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.

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:

2nd Year:

Subjects	Course No.	Full Marks	Pass Marks
Basic Chemistry II	CHE-201	100	35
Basic Chemistry Practical II	CHE-202	50	20

Four Year B. Sc. Chemistry Course of Study

(Revised–2073)

Course Title: Basic Chemistry II

Course No.: CHE 201 (major)

Nature of the Course: Theory

Full Marks: 100

Pass Marks: 35

Year: II

Lecture : 150

Course Objectives:

- To explain their knowledge in terms of the relevant principles, concepts, theories, definition, patterns and generalization.
- To explain everyday applications and uses of chemistry.
- To present chemical ideas in a clear and logical forms.
- To provide mechanistic approaches of organic reactions.

Group A: Inorganic Chemistry

Refining and purification of metals: Applications of the following processes in the refining, separation and extraction of metal; ion exchange chromatography, solvent extraction, oxidative refining, parting process, zone refining, Mond's process. **5 hrs**

Comparative study of s- & p- block elements and their important compounds:- General group trends, electron configuration, atomic radii, ionization potential, electron affinity, electronegativity, inert pair effect, general properties of the elements, the occurrence and isolation of the elements, factors influencing the choice of extraction process, comparative study of s and p block elements and their important compounds.

Alkali metals: Solubility in NH_3, hydration energy and mobility of ions, R-Li, chlor-alkali industry and its application, crown and crypt ethers.

Alkaline earth metals: Be-anomalous behavior, CaH_2, Grignard's reagent, chlorophyll, biological properties of Ca and Mg.

Gr III: Principle of extraction of Al, alums, BF_3, Borax, $2e^-$ 3 centred bond, halides of Al, aluminum alkyls, cement, inert pair effect (Gr III, IV,V)

Gr IV: Structure and allotropy of the element, difference between C, Si and other remaining elements.

Carbon clusters: Fullerene (preparation, structure and applications).

Carbides, carbonyls, silicon carbide, silicates, freons, internal π bonding using d orbital (structure of $(CH_3)_3N$ and $(Si\ H_3)_3N$).

Gr V: Nitrogen cycle, liquid ammonia as solvent, phosphate fertilizers, halides, role of phosphate esters in biological process.

Gr VI: Acid rain, Pπ - dπ bonding, difference between oxygen and other elements, thionyl chloride, tetra sulfur tetra nitride, reactivity and oxidizing property of halogen.

Gr VII: Prechloric acid, isolation of fluorine, electropositive character of iodine

Gr 0: Isolation of noble gases, clathrate compounds, uses of noble gases. **20 hrs**

Chemistry of d-block elements and their compounds: General trends in electronic configurations, ionic and covalent atomic radii, electronegativity, electron affinity, ionization potential, colour and magnetic properties, variable valancy, complex formation with reference to 3d-block elements, general introduction of first transition (3d) second transition (4d) and third transition series, comparison of the elements of 3d series with 4d and 5d transition series in terms of (i) electronic configuration (ii) reactivity of element (iii) stability of oxidation state (iv) highest oxidation state and (v) stability of complexes, concept of co-ordination complexes, Werner's theory of co-ordination compounds, comparative study of chemistry of elements of 3d- series (excluding Sc, Ti, V) chemistry of representative compounds of 3d- block elements (TiO_2, $TiCl_4$, Zeigler-Natta catalyst, vanadates, V_2O_5, CrO_2Cl_2, K_2CrO_7, ferrocene, nickel carbonyl), bioinorganic chemistry of iron, chromium and copper. **14 hrs**

Preparation, properties, bonding and structure of the following: Oxides and oxyacids of phosphorous (structure and application only) hydrazine, hydroxylamine, hydrazoic acid, hydrogen peroxide, ozone, sodium thiosulphate, peracids of sulphur, potassium permanganate, potassium dichromate. **11 hrs**

Group B: Organic Chemistry

Cyclic aliphatic compounds: Nomenclature, industrial source, preparation, reactions, reactivity of cyclopropane and cyclobutane by comparing with alkanes, stability of cycloalkanes–Baeyer's strain theory, Sachse and Mohr prediction and Pitzer's strain theory, factors affecting stability of conformations, conformational structure of cyclobutane, cyclopentane and cyclohexane, equatorial and axial bonds. **5 hrs**

Aromaticity: Concepts of aromaticity, antiaromaticity and non-aromaticity, structure of benzene, resonance structure and orbital picture of benzene, stability of benzene (resonance energy), Huckel's rule and its application to benzenoid (benzene and naphthalene) and non benzenoid (cyclopropenylcation, cyclopentadienyl anion and tropylium ion), general mechanism of electrophilic

substitution, mechanism of nitration, sulphonation, halogenations, Friedel Craft's alkylation and acylation, theory of reactivity and orientation, effect of substituent groups, ring activating and deactivating groups with examples, effect of halogen on electrophilic aromatic substitution, electrophilic substitution in naphthalene. **9 hrs**

Aldehydes and ketones: Nomenclature of aliphatic and aromatic carbonyl compounds, structure of carbonyl group, synthesis of aldehydes and ketones, physical properties (keto- enoltautomerism, reactivity of carbonyl group in aldehydes and ketones), nucleophilic addition reactions, oxidation, reduction, Clemmensen reduction, Wolf Kishner reaction, base and acid catalyzed halogenation reactions, addition of Grignard's reagent, planning a Grignard's synthesis, limitation of Grignard's synthesis, base and acid catalyzed halogenation of ketones, aldol condensation, dehydration of aldol products, use of aldol condensation in synthesis, cross aldol condensation, Wittig reaction, Claisen condensation, Cannizarro's reaction, Perkin reaction, analysis of aldehydes and ketones with 2,4-DNP test, Tollen's test, Fehling's test, Schiff test and Haloform test with equations, spectroscopic analysis. **12 hrs**

Carboxylic acids: Structure and Nomenclature, Industrial source, Methods of preparation by carbonation of Grignard regents, Hydrolysis of nitrile, amides and esters, Preparation of aromatic acids by oxidation of side chain, hydrolysis of benzotrichlorides and Kolbe reaction, Physical properties, hydrogen bonding, dimmeric association, acidity strengths (relative differences in the acidities of aromatic and aliphatic acids), Effect of substituent in acidity, Chemical properties: (reaction involving H, OH and COOH groups), Salt formation, Anhydride formation, Acid chloride formation, Amide formation, introduction to polyamide and ester formation with mechanism), Reduction to alcohols, Carbanion in organic synthesis, Active methylene compounds such as Malonic acid synthesis of carboxylic acid, Acetoacetic ester synthesis of ketones, decarboxylation of β-keto acid and malonic acid, Synthetic application of acetoacetic esters (Preparation of monocarboxylic acid and dicarboxylic acids) and malonic acid esters (Preparation of monocarboxylic acid and dicarboxylic acid and α,β-unsaturated carboxylic acids), spectroscopic analysis of carboxylic acid. **14 hrs**

Amines: Structure, nomenclature, classification, industrial source, preparation, physical properties, industrial source preparation, reduction of nitro compounds, amminolysis of halides, reductive amination, Hofmann rearrangement, structure and basicity, effect of substituent on basicity of aromatic amines, ring substitution in aromatic amines, reactions of amines with nitrous acid, reactions of diazonium salt (azo coupling, Sandmeyer reaction), reactions of hydrazo compounds (benzedine rearrangement), reactions of diazomethane, synthesis of phenol, diazonium salt (replacement by –H), synthesis using diazonium salts, synthesis of azo-compounds, spectroscopic analysis of amine.

7 hrs

Phenols: Structure, nomenclature, physical properties, salts of phenols, industrial source, preparation, reactions, acidity of phenols, Fries rearrangement, ring substitution, Kolbe's reaction, Riemer-Tiemann reaction, formation of aryl ethers. Gattermann synthesis, chelation, spectroscopic analysis of phenol. **3 hrs**

Group C: Physical Chemistry

Colloidal Chemistry: Colloidal state of matter, lyophilic and lyophobic colloids, preparation, purification and properties (kinetic, optical and electrical properties) of colloids, Helmholtz and diffuse layer in colloids, zeta potential, precipitation of sol, gold number, Hardy-Schultz law, association of colloids, emulsion and gels, soap and detergents, cleansing actions of soap & detergents **10 hrs**

Photochemistry & Catalysis: Thermo-chemical and photochemical reactions, Grothus Draper law, Stark Einstein law of photochemical equivalence, primary and secondary processes in photochemical reaction, quantum yield, reason for high and low quantum yields, Lambert- Beer's law and its application, photochemical processes: fluorescence, phosphorescence, chemiluminescence and photosensitization.

Types of catalysis, poisons, promoters and inhibitors, Criteria of catalysis, activation energy and catalysis, theories of catalysis: intermediate compound formation and adsorption theories, general acid base catalysis, enzyme catalysis. **10 hrs**

Electrochemistry:

Electrolytic Conductance: Review on the electrolytic conductance, Kohlraush law of independent migration, ionic conductance and ionic mobility, conductivity water, Hittorf's rule, transference number, determination of transference number by moving boundary and Hittorf's methods, some applications of conductance measurements: determination of (a) solubility products of sparingly soluble salts, (b) degree of ionization and ionization constant of weak acids and (c) ionic product of water, conductometric titration: involving neutralization and precipitation reactions, advantages of the conductometric titration

Electrochemical Cells: Review on electrochemical cells, Nernst's equation and derivation of emf of a cell under non-standard conditions, reference electrodes, standard hydrogen electrode and secondary reference electrodes, measurement of standard electrode potential, electrochemical series, representation of electrochemical cell, calculation of equilibrium constant of a cell reaction from standard emf of a cell, potentiometer for measurement of emf of a cell, applications of emf measurements: determination of pH using glass, quinhydrone and antimony-antimony oxide electrodes, potentiometric titrations, ion-selective electrodes. **15 hrs**

Thermodynamics: Adiabatic expansion of an ideal gas (TV-relation, PV-relation and PT relation), comparison between isothermal and adiabatic expansion, work done in reversible adiabatic expansion, Joule's Thomson effect, inversion temperature, second law of thermodynamics: different statements of the law, Carnot's cycle, thermodynamic efficiency, entropy and its mathematical derivation from Carnot's cycle, physical significances of entropy: entropy and unavailable energy, entropy and probability (qualitative), entropy and randomness. Entropy changes of a system, surrounding and universe, entropy change in isothermal and adiabatic processes, relation between enthalpy change and entropy change, entropy change during expansion of an ideal gas, Free energy and work function and their significances, criteria of spontaneity and equilibrium in terms of entropy and free energy, related numericals **15 hrs**

Tribhuvan University

Institute of Science and Technology

4 Years B. Sc. Chemistry Course of Study

Course title: Basic Chemistry Practical II
Course No.: CHE 202 (major \ minor)
Nature of the course: Practical

Full Marks: 50
Pass Marks: 20
Year: II

Course Objectives:

- To handle and manipulate chemical apparatus and materials safely.
- To record accurately and clearly the result of experiments.
- To apply appropriate chemical principle and make generalizations and predictions from chemical facts, observations and experiment data.

