Department of Pure and Applied Chemistry
University of Kota, Kota

Lecture Plan

M.Sc. I Semester Industrial Chemistry

Paper-I: IND-CHEM-511: Inorganic Chemistry

S. No.	Unit wise Broad Topics of the Syllabus	Tentative Lecture No.
Unit-I: Bonding and Structure:		
1.	Ionic Bonding: General characteristics of ionic bonding, energy considerations in ionic bonding.	1
2.	lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds,	2
3.	statement of Born-Lande equation for calculation of lattice energy	3
4.	Born-Haber cycle and its applications	4
5.	polarizing power and polarizability	5
6.	Fajan's rules, ionic character in covalent compounds	6
7.	bond moment, dipole moment and percentage ionic character	7
8.	MO Approach : Rules for the LCAO method, bonding and anti-bonding MOs and their characteristics for s-s, s-p and p-p combination of atomic orbitals, non-bonding combination of orbitals	8-11
9.	MO treatment of homo-nuclear diatomic molecules of 1^{st} and 2^{nd} periods (including idea of s-p mixing) and hetero-nuclear diatomic molecules such as CO, NO and NO^{+}.	12-15
Unit-II: Solid State Chemistry:		
10.	Structure of Solids: Types of matter, classification of solids,	16
11.	laws of crystallography, crystallographic systems,	17
12.	close packing of atoms; voids in closest packing;	18
13.	radius ratio rule, structure of ionic crystals;	19
14.	ionic crystals with stoichiometry MX, ionic crystals with stoichiometry MX_2, spinel structure.	20-22
15.	Crystal Defects: Classification of defects: subatomic, atomic and lattice defects in solids;	23-25
16.	thermodynamics of vacancy in metals, thermodynamics of Schottky defects in ionic solids; thermodynamics of Frenkel defects in silver halides;	26-27
17.	calculation of number of defects and average energy required for defect,	28-29
18.	non-stoichiometry and its classifications, colour centres	30
Unit-III: Nuclear Chemistry:		
19.	Nuclear Structure: Stability of nuclei, packing fraction, even-odd nature of nucleons, n/p ratio,	31-32
20.	nuclear potential, binding energy and exchange forces, properties of isobars,	33-34
21.	shell model and liquid drop model	35
22.	decay of radio nuclei, rate of decay, determination of half-life period	36-37
23.	modes of decay: alpha, beta, gamma and orbital electron capture	38-39
24.	nuclear isomerism; internal conversions; Q value; nuclear cross section; threshold energy and excitation functions	40-41
25.	Nuclear Fission: Conformation of nuclear fission, types of fission reaction,	42-43

	mass distribution of fission product,	
26.	emission of neutron in fission, fissile and fissionable nuclides,	44
27.	theory of nuclear fission, critical energy for fission, products of nuclear fission	45
Unit-IV: Coordination Chemistry:		
28.	Studies of coordination compounds in solution, detection of complex formation in solution,	46-47
29.	stability constants, stepwise and over-all formation constants,	48-49
30.	simple methods (potentiometric, pH metric and spectrophotometric methods) of determining the formation constants	49-51
31.	factors affecting stability	52
32.	Kinetics and mechanism of reactions in solution	53
33.	labile and inert complexes, ligand displacement reactions in octahedral and square planar complexes	54-55
34.	acid hydrolysis, base hydrolysis and anation reactions,	56
35.	trans effect, inner sphere and outer sphere processes,	57
36.	reactions of coordinated ligands, template effect and its application for the synthesis of macrocyclic ligands	58-60
Unit-V: Organometallic Chemistry:		
37.	Introduction and nature of bonding in organometallic compounds of transition metals,	61-62
38.	σ- and π-bonded organometallic compounds	63-64
39.	Introduction, classification and synthesis, general characteristics, chemical reactions, bonding and structure;	65-66
40.	π-bonded organometallic compounds: η^2-alkene, η^3-allyl (or enyl) and η^5-cyclpentadynyl complexes: Preparative methods, physical properties, chemical properties, bonding of structure	67-73
41.	industrial applications of organometallic compounds Zn, Pd and Fe	74-75

Range of lectures required for completion of broad topics of the Syllabus : 65-75

Books:

