

[Question of Term Final Examination]

KHULNA UNIVERSITY

School: Science, Engineering & Technology Discipline: Chemistry Program: B. Sc. (Hon's)
 Year: Third Term: Second Examination Year: 2026 Session: 2024-2025
 Course Code: 0531 18 Chem 3201 Course Title: Organometallic Chemistry
 Total Marks: 60 Time: 3 hours Credit: 3.0

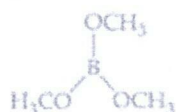
- Use separate answer script for each section.
- Figures in the margin indicate full marks. Questions are of equal value.

Section A

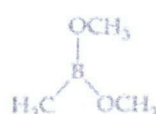
There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
1. a)	Classify organometallic compounds on the basis of bond type with example. [L2, CLO1]	2
b)	Draw the structure of anion of Zeise salt. Explain why tetramethylsilicon is more stable than tetramethyllead. [L4, CLO1]	3
c)	Compare main group organometallics and transition metal organometallics. [L2, CLO1]	3
d)	Give your opinion with explanation which is organometallic compounds of the followings: [L5, CLO1]	2

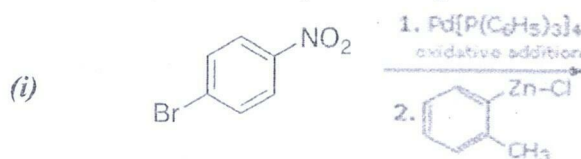
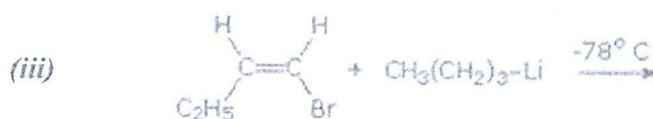
(i)

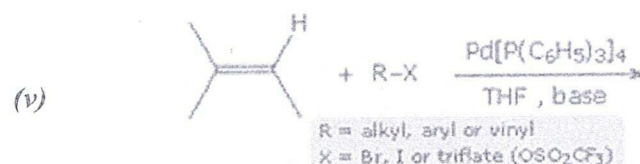


(ii)

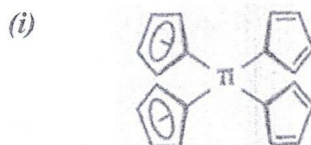
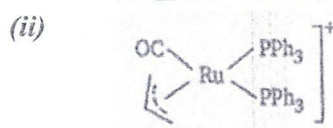


2. a) What are π -allyl complexes? Outline a reaction scheme η^1 -allyl to η^3 -allyl compound by the loss of carbonyl. [L2, CLO3] 3
- b) Complete the following reactions: [L4, CLO2] 5





- c) Construct a methoxycarbene complex with possible resonance structure using phenyllithium and hexacarbonyl chromium. [L6, CLO2] 2
3. a) Elaborate the steps which are involved in the formation of linear metallic nitrosyl using molecular orbital [MO] diagram in terms of bonding. [L6, CLO3] 5
- b) Comment on the bridging and terminal carbonyl compounds differentiation using FTIR. [L5, CLO3] 2
- c) Draw the all-possible modes of bridging CO including symmetric and asymmetric. [L4, CLO3] 3
4. a) Explain the steps of nitric oxide anion during the formation of metal nitrosyl compounds. [L4, CLO3] 3
- b) Explain the 18-electron rule. Count the electrons of the following complexes using covalent model and ionic model. [L2, CLO2] 5



- c) 'The 6-coordinate metal alkyl $\text{W}(\text{CH}_3)_6$ can be melted at 30°C without decomposition whereas 4-coordinate $\text{Ti}(\text{CH}_3)_4$ is subject to decompose at -40°C '. Justify the statement. [L5, CLO2] 2

Section B

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
5. a)	Define metallocenes and classify them. Furthermore, explain the key differences that distinguish metallocenes from conventional coordination complexes. [L2, CLO1]	2.5