Experiments on Inorganic Chemistry

Gravimetric Analysis:- Quantitative estimation of barium and sulphate ions as barium sulphate, iron as ferric oxide (Mohr salt). **21 hrs**

Qualitative analysis of simple inorganic salt mixture containing 2 cations and 2 anions:- Hg^{+}, Pb^{++}, Ag^{+}, Cu^{++}, Hg^{++}, As^{+++}, Sb^{+++}, Sn^{++}, Bi^{+++}, Cd^{++}, Al^{+++}, Zn^{++}, Mn^{++}, Fe^{+++}, Co^{++}, Ni^{++}, Cr^{+++}, Ca^{++}, Ba^{++}, Sr^{++}, Mg^{++}, K^{+}, NH_4^{+}, NO_3^{-}, Cl^{-}, Br^{-}, I^{-}, SO_4^{--}, CO_3^{--}, PO_4^{---}. **27 hrs**

Spot test analysis. **12 hrs**

Experiments on Organic Chemistry

Preparative Organic Chemistry:- Single step preparation involving the following types:- Methylation of phenol using dimethyl sulphate, Esterification of acids, Acetylation of phenols, Benzoylation of amines, Nitration of nitrobenzene, Reduction of nitro compounds, Oxidation of Toluene or benzadehyde, Preparation of osazone and preparation of methyl orange. These experiments should involve basic organic experiment techniques such as hot filtration, distillation under reduced pressure, filtration under partial vacuum, etc. (Above reactions will be useful in identification of organic compounds and preparation of their derivatives). **60 hrs**

Experiments on Physical Chemistry

1. To determine the surface tension of detergent and soap solution by drop number method and compare their cleansing action.
2. To determine the precipitation values and precipitation power of monovalent and bivalent cations for arsenic sulfide sol.
3. To carry out conductometric titration between strong acid and strong base.

4. To carry out conductometric titration between weak acid and strong base.
5. To calibrate the pH meter and measure the pH using glass electrode.
6. To determine the pH of a given solution using quinhydrone electrode.
7. Determination of heat of neutralization of strong acid and strong base.
8. Determination of heat of hydration of sodium sulphate. **60 hrs**

Text Books: for theoretical course CHE 201

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. M. L. Sharma & P. N. Chaudhary, *A Textbook of B. Sc. Chemistry* (Volume II), 2nd Edition, Ekta Books Nepal, 2007.
4. D. F. Shriver & P. W. Atkins, *Inorganic Chemistry*, 5th Edition, Oxford University Press, 2010.
5. R. T. Morrison, R. N. Boyd & S. K. Bhattacharjee, *Organic Chemistry*, 7th Edition, Prentice-Hall of Pearson, 2012.
6. J. March, *Advanced Organic Chemistry*, 4th Edition, Wiley Eastern Ltd., India, 2005.
7. Jonathan Clayden, *Organic Chemistry*, 2nd Edition, Oxford University Press, India.
8. S. H. Maron & C. Prutton, *Principle of Physical Chemistry*, 4th Edition, Oxford & IBH Publ. Co., 1992.
9. P.W. Atkins & J.D. Paula, *Elements of Physical Chemistry*, 4th Edition, Oxford University Press, 2010.

Reference Books: for theoretical course CHE 201

1. R. D. Madan, Satya Prakash, *Modern Inorganic Chemistry*, S. Chand & Company Ltd., 1994.
2. A. Sharpe, *Inorganic Chemistry*, 2nd Edition, ELBS & Longman, Singapore, 1986, (recent edition).
3. K. N. Upadhyaya, *A Textbook of Inorganic Chemistry*, 2nd Edition, Vikash Publishing House Pvt., Ltd., 1995
4. C. Agrawal, *Modern Inorganic Chemistry*, Wiley Eastern, New Delhi, 1981, (available recent edition)
5. James, E. Huheey, Ellen A. Keiter & Richard L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, Addison Wesley Publishing House.
6. W.K. Li, *Problems in Structural Inorganic Chemistry*, Oxford University Press, India.
7. I. L. Finar, *Organic Chemistry*, Vol. I & Vol. II, Prentice Hall, London, (available recent edition).
8. F. Carey & R, Giuliano, *Organic Chemistry*, McGraw-Hill 8th edition, 2010.
9. Streitweiser & Heathcock, *Introductory Organic Chemistry*, Wiley and Sons, New York, 1981
10. S. Bahal & A. Bahal, *A Textbook of Organic Chemistry*, S. Chand Publication, New Delhi, India, 2012.
11. T. W. Graham Solomons, *Organic Chemistry*, (latest edition), John Wiley and Sons, New York.
12. G. M. Loudon, *Organic Chemistry*, Fourth Edition, Oxford University Press, India.
13. R. A. Bansal, *A Textbook of Organic Chemistry*, 2nd Edition, Wiley Eastern Ltd., New Delhi, 1993 (available recent edition)

14. C. Norman, *Principles of Organic Synthesis*, 2nd Edition, Chapman and Hill. London, 1978, (recent edition)
15. Warren, *Organic Synthesis*, The Disconnection Approach, Wiley, New York, 1982. (available recent edition)
16. House, *Modern Synthesis Reactions*, 2nd Edition, W. A. Benjamin. New York, 1972
17. A. S. Negi & S. C. Anand, *A Textbook of Physical Chemistry*, New Age International Ltd., New Delhi, 1999.
18. K. L. Kapoor, *Text Book of Physical Chemistry*, Vols I to V, 3rd Edition, Macmillan India Ltd., 2001.
19. D. Alberty, *Physical Chemistry*, 6th Edition, Wiely Eastern Ltd., New Delhi, 1992.
20. P. Atkins & J.D. Paula, *Atkin's Physical Chemistry*, 9th Edition, Oxford University Press, 2009.
21. D. Alberty, *Physical Chemistry*, 6th Edition, Wiely Eastern Ltd., New Delhi, 1992.
22. D. S Pahari, *Physical Chemistry*, Vol.1 & II, New Central Book Agency(p) Ltd, India, 2007.
23. M. K Sthapit & R. R. Pradhananga, *A Text book of Physical Chemistry*, Tajeju Prakashan, Nepal, 2008.
24. Arun Bahl, B. S. Bahl & G. D. Tuli, *Essentials of Physical Chemistry*, S. Chand and Company Ltd., New Delhi, 2012.
25. M. L. Sharma & P. N. Chaudhary, *A Textbook of B. Sc. Chemistry*, Vol 1, 2nd Edition, Ekta Books, Nepal, 2007.

Text Books: for practical course CHE 202

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. 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).
4. K. N. Ghimire, M. R. Pokhrel & K. P. Bohara, *University Experimental Inorganic Chemistry*, Quest Publication, Kirtipur, Kathmandu, 2008.
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 CHE 202

1. Gurdeep Raj, *Advanced Practical Inorganic*, 10th Edition, Goel Publishing House, Meerut, 1994.
2. A. I. Vogel, *A Textbook of Practical Organic Chemistry*, Including Qualitative Organic Analysis, Longmans, 1958, (Preferably available recent edition)
3. A .I. Vogel, *A Textbook of Practical Organic Chemistry*, Including Qualitative Organic Analysis, Longmans, (Latest Edition).
4. F. G. Mann & B. C. Saunders, *Practical Organic Chemistry*, Orient Longman, 1986, (recent edition).

5. D. P. Shoemaker & C. W. Garland, *Experiments in Physical Chemistry*, McGraw Hill, Kogakusha Ltd, Tokyo, 1967.
6. B. D. Khosla, A. Guali & V. C.Garg, *Senior Practical Physical Chemistry*, 5th Edition, R. Chand & Co., New Delhi, 1987.
7. J. N. Gurtu & R. Kapoor, *Advanced Experimental Chemistry* (Vol I-III), S. Chand & Co. New Delhi.
8. S. K. Agrawal & Keemti Lal, *Advanced Inorganic Chemistry*, Pragati

A. Rajbhandari (Nyachhyon) and S. Pradhananga (Shrestha), *Inorganic Salt Analysis*, 5th Edition, Rajbhandari-Pradhananga Publication, Kathmandu, 2013.

Tribhuvan University

Institute of Science and Technology

Four Year B. Sc. Chemistry Course of Study

(Revised–2073)

Course Title: General Chemistry I — **Full Marks**: 100

Course No.: CHE 301 (major) — **Pass Marks**: 35

Nature of the Course: Theory — **Year**: III

Course Objectives:

- To explain everyday applications and uses of chemistry.
- To promote studies in the acquisition of knowledge and understanding of chemical patterns and principles.
- To present chemical ideas in a clear and logical form.
- To explain properties, structure and bonding of inorganic compounds.
- To evaluate the environmental & technological implications of chemistry.
- To explain organic reaction mechanisms & basic heterocyclic chemistry.
- To explain the theories & applications of ionic electrochemistry.
- To introduce basic knowledge on principles & applications of spectroscopic techniques.
- To introduce polymer chemistry
- To provide knowledge of third law of thermodynamic and thermodynamic parameters.
- To provide mechanistic approaches of organic reactions.

Group A: Inorganic Chemistry

Hydrogen: Isotopes of hydrogen, general study of hydrides and their classification. **4 hrs**

Nobles gases and their compounds: Preparation, properties and structure of xenon fluorides and oxo-compounds (Valence bond treatment, VSEPR treatment, molecular orbital treatment for XeF_2). **6 hrs**

Detailed study of preparation, properties, bonding and structure of the followings: Boric acid, borates, boron nitride, borazines, boron hydrides, metal borohydrides, silicates, silicones, silanes, and siloxanes, interhalogen compounds, pseudohalogens, pseudohalides. **13 hrs**

Electronegativity: Review lecture, electronegativity equalization, recent advances in electronegativity theory, variation of electronegativity, choice of electronegativity system, group electronegativity.

Electron affinity and ionization energy: Anomalous ionization energies and electron affinities, alternation of electronegativites in the heavier elements. **11 hrs**

Chemical fertilizers: Nitrogen fixation and synthetic fertilizers, importance of chemical fertilizers, nitrogen cycle, main ingredients of plant fertilizers, major and minor nutrients, Haber Bosch process for the manufacture of NH_3, nitrogenase, model system for systems absorbing dinitrogen and production of NH_3, cyanamide process, manufacture of urea, phosphate fertilizers, environmental impact of chemical fertilizers.
6 hrs

Environmental pollution: An elementary study of environmental pollution in air, water and soil.

Air pollution system: Sources, emission, anthropogenic emissions, (gases and particulate matter), acid rain, smog, depletion of ozone layer.

Water pollution: Dissolved oxygen, total alkalinity, biochemical oxygen demand and chemical oxygen demand, eutrophication, classification of water pollutants, control of water pollution.

