Aga Khan University Examination Board

Notes from E-Marking Centre on HSSC-I Chemistry Annual Examination 2023

Introduction

This document has been produced for the teachers and candidates of Higher Secondary School Certificate (HSSC) Part I Chemistry. It contains comments on candidates' responses to the 2023 HSSC-I Examination indicating the quality of the responses and highlighting their relative strengths and weaknesses.

E-Marking Notes

This includes overall comments on candidates' performance on every question and *some* specific examples of candidates' responses that support the mentioned comments. Please note that the descriptive comments represent an overall perception of the better and weaker responses as gathered from the e-marking session. However, the candidates' responses shared in this document represent some specific example(s) of the mentioned comments.

Teachers and candidates should be aware that examiners may ask questions that address the Student Learning Outcomes (SLOs) in a manner that requires candidates to respond by integrating knowledge, understanding and application skills they have developed during the course of study. Candidates are advised to read and comprehend each question carefully before writing the response to fulfill the demand of the question.

Candidates need to be aware that the marks allocated to the questions are related to the answer space provided on the examination paper as a guide to the length of the required response. A longer response will not in itself lead to higher marks. Candidates need to be familiar with the command words in the SLOs which contain terms commonly used in examination questions. However, candidates should also be aware that not all questions will start with or contain one of the command words. Words such as 'how', 'why' or 'what' may also be used.

General Observations

Overall, most candidates achieved success in constructing good responses. In some concepts, candidates outperformed, particularly in the concepts of calculating molarity and concentration and determining empirical and molecular formulae. However, mentioned below are a few concepts on which teachers need to focus and give candidates more drill and practice to have a strong grip.

- Properties of cathode rays with every aspect and their difference with protons and canal rays.
- Identification of the directional and non-directional nature of bonds in a molecule along with appropriate justification.
- Interpretation of bond order and magnetic properties of homonuclear diatomic molecules based on molecular orbital theory from the energy diagram as well as differentiation between paramagnetism and diamagnetism.
- Factors affecting equilibrium and equilibrium constant with reference to Le-Chatelier's principle.
- Conceptual clarity of the relationship between pressure volume in a reversible reaction.
- Every aspect which affects the rate of reaction aligns with collision theory.
- Application of thermodynamical approach of the first law of thermodynamics and use of correct formula and conventional sign while solving its numerical.
- Different methods of stepwise balancing of ionic equations of redox reactions in different mediums.

- Appropriate use of ebullioscopy and cryoscopic method and substitution of values in the formulae required to calculate molar mass. Moreover, a clear understanding of vapour pressure and boiling point relationship is also required.

Note: Candidates' responses shown in this report have not been corrected for grammar, spelling, format, or information.

DETAILED COMMENTS

Constructed Response Questions (CRQs)

Question No. 1	
Question Text	Describe the properties of cathode rays with reference to the given attributes. a. Effect of an electric field b. Fluorescence c. Momentum d. Charge to mass ratio
SLO No.	2.1.2
SLO Text	Describe the properties of: a. cathode rays b. positive rays
Max Marks	4
Cognitive Level	U*
Checking Hints	1 mark for describing the property of cathode rays with reference to each attribute (4 required)
Overall Performance	The cohort demonstrated a satisfactory understanding of cathode rays. The overall performance could be better if candidates considered the following points. • Focus on providing more comprehensive explanations of the effect of cathode rays in the applied electric field. • Emphasise the distinction between anode and positive terminal, as some weaker responses incorrectly identified the positive terminal as anode. • Encourage students to accurately describe fluorescence properties accurately, rather than providing simplistic definitions or misconceptions. • Reinforce the definition of momentum, highlighting its connection to mass and velocity, and discourage the use of vague terms like "high" and "low" momentum. • Emphasise the importance of providing the correct value of the mass/charge (e/m) ratio for electrons, rather than just stating the mass of an electron. • Clarify the distinction between cathode rays and canal rays, as some weaker responses made incorrect comparisons between the two. • Address the misconception that cathode rays are heavier than protons by explaining particle properties and relative masses clearly.
Description of Better Responses	Better responses correctly identified the deflection of cathode rays towards the positive electrode and inferred their negative charge. They accurately described the characterisation experiment and the green fluorescence produced upon striking the walls. They also recognised that cathode rays possess momentum and are material particles with definite mass and velocity. Furthermore, they correctly identified cathode rays as electrons in part d.

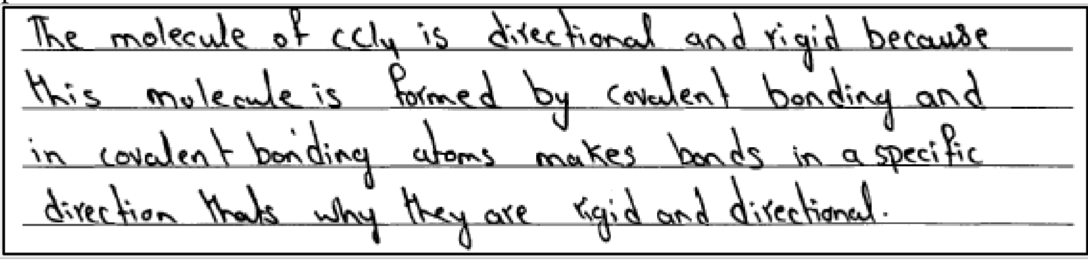
Image of Better Response	a. Effect of an electric field (1 Mark) • In an electric field the cathode rays are deflected towards the positive end showing that they are negative. b. Fluorescence (1 Mark) cathode rays produce Fluorescene (greenish light) when they strike with the anode. c. Momentum (1 Mark) • cathode rays passes momentum because they can drive a small padel wheel placed in their Path. d. Charge to mass ratio (1 Mark) • Cathode rays have same charge to mass ratio no matter which gas is used in the discharge tube because here we consider -ve charge and mass of electrons which is same in all.
Description of Weaker Responses	Weaker responses failed to describe the effect of cathode rays in the applied electric field and wrongly identified the positive terminal as an anode. In part b, they provided an incorrect definition of fluorescence or described it inadequately. They also inaccurately defined momentum and provided incorrect information regarding the mass/ charge ratio of electrons. Some weaker responses also compared cathode rays with canal rays and mistakenly stated that cathode rays are heavier than protons.
Image of Weaker Response	a. Effect of an electric field (1 Mark) cathode rays when placed a electric field, will deflect towards the north direction indicating the -ve charge on them b. Fluorescence (1 Mark) when any opaque object is placed in front of cathode rays they cast a Sharp Shadow. c. Momentum (1 Mark) The momentum of cathode rays were observed by placing a wheel which was moving when the cathode rays strike on it. d. Charge to mass ratio (1 Mark) They showed e/m ratio of 1.928×10^{-19} J mol

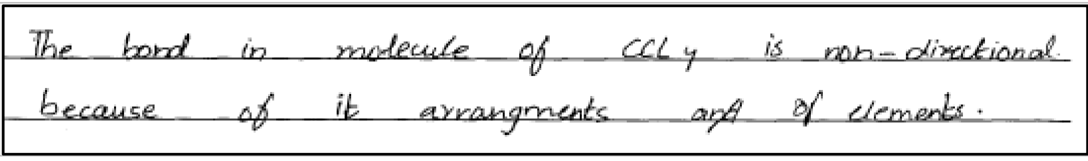
Suggestions for improvement (Highlight all that apply)

How to Approach SLO	Pedagogy** Used for that SLO	Assessment Strategies
• Understand the expectations of the command words • Look at the cognitive level • Identify the content that is required to answer that question (both in terms of understanding of concepts and any skills that may be required like analysing or evaluating)	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair and Share • Knowledge Platform videos • Questioning Technique (Socratic approach) • Practical Demonstration	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login

• Go through the past paper questions on that particular concept • Refer to the resource guide for extra resources	** For description of each Pedagogy**, refer to Annexure A	
Any Additional Suggestion: Suggestions for improvement include emphasising the importance of accurately describing the experimental observations and their implications. Students should be encouraged to provide precise definitions of scientific terms and to avoid making comparisons without proper understanding. Additionally, highlighting the significance of clear and concise explanations will help students improve their responses.		

*K = Knowledge U = Understanding A = Application and other higher-order cognitive skills

Question No. 2	
Question Text	Identify the nature of bond in a molecule of CCl_4 as directional or non-directional. Give a reason to support your answer.
SLO No.	3.4.3
SLO Text	Compare directional and non-directional nature of ionic and covalent bonds.
Max Marks	2
Cognitive Level	U
Checking Hints	1 mark for identifying the nature of the bond 1 mark for the correct reason
Overall Performance	The cohort demonstrated a satisfactory understanding of CCl_4 as a covalent molecule with directional characteristics. However, this question's performance can be improved if candidates focus on the following points. • Emphasise the concept of directional bonding in covalent molecules, highlighting the role of overlapping atomic orbitals and specific bond angles. • Provide more examples and illustrations of directional covalent molecules to reinforce the concept. • Encourage the use of VESPR theory to justify the shapes and hybridisation of molecules. • Address misconceptions regarding the dipole moment and its relation to covalent compounds, highlighting the polar nature of some covalent molecules. • Promote critical thinking by asking students to provide reasoning and explanations to support their answers, rather than relying on incorrect assumptions or general statements.
Description of Better Responses	The better responses correctly identified CCl_4 as a covalent molecule with directional characteristics. They accurately explained that directional bonding occurs due to the specific sharing of electrons and the overlap of atomic orbitals, resulting in specific bond angles between atoms. Furthermore, they justified their responses using the Valence Shell Electron Pair Repulsion (VESPR) theory, highlighting how the type of shape of the molecule and hybridisation is determined by the arrangement of electron pairs.
Image of Better Response	 The molecule of CCl4 is directional and rigid because this molecule is formed by covalent bonding and in covalent bonding atoms makes bonds in a specific direction thats why they are rigid and directional.

