis of (any two) a) Mineralacid b) Organicacid c) Salt of weak acid and strongbase.	
b.	Titration using double indicator: analysis of solution of Na2CO3 andNaHCO3.	
c.	Gravimetric analysis a) To determine the percent purity of sample of BaSO4 containingNH4Cl b) To determine the percent purity of ZnO containingZnCO3.	
Practical 3	**Unit III: Organic Chemistry**	
a.	Purification of any two organic compounds by recrystallization electingsuitable solvent. (Provide1g.). Learners are expected to report **a)** Solvent forrecrystallization. **b)** Mass and the melting points of purifiedcompound. Learners should calibrate thermometer before determining melting point.	
b.	Chromatography (Anyone) **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

Course Code	Course Title	Credits	No. of lectures
BNBUSCH2T1	**Chemistry Paper - I**	**2**	

Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to

- Study of thermodynamic parameters of chemical system.
- Study of acid-base theory.
- Introduction of analytical chemistry.
- Learned chemistry of aliphatic compounds.

Unit I :	**Gaseous State:** 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) **Chemical Equilibria and Thermodynamic Parameters:** 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)	**15**
Unit II :	**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.) **Acid Base Theories:** 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 titrationcurve involving strong acid and strongbase.	**15**
Unit III :	**Chemistry of AliphaticHydrocarbons** **Carbon-Carbon sigma bonds:** **Chemistry of alkanes:** Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity. **Carbon-Carbon pi bonds:** **Formation of alkenes and alkynes by elimination reactions:** Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. **Reactions of alkenes:**	**15**

	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.	

Course Code	**Course Title**	**Credits**	**No. of lectures**
BNBUSCH2T2	**Chemistry Paper - II**	**2**	

Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to

- Study of ionic equilibria, molecular thermodynamics, etc.
- Introduction of redox reaction
- Detail study of stereochemistry.
- Brief overview of aromatic compounds.

Unit I :	**Ionic Equilibria :** 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,pHscale,commonioneffect,dissociationconstantsofmono-,di-andtriproticacid (exact treatment for monoproticacid) Buffers: Introduction, types of buffers, derivation of Henderson equation for acidic and basic buffers, buffer action, buffer capacity (Numericals expected) **Molecular Spectroscopy :** 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 (Numerical's expected) **Chemical Thermodynamics 2 :** **Thermo chemistry:** 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 thermo chemical data, Kirchhoff's equation (Numericalsexpected). **Solid State Chemistry :** 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 (Numerical's expected)	**15**
Unit II :	**Chemical Bond and Reactivity :** 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	**15**

	VSEPR theory. **Oxidation Reduction Chemistry :** 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 redoxpotentials. **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 :	**Stereochemistry-II: Cycloalkanes and Conformational Analysis:** Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy. **Aromatic Hydrocarbons:** Aromaticity: Hückel's ruleanti-aromaticity, aromatic character of arenes, cyclic carboc ations/carbanions and heterocyclic compounds with suitable examples. **Electrophili caromatic substitution:** halogenation, nitration, sulphonation and Friedel-Craft alkylation/acylation with their mechanism. Hammond's postulate, Directing effects of the groups.	**15**

Course Code	**Course Title**	**Credits**	**No. of lectures**
BNBUSCH2P1	**Chemistry Practical**	**2**	

Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to

- Be skillful in handling various glassware and instruments.
- Introduction of instruments used in chemical laboratory
- Actively participate in chemical laboratories
- Study of characterization of organic compounds.

Practical 1	**Unit I: Physical Chemistry**	**30**
a.	To determine the rate constant for the saponification reaction between ethyl acetate and NaOH	
b.	To determine dissociation constant of weak acid (Ka) using Henderson's equation and the method of incomplete titration pHmetrically.	
c.	To verify Beer-Lambert's law, using KMnO4 solution by colorimetric method.	
d.	To standardize commercial sample of HCl using borax and to write material safety data of the chemicals involved.	
Practical 2	**Unit II: Inorganic Chemistry**	
a.	Qualitative analysis: (at least 4 mixtures to beanalyzed) Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions.	