Soil pollution: Introduction, source of soil pollution, acid rain, repeated use of same fertilizers, inadequate drainage system in agriculture field, application of pesticides and radioactive wastes.
10 hrs

Group B: Organic Chemistry

Organic reactions and methods for determining mechanism: Types of mechanism, types of reaction, thermodynamic and kinetic requirements for reaction, the Baldwin's rules of ring closure, kinetic and thermodynamic control, the Hammond postulate, microscopic reversibility, methods of determining mechanism, identification of products, determination of the presence of an intermediate, study of catalysis, isotope labeling, stereochemical evidence, rate expression for first and second order reaction, isotope effect. **10 hrs**

Reactive Intermediates: Stability, structure, generation and fate of carbocation, carbanion, carbene, nitrene and benzyne, nonclassical carbonium ion, neighboring group participation by π and σ bonds. **10 hrs**

Free radicals: History, characteristics of free radicals (formation, propagation, termination, reactivity, stereochemistry), reactions (fragmentation, substitution, addition, oxidation, reduction), detection of free radicals. **7 hrs**

Spectroscopy and Structure Determination: Introduction of the electromagnetic spectrum, infrared spectrum, ultraviolet spectrum, nuclear magnetic resonance (NMR) spectrum: ^{1}H-NMR spectrum, number of signals, equivalent and non-equivalent protons, chemical shift, peak area and proton coupling, spin-spin coupling, coupling constant, ^{13}C-NMR spectroscopy: ^{13}C-NMR chemical shift, ^{1}H-NMR and ^{13}C-NMR spectra of hydrocarbons, alcohols, aldehydes, ketones carboxylic acid, amines, phenol, ether and aromatic compounds (simple molecules only) & mass spectrum. **18 hrs**

Heterocyclic systems: Structure of pyrrole, furan and thiophene, source of pyrrole, furan and thiophene, electrophilic substitutions in pyrrole, furan and thiophene (reactivity and orientation), saturated five member hetero cycles, structure of pyridine, source of pyridine compounds,

reactions of pyridine, electrophilic substitution in pyridine, nucleophilic substitution in pyridine, basicity of pyridine, reduction of pyridine. **5 hrs**

Group C: Physical Chemistry

Electrochemistry:

Electrolytic conductance: Failure of Arrhenius theory in case of strong electrolytes, Debye-Hückel theory of interionic attraction for electrolytic conduction (elementary treatment only), activity and activity coefficients, ionic strength, Debye-Hückel limiting law (elementary treatment only).

Electrochemical cells: Reversible and irreversible cells, types of reversible electrodes, thermodynamics of reversible electrode and cell, thermodynamic quantities of cell reaction from emf ($\triangle G$, $\triangle H$, $\triangle S$ and K_{eq}), chemical cells with and without transference, concentration cells with and without transference, liquid junction potential, applications of emf measurement: determination of activities & activity coefficients, formal & standard electrode potentials, solubility products. **15 hrs**

Spectroscopy:

Introduction: Electromagnetic radiation, atomic and molecular spectra, origin of molecular spectra, classification of molecular spectra.

Rotational spectrum: Microwave spectrum, concepts of rigid & non-rigid rotors, energy levels of rigid rotor, selection rules, application of rotational spectra.

Vibrational spectrum: Infrared spectrum, energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, effect of anharmonic motion, idea of vibrational frequency of different functional groups.

Raman spectrum: Concept of polarizibility, pure rotational and pure vibrational Raman spectra of diatomic molecules, selection rules.

Electronic spectrum: Introduction, Franck-Condon principle, selection rules, application of electronic spectroscopy. **10 hrs**

Polymer Chemistry:

Introduction and classification of polymers and copolymers, properties of polymers (crystalline, amorphous, thermoplastic, thermosetting), addition and condensation polymerization, degree of polymerization, average molecular weight of polymers, determination of average molecular weight of polymers by osmometry, light scattering and viscosity measurement methods, solution of macromolecules. **7 hrs**

Thermodynamics:

Entropy, entropy change in isolated system, dependence of entropy on temperature, volume and pressure, entropy change in ideal gas, entropy of mixing, entropy change in physical and chemical transformation, third law of thermodynamics and its significance, free energy change for a reaction, Gibbs free energy change, properties of Gibbs free energy: variation with temperature (Gibbs-Helmholtz equation) and pressure, calculation of free energy change,

reaction isotherm, thermodynamic criterion of equilibrium, Clapeyron equation, Clausius-Clapeyron equation, thermodynamics equilibrium constant, K_p & K_c for gaseous reactions, variation of K_p and K_c with temperature, thermodynamics of Le-Chatelier's principle (quantitative treatment), related numericals. **18 hrs**

Course Title: General Practical Chemistry I **Full Mark**: 50

Course No.: CHE 302 (major) **Pass Mark**: 20

Nature of the Course: Practical **Year**: III

Course Objectives:

- To handle and manipulate chemical apparatus and material safely.
- To make accurate observation and measurements, being aware of possible sources of error.
- To plan and organize simple experimental investigations to test hypotheses.
- To perform numerical calculations in which guidance on the methods of solution is provided.

Experiments on Inorganic Chemistry

Qualitative analysis of salt mixture containing not more than 6 ionic species (excluding salts insoluble in acids) out of the following: Pb^{++}, Hg^{++}, Ag^{+}, Hg+, Bi^{+++}, Cu^{++}, Cd^{++}, As^{+++}, Sb^{+++}, Sn^{++}, Fe^{++}, Fe^{+++}, Cr^{+++}, Al^{+++}, Co^{++}, Ni^{++}, Mn^{++}, Zn^{++}, Ba^{++}, Ca^{++}, Sr^{++}, Mg^{++}, K^{+}, NH_4^{+}, CO_3^{-}, S^{--}, SO_3^{--}, $S_2O_3^{--}$, NO_2^{-}, CH_3COO^{-}, F^{-}, Cl^{-}, Br^{-}, I^{-}, NO_3^{-}, SO_4^{--}, $C_2O_4^{--}$, PO_4^{---} BO_3^{---}. **33 hrs**

Complexometric Titration:

Determination of Zn^{++}, Mg^{++}, Ca^{++} and total hardness of water using EDTA.

Determination of Ca Hardness of water.

Spectrophotometric Analysis: Determination of total iron in ground water.

Determination of dissolved oxygen in a sample of water. **18 hrs**

Experiments on Organic Chemistry

Qualitative analysis of organic compounds: Systematic qualitative analysis of simple mono functional organic compounds and preparation of their at least one derivative (aldehyde, ketone, carboxylic acid, carbohydrate, phenol, hydrocarbon, amine, nitro, amide and ammonium salt).

51hrs

Experiments on Physical Chemistry

1. To determine the transition temperature of hydrated sodium sulfate decahydrate by thermometric method.

2. To determine the critical micelle concentration (CMC) of a soap or detergent by surface tension method using a stalagmometer.
3. To determine the molecular weight of a polymer by viscosity measurement.
4. To determine the cell constant of the given conductivity cell.
5. To verify Ostwald dilution law and determine the dissociation constant of the weak acid.
6. To determine the equivalent conductivity of strong electrolyte at infinite dilution by conductance measurement.
7. To verify Nernst equation.
8. To determine the true thermodynamic solubility product of calcium sulfate at room temperature.

51 hrs

Text Books: for theoretical course CHE 301

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. R. T. Morrison & R. N. Boyd, *Organic Chemistry,* 6th & 7th Edition, Prentice- Hall of India Pvt., Ltd., 2008.
4. I. L. Finar, *Organic Chemistry*, Vol. I and Vol. II, Prentice Hall, London, 1955, (Available recent edition).
5. Streitweiser & Heathcock, *Introductory Organic Chemistry,* Wiley and Sons, New York, 1981.
6. J. March, *Advanced Organic Chemistry,* 4th Edition, Wiley Eastern Ltd., India, 2005.
7. Francis A. Corey & Rechard J. Sundberg, *Advanced Organic Chemistry*, 5th Edition, University of Verginia, Verginia.
8. N. D. Cheronis & J. B. Entrikin, *Identification of Organic Compounds, A Student's Text using Semi-micro Techniques,* John Wiley& Sons, Inc (Latest Edition).
9. R. L. Shriner, R. C Fusion & D. Y. Cartin, *The Systematic Identification of Organic Compounds,* A Hand Manual, John Wiley and Sons, Inc. New York (Latest edition).
10. M. R. Pokhrel & B. R. Poudel, *A Text Book of Inorganic Chemistry,* National Book Centre, Bhotahity, Kathmandu, Nepal, 2013.
11. D. F. Shriver & P. W. Atkins, *Inorganic Chemistry*, 5th Edition, Oxford University Press, 2010.
12. Stanley H. Pine, *Organic Chemistry*, Special Indian Edition, The McGraw-Hill Companies, New Delhi, India (Latest Edition).

13. G. T. Miller Jr, *Living in the Environment: An Introduction to Environmental Science*, Wardsworth Publication, California, USA, 1994.
14. A. K. De, *Environmental Chemistry*, New Age International Publishers, New Delhi, India, 2008.
15. S. H. Maron & C. Prutton, *Principles of Physical Chemistry*, 4th Edition, Oxford & IBH Pub. Co., 1992.
16. S. Negi & S. C. Anand, *A Textbook of Physical Chemistry*, New Age International (P) Ltd., New Delhi, 1999.
17. R. P. Rostagi & R. R. Mishra, *An Introduction to Chemical Thermodynamics*, 6th Edition, Vikash Publ. House, India, 1996.
18. 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 CHE 301

1. A. Sharpe, *Inorganic Chemistry*, 2nd Edition, ELBS & Longman, Singapore, 1986, (Preferably available recent edition).
2. R. D. Madan & Satya Prakash, *Modern Inorganic Chemistry*, S. Chand & Company Ltd., 1994.
3. K. N. Upadhyaya, *A Textbook of Inorganic Chemistry*, 2nd Edition, Vikash Publishing House Pvt., Ltd., 1995.
4. G. Marc Loudon, *Organic Chemistry*, 4th Edition, Oxford University.
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. (Preferably available recent edition).
7. Warren, *Organic Synthesis, the Disconnection Approach*, Wiley, New York, 1982. (Preferably available recent edition).
8. House, *Modern Synthesis Reactions*, 2nd Edition, W. A. Benjamin. New York, 1972.
9. R. M. Silverstein, F. X. Webster, D. J. Kiemle & D. L. Bryce, *Spectrometric Identification of Organic Compounds*, 8th Edition, Wiley Student Edition, Wiley India Pvt. Lt., 2015.
10. C. Agrawal, *Modern Inorganic Chemistry*, Wiley Eastern, New Delhi, 1981, (Preferably available recent edition).
11. T. W. Graham Solomons, *Organic Chemistry*, John Wiley and Sons, New York. (Available recent edition).
12. R. A. Bansal, *A Textbook of Organic Chemistry*, 2nd Edition, Wiley Eastern Ltd., New Delhi, 1993 (Available recent edition).

