SECTION A [40 MARKS]

ANSWER ALL QUESTIONS

Question 1 **[25]**

a) For each question, there are FOUR responses: A, B, C and D. Choose the corresponding letter of your response and CIRCLE it neatly. NO score will be awarded if you circle more than ONE letter.

i. The number of signal(s) produced by the aromatic compound with the molecular formula C_6H_6 in NMR spectrum is

A 1
B 3
C 5
D 6

ii. A biochemist wants to determine the molecular masses of different samples of biomolecules in the laboratory. Identify the most suitable colligative property a biochemist is likely to employ from the list given below to complete the task.

A Osmotic pressure
B Elevation of boiling point
C Depression of freezing point
D Relative lowering of vapour pressure

iii. After being stung by a honey bee, a student was advised to wash the affected area with soap and water. What could be the scientific reason behind this advice and its effectiveness of the treatment method?

A The cool sensation of water relieves the pain
B The base present in the bee sting is washed by water
C Bee sting is acidic due to hydrochloric acid and it is neutralised
D Formic acid present in the bee sting gets neutralised by the soap

iv. The pKa_1 of carboxylic group of glycine is 2.34 and pKa_2 of the amino group of glycine is 9.60. What is the isoelectric point (pI) of glycine and in which electrode does it migrate during electrolysis?

A 5.79 and migrates to anode
B 6.97 and migrates to anode
C 5.97 and migrates to cathode
D 6.79 and migrates to cathode

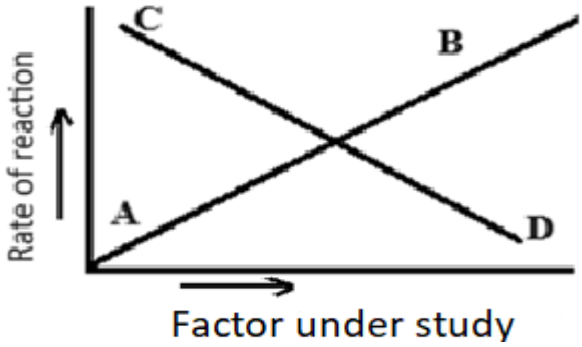
v. Standard Hydrogen Electrode (SHE) is functional at 1 molar concentration, 1 atm pressure and at 25 ^{0}C. Can the platinum electrode used in SHE be replaced by iron so that the SHE still remains functional?

A Yes, because iron is also a good conductor
B No, because iron is less reactive than hydrogen
C No, because iron is more reactive than platinum
D Yes, because iron is less expensive than platinum

vi. If X kelvin is the boiling point of $CH_3(CH_2)_3NH_2$ and Y kelvin is the boiling point of $CH_3(CH_2)_2NH_2$, what is the correct relation between the two boiling points?

A $X \geq Y$
B $X < Y$
C $X = Y$
D $X > Y$

vii. An experiment was conducted to study one of the factors affecting the rate of a chemical reaction. After collecting the data, a graph was plotted between the rate of reaction versus magnitude of various factors under study as shown below.



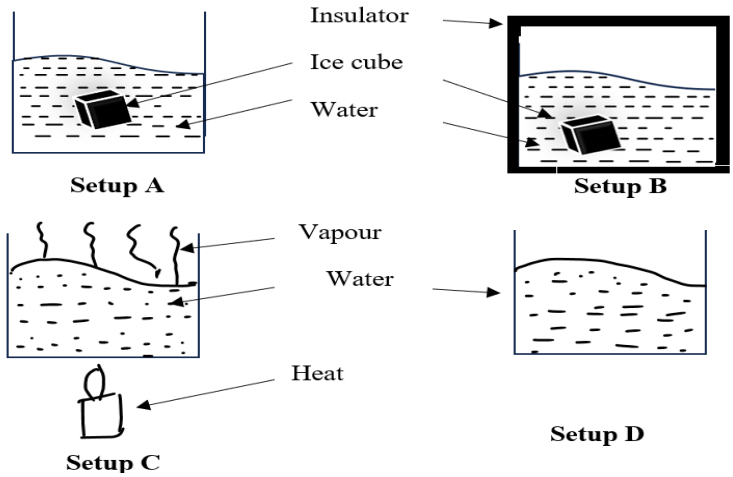
Identify the factor corresponding to the curve CD.

