آغا خان یونیورسٹی ایگزامینیشن بورڈ

AGA KHAN UNIVERSITY EXAMINATION BOARD

Notes from E-Marking Centre on HSSC-I Chemistry Annual Examinations 2025

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 2025 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 fulfil 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. It is imperative to refer to command word guide available on AKU-EB website for understanding the expectations of the command word.

General Observations

Overall, candidate performance across Questions 1 to 8 showed a clear divide between well-prepared candidates and those with limited or fragmented understanding of key chemistry concepts. Responses demonstrating sound conceptual clarity used correct terminology, logical structuring, and accurate application of theory, often supported by diagrams or balanced equations. In contrast, many candidates relied on rote memorisation, struggled with distinguishing related concepts (e.g., K_P vs. K_C, polarity vs. bond type), and showed weaknesses in calculation-based and real-life application questions. Some parts were left blank, highlighting gaps in conceptual understanding and the need for more targeted instruction and practice. However, certain areas need improvement to ensure a more comprehensive understanding and better performance next year:

- Reinforce the distinctions between similar terms or processes such as electrolytic vs. voltaic cells, K_P vs. K_C, and equilibrium vs. rate of reaction, using comparative charts and class discussions.
- Encourage candidates to explain the “why” behind each answer, particularly when writing chemical equations, interpreting graphs, or discussing experimental setups like the discharge tube.
- Link concepts such as acid-base reactions, colligative properties, and thermochemistry to familiar, real-world scenarios (e.g., gastric relief, antifreeze, airbag deployment) to build relevance and retention.
- Provide structured practice in mole concept, stoichiometry, electrolysis, and thermodynamic cycles with emphasis on unit consistency, stepwise solutions, and use of scientific constants.
- Explain students how to construct and label scientific diagrams accurately (e.g., molecular shapes, energy profiles, Born–Haber cycles), emphasising what each part represents and how it supports the response.
- Identify and address common misconceptions early through quizzes, exit slips, or topic-based assessments before introducing higher-order applications.
- Guide candidates to structure long responses using scientific language, relevant data or equations, and logical flow to ensure clarity and completeness.

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 construction and working of a discharge tube with reference to the production of cathode rays.
SLO No.	2.1.1
SLO Text	Explain the construction and working of discharge tube with reference to the discovery of electron and proton;
Max Marks	4
Cognitive Level	U*
Checking Hints	1 mark for writing each point of construction (any 2 required) 1 mark for writing each point of working (any 2 required)
Overall Performance	Overall, candidates’ performance on this question was generally strong, with many demonstrating a sound understanding of the discharge tube experiment by accurately describing its construction and explaining the principles behind cathode ray production. A substantial proportion achieved near full or full marks. However, a small group showed fundamental misconceptions, confusing the setup with unrelated experiments such as Rutherford’s gold foil experiment or electrolytic cells. This suggests that while most candidates had a firm grasp of the concept, some struggled to differentiate between core experimental setups in atomic physics.
Description of Better Responses	*Better responses* demonstrated a clear and comprehensive understanding of the construction and functioning of a discharge tube in the context of cathode ray production. Candidates accurately identified and described key components of the discharge tube—such as the sealed glass tube, cathode (negative electrode), anode (positive electrode), and the high-voltage power supply—often supplemented with well-labeled diagrams to visually support their explanations. They correctly stated that the tube contains a low-pressure gas (around

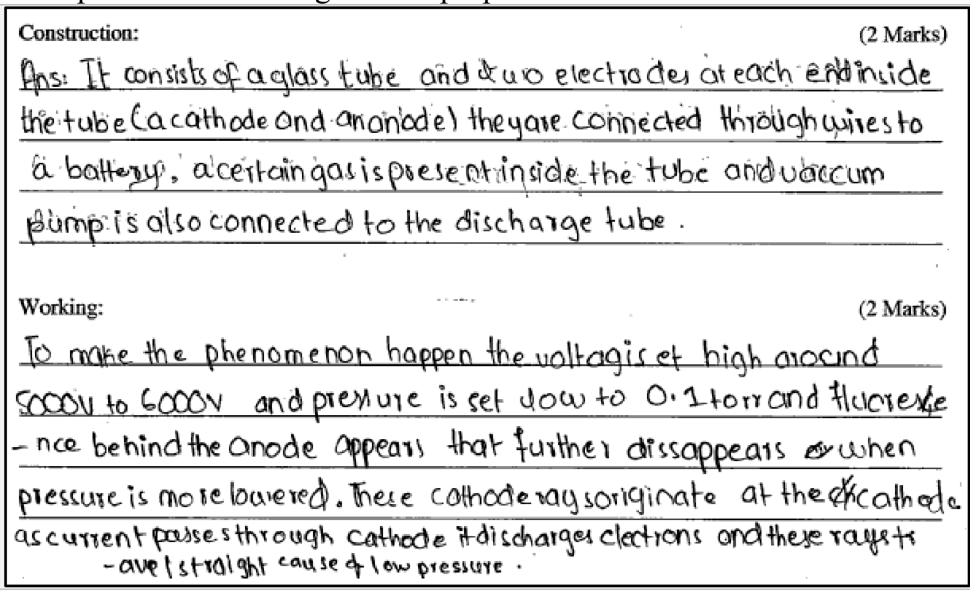
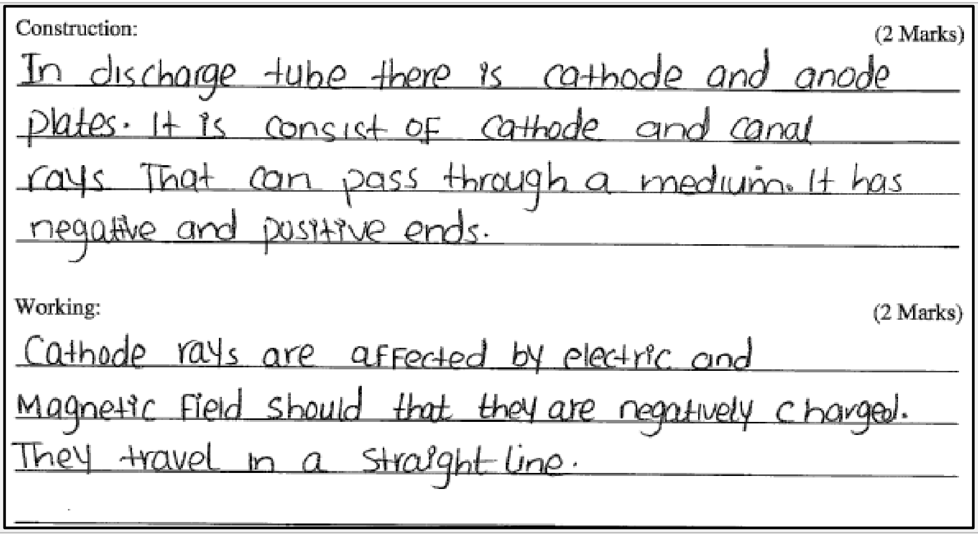
	0.01 mm of mercury), emphasising that low pressure is essential to reduce collisions between gas particles and electrons, thereby allowing cathode rays to travel in straight lines. Candidates effectively explained that when a high voltage (usually in the range of 5,000 to 10,000 volts) is applied across the electrodes, electrons are emitted from the cathode and accelerate toward the anode, forming cathode rays. These rays, composed of fast-moving electrons, were described as producing a visible glow when they strike the glass wall opposite the cathode. Some responses further highlighted the sequential changes in the discharge tube—such as the appearance of the positive column and dark spaces—as pressure changes, showing deeper insight into the behaviour of gases under electric discharge. The movement of cathode rays from cathode to anode, and their deflection by electric and magnetic fields, was also referenced by some candidates, reflecting thorough conceptual understanding of their properties and behaviour.
Image of Better Response	 Construction: (2 Marks) Ans: It consists of a glass tube and two electrodes at each end inside the tube (a cathode and an anode) they are connected through wires to a battery, a certain gas is present inside the tube and vaccum pump is also connected to the discharge tube. Working: (2 Marks) To make the phenomenon happen the voltage is set high around 5000V to 6000V and pressure is set low to 0.1 torr and fluoresce-nce behind the anode appears that further dissappears when pressure is more lowered. These cathode rays originate at the cathode as current passes through cathode it discharges electrons and these rays tr-avel straight cause of low pressure.
Description of Weaker Responses	*Weaker responses* revealed a lack of conceptual clarity regarding the construction and functioning of a discharge tube. Candidates confused the apparatus with unrelated experiments, such as Rutherford's alpha-particle scattering or electrolysis, indicating a fundamental misunderstanding of the context. Instead of explaining how cathode rays are produced, several responses merely listed their general properties—such as their deflection in electric or magnetic fields—without linking these to the production process inside the tube. A recurring issue was the failure to mention essential components and conditions for cathode ray formation, such as the presence of a high-voltage power source or the need for a low-pressure (evacuated) gas environment. In some cases, candidates incorrectly described the behaviour of positive ions or assumed the anode emitted the rays. These misconceptions highlighted a fragmented understanding of the physical setup and the principles underlying cathode ray production.

