Course Outcome of B.Sc Chemistry (H) of Ranaghat College

1st Semester

Course Outcome 1:

On completion of the **Inorganic** part,

Students will have an idea about the subatomic particles of an atom (neutron, proton and electron) and their characteristic differences. They will gain some knowledge regarding the important features of quantum mechanical model of an atom, different quantum numbers, radial and angular distribution curves, shapes of four orbitals (s, p, d and f), stability of half and full filled electronic configuration of an atom in terms of exchange energy, microstate explaining the possible arrangements of different atoms.

An idea will be developed to the students about the modern periodic table, which is a tabular arrangement of elements maintaining their atomic number, electronic configuration and recurring trends in chemical and physical properties. They will get a view about the actual amount of nuclear charge experienced by an outermost electron in a multi-electron system in terms of Slater's rule; reactivity of elements depending upon several factors like electronegativity, ionisation energy, electron gain enthalpy, atomic radii, metallic character, inert pair effect; calculation of ionic radii and electronegetivity using different measuring scales.

On completion of the **Physical** part,

Students get some fundamental understanding about the rate of a chemical reaction proportional to the number of collisions between the reactant molecules. An idea is developed about the distribution of speed of molecules in an ideal gas at a certain temperature using Maxwell-Boltzmann distribution. They develop the concept of pressure, temperature, average velocity, average energy etc. of gas molecules and will be able to derive the expressions of those properties using Kinetic Theory of gas and relate the average kinetic energy of molecules to their r.m.s speed and temperature of the gas. They learn the deviation of the properties of real gas behavior from an ideal gas, become capable to determine critical constants and to construct an equation of state that describes their properties. They also get information about the various intermolecular forces present in the system.

Students become able to describe the basic concept of Thermodynamics (First Law, Zeroth Law) in terms of changes in internal energy of the universe, system and surroundings, can develop the concepts of heat, work, internal energy, relation between heat capacities, entropy, enthalpy, reversibility, irreversibility, state and path functions. They get an idea about the relationship between the work done and the amount of heat produced by a mechanical system from Joule's experiment. Thermochemistry makes a student acquainted intimately with the study of heat and energy related to various physical transformations and chemical reactions.

Course Outcome 2:

In Inorganic practical, students get an elementary idea about primary and secondary standard solutions; learn using common laboratory apparatus. They become rich in the knowledge of acid –base titration, acid-base indicators and get a basic idea about the quantitative estimations.

In Physical practical, they get the concept of pH by color matching method; acquire some knowledge about solubility product and solubility of oxalic acid; become familiar with the concept of heat of neutralization of strong acid-base.

Course Outcome 3:

It gives to the students an elementary idea of basic structure, properties and reactivity of organic molecules; knowledge of hybridization, concept of aromaticity, different electronic effects, anomaly caused by steric hindrance. They get an overview on Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT). Development of some preliminary idea of electrophilic and nucleophilic reactions occur. Students can formulate several reaction mechanisms by correlating the fundamental properties of the reactants involved and can understand its importance. They get an idea about the structure and nature of intermediates like carbocations, carboanions, radicals and carbenes.

Students become familiar with the stereochemistry of organic compounds; able to do inter-conversion of Fischer to Newmann, Newmann to Sawhorse and others, able to assign R and S to given molecules; understand stereoselective and stereospecific reactions; acquire knowledge on topicity. They learn the concept stereochemistry and its importance; their rules and the concept of chirality.

Course Outcome 4:

Students become capable in performing experimental separation of mixture of organic compounds based on their solubility; determination of boiling points of different organic compounds and identification of different organic solid and liquid compounds by carrying out specific chemical tests.

2nd Semester

Course Outcome 5:

On completion of the **Inorganic** part,

Students become rich with the clear concept of oxidation, reduction, nature of oxidant-reductant; balancing the redox reactions; recognition of reactivity of elements based on activity series table; construction of electrochemical cell; determination of equilibrium constant; deviation of standard potential due to the effect external factors like pH, complexation etc. and introduction of formal potential. Students get familiar with the inter-related redox potential diagrams in order to illustrate the relative stability of different oxidation states of a particular substance. Students get further knowledge of precipitation reaction in which dissolved substances react to form one or more solid products and its relation with solubility product determining the nature of solubility of a substance.

