SHIVAJI UNIVERSITY, KOLHAPUR

DEAPRTMENT OF CHEMISTRY

Academic Year 2018-2019

PART – A

Name of Department: Department of Chemistry

Department Vision: Engender Human Resource to Lead the Competitive Science World for Nation Building

Department Mission: Impart most advanced scientific knowledge and training to the students so that genuine researchers and skilled scientists of world standard will be made available for the advancement of national science and technology programs as well as to cater the needs of industrial and pharma sectors

Name of Program: M.Sc. Physical Chemistry

M. Sc. Physical Chemistry, a post-graduate degree program of the Shivaji University, is one of the best in the country because it's curriculum involves most advanced topics like *ab initio* methods, semiempirical methods, density functional theory, molecular simulations, molecular dynamics, statistical mechanics of quantum particles, irreversible thermodynamics, molecular spectroscopy, nanomaterials, electrochemistry at interfaces, etc. and the practical training based on these advanced topics required to understand problems of the present time. Successful students of this course are capable of doing independent research work not only in relevant world class laboratories but also in R&D sectors and in quality teaching institutes.

Program Outcomes (POs)

PO1: Understanding fundamental principles and laws of physical chemistry

PO2: Development of abilities to study and understand properties of materials

PO3: Design and testing of electrochemical cells and electrochemical properties of materials

PO4: Understanding forces responsible for various types of structure property correlations

PO5: Studies of physicochemical properties of novel materials including nanomaterials

PO6: Studies of protein-ligand binding interactions

PO7: Solid material design, property measurements, structural analysis and application testing

PO8: Empowering the students to do independent research of high caliber.

Program Specific Outcomes (PSOs)

PSO1: Electronic structure calculation and property analysis or prediction

PSO2: Understanding kinetics and dynamics of materials in gas and condensed phases

PSO3: Structure elucidation and estimation of molecular properties

PSO4: Independently perform a computer simulation to predict structures, reaction paths, molecular/material properties, etc.

Part B

Syllabus Structure: Annexure – I

Semester-wise courses, their COs and Mapping Matrices

Semester: I

Courses:

CH-1.1 (Inorganic Chemistry – I)

CH-1.2 (Organic Chemistry – I)

CH-1.3 (Physical Chemistry – I)

CH-1.4 (Analytical Chemistry – I)

PCH-1.1 (Practical – I)

PCH-1.2 (Practical – II)

CH-1.1 (Inorganic Chemistry – I)

Course Outcomes (COs)

CO1: Students will be able to explain the basic chemistry of transition metals and its compounds, spectroscopic characteristics of such compounds, nomenclature, reactions and applications.

CO2: Students will obtain knowledge about Preparation, structure, physical and chemical properties of metal carbonyls of transition metals.

CO3: Students will be able to understand the all aspects of synthesis, bonding, structure and reactivity of organometallic compounds and their applications in homogenous catalysis.

CO4: Student will be able determine the stability of the complexes and will be able to explain the nuclear stability and reactions.

COs – POs & PSOs mapping matrix (1-Low, 2-Medium, 3-High, 0-No correlation)

PO→ CO↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	2	3	3	3	3	3	3	1	2
CO2	2	2	3	2	2	3	2	3	3	2	3	3
CO3	3	3	3	2	2	2	3	2	3	1	3	3
CO4	3	2	3	1	1	1	2	3	3	2	2	2
Total	11	9	12	7	8	9	10	11	12	8	9	10

Average	2.8	2.2	3	1.8	2	2.2	2.5	2.8	3	2	2.2	2.5

CH-1.2 (Organic Chemistry – I)

Course Outcomes (COs)

CO1: Students will able to differentiate between various organic reactive intermediates.

CO2: Students can recognize, classify, explain, and apply fundamental organic reactions.

CO3: Students will have ability to distinguish between different kinds of isomers.

CO4: Course will develop interest in writing and finding mechanisms of new reactions.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3	3	3	3	3	3	3	2	2
CO2	3	3	3	3	3	3	3	3	3	3	2	2
CO3	3	2	2	3	3	3	3	3	3	3	2	2
CO4	3	1	2	3	3	3	3	3	3	3	2	3
Total	12	9	10	12	12	12	12	12	12	12	8	9
Average	3	2.2	2.5	3	3	3	3	3	3	3	2	2.2

CH-1.3 (Physical Chemistry – I)

After completing this course, students will be able to understand basic principles of thermodynamics and statistical mechanics required to learn more advanced topics like quantum statistics and molecular dynamic simulation methods.

Course Outcomes (COs)

CO1: Students will be able to understand basic principles of thermodynamics and statistical mechanics

CO2: Able to learn advanced topics like quantum statistics and molecular dynamic simulation methods.

CO3: Develop abilities to understand how to estimate and analyze the physicochemical properties of condensed and gas phase materials.

CO3: Able to utilize spectral data to estimate molecular thermodynamic properties through partition function calculations.

CO4: Understand properties of detergents and colloidal materials

CO5: Learns the principles and techniques to understand gas and liquid adsorptions on solid surfaces

CO6: Can learn spectral techniques to study surface adsorption phenomena.