Image of Weaker Response



Construction: (2 Marks)

In discharge tube there is cathode and anode plates. It is consist of cathode and canal rays That can pass through a medium. It has negative and positive ends.

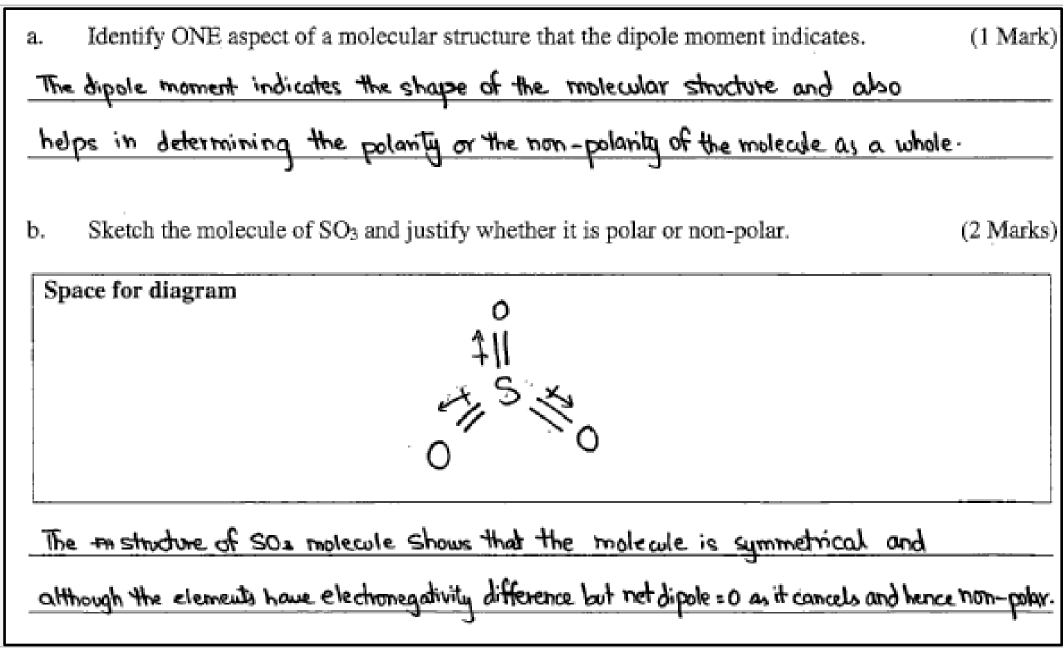
Working: (2 Marks)

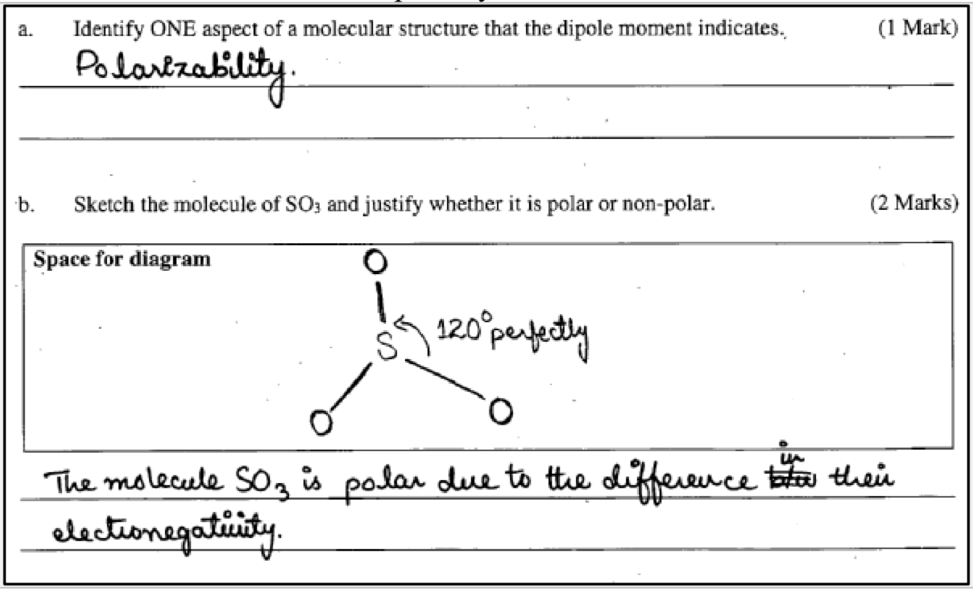
Cathode rays are affected by electric and Magnetic Field should that they are negatively charged. They travel in a straight line.

Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	Preferred Pedagogy** Used for this SLO	Assessment Strategies
• Identify the expectation of command words (use Command Word Guide) • Ensure the content is taught at the relevant cognitive level • Identify necessary content required (skills + concepts) • Review past paper questions on the concept • Utilise the resource guide for additional materials	• 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 ** For description of each Pedagogy, refer to Annexure A	• 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 strengthen candidates' understanding of cathode ray tube experiments and minimise confusion with other setups, teachers can use Javalab's Cathode Ray Tube simulation (https://javalab.org/en/crt_en/) which allows the application of electric and magnetic fields to observe beam deflection and visualise electron motion from cathode to anode. Animated explanations such as the YouTube video on the cathode ray tube experiment and charge to mass ratio of an electron (https://www.youtube.com/watch?v=i6zyPOSreCg) can further reinforce experimental principles and related calculations. Finally, reinforcing learning through annotated diagram practice and comparison tables—contrasting the discharge tube with experiments like the gold foil setup—can consolidate apparatus recognition, conceptual understanding, and the ability to differentiate between experimental purposes and outcomes.		

