JAI HIND COLLEGE
BASANTSING INSTITUTE OF SCIENCE
&
J.T.LALVANI COLLEGE OF COMMERCE
(AUTONOMOUS)

"A" Road, Churchgate, Mumbai - 400 020, India.

Affiliated to
University ofMumbai

Program : B.Sc.

Proposed Course : Chemistry

Semester IV

Credit Based Semester and Grading System (CBGS) with effect from the academic year 2020-21

S.Y. B.Sc. Chemistry Syllabus

Academic year 2020-2021

Semester IV			
Course Code	**Course Title**	**Credits**	**Lectures /Week**
SCHE401	Principles of Physical & Analytical Chemistry- II	3	3
SCHE402	Principles of Inorganic Chemistry- II	3	3
SCHE403	Principles of Organic Chemistry - II	3	3
SCHE4PR	Practical Course work in Chemistry IV	2.5	9

Semester IV – Theory

Course: SCHE401	**Principles of Physical and Analytical Chemistry II (Credits: 3 Lectures/Week: 3)** **<u>Course description:</u>** **Solutions & applications of phase equilibria, chemistry of materials in solid-state, principles and applications of catalysis, applications of potentiometry, pH metry and conductometry as instrumental methods of analysis**	
	Objectives: ➢ To learn different types of liquid mixtures and their methods of separation. ➢ To understand the applications of Phase Rule to one, two and three component systems. ➢ To learn characteristic features of cubic crystal lattice in detail. ➢ To understand different features of catalyst and their role in catalysis. ➢ To imbibe basic instrumental techniques and their use in carrying out titrations. ➢ To learn graphical methods of determination of equivalence point for instrumental titrations.	
	Learning Outcomes: ➢ Learner will be able to apply the theoretical principles in effecting separation of components from a solution. ➢ Learner will be able to correlate the phase diagrams with the phase equilibria observed in day to day events. ➢ Learner will be equipped with the knowledge of catalyst and will be able to choose a catalyst for a chemical reaction based on its role. ➢ Learner will be able to correlate the different types of crystal and their packing with the hardness of different solid-state materials. ➢ Learner will be able to establish the changes in instrumental signal associated with a titration and use it in chemical analysis.	
Unit I	**Unit – I: Solutions & applications of phase equilibria** **1. Solutions** a) Thermodynamics of ideal solutions: i. Ideal solutions and Raoult's law, deviations from Raoult's law–non-ideal solutions. ii. Vapour pressure-composition and temperature - composition curves of ideal and non-ideal solutions. iii. Distillation of solutions. Lever rule. Azeotropes. b) Partial miscibility of liquids: i. Critical solution temperature; effect of impurity on partial miscibility of liquids with respect to Phenol-Water , Triethanolamine – Water and Nicotine – Water systems c) Immiscibility of liquids- Principle of steam distillation. i. Nernst distribution law and its applications, solvent extraction. (**Numericals expected**)	**15L** **(7L)**

	2. Applications of Phase Equilibria: **a) Recapitulation of Phase Rule** **b) Derivation of Clapeyron equation , Clausius -Clapeyron equation and its importance in phase equilibria.** (**Numericals Expected)** **c) Phase diagrams of:** i. One component systems (water, carbon dioxide & sulphur) ii. Two component systems: simple eutectic system (Pb-Ag); congruent melting point (Zn-Mg); incongruent melting points (Na-K) iii. Three component systems: triangular plot phase diagram; types of systems; e.g. one pair of immiscible liquids	**(8L)**
Unit II	**Unit – II: Solid State & Catalysis** **1. Solid State:** **a) Recapitulation:** solid state, types of solids, amorphous and crystalline solid **b) Properties of crystals:** i. crystal lattice & lattice points, ii. unit cell, space lattice, iii. laws of crystallography iv. Types of crystals **c) Characteristics of crystal lattice:** i. simple cubic, ii. types of cubic lattices: fcc& bcc; iii. interplanar distance in cubic lattices (only expression for ratio of interplanar distances are expected) **d) Use of X-rays in the study of crystal structure:** i. Bragg's equation (derivation expected), ii. X-rays diffraction method of studying crystal lattice structure, iii. Structure of NaCl and KCl. **iv.** Determination of Avogadro's number (**Numericals expected)** **e) Crystal defects** – Schottkey and Frenkel defects. **2. Catalysis** **a)** Types of catalysis, catalytic activity, specificity and selectivity, inhibitors, catalyst poisoning and deactivation **b)** Mechanisms and kinetics of acid-base catalyzed reactions, effect	**15L** **(9L)** **(6L)**