A Size of reactants
B Pressure during reaction
C Concentration of reactants
D Temperature of the reaction

viii. While making soap, one needs to understand the saponification process to make the right adjustments. During the saponification process, addition of more fat or oil is recommended as it

A makes the soap hard faster.
B reacts with alkali completely.
C helps to increase the temperature of the mixture.
D reduces the amount of water needed in the recipe.

ix. Study the figure given below and identify the setup that can have the lowest entropy if the vapour pressure is increased.



A Setup A
B Setup B
C Setup C
D Setup D

x. A freshly cut apple turns brown on exposure to air. What happens to the acid present in the apple?

A Reduction
B Oxidation
C Esterification
D Polymerisation

xi. The radioactive isotope X undergoes alpha decay to form Y. What are the possible changes undergone by Y?

A Atomic number and mass number remain unchanged
B Atomic number increases by 2 and mass number increases by 4
C Atomic number decreases by 2 and mass number decreases by 4
D Atomic number remains the same and mass number decreases by 4

xii. A student carried out following organic reactions in the laboratory.

I. Ketone + Tollen's reagent
II. Ester + Fehling's solution
III. Carboxylic acid + Benedict's solution
IV. Aldehyde + Tollen's reagent

Select the combination which can form silver mirror.

A I
B II
C III
D IV

xiii. A jeweller selects certain gemstones based on their vibrant colours due to the presence of transition elements in them. Using your understanding of coordination complexes, which of the following explanations correctly describe the source of these colours?

A Fluorescence under UV light
B Presence of impurities in the gems
C Dispersion of light by the crystalline structure of gems
D Absorption of specific wavelengths of light by the metal ions

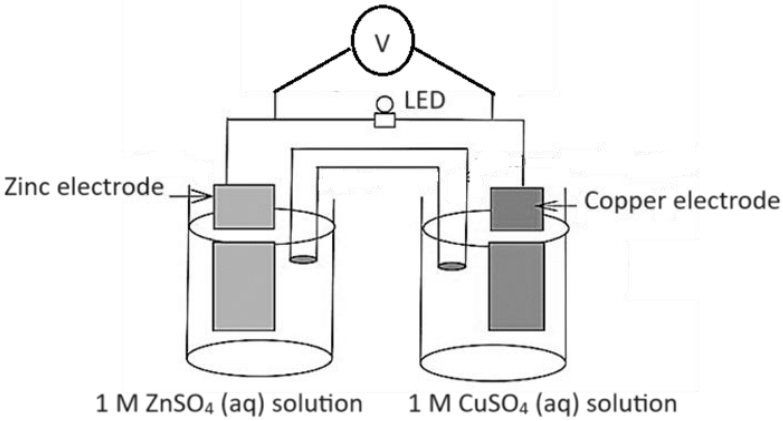
xiv. It has been found out that the eggs are boiled by adding some salt in the boiling water. Which of the following statement best supports such an approach of boiling eggs?

A Increases the freezing point
B Elevates the boiling temperature
C Decreases the osmotic pressure
D Increases the surrounding vapor pressure

xv. While investigating the quality of preserved food products, BAFRA discovers the presence of formaldehyde in dry fish and vegetables. Considering this situation, what is the potential risk associated with formaldehyde exposure?

A Respiratory ailments and allergic reactions due to inhalation
B Digestive disorders and gastrointestinal irritation upon ingestion
C Increased incidence of cardiovascular diseases from dietary intake
D Neurological impairment and cognitive deficits from chronic exposure

xvi. Study the following figure and identify the statement that accurately describes the process occurring in the cell.



