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| Course title : **Chemistry IV** | Full marks : 100 (80T + 20P) |
| Course No. : Sc. Ed. 445 | Pass marks : 28T + 8P |
| Nature of the course : Theoretical (T) & Practical (P)  Level : B.Ed. (4 Year) | Periods per week : 9 (6T + 3P) ,  Practical ( 3P) : 3 pds/week /gr |
| Year : Fourth | Total Periods : 150 |

**1. Course description:**

This course has two parts - theory and practical. The theoretical part consists of detailed knowledge about the selected topics in each inorganic, organic and physical chemistry - hydrogen & heavy water, coordinate compounds, reactions involving complex formation, noble gases, non-aqueous solvents, phase-equilibrium, adsorption, electrolytic conductance, electrochemical cells, nitro compounds, amines, malonic ester & Acetoacetic ester synthesis, aromaticity, reactive intermediates and spectroscopy. The students are required to secure pass marks in theory and practical separately.

**2. General objectives:**

The general objectives of this course are as follows:

* To provide advanced knowledge about some selected topics of inorganic, organic and physical chemistry.
* To introduce the knowledge about the spectroscopical techniques for identification of organic compounds.
* To promote the advanced studies in chemistry.
* To develop the experimental skills and recording of the experimental outputs

**3. Specific Objectives and Contents**

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| **Specific Objectives** | **Contents** | **Teaching hour** |
| * Identify the different types of hydrogen - Nascent hydrogen, Absorbed hydrogen, Active hydrogen, Atomic hydrogen * Differentiate ortho-hydrogen and para-hydrogen. * Explain the isotopes of hydrogen. * Describe the function (reactions), sources and effects of heavy water. | **Unit 1 Hydrogen and Heavy water**  1.1 Reactive forms of Hydrogen  1.1.1 Nascent Hydrogen  1.1.2 Absorbed Hydrogen  1.1.3 Active Hydrogen  1.1.4 Atomic Hydrogen  1.2 Ortho and Para Hydrogen  1.3 Isotopes of Hydrogen   * 1. Heavy water or Deuterium oxide (D2 O) | 10 |
| * Explain valence bond theory. * Draw and predict the shape of complex compounds- K4[Fe6(CN)6], K3[Fe(CN)6], [NiII (NH3)4] So4 [Ni (CN)4]2– according to VBT. * Describe Crystal Field Theory. | **Unit 2 Coordination compounds**  2.1 Introduction  2.2 Theories of Bonding in Coordination Compounds  2.2.1 Valence Bond Theory (VBT)  2.2.1.1 VBT and shape of complex compounds  2.2.1.1.1 Octahedral Complexes, K4 [Fe (CN)6], K3Fe(CN)6  2.2.1.1.2 Tetrahedral Complexes, [NiII (NH3)4]SO4  2.2.1.1.3 Square Planar Complexes, [Ni (CN)4]2  2.2.2 Crystal Field Theory | 10 |
| * Explain the complex formation reactions. * Differentiate between complex salt and double salt. * Illustrate the complex forming reactions with NaOH, KI and NH3 | **Unit 3 Reactions Involving Complex Formation**  3.1 Complex Formation  3.2 Difference between Complex salt and Double salt  3.3 Some complex forming reactions  3.3.1 Reactions with NaOH  3.3.2 Reactions with KI  3.3.3 Reactions with NH3 | 10 |
| * Define rare gases and explain the sources of rare gases. * Describe the process of isolation of rare gases from the air and liquid air. * Illustrate the properties of rare gases * Explain the structure, preparation and properties of the compounds of inert gases - Xe F2, XeF4. | **Unit 4 Elements of Zero Group (Noble Gases)**  4.1 Introduction  4.2 Sources of Rare Gases  4.3 Isolation of Rare Gases from the Air  4.4 Isolation of Rare Gases from Liquid Air  4.5 Properties of Rare Gases  4.6 Compounds of Inert Gases  4.6.1 Compounds of Xe – XeF2 (Structure, preparation, Properties)  – XeF4 (Structure, Preparation, Properties) | 8 |
| * Define & classify the solvents. * Explain liquid ammonia as solvent * Explain advantages, disadvantages of using liquid ammonia as solvent * Describe auto-ionization of liquid ammonia * Illustrate chemical reactions occurring in liquid ammonia - Precipitation reactions, Ammonia as a Proton-acceptor, Redox reaction | **Unit 5 Non Aqueous Solvents**  5.1 Introduction  5.2 Classification of Solvents  5.3 Liquid Ammonia as Solvent  5.3.1 Advantages of Using Liquid Ammonia as solvent  5.3.2 Disadvantages of Using Liquid Ammonia as solvent  5.3.3 Auto-Ionisation of Liquid Ammonia  5.3.4 Chemical Reactions Occuring in Liquid Ammonia   * + - 1. Precipitation Reaction   5.3.4.2 Ammonia as a Proton-Acceptor  5.3.4.3 Redox Reaction | 12 |
