School of Chemistry
Faculty of Sciences
University of the Punjab, Lahore
Course Outline

Semester-VII

Programme	**BS Chemistry**	**Course Code**	**Chem-401**	**Credit Hours**	**2**
Course Title	**Colloids**		**Course Type**	**Major (Elective)**	

Course Introduction

This course explores the fundamental concepts of colloids, including their classification, properties, and preparation methods, as well as the detailed study of sols, emulsions, and gels, covering aspects such as purification, stability, kinetic and electrical properties, and theories of emulsification and wetting.
Here is a brief description of course outlines:
Colloids and their classification, Colloidal dispersions, sols and their preparation methods, purification of sols, optical properties of sols, determination of particle size of sols, kinetic properties of sols, sedimention of sols, electrical properties of sols, electrophoresis and electro osmosis, stability of sols, precipitation of sols, associated colloids, macromolecular properties in solutions and molecular weight determinations. Classification, Preparation and Characterization of emulsions, Emulsifiers and their properties, Gibbs surface excess, Micellization, Theories of emulsion type; Orientation wedge theory, kinetic theory. Emulsification and wetting, Stability of emulsions. Classification and properties of gels.

Learning Outcomes

On the completion of the course, the students will be able to:

1. classify and prepare various colloidal systems, characterize their properties, and analyze the stability and behavior of sols, emulsions, and gels.
2. They will also understand the mechanisms behind emulsification, micellization, and the theories of emulsion types, as well as determine particle size and molecular weight in colloidal solutions.

Course Content		**Assignments/Readings**
Week 1	Unit-I Colloids Colloids and their classification	
	Colloidal dispersions	
Week 2	sols and their preparation methods	
	purification of sols	
Week 3	optional properties of sols	
	Continued	
Week 4	determination of particle size of sols	
	kinetic properties of sols	
Week 5	sedimentation of sols	
	electrical properties of sols	
Week 6	electrophoresis and electro osmosis	
	stability of sols	

Week 7	precipitation of sols	
	associated colloids	
Week 8	**Mid Term Examinations**	
Week 9	Macromolecular properties in solutions and molecular weight determinations.	
	Continued	
Week 10	Unit-II Emulsions Classification, Preparation and Characterization of emulsions	
	Continued	
Week 11	Continued	
	Emulsifiers and their properties	
Week 12	Gibbs surface excess,	
	Micellization,	
Week 13	Theories of emulsion type	
	Orientation wedge theory	
Week 14	kinetic theory of emulsion type	
	Emulsification and wetting	
Week 15	Stability of emulsions	
	Classification and properties of gels	
Week 16	**Final Term Examinations**	

Textbooks and Reading Material

1. Rosen, M. J., Surfactants and interfacial Phenomena, John Wiley, New York, 1978.
2. Bhatti, H. N. and Farooqi, Z. H., Modern Physical Chemistry, Revised ed., Caravan Book House, Lahore, 2014.
3. Kundu, N and Jain, S.K., Physical Chemistry, Chand and Company Ltd. 1984.
4. Atkins, P.W., Physical chemistry 5th Ed., W. H. Freeman and Company, New York, 1994.
5. Alberty, R.A. and Silbey. R.J., Physical Chemistry John Wiley, New York, 1995.
6. Engel, T. and Ried, P., Physical chemistry 1st Ed., Pearson Education, Inc. 2006.
7. Birdi, K.S., Hand book of surface and Colloid Chemistry CRC Press, 1997.

Teaching Learning Strategies

1. 1. Lectures/Assessment
2. Group Discussion
3. Quiz/Short test
4. Seminar

Assignments: Types and Number with Calendar

1. Numerical problem sets relevant to topic will be given as assignments from week 1 to week 16.
2. Literature review based assignment relevant to the course will also be given during the course.