Description of Weaker Responses	Weaker responses displayed misconceptions regarding the directional nature of CCl_4. Some candidates incorrectly labelled it as non-directional or mentioned that the dipole is zero due to its covalent nature. Others correctly identified the directional nature of the molecule but failed to provide accurate justifications for its directional characteristics.
Image of Weaker Response	 The bond in molecule of CCl4 is non-directional because of it arrangments and of elements.

Suggestions for improvement (Highlight all that apply)

How to Approach SLO	Pedagogy Used for that SLO	Assessment Strategies
• Understand the expectations of the command words • Look at the cognitive level • Identify the content that is required to answer that question (both in terms of understanding of concepts and any skills that may be required like analysing or evaluating) • Go through the past paper questions on that particular concept • Refer to the resource guide for extra resources	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair and Share • Knowledge Platform videos • Questioning Technique (Socratic approach) • Practical Demonstration	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login

Any Additional Suggestion: To enhance understanding, provide practical examples and visual aids that demonstrate the directional nature of covalent bonding. Encourage students to actively engage with the VESPR theory, emphasising how it explains molecular shape and hybridisation. Incorporate interactive activities, such as molecular model kits, to allow students to physically manipulate and visualise the directional characteristics of covalent molecules. Encourage critical thinking and problem-solving skills by posing questions that require students to apply their knowledge of directional bonding and molecular shape in real-world contexts.

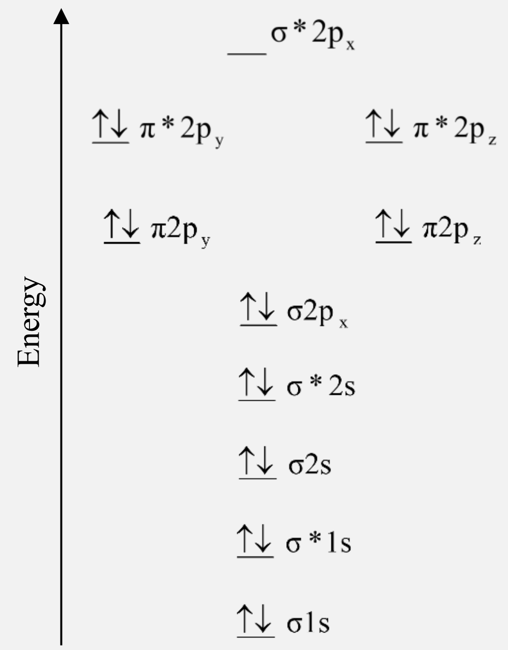
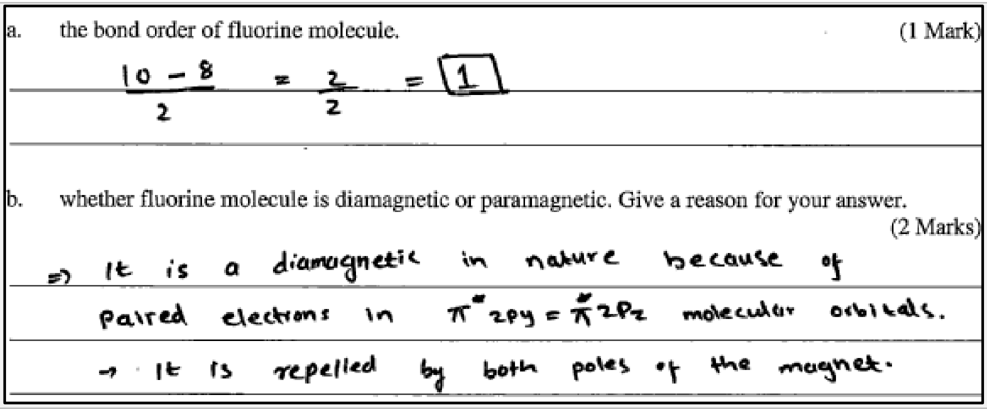
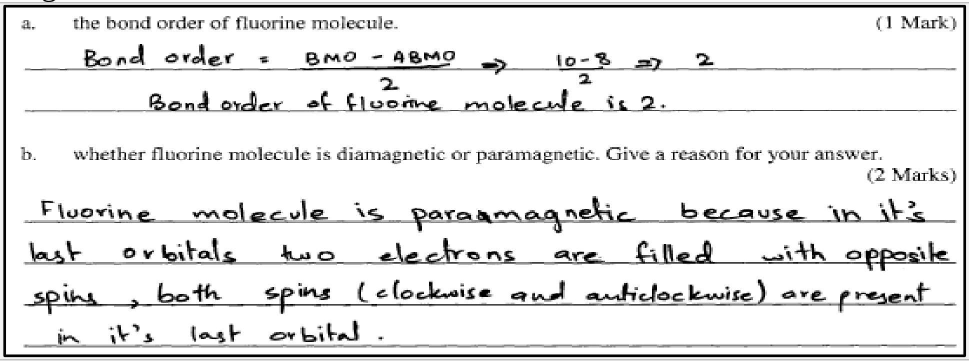
Question No. 3	
Question Text	The molecular orbital diagram for the diatomic fluorine molecule (F_2) is  With the help of the given diagram, determine a. the bond order of fluorine molecule. b. whether fluorine molecule is diamagnetic or paramagnetic. Give a reason for your answer.
SLO No.	3.3.6
SLO Text	Predict the electronic configuration, bond order and magnetic properties of homonuclear diatomic molecules with the help of MOT.
Max Marks	3
Cognitive Level	U
Checking Hints	a. 1 mark for calculating bond order b. 1 mark for writing diamagnetic 1 mark for the correct reason
Overall Performance	The cohort demonstrated a satisfactory understanding of the bond order and its relationship with the given molecular diagram. However, a lack of comprehension regarding the energy diagram of molecular orbital theory (MOT) can be catered in a better way if candidates consider the following points. • Emphasise the concept of bond order and its significance in determining the stability and properties of molecules. • Provide clear explanations and examples of how to determine bond order based on molecular diagrams. • Highlight the relationship between paired electrons and diamagnetism, as well as the distinction between diamagnetic and paramagnetic properties. • Focus on understanding the energy diagram of molecular orbital theory (MOT) and its implications for molecular stability and properties.
Description of Better Responses	The better responses accurately identified the correct bond order based on the given molecular diagram by calculating the electrons involved in π^* molecular orbitals. They demonstrated knowledge of bond order and correctly associated the presence of paired electrons with diamagnetic properties in the molecule. Their understanding of the concept allowed them to make accurate predictions and draw meaningful conclusions about the molecule's stability and properties.

Image of Better Response	 a. the bond order of fluorine molecule. (1 Mark) $\frac{10-8}{2} = \frac{2}{2} = \boxed{1}$ b. whether fluorine molecule is diamagnetic or paramagnetic. Give a reason for your answer. (2 Marks) ⇒ It is a diamagnetic in nature because of paired electrons in $\pi^*2p_y = \pi^*2p_z$ molecular orbitals. → It is repelled by both poles of the magnet.
Description of Weaker Responses	Weaker responses struggled to determine the correct bond order and mistakenly linked the presence of unpaired electrons with diamagnetism. They showed a lack of comprehension regarding the energy diagram of molecular orbital theory (MOT) and failed to provide accurate explanations or predictions based on the given molecular diagram.
Image of Weaker Response	 a. the bond order of fluorine molecule. (1 Mark) Bond order = $\frac{BMO - ABMO}{2}$ ⇒ $\frac{10-8}{2}$ ⇒ 2 Bond order of fluorine molecule is 2. b. whether fluorine molecule is diamagnetic or paramagnetic. Give a reason for your answer. (2 Marks) Fluorine molecule is paramagnetic because in it's last orbitals two electrons are filled with opposite spins, both spins (clockwise and anticlockwise) are present in it's last orbital.

Suggestions for improvement (Highlight all that apply)

How to Approach SLO	Pedagogy Used for that SLO	Assessment Strategies
• Understand the expectations of the command words • Look at the cognitive level • Identify the content that is required to answer that question (both in terms of understanding of concepts and any skills that may be required like analysing or evaluating) • Go through the past paper questions on that particular concept • Refer to the resource guide for extra resources	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair and Share • Knowledge Platform videos • Questioning Technique (Socratic approach) • Practical Demonstration	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login

Any Additional Suggestion: To enhance understanding, provide more opportunities for practice with different molecular diagrams to predict bond orders. Introduce the concept of molecular orbital theory (MOT) gradually, with clear explanations and visual aids to help students grasp the energy diagram and its implications. Offer interactive activities, such as virtual simulations or hands-on experiments, to reinforce the relationship between bond order, electron pairing, and magnetic properties, and encourage students to think critically and apply their knowledge to correctly interpret molecular diagrams and predict bond orders.

Question No. 4	
Question Text	Given is an example of a reversible reaction at equilibrium. $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$ The K_c for this reaction is $K_c = \frac{4x^2}{V(a-x)}$ Why is the factor of volume written in the denominator in the K_c expression? With reference to the change in pressure, describe the effect of volume on the equilibrium state and the value of K_c.
SLO No.	7.2.2
SLO Text	Predict the effect of catalyst, temperature, pressure, volume and concentration on the equilibrium state and yield of industrial products using Le-Chatelier’s principle.
Max Marks	4
Cognitive Level	U
Checking Hints	1 mark for writing about the numbers of moles of products greater than those of reactants 1 mark for writing about the increase in pressure decreasing the volume/ number of moles of product (x) 1 mark for writing about the value of K_c remaining constant 1 mark for writing about the equilibrium state moving in the backward direction
Overall Performance	The cohort displayed an adequate understanding of the relationship between pressure, volume, and the equilibrium constant (K_c). The candidates could perform better if focus on the following points. • Reinforce the concept of equilibrium and the equilibrium constant (K_c) with clear explanations and examples. • Emphasise the relationship between pressure, volume, and the number of moles of reactants and products. • Clarify the reason for the volume factor in the denominator of the K_c expression, highlighting the relative quantities of reactants and products. • Provide additional practice problems that require students to apply the concepts of equilibrium, pressure, and volume to predict the direction of the reaction. • Encourage students to think critically and provide clear explanations, focusing on the cause-and-effect relationship between pressure, volume, and the equilibrium state.
Description of Better Responses	Better responses correctly explained that the factor of volume in the denominator of the K_c expression is due to the greater number of moles of products compared to reactants. They demonstrated an understanding that an increase in pressure would decrease the volume or the number of moles of product, keeping K_c constant. They accurately identified the inverse relationship between pressure and volume and provided clear reasoning for the effect of pressure on the equilibrium state.