- b) Explain why ferrocene is considered “super-aromatic.” Compare its rate of electrophilic aromatic substitution (EAS) with that of benzene and justify the difference based on electron density. [L5, CLO1] 3
- c) Demonstrate how ferrocene obeys the 18-electron rule using both the Neutral and Ionic counting methods. What does this stability imply about its resistance to addition reactions? [L2, CLO1] 2.5
- d) Explain the reaction of ferrocene with n-butyllithium. Why is lithiation a crucial step for the synthesis of substituted ferrocene derivatives? [L4, CLO2] 2
6. a) Identify and describe the three structural and electronic prerequisites necessary for an organometallic alkyl complex to undergo β -hydride transfer. Why do methyl and neopentyl complexes resist this reaction? [L3, CLO2] 3
- b) Describe the geometry and key features of the transition state for the insertion reaction in organometallic chemistry. [L2, CLO4] 3
- c) Consider the complex $[PtCl_2(PPh_3)_2]$. If this complex undergoes oxidative addition with H_2 , determine the oxidation state and coordination number of the product. Does the product obey the 18-electron rule? Show your calculation. [L5, CLO2] 4
7. a) Predict the product when 1-hexene is treated with a mixture of CO and H_2 in the presence of a cobalt carbonyl catalyst. Show the steps leading to the linear vs. branched aldehyde and explain how ligand bulkiness shifts the ratio. [L5, CLO2] 5
- b) Provide the full catalytic cycle for the oxidation of ethene to acetaldehyde using $PdCl_2$ and $CuCl_2$. [L2, CLO2 & 3] 3
- c) Compare the mechanisms of Ziegler-Natta and Metallocene catalysts in the polymerization of alkenes. [L4, CLO2 & 3] 2
8. a) Provide a descriptive MO treatment of the bonding between the Fe^{2+} ion and the two Cp rings. [L2, CLO4] 4
- b) Sketch the structure of the following metal clusters: [L2, CLO4] 3
- (i) $[Ni_5(CO)_9(\mu_2-CO)_3]^{2-}$
- (ii) $[Pt_9(CO)_9(\mu_2-CO)_3]^{2-}$
- c) Draw the intermediate for the isomerization of 1-butene to 2-butene using $HNi[P(OEt)_3]^{4+}$. Clearly show the hydride shift and the formation of the π -complex. Identify whether the reaction follows a 1,2-shift or a 1,3-shift mechanism. [L4, CLO3] 3

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School: Science, Engineering & Technology **Discipline:** Chemistry **Program:** B.Sc. (Hon's)

Year: Third **Term:** Second **Examination Year:** 2026 **Session:** 2024-2025

Course Code: 0531 18 Chem 3203 **Course Title:** Advanced Organic Chemistry

Total Marks: 60

Time: 3 hours

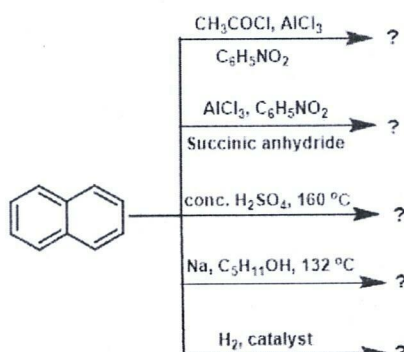
Credit: 3.0

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Section A

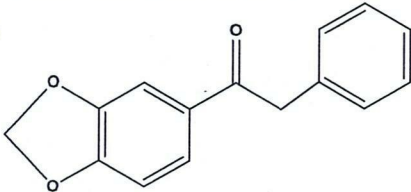
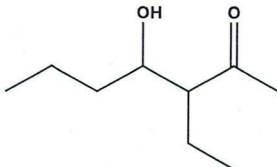
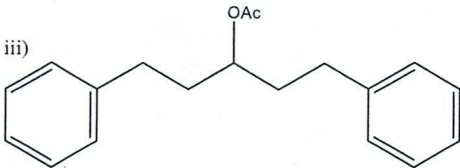
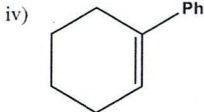
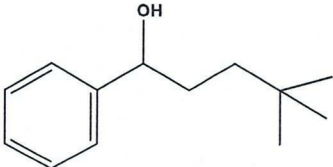
There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
1. a)	Explain the conditions under which a molecular orbital becomes significantly more stable than the atomic orbitals. [L4, CLO1]	5
b)	Illustrate and discuss the π -molecular orbital energy diagram of the allyl cation, radical, and anion, showing the electron distribution in each case. [L2, CLO1]	5
2. a)	Justify the statement that electrocyclic reactions are both stereoselective and stereospecific. [L5, CLO2]	5
b)	Explain the fact that the thermal conversion of 1,3-butadiene to cyclobutene through a conrotatory mode is allowed, whereas the photochemical conrotatory ring closure is forbidden. [L4, CLO2]	5
3. a)	Explain cycloaddition reaction. Compile various aspects of the stereochemistry involved in the Diels-Alder reaction. Why is this reaction termed as pericyclic reaction? [L2, CLO3]	5
b)	Show that a suprafacial [1,3]-sigmatropic shift leads to inversion of configuration, while a suprafacial [1,5]-sigmatropic shift results in retention of configuration. How these sigmatropic shifts differ from [3,3] shift? [L4, CLO3]	5
4. a)	Define aromatization and describe various methods of aromatization. [L2, CLO3]	5
b)	Predict the products of the following reactions: [L3, CLO3]	5



