SEMESTER IV

INORGANIC & PHYSICAL CHEMISTRY

THEORY

Program: B.Sc. **Max. Hours: 60**
Course Code: U20/CHE/DSC/401 **Hours per week: 4**
Course Type: DSC-4 **Max. Marks: 100**
No. of Credits: 4

COURSE OBJECTIVES:

- To understand the nature and properties of d & f-block elements.
- To learn about organometallic chemistry and the application of metals ions in the biological systems.
- To acquire knowledge on qualitative analysis and apply practically.
- To know the basic concepts of thermodynamics and to explain thermodynamic properties.
- To elucidate the use of chemical kinetics in understanding reaction mechanisms and to apply the theories and concepts of it for homogenous and heterogeneous catalyzed reactions
- To understand the photochemical reactions.

COURSE OUTCOMES:

CO 1: Acquire knowledge about the properties of d & f-block elements and their separation techniques.

CO 2: Interpret the concepts of semi micro analysis, non-aqueous solvents, organometallic chemistry, bonding in metals and the role of metal ions in biological systems.

CO 3: Describe the fundamental laws and concepts of thermodynamics.

CO 4: Comprehend the concepts of kinetics and apply the principles in calculating reaction rates, activation energies, order of reactions. Summarizes the laws and various photo processes in Photochemistry.

INORGANIC CHEMISTRY

MODULE 1: d & f BLOCK ELEMENTS AND THEORIES OF BONDING IN METALS (15 Hrs)

d- BLOCK ELEMENTS (6Hrs)

Chemistry of d-block elements : Characteristics of d-block elements with special reference to electronic configuration variable valency, ability to form complexes, magnetic properties. Determination of magnetic susceptibility using Guoy's balance & catalytic properties. Stability of various oxidation states and Standard reduction potential. Comparative treatment of second and third transition series with their 3d analogues. Study of Ti, Cr and Cu triads. Titanium triad – electronic configuration and reactivity of +3 and +4 states – oxides and halides. Chromium triad – reactivity of +3 and +6 states. Copper triad – reactivity of +1, +2 and +3 states.

CHEMISTRY OF f-BLOCK ELEMENTS (5 Hrs)

Chemistry of Lanthanides: Position in periodic table, Electronic structure, oxidation state, ionic and atomic radii- lanthanide contraction- cause and consequences, anomalous behaviour of post lanthanides- complexation- type of donor ligands preferred. Magnetic properties- paramagnetism. Colour and spectra, f-f transitions –occurrence and separation – ion exchange method, solvent extraction. Chemistry of actinides- general features – electronic configuration, oxidation state, actinide contraction, colour and complex formation. Comparison with lanthanides.

THEORIES OF BONDING IN METALS (4 Hrs)

Valence bond theory, Explanation of metallic properties and its limitations, Free electron theory, thermal and electrical conductivity of metals, limitations, Band theory, formation of bands, explanation of conductors, semiconductors n-type and p-type, extrinsic & intrinsic semiconductors, and insulators.

MODULE 2: ORGANOMETALLIC COMPOUNDS, SEMI-MICRO ANALYSIS, BIO – INORGANIC CHEMISTRY&NON AQUEOUS SOLVENTS (15 Hrs)

ORGANOMETALLIC CHEMISTRY (4 Hrs)

Definition, nomenclature and classification of organometallic compounds.Methods of preparation, properties and applications of alkyl and aryl compounds of Li, Mg &Al. Preparation and properties of ferrocene.

GENERAL PRINCIPLES OF INORGANIC QUALITATIVE ANALYSIS (3 Hrs)

Anion analysis: Theory of sodium carbonate extract, classification and reactions of anions- CO_3^{2-}, Cl Br^-, SO_4^2 PO_4^3 BO_3^{3-}.CH_3COO^-, NO_3

Cation Analysis: Principles involved - Solubility product, common ion effect, general discussion for the separation and identification of group I individual cations (Hg_2^{2+}, Ag^+, Pb^+) with flow chart and chemical equations. Principle involved in separation of group II & IV cations.