A Cu^{2+} ions migrate from the $CuSO_4$ solution to the $ZnSO_4$ solution
B The cell stops functioning when all the $ZnSO_4$ solution is consumed
C The salt bridge prevents the flow of ions between the Zn and Cu solutions
D Electrons flow from the Zn electrode to the Cu electrode through the external circuit

xvii. In a practical class, students are assigned a task to investigate the acidity of different carboxylic acids. What key information about these acids would allow students to predict and compare their relative acidity?

A How well the acids dissolve in different liquids
B How well the acids can form hydrogen bonds with water
C The length of the carbon chain attached to the carboxyl group
D The presence of electron-withdrawing groups on the molecule

xviii. Which key thermodynamic process listed below is responsible for cooling the interior of a household refrigerator and its operational principle?

A Isobaric heating
B Adiabatic expansion
C Isothermal expansion
D Adiabatic compression

xix. The motive that best supports the approach of producing biofuels from oils, fats and local organic waste is to

A minimize waste disposal costs.
B reduce dependence on fossil fuels.
C increase profitability in agricultural sectors.
D promote technological advancements in bio-refinery processes.

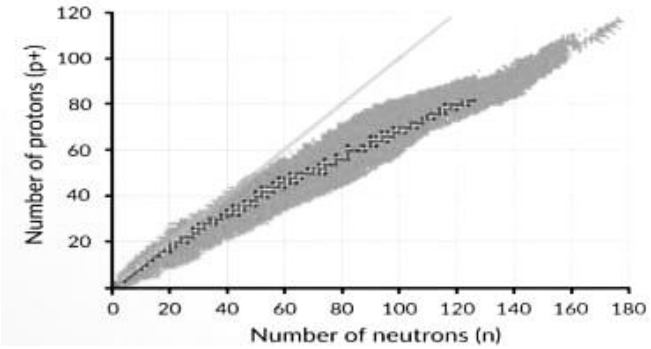
xx. The statement that accurately analyses the conditions for a chemical reaction to occur according to collision theory is

A the reaction rate is independent of the energy of colliding molecules.
B all collisions between reactant molecules result in a chemical reaction.
C only collisions with sufficient energy and proper orientation lead to a chemical reaction.
D collisions at lower temperatures are more likely to cause a reaction than those at higher temperatures.

xxi. Imagine you are developing a new drug to treat a specific medical condition. How would your understanding of amines influence your approach to designing this drug?

A Amines can be used as solvents to aid in drug formulation
B Amines can improve the colour and appearance of the drug product
C Amines can serve as preservatives to prolong the shelf life of the drug
D Amines can interact with biological targets potentially enhancing the drug's effectiveness

xxii. The graph below represents the serge chart that shows the relationship between number of neutrons and protons.



How does a nucleus which lies below the zone of stability attain stability?

I. Converting its proton into neutron
II. Emitting beta particle
III. Emitting positron
IV. Converting neutron into proton

A I and II
B II and III
C I and III
D III and IV

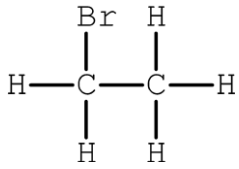
xxiii. You are a nutritionist advising a local community centre on vegetarian diets. A group of adults has recently adopted a vegetarian lifestyle. Choose the best statement that you would suggest.

A Suggest consuming high-fat dairy products to increase amino acid absorption
B Encourage avoiding all plant-based proteins to prevent amino acid imbalances
C Recommend regular intake of vitamin supplements to compensate for amino acid deficiencies
D Suggest the importance of combining complementary plant-based proteins such as beans and rice to ensure adequate amino acid intake

xxiv. Identify the statement that best describes acids and bases according to the Bronsted-Lowry concept.