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

Question No. 2	
Question Text	a. Identify ONE aspect of a molecular structure that the dipole moment indicates. b. Sketch the molecule of SO_3 and justify whether it is polar or non-polar.
SLO No.	3.1.7
SLO Text	Exemplify dipole moment;
Max Marks	3
Cognitive Level	U
Checking Hints	a. 1 mark for identifying the information provided by dipole moment b. 1 mark for the sketch of SO_3 1 mark for the correct reason
Overall Performance	Candidate responses to this question showed mixed levels of understanding. While some demonstrated a strong grasp of dipole moments—accurately identifying their role in determining molecular polarity and correctly justifying the non-polar nature of SO_3 based on its symmetrical geometry—others struggled with fundamental concepts. A few candidates confused dipole moment with bond type or failed to consider the impact of molecular shape on overall polarity. Many focused only on bond polarity or lone pairs without applying VSEPR theory effectively. These patterns highlight the need to strengthen conceptual links between electron distribution, molecular geometry, and polarity.
Description of Better Responses	*Better responses* demonstrated a sound understanding of molecular polarity and dipole moments. In part (a), they correctly identified that the dipole moment reflects the overall molecular polarity—indicating whether a molecule has a net separation of charge due to differences in electronegativity and asymmetric geometry. These candidates recognised that the dipole moment is a vector quantity and can be used to assess the distribution of charge within a molecule. In part (b), *better responses* accurately sketched the trigonal planar structure of SO_3, showing the sulphur atom at the centre bonded to three oxygen atoms at 120° angles. They clearly justified that SO_3 is a non-polar molecule, despite the individual S=O bonds being polar, because the symmetrical arrangement of the molecule results in cancellation of dipole moments. This explanation reflected integration of VSEPR theory with polarity concepts and was often supported by clear vector diagrams showing dipole cancellation.
Images of Better Responses	 a. Identify ONE aspect of a molecular structure that the dipole moment indicates. (1 Mark) The dipole moment indicates the shape of the molecular structure and also helps in determining the polarity or the non-polarity of the molecule as a whole. b. Sketch the molecule of SO_3 and justify whether it is polar or non-polar. (2 Marks) Space for diagram The structure of SO_3 molecule shows that the molecule is symmetrical and although the elements have electronegativity difference but net dipole = 0 as it cancels and hence non-polar.
Description of Weaker Responses	*Weaker responses* revealed conceptual confusion regarding the significance of dipole moments. In part (a), candidates often equated the dipole moment to the presence of lone pairs or focused solely on individual bond polarities without recognising the importance of molecular geometry in determining overall polarity. Some misidentified the dipole moment

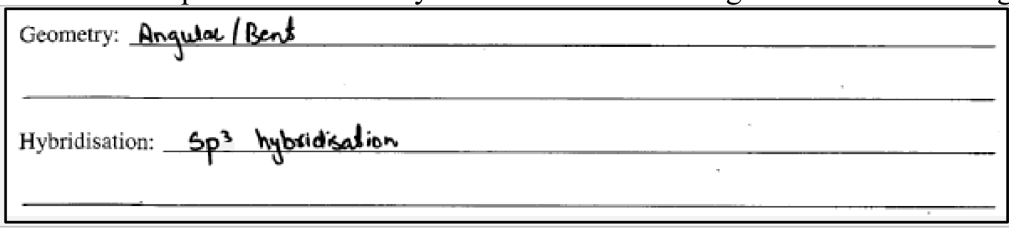
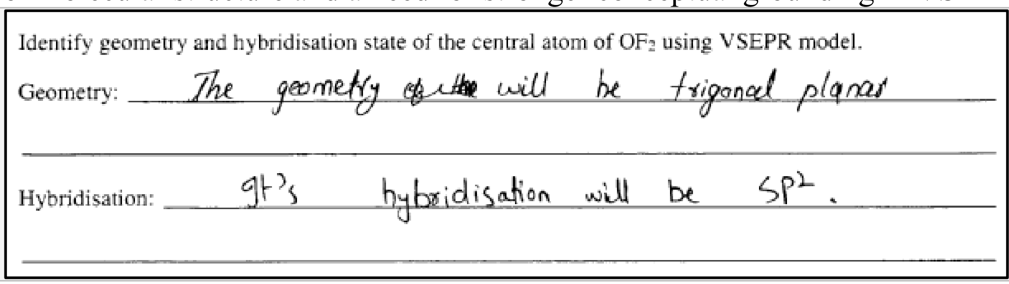
	as relating to bond type (e.g., sigma or pi bonds) rather than molecular polarity. In part (b), several candidates either failed to sketch the correct shape of SO_3 or incorrectly labelled it as a polar molecule due to the presence of polar bonds. These responses did not consider that SO_3's symmetrical geometry leads to net dipole cancellation, making the molecule non-polar. Others mistakenly included lone pairs on sulphur or used a bent structure, which led to incorrect conclusions about polarity.
Images of Weaker Responses	 a. Identify ONE aspect of a molecular structure that the dipole moment indicates. (1 Mark) Polarizability. b. Sketch the molecule of SO_3 and justify whether it is polar or non-polar. (2 Marks) Space for diagram O S O O 120° perfectly The molecule SO_3 is polar due to the difference ~~two~~ in their electronegativity.

Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	Preferred Pedagogy Used for this SLO	Assessment Strategies
• Identify the expectation of command words (use Command Word Guide) • Ensure the content is taught at the relevant cognitive level • Identify necessary content required (skills + concepts) • Review past paper questions on the concept • Utilise the resource guide for additional materials	• 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 address gaps in understanding molecular polarity and dipole moments, teachers can employ strategies that strengthen both conceptual clarity and application. Using 3D molecular models or digital simulations enables candidates to visualise molecular geometries and observe how individual bond dipoles either cancel or reinforce one another, directly linking molecular shape to net polarity. Drawing practice with dipole vectors on various molecular structures further reinforces the relationship between bond polarity, vector direction, and overall molecular polarity. Additionally, teaching VSEPR theory and molecular polarity in an integrated manner helps candidates understand how geometry influences polarity not just as a theoretical concept but as a practical tool for prediction and analysis. These strategies aim to deepen conceptual learning, reduce confusion between related terms, and improve candidates' ability to accurately apply polarity concepts across a variety of molecular structures.

Question No. 3	
Question Text	Identify geometry and hybridisation state of the central atom of OF2 using VSEPR model.
SLO No.	3.3.4
SLO Text	Describe the shapes of simple molecules using orbital hybridisation (sp, sp^2, sp^3);
Max Marks	2
Cognitive Level	U
Checking Hints	1 mark for identifying/ drawing the correct geometry 1 mark for identifying the hybridisation as sp^3
Overall Performance	Candidate performance on this question was clearly divided. Better responses demonstrated a solid understanding of the VSEPR theory, correctly identifying the molecular geometry of OF_2 as bent (angular) and the hybridisation of the central oxygen atom as sp^3. These candidates considered both bonding and lone pairs in their reasoning. In contrast, weaker responses often misapplied key concepts—failing to account for lone pairs, misidentifying the geometry as linear or trigonal planar, or incorrectly assigning hybridisation. This suggests a need to reinforce the relationship between electron domains, hybrid orbitals, and molecular shape.
Description of Better Responses	*Better responses* reflected a solid understanding of molecular geometry and hybridisation principles as per the VSEPR (Valence Shell Electron Pair Repulsion) model. Candidates accurately identified that the central atom in OF_2—oxygen—has two bonding pairs and two lone pairs of electrons, resulting in a bent/ angular geometry due to the repulsion among electron domains. They correctly assigned sp^3 hybridisation to oxygen, recognising that four regions of electron density (two bond pairs and two lone pairs) require four hybrid orbitals. Some candidates effectively compared OF_2 with H_2O to reinforce their reasoning, noting that both molecules adopt similar shapes due to identical electron domain arrangements. These responses demonstrated a strong grasp of how lone pair repulsion influences molecular shape and successfully linked electronic configuration to observed geometry.
Images of Better Responses	 Geometry: Angular / Bent Hybridisation: Sp³ hybridisation
Description of Weaker Responses	*Weaker responses* revealed several misconceptions in applying the VSEPR model to OF_2. Many candidates incorrectly identified the molecular geometry as linear or trigonal planar, failing to account for the two lone pairs on the central oxygen atom. This indicated a lack of understanding of how lone pairs influence molecular shape. Some also misassigned the hybridisation of oxygen, stating it as sp or sp^2 rather than the correct sp^3, suggesting confusion between the number of electron domains and hybrid orbital types. Additionally, a few responses focused solely on bond angles or polarity without clearly linking them to electron pair repulsion or overall geometry. These errors reflected surface-level knowledge of molecular structure and a need for stronger conceptual grounding in VSEPR theory.
Images of Weaker Responses	 Identify geometry and hybridisation state of the central atom of OF_2 using VSEPR model. Geometry: The geometry will be trigonal planar Hybridisation: It's hybridisation will be SP².

Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	Preferred Pedagogy Used for this SLO	Assessment Strategies
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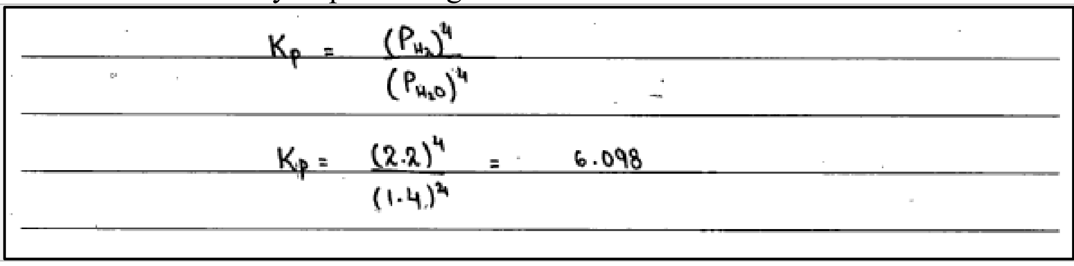
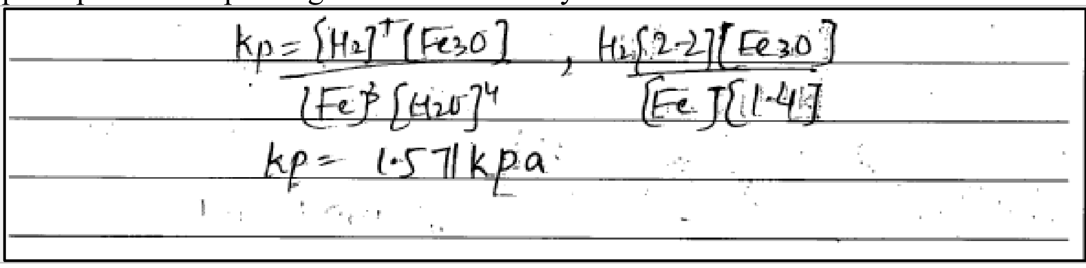
Any Additional Suggestion:
To improve candidates' understanding of molecular geometry and hybridisation using the VSEPR model—particularly for molecules like OF_2—targeted instructional strategies should emphasise visualisation, stepwise reasoning, and comparative analysis. Using 3D molecular models, whether physical (ball-and-stick) or digital, allows candidates to observe how bonding and lone pairs influence geometry, such as the bent shape in OF_2 due to lone pair repulsion. A step-by-step scaffolding approach can further enhance clarity, guiding candidates to count electron domains, determine electron geometry, and then refine the molecular shape based on lone pair presence. Comparative analysis of similar molecules—such as H_2O vs. OF_2 or CO_2 vs. SO_2—can help candidates recognise how lone pairs alter geometry and hybridisation patterns. Additionally, interactive simulations on platforms like PhET or MolView allow for hands-on molecule manipulation, offering immediate visual feedback and reinforcing abstract concepts through active engagement. Collectively, these strategies support deeper understanding, reduce common misconceptions, and strengthen candidates' ability to apply VSEPR theory and hybridisation concepts accurately.

Question No. 4a	
Question Text	A mixture of iron and steam is allowed to come to equilibrium at 600°C. The equation for the chemical reaction is: $3Fe_{(s)} + 4H_2O_{(g)} \leftrightharpoons 4H_{2(g)} + Fe_3O_{4(s)}$ If the equilibrium pressures of hydrogen and steam are 2.2 kPa and 1.4 kPa respectively, then write the equilibrium constant expression (K_p) and determine its value for the given reaction.
SLO No.	7.1.4
SLO Text	Determine the equilibrium constant expression in terms of concentration, partial pressure, number of moles and mole fraction;
Max Marks	2
Cognitive Level	A
Checking Hints	1 mark for the equilibrium constant expression 1 mark for the value of equilibrium constant expression
Overall Performance	Most candidates were unable to demonstrate even a basic understanding of equilibrium concepts, showing significant difficulty in applying them to partial pressure expressions. While a small number correctly identified the form of the K_p expression and excluded solids, a large proportion failed to distinguish between K_p and K_c, often defaulting to concentration-based formats. Others incorrectly included solid phases in the equilibrium expression or omitted proper stoichiometric exponents, leading to inaccurate representations. These

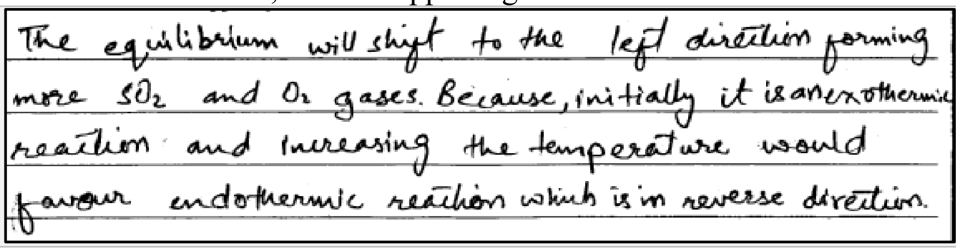
	trends indicate a need for more focused instruction on gas-phase equilibria and the correct formulation of equilibrium constants under different conditions.
Description of Better Responses	*Better responses* demonstrated a sound understanding of writing and calculating equilibrium expressions for reactions involving gases. In part (a), these candidates correctly recognised that solids like iron are not included in the K_p expression, focusing only on the gaseous components—steam (H_2O) and hydrogen (H_2). They wrote the equilibrium expression accurately, such as: $K_p = \frac{pH_2{}^4}{pH_2O^4}$ This reflects the balanced equation: $3Fe_{(s)} + 4H_2O_{(g)} \leftrightharpoons 4H_{2(g)} + Fe_3O_{4(s)}$ In part (b), better responses used the given equilibrium pressures of hydrogen (2.2 kPa) and steam (1.4 kPa) and correctly substituted them into the K_p expression: $K_p = \left(\frac{2.2}{1.4}\right)^4 = 6.09$ These candidates ensured that stoichiometric coefficients matched the balanced equation and maintained clarity in presenting their calculations.
Images of Better Responses	 $K_p = \frac{(P_{H_2})^4}{(P_{H_2O})^4}$ $K_p = \frac{(2.2)^4}{(1.4)^4} = 6.098$
Description of Weaker Responses	*Weaker responses* revealed several conceptual and procedural misunderstandings regarding equilibrium in gaseous systems. A common error was the incorrect formulation of the K_p expression—many candidates mistakenly treated it like K_c, using concentrations (mol/dm³) instead of partial pressures, or mixed both units, leading to dimensional inconsistency. Another frequent issue was the inclusion of solids (such as Fe and Fe_3O_4) in the equilibrium expression, which indicates a gap in understanding that pure solids and liquids do not appear in equilibrium constant calculations. Some candidates misapplied stoichiometric coefficients as exponents or failed to use them altogether, leading to incorrect mathematical expressions. Additionally, when referencing the relationship between K_p and K_c using $K_p = K_c(RT)^{\wedge\Delta n}$, weaker responses often confused or incorrectly calculated Δn, either treating it as total moles or using product minus product instead of product minus reactant gases. These errors suggest a need for stronger emphasis on distinguishing gas-phase equilibrium principles and improving calculation fluency.
Images of Weaker Responses	 kp = {H2]⁴[Fe3O] / [Fe]³{H2O]⁴ , H2{2.2][Fe3O] / [Fe][1.4] kp = 1.571 kpa

Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	Preferred Pedagogy Used for this SLO	Assessment Strategies

• Identify the expectation of command words (use Command Word Guide) • Ensure the content is taught at the relevant cognitive level • Identify necessary content required (skills + concepts) • Review past paper questions on the concept • Utilise the resource guide for additional materials	• 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 strengthen candidates' conceptual and procedural understanding of equilibrium expressions involving partial pressures, teachers can implement strategies that promote clarity and practical application. Developing comparative tables that place K_p and K_c side by side for the same reaction helps highlight the distinction between using partial pressures and concentrations, making the structural differences in the expressions more evident. Incorporating colour-coded equations or visual cues to emphasise which phases are included—such as gases only for K_p—can further reduce confusion and reinforce correct formulation. Additionally, introducing real-world industrial applications, such as the Haber or contact processes, contextualises K_p expressions and demonstrates their relevance beyond the classroom. Together, these strategies aim to deepen conceptual understanding, minimise procedural errors, and support accurate application of equilibrium principles in both academic and practical settings.

Question No. 4b	
Question Text	Given below is a reversible reaction at equilibrium. $2SO_{2(g)} + O_{2(g)} \leftrightharpoons 2SO_{3(g)} \qquad \Delta H = -194 \text{ kJ mol}^{-1}$ In which direction will the equilibrium shift when the temperature is increased? Provide a suitable reason to support your answer.
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	2
Cognitive Level	A
Checking Hints	1 mark for predicting the correct effect/ shift 1 mark for the correct reason
Overall Performance	Candidate performance on this question reflected a generally good grasp of Le Chatelier's principle, with many recognising that temperature changes influence the position of equilibrium. Some responses accurately linked the direction of the shift to the exothermic nature of the reaction, as indicated by the negative ΔH value. However, a considerable number of candidates confused the concept of equilibrium shift with reaction rate, citing collision frequency or activation energy without addressing the impact on equilibrium composition. These patterns highlight the need to reinforce the distinction between kinetic and thermodynamic effects in chemical systems.
Description of Better Responses	*Better responses* demonstrated a strong understanding of Le Chatelier's Principle and thermodynamic reasoning. These candidates correctly identified the forward reaction as exothermic based on the negative ΔH value (–194 kJ mol^{-1}) and explained that increasing temperature favours the endothermic reverse reaction. They recognised that adding heat shifts the equilibrium to the left, reducing SO_3 formation. Many responses effectively distinguished between changes in the equilibrium position and reaction rate, noting that although temperature influences both, only the equilibrium position shifts directionally in response to changes in heat. Additionally, well-prepared candidates linked their reasoning to the equilibrium constant (K_c), explaining that an increase in temperature decreases K_c for exothermic reactions, further supporting the backward shift.
Images of Better Responses	 The equilibrium will shift to the left direction forming more SO_2 and O_2 gases. Because, initially it is an exothermic reaction and increasing the temperature would favour endothermic reaction which is in reverse direction.
Description of Weaker Responses	*Weaker responses* revealed several prevalent misconceptions regarding the effect of temperature on equilibrium. Many candidates equated an increase in temperature with a faster forward reaction, regardless of whether the reaction was exothermic or endothermic, thereby overlooking the thermodynamic implications of the enthalpy change (ΔH). A common issue was the failure to distinguish between kinetics (rate of reaction) and thermodynamics (position of equilibrium), leading to confused or contradictory explanations. Several responses omitted the sign of ΔH altogether or failed to recognise that a negative ΔH indicates an exothermic reaction, where heat acts as a product. As a result, candidates often made incorrect predictions about the direction of equilibrium shift, mistakenly assuming that increased temperature always favours the forward reaction. These misconceptions highlight the need to reinforce the conceptual difference between how temperature influence's reaction rate versus equilibrium position.

Images of Weaker Responses	If the temperature increases, that means the reaction is endothermic. so the equilibrium will shift toward the forward direction.

Suggestions for improvement (Highlight all that apply)

<table>
<tr><th>Maximising SLO Achievement</th><th>Preferred Pedagogy Used for this SLO</th><th>Assessment Strategies</th></tr>
<tr><td>

- Identify the expectation of command words (use Command Word Guide)
- Ensure the content is taught at the relevant cognitive level
- Identify necessary content required (skills + concepts)
- Review past paper questions on the concept
- Utilise the resource guide for additional materials

</td><td>

- 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

</td><td>

- Past paper questions
- Discussion on E-Marking Notes
- AKU-EB Digital Learning Solution powered by Knowledge Platform

https://akueb.knowledgeplatform.com/login

</td></tr>
<tr><td colspan="3">Any Additional Suggestion: To strengthen candidates' understanding of how temperature affects equilibrium—particularly in distinguishing the behaviour of exothermic and endothermic reactions—teachers can adopt a range of targeted strategies. Energy profile diagrams serve as powerful visual tools to contrast these reaction types, linking ΔH values to heat flow and energy changes. Familiar industrial examples from the textbook, such as the Haber and Contact processes, help illustrate how temperature affects equilibrium and product yield, making the concept easier to understand. Predict-observe-explain activities, where candidates engage with temperature-dependent equilibrium experiments, foster deeper understanding by encouraging them to anticipate changes, observe outcomes, and apply Le Chatelier's Principle to explain the results. Finally, structured discussions around common misconceptions—such as the confusion between reaction rate and equilibrium position—can help clarify key concepts and reinforce accurate thermodynamic reasoning. Together, these strategies promote a clearer conceptual framework and more precise application of equilibrium principles.</td></tr>
</table>