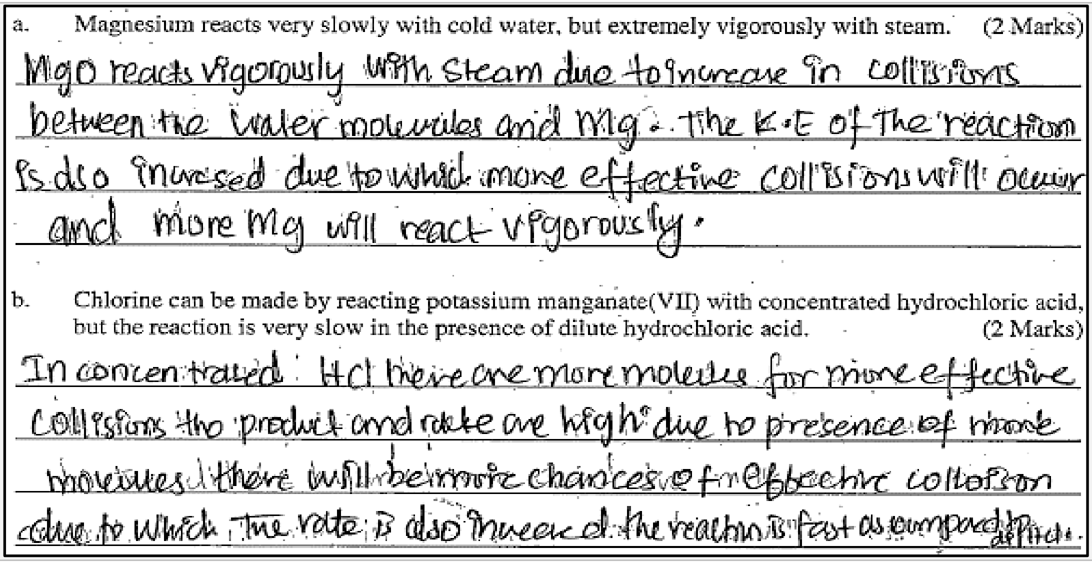
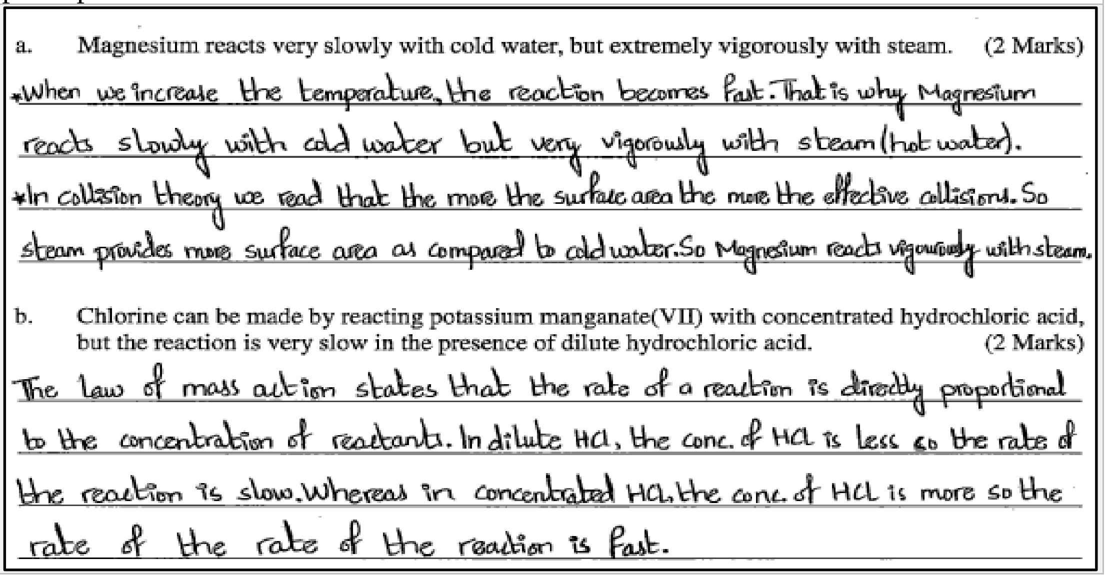
Image of Better Response	The factor of volume is written in the denominator because moles on the product side are more in number than moles on the reactant side. Whenever pressure is changed, the volume changes too, but Kc remains same as it is only affected by temperature. When pressure is increased, the volume decreases and the reaction shifts towards the side with less no of moles. In the above case, the product side. When pressure is decreased, the volume has to be increased (as these quantities are inversely proportional) and the reaction shifts towards the side with more number of moles. In the above case, the product side. These changes are done to keep Kc constant.
Description of Weaker Responses	Weaker responses struggled to explain the reason for the volume factor in the denominator of the K_c expression and failed to understand the relationship between pressure, volume, and the equilibrium constant (K_c). They incorrectly associated K_c with changes in pressure and volume, and some responses also displayed misconceptions regarding the relationship between pressure and volume.
Image of Weaker Response	Volume is written in the denominator as during calculation it is in the numerator but is in the division state. So according to maths if we bring it in the denominator it will be multiplied. Also since volume is inversely proportional to kc in the reaction thatt why it's written in denominator. Pressure is directly proportional to the no. of moles in a reaction and pressure and volume have an inverse relation. So in this equation, pressure is more on the product side and volume will be less while vice versa on the reactant side. If we increase pressure kc will increase.

Suggestions for improvement (Highlight all that apply)

How to Approach SLO	Pedagogy Used for that SLO	Assessment Strategies
• Understand the expectations of the command words • Look at the cognitive level • Identify the content that is required to answer that question (both in terms of understanding of concepts and any skills that may be required like analysing or evaluating) • Go through the past paper questions on that particular concept • Refer to the resource guide for extra resources	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair and Share • Knowledge Platform videos • Questioning Technique (Socratic approach) • Practical Demonstration	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login

Any Additional Suggestion: The teacher can provide more examples and illustrations that highlight the relationship between pressure, volume, and the equilibrium constant (K_C). Use real-world scenarios or chemical reactions to demonstrate the impact of pressure changes on the equilibrium state. Encourage students to clearly articulate their reasoning and provide step-by-step explanations of the cause-and-effect relationship between pressure, volume, and the equilibrium position. Additionally, address any misconceptions regarding the direct relationship between pressure and volume, emphasising the inverse relationship instead.

<table>
<tr><th colspan="2">Question No. 5</th></tr>
<tr><td>Question Text</td><td>Following are the observations of a student while working in the laboratory. Explain each of his/ her observations with reference to chemical kinetics.
a. Magnesium reacts very slowly with cold water, but extremely vigorously with steam.
b. Chlorine can be made by reacting potassium manganate (VII) with concentrated hydrochloric acid, but the reaction is very slow in the presence of dilute hydrochloric acid.</td></tr>
<tr><td>SLO No.</td><td>9.3.5</td></tr>
<tr><td>SLO Text</td><td>Explain the effect of concentration, temperature and surface area on rate of reaction by using collision theory.</td></tr>
<tr><td>Max Marks</td><td>4</td></tr>
<tr><td>Cognitive Level</td><td>U</td></tr>
<tr><td>Checking Hints</td><td>a. 1 mark each for writing about the direct relationship
• between temperature and kinetic energy
• amongst K.E, effective collision and rate of reaction/ formation of magnesium hydroxide hinders further reaction
b. 1 mark each for writing about the direct relationship
• between concentration and number of particles
• amongst particles, effective collision and rate of reaction</td></tr>
<tr><td>Overall Performance</td><td>Almost 70% of the cohort successfully demonstrated a satisfactory understanding of the relationship between temperature, concentration, and reaction rates with appropriate justification. However, the shortcomings of the misconceptions can be fostered by reflecting on the following recommendations.
• Provide more examples and illustrations that demonstrate the relationship between temperature, kinetic energy, and reaction rates.
• Encourage students to clearly explain the mechanism by which an increase in temperature leads to more collisions and a higher rate of reaction.
• Reinforce the concept of concentration and its impact on the number of particles, effective collisions, and reaction rates.
• Use visual aids or interactive activities to help students visualise the concept of collisions and how they relate to reaction rates.
• Incorporate more practice problems that require students to apply their understanding of temperature, concentration, and reaction rates to real-world scenarios.</td></tr>
<tr><td>Description of Better Responses</td><td>Better responses accurately described the relationship between temperature and kinetic energy, explaining how an increase in temperature leads to more vigorous reactions due to an increase in effective collisions. They also correctly related the decrease in concentration to a decrease in the number of particles, resulting in fewer collisions and a decreased rate of reaction. Their explanations demonstrated a solid understanding of the concept and its applications.</td></tr>
</table>

Image of Better Response	 a. Magnesium reacts very slowly with cold water, but extremely vigorously with steam. (2 Marks) MgO reacts vigorously with steam due to increase in collisions between the water molecules and Mg. The K.E of the reaction is also increased due to which more effective collisions will occur and more Mg will react vigorously. b. Chlorine can be made by reacting potassium manganate(VII) with concentrated hydrochloric acid, but the reaction is very slow in the presence of dilute hydrochloric acid. (2 Marks) In concentrated HCl there are more molecules for more effective collisions the product and rate are high due to presence of more molecules there will be more chances of effective collision due to which the rate is also increased the reaction is fast as compared to dilute.
Description of Weaker Responses	Weaker responses pull out all the stops to justify the relationship between temperature and kinetic energy, as well as the relationship between concentration, number of particles, effective collisions, and the rate of reaction. They were unable to provide clear explanations and showed a short of an understanding of the underlying principles involved.
Image of Weaker Response	 a. Magnesium reacts very slowly with cold water, but extremely vigorously with steam. (2 Marks) *When we increase the temperature, the reaction becomes fast. That is why Magnesium reacts slowly with cold water but very vigorously with steam (hot water). *In collision theory we read that the more the surface area the more the effective collisions. So steam provides more surface area as compared to cold water. So Magnesium reacts vigorously with steam. b. Chlorine can be made by reacting potassium manganate(VII) with concentrated hydrochloric acid, but the reaction is very slow in the presence of dilute hydrochloric acid. (2 Marks) The law of mass action states that the rate of a reaction is directly proportional to the concentration of reactants. In dilute HCl, the conc. of HCl is less so the rate of the reaction is slow. Whereas in concentrated HCl, the conc. of HCl is more so the rate of the rate of the reaction is fast.