13. M. L. Sharma & P. N. Chaudhary, *A Textbook of B. Sc. Chemistry* (Vol. I & II), 2nd Edition, Ekta Books Nepal, 2007.

14. A. K. Bhagi and G. R. Chatwal, *Bioinorganic and Supramolecular Chemistry,* Himalaya Publishing House, Mumbai (Available recent edition).

15. A. K. Bhagi & G. R. Chatwal, *Environmental Chemistry*, Himalaya Publishing House, Mumbai, (Available recent edition).

16. James, E. Huheey, Ellen A. Keiter, Richard L. Keiter & Okhil K. Medhi, *Inorganic Chemistry: Principles of Structure and Reactivity*, Fourth Edition, Dorling Kindersley (India) Pvt. Ltd., 2008.

17. S. Glasstone & D. Lewis, *Elements of Physical Chemistry*, Mcmillan & Co., Ltd.

18. P. Atkins & J. D. Paula, *Atkin's Physical Chemistry*, 10th Edition, Oxford University Press, 2014 (reprinted).

19. A. Bahal, B. S. Bahal & G. D. Tuli, *Essential of Physical Chemistry,* Revised Multicolor Edition, S. Chand & Co. Ltd., New Delhi, 2009.

20. K. L. Kapoor, *Textbook of Physical Chemistry*, Macmillan India Ltd., Vol. I to Vol.V, 3rd Edition, 2001.

21. D. Alberty, *Physical Chemistry*, 6th Edition, Wiley Eastern Ltd., New Delhi, 1992.

22. G. M. Barrow, *Physical Chemistry*, 5th Edition, Tata McGraw Hill Edition D. N. Bajpai, *Advanced Physical Chemistry,* S. Chand & Co., New Delhi.

23. V. K. Jha, *Theoretical Principles of Molecular Spectroscopy*, Kathmandu, Nepal, 2011.

Text Books: for practical course CHE 302

1. A. I. Vogel, *A Textbook 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, (Preferably available recent edition).

3. 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).

4. B. P. Levitt, ed. Findlay's *Practical Physical Chemistry*, Longman, London, 1973.

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 CHE 302

1. Gurdeep Raj, *Advanced Practical Inorganic Chemistry*, 10th Edition, Goel Publishing House, Meerut, 1994.

2. A. I. Vogel, *A Textbook of Practical Organic Chemistry, Including Qualitative Organic Analysis,* Longmans, (Latest Edition).

3. F. G. Mann & B. C. Saunders, *Practical Organic Chemistry*, Orient Longman, 1986, (Preferably recent edition).
4. D. P. Shoemaker & C. W. Garland, *Experiments in Physical Chemistry*, McGraw Hill, Kogakusha Ltd, Tokya, 1967.
5. B. D. Khosla, A. Guali & V. C. Garg, *Senior Practical Physical Chemistry*, 5th Edition, R. Chand & Co., New Delhi, 1987.
6. J. N. Gurtu and R. Kapoor, *Advanced Experimental Chemistry* (Vol I-III), S. Chand & Co. New Delhi, 1984.
7. J. N. Gurtu and A. Gurtu, *Advanced Physical Chemistry Experiments*, 4th Edition, Pragati Prakashan, 2008.
8. S. K. Agrawal and Keemti Lal, *Advanced Inorganic Chemistry*, Pragati Prakasan, Meerut (Latest Edition).

Course Title: Basic Biochemistry (Elective) **Full Marks**: 50

Course No.: CHE 303 **Pass Marks**: 17.5

Nature of the course: Theory **Year**: III

Course Objectives:

- To explain the basic tenets of biochemistry
- To explain the functions of biomolecules in the living organisms

Biochemistry: Definition and short history and its application, pH scale and pH of biological fluids, Henderson-Hassel balch equation and its importance; Biologically important buffers. **3 hrs**

Nucleic acids: Nucleotides, building blocks of nucleic acids, nucleotides and nucleic acids have characteristic bases and pentoses, phosphodiester bonds link successive nucleotides in nucleic acid , nucleic acids structure, DNA store genetic information, DNA molecules have distinctive base compositionproperties, DNA is a double helix, DNA can occur in different three dimensional form, biosynthesis of DNA (replication), biosynthesis of RNA(transcription), genetic code, mutation (nucleotides and nucleic acid undergo nonezymatic transformation, and mutants, DNA repair, DNA sequencing (Frederic Sanger), recombinant DNA technology, DNA cloning, restriction endonucleases and DNA ligase yield recombinant DNA, clonong vector allow amplification of insert DNA Segments), PCR (polymerase chain reaction amplifies specific DNA biological functions of DNA and RNA, biosynthesis and repair of DNA and mRNA, codon, mutation, DNA sequencing by Frederick Sanger method, DNA cloning, the polymerase chain reaction amplifies specific DNA sequences, its application), DNA polymorphism, genetic diseases, human genome project. **22 hrs**

Amino acids, peptide and proteins: Amino acids: amino acids share common structural features, amino acid residues in proteins are L-stereoisomers, amino acid can be, amino acids can

be classified by R. group, uncommom amino acid also have important functions, amino acids not found in proteins, degradation of amino acids (oxidative deamination, transamination, decarboxylation, functions of pyridoxal phosphate (PLP), biosynthesis of glycine, methionine, serine, and tyrosine, amino acid sequencing (terminal group analysis (Edman-N-terminal sequencing), quantitative estimation of proteins (SDS-PAGE). **15 hrs**

Enzymes: Definition, properties, terminologies, coenzymes, cofactors and prosthetic group, enzyme kinetics, Michaelis-Menten equation, transformations of Michaelis-Menten equation, Lineweaver-Burk plot, Eadie-Hofstee plot, enzyme inhibition(competitive, noncompetitive and uncompetitive), effect of pH, temperature, substrate concentration and incubation time on enzyme action, mechanism of enzyme action(lock and key model and induced fit model), regulation of enzyme activity, enzymes of industrial and clinical diagnostic importance. **12 hrs**

Carbohydrates: Glycogenesis, gluconeogenesis, glycolysis, TCA cycle, relation between glycolysis, relation between glycolysis and respiration, pentose phosphate pathway, principle of bioenergetics, electron transport system and oxidative phosphorylation. **8 hrs**

Lipids: Definition, classification of lipids (natural lipids, fats, waxes, soaps, phospholipids, glycolipids, steroids), saponification number, iodine value, acid number, rancidity, auto-oxidation (rancidity), fatty acids: saturated and unsaturated fatty acids, metabolism (β-oxidation of fatty acids), biosynthesis of fatty acids (palmitic acid and lipid (tripalmitin, cholesterol biosynthesis, and bile salts derived from cholestrol, theories of fat absorption, prostanoids, eicosanoids, leukotrienes, lipooxygenase and cyclooxygenase pathway. **15 hrs**

Text Books: for Biochemistry CHE 303

1. David L. Nelson & Michael M. Cox, *Lehninger's Principle of Biochemistry*, Worth Publishers, New York, USA, 2005.
2. Lubert Stryer, *Biochemistry,* W. H. Freeman and Company, New York, USA, 1975.

Reference Books: for Biochemistry CHE 303

1. L. Veerakumari, *Biochemistry*, MJP Publishers, Chennai, India, 2004.
2. A. Mazur & B. Harrow, *Text Book of Biochemistry,* W. B. Saunders Co., Philadelphia, USA, 1971.
3. J. L. Jain, *Biochemistry*, Sultan Chand and Co., 1999.
4. P. K. Kuchel & G. B. Ralston, *Theory and Problems of Biochemistry,* Shaum Series, McGraw Hills Book Company, New York, USA, 1988.
5. T. Devasena, *Enzymology*, Oxford University Press, New Delhi, India, 2010.
6. A. C. Deb, *Fundamentals of Biochemistry,* New central book agency (P) Ltd, India, 2012.
7. A.V. S. S. Rama Rao, *A Textbook Biochemistry*, 7th Edition, UBS Publishers' Distributors Ltd.

8. B. R. Pandey, *An Easy Approach to Basic Biochemistry*, Heritage Publishers & Disstributors Pvt. Ltd., Kathmandu, 2015.
9. S. K. Kalauni, *A Textbook of Basic Biochemistry*, ABC Publication, Kathmandu, 2016.

Course Title: Analytical Chemistry (Elective) **Full Marks**: 50

Course No.: CHE 305 **Pass Marks**: 17.5

Nature of the Course: Theory **Year**: III

Course Objectives:

- To explain the basic tenets of analytical chemistry
- To explain the principle and instrumentation of different analytical techniques

Basic Concept: Introduction to analytical chemistry, Qualitative and quantitative analysis, Analytical methodology: Sampling, Conversion of analyte to a measurable form, Measurement, Calculation and interpretation of the measurement, The analytical balance. Factors affecting the choice of analytical methods, destructive and non-destructive methods, Choice of analytical methods depending upon sample size: a) macro analysis, b) microanalysis, c) semi-microanalysis d) ultra micro analysis, e) trace analysis, interference, sensitivity and detection limits. **20 hrs**

General Concept of Statistical Methods in Chemical Analysis: Errors in chemical analysis, Absolute and relative errors, Accuracy and precision, Types of errors in experimental data, Determinate and indeterminate errors, Systematic errors, Proportional errors, Random errors, Sources of random errors, Distribution of experimental data, Statistical treatment of random error, Significant figures, Confidence limits and reliability of results, Student's t test, Criteria for rejection of result (Q-test), Regression analysis,. **14 hrs**

Titrimetric Methods of Analysis: General principle, Requirements for reactions used in titrimetric analysis, Concentration system, Stoichiometric calculations, Aliquots, Introduction to redox, precipitation and complexometric titrations, Calibration of volumetric glasswares. **8hrs**

Gravimetric Methods of Analysis: General principle, Stoichiometry of gravimetric reactions, Formation and properties of precipitate, Coprecipitation and purity of precipitates, Post precipitation, Drying and ignition of precipitates, Use of common organic reagents in gravimetric analysis, Applications of gravimetric analysis. **6hrs**

Separation Methods: Solvent extraction: Nernst distribution law, Distribution coefficient, Distribution ratio, Applications of solvent extraction. **5hrs**

Chromatography: Definition and classification of chromatography, stationary and mobile phase, Paper chromatography, Ion exchange chromatography, Gas chromatography, HPLC, Affinity chromatography, Exclusion chromatography, Column chromatography and thin layer chromatography. **12hrs**

Instrumental Methods

Principle, instrumentation and applications of atomic absorption spectroscopy, flame photometry, UV-visible spectrophotometry & polarography.
10hrs

Text Books: for Analytical Chemistry CHE 305

1. R. A. Day jr & A. L. Underwood, *Quantative Analysis*, 6th Edition, Prentice Hall of India, New Delhi,2009.
2. Douglas A. Skoog, F. James Holler & Timothy A. Nieman, *Principles of Instrumental Analysis*, 5th Edition, Thomson Brooks/Cole, 1998.
3. Willard, Merritt, Dean & Settle, *Instrumental Methods of Analysis*, 6th Edition, CBS Publishers, India, 1986.
4. *Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition,* Pearson Education 2008.