	of pH **c)** Mechanisms and kinetics of enzyme catalyzed reactions (Michaelis-Menten equation) **d)** Effect of particle size and efficiency of nanoparticles as catalyst	
Unit III	**Unit – III: Instrumental Methods- II** **1. Potentiometry:** i. Principle. ii. Role of Reference and indicator electrodes iii. Applications in Neutralization reactions with reference to the titration of a strong acid against a strong base (using quinhydrone electrode) (**Numericals expected**) iv. Graphical methods for detection of equivalence points **2. pH metry:** i. Principle ii. Combined glass electrode- Principle, Construction, working and precautions. iii. Applications of pH metry method in: Titrimetry (strong acid-weak base, weak acid- strong base), biological and environmental analysis. (**Numericals expected**) **2. Conductometry:** i. Principle ii. Conductivity cell - construction and care iii. Applications in neutralization titrations with respect to: a) Strong acid-strong base b) Strong acid-weak base c) Strong base-weak acid d) Weak acid-weak base iv. Advantages & limitations of conductometric titrations.	**15L** **(4L)** **(5L)** **(6L)**

References:

<u>Unit – I</u>

1. Barrow, G.M., *Physical Chemistry,*Tata McGraw-Hill (2007)
2. Levine, I .N. Physical Chemistry 6th Ed.,Tata Mc Graw Hill 2010.
3. B. R. Puri, L.R. Sharma, M. S. Pathania, Physical Chemistry, Vishal Publish Co., 45thedn.
4. Glasstone& Lewis, Elements of Physical Chemistry.
5. Atkins P. W., and Paula J. De, Atkin's Physical Chemistry, 10thedn, Oxford University, 12 press (2014).
6. Castellan, G.W., *Physical Chemistry*, 4th Ed. Narosa (2004)
7. Kotz, J.C., Treichel, P.M. & Townsend, J.R., *General Chemistry*, Cengage Learning India Pvt. Ltd., New Delhi (2009)
8. Mahan, B.H., *University Chemistry,* 3rd Ed. Narosa (1998)

9. Petrucci, R.H., *General Chemistry,* 5th Ed. Macmillan Publishing Co., NewYork (1985).
10. K. L. Kapoor, *A Textbook of Physical Chemistry,* Vol.1 &2,(3rd Ed.) Macmillan Publishing Co., New Delhi (2001)

Unit II:

1. Barrow, G.M., *Physical Chemistry*, (6th Edition), Tata McGraw Hill Publishing Co. Ltd. New Delhi
2. Levine, I. N., *Physical Chemistry, (*6th Ed. 2010), Tata McGraw Hill
3. Puri, B. R., Sharma, L.R., Pamania, M.S., *Physical Chemistry,* (45th Ed.), Vishal Publish Co.
4. Glasstone& Lewis, *Principles of Physical Chemistry*
5. Atkins P. W., and Paula J. De, *Physical Chemistry*, 10th ed., Oxford University, 12 press (2014)5.
6. Kapoor, K.L. *Textbook of Physical Chemistry*, (2006) McMillan Publishers.