General discussion for the separation and identification of group II (Hg^{2+}, Pb^{2+}, Bi^{3+}, Cd^{2+}, Sb^{2+}), III (Al^{3+}, Fe^{3+}), IV ((Mn^{2+}, Zn^{2+}) individual cations with flow chart and chemical equations. Application of concept of hydrolysis in group V cation analysis. General discussion for the separation and identification of group V individual cations (Ba^{2+}, Sr^{2+}, Ca^{2+}) with flow chart and chemical equations. Theory of flame test. Identification of Group VI cations (Mg^{2+}, NH_4^+).

NON – AQUEOUS SOLVENTS **(4 Hrs)**

Classification and characteristics of a solvent. Reactions in liquid ammonia – physical properties, auto-ionisation, examples of ammono acids and ammono bases. Reactions in liquid ammonia – precipitation, neutralization, solvolysis, solvation - solutions of metals in ammonia, complex formation, redox reactions. Reactions in HF – auto-ionisation, reactions in HF – precipitation, acid – base reactions, protonation.

BIOINORGANIC CHEMISTRY **(4 Hrs)**

Essential elements, biological significance of Na , K, Mg, Ca, Fe, Co, Ni, Cu, Zn and chloride (Cl^-). Toxic metal ions As, Hg & Pb Oxygen transport and storage – structure of haemoglobin, binding and transport of oxygen. Fixation of CO_2 in photosynthesis- overview of light and dark reactions in photosynthesis. Structure of chlorophyll and coordination of magnesium. Electron transport in light reactions from water to $NADP^+$ (Z – scheme)

PHYSICAL CHEMISTRY

MODULE 3: THERMODYNAMICS: (15 Hrs)

Definition of thermodynamic terms: system, surroundings, types of systems, intensive and extensive properties, state and path functions and their differentials. Thermodynamic processes, concept of heat & work. First law of thermodynamics-statement, definition of internal energy & enthalpy, Heat capacity, heat capacities at constant volume & pressure and their relationship. Joule's law, Joule Thomson coefficient and inversion temperature. Calculation of W, q, dU, dH for expansion of ideal gases under isothermal & adiabatic conditions for reversible process. Temperature dependence of Enthalpy, Kirchoff's equation.

Second law of thermodynamics, need for the law, different statements of the law. Carnot's cycle and its efficiency, Carnot theorem, thermodynamic scale of temperature concept of Entropy, Entropy as a state function, entropy changes in cyclic reversible and irreversible phase changes. Entropy as a function of V&T. Entropy as a function of P&T. Entropy change in physical processes.

Gibbs and Helmholtz functions: Gibbs function (G) & Helmholtz function (A) as thermodynamic quantities. A&G as criterion for thermodynamic equilibrium and spontaneity. Their advantage over Entropy change. Gibbs equations and Maxwell relations. Variation of G with P, V& T.

MODULE 4: CHEMICAL KINETICS & PHOTOCHEMISTRY (15 Hrs)

CHEMICAL KINETICS (10 Hrs)

Rate of reaction, Factors influencing rate of reaction- concentration, temperature, pressure, solvent, light and catalyst. Concentration dependence of rates, mathematical characteristics of simple chemical reactions. Zero order, First order Examples- Decomposition of H_2O_2 and decomposition of oxalic acid, Second order, examples- Saponification of ester, $2O_3 \rightarrow 3O_2$, $C_2H_4+H_2 \rightarrow C_2H_6$ & Pseudo first order, Hydrolysis of methyl acetate, inversion of cane sugar Half-life. Determination of order of a reaction – differential method, method of integration, half-life method and isolation method. Arrhenius equation and concept of Activation energy, Theories of chemical Kinetics. Effect of temperature on rate of a reaction, simple collision theory based on hard sphere model. Elementary treatment of transition state theory.