Reference Text Books: for Analytical Chemistry CHE 303

1. H. Kaur, *Instrumental Methods of Chemical Analysis*, Second Edition, Pragati Prakashan, Meerut.
2. B. Sivasankar, *Instrumental Methods of Analysis*, Oxford University Press, 2012.
3. A. K. Srivastava & P. C. Jain, *Instrumental Approach to Chemical Analysis,* S, Chand and Company, New Delhi.
4. S. K. Gautam, B. R. Poudel & H. R. Sharma, *Concise Analytical Chemistry*, Natural Book Centre, 2016.
5. B. R. Pandey, *An Easy Approach to Analytical Chemistry*, Heritage Publishers and Distributors Pvt. Ltd., Kathmandu, 2016.

Tribhuvan University

Institute of Science and Technology

4 Years B.Sc. 4th Year Chemistry Course

(Revised-2073)

Course Title: General Chemistry-II | **Full Marks**: 100

Course No.: CHE 401 (major) | **Pass Marks**: 35

Nature of the Course: Theory | **Year**: IV

Course Objectives:

- To develop student's ability to communicate in appropriate ways.
- To encourage student's to apply their chemical knowledge and understanding to familiar and unfamiliar higher studies in chemistry.
- To pursue higher studies in chemistry.
- To explain the social, economic, environmental and technological implications of chemistry.
- To explain the fundamentals organic synthesis.
- To explain the mechanism, stereochemistry and scope of widely used organic reactions.
- To introduce phase equilibrium & surface chemistry.
- To explain solid structures & its defects.
- To introduce the basic concepts of quantum & statistical mechanics.
- To provide mechanistic approaches of organic reactions.

Group A: Inorganic Chemistry

Reactions in Nonaqueous Solvents: Protic and non protic solvents, criteria of selection of non aqueous solvents, reactions of NH_3, reactions of SO_2. **6 hrs**

Inorganic Polymers: Introduction, review, types of polymerization, homopolymers and heteropolymers, organosilicon compounds and silicones, phosphonitrilic compounds, polythiazyles $(SN)_x$, geopolymer, Silicon nitrides. **10 hrs**

Organometallic Compounds: Non transition metals: general survey of types, synthetic methods, metal alkyls of group I, II and III elements, transition metals: transition metal to carbon σ bonds, alkene complexes, haptonomenclature, alkyne complexes, allyl complexes, metallocenes (preparation, properties, structure and elementary approach of bonding with reference to ferrocene), Homogeneous catalysis, Heterogeneous catalysis, Selection of criteria of catalyst.

10 hrs

Bioinorganic Chemistry: Introduction, Roles of metals in biological system, Essential and trace elements in biological system, Metals and its complex as therapeutic agents, Iron and copper as oxygen carriers in biological system, The chemistry of elements in medicine, Chelation therapy and anticancer drugs, Introduction to anticancer drugs and its mechanism with reference to cis-platin. **13 hrs**

Lanthanides and actinides: Lanthanides: Comparative study of lanthanide elements, with respect to electronic configuration, atomic radii, oxidation state and complex formation, colour and spectra, magnetic properties, lanthanide contraction, occurrence and principles of separation of lanthanides, General features and chemistry of actinides, principles of separation of Np, Pu, Am from U. Trans-uranium elements: Introduction, synthesis of transuranium elements from $_{93}$Np to $_{103}$Lr). **11 hrs**

Group B: Organic Chemistry

Name Reactions: Introductory study of glossary of at least 30 name reactions, their simple mechanism, applications and the utilities of the synthetic reagents involved therein under the following heading of reaction types– oxidation, reduction, condensation, rearrangement, addition and elimination (name reactions are given in the Appendix I) **16 hrs**

Introduction of Green Chemistry: Introduction, definition of green chemistry, price of achievements of green chemistry, foundation pillars of green chemistry, future status of green chemistry, green catalyst (phase transfer catalyst). **2 hrs**

Organic Synthesis: Retrosynthetic Analysis by Disconnection Approach– Gradual development of organic synthesis, Retrosynthesis, Monofunctional disconnection (Examples of alcohol, alkene, ketone, carboxylic acid and their derivative, alkane, amine disconnections), Bifuntional disconnection, Microwave assisted organic synthesis, Protection of functional groups, Introduction, Protection of C-H bond, C=C bond, alcoholic-OH, amino group, aldehydes and ketones, carboxylic group, solid support synthesis, combinatorial synthesis, common solid supports, peptide synthesis on solid support. **12 hrs**

Introduction to Supramolecular Chemistry: Host-Guest Chemistry– Introduction, cation binding host molecules, selectivity of host molecules, a few synthetic cation binding host molecules, some uses of cation binding host compounds, anion binding host compounds, neutral molecule trapping host compounds. **6 hrs**

Drugs: Chemotherapeutic and Pharmacodynamic Agents: Introduction, classification of drugs, chemotherapeutic agents, antibacterial drugs, antibiotics, synthetic antibacterial agents, antiprotozoal drugs, antifungal agents, antiviral drugs, action of chemotherapeutic agents against microorganisms, pharmacodynamic agents, analgesic and anti-inflammatory agents, psycotropic drugs, antihistamines, antidiabetic drugs, drugs for cardiovascular diseases, antineoplastic drug, drug resistance, new development in drug research, drug designing, computer aided drug designing. synthetic dyes, classification and uses of dyes, brightening agents. **14 hrs**

Group C: Physical Chemistry

Phase Equilibrium:

Introduction, definition and meaning of the terms–phase, component and degree of freedom, Gibbs phase rule, phase diagram, phase equilibrium of one component system: water.

Phase equilibrium of two component system (solid-liquid system)– Introduction and cooling curves, simple eutectic Pb–Ag system, desilverization of lead, system involving compound formation with congruent melting point (phase diagram of Mg–Zn) and system involving compound formation with incongruent melting point (phase diagram of NaCl-water).

Binary liquid systems– Completely miscible liquid pairs, ideal and non-ideal liquid mixture, distillation of binary liquids, ratio of distillate to residue, fractional distillation, azeotropes.

Partial miscible liquid pairs– Phenol–water system, tri–ethylamine water system, nicotine water system, lower and upper consolute temperatures, Henry's law, Nernst distribution law and applications, distribution of solute between two phases, solvent extraction.

Completely immiscible liquid pairs– Benzene water system, steam distillation. **14 hrs**

Solid State Chemistry:

Interplanar distance in cubic system, Braggs law and its application, crystal structure of NaCl and KCl, defects in crystals: point defects (Frenkel, Schottky and self-interstitial defects), line defects (edge and screw dislocations) and plane defects (grain boundary and stacking faults), color centers and formation of F-centre, classification of solids based on the formation of band: conductor, semiconductor, insulator and superconductor. **14 hrs**

Surface Chemistry:

Adsorption: absorption and sorption, physical and chemical adsorptions, types of physical adsorption isotherms, Gibbs adsorption equation, Freundlich adsorption isotherm & Langmuir adsorption isotherm: postulates, derivation, interpretation and limitation; Brunauer-Emett-Teller (BET) adsorption: postulates, equation, interpretation and limitations, determination of surface area of solid adsorbents **10 hrs**

Quantum & Statistical Mechanics:

Quantum Mechanics– Introduction, history of quantum mechanics (Max Planck to Schrödinger), ultraviolet catastrophe, wave-particle duality, time independent Schrödinger wave equation, wave function and probability, concept of orthogonal and normalized wave functions, postulates of quantum mechanics, quantum mechanical operators, particle in a box (one dimensional and three dimensional).

Statistical Mechanics– Introduction, history of statistical mechanics, concept of phase space, ensemble, entropy and thermodynamic probability, distribution of identical but distinguishable particles, Boltzmann distribution law **12 hrs**

Course Title: General Practical Chemistry-II | **Full Marks**: 50

Course No.: CHE 402 (major) | **Pass Marks**: 20

Nature of the Course: Practical | **Year**: IV

Course Objectives:

- To follow instructions for practical work.
- To make students aware of the importance to scientific method of accurate observation and measurements being aware of possible sources of error.
- To record and interpret accurately and clearly the results of experiments.
- To explain practical techniques, procedures and safe laboratory working practices.

Experiments in Inorganic Chemistry

Quantitative Estimation

- Precipitation titration of silver nitrate in acidic media (Volhard Method).
- Redox titration involving potassium dichromate (Determination of iron in Mohr's salt and haematite). **12 hrs**

Gravimetric Analysis

- Nickel as complex with dimethyl glyoxime; Copper as cuprous thiocyanate; Aluminum as oxinate; Lead as lead chromate; Magnesium as magnesium ammonium phosphate and as pyrophosphate. **27 hrs**

Paper Chromatography

- Qualitative analysis of some inorganic anions and cations by paper chromatography (two each). **6 hrs**

Ion–Exchange chromatography

- Separation of metal ions from mixture.

Preparation of complex

- Preparation of potassium trioxalatoferrate(III) trihydrate and measurements of its conductivity. Estimate the amount of iron present in the above complex. **6 hrs**

Experiments in Organic Chemistry

1. Spectral analysis (spectra of simple organic compounds including aliphatic and aromatic hydrocarbons, alcohols, aldehydes, ketones, carboxylic acid, amines, etc will be provided and students are required to interpret the given spectra and find out the structures of organic compounds).

2. Two-three sets of two steps synthesis.
3. Purification and separation of organic mixtures by paper, thin layer and column chromatographic techniques.
4. Determination of the amount of aspirin present in the given 150 mg aspirin tablet by indirect titration against the standard HCl.
5. Estimation of ascorbic acid in vitamin C tablet iodometrically.
6. Benzoin condensation (a green synthesis using thiamine hydrochloride replacing KCN).
7. Introduction to micro scale organic experiments. **51 hrs**

Experiments in Physical Chemistry

1. To carry out conductometric titration between the mixture of hydrochloric and acetic acids against standard sodium hydroxide solution.
2. To study the kinetics of acid catalyzed iodination of propanone.
3. To study the kinetics of oxidation of ethyl alcohol with potassium dichromate in acidic media.
4. To determine the partition coefficient of iodine between organic liquid and water.
5. To determine the freezing point curve of the mixture of naphthalene and biphenyl and also to construct the phase diagram.
6. To verify the Beer-Lambert's law and to determine the concentration of a color solution of unknown strength using filters colorimeter/spectrophotometer.
7. To determine the critical solution temperature of phenol-water system and the composition of the solution at CST.
8. To study the adsorption of acetic acid from aqueous solution by activated charcoal and to examine the validity of Freundlich and Langmuir's adsorption.

51 hrs

Course Title: General Chemistry-III **Full Marks**: 100

Course No.: CHE 403 (major) **Pass Marks**: 35

Nature of the Course: Theory **Year**: IV

Course Objectives:

- To understand the fundamentals of coordination compounds.
- To know the chemistry of lanthanides and actinides.
- To understand the chemistry of bio-organic molecules.
- To discuss different types of chemical and photochemical reactions, and their kinetics.