Assessment			
Sr. No.	**Elements**	**Weightage**	**Details**
1.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
2.	Formative Assessment	25%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
3.	Final Assessment	40%	Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Semester-VII					
Programme	**BS Chemistry**	**Course Code**	**Chem-402**	**Credit Hours**	**1**
Course Title	**Physical Chemistry Lab –I**		**Course Type**	**Major (Elective)**	

Course Introduction

This course provides hands-on experience with key techniques in colloid and surface chemistry, including the determination of critical micelle concentration, partition coefficients, and surface excess concentration, as well as the preparation and characterization of silver and arsenious sulfide sols using UV-visible spectroscopy and hydrolysis methods.
Here is a brief description of course outlines:
Determination of Critical micelle concentration of various ionic surfactants in water.
Determination of the partition coefficient of benzoic acid between organic solvent and water.
Determination of the partition coefficient of iodine between CCl_4 and H_2O.
Preparation of silver sol and its characterization by UV-visible spectroscopy.
Determination of surface excess concentration of given surfactant in aqueous medium.
Preparation of arsenious sulfide sol using hydrolysis of arsenious oxide

Learning Outcomes

On the completion of the course, the students will be able to:

1. to determine critical micelle concentrations and partition coefficients for various substances, characterize sols and surfactants using UV-visible spectroscopy, and prepare and analyze different colloidal systems.

	Course Content	Assignments/Readings
Week 1	Determination of Critical micelle concentration of various ionic surfactants in water.	
	Continued	
Week 2	Continued	
	Continued	
Week 3	Continued	
	Determination of the partition coefficient of benzoic acid between organic solvent and water.	
Week 4	Continued	
	Continued	
Week 5	Continued	
	Continued	
Week 6	Determination of the partition coefficient of iodine between CCl_4 and H_2O.	
	Continued	
Week 7	Continued	
	Continued	

Week 8	**Mid Term Examinations**	
Week 9	Preparation of silver sol and its characterization by UV-visible spectroscopy.	
	Continued	
Week 10	Continued	
	Continued	
Week 11	Continued	
	Determination of surface excess concentration of given surfactant in aqueous medium.	
Week 12	Continued	
	Continued	
Week 13	Continued	
	Continued	
Week 14	Preparation of arsenious sulfide sol using hydrolysis of arsenious oxide.	
	Continued	
Week 15	Continued	
	Continued	
Week 16	**Final Term Examinations**	

Textbooks and Reading Material

1. Garland, C. W., Nibler, J. W., Shoemaker, D. P., Experiments in Physical Chemistry, 6th ed., WCB McGraw-Hill,1996.
2. Singh, A., Advanced Experimental Physical Chemistry, Campus Books International, 2007.
3. Daniels F., Experimental Physical Chemistry, 7th ed., McGraw-Hill College, 1970.
4. Matthews, G. P., Experimental Physical Chemistry, Oxford University Press, 1986.
5. Bhatti, H. N. & Farooqi, Z. H., Experimental Physical Chemistry for Graduate and Postgraduate Students, Revised ed., Caravan Book House, Lahore, 2014.

Teaching Learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Assignments: Types and Number with Calendar

1. Lab activities and practical performance from week 1 to week 16.
2. Literature review based assignment relevant to the course will also be given during the course.

Assessment			
Sr. No.	**Elements**	**Weightage**	**Details**
4.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
5.	Formative Assessment	25%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
6.	Final Assessment	40%	Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Semester-VII					
Programme	**BS Chemistry**	**Course Code**	**Chem-403**	**Credit Hours**	**2**
Course Title	**Solution Chemistry**		**Course Type**	**Major (Elective)**	

Course Introduction

This course explores the thermodynamic properties of solutions, including the solution process, phase equilibrium conditions, and the theoretical basis of Raoult's law. Students will study the temperature dependence of vapor pressure, deviations from ideal behavior, compound formation, and the separation of solutions. The course also covers semi-permeable membranes, osmotic pressure mechanisms, dilute solutions, and the gas laws, including the Bombardment theory and its objections. Additionally, students will learn about determining molecular weight using cryoscopy and osmometry.
Here is a brief description of course outlines:
The thermodynamic properties of solution. The solution process. Conditions of equilibrium between phases. Theoretical basis of Raoults equation. Temperature dependence of vapor pressure. Deviation from ideal behavior. Compound formation and association. Separation of solid solutions.
Semi Permeable membranes. The cause of semi-permeability. Mechanism of osmotic pressure. Dilute solutions and the Gas Laws. The Bombardment theory. Objections to the Bombardment theory. Review of the theories. Determination of the molecular weight by cryoscopy and Osmometry.