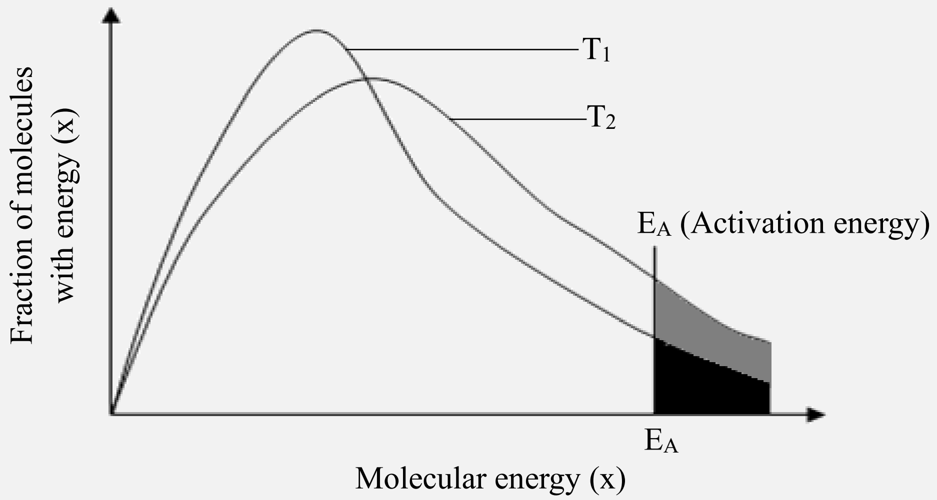
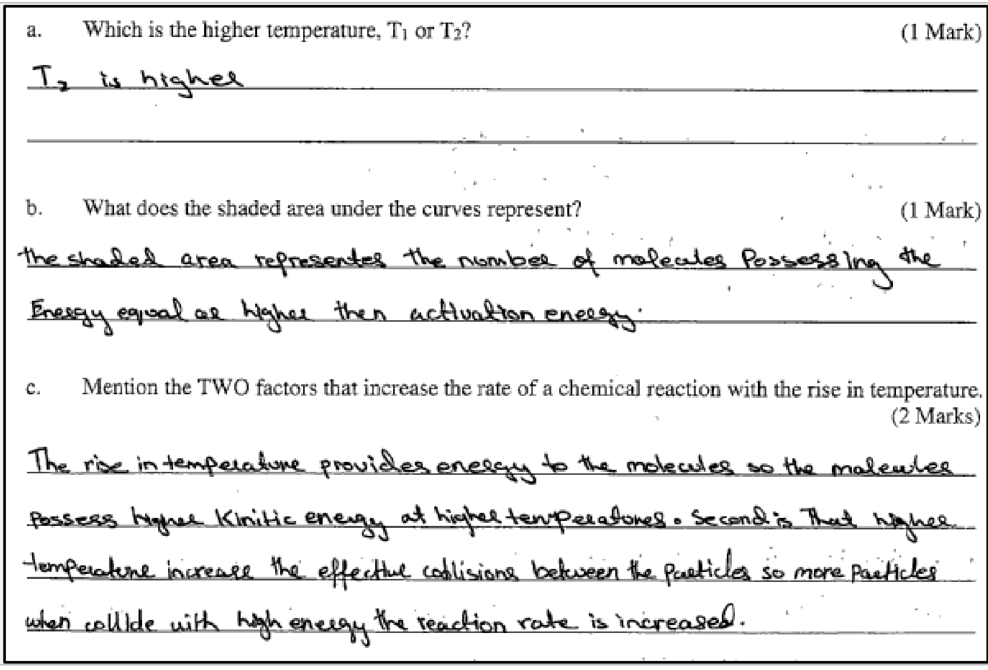
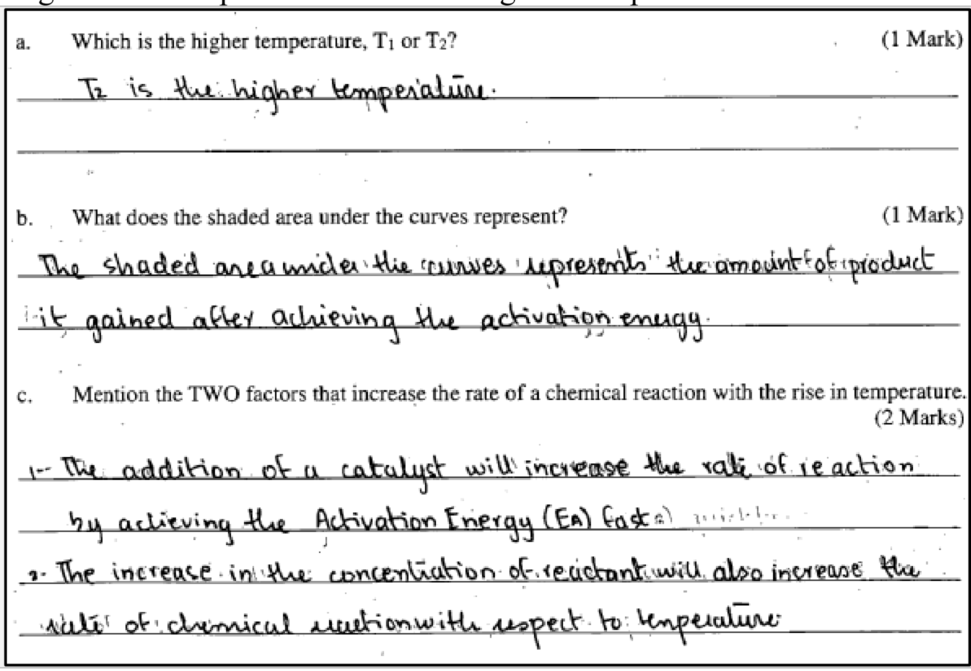
Question No. 5	
Question Text	Consider the given graph with reference to the distribution of molecular energies at two different temperatures.  a. Which is the higher temperature, T_1 or T_2? b. What does the shaded area under the curves represent? c. Mention the TWO factors that increase the rate of a chemical reaction with the rise in temperature.
SLO No.	9.3.5
SLO Text	Explain the effect of concentration, temperature and surface area on rate of reaction by using collision theory;
Max Marks	4
Cognitive Level	U
Checking Hints	a. 1 mark for identifying T_2 as the higher temperature b. 1 mark for describing the shaded area under the curve c. 1 mark for mentioning each factor (TWO required)
Overall Performance	Conceptual understanding of the Boltzmann distribution was generally weak. While a few candidates correctly identified that increased temperature leads to a broader and flatter distribution curve, most struggled to connect this change to the proportion of molecules exceeding the activation energy threshold. Many responses incorrectly associated the effect of temperature with changes in activation energy itself or confused it with the impact of catalysts or concentration. This indicates a need to strengthen foundational understanding of how temperature influences molecular energy distribution and reaction kinetics through the Boltzmann model.
Description of Better Responses	*Better responses* demonstrated strong conceptual understanding of the Maxwell-Boltzmann distribution and the effect of temperature on molecular energy. In part (a), candidates correctly identified T_2 as the higher temperature, recognising that the curve for T_2 is broader and lower in height, indicating that more molecules have higher kinetic energy. They also understood that increasing temperature shifts the peak to the right and flattens the curve. In part (b), these responses accurately explained that the shaded area under the curve represents the number of molecules with energy equal to or greater than the activation energy. Candidates clearly stated that this area is larger at T_2, showing that more molecules can undergo successful collisions, hence increasing the reaction rate. For part (c), better responses accurately mentioned two key factors explaining the temperature effect: 1. An increase in the number of molecules with energy ≥ activation energy, and 2. An increase in the frequency of collisions due to higher kinetic energy. These responses showed a clear understanding of how temperature affects both collision energy and collision frequency, contributing to a faster reaction rate.

Image of Better Response	 a. Which is the higher temperature, T_1 or T_2? (1 Mark) T_2 is higher b. What does the shaded area under the curves represent? (1 Mark) the shaded area representes the number of molecules Possessing the Energy equal or higher then activation energy. c. Mention the TWO factors that increase the rate of a chemical reaction with the rise in temperature. (2 Marks) The rise in temperature provides energy to the molecules so the molecules possess higher Kinitic energy at higher temperatures. Second is That higher temperature increase the effective collisions between the particles so more particles when collide with high energy the reaction rate is increased.
Description of Weaker Responses	*Weaker responses* revealed several conceptual misunderstandings regarding the Maxwell-Boltzmann distribution and the effect of temperature on reaction rates. In part (a), many candidates struggled to identify the correct temperature curve, often misinterpreting the relationship between temperature and the shape of the distribution. Some incorrectly suggested that the peak should shift upward rather than broaden and lower at higher temperatures. In part (b), several candidates conflated the effect of temperature with a change in activation energy itself, incorrectly stating that higher temperature lowers the activation energy. Others failed to explain what the shaded area represented, with vague references to “more energy” or “more molecules reacting” without linking it to the threshold of activation energy. In part (c), weaker responses frequently described unrelated factors like catalyst addition or increased concentration as reasons for increased reaction rate, rather than focusing on how temperature specifically increases the number of molecules with sufficient energy and collision frequency. There was also a recurring issue of referencing collision theory without connecting it to the molecular energy distribution, which reflects a fragmented or superficial understanding of the topic.
Image of Weaker Response	 a. Which is the higher temperature, T_1 or T_2? (1 Mark) T_2 is the higher temperature. b. What does the shaded area under the curves represent? (1 Mark) The shaded area under the curves represents the amount of product it gained after achieving the activation energy. c. Mention the TWO factors that increase the rate of a chemical reaction with the rise in temperature. (2 Marks) 1- The addition of a catalyst will increase the rate of reaction by achieving the Activation Energy (Ea) faster 2- The increase in the concentration of reactant will also increase the rate of chemical reaction with respect to temperature

Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	Preferred Pedagogy Used for this SLO	Assessment Strategies
• Identify the expectation of command words (use Command Word Guide) • Ensure the content is taught at the relevant cognitive level • Identify necessary content required (skills + concepts) • Review past paper questions on the concept • Utilise the resource guide for additional materials	• 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 address conceptual misunderstandings surrounding the effect of temperature on molecular energy distribution and reaction rates, teachers should implement strategies that bridge abstract theory with visual understanding. Encouraging candidates to sketch and compare energy distribution graphs at different temperatures on the same axes reinforces key concepts such as peak broadening and shifts in the area under the curve. Molecular animations (e.g., PhET simulations, Javalab Science Simulations or LabXchange virtual lab simulations) or physical models (such as ball-and-stick kits) can be used to show how increased temperature increases molecular motion, helping candidates connect particle-level changes with observable shifts in equilibrium. Emphasising activation energy as a 'hurdle'—and visually demonstrating how more molecules can overcome it at higher temperatures—strengthens conceptual clarity. Additionally, designing comparative exercises that contrast the effects of temperature and catalysts helps candidates distinguish that while catalysts lower activation energy, temperature increases the proportion of particles exceeding that threshold. Together, these strategies foster deeper understanding of reaction kinetics and the role of temperature in influencing reaction rates.

Question No. 6	
Question Text	a. Which pair of elements, one from Group IA and the other from Group VIIA, results in a compound exhibiting the most negative value of lattice enthalpy? b. Calculate the lattice enthalpy of potassium chloride using the given values (all in kJ mol^{-1}). ΔH_{at}(K) = +90; ΔH_{at}(Cl) = +122; 1st IE(K) = +418; 1st EA(Cl) = –349; ΔH_f(KCl) = –437
SLO No.	11.5.3
SLO Text	Calculate lattice energy and enthalpy of formation of ionic compounds from given set of appropriate data;
Max Marks	4
Cognitive Level	A
Checking Hints	a. 1 mark for identifying lithium 1 mark for identifying fluorine b. 1 mark for the formula/ substitution 1 mark for the correct value of lattice energy with negative sign
Overall Performance	Performance on this question was notably weak. Many candidates defaulted to familiar compounds such as NaCl, rather than selecting appropriate elements from Group IA and Group VIIA that would result in the most negative lattice enthalpy (e.g., LiF), indicating reliance on rote learning rather than conceptual understanding. The application of the Born–

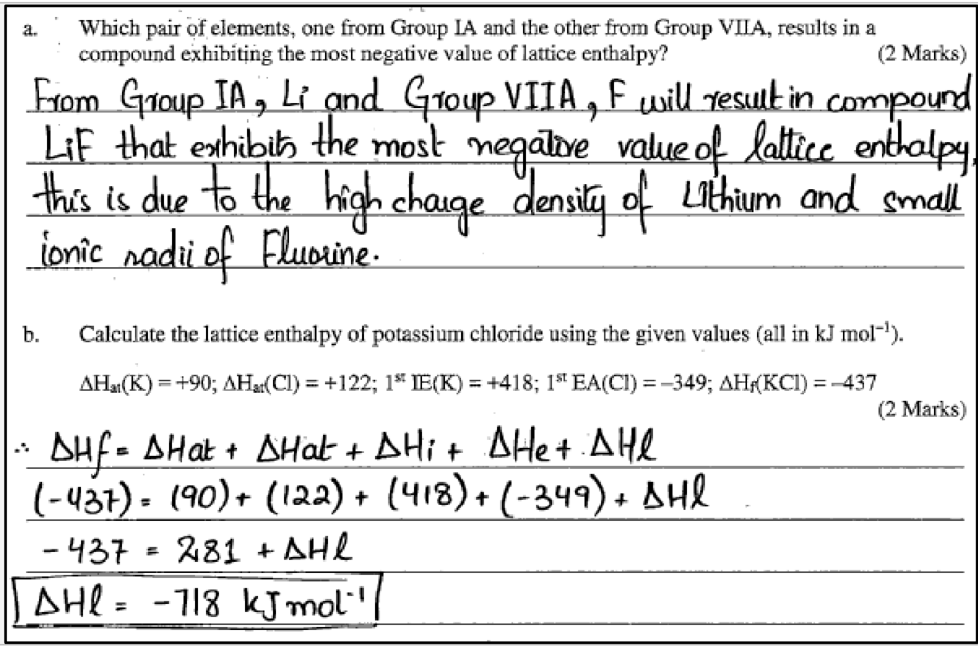
	Haber cycle proved particularly challenging for many, with frequent errors in sign conventions, omission of key enthalpy steps, and poor sequencing of calculations. These patterns suggest a lack of foundational understanding of the thermochemical principles involved in lattice enthalpy determination and the systematic approach required for solving such problems.
Description of Better Responses	*Better responses* demonstrated a solid grasp of lattice enthalpy concepts and the Born-Haber cycle. In part (a), they correctly identified that the combination of a small Group IA metal (lithium) and a small, highly electronegative Group VIIA non-metal (fluorine) forms lithium fluoride (LiF), which exhibits the most negative lattice enthalpy. Their reasoning was based on ionic size and charge density, recognising that smaller ions lead to stronger electrostatic attractions and hence a more exothermic lattice enthalpy. In part (b), these candidates skillfully applied the Born-Haber cycle, correctly arranging the given enthalpy terms and used the relationship: $\Delta H_L = \Delta H_f - [\Delta H_{at}(K) + \Delta H_{at}(Cl) + IE_1(K) + EA_1(Cl)]$ Their responses showed accuracy in substituting values, maintained sign conventions correctly (particularly for the exothermic electron affinity), and included proper units throughout. These answers reflected analytical thinking and confident manipulation of thermochemical data.
Image of Better Response	 a. Which pair of elements, one from Group IA and the other from Group VIIA, results in a compound exhibiting the most negative value of lattice enthalpy? (2 Marks) From Group IA, Li and Group VIIA, F will result in compound LiF that exhibits the most negative value of lattice enthalpy, this is due to the high charge density of Lithium and small ionic radii of Fluorine. b. Calculate the lattice enthalpy of potassium chloride using the given values (all in kJ mol^{-1}). $\Delta H_{at}(K) = +90$; $\Delta H_{at}(Cl) = +122$; 1st IE(K) = +418; 1st EA(Cl) = –349; $\Delta H_f(KCl) = -437$ (2 Marks) ∴ $\Delta Hf = \Delta Hat + \Delta Hat + \Delta Hi + \Delta He + \Delta Hl$ $(-437) = (90) + (122) + (418) + (-349) + \Delta Hl$ $-437 = 281 + \Delta Hl$ $\Delta Hl = -718$ kJ mol^{-1}
Description of Weaker Responses	*Weaker responses* revealed several systemic issues and conceptual gaps in understanding lattice enthalpy and the application of the Born–Haber cycle. In part (a), many candidates incorrectly selected elements such as sodium or hydrogen instead of lithium and chlorine in place of fluorine, indicating a lack of awareness that smaller ions with higher charge density form compounds with more negative lattice enthalpy. In part (b), several candidates failed to construct or apply the correct formula for calculating the enthalpy of formation. Common mistakes included incorrect or inconsistent use of signs for enthalpy changes—for example, treating exothermic values as positive. Others skipped crucial steps in the Born–Haber cycle or substituted values without understanding the thermochemical relationships involved (e.g., neglecting $\Delta H_{at}(Cl)$ or dividing its value by 2 under the mistaken assumption that it must be halved due to chlorine's diatomic nature). Additional errors included incorrect sequencing of steps and omission of proper units. These responses often lacked structure, reflected guesswork rather than informed reasoning, and demonstrated a weak grasp of the energy changes involved in ionic compound formation.