- To provide knowledge on modern electrochemistry and its uses.
- To introduce the basic concepts of corrosion sciences.

Group A: Inorganic Chemistry

Coordination Compounds: Isomerism in coordination complexes: (a) polymerization isomerism, (b) ionization isomerism, (c) hydrate isomerism (d) linkage isomerism, (e) coordination isomerism, (f) coordination position isomerism (g) geometric isomerism, (h) optical isomerism, IUPAC nomenclature of coordination compounds, **8 hrs**

Bonding and Application of Coordination Compounds: Valence bond theory, inner and outer orbital complexes, crystal field theory, Jahn Teller distortion in octahedral and tetrahedral complexes, characterization of complexes by spectroscopic, Optical and magnetic methods, chelates and polynuclear complexes, high spin and low spin complexes, stereochemistry of complexes with coordination number 4 and 6, substitution reactions and trans effect, application of complexes in analytical and biological fields.

Stability constant or formation constant: Kinetic stability (Labile and inert complexes), thermodynamic stability, (stable and unstable complexes), stepwise stability constant and overall stability constant of complexes, factors influencing the formation of complexes (thermodynamic and kinetic stability). **22 hrs**

Inorganic Reaction Mechanism:

Fundamentals of ligand substitution reaction: Activated complex, Labile and inert complexes, mechanism of substitution reaction: 1. dissociative (d) mechanism, 2. Associative (a) mechanism, basic idea of redox reaction in coordination complexes: atom transfer mechanism and electron transfer mechanism.

10 hrs

Elementary study of carbonyls and nitrosyls: General method of preparation, bonding, application of 18 electron rule, structure of carbonyls, polynuclear carbonyls and nitrosyls.

10 hrs

Group B: Organic Chemistry

Bio-organic Chemistry: Biological oxidation and reduction, (ethanol and acetaldehyde), biological oxidation and reduction (deuterium labeling experiments), stereochemistry of biological oxidation and reduction, organic chemistry of vision, biosynthesis of fatty acids, mechanism of enzyme action (chymotrypsin). **10 hrs**

Carbohydrates: Introduction, definition and classification, (+)–glucose as an aldohexose, (-)-fructose as a 2-keto hexose, stereo isomers of (+) –glucose, oxidation (effect of alkali, osazone formation (epimers), lengthening and shortening the carbon chain of aldoses, conversion of an aldose into its epimer, conversion of aldose into ketose and vice versa, configuration of (+)–glucose (the Fischer proof), configuration of aldoses, optical families D and L, tartaric acid,

families of aldoses (absolute configuration), open and cyclic structure of glucose, configuration about C-1, methylation, determining ring size, conformation. **18 hrs**

Lipids: Lipids, occurrence and composition of fats, hydrolysis of fats, fats as a source of pure acids and alcohols, detergents, unsaturated fats, phosphoglycerides, cell membrane, steroids. **6 hrs**

Proteins & Nucleic Acid: Protein, structure of amino acids, amino acids as dipolar ions, isoelectric point, configuration of natural amino acids, preparation of amino acids, reactions of amino acids, Dopa mine and its uses in medicine peptides (geometry of peptide linkage), determination of structure of peptides, synthesis of peptides, proteins (classification and functions), structure of protein, peptide chain, side chain (isoelectric point, electrophoresis), conjugated proteins, secondary structure of protein, nucleoproteins and nucleic acids, the genetic code. **16 hrs**

Group C: Physical Chemistry

Chemical Kinetics:

Consecutive reaction, parallel reaction, opposing reaction, theories of reaction rates: collision theory of a bimolecular and unimolecular reactions, transition state theory, chain reaction, kinetics of some gas phase photochemical reactions: (a) decomposition of ozone, (b) hydrogen and chlorine (c) hydrogen and bromine, kinetics of condensation polymerization **15 hrs**

Modern Electrochemistry:

Ion-solvent and ion-ion interactions: Ion-solvent interaction, solvation (thermodynamic and spectroscopic approaches) and dielectric effects, quantitative treatment of the Debye-Hückel (ion cloud) theory of ion-ion interactions, Debye-Hückel theory of activity coefficient and its limitations **15 hrs**

Polarization & Commercial Cell:

Polarization of electrochemical cell, types of polarization (activation, concentration & overvoltage), determination of hydrogen overvoltage, application of overvoltage (deposition of metal), commercial cells; principles, applications and limitations of primary cell (Leclanche cell) and secondary cells (lead-acid and nickel-cadmium cells), fuel cells (introduction & types) **8 hrs**

Corrosion of Metallic Materials:

Introduction, cost & importance of corrosion study, types of corrosion: based on corroded surfaces & environments (aqueous, atmospheric, soil & concrete), fundamentals of corrosion cells, brief discussion of corrosion control methods (including inhibitors and cathodic protection techniques) **12 hrs**

Full Marks: 50

Course Title: General Practical Chemistry-III

Course No.: CHE 404 (major) **Pass Marks**: 20

Nature of the Course: Practical **Year**: IV

Course Objectives:

- To follow instructions for practical work.
- To make students aware of the importance to scientific method of accurate observation and measurements being aware of possible sources of error.
- To know the principles of qualitative and quantitative analysis of chemical substances.
- To record and interpret accurately and clearly the results of experiments.
- To explain practical techniques, procedures and safe laboratory working practices.

Experiments in Inorganic Chemistry

Qualitative analysis of salt mixture containing 6 radicals (including interfering radicals) **30 hrs**

Iodometric Titration **6 hrs**

1. Estimation of available chlorine in bleaching powder iodometrically.
2. Determination of dissolved oxygen in water sample by Winkler's iodometric method.

Complexometric Titration **6 hrs**

1. Determination of amount of Magnesium and Manganese in a given mixture solution by EDTA.
2. Determination of amount of Copper and Iron in a given mixture solution by $K_2Cr_2O_7$ solution.

Colorimetric Analysis **9 hrs**

1. Determination of Pb as dithizone complex colorimetrically.
2. Colorimetric determination of PO_4^{-3} by molybdenium blue method.

Experiments in Organic Chemistry

1. Quantitative analysis of any two: (OH-group, nitrogen, sulphur, glucose, carbonyl group),
2. Isolation of the following natural products (any two): lactose, caffeine, camphor, essential oil.
3. Perform the characteristic reactions of carbohydrates, fats and protein.
4. Determination of acid value of fats or oil.

5. Determination saponification value of fats or oil.
6. Determination of iodine number of fat or oil.

51 hrs

Experiments in Physical Chemistry

1. To determine the size of a molecule of the given compound by viscosity measurement.
2. To determine concentration of Cl^- in KCl or I^- in KI solution titrating with standard silver nitrate solution potentiometrically.
3. To determine rate constant for the saponification of ethyl acetate by sodium hydroxide by conductivity method.
4. To determine the concentration of phosphoric acid in cola beverage using pH meter.
5. To study the effect of concentration of catalysts on the reaction rate for acid catalyzed hydrolysis of methyl acetate.
6. To determine the activation energy for the reaction between potassium persulfate and potassium iodide by iodine clock method.
7. To determine the λ_{max} and molar absorbtivity coefficient (ε) for ferric-thiocynate complex and also to determine the concentration of iron in a given sample of water.
8. To carry out potentiometric titration of acetic acid with sodium hydroxide using quinhydrone electrode and to determine the dissociation constant.

51 hrs

Text Books: for theory courses CHE 401 & CHE 403:

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. M. R. Pokhrel & B. R. Poudel, *A Textbook of Inorganic Chemistry*, 2nd Edition, National Book Centre, Kathmandu, 2011.
4. D. F. Shriver & P. W. Atkins, *Inorganic Chemistry*, 5th Edition, Oxford University Press.
5. J. E. Huheey, E. A. Keiter & R. L. Keiter, *Inorganic Chemistry, Principles of structure and Reactivity*- Addison Wesley Publishing House, 1990.
6. S. Pimplapure, R. Jain, A. Sahai & U. Soni, *Inorganic Polymer Chemistry*, Pragati Prakashan, Meerut, 2012.
7. W. U. Malik, G. D. Tuli & R. D. Madan, *Selected Topics in inorganic chemistry*, .S. Chand & Company, New Delhi, 1995.
8. B. Doglas, D. MacDaniel & J. Alexander, *Concepts and Models of Inorganic Chemistry*, Recent edition

9. F. Basolo & R. G. Pearson, *Inorganic Reaction Mechanism*, 2nd edition, Wiley, New York, 1967.
10. R. B. Jordan, *Reaction Mechanism of Inorganic and Organometallic Systems*, 3rd edition, oxford University Press, 2007.
11. R. T. Morrison, R. N. Boyd & S. K. Bhattacharjee, *Organic Chemistry*, 7th Edition, Prentice- Hall of Pearson, 2012.
12. J. March, *Advanced Organic Chemistry*, 4th Edition, Wiley Eastern Ltd., India, 2005.
13. Jonathan Clayden, *Organic Chemistry*, 2nd Edition, Oxford University Press, India.
14. F. Carey, R, Giuliano, *Organic Chemistry*, McGraw-Hill 8th Edition, 2010.
15. S. H. Maron & C. Prutton, *Principles of Physical Chemistry*, 4th Edition, Oxford & IBH Pub. Co., 1992.
16. J. O'M Bockris & A. Reddy, *Modern Electrochemistry*, **Vol. I**, 2nd Edition, Plenum Pub. Corp., New York, 1998.
17. 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.
18. R. W. Revie & H. H. Uhlig, *Corrosion and Corrosion Control; an Introduction to Corrosion Science and Engineering*, 4th Edition, John Wiley & Sons, Inc., New York, 2008.
19. S. O. Pillai, *Solid State Chemistry*, Wiley Eastern Ltd., 1994.
20. A. K. Chandra, *Introductory Quantum Chemistry*, 4th Edition, Tata McGraw-Hill, New Delhi, India, 1994.

Reference Books: for theory courses CHE 401 & CHE 403:

1. R. D. Madan & Satya Prakash, *Modern Inorganic Chemistry*, S. Chand & Company Ltd., 1994.
2. A. K. Bhagi & G. R. Chatwal, *Bioinorganic and Supramolecular Chemistry*, Himalaya Publishing House, Mumbai.
3. A. Sharpe, *Inorganic Chemistry*, 2nd Edition, ELBS & Longman, Singapore, 1986, (Recent edition).
4. M. L. Sharma & P. N. Chaudhary, *A Textbook of B. Sc. Chemistry* (Volume I and II), Second Edition, Ekta Books Nepal, 2007.
5. K. N. Upadhyaya, *A Textbook of Inorganic Chemistry*, 2nd Edition, Vikash Publishing House Pvt., Ltd., 1995
6. C. Agrawal, *Modern Inorganic Chemistry*, Wiley Eastern, New Delhi, 1981, (Latest edition).
7. I. L. Finar, *Organic Chemistry*, Vol. I and Vol. II, Prentice Hall, London, (Latest edition).