Students get an idea about different types of acids and bases and their definitions using different theory; effects of solvent system influencing the chemical reactivity or molecular associations. It gives a clear concept about pH explaining the nature of acidity and basicity; buffer behavior and its necessity; identification of conjugate acid-base pairs and various indicators for determination of end-point of the neutralization reactions. They learn Pearson's Hard-Soft acid base concept explaining the stability of compounds.

On completion of the **Physical** part,

Students will be able to illustrate the basic concepts of second Law of thermodynamics in the form of Kelvin–Planck and Clausius statements; related state functions with the concepts for spontaneity and equilibrium of the reactions; thermodynamic definition of entropy; concepts of Gibbs free energy, Gibbs-Helmholtz relations. They can be able to demonstrate reversible and irreversible processes; Carnot's principle and the Carnot cycle with the roles of all four processes involved along with calculation of thermal efficiency of heat engines and coefficient of performance of refrigerators and heat pump. They also learn the various important thermodynamic relations, various partial molar quantities including specific heat capacities at constant pressure and volume and dependence of thermodynamic parameters on composition.

Students come to know how fast a chemical reaction can occur under certain physical conditions depending on the concentrations of species that appear in the rate law and the specific roles of different parameters affecting the speed or rate of any chemical reaction. They able to get an idea about the relationship between the order and molecularity of a reaction with the stoichiometric coefficient for the reactant in the overall balanced chemical equation and also the variation of the rate of different chemical reaction changes as a function of time. They understand how the collision frequency, kinetic energy and orientation of colliding reactant molecules affect the rate of a chemical reaction explaining the concept of activation energy using Arrhenius equation. They also understand the utility of catalysts and biocatalyst (e.g. enzymes etc.) in a catalyzed reaction; the chemical and physical transport processes and their mechanism.

Course Outcome 6:

Students become expertise with the Inorganic quantitative estimation of single metal ion by using titration method. They get idea about permanganometry and dichrometry; iodometric titration using thiosulphate; role of self indicator, use of starch and also calculations for determination of exact quantity of metal ion present in the supplied solution.

Students get familiar with the basic concepts of measurement of kinetics using stopwatch of various chemical reactions like hydrolysis of methyl acetate catalyzed by acid and decomposition of hydrogen peroxide, from which they can determine the order of the corresponding reactions by plotting graph with the data obtained during the course of the experiment.

Course Outcome 7:

Students acquire knowledge on various aspects of **C**hirality arising out of stereoaxis, prostereoisomerism. They learn to identify and differentiate pro-chirality and chirality at centres, axis, planes and helices and determine the absolute configuration. They come to know the fact that numerous chiral molecules exist which are devoid of chiral centres, but substituted allenes, substituted cumulenes with even number of double bonds, alkylidenecycloalkanes, spiranes, biaryls, etc., exhibit stereoisomerism which is attributed to the presence of chiral axis. They also learn that the enantiomers of axially chiral compounds are usually given the stereochemical labels R and S and these designations are based on Cahn-Ingold-Prelog priority rules used for tetrahedral stereocentres. They get idea about the Topicity which is the stereo-chemical relationships between individual atoms or groups within a single molecule; homotopic, heterotopic, enantiotopic and diastereotopic ligands and faces; about the property prochirality, in which the replacement of two similar atoms or groups of a carbon center generates the chirality; about stereospecific and stereoselective syntheses. They get to know about the configuration of molecular entities possessing axial chirality, specified by the stereodescriptors R_a and S_a (or by P or M). Students can depict anti, gauche, eclipsed and fully eclipsed conformers of butane or a similar compound using sawhorse and Newman projections and can discuss about torsional and steric repulsion.

Students become enriched with the concept of difference between nucleophile and base, when nucleophile is an electron-rich species donates two electrons to carbon and forms a bond with it, a base is also an electron-rich species, but it gives hydrogen a pair of electrons; nature of hydrogen bonding in proton sponges affecting acidity and basicity and hard-soft acid-base principle. They become familiar with the idea of different types of tautomerism, where a single chemical compound tends to exist in two or more interconvertible structures that are different in terms of the relative position of one atomic nucleus, generally hydrogen. They get a very simplistic idea about the Hammond Postulate, which relies on an assumption that potential energy surfaces are parabolic.