PHOTOCHEMISTRY (5 Hrs)

Interaction of radiation with matter, difference between thermal and photochemical process.Lawsof photochemistry- Grothus Draper law, Stark Einstein law. Quantum yield, Problems based on quantum efficiency. photochemical combinations of Hydrogen- Chlorine & Hydrogen –Bromine. Jablonski diagram depicting various process occuring in excited state. Qualitative description of Fluorescence, phosphorescence, non radiative process (internal conversion, intersystem crossing).

Text Books:

1. Malik, W.U., Tuli G.D., and Madan, R.D. (2004). *Selected Topics in Inorganic Chemistry*.Ram Nagar, New Delhi: S. Chand and Company.
2. Puri, B.R., Sharma, L.R., Kalia, K.C., (2006). *Principles of Inorganic Chemistry.* Pitampura, Delhi: Vallabh Publications.
3. Puri, B.R., Sharma L.R., and Pathania, M.S. (2003). *Elements of Physical Chemistry.* Jalandhar, Delhi: Vishal Publishing Co.
4. Bahl, A,Bahl B.S & G.DTuli (2009). *Essentials of physical chemistry: A textbook for B. Sc. classes as per UGC model syllabus* (Rev. Multicoloured). New Delhi: S. Chand.

Reference Books:

1. Cotton, F.A., Wilkinson, G., And Gaus,P.L.(1995). *Basic Inorganic Chemistry*. Singapore: John Wiley And Sons.
2. Lee, J.D (1998). *Concise Inorganic Chemistry* (5th Edn.) Oxford: Blackwell Science.
3. Soni, P.L (1979). *A Textbook Of Physical Chemistry* (11th Edn.). New York: Academic Press.
4. Prutton, C., & Maron, S. (1965). *Principles Of Physical Chemistry* (4th Edn.). New York: Macmillan.

INORGANIC & PHYSICAL CHEMISTRY
MODEL QUESTION PAPER

THEORY

Course Code: U20/CHE/DSC/401 **Max. Marks: 60**
Credits: 4 **Max. Time: 2 Hrs**

SECTION - A

I. Answer the following **4X10=40 M**

I.

1. a) What is Lanthanide contraction? Explain its Consequences. (CO 1) 5M
   b) Explain the separation of lanthanides using ion exchange method. (CO 1) 5M

OR

2. What are Transition elements? Explain the general properties with reference to Complex formation, magnetic properties and variable oxidation states. (CO 1) 10M
3. a) Explain the classification of organometallic compounds based on metal-carbon Bond. (CO-3) 6M
   b) Discuss the Precipitation & neutralization reactions in liq. NH_3. (CO 3) 4M

OR

4. a) What is Common ion effect? Discuss its application in the separation of cations. (CO -2) 5M

   b) Discuss the structure of Haemoglobin? Explain its role as oxygen carrier. (CO2) 5M

5. a) Derive an expression for Work done in reversible isothermal expansion of an ideal gas (CO -4) 5M

   b) Show that for one mole of an ideal gas $Cp-C_v = R$ (CO 4) 5M

OR

6. Describe in detail the Carnot cycle. (CO 4) 10M
7. a) What is second order reaction? Derive the expression for k of Second order reaction. (CO 5) 5M

   b) Explain any two methods for the determination of order of a reaction. (CO 5) 5M

OR

8. a)Explain the terms Fluorescence and phosphorescence by using Jablonski diagram (CO 6) 5M

b) What is quantum yield? Explain the photochemical combination of H_2 and Cl_2, H_2 and Br_2. (CO 6) 5M

SECTION - B

II. Answer any <u>FOUR.</u> **4 x 5 = 20 M**

9 Write a short note on the Copper triad. (CO 1)

10 Explain the role of Calcium in Blood clotting. (CO 3)

11 What is a Solubility product? Explain why Zn^{+2} ions do not precipitate when H_2S is added in Group II. (CO 2)

12 Discuss the Arrhenius equation for temperature dependence of reaction rates. (CO 5)

13 Prove that Joule Thomson effect is an isenthalpic process.(CO 4)

14 Calculate the work done in an isothermal reversible expansion of one mole of an ideal gas at $27^{\circ}C$ from a volume of $10dm^3$ to $20dm^3$