	Cations (from amongst): Pb2+, Ba2+, Ca2+, Sr2+, Cu2+, Cd2+, Fe2+, Ni2+, Mn2+, Mg2+, Al3+, Cr3+, K+,NH4+ Anions (From amongst): CO32-, S2-, SO 2-, NO2-, NO3-, Cl-, Br_3, I-, SO42-, PO43- (Scheme of analysis should avoid use of sulphide ion in any form for precipitation / separation of cations.) Redox Titration: To determine the percentage of copper(II) present in agiven sample by titration against a standard aqueous solution of sodium thiosulfate (iodometrytitration)	
Practical 3	**Unit III: Organic Chemistry**	
a.	Characterization of organic compound containing C, H, (O), N, S, X elements. (minimum 6 compounds)	

References

Theory					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Physical Chemistry	I. N. Levine	Tata Mc Graw Hill	**6th**	**2010**
2.	Molecular Thermodynamics	D. A. McQuarrie	Viva Books Pvt. Ltd.,New Delhi		2004
3.	Physical Chemistry	P.W. Atkins	Oxford University Press	10th	2014
4.	Concise Inorganic Chemistry	J. D. Lee	ELBS		1991
5.	StereochemistryConformation andMechanism	Kalsi,P.S.	NewAgeInternational	-	2005
6.	Organic Chemistry	R. T. Morrison	Dorling Kindersley (India) Pvt Ltd. (PearsonEducation)	-	2011
7.	Stereochemistry of Organic Compounds Principles and applications	D. Nasipuri	New Age International Publishers	**2nd**	2012

Practical					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Senior Practical Physical Chemistry	B. D. Khosla	-	-	2011
2.	Vogel's *Quantitative Chemical Analysis*	J. Mendham	**Pearson**	**6th**	2009
3.	Practical Organic Chemistry	F.G. Mann,	Pearson Education	-	2009
4.	Textbook of Practical Organic Chemistry	A. I. Vogel	Prentice-Hall	**5th**	1996

Evaluation Scheme

Internals

Attendance	Group discussion	Assignments	Leadership qualities	Total
10	10	10	10	40
OR Class Test				
OR Certification of Swayam / NPTEL in concern course				

Theory Examination: Suggested Format of Question paper

Duration: 2 Hours **Total Marks : 60**

- **All questions are compulsory**

Q. 1	Answer ***any TWO*** of the following		**16**
	a	Based on Unit I	
	b	Based on Unit I`	
	c	Based on Unit I	
	d	Based on Unit I	
Q. 2	Answer ***any TWO*** of the following		**16**
	a	Based on Unit II	
	b	Based on Unit II	
	c	Based on Unit II	
	d	Based on Unit II	
Q. 3	Answer ***any TWO*** of the following		**16**
	a	Based on Unit III	
	b	Based on Unit III	
	c	Based on Unit III	
	d	Based on Unit III	
Q. 4			**12**
	a	Multiple choice questions	
	b	One sentence question	
	c	True and False	

Marks Distribution and Passing Criterion for Each Semester

Semester 1

Theory					Practical		
Course Code	Internal	Min marks for passing	Theory Examination	Min marks for passing	Course Code	Practical Examination	Min marks for passing
BNBUSCH1T1	**40**	**16**	**60**	24	BNBUSCH1P1	**100**	**40**
BNBUSCH1T2	**40**	**16**	**60**	24			

Semester 2

Theory					Practical		
Course Code	Internal	Min marks for passing	Theory Examination	Min marks for passing	Course Code	Practical Examination	Min marks for passing
BNBUSCH2T1	**40**	**16**	**60**	24	BNBUSCH2P1	**100**	**40**
BNBUSCH2T2	**40**	**16**	**60**	24			

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