Students learn elementary mechanistic aspects of nucleophilic substitution reactions (S_N1 & S_N2), NGP, S_Ni; stereochemical and regiochemical outcome of elimination reactions (E1 & E2). They get idea about an electron rich nucleophile attacks a positively charged electrophile to replace a leaving group. They can predict about the kinetics and reaction mechanism of phase transfer catalyzed reactions; efficiency of crown-ethers as phase transfer catalysts. Going through this course students gain knowledge about elimination reactions (E1, E2, E1cb and pyrolytic syn eliminations); Bredt's rule where bridged ring systems cannot have a double bond at the bridgehead position; Saytzeff and Hofmann elimination products. They learn about the essential difference between a substitution reaction, where an existing group on the substrate is removed and a new group takes its place when an elimination reaction, the group is simply removed and no new group comes to take its place.

Course Outcome 8:

Students get skilled in preparation, purification of crude product, melting point derermination and yield calculation for various organic compounds. They also become trained in different methodologies of organic syntheses like nitration, hydrolysis, acetylation, benzoylation, diazo-coupling, bromination, side chain oxidation etc.

3rd Semester

Course Outcome 9:

Students get idea at a molecular level about viscosity which is a result of interaction between the different molecules in a fluid or as friction between the molecules in the fluid like the case of friction between moving solids. They can Identify the formula for viscosity, and explain each variable; can determine the energy required to make a fluid flow; viscosity coefficient and various methods to measure Viscosity, depending upon the type of materials used and the circumstances. They also gain idea about the huge impact of temperature on viscosity. Students get good command on the concept of transport number represents the fraction of electric current carried by an ion, also represents the total conductance of an ion; weak and strong electrolytes involving Kohlrausch law helps in the determination of limiting molar conductivities for any electrolyte; Ostwald's Dilution Law, which is an application of the expression for an electrolyte's equilibrium constant.

Students become knowledgeable with the concept of use of Chemical potentials to explain the slopes of lines on a phase diagram by using the Clapeyron equation, which in turn can be derived from the Gibbs–Duhem equation and explains the colligative properties. They learn about the conditions of chemical equilibrium and application of thermodynamic laws to explain chemical equilibrium; to derive reaction isotherm; equilibrium constants based on different standard states; dependence of equilibrium constants on temperature and pressure; derivation of Van't Hoff reaction isotherm and reaction isochore; effect of various parameters governing the equilibrium position of a chemical reaction; Le Chatelier principle and its thermodynamic derivation and determination if a system is at equilibrium and if not which direction the reaction will shift to achieve equilibrium.

Students get command on the basic idea of non-relativistic quantum-mechanics. They Acquire fundamental knowledge regarding Planck's hypothesis and quantization of energy level, historical chronology leading to the development of Quantum Mechanics, wave-particle duality of light and its consequences, explanation of several physical processes such as Black-body radiation, photo-electric effect, Compton effect, specific heats of solids, etc. They learn time-dependent and independent Schrödinger equation for simple potentials like harmonic oscillator and hydrogen like atoms; approximate methods for solving the Schrödinger equation (the variational method, perturbation theory, Born approximations; several mathematical techniques viz. operator algebra and their application to determine the physical property of different model and real quantum mechanical system, such as particle in a box, simple harmonic oscillator, rigid rotor and one-electron system like hydrogen atom.

Course Outcome 10:

Students become expertise to measure the viscosity of unknown solution with viscometer. They can perform the saponification of ethyl acetate, follow its progress using titrimetry and can determine the kinetics of the reaction; determine the partition coefficient knowing it is a measure of the ability of a solute to move into and between two solvents that do not mix together. They gain practical idea about different conductometric titrations; Ostwald's dilution law determining the degree of dissociation of weak electrolyte.

Course Outcome 11:

Students become capable of explaining how positively and negatively charged ions are formed by the complete transfer of some electrons from one atom to another forming ionic bond, which is an electrostatic attraction between oppositely charged ions. They gain knowledge regarding lattice enthalpy which is the most important energy factor in determining the stability of an ionic compound; Born-Haber cycle determining the lattice energy of ionic solids; polarization power which is the tendency of a cation to distort an anion and concept of polarizability. Students able to understand relation between covalent nature of an anion and polarization explaining Fajan's rule. They also able to interpret selected crystal structures; the parameters affecting the crystal structure of a compound; the origin and nature of defects in crystals.