- *Advanced Inorganic Chemistry 5th Edition by F. A. Cotton and G. Wilkinson, Wiley Eastern.*
- *Inorganic Chemistry-Principles of structure and reactivity, 4th edition by J. E. Huheey, E.A. Keiter and R L. Keiter, Pearson-Education.*
- *Mechanism of Inorganic Reactions by F. Basolo and R.G. Pearson Wiley Eastern.*
- *Essentials of Nuclear Chemistry 2nd Edition by H. J. Arniker, Wiley eastern Co.*
- *Elements of Nuclear Chemistry by A. K. Srivatsava and P.C. Jain, S. Chand and Co.*
- *Basic Organometallic Chemistry by J. Haiduc and J.J. Zuckerman, Walter de Gruyter.*
- *Basic Solid State Chemistry by A. R. West, John Wiley & Sons.*
- *Solid-State Chemistry an Introduction, 2nd Ed by Lasley Smart and Elaine Moore, Chapman & Hall*
- *Solid State Chemistry by D. K. Chakraborty, New Age International Pvt. Ltd.*
- *Principles of the Solid State, by H. V. Keer, Wiley Eastern Ltd.*

Paper-II: IND-CHEM-512: Organic Chemistry

S. No.	Unit wise Broad Topics of the Syllabus	Tentative Lecture No.
Unit-I: Basic Concepts of Organic Chemistry:		
1.	Basic concept of resonance, tautomerism, conjugation	1
2.	aromaticity, non-aromatic and anti-aromaticity;	2
3.	generation, types, structure and stability of reaction intermediates (carbocations, carbanions, free radicals);	3-4
4.	types of organic reactions;	5
5.	kinetic and thermodynamic control of chemical reactions;	6
6.	methods of determination of mechanisms of organic reactions (kinetic methods: primary and secondary kinetic isotopic effects;	7-10
7.	non-kinetic methods: study of intermediates, product analysis, isotope labelling, stereochemical studies and cross over experiments);	11-12
8.	linear free energy relationship;	13
9.	Hammett equation: significance of reaction and substituent constants; Taft equation.	14-15
Unit-II: Stereochemistry:		
10.	Fundamentals of organic stereochemistry, introduction of configuration and conformation,	16
11.	determination of configuration of geometrical isomers,	17
12.	d/l, D/L, R/S and E/Z nomenclature,	18-20
13.	Newman, Sawhorse, flying wedge and Fisher projection formulae and inter-conversions;	21
14.	conformation of ethane, n-butane, cycloalkanes; effect of conformation on reactivity;	22
15.	symmetry, groups and faces;	23
16.	chirality, molecules with more than one chiral center, threo and erythro isomers, enantiotopic and diastereotopic atoms;	24-26
17.	stereospecific and stereoselective synthesis, asymmetric synthesis,	27-29
18.	optical activity in the absence of chiral carbon (biphenyls, allenes).	30
Unit-III: Reagents in the Organic Synthesis:		
	Use of reagents in organic synthesis and functional group transformation:	
19.	Grignard's reagent, Gilman's reagent,	31-32
20.	metal hydrides, lithium diisopropylamide (LDA),	33-34
21.	dicyclohexyl carbodimide (DCC), DDQ,	35-36
22.	trimethylsilyl iodide, tri-n-butyltin hydride,	37-38
23.	osmium tetraoxide, selenium oxide,	39-40
24.	phase transfer catalysts, crown ethers,	41-42
25.	Merrifield resin, Backer yeast, Wilkinson's catalyst,	43
26.	1,3-dithiane (reactivity umpolung),	44
27.	Woodward and Prevost hydroxylation, Peterson's synthesis	45
Unit-IV: Photochemistry:		
28.	Types of excitations, fate of excited molecule,	46
29.	quantum yield, transfer of excitation energy;	
30.	photochemistry of alkenes: inter- & intra-molecular reactions of the olefinic bond, isomerization and cyclisation reactions,	47-48
31.	photochemistry of 1,3-, 1,4- and 1,5-dienes;	49-51
32.	photochemistry of carbonyl compounds: cyclic, acyclic and α,β-	52-53

	unsaturated carbonyl compounds,	
33.	cycloaddition reactions: dimerisations and oxetane formation;	54-55
34.	photochemistry of aromatic compounds: transformation, isomerisation,	56-57
35.	additions and rearrangements,	58-59
36.	photo-Fries rearrangement.	60
Unit-V: Heterocyclic Chemistry:		
37.	Nomenclature, classification and importance of heterocycles;	61-62
38.	five-membered heterocycles: synthesis and reactions of pyrrole, furan and thiophen,	63-65
39.	order of aromaticity and reactivity in five-membered heterocycles,	66
40.	benzo-fused five-membered heterocycles: synthesis and reactions including medicinal applications of indole;	67-69
41.	six-membered heterocycles with one heteroatom: synthesis and reactions of pyridines;	70-72
42.	benzo-fused six-membered heterocycles with one heteroatom: synthesis and reactions including medicinal applications of quinoline and isoquinoline.	73-75