CO7: Learn principles and techniques for estimation of average molecular weight of a polymer or biological macromolecules

CO8: Develop abilities to characterize polymers through understanding theories of virial coefficients, concepts of glass transition temperatures, etc.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
COs ↓												
CO1	3	2	1	3	3	3	3	3	2	2	3	1
CO2	2	2	1	3	2	3	2	3	1	2	1	2
CO3	3	3	2	3	3	3	3	3	3	3	3	3
CO4	3	3	2	3	3	2	2	3	1	2	2	2
CO5	3	1	0	3	3	1	2	3	1	1	3	1
CO6	3	3	1	3	3	1	3	3	2	1	3	1
CO7	3	3	1	3	3	3	2	3	1	2	3	2
CO8	3	3	0	3	3	2	1	3	1	2	3	2
Total	23	20	8	24	23	18	18	24	12	15	21	14
Average	2.9	2.5	1	3	2.9	2.2	2.2	3	1.5	1.9	2.6	1.7

CH.1.4: Analytical Chemistry-I

Course Outcomes (COs)

CO1:Students would acquire the knowledge about the fundamentals of Analytical Chemistry including the sampling, sample pretreatment, basic techniques, methods and data handling, processing and statistical analysis of the same.

CO2: Students would acquire the knowledge and understand the scope of Analytical Chemistry spanning various fields. The students will learn fundamentals of qualitative analysis using conventional techniques

CO3: Students will learn the chromatographic techniques, choice of chromatographic techniques and tuning of the chromatographic technique as per the need based on the samples to deal with, learn electroanalytical techniques and computation chemistry which would groom them for alternative analytical strategies which form one of the important components of analytical chemistry.

CO4:Students will learn about referring to the standard reference books and infer information from the same. Analytical case study problems would be discussed to familiarize with the scope and advantages of Analytical Chemistry.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3	3	3	3	3	3	3	2	2
CO2	3	3	3	3	3	3	3	3	3	3	2	2
CO3	3	2	2	3	3	3	3	3	3	3	2	2
CO4	3	1	2	3	3	3	3	3	3	3	2	3
Total	12	9	10	12	12	12	12	12	12	12	8	9
Average	3	2.2	2.5	3	3	3	3	3	3	3	2	2.2

PCH-1.1 (Practical – I)

Course Outcomes (COs)

CO1: Ability in professional sampling and sample treatment before actual analysis

CO2:Ability to treat and evaluate the results of analysis

CO3: Understanding and capability of performing basic chemical processes in a chemical laboratory

CO4: Capability of performing measurements on basic analytical instruments (photometers, spectrometers, chromatographs, ion-selective electrodes)

COs – POs & PSOs mapping matrix (1-Low, 2-Medium, 3-High, 0-No correlation)

PO→ CO↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	2	3	3	2	3	2	3	3	3
CO2	2	3	3	2	3	3	2	2	3	3	3	2
CO3	2	2	2	2	3	3	3	2	1	3	3	3
CO4	2	3	3	2	3	3	3	1	2	3	3	3
Total	8	11	11	8	12	12	10	8	8	12	12	11
Average	2	3	3	2	3	3	2.5	2	2	3	3	3

PCH-1.2 (Practical – I)

Course Outcomes (COs)

CO1: Students can be able to prepare various concentration solutions like molar, normal, ppm, etc.

CO2: Determine the rate constants of various first order and second order reactions

CO3: Determine the redox potential of a system, relative strength of acid etc using potentiometer, conductometer

CO4: Know the formation of alloys like Brass, Bronze, phase diagram for binary and ternary systems studied in details like a composition, critical temperature, etc

CO5:Validity of Freundlich adsorption isotherms to remove toxic material such as dye, acetic acid, and other industrial effluents

Cos – Pos & PSOs mapping matrix (1-Low, 2-Medium, 3-High, 0-No correlation)

PO→ CO↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	2	3	3	2	3	2	3	3	3
CO2	2	3	3	2	3	3	2	2	3	3	3	2
CO3	2	2	2	2	3	3	3	2	1	3	3	3
CO4	2	3	3	2	3	3	3	2	2	3	3	3
CO5	2	2	2	1	2	1	2	1	2	2	1	2
Total	10	13	13	9	14	13	12	10	10	14	13	13
Average	2	2.6	2.6	1.8	2.8	2.6	2.4	2	2	2.8	2.6	2.6

Semester: II

Courses:

CH-2.1 (Inorganic Chemistry – II)

CH-2.2 (Organic Chemistry – II)

CH-2.3 (Physical Chemistry – II)

CH-2.4 (Analytical Chemistry – II)

PCH-2.1 (Practical – III)

PCH-2.2 (Practical – IV)

CH-2.1 (Inorganic Chemistry – II)

Course Outcomes (COs)

CO1: Students will get the knowledge of the basic chemistry of non-transition elements and their compounds, synthesis and structural features, and applications.

CO2: To be able to explain the structures of inorganic compounds based on different theories. Student will understand the chemistry of various types of solvents.

CO3: Be well versed with the knowledge about the chemistry of Lanthanides and Actinides with respect to occurrence, separation, compounds and applications.

CO4**:**To understand the three dimensional structures of solid-state materials of industrial importance and to get the knowledge of bio-inorganic Chemistry.

COs – POs & PSOs mapping matrix (1-Low, 2-Medium, 3-High, 0-No correlation)

PO→ CO↓	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	3	3	3	3	1	3	2
CO2	3	1	3	3	2	3	2	2	3	3
CO3	2	2	2	3	3	3	3	2	3	3
CO4	3	3	3	3	3	3	1	3	3	2
Total	11	8	11	12	11	12	9	8	12	10
Average	3	2	3	3	3	3	2	2	3	3

CH-2.2 (Organic Chemistry – II)

Course Outcomes (COs)

CO1: Illustration of modern synthetic methods and applications of reagents.

CO2: Provide knowledge of different organometallic compounds and various coupling reactions.