Students learn to calculate formal charge of covalent molecules; draw Lewis dot structure of molecules predicting their geometry, polarity and reactivity. They acquire knowledge about Valence Bond theory to explain covalent bonding in molecules of main group elements; VSEPR theory about the repulsion between electronic groups determining molecular geometry and shape. They learn about Bent's rule explaining the preference of atoms having different electronegetivities to occupy the hybrid orbitals which are non equivalents: different s-character and p- character; Berry's pseudorotation, an interchange between axial and equatorial atoms in fluxional processes. They able to construct molecular orbital diagrams for homo and heteronuclear di and triatomic molecules; interrelate bond order, bond length, and bond strength for di and triatomic molecules including neutral and ionized forms to predict molecular geometry and use s, p, and d orbitals (and more rarely f orbitals) to make bonding and antibonding combinations resulting in σ, π, and δ bonds. They can explain band structure of solids and their electrical properties.

Students get idea about ores and minerals, their uses and operations associated with industry standard processes; the methodology for the extraction of pure Ti, Ni, U from their ores. They learn to purify materials and produce high-grade alloys which are used in catalysis.

Course Outcome 12:

Students get an understanding about the titrimetric experiments based on the use of secondary standard potassium permanganate and primary standard potassium dichromate solution for the quantitative estimation of metal ions from their binary mixtures; the calculations for determining the amount of metal ion present in the solution, idea of concentration of solutions in terms of molarity, normality. Students also learn about redox potentials; use of redox indicators, masking and demasking agents.

Course Outcome 13:

Students will be able to describe the reactants, catalysts, and reaction conditions for the hydrogenation and halogenation of alkenes and alkynes; describe the test for both using bromine water and Baeyer'sreagent; understand Markownikoff and anti- Markownikoff addition rule and its use to predict the products of addition reactions of alkenes and alkynes. They learn the reactants and reaction conditions for the addition of hydrogen halides to alkenes, alkynes; for direct and indirect hydration of alkenes to form alcohols, predict the products of the addition reactions of alkenes and alkynes. They also learn about oxymercuration-demercuration, hydroboration-oxidation reactions to alkenes and alkynes; stereoselectivity and regioselectivity of some reactions.

Students get to know about the arenium ion mechanism; orientation and reactivity, energy profile diagram; the ortho / para ratio, ipso attack, orientation in other ring system, quantitative treatment of reactivity in substrates and electrophiles. They get knowledge about diazonium coupling, Vilsmeir-Haack reaction, Gatterman-Koch reaction, Reimer-Tiemann, Kolbe-Schmidt reactions; detailed mechanism for the nitration and sulfonation of benzene. They learn about Nucleophilic aromatic substitution reaction which is a classical reaction in which a nucleophile displaces a leaving group on an aromatic ring. The presence of the electron-withdrawing group increases the rate of nucleophilic aromatic substitution. They also get idea about the reactions involving benzyne intermediate.

Students acquire knowledge about general methods of preparation of carbonyl compounds; nucleophilic addition to the carbonyl group; the properties, reactions of carbonyl compounds and corresponding reaction mechanisms; acidity of □-H of carbonyl compounds and can explain why those are more acidic than hydrogens in a typical hydrocarbon. They learn about conjugation of a double bond to a carbonyl group which transmits the electrophilic character of the carbonyl carbon to the beta-carbon of the double bond.

Students can explain for the formation of primary, secondary and tertiary alcohols by adding Grignard reagents to carbonyl compounds; formation of an alkyllithium from an alkyl halide; formation of lithium dialkylcopper (Gilman) reagent from an alkyllithium and copper(I) iodide; coupling of a lithium dialkylcopper reagent with an alkyl halide i.e, Corey-House synthesis. They become enriched with the knowledge of the successful addition of nucleophiles to the delta positive carbon atom of a ketone i.e, Reformatsky reaction and Blaise reaction; concept of reversal polarity i.e, umpolung.

Course Outcome 14:

Students become expertise in the qualitative detection of nitrogenous and non-nitrogenous functional groups present in single solid organic compounds followed by its detection of melting point; preparation of a crystalline derivative of an organic compound along with its purification and determination of melting point.