Learning Outcomes

On the completion of the course, the students will be able to:

1. Understand the thermodynamic properties of solutions and the solution process.
2. Apply principles of phase equilibrium and Raoult's law.
3. Analyze the temperature dependence of vapor pressure and deviations from ideal behavior.
4. Explain compound formation, association, and the separation of solid solutions.
5. Describe the function and mechanisms of semi-permeable membranes and osmotic pressure.
6. Apply the gas laws to dilute solutions and critically evaluate the Bombardment theory.
7. Determine molecular weights using cryoscopy and osmometry techniques.

	Course Content	Assignments/Readings
Week 1	The solution process	
	Continued	
Week 2	thermodynamic properties of ideal solutions	
	thermodynamic properties of real solutions	
Week 3	Conditions of equilibrium between phases	
	Continued	
Week 4	Theoretical basis of Raoult’s equation	
	Continued	
Week 5	Temperature dependence of vapor pressure	
	Deviation from ideal behavior	

Week 6	Association and Compound formation	
	Class assement thorugh quiz	
Week 7	Separation of solid solutions	
	Separation of liquid solutions	
Week 8	Mid Term Examinations	
Week 9	Osmosis and Osmotic pressure and determination of osmotic pressure	
Week 10	Mechanism of osmotic pressure, the cause of semi-permeability,	
Week 11	Semi-permiable membranes: natural semi permeable membranes, artificial semipermeable membranes, cause of semi permeability	
Week 12	Dilute solutions and the Gas Laws	
Week 13	The Bombardment theory.	
	Objections to the Bombardment theory	
Week 14	Review of the theories	
Week 15	Determination of the molecular weight by Osmometry method.	
Week 16	Final term examinations	

Textbooks and Reading Material

1. Bahl A., Bahl B.S. and Tuli G.D., Essential of Physical Chemistry, S. Chand & Co., New Dehli, 2000.
2. Bhatti, H. N. and Farooqi, Z. H., Modern Physical Chemistry, Revised ed., Caravan Book House, Lahore, 2014.
3. Kundu, N and Jain, S.K., Physical Chemistry, Chand and Company Ltd. 1984.
   Atkins, P.W., Physical chemistry 5th Ed., W.H.Freeman and Company, New York, 1994.
4. Alberty, R.A. and Silbey. R.J., Physical Chemistry John Wiley, New York, 1995.
5. Ullah, S., (2020) *"Ilmi Manual of Textbook of Physical Chemistry"*, Ilmi Kitab Khana, Lahore.
6. Ullah, S., (2020) *"A Textbook of Physical Chemistry"*, Ilmi Kitab Khana, Lahore.
7. Engel, T. and Ried, P., Physical chemistry 1st Ed., Pearson Education, Inc. 2006.
8. Maron S.H. and Prutton C.F., Principles of Physical chemistry, the Macmillan Company, Collier Macmillan Ltd. London, 1965.

Teaching Learning Strategies

1. 1. Lectures/Assessment
2. Group Discussion
3. Quiz/Short test
4. Seminar

Assignments: Types and Number with Calendar

1. Numerical problem sets relevant to topic will be given as assignments from week 1 to week 16.
2. Literature review based assignment relevant to the course will also be given during the course.