CO3: Understand principle and applications of protection and deprotection of various functional groups.

CO4: It will elaborate to understand the concept of chemoselectivity, regioselectivity and enantioselectivity.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3	3	3	3	3	3	3	1	2
CO2	3	3	2	3	3	3	3	3	3	2	2	2
CO3	3	2	2	3	2	3	3	2	3	3	2	2
CO4	3	1	2	3	3	3	3	3	3	3	2	2
Total	12	9	9	12	12	12	12	12	12	11	7	8
Average	3	2.2	2.2	3	3	3	3	3	3	2.7	1.7	2

CH2.3 (Physical Chemistry – II)

Students will learn the fundamentals of quantum mechanics and how to solve the Schrodinger wave equation for some simple systems as well as derive selection rules for such systems. Knowledge gained through this course will help students to learn more advanced topics in quantum mechanics and hence becomes the basis or essential requirement for the course "Advanced Quantum Chemistry"

Course Outcomes (COs)

CO1: Students will learn basics of quantum mechanics.

CO2: Knowledge of the course will form the basis or essential requirement for the course "Advanced Quantum Chemistry"

CO3: Able to understand selection rules and to predict the electronic spectra of conjugated organic molecules.

CO4: Able to study photochemical and photophysical phenomena

CO5: Capable of qualitative and quantitative analysis of various ingredients from industrial, food and pharma samples using techniques of emission spectroscopy.

CO6: Capable of understand the electrochemical aspects of materials, ionic processes and electrochemical sensors, battery materials and characterizations etc.

CO7: Able to study electrokinetic effects and their applications in the field of protein separation, characterization etc.

CO8: Understanding the molecular dynamics through kinetic studies. Applications to explore reaction pathways, protein-ligand binding rates, etc. will help to understand life governing processes.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	3	3	2	3	3	3	2	3	3
CO2	3	2	1	3	3	2	3	3	3	2	3	3
CO3	3	3	1	3	3	0	3	3	3	1	3	3
CO4	3	3	0	3	3	3	3	3	2	2	3	2
CO5	2	3	0	3	3	3	3	3	2	0	2	1
CO6	2	3	3	2	3	0	3	3	3	1	2	1
CO7	3	3	3	3	1	2	1	3	1	1	2	2
CO8	3	2	1	3	2	3	2	3	1	3	2	3
Total	22	22	10	23	21	15	21	24	18	12	20	18
Average	2.7	2.7	1.2	2.9	2.6	1.9	2.6	3	2.2	1.5	2.5	2.2

CH.2.4: Analytical Chemistry-II

Course Outcomes (COs)

CO1: Students will acquire the knowledge of spectroscopic tools/instruments used in chemical analysis and interpretation of the data. The scope and limitations of the spectroscopic tools would be discussed so that the students learn about the type of samples which could be analyzed by these tools offering choices among the spectroscopic tools.

CO2: Students will learn about the simple and advanced instruments used for analysis like NMR, MS, AAS, ICP and thermal analysis (TGA, DTA, DSC etc.) techniques spanning wide variety of samples to be considered for analysis.

CO3:Students will learn about the instrumentation, sample preparation and handling of sample, analysis and data interpretation and structural elucidation.

CO4: Learning about different instruments will give them idea about appropriate choice of the instrument for analysis based on the source and type of analyte(s) in the sample under consideration.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3	3	3	3	3	3	3	1	2
CO2	3	3	2	3	3	3	3	3	3	2	2	2
CO3	3	2	2	3	2	3	3	2	3	3	2	2
CO4	3	1	2	3	3	3	3	3	3	3	2	2
Total	12	9	10	12	12	12	12	12	12	12	8	9
Average	3	2.2	2.5	3	3	3	3	3	3	3	2	2.2

PCH-2.1 (Practical – III)

Course Outcomes (COs)

CO1: Students developed for precise sample solution preparation and sample treatment before actual analysis.

CO2:Students can be able to perform the calculations and error analysis

CO3: Develop understanding of basic chemical processes and deciding methods of analysis.

CO4: Capability of performing measurements on basic analytical instruments (photometers, spectrometers, chromatographs, high end thermometers, refractometer, pH meter etc.)

COs – POs & PSOs mapping matrix (1-Low, 2-Medium, 3-High, 0-No correlation)

PO→ CO↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	2	3	3	2	3	2	3	3	3
CO2	2	3	3	2	3	3	2	2	3	3	3	2
CO3	2	2	2	2	3	3	3	2	2	3	3	3
CO4	2	3	3	2	3	3	3	2	2	3	3	3
Total	8	11	11	8	12	12	10	9	9	12	12	11
Average	2	3	3	2	3	3	2.5	2.2	2.2	3	3	3

PCH-2.2 (Practical – IV)

Course Outcomes (COs)

CO1: Students can be able to prepare various concentration solutions like molar, normal, ppm, etc.

CO2: Determine the unknown concentration and thermodynamic parameters using conductometer

CO3: Student will explore how to estimate order of reaction and the catalysis

CO4: students can estimate refractive index and molecular weights of species.