4th Semester

Course Outcome 15:

Students can express concentration of solutions using mole fraction and molality. They understand the idea of colligative property, related to the number of particles in solution and not to the chemical properties of the solute; can describe the effect of solute concentration on various solution properties like vapor pressure lowering, boiling point elevation, freezing point depression and osmotic pressure. Students can define and explain the terms like phase, component and degrees of freedom in the context of phase equilibrium; can calculate the number of phases, components and degrees of freedom for a given system; can derive Clapeyron and Clausius-Clapeyron equations and apply them to heterogeneous systems in equilibrium. They learn about Duhem-Margules equation, Henry's law and Konowaloff's rule. They also come to know that azeotropes are the binary mixtures of solution having the same composition in liquid and vapour phase and have constant boiling points throughout distillation.

Students get an idea about activity and activity coefficient of various ionic species present in the solution; variation of activity coefficient with ionic strength. They get qualitative ideas about Debye-Huckel limiting law, its assumptions, applications and limitations. They get familiar with simple electrolysis, the workings of a typical electrolytic cell and various electrochemical processes; different types of electrodes; derivation of expression of EMF of an electrode and EMF of a cell using Nernst equation. They learn how molar polarization can be obtained for both polar and non polar molecules. They can also explain how Debye modified Clausius Mosotti equation to explain the behavior of polar molecule. They gain ideas of induced dipole moment; different kinds of polarization involving electronic, atomic and orientation polarization.

Students get to know about the angular momentum operator that plays a vital role in the theory of atomic and molecular physics and other quantum problems involving rotational symmetry. They learn about rigid rotor where the distance between particles does not change as they rotate and only approximates a rotating diatomic molecule; They learn to construct and solve the Schrödinger wave equations for vibrational motion of a system by modelling it as simple harmonic oscillator, rotational motion of the system by modelling it as rigid rotor and the real system hydrogen atom and hydrogen like ions. They understand that Linear combination of atomic orbitals (LCAO) is a simple method of quantum chemistry resulting a qualitative picture of the molecular orbitals in a molecule and also the basics of Hartree-Fock Self-Consistent Field (HF-SCF) Method

Course Outcome 17:

Students acquire knowledge about the radioactivity and related phenomena of radioactive atoms. They gain idea about the stability of nuclei, different bombarding particles; moderator, slowing down high speed neutrons; nuclear chain reaction and its application in both a fission, fusion reactions and in a nuclear plant. They come to know about versatile applications of radiochemistry in different fields like in determination of age of an ancient species, reaction mechanism through isotope labeling, in medicinal chemistry etc. They also understand the hazards of radiations and know the safety measures.

Students get to know fundamentals of physical and chemical properties of main group elements including trends in oxidation states, periodic properties and complex formation tendency. They can discuss the anomalous properties of Boron and carbon; infer the chemistry of some important compounds of boron, carbon and silicon. They learn about diagonal relationship where the diagonal elements possess similar properties like density, atomic size, electronegativity, polarizing power and other chemical properties. The students will be able to state the principle resemblances of elements within each main group in particular alkali metals, alkaline earth metals, halogens and noble gases. They also learn the application of phosphazenes in electro- dialysis, microfiltration and ultra-filtration, water purification; application of silicone polymers.

Students learn the difference between complex salts and double salts along with their pattern of dissociation; postulates of Werner's theory proposing that a metal atom or ion in a coordination complex uses two types of linkages (primary and secondary); rules of naming inorganic complexes arranging the ligands alphabetically according to their names. They understand metal-ligand equilibria in solution from which they can determine the stepwise and overall formation constants of complexes and their interaction. They also get idea about trans directing ligand showing trans effect; inert and labile complexes; geometrical, optical isomerism of mainly square planar and octahedral complexes.

Course Outcome 18:

Students become skilled in doing volumetric analysis via complexometric titration in the estimation of calcium, magnesium and zinc metal ions. They learn about metal-ion indicator, their color change in metal-complexed and free form. They become knowledgeable in the preparation of different inorganic coordination complexes of cobalt, chromium, copper, nickel; learn yield calculation method and get to know about their percentage yield.

