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| Course title : **Chemistry II** | | Full marks : 100 (80T + 20P) | |
| Course No. : Sc. Ed. 423 | | Pass marks : 28T + 8P | |
| Nature of the course : Theory & Practical  Level : B.Ed. (4 Year) | | Periods per week : 9 (6T + 3P) ,  Practical ( 3P) : 3pds/day/Week/gr. | |
| Year : Second | | Total Periods : 150  Time per period : 45 minutes | |
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1. **Course Description**

This course is designed with the aim of providing theoretical and practical knowledge and skills in the area of Chemistry Education. The course is divided into two parts i.e., theoretical part and practical part. The theoretical part comprise of different units from physical, inorganic and organic chemistry. This part consists of 15 units and provides the theoretical knowledge related to nuclear chemistry, covalent bond, coordinate covalent compounds, comparative study of s- and p-block elements and their important compounds, chemistry of d-block elements and their important compounds, thermodynamics, thermo chemistry, gaseous state, liquid state, solid state, alkyl halides, alcohols, ethers, aldehydes, ketones, carboxylic acids and their derivatives and alicyclic compounds.

In Practical Part, laboratory experiments related to the theoretical portions are included so that students can perform experiment and sharpen their knowledge and develop the necessary practical skills in the area of chemistry education. The students are required to secure pass marks in theory as well as practical part separately.

1. **General Objectives:**

The general objectives of the course are as follows:

* Familiarize the students with radioactivity, nuclear reactions and develop the capacity to solve the numerical problems related to the radioactivity of radioactive elements.
* Acquaint the students with different approaches about the covalent bond formation and enable them to predict the shape of molecules using these approaches.
* Enable the students to understand Werner’s theory, Sidgwick model of coordination compounds and the factors affecting the stability of coordination compounds.
* Develop the capacity to understand s- and p- block elements and their compounds.
* Provide in-depth knowledge about the general trends of periodic properties in 3d and 4d series of transition elements and their biologically important compounds.
* Make them able to understand the different principles, theories, laws, phenomenon and systems related with thermodynamics and thermo chemistry and solve numerical problem.
* Understand the theories, characteristic properties, behavior, determination of some important properties, factors affect on their properties and classification of the states of matter.
* Provide in-depth knowledge about alkyl halides, alcohols, ethers, aldehydes, ketones, carboxylic acids and their derivatives and alicyclic compounds.