CO5:Students can understand the estimation of equilibrium properties like redox potential, phase diagram etc

Cos – Pos & PSOs mapping matrix (1-Low, 2-Medium, 3-High, 0-No correlation)

PO→ CO↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	2	3	3	2	3	2	3	3	3
CO2	2	3	3	2	3	3	2	2	3	3	3	2
CO3	2	2	2	2	3	3	3	2	1	3	3	3
CO4	2	3	3	2	3	3	3	2	2	3	3	3
CO5	2	2	2	2	2	2	2	2	2	2	1	2
Total	10	13	13	10	14	14	12	11	10	14	13	13
Average	2	2.6	2.6	2	2.8	2.8	2.4	2.2	2	2.8	2.6	2.6

Semester III

Courses:

PCH-3.1 (Advanced Quantum Chemistry)

PCH-3.2 (Electrochemistry)

PCH-3.3 (Molecular Structure-I)

PCH-3.4 (A) (Solid State Chemistry)

PCH-3.4 (B) (Advanced Chemical Kinetics)

PCH-3.4 (C) (Radiation and Photochemistry)

PCH-V (Practical Course – V)

PCH-VI (Practical Course – VI)

PCH-3.1 (Advanced Quantum Chemistry)

This course is designed by keeping in mind today's power and utility of computational science in the advancement of our understanding at molecular level and in the developments of new technologies. The knowledge of basic quantum mechanics helps to understand spectral selection rules, concept of atomic orbitals, electronic transitions etc and that of advanced quantum chemistry topics such as *ab initio* methods, electron correlation techniques and density functional theory is useful to solve electronic structures of atoms and molecules. This helps students to learn how to predict and calculate the reaction mechanisms, transition state analysis, design of new molecules, spectral and other molecular properties of molecules and molecular assemblies etc. All these if supported through computational lab experiments will make the students capable of doing most advanced science through experimentation and computational tools.

Course Outcomes (COs)

CO1: Learn concepts of atomic orbitals and their shapes, spectroscopic selection rules, ionization potentials, etc.

CO2: Learn advanced quantum methods such HF-SCF theory and post-HF methods and learners will be able to do accurate electronic energy and molecular structure calculations

CO3: Knowledge of the course will be used to do computer simulations to calculate molecular properties, nmr shift, IR and Raman spectra etc. for small to medium sized molecules or molecular assemblies.

CO4: Will familiarize in understanding and choosing the appropriate basis sets for electronic structure calculations with appropriate corrections through use of electron correlation methods

CO5: Students will learn most advanced method of quantum mechanics i.e Density Function Theory for electron structure calculations

CO6: Learners will be capable of calculate the transition states, potential energy surfaces and reactions paths for chemical reactions using DFT method

CO7: Students can predict all the properties of materials at molecular level even for nanostructures, drugs, solids oxides, composites, solid electrolytes, electrode materials used in batteries and other electronic devices, etc.

CO8: For larger molecules like macrocycles, polymers, peptides etc., learners will be capable of replace or modify computationally demanding two-electron integrals through use semiempirical methods and parameterization tools used in these methods.

CO9: Knowledge of this course will make learners a potential candidate to work independently in any R&D laboratory or research laboratory or academic institutes of international repute.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	3	3	2	3	3	3	2	3	3
CO2	3	3	1	3	3	3	3	3	3	1	3	3
CO3	3	3	2	3	3	1	3	3	3	1	3	3
CO4	3	3	1	3	3	1	3	3	3	2	3	3
CO5	3	3	3	3	3	2	3	3	3	3	3	3
CO6	3	3	3	3	3	2	3	3	3	3	3	3
CO7	3	3	2	3	3	2	3	3	3	3	3	3
CO8	2	3	1	3	3	1	3	3	3	3	3	3
CO9	3	3	2	3	3	2	3	3	3	3	3	3
Total	26	27	16	27	27	16	27	27	27	21	27	27
Average	2.9	3	1.8	3	3	1.8	3	3	3	2.3	3	3

PCH-3.2 (Electrochemistry)

Course Outcomes (COs)

CO1: Students will be able to understand basic principles of electrochemistry

CO2: Study of electrochemical charge transfer properties of materials and designing of applied experiments for electroanalytical testing of materials.

CO3: Charge of the material can be quantified and used for testing of electrokinetic phenomenon.

CO4: Study of electrode electrolyte interfaces based on the properties of material shows the energetically viability of electron transfer

CO5: Learn the principles and techniques to understand adsorptions and desorption from the electrode interface in the electrolyte solution

CO6: Fundamental equation of electrodics to study the reversible charge transfer behavior in the materials electrolyte interfaces.

CO7: Learn principles and techniques for estimation of charge transfer behaviors in semiconductor materials

CO8: Develop abilities to characterize materials through understanding theories electrode reaction.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	2	0	0	3	2	2	1	3
CO2	2	3	3	3	2	1	2	3	3	3	2	3
CO3	3	2	3	2	3	3	0	3	3	3	2	3
CO4	3	3	**3**	3	2	2	2	3	3	3	2	3
CO5	3	2	3	2	3	2	3	3	3	3	2	3
CO6	3	3	3	2	3	1	2	3	3	3	2	3
CO7	3	3	3	2	2	2	3	3	2	3	1	3
CO8	3	3	3	2	3	2	1	3	3	2	2	3
Total	23	21	22	18	20	13	13	24	22	22	14	24
Average	2.9	2.6	2.8	2.2	2.5	1.6	1.6	3	2.8	2.8	1.8	3

PCH- 3.3: Molecular Structure - I

Course Outcomes (COs)

CO1: Students will learn basics principles and laws ofspectroscopy.