Section B

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
5.	Explain possible disconnection, synthesis and mechanism of the following target molecules formation: [L6, CLO4]	3+2+3+2
	<p>i) </p> <p>ii) </p> <p>iii) </p> <p>iv) </p>	
6. a)	Determine all feasible retrosynthetic routes for the given molecules, along with the corresponding synthesis reactions and detailed mechanisms. [L3, CLO4]	6
		
b)	Define the following terms (according to the designing organic synthesis): [L2, CLO4]	4
	<p>i) Starting material</p> <p>ii) Functional group interconversion (FGI)</p> <p>iii) Synthetic equivalent</p> <p>iv) Retrosynthetic analysis</p>	
7. a)	"All stereospecific reactions are stereoselective, but all stereoselective reactions are not stereospecific." Explain with examples. [L4, CLO5]	3
b)	Explain the concept of regioselectivity with reference to the addition of HBr to alkenes. [L3, CLO5]	4
c)	Distinguish between enantioselectivity and diastereoselectivity. [L4, CLO5]	3
8. a)	Illustrate the laboratory synthesis of Longifolene highlighting the key cyclization and rearrangement steps. [L6, CLO5]	5
b)	Describe the synthetic strategy and key intermediates used in the synthesis of cis-Jasmone. [L6, CLO5]	5

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KHULNA UNIVERSITY

School: Science, Engineering & Technology Discipline: Chemistry Program: B.Sc. (Hon's)
Year: Third Term: Second Examination Year: 2026 Session: 2024-2025
Course Code: 0531 18 Chem 3205 Course Title: Advanced Chemical Spectroscopy
Total Marks: 60 Time: 3 hours Credit: 3.0

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- Figures in the margin indicate full marks. Questions are of equal value.

Section A

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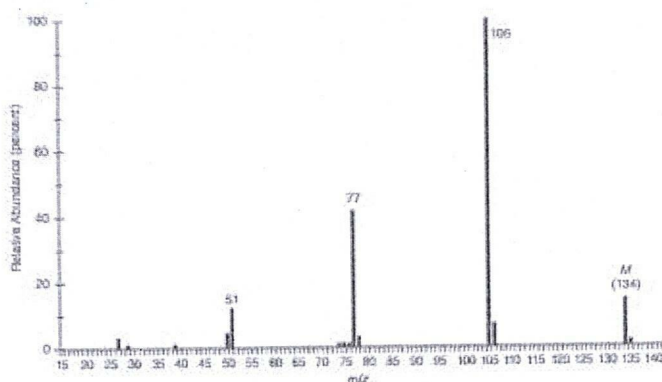
Question No.	Question Description	Marks
1.	a) Define the four main categories of molecular rotors based on their moment of inertia (I_A , I_B , and I_C) and provide one example for each. [L1, CLO1]	2
	b) Suppose you record the microwave spectrum of hydrogen chloride and find that the absorption lines are equally spaced by 20.88 cm^{-1} . Calculate the bond length (r) in Angstroms ($\text{\AA}$). [L3, CLO3]	4
	c) Analyze why the rotational spectrum of carbonyl sulfide undergoes splitting when placed in an external electric field, whereas the spectrum of methane remains unchanged. In your analysis, distinguish between the structural requirements for microwave activity and the specific criteria necessary for the observation of the Stark Effect. [L2, CLO2]	4
2.	a) Explain the fundamental difference between the selection rules for Raman and Infrared spectroscopy. Why is it often said that these two techniques are 'complementary' when analyzing the vibrational modes of a homonuclear diatomic molecule versus a heteronuclear one? [L2, CLO2]	3
	b) Critique the reliability of the I_D/I_G intensity ratio as a sole indicator for 'defect density' during the chemical reduction of graphene oxide to reduced graphene oxide. If the ratio unexpectedly increases during reduction, justify whether this signifies further structural degradation or an increase in the number of smaller sp^2 domains. [L5, CLO4]	5
	c) Explain why certain vibrational modes of carbon dioxide are IR-active while others are Raman-active. Discuss this in the context of the mutual exclusion principle. [L2, CLO2]	2
3.	a) Derive the ESR resonance condition and explain how the energy levels split in the presence of an external magnetic field. [L5, CLO4]	5