A Acids lower the pH of a solution and bases raise it
B Acids donate a proton and a base accepts a proton
C Acids donate electron pairs and bases accept electron pairs
D Acids increase the concentration of hydroxide ions and bases decrease it

xxv. A student analysed an organic compound given below using NMR spectroscopy. The mass of its molecular ion is 108. It produced two signals in the NMR spectrum.



Predict the splitting pattern of the 3H and 2H protons respectively.

A Quartet and Triplet
B Triplet and Quartet
C Doublet and Triplet
D Triplet and Doublet

b) Match each item in column A with the most appropriate item in column B. Write the correct letter in the space provided in the 'Answer' column. **[5]**

	Column A	**Column B**	**Answer**	
i.	Van't Hoff factor	a. emf at non-standard condition	i.	
ii.	Landsberger's method	b. splitting of d-orbitals	ii.	
iii.	Nernst equation	c. spontaneity of a reaction	iii.	
iv.	Catalyst	d. oxidation of formaldehyde	iv.	
v.	Gibbs free energy	e. separation of components	v.	
vi.	Crystal Field Theory	f. elevation of boiling point	vi.	
vii.	Cannizzaro's reaction	g. preparation of perfumes	vii.	
viii.	Benzoic acid	h. detection drugs in the urine	viii.	
ix.	Acetic acid	i. multiply industrial output	ix.	
x.	TLC	j. molecular collision	x.	
		k. preparation of vinegar		
		l. behavior of solute		

c) Fill in the blanks with the most appropriate word(s). **[5]**

i.	The position of signals changes due to shielding and deshielding of protons in _____spectroscopy.	
ii.	The formation of different derivatives of carboxylic acid depends on the nature of _____which participates in reaction.	
iii.	The melting point of carboxylic acids depends on the size of the alkyl group. Carboxylic acids with longer alkyl chains typically exhibit _____ melting points.	
iv.	The test used to distinguish aliphatic aldehyde from ketone and benzaldehyde is _____.	
v.	The number of ligands each metal atom can have in a coordination compound is determined by its _____.	
vi.	The law that focuses on energy conservation without addressing the spontaneity or entropy changes in processes is _____ law of thermodynamics.	
vii.	A reaction that is proceeding with slow rate if transferred to smaller container will _____rate of reaction at constant condition.	
viii.	A student was asked to design an experimental setup using Zn^{2+}/Zn and Cu^{2+}/Cu with -0.76 V and $+0.34$ V respectively. His experimental setup was found to be functional with the electrode potential value of _____V.	
ix.	The $NaHCO_3$ and _____acid buffer system helps human blood maintain a stable pH value.	
x.	According to Ostwald's dilution law, the strength of a _____acid and a weak base increase with dilution.	

d) Write TRUE or FALSE for the following statements in the space provided in the 'Answer' column. [5]

	Statement	Answer	
i.	Adding a non-volatile solute to a volatile solvent lowers the freezing point of the solvent.		
ii.	The osmotic pressure of a solution is directly proportional to the concentration of the solute.		
iii.	Most of the organic acids dissociate completely in aqueous solution.		
iv.	Agar is inert electrolyte used in salt bridge.		
v.	The use of coordination compounds in pharmaceuticals is aimed to mitigate environmental impacts.		
vi.	Ammonia is much weaker base than aniline.		
vii.	Amphiprotic substances such as water helps maintain stable pH level in water treatment, ensuring safe drinking water.		
viii.	Galvanic cells power torches and mobile phones, providing portable energy for light and communication.		
ix.	The fortified rice provided to the students helps in production of red blood cell.		
x.	Butter primarily contains unsaturated fat which serves as a source of energy in our body.		