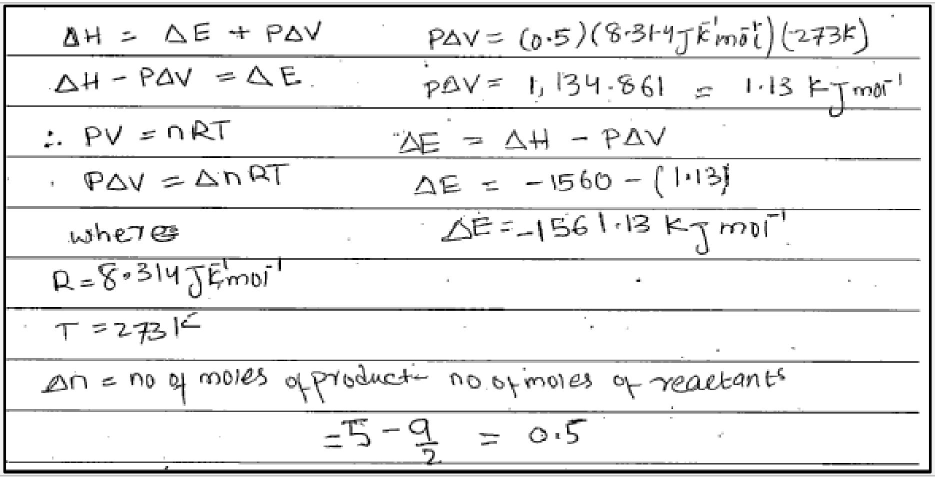
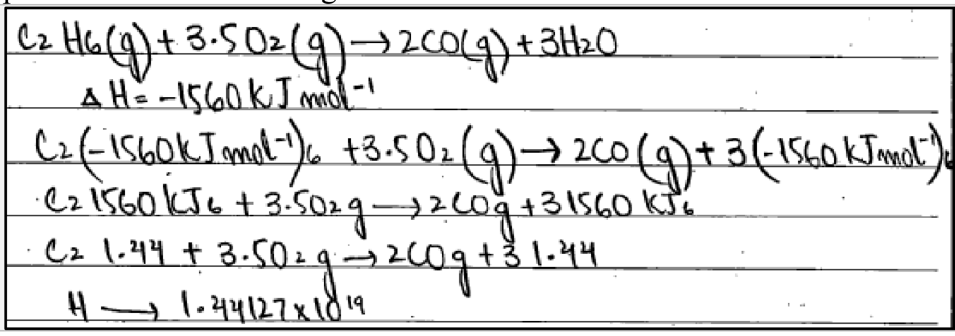
Suggestions for improvement (Highlight all that apply)

How to Approach SLO	Pedagogy Used for that SLO	Assessment Strategies
• Understand the expectations of the command words • Look at the cognitive level • Identify the content that is required to answer that question (both in terms of understanding of concepts and any skills that may be required like	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair and Share • Knowledge Platform videos • Questioning Technique (Socratic approach)	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login

analysing or evaluating) • Go through the past paper questions on that particular concept • Refer to the resource guide for extra resources	• Practical Demonstration	

Any Additional Suggestion: To enhance understanding, provide more opportunities for hands-on experiments or simulations that allow students to observe the relationship between temperature, collisions, and reaction rates. Emphasise the concept of kinetic energy and its direct link to temperature, illustrating how increased energy leads to more frequent and energetic collisions. Break down the relationship between concentration, number of particles, effective collisions, and reaction rates into smaller steps, ensuring students grasp the cause-and-effect relationships at each stage. Encourage students to think critically and apply their knowledge to explain various scenarios involving temperature, concentration, and reaction rates.

Question No. 6	
Question Text	Calculate the change in internal energy for the given reaction at T = 273 K and R = 8.314 J K^{-1} mol^{-1}. $C_2H_{6(g)} + \frac{7}{2}O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$ $\Delta H = -1560 \text{ kJ mol}^{-1}$
SLO No.	11.2.3
SLO Text	Calculate internal energy and work done of a system by applying the first law of thermodynamics.
Max Marks	4
Cognitive Level	A
Checking Hints	1 mark for calculating the value of Δn 1 mark for calculating the correct value of $P\Delta V$ 1 mark for the correct substitution of values in the formula $\Delta E = \Delta H - P\Delta V$ 1 mark for calculating the value of ΔE
Overall Performance	The cohort struggled with the question related to calculating ΔE using the Enthalpy change method, resulting in lower overall performance of the candidates. These shortcomings can be streamlined by considering the following points. • Review the concepts of Enthalpy, pressure-volume work, and the calculation of ΔE using the Enthalpy change method. • Practice problems that involve calculating ΔE and reinforce the correct formulas and signs to use. • Carefully analyse the given information, identify the relevant variables, and apply the appropriate formulas to solve the problem. • Offer step-by-step explanations and examples of how to calculate ΔE using the Enthalpy change method, highlighting the correct procedures and formulas.
Description of Better Responses	Better responses correctly determined the value of Δn, used the formula $\Delta E = \Delta H - P\Delta V$ appropriately, and calculated the value of ΔE accurately. They demonstrated a solid understanding of the Enthalpy change method and effectively applied the relevant concepts and formulas.

Image of Better Response	 $\Delta H = \Delta E + P\Delta V$ $\Delta H - P\Delta V = \Delta E$ $\therefore PV = nRT$ $P\Delta V = \Delta nRT$ where $R = 8.314\ JK^{-1}mol^{-1}$ $T = 273K$ Δn = no of moles of product − no. of moles of reactants $= 5 - \frac{9}{2} = 0.5$ $P\Delta V = (0.5)(8.314\ JK^{-1}mol^{-1})(273K)$ $P\Delta V = 1,134.861 = 1.13\ kJ\ mol^{-1}$ $\Delta E = \Delta H - P\Delta V$ $\Delta E = -1560 - (1.13)$ $\Delta E = -1561.13\ kJ\ mol^{-1}$
Description of Weaker Responses	Weaker responses struggled to calculate ΔE using the Enthalpy change method. They made errors in using formulas or signs, leading to incorrect solutions. These responses revealed a lack of understanding of the underlying concepts and the correct procedures for calculating ΔE.
Image of Weaker Response	 $C_2H_6(g) + 3.5O_2(g) \rightarrow 2CO(g) + 3H_2O$ $\Delta H = -1560\ kJ\ mol^{-1}$ $C_2(-1560\ kJ\ mol^{-1})_6 + 3.5O_2(g) \rightarrow 2CO(g) + 3(-1560\ kJ\ mol^{-1})$ $C_2 1560\ kJ_6 + 3.5O_2 g \rightarrow 2CO g + 3 1560\ kJ_6$ $C_2\ 1.44 + 3.5O_2 g \rightarrow 2CO g + 3\ 1.44$ $H \rightarrow 1.44127\times10^{19}$

Suggestions for improvement (Highlight all that apply)

