Tribhuvan University
Institute of Science and Technology
4 Years B. Sc. Chemistry Course of Study
(Revised–2073)

The structure of the course for the 4 Years B. Sc. Chemistry will be as follows:

1st Year:

Subjects	Course No.	Full Marks	Pass Marks
Basic Chemistry I	CHE-101	100	35
Basic Chemistry Practical I	CHE-102	50	20

Tribhuvan University
Institute of Science and Technology
Four Year B. Sc. Chemistry Course of Study
(Revised–2073)

Course Title: Basic Chemistry I
Course No.: CHE 101 (major/minor)
Nature of the Course: Theory

Full Marks: 100
Pass Marks: 35
Year: I

Course Objectives:

- To stimulate, create and sustain their interest in the study of chemistry.
- To provide a body of chemical knowledge appropriate for higher studies.
- To make aware the importance of scientific method of accurate experimental work.
- To provide mechanistic approaches of organic reactions.

Group A: Inorganic Chemistry

Atomic structure:- Bohr's theory and refinements, wave mechanical model of the atom, matter waves, de Broglie's equation, Heisenberg's uncertainty principle, Schrödinger's wave equation (time independent), physical significance of wave function, probability density pattern for hydrogen atom, radial and angular wave functions, radial distribution curves, shapes of s, p, d orbital ; charge cloud diagrams and boundary surface diagrams, nodal planes, quantum numbers and their significance, energy level diagram. **9 hrs**

Multi-electron system:- Pauli exclusion principle, Hund's rule of maximum multiplicity, energy level diagrams across d-block elements, stability of completely filled, half filled and empty orbital. **3 hrs**

Nuclear Chemistry:- Composition of nucleus, nuclear stability, binding energy, radioactivity, half life determination and nuclear reactions, group displacement law and radioactivity series, application of nuclear chemistry. **4 hrs**

Periodic classification of elements and physical properties: Long form of periodic table (significance and limitation), IUPAC classification of periodic table and its merits and demerits, periodicity of elements, s, p, d and f blocks, long form of periodic table, discussion of properties like atomic, ionic and covalent radii, ionization potential, screening or shielding effect, electro negativity, different scales of electro negativity measurements (Pauling, Mulliken and Allred and Rochow), electron affinity (Periodic variation, experimental determination of electron affinity).

7 hrs

Chemical bonding : Ionic bond: packing of ions in crystal, radius ratio, lattice energy, Born equation, Born-Haber cycle, covalent character in ionic compounds, polarizing power and polarizability (Fajan's rule), bond moment and dipole moments, percentage ionic character from dipole moments and electro negativity differences, characteristics of ionic compounds, structure of ionic solids, ionic compounds of type AX (NaCl, CsCl, ZnS), AX_2 (CaF_2, TiO_2), layer structures, stoichometric and non- stoichometric defects. **8 hrs**

Covalent Bond: General characteristics of coordinate-covalent bond, valence bond approach, directional characteristics of covalent bond, resonance energy, hybridization, the extent of orbital participation in molecular bonding, (sp, sp^2, sp^3, d^2sp^3, dsp^2, sd^3, dsp^2, dsp^3), multiple bonding, three electron bond, two electron three centered bond, sigma-and pi-bonds, bond length and bond order, bond strength, valence shell electron pair repulsion theory (VSEPR), theory of directed valence, shapes of simple inorganic molecules and ions containing bonds and lone pairs, hydrogen bond (theories of hydrogen bonding, valence bond treatment), metallic bond (Free electron theory and band theory), conductors, insulators and semiconductors, elementary idea of L.C.A.O. and concept of united atoms in molecular orbital theory, bonding, antibonding, and non-bonding orbitals, M.O. configurations of simple diatomic molecules (H_2, He_2, N_2, O_2, F_2, CO, NO, HCl and related species) and molecular ions (O_2^-, O_2^{--}, NO^+, CO^+). σ and π bonds and delocalized π-bonds in inorganic species (CO_2, SO_2, SO_3^{--}, CO_3^{--}, NO_3^-, N_3^- etc). **10 hrs**

Acids and Bases: Lewis acid-base concept, hard and soft acids and bases (HSAB), application of HSAB principle, relative strengths of acids and bases and the effect of substituents and solvents on them. **4 hrs**