Range of lectures required for completion of broad topics of the Syllabus : 65-75

Books:

- *Advanced Organic Chemistry: Reactions, Mechanisms and Structure by J. March, John Wiley & Sons.*
- *Advanced Organic Chemistry, Part A & B, III Edn. by F. A.Carey and Sundberg, Plenum Press.*
- *Principles of Organic Synthesis, II Edn. by R.O.C. Norman, Chapman and Hall.*
- *Organic Chemistry, IV Edn. by S. H.Pine, Hendrickson, D.J.Cram and G.S.Hammond, McGraw-Hill.*
- *Organic Chemistry, Vol. I & II, V Edn. by I. L. Finar, Pearson Education Asia Pvt. Ltd.*
- *Organic Chemistry by P. Mehta and M. Mehta, Prentice Hall India.*
- *A Guide Book to Mechanisms in Organic Chemistry by P. Sykes, Longmans Scientifics and Technical.*
- *Reaction Mechanism in Organic Chemistry, III Edn. by S. M. Mukherji and S. P. Singh,MacMillan*
- *Organic Reactions and Mechanisms, II Edn. by P. S. Kalsi, New Age International Publishers*
- *Organic Reaction Mechanisms by R. K. Bansel, Tata McGraw Hill.*
- *Mechanism and Theory in Organic Chemistry by T.H. Lowry and K.S. Richardson, Harper and Row*
- *Stereochemistry of Carbon Compounds by Ernest L. Eliel, Tata McGraw-Hill Publishing Company*
- *Stereochemistry of Organic Compounds by D. Nasipuri, New Age International Publishers.*
- *Fundamentals of Organic Reaction Mechanisms by J.M.Harris and C.C. Wamser, John Wiley & Sons*

Paper-III: IND-CHEM-513: Physical Chemistry

S. No.	**Unit wise Broad Topics of the Syllabus**	**Tentative Lecture No.**
Unit-I: Chemical Kinetics:		
1.	Introduction, collision theory, activated complex theory, Arrhenius equation,	1-2
2.	salt effect, steady state kinetics,	3-4
3.	unimolecular, bimolecular and trimolecular reactions, chain reactions,	5-6
4.	measurement of rate of slow reactions, fast reactions,	7-8
5.	calculation of conversion and reactor size,	9
6.	heterogeneous reactions, vapour phase catalytic reactions,	10-11
7.	catalytic rate equations, use of rate equations in reactor design,	12
8.	factor affecting chemical process, reactor shape and their kinetic behaviuor,	13-14