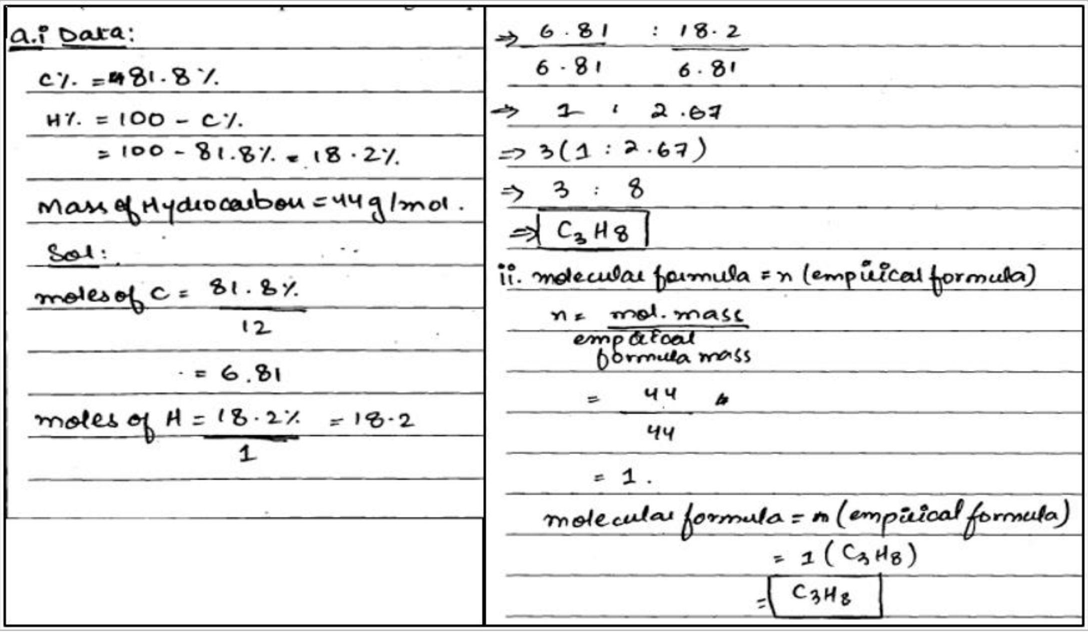
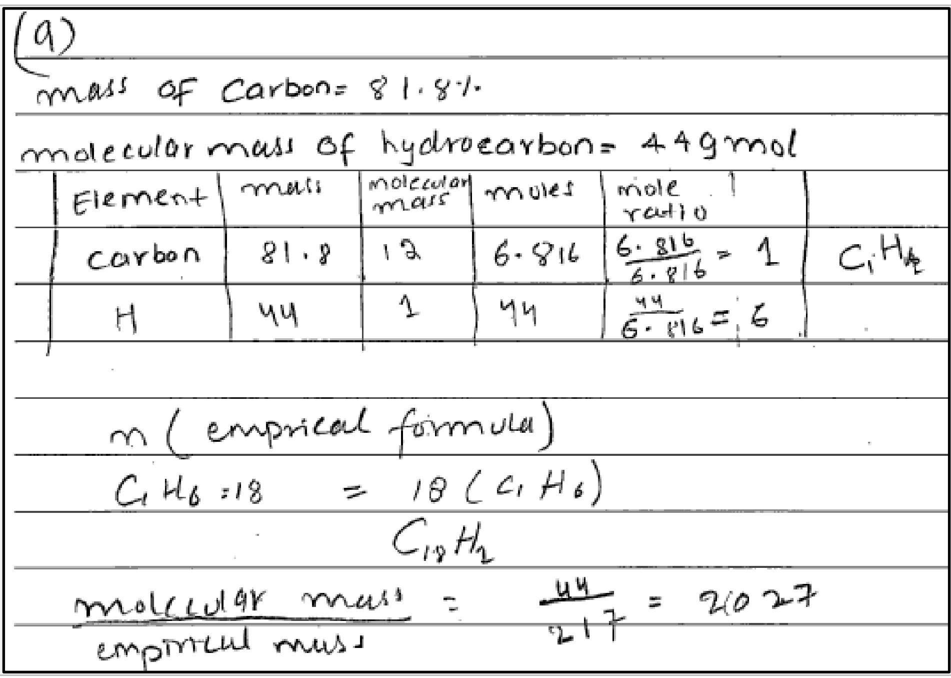
How to Approach SLO	Pedagogy Used for that SLO	Assessment Strategies
• Understand the expectations of the command words • Look at the cognitive level • Identify the content that is required to answer that question (both in terms of understanding of concepts and any skills that may be required like analysing or evaluating) • Go through the past paper questions on that particular concept • Refer to the resource guide for extra resources	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair and Share • Knowledge Platform videos • Questioning Technique (Socratic approach) • Practical Demonstration	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login
Any Additional Suggestion: To improve comprehension, provide more examples and practice problems that involve calculating ΔE using the Enthalpy change method. Break down the steps and emphasise the correct		

formulas and signs to use. Offer guided exercises or tutorials to help students understand the proper application of the Enthalpy change method. Encourage students to review their calculations carefully, paying attention to signs and units, to avoid errors. Additionally, reinforce the connection between Enthalpy, pressure-volume work, and the calculation of ΔE to enhance students' understanding of the topic.

Extended Response Questions (ERQs)

Extended response questions offered a choice between parts ‘a’ and ‘b’

Question No. 7a	
Question Text	The analysis of a hydrocarbon shows that it consists of 81.8% carbon. The relative molecular mass of the hydrocarbon is 44 g mol^{-1}. i. Calculate the empirical formula of the compound. ii. Determine its molecular formula. (**Note**: Molar mass of C = 12 g mol^{-1} and H = 1 g mol^{-1})
SLO No.	1.3.2
SLO Text	Deduce empirical and molecular formula of compounds.
Max Marks	7
Cognitive Level	A
Checking Hints	1 mark for calculating the mass of hydrogen 1 mark for calculating the number of moles of carbon 1 mark for calculating the number of moles of hydrogen 1 mark for finding the simplest ratio 1 mark for determining the empirical formula by multiplying simplest ratio with 3 1 mark for determining the empirical formula mass 1 mark for determining the molecular formula
Overall Performance	The cohort exhibited mixed performance in calculating empirical and molecular formulae. The following attributes can streamline the responses of the candidates. • Emphasise on the importance of stepwise calculations and clear data substitution to accurately determine empirical and molecular formulae. • Practice problems that involve calculating empirical and molecular formulae to reinforce the correct usage of formulas and value substitutions. • Highlight the significance of calculating moles and using them to determine atomic ratios in the empirical formula. • Encourage students to double-check their calculations and ensure proper unit conversions, avoiding common errors like directly using percentages or incorrect formulae. • Reinforce the concept of percent composition and its relation to empirical and molecular formula calculations. • Practice examples of different compounds to calculate empirical and molecular formulae using various methods, promoting critical thinking and problem-solving skills.
Description of Better Responses	Better responses demonstrated accurate and systematic calculations, utilising the correct formulae and value substitutions to determine the number of moles for each element. They presented clear steps for finding the simplest atomic ratios and provided alternative methods, such as using % composition and mass of elements and the simplest atomic ratios for determining the empirical formula in their calculations in part ‘i’. These responses showcased a strong understanding of the concepts and displayed precise and logical reasoning throughout their calculations. In part ‘ii’ candidates worked out the value of ‘n’ using the correct formula and values to find the molecular formula. Furthermore, in a few responses, candidates showed another

	method of calculations, they solved the given numerical by applying % composition and mass of the elements.
Image of Better Response	 a.i Data: C% = 81.8% H% = 100 − C% = 100 − 81.8% = 18.2% Mass of Hydrocarbon = 44 g/mol. Sol: moles of C = 81.8% / 12 = 6.81 moles of H = 18.2% / 1 = 18.2 ⇒ 6.81/6.81 : 18.2/6.81 ⇒ 1 : 2.67 ⇒ 3(1 : 2.67) ⇒ 3 : 8 ⇒ C_3H_8 ii. molecular formula = n (empirical formula) n = mol. mass / empirical formula mass = 44/44 = 1. molecular formula = n (empirical formula) = 1 (C_3H_8) = C_3H_8
Description of Weaker Responses	Weaker responses struggled with sequential data substitution, formula usage, and value substitutions. They directly used percentages instead of calculating moles, leading to errors in determining the empirical formula and the value of 'n'. Consequently, they calculated incorrect molecular formulae. These responses exhibited a lack of understanding of stepwise calculations and the utilisation of appropriate formulae and values. These responses also demonstrated the lack of use of elemental percentages in calculating the mole ratios. In some responses, candidates directly used percentages to find the simplest elemental ratio/ used the wrong method to find the number of moles/ used multiplication or division by 100 in the calculation for the number of moles which led to the incorrect calculation of mass and molecular formula.
Image of Weaker Response	 (a) mass of Carbon = 81.8% molecular mass of hydrocarbon = 44 g mol Element | mass | molecular mass | moles | mole ratio carbon | 81.8 | 12 | 6.816 | 6.816/6.816 = 1 | C_1H_6 H | 44 | 1 | 44 | 44/6.816 = 6 n (emprical formula) C_1H_6 = 18 = 18 (C_1H_6) $C_{18}H_2$ molecular mass / emprical mass = 44/217 = 2027

Suggestions for improvement (Highlight all that apply)

How to Approach SLO	Pedagogy Used for that SLO	Assessment Strategies
• Understand the expectations of the command words • Look at the cognitive level • Identify the content that is required to answer that question (both in terms of understanding of concepts and any skills that may be required like analysing or evaluating) • Go through the past paper questions on that particular concept • Refer to the resource guide for extra resources	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair and Share • Knowledge Platform videos • Questioning Technique (Socratic approach) • Practical Demonstration	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login
Any Additional Suggestion: To enhance understanding, provide more examples and practice problems that involve calculating empirical and molecular formulae, focusing on stepwise calculations and formula usage. Reinforce the concept of percent composition and its relation to mole calculations and atomic ratios. Offer guided exercises or tutorials to help students understand the proper sequence of data substitution and emphasise the importance of unit conversions and accurate formula usage. Encourage critical thinking by presenting different compounds and challenging students to calculate empirical and molecular formulae using various methods.		

Question No. 7b	
Question Text	The given equation shows a reaction that takes place in a basic medium. Balance this equation using the half-reaction method. Equation: $MnO^-_{4(aq)} + NO^-_{2(aq)} \rightarrow MnO_{2(s)} + NO^-_{3(aq)}$ Reduction half-reaction: $MnO^-_{4(aq)} \rightarrow MnO_{2(s)}$ Oxidation half-reaction: $NO^-_{2(aq)} \rightarrow NO^-_{3(aq)}$ (**Note**: Show all the steps of balancing in sequence.)
SLO No.	12.1.6
SLO Text	Balance a chemical equation using half-reaction method.
Max Marks	7
Cognitive Level	A
Checking Hints	1 mark for each step (7 required)
Overall Performance	The overall performance of the cohort remained moderate in balancing the given ionic equation using the half-reaction method. Better responses accurately and systematically balance each equation step by step. However, weaker responses that