Course Outcome 19:

On completion of this part, students can predict the reactivity of aliphatic and aromatic amines as bases and nucleophiles; can explain that aliphatic amines are more basic than aromatic amines; recognize their method of preparation, basic properties (structure, physical and chemical properties); can identify and separate primary, secondary and tertiary amines by Hinsberg method; get idea about iminium ion and very reactive mannich bases. They able to understand the nucleophilic addition of a nitroalkane (or the corresponding nitronate anion) to an imine, resulting in the formation of a beta-nitroamine which further undergoes Nef reaction forming alpha-amino carbonyl compounds. They get the concept of coupling reactions; learn about reaction conditions for the preparation of diazonium salt and hydrazones.

Students understand that rearrangement reaction occurs when the carbon skeleton of a molecule is rearranged to provide a structural isomer of the original molecule where migration of one group from one atom to another within the molecule takes place. Students can classify rearrangement reactions as rearrangement to electron-deficient carbon, nitrogen; identify the reactive intermediates involved; relate a particular rearrangement to the appropriate energy diagram, identify the electron deficient site formation in a rearrangement, recognize the group that is most likely to migrate. They get the concept of ring expansion, spiro system, sigmatropic rearrangement, formation of oximes, epoxidation of peracids, rearrangements of derivatives of aniline etc.

Students gather knowledge about the methods for synthesis and transformation of the most common functional groups into another by substitution, addition, elimination, oxidation or reduction and the reverse process used in retrosynthetic analysis. They can identify, analyze and evaluate synthetic routes to target molecules using retrosynthetic method of chemical synthesis involving deconstruction of a target molecule into its readily available, simple starting materials in order to assess the best synthetic route. They gain idea about synthons which are achieved by breaking the bonds of the target molecular structure into constituent fragments.

They learn about various asymmetric transformations and employ such reactions in asymmetric organic synthesis of some chiral molecules. They also learn about Felkin-Ahn model which helps to predict the predominant product when both syn- and anti- diastereomeric products are possible in a diastereoselective nucleophilic attack reaction.

Students will be able to explain the behavior of molecular systems in external electromagnetic field; can demonstrate its application to the study of chemical molecules; can describe the principles of spectroscopic methods such as NMR, IR and UV-Vis. They become efficient to identify the absorption frequencies of major functional groups which help to interpret IR and UV-Vis spectra of simple organic molecules. UV-Vis spectroscopy helps students to understand exactly how conjugation is related to the λ_{max} of a molecule; its color; Woodward's rule which determines the change in wavelength and the intensity of the absorption maxima due to the presence of auxochrome or extension of chromophore. IR spectroscopy helps students can predict the number of fundamental modes of vibration of a molecule. Students come to know how nuclear spins are affected by a magnetic field, and are able to explain what happens when radiofrequency radiation is absorbed. They can predict the number of proton and carbon NMR signals expected from a compound given its structure and also can determine the splitting pattern in the proton NMR spectrum of a compound.

Semester 5

Course Outcome 21:

Students can explain Valence bond theory (VBT) describing bond formation as a consequence of overlap of two separate atomic orbitals of different atoms that creates a region with one pair of electrons shared between the two atoms; its draw backs in explaining magnetic properties, color and spectra of complexes. They get to know about these properties of complexes from crystal field theory. They learn from crystal field theory that the interaction between metal and ligand is purely an electrostatic one; learn about loss of d-orbital degeneracy; strength of the ligands from their position in the spectrochemical series on which nature of splitting of d-orbital depends without changing the total energy of the d orbitals; crystal field stabilization energy. Students understand the color, spectra and their magnetic properties of complexes from crystal field theory; nephalauxetic series explaining the ability for formation of covalent bond. They also get idea about the pictorial representation of Orgel diagram of various d-orbital configurations explaining only the spin allowed transitions.

Students will be able to demonstrate an increased knowledge and understanding of magnetochemistry in the context of isolated spins, discrete spin clusters and extended systems. They get to know about magnetic susceptibility, the mechanisms of magnetic exchange interactions, spin crossover and single-molecule magnets. They can explain the magnetic properties of isolated organic radicals, 3d and 4f metal ions; the mechanisms of magnetic exchange interactions and single-molecule magnetism. They understand the quantum mechanical origin of magnetic phenomena in molecules and molecular materials based on transition metal and lanthanide ions, with special focus on exchange coupling, magnetic anisotropy, spin relaxation dynamics, and can calculate observable magnetic properties of these systems. They learn that the magnetic moment of most of the transition metal ions are very close to spin only magnetic moment and also can identify the metal ions having the magnetic moment higher than spin only magnetic moment.