Assessment

Sr. No.	Elements	Weightage	Details
7.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
8.	Formative Assessment	25%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
9.	Final Assessment	40%	Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Semester-VII					
Programme	**BS Chemistry**	**Course Code**	**Chem-404**	**Credit Hour**	**1**
Course Title	**Physical Chemistry-2 Lab**		**Course Type**	**Major (Elective)**	

Course Introduction

This course offers practical training in various analytical techniques for determining the properties and compositions of solutions. Students will learn to determine the molar mass of substances using the cryoscopic method and assess the percentage composition of solutions through surface tension and viscosity measurements. The course also covers refractometry for solution composition analysis, spectrophotometry of colored compounds, and methods for determining the heat of solution through solubility and calorimetric techniques. Here is a brief description of course outlines:

Determination of the molar mass of a substance by cryoscopic method.
Determination of percentage composition of given solution by surface tension measurement.
Determination of percentage composition of given solution by viscosity measurement.
4 Refractometry for determination of %age composition of solution.
Spectrophotometric determination of concentrations of two colored compounds.
Determination of heat of solution by solubility method.
Determination of heat of solution by calorimetric method

Learning Outcomes

On the completion of the course, the students will:

1. Determine the molar mass of substances using the cryoscopic method.
2. Measure the percentage composition of solutions through surface tension and viscosity methods.
3. Analyze solution composition using refractometry.
4. Conduct spectrophotometric analysis of two colored compounds.
5. Determine the heat of solution using both solubility and calorimetric methods

	Course Content	Assignments/Readings
Week 1	Determination of the molar mass of a substance by cryoscopic method	
	Continued	
Week 2	Continued	
	Continued	
Week 3	Determination of percentage composition of given solution by surface tension measurement.	
	Continued	
Week 4	Continued	
	Determination of percentage composition of given solution by viscosity measurement.	
Week 5	Continued	
	Continued	
Week 6	Refractometry for determination of %age composition of solution	

	Continued	
Week 7	Continued	
	Continued	
Week 8	**Mid Term Examination**	
Week 9	Spectrophotometric determination of concentrations of two colored compounds.	
	Continued	
Week 10	Continued	
	Continued	
Week 11	Continued	
	Determination of heat of solution by solubility method.	
Week 12	Continued	
	Continued	
Week 13	Continued	
	Continued	
Week 14	Determination of heat of solution by calorimetric method	
	Continued	
Week 15	Continued	
	Continued	
Week 16	**Final Term Examination**	

Textbooks and Reading Material

1. Garland, C. W., Nibler, J. W., Shoemaker, D. P., Experiments in Physical Chemistry, 6th ed., WCB McGraw-Hill,1996.
2. Singh, A., Advanced Experimental Physical Chemistry, Campus Books International, 2007.
3. Daniels F., Experimental Physical Chemistry, 7th ed., McGraw-Hill College, 1970.
4. Matthews, G. P., Experimental Physical Chemistry, Oxford University Press, 1986.
5. Bhatti, H. N. & Farooqi, Z. H., Experimental Physical Chemistry for Graduate and Postgraduate Students, Revised ed., Caravan Book House, Lahore, 2014.

Teaching Learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Assignments: Types and Number with Calendar
1. Lab activities and practical performance from week 1 to week 16. 2. Literature review based assignment relevant to the course will also be given during the course.

Assessment			
Sr. No.	**Elements**	**Weightage**	**Details**
10.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
11.	Formative Assessment	25%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
12.	Final Assessment	40%	Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Semester-VII					
Programme	**BS Chemistry**	**Course Code**	**Chem-405**	**Credit Hours**	**2**
Course Title	**Surface Chemistry**		**Course Type**	**Major (Elective)**	

Course Introduction

This course explores the fundamental and applied aspects of adsorption and catalysis, covering various types of adsorption, isotherms, and the catalytic reactions of gases on solid surfaces. Students will study key mechanisms such as Eley-Rideal and Langmuir-Hinshelwood, analyze adsorption at the air-water interface, and examine practical applications of heterogeneous catalysis, including enzyme catalysis and inhibition.

Adsorption, types of adsorption, Adsorption isotherms, adsorption of a gas on solid surface, determination of isosteric enthalpy of adsorption of a gas on solid, catalytic reaction of a gas on solid surface, simultaneous adsorption of two gases on solid surface, catalytic reaction of two gases on solid surface, the Eley-Rideal mechanism and the Langmuir-Hinshelwood mechanism, industrial applications of heterogeneous catalysis, Adsorption at air-water interface, Gibbs adsorption isotherm, Autocatalysis, enzyme catalysis, catalysis by chemotrypsin, enzyme inhibition (competitive, uncompetitive and non competitive).