Unit-III

1. Principles of Instrumental analysis, D. A. Skoog, 5th edition, Chapters: 24& 25 Page nos: 549 – 580.
2. Vogel's Text book of quantitative chemical analysis,5thedition.[Chapter 13 (pg. no.519-527) & chapter 15 (pg. no. 548-590)]
3. Analytical Chemistry by Gary Christian,5th edition, chapters 11 &12, pg.nos. 299-370

Course: SCHE402	**Principles of Inorganic Chemistry II (Credits: 3 Lectures/Week: 3)** **<u>Course description:</u>** **Study of transition elements & co-ordination chemistry, some selected topics of p-block chemistry and ions in aqueous medium; general principles of analytical methods of separation with special focus on electrophoresis, solvent extraction and chromatography**	
	Objectives: ➢ To understand the properties of transition elements and their complexes ➢ To correlate the properties of transition metal complexes with their applications. ➢ To understand the properties of the compounds of group 15 & group 18 elements. ➢ To understand the behaviour of ions in aqueous medium. ➢ To introduce the leaner to Analytical Separations, separation methods based on various properties of analyte. ➢ To understand principle and method of Solvent extraction and its applications.	
	Learning Outcomes: ➢ Learner will be able to understand the properties of transition elements and their complexes used as reagents in a chemical laboratory ➢ Learner will be able to correlate the formation of coloured complexes as a diagnostic tool in qualitative analysis ➢ Learner will be able to extrapolate the properties of p-block elements depending the group to which they belong ➢ Learner will be able to account for many properties exhibited by aqueous solutions of ions. ➢ Learner will be equipped with the methods involved in separation and will be able to make a choice of a suitable method ➢ Learner will be able to apply the theoretical principles involved in solvent extraction and efficiency practically in the laboratory.	
Unit I	**Unit – I: Comparative Chemistry of transition elements & Co-ordination Chemistry** **1. Study of transition elements** a) Introduction: Electronic configuration with significance of special stability of d^0, d^5 & d^{10} b) Periodic properties: oxidation states, unusual oxidation states and their stabilities in aqueous solutions (with reference to vanadium & chromium) c) Colour d) Magnetic properties e) Variable valency & catalytic properties of d-block elements f) Difference between first series & the other two transition series g) Some important compounds of Cr, Mn, Fe & Co and their roles as laboratory reagents (potassium dichromate, potassium	**15L** **(8L)**

	permanganate, potassium ferrocyanide, potassium ferricyanide, sodium nitroprusside & sodium cobaltinitrite) **2. Coordination Chemistry** **a)** Recapitulation: Nomenclature & Werner's theory **b)** Theories of coordination compounds: i. EAN, 18 electron rule and its applications ii. VBT, applications to complexes of CN 4 & 6 with examples of inner and outer orbital complexes & limitations of VBT **c)** Isomerism in coordination compounds with CN 4 & 6 **d)** Metal carbonyls: electroneutrality & back bonding, M-M bonds	**(7L)**
Unit II	**Unit – II: Selected Topics in p-block chemistry & ions in aqueous and non-aqueous medium** **a) Selected Topics in p-Block chemistry** i. Diborane: structure & bonding; introduction to boranes ii. Structure, Bonding, Preparation, Properties and uses of 1. Compound of Boron with Nitrogen (Boron Nitride) 2. Borax 3. Silicates 4. Silicones 5. Interhalogen compounds iii. Occurrence, extraction and purification of Germanium and silica iv. Chemistry of Xenon and its compounds: Occurrence, inertness, uses, hydrates and clathatrates, Nature of bonding, preparation and properties of XeF_2, XeF_4, XeF_6 and oxyhalides (With structures). **b) Ions in aqueous media:** i. Acidity of cations and basicity of anions ii. Hydration and hydrolysis of cations - Effect of charge and radius iii. Latimer equation, relationship between pK_a, acidity and z^2/r ratios of ions iv. Classification of cations on the basis of acidity category with pK_a values range and examples v. Hydration of Anions, Effect of Charge and Radius, diagram classification on the basis of basicity	**15L** **(9L)** **(6L)**
Unit III	**Unit – III: Methods of Separation** **1. Separation Techniques in Analytical Chemistry** **a.** An Introduction to Analytical Separations and its importance in analysis.	**15L** **(3L)**