Principles of qualitative and quantitative Analysis: Solubility product, common ion effect, their application in group separation, principles of gravimetric and volumetric analysis. **5 hrs**

Group B: Organic Chemistry

Structure and Properties: Atomic orbitals, molecular orbitals, hybrid orbitals, polarity of bonds, melting point, acids and bases, dipole-dipole interaction, hydrogen bonding, inductive effect, electromeric effect, resonance, mesomeric effect or conjugative effect, hyperconjugation effect, steric effect, IUPAC nomenclature. **4 hrs**

Alkanes: Energy of activation, progress of reaction, energy profile diagram, exothermic and endothermic reaction, Fischer projection formulas, Andiron formulas, Newman projection formula, free rotation about the C-C single bond, conformation of n-butane, physical properties, industrial source, industrial source vs. laboratory preparation, Grignard reagent, coupling of alkyl halide with organometallic compounds, reactions: halogenations (substitution reaction), mechanism of halogenations, orientation of halogenations, relative reactivity of alkanes toward halogenations, ease of abstraction of hydrogen, homolytic bond dissociation energies and relative stability of free radicals, ease of formation of free radicals, structure of free radicals, transition state for

halogenations, orientation, reactivity and selectivity, non-rearrangement of free radicals, combustion, pyrolysis. **10 hrs**

Stereochemistry: Introduction, structural isomers and stereoisomer, stereoisomerism, optical activity, polarimeter, specific rotation, enantiomerism and optical activity, chirality, chiral centre, enantiomers, racemic modification, resolution of racemic modification, configuration, absolute configuration (R and S), sequence rules, diastereomers, meso compound, reaction involving stereoisomers, generation of a chiral centre (only one chiral centre), geometrical isomerism. **7 hrs**

Alkyl Halide (Nucleophilic Substitution): Homolytic and heterolytic fission, structure (the functional group), classification and nomenclature of alkyl halides, physical properties, preparation, nucleophilic aliphatic substitution reactions, nucleophiles and leaving groups, rate of reaction (effect of concentration), the S_N2 reaction (mechanism and kinetics), the S_N2 reaction (stereochemistry, inversion of configuration), the S_N1 reaction (mechanism and kinetics), carbocations (structure and relative stability), S_N1 reaction (stereochemistry), rearrangement of carbocations, S_N1 vs. S_N2 reaction, factors affecting S_N mechanism (effect of substrate, nucleophile, solvent, and leaving group). **10 hrs**

Alcohols and Ethers: Introduction, nomenclature, structure, physical properties, industrial source, fermentation, fuel from carbohydrate, ethanol, preparation, reactions, alcohols as acids, bases, reaction of alcohols with hydrogen halides, formation of alkyl sulphonates, oxidation of alcohols, industrial source of ethers, preparation of ethers, Williamson synthesis, reactions of ethers (PCl_5, HX), role of solvent, solubility (ionic solutes, protic and aprotic solvents, ionic pair). **6 hrs**

Alkenes: Physical properties, industrial source, preparation, dehydrohalogenation of alkyl halide, kinetics of dehydrohalogenation, E2 reaction (mechanism, orientation and reactivity), E1 reaction (mechanism, orientation and reactivity), dehydration of alcohols, reaction of alkenes, reaction at the carbon-carbon double bond, (hydrogenation, addition of hydrogen halides, addition of hydrogen bromide and peroxide effect, addition of sulphuric acid, addition of water, electrophilic addition (mechanism, orientation and reactivity), addition of halogens, and mechanism, halohydrin formation, oxymercuration-demercuration, hydroboration-oxidation, (orientation and mechanism of hydroboration), free radical addition (mechanism and orientation), hydroxylation, ozonolysis, analysis of alkenes, application of alkenes to prepare polymers (polypropelene and polyethylene). **9 hrs**

Alkynes: Structure of acetylene, physical properties, industrial source of acetylene, preparation of alkynes, reactions of alkynes, reduction to alkenes, electrophilic addition to alkynes, hydration of alkynes, acidity of alkynes, reactions of metal acetylides, analysis of alkyne. **4 hrs**

Group C: Physical Chemistry

Gaseous State: Review on kinetic theory of gases, derivation of kinetic gas equation, average velocity, most probable velocity, average kinetic energy of gas molecules, molecular interpretation of temperature, gas laws (Boyle's, Charles's, Graham's, Avogadro's & Dalton's laws) and root mean square velocity of gas molecules derived from kinetic gas equation, related numericals

Maxwell-Boltzmann distribution law for molecular velocities, distribution of velocities, different types of velocities (most probable, average & root mean square) of gas molecules and their derivation from Maxwell's equation, collision properties: collision diameter, collision frequency, mean free path, related numericals

Deviation of real gas from ideal behavior, van der Waals equation (derivation and explanation of volume and pressure corrections), Boyle's temperature and van der Waals constants, compressibility factors and its uses, critical phenomenon, relation between van der Waals constants and critical constants, related numericals.