Students learn about physical and chemical properties including reactivity, variation of oxidation states, spectral and magnetic behavior of d-block elements, which have incompletely filled d-subshell in their ground state or most stable oxidation state. They get idea about the comparative study of 3d, 4d and 5d elements with respect to their different properties. Students can clarify the effects of lanthanide contraction of 4f electrons due to inadequate shielding of nuclear charge resulting in a decreased atomic radius of lanthanide elements. They get a view of comparative study of magnetic and spectral nature of lanthanides and actinides; can explain the difference in magnetic moment value between the observed and calculated one. Students get familiar with the different separation techniques of lanthanides as they are very difficult to separate and depend on the stability constant of the metal-ligand lanthanide complexes.

Students gain knowledge about substitution reaction in square planar complexes which occurs via associative mechanism forming a square pyramidal intermediate followed by a trigonal bipyramidal intermediate. They understand the thermodynamic influence towards the stability of the complexes undergoing substitution reaction; role of spectator ligand; the role of incoming nucleophilic ligand, the kinetics of leaving ligand. They learn about Trans effect, which is the effect of a ligand over substitution rate of another ligand positioned trans to it in square planar complexes. They can also explain cis-labilizing effects of ligands in substitution reaction.

Course Outcome 21:

They get practical knowledge for estimation of several metal ions using permanganometric titration method where potassium permanganate behaves as a self indicator. They get idea about iodometric titration process using thiosulphate as the secondary standard solution. They learn about formation of intense blue starch-iodine adsorption complex during iodometric titration; process of dissolution of metals in acid solution for its quantitative analysis; gravimetric estimation of metal ions through the method of constant weight measurement. They can determine retention factor, know about mobile and stationary phase in chromatographic separation process. They come to know about the principle of colorimetric estimation and nature of the spectrochemical graph.

Course Outcome 22:

Students become knowledgeable with Born-Oppenheimer approximation where the electronic motion and the nuclear motion in molecules can be separated and it simplifies Schrödinger equation of molecules. They can explain the behavior of molecular systems in external electromagnetic field. They learn about rotational spectra of rigid diatomic molecules, selection rules; They get to know about quantised vibrational energy levels. They come to know about zero point energy, force constant & bond strength; can describe selection rules for vibronic transition; vibrational spectra of linear and non linear triatomic molecules as well as polyatomic molecules; vibration-rotation spectra and P, Q, R Branches; two fundamental modes of vibration for molecules, stretching and bending. They can understand classical and quantum mechanical theories of Raman effect; Mutual exclusion Principle with suitable examples; can explain complementary nature of Raman and Infrared spectra.

Students learn to formulate the macroscopic and quantum laws of absorption of light by molecules and solids; can describe the various deactivation processes of molecular excited states; can characterize the kinetics of deactivation processes and their role in the photochemical reactivity. They can recognize the nature of light and the photon; can explain the potential energy curves and Frank-Condon principle. They come to know about the representation of various photo-physical processes by Jablonskii diagram where Excited states may be classified as singlet or triplet based upon their electron spin angular momentum. They get idea about the efficiency with which a given photochemical process occurs, given by its Quantum Yield. They also learn about chemiluminescence, which is the emission of light as a result of a chemical reaction.

Students correlate the property of surface tension with different natural phenomena; understand the concept of capillarity in liquids; variation of surface tension with temperature. Students get to know about basic laws governing the adsorption; acquire an elementary idea about physisorption and chemisorptions. They gain knowledge about different adsorption isotherms and their theoretical derivation, thermodynamic aspects of sorption processes, role and function of heterogeneous catalysts. They can efficiently solve numerical problems related to this topic. They can describe interactions between colloidal particles; explain the stability of colloids through intermolecular interactions and describe how this stability can be disrupted. They can also explain the Tyndall effect and use it to distinguish between a colloid and a solution.