SECTION B [60 MARKS]

ATTEMPT **ANY SIX** QUESTIONS

Question 2

a) You are provided with the solution prepared by dissolving 20 grams of glucose with the molecular formula $C_6H_{12}O_6$ in 500 grams of water.

i. Calculate the elevation in boiling point if the boiling point elevation constant (K_b) for water is 0.512 °C kg/mol. **[2]**

ii. Calculate the boiling point of the solution. **[1]**

b) The pH of a ripened orange is typically between 3.0 and 4.0, while the pH of an unripen orange is generally between 2.0 and 3.0. Design an experiment to assess the ripeness of an orange using the concept of acid-base titration. **[3]**

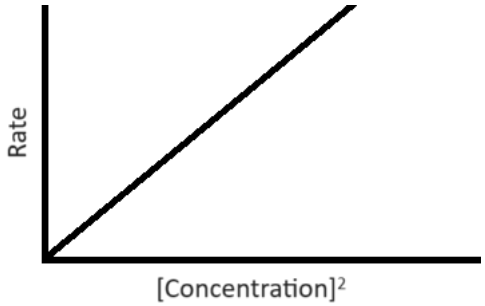
c) Consider a galvanic cell constructed using Pb and Hg half cells. **[2]**

$E^{o}_{Pb^{2+}/Pb} = -0.13\ V,$ $E^{o}_{Hg^{2+}/Hg} = +0.85\ V$

Is the above cell reaction feasible? Support your prediction with a reason.

d) Dentist recommend the use of toothpaste containing calcium carbonate for dental health. What could be the scientific reason behind this recommendation? **[1]**

e) What is the order of reaction indicated by the graph given below? **[1]**



Question 3

a) You are provided with the materials such as LED bulb, graphite rod, salt, stainless steel rod, potassium nitrate, U-shaped glass rod, beakers and a bottle of water.

i. Propose a method to generate electricity that could power your tent at night. **[2]**

ii. How can you optimise the cell to generate more power? **[1]**

b) Consider the reaction A + B → C. The concentration and the rate are reflected in the table below.

Experiment No.	Initial concentration [mol L^{-1}]		Rate [mol $L^{-1}s^{-1}$]
	A	B	
1	0.100	0.200	3.50×10^{-4}
2	0.200	0.200	7×10^{-4}
3	0.100	0.400	1.4×10^{-3}

i. Find out the order of reaction with respect to reactant A and B. **[2]**

ii. Write the rate law. **[1]**

c) "The enthalpy change (ΔH) alone determines the spontaneity of a reaction." Do you agree with the statement, why? **[2]**

d) Imagine you are a chemist appointed to synthesise a new medicine at a pharmaceutical company. What steps would you take to increase the yield of the medicine? **[1]**

e) Write the chemical reaction to prepare acetyl chloride from glacial acetic acid using phosphorus pentachloride? **[1]**

Question 4

a) You are constructing a house at high altitude where most of the time the temperature is cold. Using the knowledge of thermodynamics, choose any **ONE** material from the list in bracket given below to build the house and write its property and thermodynamic function. **[3]**

(Wood, Foam, Mud, Steel)

b) A nuclear reaction involves the transformation of atomic nuclei releasing significant amount of energy. It results in the formation of different elements or isotopes in the process.

In view of the above statement, answer the following questions.

i. Nuclear reactions involving emission of radioactive rays are considered hazardous. Justify the statement with **TWO** suitable reasons. **[2]**

ii. Calculate the number of alpha and beta particles formed in the nuclear reaction given below. **[1]**

$$Th_{90}^{232} \rightarrow Pb_{82}^{208}$$

c) Give the IUPAC name for the following coordination compounds **[2]**

i. $[Cr(NH_3)_6]Cl_3$

ii. $[Cu\ (en)_2]^{2+}$

iii. $[Ag(NH_3)_2]^+$

iv. $[Fe(CN)_6]^{3-}$

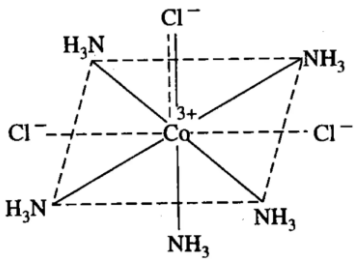
d) X is the radioisotope which is administered to the patient suffering from thyroid disorder. Identify the radioisotope X. **[1]**

e) Complete and balance the chemical reaction given below. **[1]**

$$CH_3CH_2OH + [O] \xrightarrow{K_2Cr_2O_7 \ / \ H_2SO_4} \text{.....} + \text{.....}$$