Liquefaction of gases: Faraday method, Linde's and Claude's principles of liquefaction of air.

12 hrs

Liquid and Solid States: Properties of liquids, surface tension and its determination by drop weight & capillary rise methods, viscosity and fluidity, effect of temperature on viscosity & surface tension, determination of viscosity by Ostwald's viscometer, applications of surface tension and viscosity measurements, numericals.

Properties of crystalline & amorphous; ionic, covalent, metallic & molecular solids, crystal structure and unit cells, crystal systems and Bravais lattices, cubic crystals (simple, body centered and face centered cubic), laws of crystallography, Miller indices, numericals. **8 hrs**

Chemical and Ionic Equilibriums: Applications of law of mass action to homogeneous equilibrium, effect of temperature, pressure, concentration and inert gases on chemical equilibrium, numerical problems on chemical equilibrium

Quantitative treatments on hydrolysis of salts and related numerical problems, common ion effects in ionic equilibrium, buffer solution, buffer capacity and buffer range, numerical problems in pH and buffer, pH change in acid base titration (weak and strong), theory of acid base indicator: Ostwald's theory, quinonoid theory, selection of acid base indicators in titrations.

8 hrs

Colligative Properties: Raoult's law and determination of vapor pressure lowering, laws of elevation of boiling point and depression of freezing point, osmotic pressure and determination of molecular weight from colligative properties, van't Hoff factor, abnormalities in solution due to association and dissociation, numerical problems. **6 hrs**

Chemical Kinetics: Review on the rate of a chemical reaction, pseudo order reaction, rate equations (differential and integrated form) for zero and second order reaction, half life of reaction, determination of order of a reaction, effect of temperature on the reaction rate: Arrhenius equation and activation energy, related numerical, kinetic study of some reaction mechanism (reaction between O_2 and HBr, I_2 and propanone in acidic medium) **8 hrs**

Thermodynamics and Thermo-chemistry: Review on (some thermodynamic terms, Hess law & bond energy), isothermal but not reversible expansion of an ideal gas, isothermal reversible expansion of an ideal gas, experimental determination of $\triangle E$ using bomb calorimeter, (H) enthalpy, experimental determination of $\triangle H$, enthalpy of physical changes (enthalpy of fusion, vaporization, sublimation), molar heat capacity at constant pressure and volume, relation between C_p and C_v, variation of heat of reaction with temperature (Kirchoff's equation), calorific value of fuel and food, numerical problems. **8 hrs**

Tribhuvan University

Institute of Science and Technology

Course Title: Basic Chemistry Practical I
Course No.: CHE 102 (major/minor)
Nature of the Course: Practical

Full Mark: 50
Pass Mark: 20
Year: I

Course Objectives:

- To make students aware of the importance of scientific methods of accurate experimental works about chemistry.
- To develop in students' abilities to perform experiments having due regard for safety.
- To develop in students skill of observation and their ability to record and interpret those observations.

Experiments on Inorganic Chemistry

Volumetric analysis: Volumetric analysis involving acidimetry and alkalimetry (combination of strong and weak acids and bases); Determination of total alkalinity and phenolphthalein alkalinity in a given sample of water, Permanganate titration (estimation of iron in Mohr's salt), Determination of calcium in calcium carbonate, Silver nitrate titration (determination of chloride content in a given sample of water), Iodometric titration (potassium dichromate and copper sulphate, determination of residual chlorine in a given sample of water). **27 hrs**

Inorganic Preparation: Sodium thiosulphate, Potassium dichromate, Ammonium ferric sulphate, Potash alum, Tetrammine copper sulphate, Prussian blue **33 hrs**

Experiments on Organic Chemistry

1. Thermometer calibration.
2. Purification of crude organic compounds.
3. Re-crystallization (acids, acetanilide, amides, benzoates, etc.).
4. Determination of melting point and mixed melting point.
5. Purification of liquid compounds by distillation.
6. Determination of boiling points (aniline, nitrobenzene, nitroaniline, etc.).
7. Isolation of steam volatile compounds.
8. Classification of organic compounds by solubility (water, ether, 5% HCl, 5% sodium hydroxide, 5% sodium bicarbonate, conc. H_2SO_4).
9. Identification of functional groups.