	b. Estimation of an analyte without effecting separation. **c.** Types of separation methods i. Based on Solubilities (Precipitation, Filtration, Crystallization) ii. Based on Gravity- Centrifugation iii. Based on volatility-Distillation iv. Based on Electrical Effects-Electrophoresis v. Based on retention capacity of a Stationary Phase-Chromatography vi. Based on distribution in two immiscible phases-Solvent Extraction vii. Based on capacity to exchange with a resin-Ion Exchange **2. Electrophoresis** **a)** Principles **b)** Basic Instrumentation **c)** Working and Application in separation of biomolecules like enzymes and DNA. **3. Solvent Extraction** **a.** Introduction, Nernst distribution law, Distribution Ratio, Partition Coefficient. **b.** Conditions of extraction: Equilibration time, Solvent volumes, temperature, pH. **c.** Single step and multi-step extraction, Percentage extraction for single step and multistep extraction. Separation factor. (**Numericals expected**) **d.** Batch and continuous extraction **e.** Counter current extractions –Craig's counter current apparatus **3. Chromatography** **a.** Introduction to Chromatography **b.** Classification of chromatographic methods based on stationary and mobile phase **c.** Paper Chromatography: Principle, techniques and applications of Paper Chromatography in separation of cations. **d.** Thin layer Chromatography: Principle, technique and Applications in determining the purity of a given solute; following progress of a given reaction.	**(3L)** **(5L)** **(4L)**

References:

<u>Unit I & Unit II:</u>

1. Bruce H. Mahan, *University Chemistry*, Narosa Publishing House,
2. R. Gopalan, *Inorganic Chemistry for Undergraduates*
3. *Chemistry of Transition Element,* Universities Press India Pvt. Ltd.
4. J.D.Lee, *Concise Inorganic Chemistry*, 4th Ed^{n}, ELBS,
5. D.F. Shriver & P.W Atkins, *Inorganic Chemistry*, 3rd edn. Oxford University Press(1999)

6. James E. Huheey, *Inorganic Chemistry: Principles of Structure & Reactivity*
7. Emeleus & Anderson, *Modern Aspects of Inorganic Chemistry*
8. Cotton & Wilkinson, *Advanced Inorganic Chemistry*, 3rd Edition,
9. Gary Wulfsberg, *Inorganic Chemistry*, Viva Books Pvt. Ltd., (2002)
10. Puri, Sharma & Kalia, *Principles of Inorganic Chemistry*, Milestone publishers
11. Ramesh Kapoor and R.S. Chopra, *Inorganic Chemistry*, R. Chand publishers, New Delhi.
12. CNR Rao edited, *University General Chemistry*

Unit-III

1. D.A. Skoog, D.M. West, F.J. Holler and Stanley R. Crouch – *Fundamentals of Analytical chemistry*, 8th edition.
2. G.H. Morrison and H. Freiser ,*Solvent extraction in analytical chemistry*.
3. Peter A. Sewell and B. Clarke, *Chromatographic separations* , Analytical chemistry by open Learning , John Wiley and sons, 1987.
4. *Modern Analytical Chemistry* , David Harvey (pg. nos. 215 -217 & 597 -606)