Question 5

a) Study the structure of $CoCl_3.5NH_3$ given in the figure below and answer the questions that follow.



i. Explain the formation of above structure on the basis of Werner's coordination theory. **[2]**

ii. Write the chemical reaction, if this coordination compound is treated with silver nitrate. **[1]**

b) Explain why carbonyl compounds are polar and describe **TWO** effects of polarity on their chemical properties. **[3]**

c) Weavers traditionally use vinegar to dye the threads before weaving cloth. Discuss **TWO** reasons why vinegar might be used in this process, considering its chemical properties and effects on the dyeing process. **[2]**

d) When fuel undergoes combustion, 10 kJ of work is done on the system and 2 kJ of heat is released from the system into the surrounding. Calculate the change in internal energy. **[1]**

e) Given below are lists of food items. Choose the list which is best for health and suggest one disease associated with the list if chosen otherwise. **[1]**

List A: rice, meat, butter and cereals

List B: rice, vegetables, fruits

Question 6

a) During an experiment, students compared the solubility of acetic acid and benzoic acid in water. They found out that benzoic acid exhibits significantly lower solubility in water than the acetic acid.

i. Explain the factors that contribute to the difference in solubility. **[2]**

ii. How does the low solubility of benzoic acid in water minimize environmental contamination? **[1]**

b) In the food processing industry, one of the very important reactions is the reaction between ethanol and acetic acid as mentioned below.

$$C_2H_5OH + CH_3COOH \rightarrow CH_3COOC_2H_5 + H_2O$$

i. Name and explain the importance of the reaction in regard to property of the product formed. **[2]**

ii. How does this reaction demonstrate the concept of nucleophilic acyl substitution reaction? **[1]**

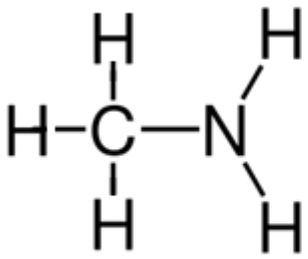
c) Why does acetaldehyde produce a yellow precipitate in the iodoform test, while formaldehyde does not? Provide an explanation based on the structure of acetaldehyde and formaldehyde. **[2]**

d) Write **TWO** differences between fats and oils. **[1]**

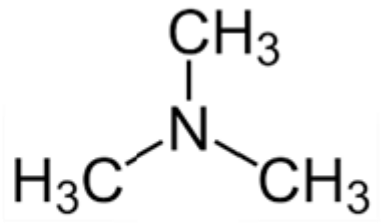
e) Calculate the value of pK_b for ammonia if its K_b value is 1.8×10^{-5}. **[1]**

Question 7

a) Study the structures given below and answer the questions that follow.



Structure A



Structure B

i. Compare the basicity of structure A and structure B. Support your answer with **ONE** reason. **[2]**

ii. Wastewater is treated with lime and caustic soda. Evaluate the feasibility of replacing these chemicals with amines for wastewater treatment. **[1]**

b) The figure below shows the spectrum of two different compounds. Study the figure and answer the questions that follow.