CO2: From this course student will learn symmetry operations and groups theory for probing the detail spectral detail of molecule

CO3: Understand the fundamental modes of oscillations of molecules based on the properties like dipole movement of the molecules

CO4: Applications of rotational and vibrational spectroscopy

CO5: Fundamental of polarizability of molecules and Raman active modes

CO6: Structural investigations of the material based on the microwave, IR and Raman spectra and various theories of peak splitting

CO7: Basic Principles of Electronic spectroscopy, progression, sequencing and Birje Spooner plots

CO8: Instrumentation and applications of the Electronic spectroscopy for structural elucidation.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	3	2	3	3	3	3	3	3	3
CO2	3	2	1	3	0	3	3	3	3	3	1	3
CO3	3	2	2	3	1	3	3	3	3	3	3	3
CO4	3	0	1	2	2	3	3	3	3	3	0	3
CO5	3	3	1	1	1	3	3	3	3	3	3	3
CO6	2	3	1	2	2	3	3	3	2	2	2	3
CO7	3	2	2	3	1	3	3	3	0	2	2	3
CO8	2	2	1	2	3	3	3	3	3	2	2	3
Total	22	16	11	19	12	24	24	24	20	21	16	24
Average	2.8	2	1.4	2.4	1.5	3	3	3	2.5	2.6	2	3

PCH-3.4 (A) (Solid State Chemistry)

Course Outcomes (COs)

CO1:Students can be able to provide an introduction to the concepts underlying solid state chemistry.

CO2: Describe specific crystal structures by applying basic crystallographic concepts

CO3: Understand generation of X-ray radiation and its effects of on matter as well Bragg's diffraction equation to find out structural information of solid materials

CO4: Understand the atomic and electronic structure, electric conductivity, optical property, magnetism of solid materials.

CO5: Understand the physical and optical properties of metal, semiconductor, and insulator using free electron theory and band theory

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	3	2	3	3	3	3	3	3	3
CO2	3	2	2	3	1	3	3	3	3	3	1	3
CO3	3	2	2	3	2	3	3	3	3	3	3	3
CO4	3	1	2	2	2	3	3	3	3	3	1	3
CO5	3	3	1	1	2	3	3	3	3	3	3	3
Total	15	10	9	12	9	15	15	15	15	15	11	12
Average	3	2	1.8	2.4	1.8	3	3	3	3	3	2.2	2.4

PCH-3.4 (B) (Advanced Chemical Kinetics)

Course Outcomes (COs)

CO1: Students can understand the basic principles of kinetics, proton transfer and effect of proton ion on the rates of reaction

CO2: Various electron transfer process like inner sphere and outer sphere reactions

CO3: Different models to study catalysis and reaction mechanisms

CO4: Different methods of catalysis like micellization and pseudo ion exchange

CO5: students can learn the advanced theories of chromium ion reduction

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	3	2	3	3	3	3	3	3	3
CO2	3	2	2	3	2	3	3	3	3	3	1	3
CO3	3	2	2	3	2	3	3	3	3	3	3	3
CO4	3	2	2	2	2	3	3	3	3	3	1	2
CO5	3	3	2	2	2	3	3	3	3	3	2	3
Total	15	11	10	13	10	15	15	15	15	15	10	11
Average	3	2.2	2	2.6	2	3	3	3	3	3	2	2.2

PCH-3.4 (C) (Radiation and Photochemistry)

Course Outcomes (COs)

CO1: student will learn basic principles and advanced radicochemical processes

CO2: Student will be familiar with lases and their wide applications

CO3: Students will learn basic principles of photochemistry

CO4: They may do the data interpretation of rates of radiative process for the obtaioned data from the electrochemical transient and flash photloysis.

CO5: Applications of photochemistry for degradation of polymers and other smog,singlet molecular oxygen generation etc.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4

CO1	3	2	2	3	2	3	3	3	3	3	3	3
CO2	3	2	2	3	1	3	3	3	3	3	1	3
CO3	3	2	2	3	2	3	3	3	3	3	3	3
CO4	3	2	2	2	2	3	3	3	3	3	1	3
CO5	3	3	1	1	2	3	3	3	3	3	3	3
Total	15	11	9	12	9	15	15	15	15	15	12	12
Average	3	2.2	1.8	2.4	1.8	3	3	3	3	3	2.4	2.4

PRACTICAL COURSES

Experimentation/practical training is provided in such way that the students will learn to plan, design, execute and analyze the particular laboratory work independently. Furthermore, the practical course is correlated to the theory courses so that the learners can have better understanding of the theoretical concepts through practical approach. The training provided through variety of experiments, computational tools like electronic structure calculations, molecular mechanics and molecular dynamic simulations will make students self-sufficient to work independently at national or international laboratories on their chosen topics or to work in high standard R&D sectors.

Practical PCHP – V

Course Outcomes (COs)

CO1: In-depth training on laboratory solution preparations on all concentration scales

CO2: Training on laboratory safety and lab ethics in scientific work

CO3: Training on planning, design and execution of experiments

CO4: Training on uncertainty estimations for experimentally measured and derived properties of solutions

CO5: Training on buffer preparations, equilibrium studies and spectral analysis.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

Pos→	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4

Cos ↓												
CO1	2	3	3	2	3	3	2	3	1	3	3	2
CO2	1	1	2	0	3	2	3	3	1	2	1	1
CO3	2	3	3	3	3	3	3	3	3	3	3	3
CO4	2	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	2	3	3	2	3	3	3	2	3	3
Total	10	13	13	11	15	13	14	15	11	13	13	12
Average	2	2.6	2.6	2.2	3	2.6	2.8	3	2.2	2.6	2.6	2.4

Practical PCHP – VI

Course Outcomes (COs)

CO1: Training on scientific literature search, defining the objective of the work, research skills, data representation in tabular and graphical form etc.