8. Streitweiser & Heathcock, *Introductory Organic Chemistry*, Wiley and Sons, New York, 1981.
9. B. S. Bahl & A. Bahl, *A Textbook of Organic Chemistry*, S. Chand Publication, New Delhi, India, 2012.
10. T. W. Graham Solomons, *Organic Chemistry*, (latest edition), John Wiley and Sons, New York.
11. G. M. Loudon, *Organic Chemistry*, Fourth Edition, Oxford University Press, India.
12. R. A. Bansal, *A Textbook of Organic Chemistry*, 2nd Edition, Wiley Eastern Ltd., New Delhi, 1993 (Available recent edition).
13. C. Norman, *Principles of Organic Synthesis*, 2nd Edition, Chapman and Hill. London, 1978, (recent edition)
14. Warren, *Organic Synthesis, The Disconnection Approach*, Wiley, New York, 1982. (available recent edition)
15. H. House, *Modern Synthetic Reactions*, 2nd Edition, W. A. Benjamin. New York, 1972.
16. S. Glasstone & D. Lewis, *Elements of Physical Chemistry*, Mcmillan & Co., Ltd.
17. P. Atkins & J. D. Paula, *Atkin's Physical Chemistry*, 10th Edition, Oxford University Press, 2014 (reprinted).
18. J. O'M Bockris, A. Reddy & M. Gamboa-Aldeco, *Modern Electrochemistry* Vol. 2A, 2nd Edition, Kluwer/Plenum Publishers, New York/London/Moscow, 2000.
19. S. Negi & S. C. Anand, *A Textbook of Physical Chemistry*, New Age International (P) Ltd., New Delhi, 1999.
20. A. Bahl, B. S. Bahl & G. D. Tuli, *Essential of Physical Chemistry,* Revised Multicolor Edition, S. Chand & Co. Ltd., New Delhi, 2009.
21. D. Alberty, *Physical Chemistry*, 6th Edition, Wiley Eastern Ltd., New Delhi, 1992.
22. J. Bhattarai, *Frontiers of Corrosion Science*, 1st Edition, Kshitiz Publication, Kathmandu, 2010.
23. J. Bhattarai & D. B. Khadka, *Surface Characterization and Solid State Chemistry*, Sunlight Publication, Kathmandu, 2010.
24. K. L. Kapoor, *Text Book of Physical Chemistry*, Macmillan India Ltd., Vol. I to Vol.V, 3rd Edition, 2001.
25. D. N. Bajpai, *Advanced Physical Chemistry,* S. Chand & Co., New Delhi.
26. J. N. Gurtu & A. Gurtu, *Advanced Physical Chemistry*, 8th Edition, Pragati Publication, Meerut, India, 2006.
27. H. V. Keer, *Principles of the Solid State*, New Age International (P) Ltd., New Delhi, 2002.
28. V. K. Jha, *Introductory Quantum Mechanics*, Balkhu, Kathmandu, Nepal, 2012.

29. S. K. Gautam, S. K. Kalauni, K. R. Sharma, B. R. Poudel, D. Wagle, *Text Book of Chemistry*, vols 1 & 2, National Book Centre, 2016.

Text Books: for practical courses CHE 402 & CHE 404:

1. A. I. Vogel, *A Text Book of Quantitative Inorganic Analysis, Including Elementary Instrumental Analysis*, ELBS & Longman, 1969, (Preferably available recent edition).
2. 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).
3. N. K. Vishnoi, *Advanced Practical Organic Chemistry* (2nd Revised Ed), Vikas Publishing Pvt. Ltd. India.
4. Moti Kaji Sthapit & R. R. Pradhananga, *Experimental Physical Chemistry*, Taleju Prakasan, Kathmandu, 1998.
5. N. M. Khadka, S. D. Gautam & P. N. Yadav, *A Core Experimental Chemistry for B.Sc.* Heritage Publication, Kathmandu, 2016.

Reference Books: for practical courses CHE 402 & CHE 404:

1. Gurdeep Raj, *Advanced Practical Inorganic*, 10th Edition, Goel Publishing House, Meerut, 1994.
2. A. I. Vogel, *A Textbook of Practical Organic Chemistry*, Including Qualitative Organic Analysis, Longmans, (Latest Edition).
3. F. G. Mann & B. C. Saunders, *Practical Organic Chemistry*, Orient Longman, 1986, (recent edition).
4. M. R. Pokhrel, P.N. Yadav & S. Shrestha, *Advanced Practical Inorganic Chemistry for M. Sc.*, Kshitiz Publication, 2009.
5. A. K. De, *Environmental Chemistry*, New age International Ltd Publishers, New Delhi.
6. J. N. Gurtu & A. Gurtu, *Advanced Physical Chemistry Experiments*, 4th Edition, Pragati Prakashan, 2008.
7. J. N. Gurtu & R. Kapoor, *Advanced Experimental Chemistry* (Vol I-III), S. Chand & Co. New Delhi, 1984.
8. J. B. Yadav, *Advanced Practical Physical Chemistry*, 33rd Edition, Goal Publ. House, Meerut, 2014.
9. A. Rajbhandari (Nyachhyon) and S. Pradhananga (Shrestha), *Inorganic Salt Analysis*, 1st Edition, Rajbhandari-Pradhananga Publication, Kathmandu, 2013.

Course Title: Applied Chemistry | **Full Marks:** 100

Course No.: CHE 405 | **Pass Marks:** 35

Nature of the Course: Theory | **Year:** IV

Course Objectives:

The outcome of this course will be:

- To encourage students to apply chemical knowledge in understanding the chemical process involved in the industrial processes.
- To understand the natural wealth of Nepal and develop ideas to apply these resources for the industrial growth of Nepal.
- To develop student's ability in the applied field of chemistry.

Introduction of Applied Chemistry: **5 hrs**

Introduction, chemical industries-facts and figures.

Unit operation and unit process (outlines of unit operations, general principle applied in studying industry, process and design with focus on block diagrams.

Economics (profitability analysis-capital investment, total production costs, economic analysis (return on investment), principle of economic balance-choice between alternative processes.

Inorganic Chemical Industries: **35 hrs**

Introduction on inorganic chemical industries.

Fertilizer industries: introduction, NPK fertilizers, consumption and scopes.

Nitrogen industries: introduction, consumption and major products.
Urea: properties, consumption pattern, methods of production (from ammonium carbamate decomposition), raw materials, process description, flow sheet, major engineering problems, economics.

Phosphorus industries: introduction, consumption pattern, major products

Calcium phosphate: superphosphate vs triple phosphate, production of superphosphate and triple phosphate, raw materials, process description, flow sheet, major engineering problem, economics

Cement and lime: Introduction, properties (constituents of cement-Portland and its type, high alumina, hydraulic hydrated lime), compressive strength, Cement industries in Nepal, methods of production (Portland cement), raw materials with emphasis on Nepalese context, process description, flow sheet, major engineering problems, economics, overall factors to be considered in cement industries
Lime: properties, consumption patter, methods of production, process description, flow sheet, major engineering problem, economics

Ceramics: Introduction, manufacturing process, raw materials (clay minerals, kaolin, ball clay, fire clay), methods of production: firing, stages of firing, types of kilns, properties, consumption pattern, ceramics industries in Nepal, economics

Water industries: Introduction, sources of water, consumption pattern, water storage and related problems, methods of treating fresh water, process description, flow sheet, major engineering problem, economic considerations, waste water treatment and disposal.

Natural Products Industries: **25 hrs**

Oils: Introduction, raw materials of oils, methods of extractions (mechanical, solvent extraction, purification), hydrogenation of oils (with flow sheet diagram).

Soaps and detergents: Introduction, classification of cleansing compounds, use of soap and detergents, methods of soap production: continuous process for fatty acids, soap, and glycerine, methods of detergent manufacture, consumption pattern.

Paints and varnishes: Introduction, pigments and extenders, functions of oils in paints, uses of driers in paints, uses of resins, diluents in paints and varnishes, economics of paints and varnishes industries.

Fermentation industries: Introduction, characteristics and economics of fermentation industries, kinetics and scale-up of submerged and aerobic fermentation process, air and media sterilization, continuous and batch fermentation, consumption pattern of ethyl alcohol, methods of ethyl alcohol production with flow sheet diagram, economics of ethyl alcohol industry.

Pulp and paper industries: *Pulp:* Introduction, methods of production, sulfate (Kraft) pulp process, comparison of chemical pulping process for cellulose fibers, major engineering problems. *Paper:* introduction, types of paper, raw materials, methods of production (including Nepali paper- Lokta) and economics of paper industries.

Polymerization Industries: **15 hrs**

Polymerization technology: Introduction, classification of polymer applications (adhesive, coatings, fibers, solid shapes).

Polymer manufacturing process: Process description with flow sheet and economics involved in plastic (polyethylene, PVC, epoxide), butadiene-styrene rubber and fibers (nylon).

Metallurgical Industries: **30 hrs**

Iron and Steel: Introduction

Iron: Raw materials, sources of ores with reference to Nepal, production of Pig iron (process description with flow sheet), major engineering problems.

Steel: Raw materials, production of steel, process description with flow sheet-Open Hearth process, major engineering problems and economics.

Aluminum: Raw materials, method of production, process description, major engineering problems and economics.

Copper: Raw materials, method of production with flow sheet diagram.

Lead: Raw materials and production.

Zinc: Raw materials and production.

Electrochemical Industries: **15 hrs**

Introduction

Some practical problems in using electrochemical theory (voltage efficiency (polarization), current efficiency, energy efficiency, decomposition efficiency

Example of electrochemical industries: 1. electroplating of Nickel and chrome on steel; 2. Fuel cells-efficiency, H_2-O_2 fuel cell, development of commercial fuel cell and battery-lead–acid battery; 3. Electro-organic chemical processes: production of adiponitrile and tetraethyl lead-raw materials, flow sheet with process description and major engineering problems; 4. Corrosion and its prevention: selection of materials, proper design, altering environments, inhibitors, coatings

Safety Considerations in Chemical Process Industries: **25 hrs**

Introduction

Chemical storage-safety issues: past experience, layout, safety standards, safety features, operational hazards, packaged chemical storage, safety measures, fire protection and loss prevention

Observations related to safety aspects: management's concern for safety, plant design, hazard identification and safety audit, system and procedures, maintenance, technical services, safety organization, firefighting facilities, emergency preparedness, human inhabitation in the vicinity of chemical plants, factory act and statuary bodies

Specific recommendations for hazard control and improved plant safety: Nepalese Guidelines/acts, Guidelines from developed countries, environment protection act, hazards and safety of chemical plants.

Packaging of chemical and dangerous goods: basic requirements, types of container, sacks, glass carboys, plastic containers, intermediate-bulk containers.

Chemical plant safety-from concept to decommissioning: Technology-selection and development, process design, instrument design, equipment design, plant layout, plant erection, training, plant start-up and commissioning, regular plan operation and maintenance, plant decommissioning or demolition.