	showed a poor understanding of oxidation and reduction concepts can be mitigated by taking the following points into consideration. • Emphasising the steps involved in balancing equations using the half-reaction method. • Practice more examples and problems that involve balancing ionic equations, focusing on stepwise balancing and conservation of mass and charge. • Reinforce the importance of correctly adding species to balance oxygen and hydrogen atoms, as well as electrons, in each half-reaction, based on the medium provided, either acidic or basic. • Emphasis the need to multiply the equations to cancel out the electrons and obtain a balanced overall equation. • Apply critical thinking and step-by-step calculations to avoid the common mistake of directly summing up equations without proper balancing.
Description of Better Responses	Better responses in question 7b accurately balanced the given ionic equation using the half-reaction method. They systematically balanced each equation by adding species to ensure the conservation of mass and charge. In the reduction half-reaction, they correctly added $2H_2O$ to balance oxygen atoms and $4H^+$ to balance hydrogen atoms. The candidates also added $3e^-$ to balance the charges. They were able to obtain a balanced equation by multiplying the given equations and cancelling out the common species, $6e^-$. In the next step, they added $2OH^-$ to neutralise H^+ in the basic solution. They successfully balanced the equation, accounting for the number of water molecules on both sides. The final balanced reaction in the basic medium was obtained.
Image of Better Response	Step 1):- Separation:- • $MnO_4^- \to MnO_2$ • $NO_2^- \to NO_3^-$ Step2:- oxidation state:- $MnO_4^{-1} \to MnO_2$ (Reduction) $NO_2^{-1} \to NO_3^{-1}$ (oxidation) Step3:- Balanced atom which are oxidized or reduced. $MnO_4^{-1} \to MnO_2$ $NO_2^{-1} \to NO_3^{-1}$ (Already balanced). Step4:- Add (OH^-) to balanced oxygen and a water molecule to balance hydrogen:- • $2H_2O + MnO_4 \to MnO_2 + 4OH^-$ • $2OH^- + NO_2 \to NO_3 + H_2O$ Step5:- Balanced charged:- • $(2H_2O + MnO_4 + 3e^- \to MnO_2 + 4OH^-)\ 2$ • $(2OH^- + NO_2 \to NO_3 + H_2O + 2e^-) \times 3$ $= 4H_2O + 2MnO_4 + 6e^- \to 2MnO_2 + 8OH^-$ $6OH^- + 3NO_2 \to 3NO_3 + 3H_2O + 6e^-$ Step6:- Addition:- $4H_2O + 2MnO_4 + 6e^- \to 2MnO_2 + 8OH^-$ $6OH^- + 3NO_2 \to 3NO_3 + 3H_2O + 6e^-$ $H_2O + 2MnO_4 + 3NO_2 \to 2MnO_2 + 3NO_3 + 2OH^-$ Balanced.

Description of Weaker Responses	Weaker responses showed an inadequate understanding of the concepts of oxidation and reduction. In question 7b, candidates remained unsuccessful in balancing the number of electrons in each equation and directly summed up the equations without proper balancing. These responses demonstrated a lack of comprehension of the stepwise balancing process and the conservation of mass and charge in ionic equations.
Image of Weaker Response	b) $MnO_4^- + NO_2^- \rightarrow MnO_2 + NO_3^-$ Step#1: Separate Equation. $MnO_4^- \rightarrow MnO_2$ $NO_2^- \rightarrow NO_3^-$ Step#2: Balance the atom which are being reduced or oxidized. Reduction $MnO_4^- \rightarrow MnO_2$ Oxidation $NO_2^- \rightarrow NO_3^-$ Step#3: Now add double (OH^-) to balanced the oxygen to required quantity. $MnO_4^- \rightarrow MnO_2 + \cancel{6H_2O}\ \cancel{12OH^-}\ 8OH^-$ $NO_2^- \rightarrow NO_3^- + \cancel{6H_2O}\ 12OH^-\ 4OH^-$ Step#4: Now add hydrogen by the addition of H^+ ions. $8H^+ + MnO_4^- \rightarrow MnO_2 + 8OH^-$ $4H^+ + NO_2^- \rightarrow NO_3^- + 4OH^+$ Step#5: Balance the charge. $1\times 8H^+ + MnO_4^- \rightarrow MnO_2 + 8OH^- + 2e^-$ $2\times 4H^+ + NO_2^- \rightarrow NO_3^- + 4OH^- + 4e^-$ $2H^+ + MnO_4^- + NO_2^- \rightarrow MnO_2 + NO_3^- + 2OH^- + 2e^-$

Suggestions for improvement (Highlight all that apply)

How to Approach SLO	Pedagogy Used for that SLO	Assessment Strategies
• Understand the expectations of the command words • Look at the cognitive level • Identify the content that is required to answer that question (both in terms of understanding of concepts and any skills that may be required like analysing or evaluating) • Go through the past paper questions on	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair and Share • Knowledge Platform videos • Questioning Technique (Socratic approach) • Practical Demonstration	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login

that particular concept • Refer to the resource guide for extra resources		

Any Additional Suggestion: Encourage critical thinking by challenging students to explain each step and justify their choices in balancing the equations. Offer guided exercises or tutorials to help students grasp the concept and build confidence in balancing ionic equations in different mediums.

Question No. 8a	
Question Text	Calculate the molarity of 500 cm^3 sulphuric acid solution neutralised by 18 g of 6 dm^3 of sodium hydroxide solution. (**Note**: • $^{23}_{11}Na$, $^{1}_{1}H$, $^{16}_{8}O$ and $^{32}_{16}S$ • Show the complete steps of working.)
SLO No.	8.1.4
SLO Text	Calculate molarity, molality and strength of sample solutions based on acid-base titration.
Max Marks	7
Cognitive Level	A
Checking Hints	**Solution 1** 1 mark for writing a balanced chemical equation 1 mark for converting cm^3 of H_2SO_4 into dm^3 (in data) 1 mark for writing the correct formula of molarity/ substitution of values in the formula 1 mark for calculating the exact molarity of NaOH 1 mark for writing the correct formula $\frac{M_1V_1}{n_1} = \frac{M_2V_2}{n_2}$ 1 mark for showing correct substitution of values/ working w.r.t. acid and base 1 mark for calculating the exact molarity of H_2SO_4 **Solution 2** 1 mark for writing a balanced chemical equation 1 mark for writing the difference in the number of moles of acid versus base in the data 1 mark for showing the correct relationship between the masses of NaOH and H_2SO_4 based on a balanced chemical equation 1 mark for calculating the correct mass of H_2SO_4 1 mark for writing the correct formula of molarity 1 mark for showing correct substitution of values/ working 1 mark for calculating the exact molarity of H_2SO_4
Overall Performance	The cohort displayed overall better performance in solving the problem related to determining molarity and conducting neutralisation reactions. Weaker responses, however, exhibited inaccurate interpretation of the data, leading to incorrect equations and inability to balance them which can be coped up if focused on the following points. • Strengthen the concept of molarity and its calculation, emphasising the relationship between moles, volume, and concentration. • Practice more problems that involve acid-base titration and neutralisation reactions and apply the understanding of balanced chemical equations.

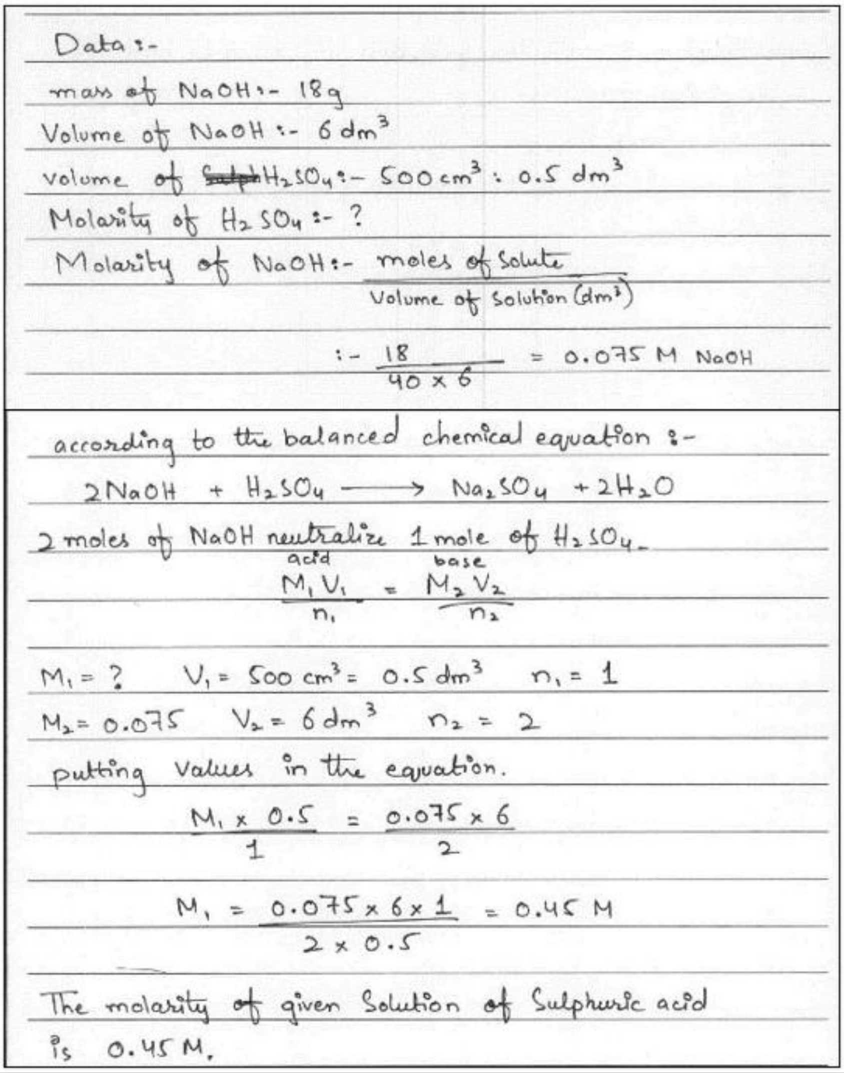
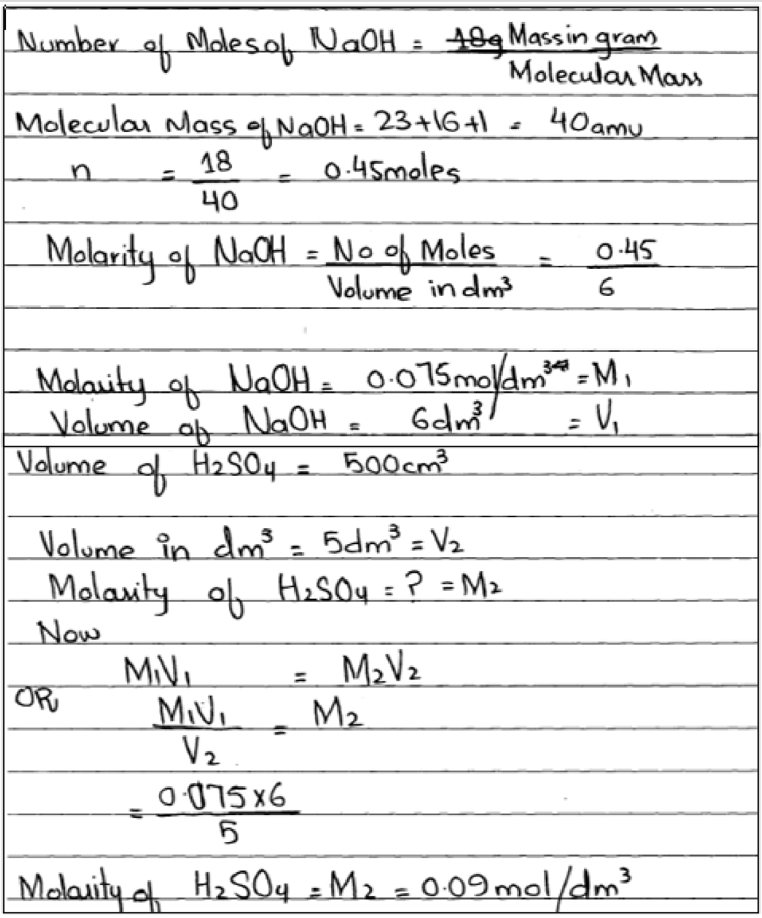
	• Careful interpretation of data and clear identification of reactants in the question to avoid errors in equation writing and balancing. • Emphasise the step-by-step process of neutralisation, including complete neutralisation of all acidic protons. • Application of the correct use of the dilution formula and the distinction between dilution and molarity calculations.
Description of Better Responses	Better responses demonstrated appropriate problem-solving skills by determining the correct number of moles using a balanced chemical equation. In such responses, candidates manipulated the values given in the stimulus well and calculated the exact molarity of the Sulphuric acid solution. These responses were well aligned with the concept of molarity and neutralisation/ acid-base titration followed by balanced chemical equations for the reaction, data, formula, and solution.
Image of Better Response	 Data :- mass of NaOH :- 18g Volume of NaOH :- 6 dm^3 volume of ~~Sulph~~ H_2SO_4 :- 500 cm^3 : 0.5 dm^3 Molarity of H_2SO_4 :- ? Molarity of NaOH :- $\frac{\text{moles of Solute}}{\text{Volume of solution } (dm^3)}$:- $\frac{18}{40 \times 6}$ = 0.075 M NaOH according to the balanced chemical equation :- $2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$ 2 moles of NaOH neutralize 1 mole of H_2SO_4. $\frac{M_1 V_1}{n_1} = \frac{M_2 V_2}{n_2}$ (acid, base) $M_1 = ?$ $V_1 = 500\ cm^3 = 0.5\ dm^3$ $n_1 = 1$ $M_2 = 0.075$ $V_2 = 6\ dm^3$ $n_2 = 2$ putting values in the equation. $\frac{M_1 \times 0.5}{1} = \frac{0.075 \times 6}{2}$ $M_1 = \frac{0.075 \times 6 \times 1}{2 \times 0.5} = 0.45$ M The molarity of given Solution of Sulphuric acid is 0.45 M.
Description of Weaker Responses	Weaker responses mostly showed an inaccurate interpretation of data, and an incorrect equation of neutralisation using different reactants other than those given in the question. Some candidates were unable to balance the chemical equation. Moreover, they were unable to calculate the molarity of the sodium hydroxide solution. A few of these respondents wrote the definition of neutralisation and its formula for molarity. Mostly included incomplete neutralisation of sulphuric acid with sodium hydroxide solution, neutralisation of hydrochloric acid with sodium hydroxide, incorrect identification of the number of moles, and use of dilution formula in place of molarity or vice versa.