| * Define and explain the terms - phase, component, degree of freedom. * State and explain phase rule (Gibbs phase rule). * Draw and explain the phase diagram of one component system solid-solid system. * Draw and explain the phase diagram of two component system (solid-liquid system). * Define & discuss cooling curves. * Explain simple Eutectic Pb-Ag system. * Describe desilverization of lead. | **Unit 6 Phase - equilibrium**  6.1 Introduction  6.2 Definition and Meaning of the Term - Phase  6.3 Component and Degree of Freedom  6.4 Gibbs phase rule  6.5 Phase Diagram  6.6 Phase equilibrium of One Component System (Solid-Solid System)  6.7 Phase equilibrium of Two Component System (Solid-Liquid System)  6.7.1 Introduction of Cooling Curves  6.7.2 Simple Eutectic Pb - Ag System  6.7.3 Desilverization of Lead | 18 |
| * Explain the adsorption of a dye by charcoal * Explain the adsorption of a gas by charcoal. * Distinguish between adsorption and absorption. * Describe the mechanism of adsorption. * Define physical adsorption & chemical adsorption. * Differentiate the physical adsorption & chemical adsorption * Describe different types of adsorption. | **Unit 7 Adsorption**  7.1 Adsorption of a Dye by Charcoal  7.2 Adsorption of a Gas by Charcoal  7.3 Adsorption Versus Absorption  7.4 Mechanism of Adsorption  7.5 Type of Adsorption  7.5.1 Physical Adsorption  7.5.2 Chemical Adsorption or Chemisorption  7.5.3 Difference between Physical and Chemical Adsorption  7.6 Adsorption of Gases by Solids | 10 |
| * Describe strong electrolytes & weak electrolytes. * Define the terms electrical resistance and conductance. * Explain conductance, specific conductance and conductivity water preparation. * Distinguish between equivalent conductivity and molar conductivity. * Determine specific conductance, equivalent conductance and molar conductance. * Relate between equivalent conductance and molar conductance. * Explain the effect of dilution on conductance | **Unit 8 Electrolytic Conductance**  8.1 Introduction  8.2 Strong Electrolytes and Weak Electrolytes  8.3 Electrical Resistance and Conductance  8.3.1 Conductance  8.3.2 Specific Conductance  8.3.3 Conductivity Water Preparation  8.4 Equivalent and Molar Conductivities  8.4.1 Equivalent Conductivity  8.4.2 Molar Conductivity  8.4.3 Determination of Specific Conductance  8.4.4 Determination of Equivalent and Molar Conductance  8.4.5 Relation between Equivalent and Molar Conductance  8.4.6 Variation of Conductance with Dilution | 10 |
| * Describe electrochemical cells, electrolytic cells and galvanic cell. * Differentiate between a galvanic cell and electrolytic cell. * Describe redox reaction in electrochemical cell. * Explain the working principle of Daniell cell. * Explain single electrode potential and standard hydroen electrode. * Measure EMF of a cell. * Measure standard electrode potential. | **Unit 9 Electrochemical Cells**  9.1 Electrochemical Cells  9.2 Electrolytic Cells  9.3 Redox Reaction  9.4 Galvanic Cell  10.4.1 Zn - Cu Cell (Daniell Cell)  9.5 Single Electrode Potential and Standard Hydrogen electrode  9.6 Measurement of EMF of a Cell  9.7 Measurement of Standard Electrode Potential | 10 |
| * Describe the different types of nitrocompounds. * Describe the methods of preparation of nitroalkanes from alkanes, haloalkanes and primary amines. * Explain the physical properties of nitro compounds. * Describe the reaction of nitro - compounds with alkali, halogen, aldehydes, nitrous acid and reduction.   . | **Unit 10 Nitro Compounds**  10.1 Introduction  10.2 Preparation  10.2.1 From Alkanes by Nitration  10.2.2 From Haloalkanes  10.2.3 From Primary Amines  10.3 Physical Properties  10.4 Chemical properties  10.4.1 Reaction with Alkali (NaOH)  10.4.2 Reaction with Halogen  10.4.3 Reaction with Aldehydes  10.4.4 Reaction with Nitrous Acid  10.4.5 Reduction | 8 |