Learning Outcomes

On the completion of the course, the students will be able to:

1. to analyze and interpret adsorption isotherms, determine isosteric enthalpy of adsorption, and evaluate catalytic reactions and mechanisms on solid surfaces.
2. They will also understand industrial applications of heterogeneous catalysis, adsorption at the air-water interface, and enzyme catalysis, including various types of enzyme inhibition.

	Course Content	Assignments/Readings
Week 1	Adsorption	
	types of adsorption	
Week 2	Continued	
	Adsorption isotherms	
Week 3	adsorption of a gas on solid surface	
	determination of isosteric enthalpy of adsorption of a gas on solid	
Week 4	Continued	
	catalytic reaction of a gas on solid surface	
Week 5	simultaneous adsorption of two gases on solid surface	
	Continued	
Week 6	catalytic reaction of two gases on solid surface	
	Continued	
Week 7	the Eley-Rideal mechanism and the Langmuir-Hinshelwood mechanism	

	Continued	
Week 8	**Mid Term Examinations**	
Week 9	Industrial applications of heterogeneous catalysis	
	Continued	
Week 10	Adsorption at air-water interface	
	Continued	
Week 11	Gibbs adsorption isotherm	
	Autocatalysis	
Week 12	Enzyme Catalysis	
	Continued	
Week 13	catalysis by chemotrypsin,	
	Continued	
Week 14	enzyme inhibition	
	enzyme inhibition (competitive)	
Week 15	enzyme inhibition (uncompetitive)	
	enzyme inhibition (non-competitive)	
Week 16	**Final Term Examinations**	

Textbooks and Reading Material

1. Logan, S.R, Fundamentals of chemical kinetics, Longman Group Ltd. 1996.
2. Bhatti, H. N. and Farooqi, Z. H., Modern Physical Chemistry, Revised ed., Caravan Book House, Lahore, 2014.
3. Kundu, N and Jain, S.K., Physical Chemistry, Chand and Company Ltd. 1984.
4. Atkins, P.W. Physical Chemistry, 5th Ed., W.H.Freeman and Company, New York, 1994.
5. Alberty, R.A. & Silbey. R.J., Physical Chemistry, John Wiley, New York, 1995.
6. Engel, T. and Ried, P., Physical chemistry, 1st Ed., Pearson Education, Inc. 2006.

Teaching Learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Assignments: Types and Number with Calendar

1. Numerical problem sets relevant to topic will be given as assignments from week 1 to week 16.
2. Literature review based assignment relevant to the course will also be given during the course.

Assessment			
Sr. No.	**Elements**	**Weightage**	**Details**
13.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
14.	Formative Assessment	25%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
15.	Final Assessment	40%	Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Semester-VII					
Programme	**BS Chemistry**	**Course Code**	**Chem-406**	**Credit Hour**	**1**
Course Title	**Physical Chemistry Lab–3**		**Course Type**	**Major (Elective)**	

Course Introduction

This course provides hands-on training in advanced analytical techniques, focusing on spectrophotometric determination of concentrations, potentiometric titration for acid concentration measurement, and the verification of Freundlich and Langmuir adsorption isotherms using oxalic acid and activated charcoal. Here is a brief description of course outlines:
Study of variation of surface tension of water with concentration of surfactant.
Determination of surface excess concentration of surfactant in aqueous medium.
Determination of minimum area per surfactant molecule at air-water interface.
Surface tension method for determination of surface excess concentration of an amphiphilic substance.
Determination of fraction of counter ions binding of a surfactant in aqueous medium by conductance measurement.
Determination of Gibbs free energy of adsorption of a surfactant at air-water interface.
Determination of Gibbs free energy change of micellization of a surfactant.
Verification of Freundlich adsorption isotherm for Adsorption of oxalic acid on activated charcoal.
Verification of Langmuir adsorption isotherm for Adsorption of oxalic acid on activated charcoal.
Study of a catalytic reaction using spectrophotometric method.