9.	back mixing, selection and sizing of homogeneous catalytic reactors.	15
Unit-II: Thermodynamics:		
10.	Classical Thermodynamics: Law of thermodynamics, concept of entropy, Gibbs function,	16
11.	Gibbs-Helmholtz equation, Maxwell relations,	17
12.	thermodynamic equation of state, thermodynamics of systems of variable compositions,	18-19
13.	partial molar quantities, partial molar volume, chemical potential,	20-21
14.	Gibbs-Duhem equation,	22
15.	fugacity of real gases and its determination,	23
16.	heat engine, Carnot's cycle, free energy work function	24-25
17.	Statistical Thermodynamics: Definitions of state of a system, Boltzmann distribution law and its derivations,	26-28
18.	Boltzmann-Planck equation, Fermi-Dirac and Bose-Einstein statistics	29-30
Unit-III:Surface Chemistry:		
19.	Adsorption: Definition, thermodynamics of adsorption,	31
20.	Langmuir adsorption isotherm, Langmuir constant and Gibbs energy of adsorption, Langmuir adsorption with lateral interaction,	32-34
21.	BET adsorption isotherm, adsorption on heterogeneous surface	35-36
22.	Liquid Surface: Microscopic picture of liquid surface, surface tension,	37
23.	equation of Young and Laplace (derivation and application),	38
24.	curve surface, Kelvin equation, capillary condensation, porous solids and nucleation theory.	39-40
25.	Surfactants: Micelles and Emulsions: Surfactants, types of micelles, Ostwald ripening, critical micelle concentration,	41-42
26.	thermodynamics of micellization, structure of surfactants, aggregates,	43
27.	biological membranes, microemulsion, inverse microemulsion formation and stabilization.	44-45
Unit-IV: Electrochemistry:		
28.	Introduction and over view of electrochemical processes: Electrochemical cell and reactions, Faradic and non-Faradiac processes,	46
29.	basic electrochemical thermodynamics, free energy and cell EMF,	47
30.	half-cell reactions and reduction potentials, formal potentials,	48
31.	reference electrodes, measurements of potential differences,	49
32.	electrochemical potentials, absolute potentials, liquid junction potential	50
33.	Ion-ion interactions: Ideal solution, deviation from ideality,	51
34.	activity and activity coefficient,	52
35.	Debye-Huckel theory, limited and extended law	53-54
36.	Electrochemical devices: Batteries and Fuel cells.	55
Unit-V: Corrosion:		
37.	Introduction, economic aspects of corrosion, theories of corrosions,	61
38.	factor affecting corrosions,	62
39.	kinetics of corrosion,	63-64
40.	thermodynamics of corrosions,	65-66
41.	uses and abuses of corrosion and corrosion potential: Evans diagrams, measurement of corrosion rate: (i) weight loss method, (ii) electrochemical method,	67-69
42.	inhibiting corrosion: Cathodic and anodic protection. (i) Inhibition by addition of substrates to the electrolyte environment, (ii) by charging the corroding method from external source,	70-72

43.	anodic protection, organic inhibitors, green inhibitors,	73-74
44.	passivation: nature's method for stabilizing surfaces	75

Range of lectures required for completion of broad topics of the Syllabus : 65-75

Books:

- *Kinetics and Mechanism of Chemical Transformations by J. Rajaram and J. C. Kuriacose, MacMillan.*
- *Atkins Physical Chemistry, Oxford University Press, Oxford*
- *Chemical Kinetics by K. J. Laidler, Harper and Row.*
- *Physical Chemistry of Surfaces by A. W. Anderson, Wiley-Interscience.*
- *Introduction to Electrochemistry by S. Glasstone, Affiliated East west Press.*

Paper-IV: IND-CHEM-514: Mathematics for Chemists (For students without Mathematics in B. Sc.)

S. No.	Unit wise Broad Topics of the Syllabus	Tentative Lecture No.
Unit-I: Basic Mathematics:		
1.	Matrix algebra, determinants,	1-2
2.	linear equations,	3
3.	Eigen values and Eigen vectors,	4-5
4.	basic rules for differentiation,	6-7
5.	applications of differentiation in chemistry,	8-9
6.	partial differentiations, maxima and minima,	10-11
7.	basic rules for integration,	12-13
8.	application of integral calculus	14-15
Unit-II: Mathematics and Linear Programming Problems:		
9.	Differential equations,	16
10.	solution of linear differential equations,	17
11.	applications of differential equations;	18-19
12.	Vectors: definition dot, triple and cross product,	20
13.	Vector Calculus: gradient, divergence and curl;	21
14.	linear programming problems: Formulation, graphical solution, simplex method, solution by simplex method (up to 2 variables)	23-30
Unit-III: Basic Operations Research:		
15.	Operations research-concept and applications of OR,	31-32
16.	transportation problem,	33-34
17.	assignment problems,	35-36
18.	basic concepts of inventory control,	37-38
19.	inventory control models,	39-40
20.	basic concepts of replacement problems,	41-42
21.	solutions of replacement problems,	43-44
22.	basic concepts of theory of reliability.	45
Unit-IV: Basic Statistics:		
23.	Quality control and ABC analysis	46-48
24.	curve fitting: methods of least square,	49-50
25.	permutation & combination,	51-52
26.	probability theory,	53
27.	representation of data-histogram, Pie chart,	54
28.	measures of central tendency,	55
29.	deviation, dispersion,	56-57
30.	skewness and kurtosis	58

31.	random variables, mathematical expectations.	59-60
Unit-V: Statistical Inference:		
32.	Probability distribution: discrete (binomial and Poisson),	61
33.	probability distribution: continuous (normal) distribution,	62
34.	correlation,	63-64
35.	regression,	65-66
36.	sampling concepts,	67-68
37.	sampling test for mean,	69
38.	testing of hypothesis-test based on t-distribution (t-test),	70-71
39.	test based on Chi square distribution (Chi square test),	72-73
40.	basic concepts of estimation	74-75