Image of Weaker Response	

Number of Moles of NaOH = ~~40g~~ Mass in gram / Molecular Mass

Molecular Mass of NaOH = 23+16+1 = 40amu

$n = \frac{18}{40} = 0.45$ moles

Molarity of NaOH = No of Moles / Volume in dm^3 = $\frac{0.45}{6}$

Molarity of NaOH = 0.075 mol/dm^3 = M_1

Volume of NaOH = 6 dm^3 = V_1

Volume of H_2SO_4 = 500 cm^3

Volume in dm^3 = 5 dm^3 = V_2

Molarity of H_2SO_4 = ? = M_2

Now

$M_1V_1 = M_2V_2$

OR

$\frac{M_1V_1}{V_2} = M_2$

$= \frac{0.075 \times 6}{5}$

Molarity of H_2SO_4 = M_2 = 0.09 mol/dm^3

Suggestions for improvement (Highlight all that apply)

How to Approach SLO	Pedagogy Used for that SLO	Assessment Strategies
• Understand the expectations of the command words • Look at the cognitive level • Identify the content that is required to answer that question (both in terms of understanding of concepts and any skills that may be required like analysing or evaluating) • Go through the past paper questions on that particular concept • Refer to the resource guide for extra resources	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair and Share • Knowledge Platform videos • Questioning Technique (Socratic approach) • Practical Demonstration	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login

Any Additional Suggestion: To enhance understanding, provide more examples and practice problems that involve molarity calculations and neutralisation reactions. Emphasise the importance of accurately interpreting data and identifying the correct reactants in the question. Reinforce the step-by-step process of neutralisation, ensuring complete neutralisation of all acidic protons. Offer guided exercises or tutorials to help students grasp the concepts and apply them effectively. Provide clear explanations and examples differentiating between dilution and molarity calculations. Encourage critical thinking by challenging students to explain their reasoning and justify their choices in solving acid-base titration problems.

Question No. 8b	
Question Text	The boiling point of a solution containing 5 g of an organic solid in 45 g of diethyl ether is 39°C. The molal boiling point constant of diethyl ether is 2.16°C/m and its boiling point in pure state is 34.6°C. The empirical formula of the organic solid is CH_2O. i. For the given organic solid, calculate its I. relative molar mass. II. molecular formula. ii. Why is the boiling point of the solution higher than that of pure diethyl ether? (**Note**: Show the complete steps of working.)
SLO No.	10.5.3
SLO Text	Calculate molar mass of a substance using ebullioscopic and cryoscopic methods.
Max Marks	7
Cognitive Level	A
Checking Hints	i. I. 1 mark for writing data/ substitution of correct values in the formula 1 mark for calculating the elevation of boiling point (ΔT_b) 1 mark for writing the correct formula for calculating molar mass/ substitution of values in the formula 1 mark for calculating the correct molar mass II. 1 mark for calculating the correct empirical formula mass 1 mark for calculating the correct molecular formula ii. 1 mark for writing the correct reason
Overall Performance	An equal number of candidates from the cohort chose part 'b' of question 8 compared to part ‘a’, and they displayed diverse levels of understanding regarding the concept of boiling point elevation and its underlying reasons. On the other hand, shortcomings of weaker responses with reference to conceptual understanding can be minimised by keeping the following points in consideration. • Streamline the concept of boiling point elevation and its relationship to the concentration of solute in a solution. • Practice problems that involve calculating boiling point elevation and understanding the changes in vapour pressure. • Emphasise the importance of using the correct formulas and substituting values accurately in calculations. • Understand the relationship between boiling point to the decrease in vapour pressure caused by the addition of a non-volatile solute. • Highlight the concept of colligative properties and their impact on boiling point elevation, understand that it is not just any substance that alters boiling point, but rather the concentration of non-volatile solute.
Description of Better Responses	Better responses accurately substituted values in the formula to calculate the elevation of boiling point (ΔT_b) and used the correct formula for calculating molar mass. These