1. **Specific Objectives and Contents**

**Part- I Theory**

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| **Specific Objective** | **Content** | **Periods** |
| * Name nucleon and nuclide * Explain the stability of nucleus based on mass defect, binding energy, and packing fraction. * Define binding energy and describe the relative stability of isotopes. * Explain α-, β- and - rays and explain radioactivity is a nuclear property * Define and differentiate Nuclear fission and Nuclear fusion * Describe mean life and half-life period of radioactive elements. * Solve the simple numerical problems related with mean life and half-life period. | **Unit: I. Nuclear Chemistry**   * Composition of nucleus * Mass defect * Binding energy * Packing fraction * Nuclear stability * Radioactivity * Nuclear reaction * Mean life and half-life period. | 5 |
| * Explain valence bond approach and concept of covalent bond. * Describe the postulates and limitations of valence bond theory. * Define and explain different types of   hybridization.   * Predict the shape of some molecules according to hybridization. * Explain molecular orbital approach and linear combination of atomic orbitals (LCAO). | **Unit: II. Covalent Bond**   * Valence bond approach * Concept of covalent bond * Postulates and Limitations of Valence Bond Theory. * Hybridization and its types * Shape of molecules according to hybridization: CH4, C2H6, C2H4, C2H2, H2O, NH3, CO2, PCl5, BF3, SiF6. * Molecular Orbital Approach * LCAO method | 11 |
| * Explain Werner's theory of coordination compounds. * Explain electronic interpretation of coordination on basis of Sidgwick model. * Define E.A.N. and determine E.A.N. of different metal ions (Fe 2+, Co3+, Cu+, Cr3+, Fe3+, Ni3+, Ni2+) * Name the coordination compounds and complex ions. * Explain the factors that affecting the stability of complex compounds. | **Unit III. Coordinate Covalent Compounds**   * Werner's co-ordination theory * Electronic interpretation of coordination (Sidgwick Model) * Effective Atomic Number (E.A.N.) * Nomenclature of coordination compounds and complex ions * Factors affecting the stability of complex compounds | 6 |
| * Explain the general trends of periodic properties- electronic configuration, atomic radii, ionization potential, electronegativity, electron affinity. * Describe occurrence, General method of preparation, isolation of the elements and factors influencing the choice of extraction process and the general physical and chemical properties of the s block and p block elements. * Explain solubility of alkali metals in liquid NH3, hydration energy and mobility of ions. * Explain anomalous behavior of Be, Grignard reagents, chlorophyll and Biological properties of Ca & Mg * Describe the principle of extraction of Al, Alums. * Explain structure and allotropy of the elements, differences between C, Si. S and other remaining elements, Fullerene. * Describe nitrogen cycle, liquid ammonia as a solvent, phosphate fertilizers, and role of   phosphate esters in biological process.   * Explain acid rain and differences between oxygen and other elements. * Explain perchloric acids. * Explain isolation of Noble gases. | **Unit IV. Comparative Study of S- and P- Block Elements and their Important Compounds:**   * General group trends: electronic configuration, atomic radii, ionization potential, electronegativity, electron affinity * Occurrence and isolation of the elements * Factors influencing the choice of extraction process. * General properties of the elements * Comparative study of S- and P- block elements and their important compounds. * Alkali metals- solubility in NH3, Hydration energy and mobility of ions. * Alkaline-earth metals - Be- anomalous behavior, Grignard reagent, chlorophyll and biological properties of Ca and   Mg,   * Group III- Principle of extraction of Al, Alums. * Group IV- Structure and allotropy of the elements, Difference between C, Si and other remaining elements. Carbon clusters- Fullerene (preparation, structure and application). * Group V- Nitrogen cycle, liquid ammonia as solvent, phosphate fertilizers, and role of phosphate esters in biological process. * Group VI - Acid rain, difference between oxygen and other elements. * Group VII - Perchloric acids * Group Zero - Isolation of Noble gases | 20 |
| * Explain the general trends in electronic configuration, ionic and covalent radii, electronegativity, electron affinity, ionization potential, color and magnetic properties, variable valences, complex formation with reference to 3d- block elements. * Describe general introduction of first transition (3d) and second transition (4d) series. * Compare the elements of 3d series and 4d series in terms of electronic configuration, reactivity of elements, stability of oxidation states, highest oxidation states, stability of complexes, bio-inorganic chemistry of iron and copper. | **Unit V: Chemistry of d-Block Elements and their Important Compounds.**   * General trends in electronic configuration, ionic and covalent radii, electronegativity, electron affinity, ionization potential, color and magnetic properties, variable valences, complex formation with reference to 3d- block elements. * General introduction of first-transition (3d) and second transition (4d) series. * Comparison of the elements of 3d series with 4d transition series in terms of electronic configuration, reactivity of elements, stability of oxidation states, highest oxidation states, stability of complexes. Bioinorganic chemistry of iron, and copper. | 10 |