Course Outcome 23:

They develop practical skills in the determination of surface tension; learn about certain properties of water using the concepts of cohesive forces and surface tension; different spectrophotometric and surface phenomenon experiments. They also learn to apply Beer and Lambert's Law in the experiments using intense colored solutions like permanganate and dichromate.

6th Semester

Course Outcome 24:

Students can identify symmetry elements, which are geometric entitites of point, line, plane of molecule about which symmetry operations can be performed. They get idea about different elements of symmetry like identity of symmetry, axis of symmetry, plane of symmetry, improper axis of symmetry, point of symmetry. They get the concept of axial and non-axial point group and become capable in determining the point group of different molecules. They know about symmetry of atomic orbitals which helps to characterize the core, bonding, nonbonding and antibonding molecular orbitals. They understand about the optical activity of molecule in terms of symmetry; conditions of optical activity; chirality and achirality of molecules.

Students understand different structures and biological functions of different biomolecules like the metalloproteins, metalloenzymes etc containing metal ions. They know about the active site structures and different aspects of oxygen transport and electron transport proteins; different amino acids; hydrolysis of peptides in vertebrates and invertebrates; cooperative and non-cooperative dioxygen binding. They get idea about zinc containing metalloprotein carbonic anhydrase controlling the excess amount of carbon dioxide in our body converting it into bicarbonate; molecular mechanism of ion transport across membrane; significance of chlorophyll in photosynthesis. They get concept about the reduction of dinitrogen to ammonia by the enzyme system, nitrogenase. They also acquire knowledge about the deficiency or excess of bulk or trace metal ions giving rise to metabolic disorders in growth and other diseases.

Students become familiar with the 18 electron rule to predict the structure and reactivity of organometallic complexes describing the tendency of the central metal to achieve the noble gas configuration in its valence shell. They learn about the back donation of carbonyl which reinforces the sigma donation and vice-versa; preparation of organometallic metal-alkene complex, Zeise's salt. They get to know about selective hydrogenation of alkenes and alkynes; the formation of linear or branched aldehydes by oxo synthesis using organorhodium or organocobalt compounds as catalyst; enhanced rate of polymerization reaction.

Course Outcome 25:

They learn to detect the acid and basic radicals present in inorganic sample salt by carrying out several qualitative analytical tests. They gain some idea about the composition of the compounds present in the unknown sample through the observations obtained in the experiments; from color of the sample; solubility of the sample in water, acid. They get practical knowledge about sublimation, effervescence, melting, boiling and swelling. They learn to observe colored fumes, color of flame and color of borax bead. They also learn the use of platinum wire, mica foil and blow pipe.

Course Outcome 26:

Students understand that crystalline solids have definite patterns which arise due to the definite patterns in which the different atoms of the crystals are placed. They can describe the symmetry elements exhibited by crystals; centro – symmetric crystals; symmetry about an axis. They can explain that crystals exhibit two -, three-, four – and six - fold axis of rotation; crystal form showing symmetry about a plane. They get idea about combination of rotation and inversion through a point giving rise to a different set of symmetry operation. They gain knowledge about translational periodicity as the most fundamental feature of the Bravais lattice and also the concept of the fundamental building block of a crystal.

Students understand the role of statistical thermodynamics in bridging the Thermodynamics and Quantum Mechanics. They get idea about the "inside out" approach of this subject and acquire the basic knowledge about ensemble, kinds of ensemble; partition function, its significance and representation of different thermodynamic quantities in terms of partition function. They come to know about classical statistical thermodynamics and Quantum statistics on an elementary level; understand the relation between entropy and arrangement of different particles in various energy levels at the atomic level; learn the mathematical derivation of Maxwell-Boltzmann distribution law and also able to solve numerical problems related to this topic.

Students learn about Dulong Petit's Law stating that the product of specific heat and atomic mass or gram-atomic heat capacity of an element is always a constant. They get to know about Einstein theory of heat capacities of solids; can derive electronic partition function. They gain knowledge about the absolute entropy of a pure substance at a given temperature; can calculate entropy changes for phase transitions and chemical reactions under standard conditions.

Course Outcome 27:

Students learn about numerical differentiation, integration, probability distribution of gases, roots of equation involving comparison of vander Waals gas with ideal gas using different computer programming.