Learning Outcomes

On the completion of the course, the students will be able to:

1. determine the concentrations of colored components in solutions using spectrophotometry
2. measure the concentration of HCl via potentiometric titration
3. verify both Freundlich and Langmuir adsorption isotherms for the adsorption of oxalic acid on activated charcoal.

	Course Content	Assignments/Readings
Week 1	Study of variation of surface tension of water with concentration of surfactant.	
	Continued	
Week 2	Determination of surface excess concentration of surfactant in aqueous medium	
	Continued	

Week 3	Determination of minimum area per surfactant molecule at air-water interface	
	Continued	
Week 4	Surface tension method for determination of surface excess concentration of an amphiphilic substance.	
	Determination of fraction of counter ions binding of a surfactant in aqueous medium by conductance measurement	
Week 5	Continued	
	Continued	
Week 6	Determination of Gibbs free energy of adsorption of a surfactant at air-water interface	
	Continued	
Week 7	Determination of Gibbs free energy change of micellization of a surfactant	
	Continued	
Week 8	**Mid Term Examinations**	
Week 9	Verification of Freundlich adsorption isotherm for Adsorption of oxalic acid on activated charcoal.	
	Continued	
Week 10	Continued	
	Continued	
Week 11	Continued	
	Continued	
Week 12	Verification of Langmuir adsorption isotherm for Adsorption of oxalic acid on activated charcoal.	
	Continued	
Week 13	Continued	
	Continued	
Week 14	Continued	
	Study of a catalytic reaction using	

	spectrophotometric method	
Week 15	Continued	
	Continued	
Week 16	**Final Term Examinations**	

Textbooks and Reading Material

1. Garland, C. W., Nibler, J. W., Shoemaker, D. P., Experiments in Physical Chemistry, 6th ed., WCB McGraw-Hill,1996.
2. Singh, A., Advanced Experimental Physical Chemistry, Campus Books International, 2007.
3. Daniels F., Experimental Physical Chemistry, 7th ed., McGraw-Hill College, 1970.
4. Matthews, G. P., Experimental Physical Chemistry, Oxford University Press, 1986.
5. Bhatti, H. N. & Farooqi, Z. H., Experimental Physical Chemistry for Graduate and Postgraduate Students, Revised ed., Caravan Book House, Lahore, 2014.

Teaching Learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Assignments: Types and Number with Calendar

1. Lab performance and activities relevant to topic will be given as assignments from week 1 to week 16.
2. Literature review based assignment relevant to the course will also be given during the course.

Assessment

Sr. No.	Elements	Weightage	Details
16.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
17.	Formative Assessment	25%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
18.	Final Assessment	40%	Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

Semester-VII					
Programme	**BS Chemistry**	**Course Code**	**Chem-407**	**Credit Hours**	**3**
Course Title	**Quantum Chemistry**		**Course Type**	**Major (Elective)**	

Course Introduction

This course covers advanced concepts in quantum chemistry and molecular physics, including the postulates of quantum theory, Schrödinger's wave equation, and eigenfunctions. Students will study quantum mechanical phenomena such as tunneling and quantum wells, explore the behavior of particles in one- and three-dimensional boxes, and apply quantum mechanical principles to molecular orbital theory, bond strength, and vibrational frequencies. The course also addresses classical concepts such as the van der Waals equation, Maxwell distribution of molecular velocities, and methods for determining Avogadro's number**.** Here is a brief description of course outlines:

Postulates of quantum theory, Eigen functions, operators, Schrödinger's wave equation, particle in one dimensional box, Normalized wave function and orthogonality, Quantum mechanical tunneling, the tunneling scanning microscope, Tunneling in chemical reactions, quantum wells and quantum dots, motion of particle in three dimensional box and idea of degeneracy, electronic spectra of polyenes, Schrodinger wave equation in polar coordinates, separation of variables and derivation of quantum numbers, Mathematical treatment of rigid rotator and calculation of bond strength of simple molecules, harmonic oscillator and calculation of bond length of simple molecules, harmonic oscillator and calculation of vibrational frequencies, formation of covalent bond, Mathematical treatment of He^{2+} and H_2 molecules, discussion of overlapping integrals, molecular orbital theory and formation of H_2 and O_2 molecules.