| * Define different terms related with thermo dynamics and classify different types of thermodynamic systems. * Compare extensive and intensive properties. * Explain equilibrium and non- equilibrium states * Explain thermodynamic processes. * Compare reversible and irreversible processes * Explain internal energy * State and explain the first law of thermodynamics * Explain the enthalpy of system * Solve the related numerical problems. | **Unit VI : Thermodynamics**   * Some thermodynamic terms and definitions * Extensive and Intensive properties * Thermodynamic processes * Internal energy * First law of thermodynamics * Enthalpy of system * Numerical problem. | 12 |
| * Explain enthalpy of reactions * Differentiate exothermic and endothermic reactions. * Explain thermo-chemical equations * Classify and explain types of enthalpy of reactions. * Explain heat of combustion and its applications. * Explain the heat of solution, neutralization, vaporization, sublimation and transition. * Define and explain Hess’s law of constant heat of summation and its application. * Describe bond energy. * Explain molar heat capacity at constant pressure and volume. * Relate and deduce the equation between Cp and Cv. * Describe calorific value of fuel and food. * Solve the related numerical problems. | **Unit VII: Thermo Chemistry**   * Enthalpy of reaction, exothermic and endothermic reactions. * Heat of combustion and its applications. * Heat of solution, neutralization, vaporization, sublimation and transition. * Hess's law of constant heat of summation and its applications. * Bond energy * Molar heat capacity at constant pressure volume * Relation between Cp and Cv * Calorific value of fuel and food * Related numerical problems | 10 |
| * State and explain the kinetic theory of gases. * Derive the kinetic gas equation * Explain average kinetic energy of gas molecules * Describe molecular interpretation of temperature * State and explain various gas laws * Deduce Boyle's, Charles’s, Graham’s of diffusion Avogadro's and Dalton's law of partial pressure from the kinetic gas equation. * Explain different types of speeds of gaseous molecules * Explain the collision properties. * Solve related numerical. * Explain deviation from ideal gas equation by real gases. * Justify the causes of deviation of real gas. * Explain Van der Waal’s equation. * Explain critical phenomenon in liquefaction of gases. * Explain the various methods of liquefaction of gasses. | **Unit VIII. Gaseous state**   * Kinetic theory of gases * Kinetic gas equation * Average kinetic energy of gas molecules * Molecular interpretation of temperature * Gas laws * Deduction of gas laws from the kinetic gas equations; (Boyle's law, Charles’s law, Graham's law of diffusion, Avogadro's Dalton's law of partial pressure) * Different types of speeds of gaseous molecules(root mean square, average and most probable speed) * Collision properties (collision   diameter, collision frequency mean free path)   * Related numerical * Deviation from ideal gas equation by real gases. * Causes of deviation and Van der Waal’s equation. * Critical phenomenon * Liquefaction of gases(Faraday’s, Linden’s and Claude’s method | 15 |
| **:**   * Explain the qualitative behavior of liquids * Define and explain surface tension. * Determine surface tension by drop weight method. * Define and explain viscosity. * Determine the viscosity by Ostwald's viscometer * Describe the effect of temperature on surface tension and viscosity. * Explain the applications of surface tension and viscosity measurement. | **Unit IX: Liquid States**   * Qualitative treatment of liquids * Surface tension and its determination by drop weight method * Viscosity and determination of viscosity by Ostwald's viscometer. * Effect of temperature on surface tension and viscosity. * Applications of surface tension and viscosity measurements. | 5 |
| * Explain the characteristic properties of crystalline and amorphous solids * Explain crystal structure and unit cells (simple, body centered and face centered cubic) * Classify the solids on the basis of dominant bonds and explain their properties with examples | **X. Solid State**   * Properties of crystalline and amorphous solids * Crystal structure and unit cells * Classification of solid on the basis of Dominant type of bond (ionic, covalent, metallic and molecular crystals) with examples and their properties. | 6 |
| * Define, classify and name the alkyl halides. * Explain the general methods of preparation of alkyl halides with examples. * Describe the physical properties. * Explain nucleophilic substitution reactions of alkyl halides with examples. * Differentiate SN1 and SN2 reactions in terms of mechanism, kinetics, reactivity and stereo- chemistry * Justify the rearrangement of carbocation on the basis of stability. * Explain E1 and E2 reaction with examples. * State and apply Saytzeff's rule. * Give Wurtz reaction and reaction of alkyl halide with magnesium. | **XI. Alkyl Halides**   * Introduction, classification, nomenclature of alkyl halides * General preparation of alkyl halides * Physical properties * Chemical properties (nucleophilic substitution reactions: SN1 and SN2- reactions, mechanism, kinetics, reactivity and stereochemistry of SN1 and SN2 reactions) * Rearrangement of carbocations * Comparative study between SN1 and SN2 reactions * Elimination reactions (E1 and E2 reactions, Saytzeff's rule) * Wurtz reaction * Reaction with magnesium | 10 |