Course: SCHE403	**Principles of Organic Chemistry-II (Credits: 2 Lectures/Week: 3)** **Course description:** **Functional group chemistry of nitrogen containing compounds; Stereochemistry; Industrial Chemistry**	
	Objectives: ➢ To describe the mechanism of reactions of carboxylic and sulphonic acids and their derivatives ➢ To compare the acidity of carboxylic and sulphonic acids and their substituted derivatives ➢ To reproduce the chemistry of nitrogen containing organic compounds such as aromatic nitro compounds and aromatic and aliphatic amino compounds ➢ To recapitulate the configurational nomenclature of organic compounds containing two or more than two stereogenic centres; to understand the basic principles of resolution and optical purity ➢ To acquaint the learner with different parameters of a chemical manufacturing plant ➢ To introduce a few products of wide applications made by manufacturing Plants	
	Learning Outcomes: ➢ Learner will be able to understand the mechanism of the reaction of acid functional group and suitably be able to maintain conditions to optimize the reaction. ➢ Learner will be able to infer the correlations between the acidity of carboxylic and sulfonic acid with the reagents used for their chemical separations in the laboratory. ➢ Learner will be equipped with the knowledge of nitrogen containing functional groups and their interconversions for application in a synthetic pathway. ➢ Learner will be acquainted with the experimental methods in stereochemistry, specifically resolution of racemates. ➢ Learner will have a basic understanding of chemical industry and will have the basic pre-requisites to engage in chemical manufacturing process.	
Unit I	**Unit III: Functional group chemistry of carboxylic and sulphonic acids and their derivatives** **1. Carboxylic acids & their derivatives:** a) Applications of carboxylic acid and their derivatives b) Structure & physical properties- effect of substituents on acid strength (aliphatic & aromatic) c) Preparation i. Oxidiation of alcohols & alkylbenzene ii. Carbonation of grignard iii. Hydrolysis of nitrile iv. Kolbe's reaction d) Reactions: Decarboxylation, reduction with LAH, diborane; HVZ	**15L** **(9L)**

	reaction, conversion to acid chlorides, anhydrides, esters & amides and their reactivity e) Mechanism of nucleophilic acyl substitution, interconversion of acid derivatives f) Mechanism of acid catalysed esterification ($A_{AC}2$) & mechanism of saponification ($B_{AC}2$) g) Mechanism of Claisen condensation & Dieckmann condensation **2. Sulphonic acids** a) Applications of sulphonic acids and their derivatives b) Preparation of sulphonic acids by sulphonation of benzene (with mechanism), toluene & naphthalene (thermodynamic & kinetic control) c) Physical properties- comparison of acidity between carboxylic and sulphonic acids Reactions- preparation of sulphonyl chlorides, sulphonamides, sulphonic esters & their applications	**(6L)**
Unit II	**Unit – II: Chemistry of nitrogen containing compounds & stereochemistry** **a) Nitro containing compounds** **i.** Preparation (nitration of aromatics) **ii.** Reduction in acidic, basic, neutral medium & catalytic hydrogenation **iii.** Test for nitro group (Mulliken's test) **b) Amines** **i.** Physical properties: effect of substituent on basicity of aliphatic and aromatic amines **ii.** Preparation: reduction of nitriles, reductive ammination, Hofmann bromamide reaction **iii.** Reactions: N-alkylation, N-acylation, quaternization, Hofmann's exhaustive methylation, diazotisation and reaction of diazonium salts- Sandmeyer, Gattermann & coupling reactions, electrophilic substitution in aromatic amines (nitration & sulfonation) **iv.** Differentiating tests for primary, secondary and tertiary amines (carbylamine, hindsberg test, nitrous acid test) **c) Stereochemistry** **i.** Assigning configurational descriptor (R/S & E/Z) for molecules containing 2 or more stereogenic centres. **ii.** Recapitulation of optical purity and enantiomeric excess **iii.** Resolution of racemic mixtures- chemical & chromatographic methods	**15L** **(3L)** **(8L)** **(4L)**

Unit III	**Unit – III: Aspects of chemical manufacturing processes**	**15L**
	A. Introduction to aspects of chemical manufacturing plant: i. Significance of location of plant ii. Choice of raw material iii. Energy requirements, availability and conservation iv. Capital investment v. Labour: availability; skilled/unskilled vi. Environmental compliance vii. Tax benefits	**(3L)**
	B. Products of Chemical Plants:	
	a) Phase Transfer Catalysts: i. Introduction ii. Mechanism of action iii. Advantages with examples	**(3L)**
	b) Perfumes i. Introduction ii. Biological basis of olfaction iii. Molecular modelling (Structure relationship & homologation) iv. Composition**,** extraction/isolation. v. Synthesis of β- ionones, oil of wintergreen vi. Applications	**(3L)**
	c) Flavours i. Introduction ii. Classification (natural and synthetic) iii. Synthesis of vanillin & veratraldehyde iv. Applications	**(3L)**
	d) Sweeteners i. Introduction ii. Classification (Natural & Synthetic) iii. Natural- carbohydrates (glucose & fructose) iv. Synthetic- (I) Sucralose; (II) Sulphonamide (saccharin); (III) Peptides, synthesis of aspartame v. Long term side effects of synthetic sweetners	**(3L)**