CO2: Training on experimental verification of fundamental theories, comparison of data with literature and scientific discussion on any deviation of data from expected theoretical values or reported literature.

CO3: Experimental spectral measurements and analysis for understanding binding equilibria

CO4: Training on evaluation of bulk thermodynamic properties of condensed states

CO5: Computer lab training to perform *ab initio* and DFT electronic structure calculation through computer simulations

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	0	1	2	0	2	2	2	3	2	1	1	2
CO2	3	3	3	3	3	3	3	3	2	3	3	2
CO3	2	3	2	3	3	3	2	3	1	2	2	1

CO4	3	3	3	1	3	1	2	3	1	1	2	3
CO5	3	2	3	2	1	2	3	2	3	3	2	2
Total	11	12	13	9	12	11	10	14	9	10	10	10
Average	2.2	2.4	2.6	1.8	2.4	2.2	2.0	2.8	1.8	2.0	2.0	2.0

Semester – IV

Courses:

PCH-4.1 (Thermodynamics and Molecular Modelling)

PCH-4.2 (Chemical Kinetics)

PCH-4.3 (Molecular Structure-II)

PCH-4.4 (A) (Surface Chemistry)

PCH-4.4 (B) (Chemistry of Materials)

PCH-4.4 (C) (Biophysical Chemistry)

PCH-VII (Practical Course – VII)

PCH-VIII (Practical Course – VIII)

PCH4.1 (Paper – XIII, Thermodynamics and Molecular Modeling)

The topics covered under this course are focused towards understanding of thermodynamics principles and their applications to study real life processes not only experimentally but also through computer simulations so that the contribution of individual forces to the observed total thermodynamic quantities can be explored. Furthermore, the students are aimed to understand the principles of industrial processes such as thermoelectricity, osmosis, etc. by knowing irreversible processes through principle of microscopic reversibility and Saxen's relations. Overall, the advanced knowledge of modern thermodynamics including statistical mechanics and molecular simulations of large biological systems will be imparted to the students which will help them to perform independent study of real time problems and their analysis in the field of research and development as well as in chemical and pharmaceutical sectors.

Course Outcome (COs)

CO1: Students with weaker background in mathematical principles will learn how to explore the scientific findings with mathematical models and advance it further.

CO2: Learn principles of statistics to understand and estimate bulk thermodynamic properties of materials.

CO3: Understand how microscopic properties where quantum effects are predominant can be correlated to macroscopic properties where classical thermodynamics is important through an ensemble theories and statistical distribution laws.

CO4: Through these studies, students will be able to evaluate the thermodynamic properties of systems of quantum particles such as bosons and fermions.

CO5: Knowledge can be used to utilize the classical and statistical thermodynamic principles for computer simulation of real life processes through molecular dynamic simulations.

CO5: Learn techniques of MD simulations to evaluate the molecular properties and structural features for understanding the functions of biopolymers and it's applications in drug design, material design, protein chemistry, polymer industry, etc.

CO6: Training to do the simulations independently through this advanced course will make learners a trained potential candidate for placement in world class research laboratories, institutes, R and D sectors of pharma industries, etc.

CO7: Students will learn applicability of principles of thermodynamics where irreversible effects or near equilibrium phenomena exists.

CO8: Students will gain knowledge about science behind the industrially important phenomena like production of electricity from thermal sources, Peltier effects, electrophoresis, osmosis, thermos-diffusion, thermos-conductivity etc.

CO9: Knowledge gained on entropy production and entropy flow in chemical and biological systems will help learners to understand coupling reactions mostly existing in living organisms.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
COs ↓												

CO1	2	3	2	3	1	2	3	3	2	1	3	3
CO2	3	2	2	3	3	3	3	3	1	2	3	3
CO3	3	3	1	3	3	3	3	3	3	2	3	3
CO4	3	3	1	3	3	1	3	3	2	2	3	3
CO5	3	3	2	3	3	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3
CO7	3	3	2	3	3	3	2	3	2	3	3	2
CO8	3	3	3	3	3	2	3	3	2	3	2	3
CO9	3	3	3	3	3	3	3	3	2	3	2	3
Total	26	26	19	27	25	23	26	27	20	22	25	26
Average	2.9	2.9	2.1	3	2.8	2.6	2.9	3	2.2	2.4	2.8	2.9

PCH-4.2 (Chemical Kinetics)

COs

CO1: Students can understand the basic principles of Kinetics

CO2: Students can learn different theories of rates of reaction

CO3: Learn from fundamental to advanced theories and applications of chemical kinetics

CO4: Different methods of study of dynamics of fast reaction mechanism

CO5: Different mechanistic aspects of surface reaction and industrial applications

CO6: Reaction mechanism and photocatalytic applications of materials

CO7: Linear free energy equation and substitutions on aromatic group

CO8: Students learn effect different equations expressions expressing reaction constant and substitution constant.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	3	0	0	3	2	3	1	1	2	3	3
CO2	3	3	1	2	3	1	1	2	1	3	3	3
CO3	3	2	1	3	3	1	2	3	2	2	2	3
CO4	3	0	1	3	3	1	3	3	2	2	2	3

CO5	3	3	2	3	3	2	2	1	3	3	2	3
CO6	3	3	2	3	3	2	2	3	3	2	1	3
CO7	3	3	2	3	3	3	3	1	2	2	1	3
CO8	3	1	2	3	3	3	3	1	2	1	1	3
Total	24	18	11	20	24	15	19	15	16	17	15	24
Average	3	2.3	1.4	2.5	3	1.9	2.4	1.9	2	2.1	1.9	3

PCH- 4.3 (Molecular Structure – II)

COs

CO1: Students will learn basics principles and laws ofelectronic structure and spectroscopy.