- b) The ^{13}C hyperfine coupling in the methyl radical is 41 gauss, and the proton hyperfine coupling is 23 gauss. Sketch the ESR spectrum and explain it for $^{13}\text{CH}_3$ radical. [L4, CLO4] 5
4. a) A sample of $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ shows significant quadrupole splitting, while $[\text{Fe}(\text{CN})_6]^{4-}$ shows almost none. Explain this observation in terms of electric field gradients. [L2, CLO5] 3
- b) Explain how Mössbauer spectroscopy can identify a "Spin Crossover" event in an Iron (II) complex. [L2, CLO5] 3
- c) A researcher synthesizes a series of iron-based nanoparticles. One batch is perfectly spherical and crystalline, while another is "doped" with a large organic ligand that creates a distorted octahedral environment. How would you use quadrupole splitting to distinguish between these two samples? [L3, CLO5] 4

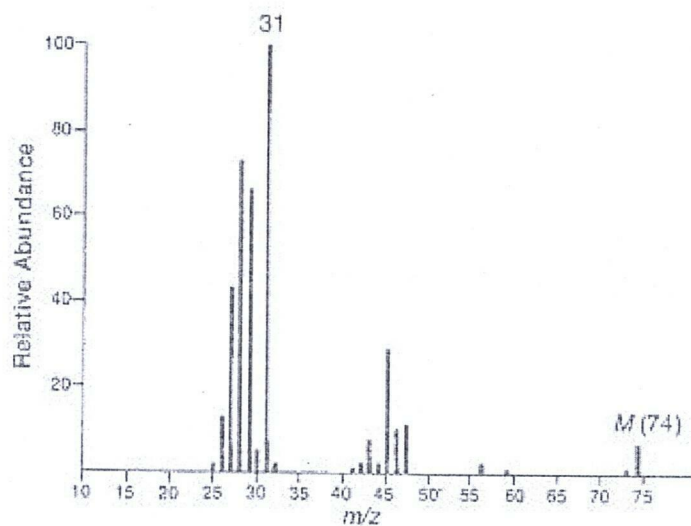
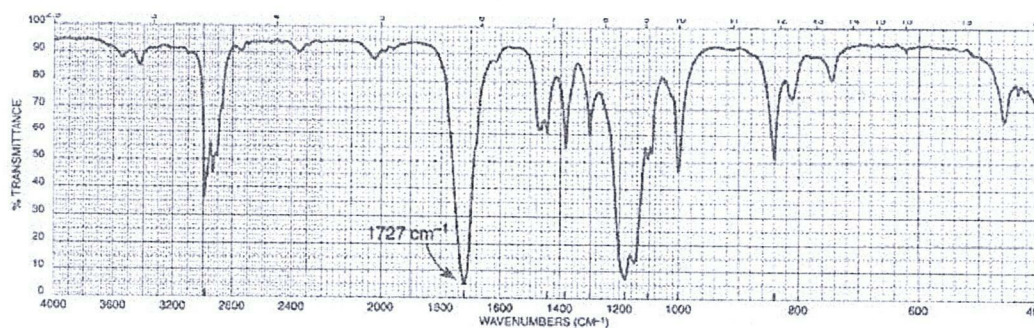
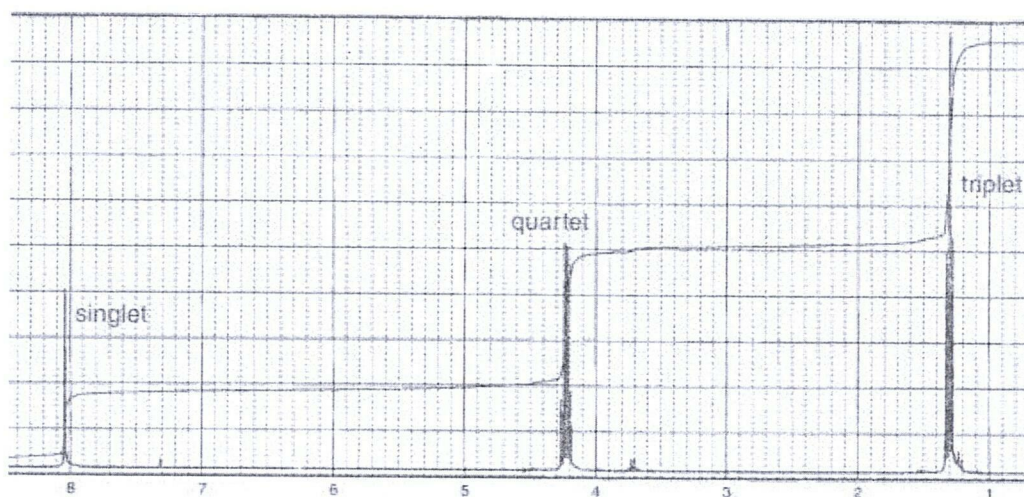
Section B