References:

Unit I & II

1. Morrison, R. T.; Boyd, R. N. (2012). *Organic Chemistry*. Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. (2012). *Organic Chemistry (Volume 1)*. Dorling Kindersley (India) Pvt
3. , T.W.G. (2009).*Organic Chemistry*,John Wiley & Sons, Inc.
4. Ahluwalia, V.K.; Parashar, R.K. (2006) *Organic Reaction Mechanisms.* Narosa Publishing House.
5. Mukherji; Singh; Kapoor. (2002) *Reaction Mechanisms in Or*
6. Mc Murry, J.E. (2013). *Fundamentals of Organic Chemistry, 7th Ed.* Cengage Learning India Edition.
7. Kalsi, P. S. (1990) *Textbook of Organic Chemistry 1st Ed.* New Age International (P) Ltd. Pub.
8. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P. (2012) *Organic Chemistry.* Oxford UniversityPress.

Unit III

1. Government of India, Department of Chemicals & Petrochemicals https://chemicals.nic.in/
2. Indian Chemical Industry- XII Five Year Plan 2012-2017, Department of Chemicals & Petrochemicals, Government of India.
3. Charles M.Starks; Charles L. Liotta; Marc Halpern. (1994) *Phase Transfer Catalysis*, Springer.
4. Charles S. Sell. (2019) *Fundamentals of Fragrance Chemistry*, Wiley-VCH.
5. Karl A.D. Swift (2002) *Advances in Flavours and Fragrances*, Royal Society of Chemistry.
6. R. G. Berger. (2007) *Flavours and Fragrances*, Springer.
7. Helen Mitchell, (2006) *Sweeteners and Sugar Alternatives in Food Technology*, Backwell.

Semester IV – Practical

Course:	Practical Course work in Chemistry-IV (Credits: 2.5 Practicals/Week: 3)
SCHE4PR	

PRACTICAL – I

Physical Chemistry

1. Extraction of Fe(III) from aqueous medium and determine the distribution ratio and extraction efficiency.
2. Compare the strengths of HCl and H_2SO_4 by studying kinetics of acid hydrolysis of methyl acetate.
3. To estimate the amount of vitamin C in the given tablet pH-metrically.
4. To estimate Fe(II) in the given solution by titrating against potassium dichromate potentiometrically and calculation of percentage error.
5. Estimation of given acid (strong/ weak) by conductometric titration with a strong base and calculation of percentage error.
6. CST

PRACTICAL – II

Inorganic Chemistry

Inorganic Preparations

1. Trisethylenediaminenickel (II) thiosulphate
2. Hexamminenickel (II) chloride
3. Tristhioureacopper (II) sulphate
4. Potassium trioxalatoferrate (III)

Volumetric Estimation

1. Estimation of Zn(II) by complex metric titration
2. Estimation of total hardness of water

PRACTICAL – III

Organic Chemistry

1. Quantitative Separation of binary mixture (Chemical Separation)

a. Solid-solid binary mixture (Water insoluble-water insoluble)

i. Detection of type of binary mixture
ii. Separation of binary mixture (Chemical separation) using a fixing reagent

2. Detection of Organic Compounds by Micro scale Organic Spotting

Evaluation Scheme

A. Evaluation scheme for Theory courses

I. Continuous Assessment (C.A.) - 40 Marks

(i) C.A.-I: Test – 20 Marks of 40 mins. duration

(ii) C.A.-II: Assignment/ Poster/Worksheets for 20 marks

II. Semester End Examination (SEE)- 60 Marks

B. Evaluation scheme for Practical courses

I. Semester End Examination (SEE)