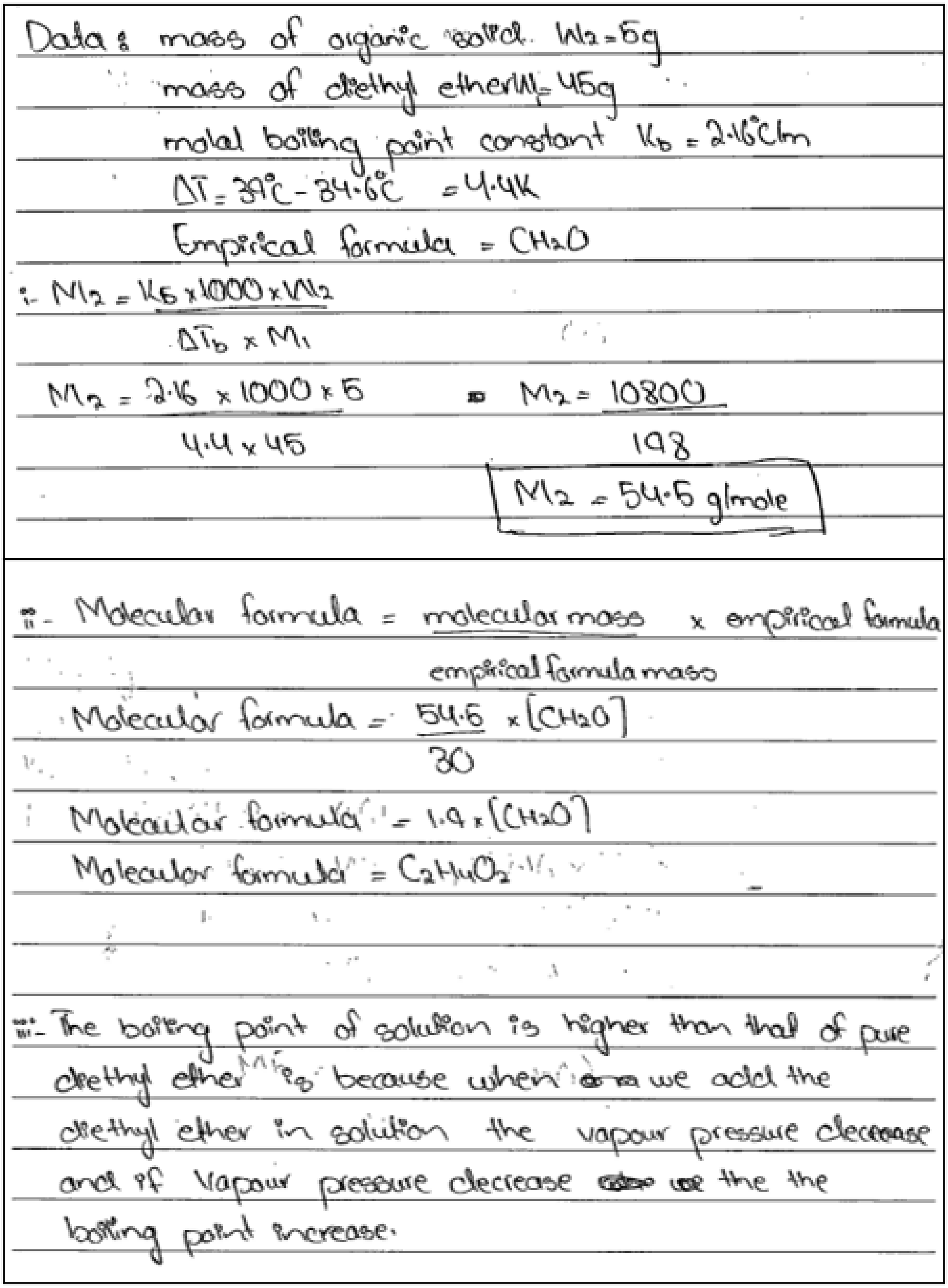
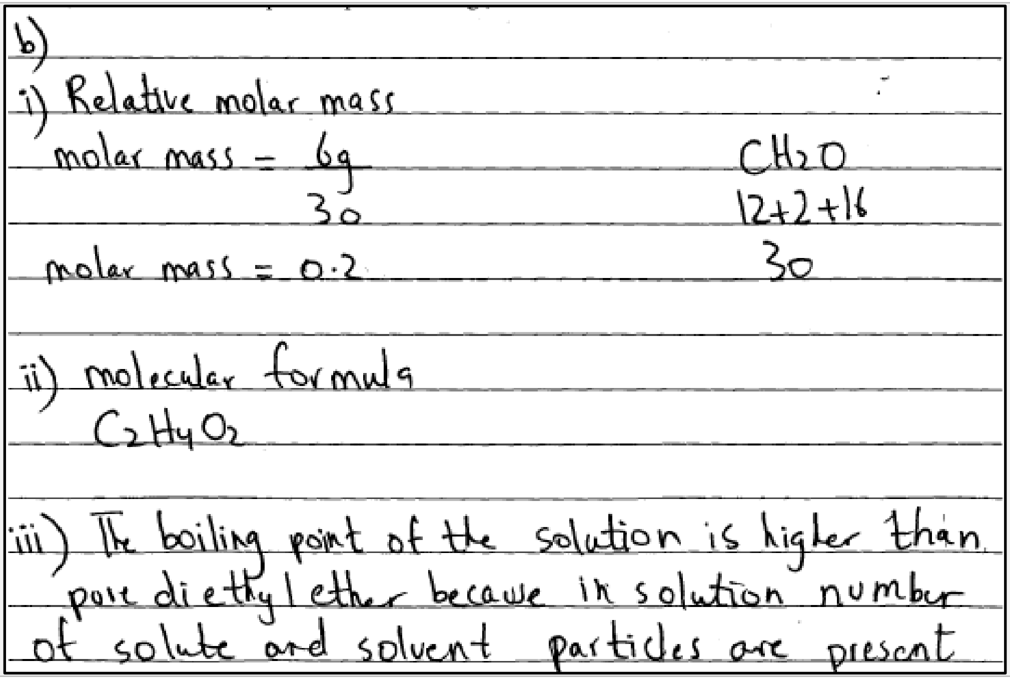
	responses provided clear explanations for why the boiling point of the solution is higher than that of the pure solvent. They correctly identified the decrease in vapour pressure caused by the addition of a non-volatile solute, leading to a higher boiling point. These responses demonstrated a solid understanding of the concept and effectively applied the relevant formulas and principles.
Image of Better Response	 Data: mass of organic solid $W_2 = 5g$; mass of diethyl ether $W_1 = 45g$; molal boiling point constant $K_b = 2.16°C/m$; $\Delta T = 39°C - 34.6°C = 4.4K$; Empirical formula $= CH_2O$. i- $M_2 = \frac{K_b \times 1000 \times W_2}{\Delta T_b \times W_1}$; $M_2 = \frac{2.16 \times 1000 \times 5}{4.4 \times 45}$ ⇒ $M_2 = \frac{10800}{198}$; $M_2 = 54.5$ g/mole. ii- Molecular formula $= \frac{\text{molecular mass}}{\text{empirical formula mass}} \times$ empirical formula; Molecular formula $= \frac{54.5}{30} \times [CH_2O]$; Molecular formula $= 1.9 \times [CH_2O]$; Molecular formula $= C_2H_4O_2$. iii- The boiling point of solution is higher than that of pure diethyl ether is because when we add the diethyl ether in solution the vapour pressure decrease and if vapour pressure decrease the the boiling point increase.
Description of Weaker Responses	Weaker responses demonstrated a lack of comprehension of the underlying concepts and principles. Candidates remained unsuccessful in calculating molecular mass by applying the correct formula. These responses lacked conceptual understanding and provided general explanations without addressing the specific reasons for boiling point elevation. They did not adequately explain the impact of a non-volatile solute on vapour pressure and the subsequent increase in boiling point.

Image of Weaker Response	

Suggestions for improvement (Highlight all that apply)

How to Approach SLO	Pedagogy Used for that SLO	Assessment Strategies
• Understand the expectations of the command words • Look at the cognitive level • Identify the content that is required to answer that question (both in terms of understanding of concepts and any skills that may be required like analysing or evaluating) • Go through the past paper questions on that particular concept • Refer to the resource guide for extra resources	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair and Share • Knowledge Platform videos • Questioning Technique (Socratic approach) • Practical Demonstration	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login

Any Additional Suggestion: To enhance understanding, provide more examples and practice problems that involve calculating boiling point elevation and understanding the changes in vapour pressure. Emphasise the importance of using the correct formulas and values in calculations and reinforce the connection between non-volatile solutes and vapour pressure reduction. Encourage students to provide clear and specific explanations for the increase in boiling point, linking it to the concentration of the solute. Offer guided exercises or tutorials to help students grasp the concept of colligative properties and their impact on boiling point elevation.

Annexure A: Pedagogies Used for Teaching the SLOs

Pedagogy: Storyboard
Description: A visual pedagogy that uses a series of illustrated panels to present a narrative, encouraging creativity and critical thinking. It helps learners organise ideas, sequence events, and comprehend complex concepts through storytelling.
Example: In a Literature class, students are tasked with creating storyboards to visually retell a novel. They draw key scenes, write captions, and present their stories to the class, enhancing their reading comprehension and fostering their imagination.

Pedagogy: Cause and Effect
Description: This pedagogy explores the relationships between actions and consequences. By analysing cause-and-effect relationships, learners develop a deeper understanding of how events are interconnected and how one action can lead to various outcomes.
Example: In a History class, students study the causes and effects of the Industrial Revolution. They research and discuss how technological advancements in manufacturing led to significant societal changes, such as urbanisation and labour reform movements.

Pedagogy: Fish and Bone
Description: A method that breaks down complex topics into main ideas (the fish) and supporting details (the bones). This visual approach enhances comprehension by highlighting essential concepts and their relevant explanations.
Example: During a Biology class on human anatomy, the teacher uses the fish and bone technique to teach about the human skeletal system. Teacher presents the main components of the human skeleton (fish) and elaborates on each bone's structure and function (bones).

Pedagogy: Concept Mapping
Description: An effective way to visually represent relationships between ideas. Learners create diagrams connecting key concepts, aiding in understanding the overall structure of a subject and fostering retention.
Example: In a Psychology assignment, students use concept mapping to explore the various theories of personality. They interlink different theories, such as Freud's psychoanalysis, Jung's analytical psychology, and Bandura's social-cognitive theory, to see how they relate to each other.

Pedagogy: Audio Visual Resources
Description: Incorporating multimedia elements like videos, images, and audio into lessons. This approach caters to different learning styles, making educational content more engaging and memorable.
Example: In a General Science class, the teacher uses a documentary-style video to teach about the solar system. The video includes stunning visual animations of the planets, interviews with astronomers, and background music, enhancing students' interest and understanding of space.

Pedagogy: Think, Pair, and Share
Description: A collaborative learning technique where students ponder a question or problem individually, then discuss their thoughts in pairs or small groups before sharing with the entire class. It fosters active participation, communication skills, and diverse perspectives.
Example: In a Literature in English class, the teacher poses a thought-provoking question about a novel's moral dilemma. Students first reflect individually, then pair up to exchange their opinions, and finally participate in a lively class discussion to explore different viewpoints.

Pedagogy: Questioning Technique (Socratic Approach)

Description: Based on Socratic dialogue, this method stimulates critical thinking by posing thought-provoking questions. It encourages learners to explore ideas, justify their reasoning, and discover knowledge through a process of inquiry.
Example: In an Ethics class, the instructor uses the Socratic approach to lead a discussion on the meaning of justice. By asking a series of probing questions, the students engage in a deeper exploration of ethical principles and societal values.

Pedagogy: Practical Demonstration
Description: A hands-on approach where learners observe real-life applications of theories or skills. Practical demonstrations enhance comprehension, skill acquisition, and problem-solving abilities by bridging theoretical concepts with real-world scenarios.
Example: In a Food and Nutrition class, the instructor demonstrates the proper technique for filleting a fish. Students observe and then practice the skill themselves, learning the practical application of knife skills and culinary precision.

(**Note:** The examples provided in this annexure serve as illustrations of various pedagogies. It is important to understand that these pedagogies are versatile and can be applied across subjects in numerous ways. Feel free to adapt and explore these techniques creatively to enhance learning outcomes in your specific context.)

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Additionally, we express our gratitude to the esteemed team of reviewers for their constructive feedback on overall performance, better and weaker responses, and validating teaching pedagogies along with suggestions for improvement.

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