60 hrs

Experiments on Physical Chemistry

1. Determination of surface tension of liquid using Stalagmometer.
2. Determination of viscosity using Ostwald viscometer.
3. Preparation of standard buffer solution using sodium acetate and acetic acid and determine the pH of unknown solution using universal indicator.
4. Preparation of standard buffer solution using ammonium hydroxide and ammonium chloride and determine the pH of unknown solution using universal indicators.
5. Determination of heat of solution of potassium acetate.
6. To study the kinetics of acid catalysed hydrolysis of methyl acetate
7. To study the kinetics of reaction between potassium persulphate and iodine by iodine clock method.
8. Determination of molecular weight of organic compound by Rast method.

60 hrs

Text Books: for theoretical course CHEM 101

1. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edition, John Wiley and sons, Inc., 2007.
2. F. A. Cotton, G. Wilkinson & C. Gaus, *Basic Inorganic Chemistry*, 3rd Edition, John Wiley & Sons (Asia), Pvt., Ltd., 2007.
3. D. F. Shriver & P. W. Atkins, *Inorganic Chemistry*, Oxford University Press.
4. R. T. Morrison & R. N. Boyd, *Organic Chemistry*, 6th and 7th Edition, Prentice- Hall of India Pvt., Ltd., 2008.
5. I. L. Finar, *Organic Chemistry*, Vol. I and Vol. II, Prentice Hall, London, 1955, (available recent edition).
6. Streitweiser & Heathcock, *Introductory Organic Chemistry*, Wiley and Sons, New York, 1981
7. J. March, *Advanced Organic Chemistry*, 4th Edition, Wiley Eastern Ltd., India, 2005.
8. N. D. Cheronis and J.B. Entrikin, *Identification of Organic Compounds*, A Student's Text using Semi-micro Techniques, John Wiley& Sons, Inc (Latest edition).
9. L. Shriner, R.C Fusion and D.Y Cartin, *The Systematic Identification of Organic Compounds*, A Hand Manual, John Wiley and Sons, Inc. New York (Latest).
10. S. H. Maron & C. Prutton, *Principles of Physical Chemistry*, 4th Edition, Oxford & IBH Pub.Co., 1992
11. P. Atkins & J. de Paula, *Elements of Physical Chemistry*, 5th Edition, Oxford University Press Inc., Printed in India by Saurabh Printers Pvt. Ltd., New Delhi, 2009.