Text Book: for theoretical course CHE 405

1. Charles E. Dryden, *Outlines of Chemical Technology*, edited and revised by M. Gopala Rao and Marshall Sittig, affiliated East-West Press Pvt. Ltd. New Delhi, 2010.

Refernce Books: for theoretical course CHE 405

1. K. H. Davi & F.S. Berner, *Handbook of Industrial Chemistry*, Vol. 1 and 2(Edited by S. C. Bhattia, CBS Publishers and Distributors, New Delhi, 2000.
2. Philip Matthews, *Advanced Chemistry*, Cambridge University Press, 1997.
3. Thankamma Jacob, *A Textbook of Applied Chemistry*, Macmillan India Limited, 1997.

4. P. K. Gangopadhyay, *Application Orientated Chemistry*, Book Syndicate Pvt. Ltd., Kolkata, 2009.
5. B. R. Pandey, *An Easy Approach to Applied Chemistry*, Heritage Publishers & Distributors Pvt. Ltd., Kathmandu, 2016.
6. *ISO-Laboratory Safety*-Accreditation by Nepal Bureau of Standards & Metrology, Kathmandu, Nepal.
7. L. P. Poudel, *Mineral Resources of Nepal*: An Analytical Study (**in Nepali**), Devi Dhakal, Kathmandu, 2011 (2068).
8. www.doind.gov.np

Course Title: Basics of Nanoscience and Technology — **Full Marks:** 50

Course No.: CHE 407 — **Pass Marks:** 17.5

Nature of the Course: Theory — **Year:** IV

Course Objectives:

- To provide fundamentals of nanoscience and nanotechnology to the undergraduate student.
- To make the students acquainted with basic techniques of nano-meterials fabrication and characterization.
- To provide the knowledge of nanotechnology and its applications.

Introduction to Nanotechnology: History of nanotechnology, definitions, nanotechnology as interdisciplinary field, nanotechnology in nature, classification of nonstructural materials. **5 hrs**

Preparation Methods of Nano-materials: Bottom up approaches: physical vapor deposition (inert gas condensation, laser ablation) & chemical vapor deposition (thermally activated CVD, plasma-enhanced CVD, spry conversion processing, sol-gel process, wet chemical synthesis, self assembly), top down approaches: mechanical alloying, nanolithography, consolidation of nanopowders: shockwave consolidation, hot isostatic processing & cold isotatic processing, spark plasma sintering. **20 hrs**

Characterization Techniques for Nano-materials: Characterization of nano-materials using X-ray diffraction (Scherrer's equation) and imaging microscopic techniques (scanning electron microscopy, scanning probe microscopy: scanning tunneling microscopy & atomic force microscopy, and transmission electron microscopy), nano-indention. **20 hrs**

Applications of Nano-materials: Nano-electronic, nanotube-based sensors, nano-catalysis, cosmetics and consumers goods, Food and agriculture, nano-medical applications, water

treatment and environment, energy, textile, paints, defense, health risks, applications in structural engineering. **20 hrs**

Nonostructural Materials with High Application Potential: Quantum dots, carbon nanotubes, nanocrystalline ZnO & TiO_2, multilayer films. **10 hrs**

Text Book: for theoretical course CHE 407:

1. B. S. Murthy, P. Shankar, Balvev Rj, B. B. Rath & James Murday. *Textbook of Nanoscience and Nanotechnology*, Series in Metallurgy and Materials Science, Baldev Raj (Ed.), Universities Press Private Hyderabad, India, 2012.

Reference Books: for theoretical course CHE 407

1. K. K. Chattopadadhyay & A. N. Banerjee. *Introduction to Nanoscience and Nanotechnology,* PHI Learning Private Limited, New Delhi, 2012.
2. C. P. Poole & F. J. Owens. *Introduction to Nanotechnology*, Wiley India Limited, 2012.
3. C. N. R. Rao, *Nanoworld: An Introduction to Nanoscience and Nanotechnology,* JNCASR, Bangalore, 2010.
4. J. Bhattarai, *Frontiers of Surface Science*, 1st Edition, Kathmandu, 2012.

Appendix I

List of name reactions:-

Condensation reactions

1. Dieckmann condensation
2. Darzen's reaction
3. Intramolecular Claisen Condensation
4. Knoevenagel condensation
5. Benzoin condensation

Rearrangement reactions

1. Beckmann rearrangement
2. Claisen rearrangement
3. Cope rearrangement
4. Favorskii rearrangement
5. Curtius rearrangement
6. Pinacol-pinacolone rearrangement
7. Wagner–Meerwein rearrangement
8. Wittig rearrangement

9. Benzelic acid rearrangement

Reduction reactions

1. Birch reduction
2. Catalytic hydrogenation reduction
3. Meerwein Ponndorf-Verley reduction

Oxidation reactions

1. Baeyer–Villiger oxidation
2. Oppenauer oxidation
3. Lead tetraacetate oxidation
4. Chromic acid oxidation
5. Permanganate oxidation
6. Peracid oxidation

Elimination reactions

1. Hofmann degradation
2. Pyrolytic elimination

Addition to Carbon Carbon multiple bond andCarbon –Hetero multiple bond

1. Michael reaction
2. Diel's Alder reaction
3. Mannich Reaction
4. Reformatsky Reaction
5. Halogenation of dienes

Tribhuvan University
Institute of Science and Technology

Course Title:	Computational Course	**Year:**	IV
Course Code:	COM408	**Full Marks:**	50
Nature of Course:	Theory / Lab	**Pass Marks:**	17.5

Course Description

This course covers the basic concepts of computers and introduction, data representation, database, networks and data communication, multimedia, computer security, GIS.

Course Objectives

The main objective of this course is to provide students knowledge of fundamental concepts of computers and information technology.

COMPUTATIONAL COURSE [80 hours]

1. **Introduction to Computer:** 1.1 Introduction; Digital and Analog Computers 1.2 Characteristics of Computer 1.3 History of Computer 1.4 Generations of Computer 1.5 Classification of Computer 1.6 The Computer System [6 hours]

2. **Operating System:** 2.1 Introduction: Objectives of Operating System 2.2 Types of OS 2.3 Functions of OS: Process Management; Memory Management; File Management; Device Management 2.4 Examples of Operating Systems: UNIX, LINUX & Windows [6 hours]

3. **Data Communication and Computer Network:** 3.1 Introduction: Importance of Networking 3.2 Data Transmission Media 3.3 Data Transmission Across Media 3.4 Data Transmission and Data Networking 3.5 Computer Network 3.6 Wireless Networking [5 hours]

4. **Internet and Internet Services:** 4.1 Introduction: History of Internet 4.2 Internetworking Protocol 4.3 The Internet Architecture 4.4 Managing the Internet 4.5 Connecting to Internet 4.6 Internet Connections 4.7 Internet Address 4.8 Internet Services [5 hours]

5. **Data Representation:** 5.1 Number System; Conversion from Decimal to Binary, Octal, Hexadecimal 5.2 Conversion of Binary, Octal, Hexadecimal to Decimal; 5.3 Logic Gates 5.4 Database System 5.5 Database System Architectures 5.5 Database Applications: Computational Biology, Data Mining, Virtual Data, Computational Nanoscience, Space Data [12 hours]

6. **Multimedia:** 6.1 Introduction: Multimedia: Definition 6.2 Characteristics of Multimedia System 6.3 Elements of Multimedia 6.4 Multimedia System 6.5 Multimedia Applications [6 hours]

7. **Computer Security:** 7.1 Introduction: Security Threat and Security Attack 7.2 Malicious Software 7.3 Hacking 7.4 Security Services; Security Mechanisms 7.5 Cryptography 7.6 Digital Signature 7.7 Firewall 7.8 Users Identification and Authentication 7.9 Other Security Measures 7.10 Security Awareness; Security Policy [10 hours]

8. **Geographical Information System & Remote Sensing:** 8.1 Introduction: Components of GIS 8.2 Map Projections : Spatial and Non-Spatial data 8.3 Data model and input, data analysis and output 8.4 Remote Sensing Applications: Agriculture – forestry – land use / land cover mapping – water resources – snow and glacier – wetland management [10 hours]

9. **Laboratory Work:** After completing this course, students should have practical knowledge of operating systems like LINUX and Windows, Word Processors, Spreadsheets, Presentation Graphics, Database Management Systems, and Internet and its services. [20 hours]

Note: *The evaluation of this course will be taken through* ***final written examination****. However, during the classes teachers are required to use computer interface through multimedia. Students should practice it in the computer.*

Text Books:

1. Sinha P. K. and Sinha P. - **Computer Fundamental**, JBA (**ISBN** : 8176567523), India (2011)
2. Huisman O. and de By R. A., **Principles of Geographic Information Systems: An introductory textbook**, International Institute for Geo-Information Science and Earth Observation, The Netherlands (2001)

Reference Books:

1. Goel A. - **Computer Fundamentals**, Pearson Education, India (2010)
3. Campbell J.B. - **Introduction to Remote Sensing**, Fourth Edition, Guilford Press (2008)

Tribhuvan University
Institute of Science and Technology

Course Title:	Project Work	**Year:**	IV
Course Code:	**PRO406**	**Full Marks:**	100
Nature of Course:	Project Work / Field Work	**Pass Marks:**	40

Course Description

This course offers students to learn the research works in physics. Students are required to review literature of his/her field of interest to identify a problem in the project work, that problem should be addressed by the students.

PROJECT WORK

RESEARCH

Project Guidelines

1) A student can do project work only if a faculty or a subject teacher agrees to supervise his/her project work. It is the responsibility of TU faculties to carry out educational and research activities.

2) The nature of project work can be field work, theoretical work, computational work, observational work and experimental work. Whatever the nature of the work, students should critically review literature of the area of interest and identify the problem specifically.

3) Students should prepare a proposal and submit it to the department within three month of fourth year final examination. The general format of the proposal should like this:
   (a) Background/Introduction
   (b) Literature Review / Problem Identification
   (c) Motivation/Objectives
   (d) Methodology / Field Survey
   (e) Expected Result / Hypothesis
   (f) References (format should be decided by concerned subject committee)

4) The final VIVA examination should be held within a couple of month of the fourth year final examination. The examination date will be proposed by the concerned colleges and is appointed by the Controller of Examination, TU.

5) The format of the project should be same as the format of M.Sc. dissertation of respective subject. The format will be decided by the Central Department Research Committee (CDRC).

6) The evaluation committee consist 4 members - HoD or program coordinator, supervisor, external and internal examiners. A separate evaluation form will be given to all four members of the evaluation committee during the VIVA examination that contains the following:

(a) Introduction to the subject	10%	(f) Methods	10%
(b) Literature review	10%	(g) Figures/plots/tables	10%
(c) Motivation/Objectives	10%	(h) Interpretation	10%
(d) Originality and creativity:	10%	(i) Comparison: published work	10%
(e) In-depth Research:	10%	(j) Presentation:	10%

7) There will be additional fee for the project. Student needs to pay this amount. A enumeration for the supervisor is recommended. It will be decided by the Dean Office, IoST, TU.