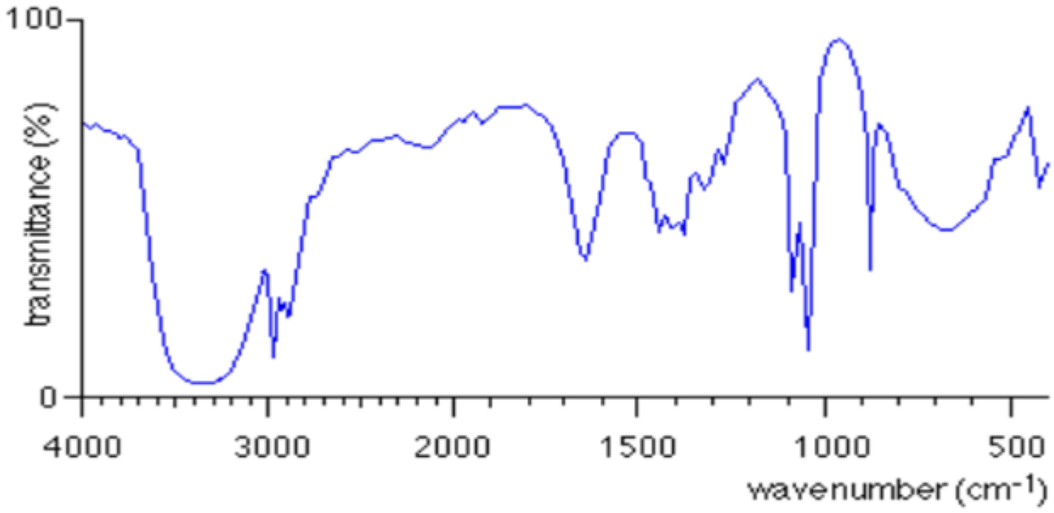


Figure I

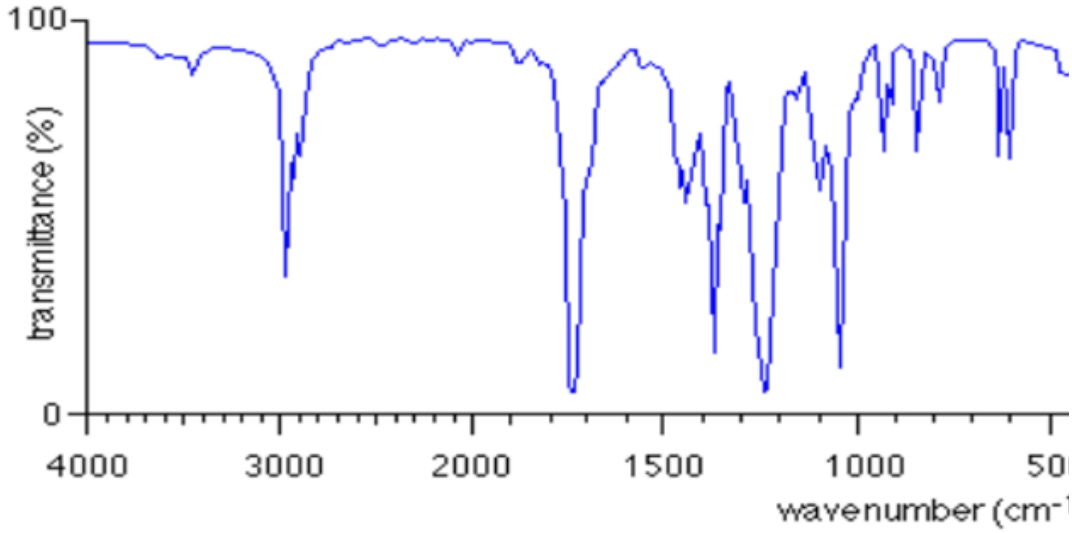


Figure II

i. Identify the two compounds. **[1]**

ii. Differentiate the two compounds based on their functional groups. **[2]**

c) 0.2 moles of $C_{12}H_{22}O_{11}$ are added in 500 g of water at 25°C. The vapour pressure of pure water at 25°C is 23.8 mmHg. Perform the necessary calculations to determine the vapour pressure of the solution. How is the vapour pressure affected? **[2]**

d) Acetic acid is generally soluble in water due to the formation of intermolecular hydrogen bond. Show the formation of hydrogen bond between a molecule of acetic acid and water. **[1]**

e) A student chose methyl orange as an indicator to titrate a weak acid and a strong base. Evaluate the suitability of methyl orange for this titration with a reason. **[1]**