The van der walls equation, Maxwell distribution of molecular velocities and energies, Derivation of average velocity and most probable velocity, Barometric formula, Determination of Avogadro's number, Maxwell-Boltzmann's law of energy distribution

Learning Outcomes

On the completion of the course, the students will be able to:

1. Understand and apply the principles of quantum theory, including Schrödinger's wave equation and eigenfunctions.
2. Analyze quantum mechanical phenomena such as tunneling, quantum wells, and particle behavior in various dimensional boxes.
3. Apply quantum mechanics to molecular orbital theory, bond strength calculations, and vibrational frequencies.
4. Derive and interpret classical equations like the van der Waals equation, Maxwell distribution, and the barometric formula.
5. Determine Avogadro's number and apply Maxwell-Boltzmann's law of energy distribution to real-world scenarios.

Course Content		Assignments/Readings
Week 1	Postulates of quantum theory	
	Eigen functions	
Week 2	Operators	
	Schrödinger's wave equation	

Week 3	particle in one dimensional box	
	Normalized wave function and orthogonality	
Week 4	Quantum mechanical tunneling	
	the tunneling scanning microscope	
Week 5	Tunneling in chemical reactions	
	Quantum wells and quantum dots	
Week 6	Motion of particle in three dimensional box	
	Idea of degeneracy Electronic spectra of polyenes	
Week 7	Schrodinger wave equation in polar coordinates	
	Separation of variables and derivation of quantum numbers	
Week 8	**Mid Term Examinations**	
Week 9	Mathematical treatment of rigid rotator and calculation of bond strength of simple molecules	
	Harmonic oscillator and calculation of bond length of simple molecules	
Week 10	Harmonic oscillator and calculation of vibrational frequencies	
	Formation of covalent bond	
Week 11	Mathematical treatment of He^{2+} and H_2 molecules	
	Discussion of overlapping integrals	
Week 12	Molecular orbital theory and formation of H_2 and O_2 molecules	
	The van der walls equation	
Week 13	Maxwell distribution of molecular velocities and energies	
	Derivation of average velocity and most probable velocity	
Week 14	Barometric formula	
	Determination of Avogadro's number	
Week 15	Maxwell-Boltzmann's law of energy distribution	
	Open Discussion Day	
Week 16	**Final Term Examinations**	

Textbooks and Reading Material

1. Bhatti, H. N. and Farooqi, Z. H., Modern Physical Chemistry, Revised ed., Caravan Book House, Lahore, 2014.
2. Prasad, R. K., Quantum chemistry. New Age International, 2001.
3. Maron, S. H., and Prutton, F. C., Principles of Physical chemistry, 4th Ed., the Macmillan Company, Collier Macmillan Ltd. London, 2017.
4. Barrow G.M., Physical Chemistry, McGraw Hill, Tokyo, 1973.
5. Moore W.J., Physical Chemistry, Rentice Hall, Englewood cliffs, New Jersey, 1972.
6. Atkins P. & de Paula J., Physical chemistry, Oxford University Press, Walton Street, Oxford, 1989.
7. Castallan G.W., "Physical Chemistry", Addison Westey Publishing Company, Menla Park, California, London,1972.

Teaching Learning Strategies

1. 1. Lectures/Assessment
2. Group Discussion
3. Quiz/Short test
4. Seminar

Assignments: Types and Number with Calendar

1. Numerical problem sets relevant to topic will be given as assignments from week 1 to week 16.
2. Literature review based assignment relevant to the course will also be given during the course.

Assessment

Sr. No.	Elements	Weightage	Details
19.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
20.	Formative Assessment	25%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
21.	Final Assessment	40%	Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.