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
5.	a) Discuss the theory of mass spectrometry. [L2, CLO5]	5
	b) Illustrate the desorption ionization techniques used in mass spectrometry. [L2, CLO5]	5
6.	a) Predict the fragmentation pattern of benzyl alcohol. [L6, CLO6]	5
	b) Analyze the fragmentation mechanism of the tropylium ion obtained from ethylbenzene. [L4, CLO6]	5
7.	An unknown compound has the mass spectrum shown. The IR spectrum of the compound shows significant peaks at 3102, 3087, 3062, 3030, 1688, 1598, 1583, 1460, 1449, 1353, 1221, 952, 746, and 691 cm^{-1} . There is also a band from aliphatic C-H stretching from 2879 to 2979 cm^{-1} . Determine the structure of the unknown compound. [L6, CLO6]	10



8. An unknown compound with the molecular formula $C_3H_3O_2$ shows no UV absorption peak above 205 nm. The ^{13}C NMR spectrum shows peaks at 14, 60, and 161 ppm. The peak at 161 ppm appears as a positive peak in the DEPT-90 spectrum. Predict the structure of the unknown compound. [L6, CLO7] 10



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School: Science, Engineering & Technology Discipline: Chemistry Program: B.Sc. (Hon's)
Year: Third Term: Second Examination Year: 2026 Session: 2024-2025
Course Code: 0531 18 Chem 3207 Course Title: Industrial and Pharmaceutical Chemistry
Total Marks: 60 Time: 3 hours Credit: 3.0

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Section A

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
1.	a) Illustrate the relationship between research and development (R&D) and long-term industrial sustainability. [L2, CLO1]	3
	b) Examine the environmental and human health impacts of chemical production, citing Bhopal or Chernobyl as examples. [L4, CLO1]	4
	c) Apply the saponification process to write the reaction of a triglyceride with NaOH. [L3, CLO1]	3
2.	a) Apply the process flow diagram to explain how sugar is obtained from sugarcane juice. [L3, CLO1]	6
	b) Justify why CO ₂ -based carbonation is considered more eco-friendly than sulphitation. [L5, CLO1]	4
3.	a) Describe why soaps are ineffective in hard water but detergents are not. [L2, CLO3]	4
	b) Design a process flow diagram for urea manufacturing from NH ₃ and CO ₂ . [L6, CLO3]	6
4.	a) Differentiate between the functions of calcareous and siliceous materials. [L1, CLO3]	3
	b) Describe the purpose of annealing in glass production. [L2, CLO3]	3
	c) Judge the impact of impurities on the optical properties of ceramics. [L4, CLO3]	4