| Define and name alcohols.   * Classify and explain the structure and isomerism of alcohols. * Describe the physical properties of alcohols * Explain the general preparation of alcohols. (from alkyl halides, alkenes, aldehydes and ketones, Hydroboration - oxidation) * Describe fermentation process of preparation of alcohols * Explain the acidic and basic properties of alcohols * Explain the reactions of alcohol with phosphorus halides, thionyl chlorides, sulphuric acid with mechanism, carboxylic acids, oxidation, reduction) * Define and name ethers * Classify and explain structure of ethers * Explain the methods of preparation of ethers (Dehydration of alcohols, Williamson synthesis) * Describe physical properties and uses of alcohols and ethers * Explain the reactions of ethers (halogenations , formation of oxonium salt, formation of peroxide, reaction with HI, PCl5, Al2O3 , steam) | **XII. Alcohols and Ethers**   * Introduction, Nomenclature Classification Isomerism and   structure of alcohols   * Physical properties * Preparation alcohols (from alkyl halides, alkenes, aldehydes and ketones, Hydroboration-oxidation), fermentation * Chemical properties (Alcohols as acids and bases, reaction with phosphorus halides,   thionyl chlorides, sulphuric acid, carboxylic acids, oxidation, reduction)   * Introduction, nomenclature, classification structure * methods of preparation (Dehydration of alcohols, Williamson synthesis) * Physical properties * Chemical properties (Halogenations, formation of oxonium salts, formation of peroxide, reactions with HI, steam, PCl5, Al2O3) * Uses | 8 |
| * Define and name aldehydes and ketones * Describe isomerism and physical properties of aldehydes and ketones. * Describe the structure of carbonyl group. * Explain the reactions of carbonyl compounds with HCN and its mechanism, NaHSO3, RMgX, alcohols with mechanism, ammonia derivatives with mechanism * Explain Aldol condensation, Cannizaro's reactions with reaction mechanism. * Distinguish aldehydes and ketones by oxidation processes. * Convert aldehydes and ketones into alcohols, alkanes by reduction processes. | **XIII. Aldedydes and Ketones**   * Introduction, Nomeuclature, Isomerism * Structure of the carbonyl group * Methods of preparation (oxidation of alcohols, dehydrogenation of alcohols, ozonolysis of alkenes, hydration of alkynes, oxo- process) * Physical properties * Chemical properties: * (Nucleophilic addition reactions- addition of HCN, NaHSO3, RMgX, alcohols, ammonia derivatives) * Aldol condensation, Cannizaro's reaction, * Oxidation(with KMnO4/H+, Tollen's reagent, Fehling's solution) * Reduction (Catalytic, Chemical, Clemmensen reduction, Wolf-Kishner reduction) | 12 |
| * Define, classify and name carboxylic acids. * Explain the general methods of preparation of carboxylic acids (Oxidation of primary alcohols or aldehydes, hydrolysis of nitriles, reaction of Grignard reagents with CO2) * Describe physical properties of carboxylic acids * Explain the acidity of carboxylic acids and effect of substituent’s on acidity. * Explain the reactions of salt formation, formation of acid halides, acid anhydrides, esters, acid amides, reduction, HVZ- reaction) * Explain the general introduction, nomenclature, preparation, physical properties, chemical reaction and acid derivatives (acid chlorides acid anhydrides, esters and acid amides) | **XIV. Carboxylic Acids and Derivatives**   * Introduction, Classification, Nomenclature * Methods of preparation (Oxidation of primary alcohols or aldehydes, hydrolysis of nitriles, reaction of Grignard reagents with CO2) * Physical properties * Chemical properties (acidity of carboxylic acids, effect of substituents on acidity, salt formation, formation of acid halides, acid anhydrides, esters, acid amides, reduction, HVZ- reaction) * Chemistry of acetyl chloride, acetic anhydride, ester and acetamide. | 12 |
| * Name and classify alicyclic compounds. * Describe the industrial source and general preparation of alicyclic compounds. * Explain chemical reactions of cycloalkanes * Explain the stability of cycloalkanes (Baeyer's strain theory, Sachse-Mohr theory) * Explain the factors affecting the stability of conformations. * Draw conformational structures of cyclohexane. * Explain conformational analysis of cyclohexane. * Differentiate equatorial and axial bonds. * Describe 1, 3- diaxial interaction with examples. | **XV. Alicyclic Compounds**   * Nomenclature, Classification, Industrial source * General preparation * Chemical reactions * stability of cycloalkares (Baeyer's strain theory, Sachse- Mohr theory) * Factors affecting stability of conformations * Conformational structures of cyclohexane * Equatorial and axial bonds * 1, 3 - diaxial interaction and stability of methyl cyclohexane. | 8 |