| * Define and describe the various types of amines. * Describe the general methods of preparation of amines. * Separate 1°-, 2° - 3°- amines by Hofmann's method. * Describe the physical properties of amines. * Explain and compare the basicity of different classes of amines. * Describe the chemical reaction of amines - alkylation, reaction with acid chlorides, nitrous acid. | **Unit 11 Amines**  11.1 Introduction  11.2 Preparation  11.2.1 From Haloalkanes  11.2.2 From Alcohols  11.2.3 Separation of Mixture of 1°-,2°-and 3°- Amines (Hofmann's Method)  11.2.4 Preparation of Amines by Reduction  11.2.5 Preparation of Amines by Hydrolysis  11.2.6 From Amides  11.3 Physical properties  11.4 Chemical properties  11.4.1 Basicity of Amines  11.4.2 Alkylation of Amines  11.4.3 Reaction with Acid Chlorides  11.4.4 Reaction with Nitrous Acid | 7 |
| * Describe the general introduction & acidity of – CH2 – group of malonic ester & acetoacetic ester. * Explain the malonic ester synthesis – to prepare mono alkyl– acetic acid, dialkylacetic acid. * Explain the acotoacetic ester synthesis (i.e. uses of acetoacetic ester) - to prepare mono alkyl and dialkylacetic acid, methyl ketoses. | **Unit 12 Malonic Ester and Acetoacetic Ester** **Synthesis**  12.1 Malonic Ester  12.1.1 Introduction  12.1.2 Acidity/Reactivity of - CH2 - Group  12.1.3 Synthetic uses  12.1.3.1 Synthesis of Alkylacetic Acid  12.1.3.2 Synthesis of Dialkylacetic Acid  12.2 Aceto-acetic Ester  12.2.1 Introduction  12.2.2 Acidity/Reactivity of - CH2 - Group  12.2.3 Synthetic uses  12.2.3.1 Synthesis of Dialkylacetic Acid   * + - 1. synthesis of Methyl Ketones | 6 |
| * Describe the brief history about the structure of benzene. * Draw and describe Kekule & resonance structures of benzene and molecular orbital diagram of benzene. * Explain the stability of benzene due to resonance (aromaticity). * Illustrate aromaticity and Huckel's rule. * Illustrate aromaticity of the species - three, five & six membered ring systems. * Explain the effects of substituents on reactivity of benzene * Illustrate the orientation of mono - substituted benzene - phenol , nitrobenzene, chlorobenzene | **Unit 13 Aromaticity**  13.1 Introduction  13.2 Structure of Benzenc  13.2.1 Kekule structure  13.2.2 Resonance structure  13.2.3 Molecular Orbital Structure  13.3 Stability of Benzene (Resonance Energy)  13.4 Huckel's Rule and Arornaticity  13.5 Aromaticity in Benzene and other Cyclic System  13.5.1 Aromaticity of Three Membered Ring systems  13.5.2 Aromaticity of Five Membered Ring System  13.5.3 Aromaticity and Six Membered Ring System  13.6 Effect of Substituents on Reactivity of Benzene  13.7 Orientation of Mono-Substituted Benzene (Phenol, Nitrobenzene, Chlorobenzene) | 12 |
| * Describe the general introduction about reactive intermediates. * Explain the structure and stability of carbocations. * Explain the structure and stability of carbanions. * Explain the structure and stability of alkyl free radicals. | **Unit 14 Reactive Intermediates**  14.1 Introduction  14.2 Carbocations  14.2.1 Stability of Carbocations  14.2.2 Structure of Carbocation  14.3 Carbanions  14.3.1 Stability of Carbanions  14.3.2 Structure of Carbanion  14.4 Alkyl Free Radicals  14.4.1 Stability of Alkyl Free Radicals  14.4.2 Structure of Alkyl Free Radicals | 7 |
| * Describe the general introduction about spectroscopy and structure of organic molecules. * Explain the general principle and application of ultraviolet visible spectroscopy in identification of organic compounds. * Explain the general principle and application of IR-spectroscopy. * Describe NMR - spectroscopy and its application in identification of organic compounds. * Describe the principle of mass spectroscopy & its application in identification of organic compounds | **Unit 15 Spectroscopy and Structure**  15.1 Introduction  15.2 Ultraviolet-Visible Spectroscopy  15.3 Infrared Spectroscopy  15.4 Nuclear Magnetic Resonance (NMR) Spectroscopy  15.5 Mass Spectroscopy | 12 |