Section B

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
5.	a) Differentiate between the ISO 9000 and ISO 9001 standards in pharmaceutical analysis. [L2, CLO4]	3
	b) Design a quality control protocol for a newly developed pharmaceutical product. [L6, CLO4]	4
	c) Explain the advantages of HPLC compared to conventional liquid chromatography techniques. [L2, CLO4]	3
6.	a) Provide a brief discussion on compressed tablets. [L2, CLO4]	5
	b) How to evaluate the "hardness" and "disintegration rate" of tablets? [L4, CLO4]	5
7.	a) Define parenteral preparations and explain their classification based on the route of administration. [L2, CLO5]	5
	b) Describe the evaluation processes of the parenteral preparations. [L2, CLO5]	5
8.	a) Demonstrate the dermatological factors that govern the selection of an ideal ointment base. [L6, CLO5]	4
	b) Describe various tests used for the identification of different types of emulsions. [L2, CLO5]	4
	c) Explain the role of emulsifying agents. [L2, CLO5]	2

[Question of Term Final Examination]

KHULNA UNIVERSITY

School: Science, Engineering & Technology Discipline: Chemistry Program: B.Sc. (Hon's)
Year: Third Term: Second Examination Year: 2026 Session: 2024-2025
Course Code: 0531 18 Chem 3209 Course Title: Colloid and Adsorption Chemistry
Total Marks: 60 Time: 3 hours Credit: 3.0

- Use separate answer script for each section.
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Section A

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
1.	a) Draw five types of physical adsorption curves and mention their significance. [L4, CLO1]	5
	b) Give a detailed account of the volumetric (manometric) method for measuring the adsorption of gases on solid surfaces, including its instrumentation, operation, and data interpretation. [L2, CLO2]	5
2.	a) Write the basic equation of the Freundlich adsorption isotherm and explain the physical meaning of its parameters. Transform the equation into its linear form and demonstrate how it leads to a straight-line plot. Draw the appropriate graph and label the slope and intercept. [L3, CLO3]	6
	b) A dye is adsorbed from water onto activated charcoal. The initial concentration of dye solution is 10 mg/L, volume of solution is 1.0 L, mass of charcoal is 1.0 g. The value of Freundlich constants, K_F is 2 (mg/g) and n is 1. Now find out the followings- (i) The equilibrium concentration of dye solution (ii) the amount of dye adsorbed per mass of charcoal. [L5, CLO3]	2+2
3.	a) Enlist the factors affecting the adsorption of gas by solid. [L1, CLO2]	2
	b) Why is the froth flotation process used for the concentration of low-grade sulphide ores? Explain briefly. [L3, CLO2]	4
	c) Illustrate the mechanism of enzyme catalysis. [L3, CLO2]	4
4.	a) What happens at the interface of a metal and electrolyte during electrocapillary phenomenon? [L2, CLO1]	3
	b) How are gases liquefied by Linde's method? Explain the principle involved and the successive stages of the process. [L2, CLO2]	5
	c) What do you understand about surface film and surface pressure? [L2, CLO1]	2

Section B

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
5.	a) Discriminate between true solution and colloidal solution. [L2, CLO4]	3
	b) Define the terms 'Disperse phase' and 'Dispersion medium'. Apply these terms on the following systems: [L4, CLO4]	4
	(i) Smoke	
	(ii) Foam	
	(iii) Aerosol	
	(iv) Sol	
	c) In what way you might prepare the colloidal solution of gold? [L3, CLO4]	3
6.	a) Define protective colloid. Give an account of gold number in this text. [L3, CLO5]	3
	b) What is Tyndall effect? How is the Tyndall effect responsible for blue eye colour? [L5, CLO4 & CLO5]	4
	c) Develop a mechanism about the origin of charge on sol particles with special reference to ionization of surface groups. [L6, CLO5]	3
7.	a) What is electrophoresis? How does this phenomenon provide information about the sign of charge on colloidal particles? [L1, CLO4 & CLO5]	3
	b) How can sols be coagulated? Explain Schulze-Hardy rule for coagulation of sols. [L5, CLO4 & CLO5]	4
	c) Illustrate the mechanism of artificial kidney machine. [L6, CLO5]	3
8.	a) What is emulsion? Express the roll of emulsifier. [L1, CLO4]	3
	b) Discuss the dilution test for the identification of emulsion. [L3, CLO4]	2
	c) Define gels. Distinguish between elastic and non-elastic gels. [L4, CLO4]	5