Reference Books: for theoretical course CHEM 101

1. A. Sharpe, *Inorganic Chemistry*, 2nd Edition, ELBS & Longman, Singapore, 1986, (recent edition)
2. R. D. Madan & Satya Prakash, *Modern Inorganic Chemistry*, S. Chand & Company Ltd., 1994.
3. K. N. Upadhyaya, *A Text Book of Inorganic Chemistry*, 2nd Edition, Vikash Publishing House Pvt., Ltd., 1995
4. G. Marc Loudon, *Organic Chemistry*, Oxford University, 4th Edition
5. Lawry & Richardson, *Mechanism and Theory in Organic Chemistry*, Haper and Row, New York, 1981
6. C. Norman, *Principles of Organic Synthesis*, 2nd Edition, Chapman and Hill. London, 1978, (recent edition)
7. Warren, *Organic Synthesis; The Disconnection Approach*, Wiley, New York, 1982. (available recent edition)
8. House, *Modern Synthesis Reactions*, 2nd Edition, W. A. Benjamin. New York, 1972
9. R. M. Silverstein, G. L.Bassler & T. C. Morril, *Spectrometric Identification of Organic Compounds*, Wiley, New York, 1981, (Preferably available recent edition)
10. C. Agrawal, *Modern Inorganic Chemistry*, Wiley Eastern, New Delhi, 1981(available recent edition)
11. T.W. Graham Solomons, *Organic Chemistry*, (latest edition), John Wiley and Sons, New York.
12. R. A. Bansal, *A Textbook of Organic Chemistry*, 2nd Edition, Wiley Eastern Ltd., New Delhi, 1993 (available recent edition)
13. K. L. Kapoor, *Textbook of Physical Chemistry*, Macmillan India Ltd., Vol. I to Vol.V, 3rd edition, 2001
14. D. Alberty, *Physical Chemistry*, 6th Edition, Wiley Eastern Ltd., New Delhi, 1992
15. S. Glasstone & D. Lewis, *Elements of Physical Chemistry*, Mcmillan & Co., Ltd.
16. S. Negi & S. C. Anand, *A Text Book of Physical Chemistry*, Wiley Eastern Ltd., 1991
17. S. Bahl, G. D. Tuli & A. Bhal, *Essential of Physical Chemistry*, 24th Edition, S. Chand & Co. 2000.
18. M. K. Sthapit & R. R. Pradhananga, *A Textbook of Physical Chemistry*, Taleju Prakashan, Nepal, 2007.
19. S. D. Gautam, M. K. Prasad & D. P. Bhattarai, *Fundamental Chemistry*, 1st Edition, Heritage Publishers and Distributors Pvt. Ltd., Nepal, 2013
20. M. L. Sharma & P. N. Chaudhary, *A Textbook of B. Sc. Chemistry* (Vol. I & II), 2nd Edition, Ekta Books Nepal, 2007.
21. A. K. Bhagi & G. R. Chatwal, *Bioinorganic and Supramolecular Chemistry*, Himalaya Publishing House, Mumbai.
22. A. K. Bhagi & G. R. Chatwal, *Environmental Chemistry*, Himalaya Publishing House, Mumbai.

23. M. R. Pokhrel & B. R. Poudel, *A Textbook of Inorganic Chemistry*, National Book Centre, Bhotahity, Kathmandu, 2011.
24. James E. Huheey, Ellen A. Keiter & Richard L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, Addison Wesley Publishing House.

Text Books: for practical courses CHEM 102

1. A. I. Vogel, *A Text Book of Quantitative Inorganic Analysis*, Including Elementary Instrumental Analysis, ELBS & Longman, 1969, (Preferably available recent edition).
2. A. I. Vogel, *A Text Book of Qualitative Inorganic Analysis*, ELBS & Longman, 1969, (recent edition).
3. K. N. Ghimire, M. R. Pokhrel & K. P. Bohara, *University Experimental Inorganic Chemistry*, Quest Publication, Kirtipur, Kathmandu, 2008.
4. R. L. Shriner, R. C. Fusion & D. Y. Cartin, *The Systematic Identification of Organic Compounds, A Laboratory Manual*, John Wiley and Sons, Inc. New York, 1986. (Preferably available recent edition).
5. Moti Kaji Sthapit & R. R. Pradhananga, *Experimental Physical Chemistry*, Taleju Prakasan, Kathmandu, 1998.
6. N. M. Khadka, S. D. Gautam & P. N. Yadav, *A Core Experimental Chemistry for B.Sc.*, Heritage Publication, Kathmandu, 2016.

Reference Books: for practical course CHEM 102

1. Gurdeep Raj, *Advanced Practical Inorganic*, 10th Edition, Goel Publishing House, Meerut, 1994.
2. A. I. Vogel, *A Text Book of Practical Organic Chemistry*, Including Qualitative Organic Analysis, Longmans, 1958, (Preferably available recent edition)
3. F. G. Mann & B. C. Saunders, *Practical Organic Chemistry*, Orient Longman, 1986, (recent edition).
4. B. D. Khosla, A. Guali & V. C.Garg, *Senior Practical Physical Chemistry*, 5th Edition, R. Chand & Co., New Delhi, 1987.
5. J. N. Gurtu & A. Gurtu, *Advanced Physical Chemistry Experiments*, 4th Edition, Pragati Prakashan, 2008.
6. S. K. L. Karna, *Chemistry Practical for B. Sc.*, Subharambha Publication, Kathmandu, 2013.
7. S. C. Rastogi & S. K. Agrawal, *Advanced Inorganic Analysis*.
8. S. K. Agrawal and Keemti Lal, *Advanced Inorganic Chemistry*, Pragati Prakasan, Meerut.
9. A. K. De, *Environmental Chemistry*, New age International Ltd. Publishers, New Delhi.