Range of lectures required for completion of broad topics of the Syllabus : 65-75

Books:

- *Mathematical Statistics-Gupta and Kapoor.*
- *Operations Research-Kanti Swaroop.*
- *The Chemistry Mathematics Book, E. Steiner, Oxford University Press.*
- *Mathematics for Chemistry, Doggett and Sucliffe, Longman.*
- *Mathematical for Physical Chemistry: F. Daniels, Mc Graw Hill.*
- *Chemical Mathematics D.M. Hirst, Longman.*
- *Applied Mathematics for Physical Chemistery, J.R. Barrnte, Prentice Hall.*
- *Basic Mathematics for Chemists, Tebbutt, Wiley.*

OR

Paper-IV: IND-CHEM-514: Biology for Chemists (For students without Biology in B. Sc.)

S. No.	**Unit wise Broad Topics of the Syllabus**	**Tentative Lecture No.**
Unit-I: Cell Structure and Functions:		
1.	Structure of prokaryotic and eukaryotic cells,	1-3
2.	intracellular organelles and their functions,	4-6
3.	comparisons of plant and animal cells,	7
4.	overview of metabolic processes: catabolism and anabolism,	8-10
5.	ATP-the biological energy currency,	11
6.	origin of life: unique properties of carbon, chemical evolution and rise of living systems.	12-15
Unit-II: Carbohydrates:		
7.	Monosaccharides: Structure, conformation	16
8.	functions of important derivatives of monosaccharides;	17
9.	structural polysaccharides: cellulose and chitin,	18-19
10.	storage polysaccharides: starch and glycogen,	20-21
11.	structure and biological functions of glucosaminoglycans or mucopolysaccharides,	22-23
12.	glycoproteins and glycolipids,	24
13.	role of sugars in biological recognition,	25
14.	blood group substances;	
15.	carbohydrate metabolism: Kreb's cycle, glycolysis, glycogenesis and glycogenolysis, gluconeogenesis, pentose phosphate pathway	26-30

Unit-III:Lipids:		
16.	Fatty acids,	31-32
17.	structure and function of triacylglycerols,	33-34
18.	structure and function of glycerophospholipids, sphingolipids,	35-36
19.	structure and function of cholesterol, bile acids, prostaglandins;	37-38
20.	liproproteins: composition and function, role in atherosclerosis;	39
21.	properties of lipid aggregates: micelles, bilayers,	40
22.	liposomes and their possible biological functions;	41
23.	biological membranes,	42
24.	fluid mosaic model of membrane structure,	43
25.	lipid metabolism: β-oxidation of fatty acids.	44-45
Unit-IV: Amino-acids and Proteins:		
26.	Amino acid metabolism: degradation and biosynthesis of amino acids,	46-47
27.	sequence determination: chemical / enzymatic / mass spectral, racemization / detection,	48-49
28.	chemistry of oxytocin and tryptophan releasing hormone (TRH)	50
29.	Chemical and enzymatic hydrolysis of proteins,	51
30.	amino acid sequencing,	52
31.	secondary structure of proteins,	53-54
32.	force responsible for holding of secondary structures,	
33.	α-helix, β-sheets,	55
34.	triple helix structure of collagen,	56
35.	tertiary structure of protein: folding and domain structure,	57-58
36.	quaternary structure	59-60
Unit-V: Nucleic Acids:		
37.	Purine and pyrimidine bases of nucleic acids,	61
38.	structure of ribonucleic acids (RNA)	62-63
39.	structure of deoxyribonucleic acid (DNA),	64-65
40.	double helix model of DNA,	66-67
41.	chemical and enzymatic hydrolysis of nucleic acids,	68
42.	chemical basis of heredity,	69
43.	an overview of replication, transcription,	70-71
44.	translation and genetic code,	72-73
45.	chemical synthesis of mono- and tri-nucleosides	74-75

Range of lectures required for completion of broad topics of the Syllabus : 65-75

Books:

- *Principles of Biochemistry, A.L. Lehnigher, Worth Publishers.*
- *Biochemistry, L. Stryer, W.H. Freeman.*
- *Biochemistry, J. David Rawn, Neil Patterson.*
- *Biochemistry, Voet and Voet, John Wiley.*
- *Outlines of Biochemistry E.E. Conn and P.K. Stumpf, John Wiley.*