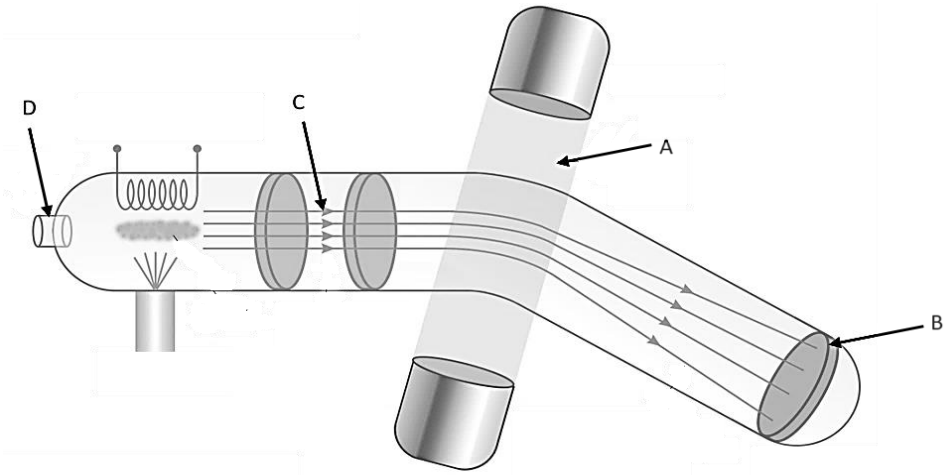
Question 8

a) Enzymes such as pepsin and trypsin play crucial roles in protein digestion within the human body, each functioning optimally in different pH environments. Pepsin operates in the acidic medium of the stomach, while trypsin functions in the basic medium of the small intestine.
In view of the above statement, answer the following questions.

i. Explain the functioning of the above amino acids in two different environments. **[2]**

ii. Explain how the unique properties of amino acids contribute to their effectiveness in skincare. **[1]**

b) The figure below shows the working mechanism of mass spectrometer. Study the figure and answer the questions that follow.



i. Name the parts marked A, B, C and D. **[2]**

ii. How are ions separated by electromagnetic field in mass spectrometers? **[1]**

c) Outline a laboratory procedure for the production of biodiesel from vegetable oils. **[2]**

d) Why are coordination compounds considered effective catalysts? Give **TWO** reasons. **[2]**

Question 9

a) Your task is to analyse a complex mixture containing multiple drug compounds, some of which are present in very low concentrations. You have access to both Thin Layer Chromatography (TLC) and High Performance Liquid Chromatography (HPLC) for your analysis.

i. Mention **TWO** reasons why HPLC is more suitable for analysing a complex mixture than TLC? **[2]**

ii. How does the presence or absence of a pressure pump affect the operation of HPLC? **[1]**

b) Why is understanding of the molarity of a solution crucial for evaluating the effectiveness of a disinfectant? Support your answer with **TWO** reasons. **[2]**

c) The following table shows different buffers with their chemical compositions.

Buffer	Chemical composition
Saliva	Bicarbonate and phosphate ions
Carbonated beverages	Carbonic acid
Milk of magnesia	Magnesium hydroxide
Yogurt	Lactic acid

Classify the above buffers as acidic or basic buffer. **[2]**

d) The electrochemical cell is constructed using SHE and Sn. The electrode potential value of Sn is $E^0_{Sn^{2+}/\ Sn} = -0.14\ V$

i. Identify oxidation half-cell and reduction half-cell. **[1]**

ii. Calculate the emf of cell under standard conditions. **[1]**

e) How is chemical kinetics relevant to the shelf- life of food products? Write **ONE** reason. **[1]**