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**

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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).