**Part II : Practical**

**General Objectives of practical course**

* To develop observational, manipulative, calculative and interference drawing skills.
* To develop ability to perform experiments with safety handling of apparatus and chemicals.
* To maintain record base of the performed experiments.

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| **Specific Objectives** | **Contents** | **Teach. hr.** |
| * To carry out the qualitative analysis of the mixture of three salts. (at least four samples). | Qualitative analysis of the mixture of three inorganic salts. | 30 |
| * To prepare the standard buffer solutions using ammonium hydroxide and ammonium chloride and determine the pH of unknown solution using universal indicators. * To prepare the standard buffer solutions using sodium acetate and acetic acid and determine the pH of unknown solution using universal indicator | 1. Preparation of basic buffer solution. 2. Preparation of acidic buffer solution. | 15 |
| * To identify the given sample of mono-functional organic compounds. (at least four samples). | Identification of mono functional organic compounds | 30 |

**4. Teaching methodology**

Lecture, Discussion, Demonstration, Problem solving, collaborative, experimental, Internet search.

**5. Evaluation**

**Theory part**

Annual examination of the theoretical part will be held by the office of the Controller of Examinations at the end of the academic session for which 80 percent of the total marks will be allocated. The number and types of questions are given below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group** | **Types of questions** | **Total questions to be asked** | **No. of questions to be answered and marks allocated** | **Total marks** |
| Group A | Multiple Choice items | 14 | 14×1 | 14 |
| Group B | Short answer questions | 6 with 2 or questions | 6×7 | 42 |
| Group C | Long answer questions | 2 with 1 or question | 2×12 | 24 |
| Total | | | | 80 |

**Practical Part**

Annual examination of the practical part will be held by the office of the Controller of Examinations at the end of the academic session for which 20 percent of the total marks will be allocated. 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 and Reference Books**

Bahl A. & Bahl B.S.( 2007 ). *Text Book of Organic Chemistry*. S.Chand & comp. Ltd., New Delhi

**(Unit 11 to 16).**

Bahl B.S., Tuli G.D., Bahl Arcon ( 1997). *Essemtials of Physical Chemistry*. S..Chand & Company

Ltd. 1997, New Delhi (Unit 1 to 6).

Chapagain S. K. & Mishra B. (2067). A Textbook of B.Sc. Physical Chemistry. Sukunda Pustak Kalsi

Bhawan, Bhotahity, Kathmandu.

Kalsi, P.S.(1999). *Text Book of Organic Chemistry*. Macnillan Ind. Ltd. **(Unit 11 to 16).**

Malik W.U., Tuli G.D. and Madan R.D.(1997*). Selected Topics in Inorganic*. Chamistry S.Chand &

Company Ltd., New Delhi(Unit 1 to 6).

Maron S.H., Prutton C.F. *Principles of Physical Chemistry* Oxford & IBH Publishing Co.Pvt.Ltd.

New Delhi (Unit 7 to 10)

Morrison R.T. and Boyd R.N. *Organic Chemistry*. Allyn & Bacon Inc., Universal Book Stall (New

York University) (Unit 7 to 10).

Prakash, S., Tuli G.D., Basu S.K., Madan R.D. *Advanced Inorganic Chemistry*. S. Chand & Sthapit

Company Ltd., New Delhi(Unit 1 to 6).

Sthapit, M.D. and Pradhanary R.R. *A Text Book of Physical Chemistry*. R.R. Taleju Prakashan,

Kathmandu(Unit 7 to 10)

**Recommended Books for Practical**

1. Dhaubdel S.P., Pradhan K.P., Joshi S.M., *Practical chemistry Guide for B.Sc.*

2. Khadka, N.M., Gautam. SD.. & Yadav,P.N. (2013). *A Core Experimental Chemistry for B.Sc*., Heritage Publication, Kath.

3. Sthapit M.K. & Pradhananga R.R.(1998). *Experimental Physical Chemistry*, Taleju Prakashan, Kathmandu.

4. Vogel A.I.(1958 preferably available recent edition). *A text Book of Practical Organic Chemistry. Including Qualitative Organic Analysis,* Longmans.