CO2: This course studies the electronic properties of materials

CO3: The molecular property dipole movement correlation with electronic structure of a molecule

CO4: Applications of Magnetic properties measurements to the coordination complexes the

CO5: Brief study of magnetic properties of materials.

CO6: Structural investigations of the material based on the NMR radiations and various theories of peak splitting

CO7: Basic Principles of Mossbauer spectroscopy w.r.t fine and hyperfine electron energy splitting

CO8: Instrumentation and applications of the Mossbauer spectroscopy.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	3	2	3	3	3	3	3	3	3
CO2	3	3	2	3	1	3	3	3	3	3	1	3
CO3	3	3	1	3	1	3	3	3	3	3	3	3
CO4	3	3	2	2	2	3	3	3	3	3	0	3
CO5	3	3	1	1	1	3	3	3	3	3	3	3
CO6	2	3	1	2	2	3	3	3	2	2	2	3
CO7	3	3	3	3	1	3	3	3	1	2	2	3

CO8	2	3	1	2	2	3	3	3	3	2	2	3
Total	22	23	13	19	12	24	24	24	21	21	16	24
Average	2.8	2.9	1.6	2.4	1.5	3	3	3	2.6	2.6	2	3

PCH-4.4 (A) (Surface Chemistry)

COs

CO1: Students can be able to understand the surface phenomenon's like adsorption, mechanism of adsorption, factors affecting adsorption. The utilization of adsorption mechanism for removal of industrial effluents and purification of materials studied in detail.

CO2: Explain the link between liquid surface tension and contact angle, and demonstrate how certain experimental techniques can be used for the assessment of liquid surface tension

CO3: Apply knowledge on thermodynamics of micellization in surfactant solutions describe the influence of physical variables such as temperature, molecular structure of surfactant, and solvent characteristics on parameters such as critical micellization concentration (CMC), association number, micelle structure etc.

CO4: Describe and explain different types of colloidal systems and interactions between colloidal particles

CO5: Instrumentation of BET surface area and adsorption isotherms to determine surface area of catalysts which is one of the important criteria to select catalyst in industries

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	3	2	3	3	3	3	3	3	3
CO2	3	3	2	3	1	3	3	3	3	3	1	3
CO3	3	3	1	3	2	3	3	3	3	3	3	3
CO4	3	3	2	2	2	3	3	3	3	3	1	3
CO5	3	3	1	1	2	3	3	3	3	3	3	3
Total	15	14	8	12	9	15	15	15	15	15	11	15
Average	3	2.8	1.6	2.4	1.8	3	3	3	3	3	2.2	3

PCH-4.4 (B) (Chemistry of Materials)

Cos

CO1: Students can differentiate between the Glasses, Ceramics, Composite and Nanomaterials

CO2: Students will understand the synthesis characterization and application of igh Tc materials

CO3: Students will adopt the different methodology of synthesis of polymers, morphology of of polymers and based on the morphologies their applications

CO4: Different mythologies of film formation and their applications

CO5: Learn to fabrications of solid state electronic devices.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	3	2	3	3	3	3	3	3	3
CO2	3	3	2	2	2	3	3	3	3	3	1	3
CO3	3	3	2	3	2	3	3	3	3	3	3	3
CO4	3	1	2	2	2	3	3	3	3	3	2	3
CO5	3	3	1	1	2	3	3	3	3	3	3	3
Total	15	13	9	11	10	15	15	15	15	15	12	15
Average	3	2.6	1.8	2.5	2	3	3	3	3	3	2.4	3

PCH-4.4 (C) (Biophysical Chemistry)

Cos

CO1: students will know about Amino acids, proteins, enzymes , DNA & RNA in living systems , electrolytes, the chirality of biological molecules , the biochemical process , weak and strong interactions, macromolecules and rubber elasticity , polyelectrolytes iopolymers.

CO2: Students will learn the applications of optical and thermodynamic technique to study the interactions of biomolecules with water

CO3: Learn about the photo-biological processes

CO4: Study about different mechanochemical processes in the body.

CO5: Kinetic properties of muscle and molecular mechanism of receptor

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	3	2	3	3	3	3	3	3	3
CO2	3	3	2	3	1	3	3	3	3	3	1	3
CO3	3	3	1	3	2	3	3	3	3	3	3	3
CO4	3	3	2	2	2	3	3	3	3	3	1	3
CO5	3	3	1	1	2	3	3	3	3	3	3	3
Total	15	14	8	12	9	15	15	15	15	15	11	15
Average	3	2.8	1.6	2.4	1.8	3	3	3	3	3	2.2	3

Practical PCHP – VII

Course Outcomes (COs)

CO1: Training on electrochemical analysis of different physicochemical aspects of materials

CO2: Training on different techniques needed to characterize the detergents

CO3: Training on Modeling properties of materials

CO4: Training on estimation of protonation states of acidic, neutral and basic natural amino acids

CO5: Understanding principles of thermodynamics through enthalpy dilution experiments

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3	3	2	3	3	2	1	2	1
CO2	2	3	0	3	2	1	2	3	1	1	0	2
CO3	3	3	2	1	2	2	3	2	1	3	2	2
CO4	3	3	2	2	3	1	3	2	2	2	3	2

CO5	2	1	3	2	1	3	2	2	3	3	2	3
Total	13	13	10	11	11	9	13	12	9	10	9	10
Average	2.6	2.6	2.0	2.2	2.2	1.8	2.6	2.4	1.8	2.0	1.8	2.0

Practical PCHP – VIII

Course Outcomes (COs)

CO1: Application of theoretical and practical knowledge for research training through mandatory research/industrial projects

CO2: Training to estimate properties of ionic and non-ionic detergents.