*Note: The number in the parenthesis indicate allocated teaching hours for each unit.*

**4. a. Instructional Techniques (Theory)**

The instructional techniques for this course are divided into two groups. First group consists of general instructional techniques application to most of the units. The second group consists of specific instructional techniques applicable to specific units.

**4.1. a. General Instructional Techniques**

* Lecture method
* Discussion method
* Demonstration method
* Project method
* Problem solving method
* Collaborative method
* Case study method
* Seminar/Workshop method

1. **Evaluation: Theory part**

The annual examination of theoretical part will be held by the Office of the Controller of Examinations. The types and number of question to be included in the annual examination are given below.

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| --- | --- | --- | --- |
| Types of questions | Total questions to be asked | Number of questions to be answered and marks allocated | Total marks |
| Group A: Multiple choice items | 14 questions | 14 × 1 mark | 14 |
| Group B: Short answer questions | 6 with 3 or questions | 6 × 7 marks | 42 |
| Group C: Long answer questions | 2 with 1 or question | 2 × 12 marks | 24 |

**Part II: Practical**

**General objectives**

* Develop observational, manipulative, calculative and interference drawing skills.
* Develop in students' ability to perform experiments having due regard for safety.
* Maintain record base of the performed experiments.

**Specific Objectives and Contents**

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| * Determine quantitative amount of chlorine chlorides. * Determine permanent and temporary hardness of water. * Prepare the inorganic compounds: tetramine copper sulphate, Prussian blue, Potash alum. * Determine surface tension & viscosity. * Determine heat of neutralization & heat of solution. * Identify organic compounds. (at least 8 samples) * Prepare Organic compounds: benzoic acid, salicylic acid, aspirin and methyl orange. | **Experiments:**   * Chlorides & free chlorine dissolved in water. * Permanent & temporary hardness of water. * Preparation of inorganic compounds: tetra amine, copper sulphate, prussian blue, potash alum. * Determination of surface tension by using Stagnometer. * Determination of viscosity by using Ostwald's viscometer. * Heat & neutralization & heat of solution. * Identification of organic compounds. * Preparation of organic compounds: benzoic acid, salicylic acid, aspirin, methyl orange. |

**Evaluation: Practical Part**

The marks allocated to practical part are given in the following table.

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| --- | --- | --- | --- |
| **Examination** | **Area of examination** | **Marks** | **Total** |
| Internal | Regularity | 1 | 4 |
| Regular practical performance | 1.5 |
| Record Book | 1.5 |
| External | Experiment | 12 | 16 |
| Viva | 4 |

**Recommended Books:**

Bahl, A., Bahl B.S. (2000). *A text book of organic chemistry*. New Delhi: S.Chand and Company. Ltd. (XI-XV units)

Lee, J.D. (2007). *Concise inorganic chemistry (5th edition).* John Wiley and Son, Inc.. (I-V units)

Madan, R.D., & Prakash, S, (1994). *Modern inorganic chemistry*. New Delhi: S.Chand and Company Ltd. (I-V units)

Maron, S.H., & Prutton, C.F. (1992). Principles of physical chemistry (4th edition). Oxford and IBH Publishing.Co. Pvt. Ltd. (VI-X units)

Morrison, R.T., & Boyd, R.N. (2008). *Organic chemistry (7th edition.* India: Prentice - Hall of India Pvt. Ltd. 2008. (XI-XV units)

Pandit C.N., Subedi, R.R, & Tiwari, P. (2011), *A Text book of chemistry.* Kathmandu: Cambridge Publication. (I-XV units)

Pokharel, M.R., & Poudel, B.R. (2011). *A Text book of inorganic chemistry*. Kathmandu: National Book Centre. (I-V units)

Sthapit, M. K., & Pradhananga R.R.(2065). *A Text book of physical chemistry*. Kathmandu: Taleju Prakashan, (VI-X units)

**Books for Practical Courses:**

Dhaubdel, S.P., Pradhan, K.P., & Joshi, S.M, *Practical Chemistry Guide for B.Sc.*Kathmandu, Nepal

Khadka, N.M., Gautam, S.D., & Yadav, P.N., A core experimental chemistry for B.Sc. Kathmandu: Kadea Book Centre,

Sthapit, M.K., & Pradhananga (1998). R.R., *Experimental physical chemistry*. Kathmandu: Taleju Prakashan.

Vishnoi, N.K. (1985). *Advanced practical organic chemistry*. India: Vikas Publishing House Pvt. Ltd.