CO3: Computer lab training to perform molecular dynamic simulations to estimate molecular properties of biomacromolecules in aqueous or mixed aqueous solutions.

CO4: Making well trained experimentalist to handle any experimentally and theoretically challenging scientific problems for advancement science and technology.

COs – POs& PSOs mapping matrix (1-low, 2-medium, 3-high, 0-No correlation)

Pos→ Cos ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	3	3	2	3	3	3	3	3	3
CO2	2	2	1	2	3	1	2	1	2	1	1	2
CO3	3	3	1	3	2	3	2	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3
Total	11	10	8	11	11	9	10	10	11	10	10	11
Average	2.7	2.5	2.0	2.7	2.7	2.2	2.5	2.5	2.7	2.5	2.5	2.7

COPO Mapping Matrix for All Courses

Course ID	Course Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CH-1.1	Inorganic Chemistry – I	2.8	2.2	3	1.8	2	2.2	2.5	2.8	3	2	2.2	2.5
CH-1.2	Organic Chemistry – I	3	2.2	2.5	3	3	3	3	3	3	3	2	2.2
CH-1.3	Physical Chemistry – I	2.9	2.5	1	3	2.9	2.2	2.2	3	1.5	1.9	2.6	1.7
CH-1.4	Analytical Chemistry – I	3	2.2	2.5	3	3	3	3	3	3	3	2	2.2
PCP-1.1	Practical – I	2	3	3	2	3	3	2.5	2	2	3	3	3
PCH-1.2	Practical – II	2	2.6	2.6	1.8	2.8	2.6	2.4	2	2	2.8	2.6	2.6
CH-2.1	Inorganic Chemistry – II	3	2	3	3	3	3	--	--	2	2	3	3
CH-2.2	Organic Chemistry – II	3	2.2	2.2	3	3	3	3	3	3	2.7	1.7	2
CH-2.3	Physical Chemistry – II	2.7	2.7	1.2	2.9	2.6	1.9	2.6	3	2.2	1.5	2.5	2.2
CH-2.4	Analytical Chemistry – II	3	2.2	2.5	3	3	3	3	3	3	3	2	2.2
PCP-2.1	Practical – III	2	3	3	2	3	3	2.5	2.2	2.2	3	3	3
PCH-2.2	Practical – IV	2	2.6	2.6	2	2.8	2.8	2.4	2.2	2	2.8	2.6	2.6
PCH-3.1	Advanced Quantum Chemistry	2.9	3	1.8	3	3	1.8	3	3	3	2.3	3	3
PCH-3.2	Electrochemistry	2.9	2.6	2.8	2.2	2.5	1.6	1.6	3	2.8	2.8	1.8	3
PCH-3.3	Molecular Structure – I	2.8	2	1.4	2.4	1.5	3	3	3	2.5	2.6	2	3
PCH-3.4 (A)	Solid State Chemistry	3	2	1.8	2.4	1.8	3	3	3	3	3	2.2	2.4
PCH-3.4 (B)	Advanced Chemical Kinetics	3	2.2	2	2.6	2	3	3	3	3	3	2	2.2

PCH-3.4 (C)	Radiation and Photochemistry	3	2.2	1.8	2.4	1.8	3	3	3	3	3	2.4	2.4
PCHP-V	Practical – V	2	2.6	2.6	2.2	3	2.6	2.8	3	2.2	2.6	2.6	2.4
PCHP-VI	Practical – VI	2.2	2.4	2.6	1.8	2.4	2.2	2.0	2.8	1.8	2.0	2.0	2.0
PCH-4.1	Thermodynamics and Molecular Modeling	2.9	2.9	2.1	3	2.8	2.5	2.9	3	2.2	2.4	2.8	2.9
PCH-4.2	Chemical Kinetics	3	2.3	1.4	2.5	3	1.9	2.4	1.9	2	2.1	1.9	3
PCH-4.3	Molecular Structure – II	2.8	2.9	1.6	2.4	1.5	3	3	3	2.6	2.6	2	3
PCH-4.4 (A)	Surface Chemistry	3	2.8	1.6	2.4	1.8	3	3	3	3	3	2.2	3
PCH-4.4 (B)	Chemistry of Materials	3	2.8	1.6	2.4	1.8	3	3	3	3	3	2.2	3
PCH-4.4 (C)	Biophysical Chemistry	3	2.8	1.6	2.4	1.8	3	3	3	3	3	2.2	3
PCHP-VII	Practical – VII	2.6	2.6	2.0	2.2	2.2	1.8	2.6	2.4	1.8	2.0	1.8	2.0
PCHP-VIII	Practical – VIII	2.7	2.5	2.0	2.7	2.7	2.2	2.5	2.5	2.7	2.5	2.5	2.7
	Total	76.2	70	59.8	69.5	69.7	73.3	72.9	74.8	70.5	72.6	64.8	72.2
	Average	2.7	2.5	2.1	2.5	2.5	2.6	2.6	2.7	2.5	2.6	2.3	2.6

Correlations between contribution of Each Course for fulfillment of POs and PSOs are defined using numbers: 0 – No correlation; 1 – Small Correlation; 2 – Large Correlation and 3 – Full Correlation