Image of Weaker Response

a. Which pair of elements, one from Group IA and the other from Group VIIA, results in a compound exhibiting the most negative value of lattice enthalpy? (2 Marks)

from group IA H (hydrogen) and from group VIIA Cl results in compound HCl (strong acid) and has negative value of lattice enthalpy also.

b. Calculate the lattice enthalpy of potassium chloride using the given values (all in kJ mol^{-1}).

$\Delta H_{at}(K) = +90$; $\Delta H_{at}(Cl) = +122$; 1^{st} IE(K) = +418; 1^{st} EA(Cl) = –349; $\Delta H_f(KCl) = -437$ (2 Marks)

Datas $\Delta H_{at}(K) = +90$, $\Delta H_{at}(Cl) = +122$, 1^{st} EA(Cl) = -349, $\Delta H_f(KCl) = -437$, 1^{st} IE(K) = +418.

Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	Pedagogy Used for that SLO	Assessment Strategies
• Identify the expectation of command words (use Command Word Guide) • Ensure the content is taught at the relevant cognitive level • Identify necessary content required (skills + concepts) • Review past paper questions on the concept • Utilise the resource guide for additional materials	• 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

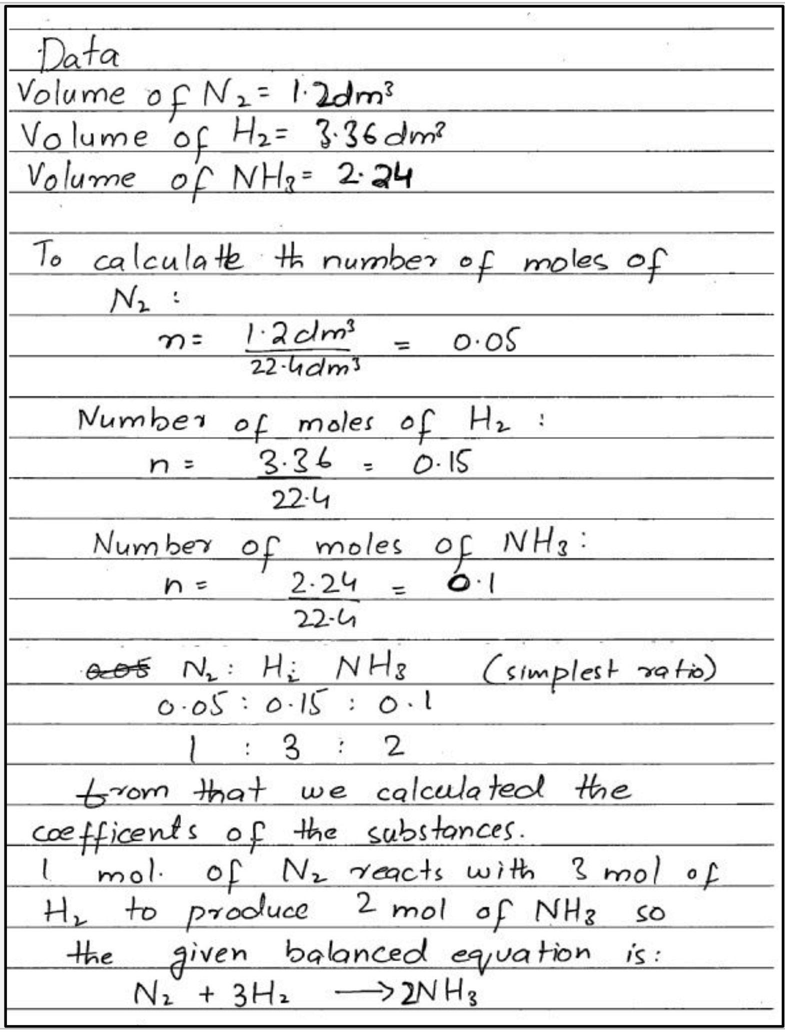
Any Additional Suggestion: To strengthen candidates' understanding of lattice enthalpy and enhance their ability to correctly apply the Born–Haber cycle, teachers can implement instructional strategies that promote both procedural fluency and conceptual insight. Flashcards featuring Group IA and Group VIIA elements can help reinforce periodic trends and support accurate element selection in ionic compound formation. Providing scaffolded Born–Haber cycle templates—using either Royal Society of Chemistry (RSC) Education's interactive arrow tool, freely downloadable worksheets such as those from Cerritos College, or custom versions created by the teacher—can guide candidates through each enthalpy change step by step, ensuring clarity in structure and purpose. To further aid retention, colour-coded visuals can be used to differentiate between exothermic (negative) and endothermic (positive) processes, reinforcing correct sign conventions. Estimation practice—such as comparing calculated values with expected outcomes (e.g., recognising that LiF has a more negative lattice enthalpy than NaCl)—helps candidates develop reasoning skills and detect errors rather than relying solely on arithmetic. Additionally, analysing real-life compounds with known lattice energies fosters comparative understanding of how ionic size and charge influence lattice enthalpy. Collectively, these strategies move candidates beyond rote memorisation toward structured, principle-based problem-solving in thermochemical contexts.

Extended Response Questions (ERQs)

Extended response questions offered a choice between parts 'a' and 'b'

Question No. 7a	
Question Text	1.12 dm^3 of N_2 gas and 3.36 dm^3 of H_2 gas can combine to make 2.24 dm^3 of NH_3. Write a balanced chemical equation with simple whole numbers by calculating the number of moles from volumes for the given reaction.
SLO No.	1.2.4
SLO Text	Calculate, using a balanced chemical equation, the a. interacting moles b. representative particles c. masses and volume of gases at STP (22.4 L) and RTP (24 L);
Max Marks	7
Cognitive Level	A
Checking Hints	1 mark for writing molar volume i.e. 22.4 dm^3 at STP and 24 dm^3 at RTP 1 mark for calculating moles of N_2 1 mark for calculating moles of H_2 1 mark for calculating moles of NH_3 1 mark for writing the equation with number of moles calculated 1 mark for dividing the equation with least number of moles 1 mark for showing correct balanced chemical equation with simple whole numbers
Overall Performance	Most candidates attempted this part of the extended response question. Among those who did, performance varied significantly. Many candidates showed weak application of the mole concept in the context of gaseous reactions, with common errors including misuse of mass-based formulas, incorrect assumptions about gas volumes, and failure to apply mole ratios correctly. Unit conversion issues—particularly between cm^3 and dm^3—were also frequent. However, those who approached the question methodically and demonstrated a clear understanding of gas volume-to-mole relationships at STP were able to correctly deduce the mole ratio and write a balanced chemical equation. These well-prepared candidates secured full marks by integrating sound stoichiometric reasoning with accurate calculations.
Description of Better Responses	*Better responses* demonstrated a clear and accurate understanding of mole–volume relationships for gases at standard temperature and pressure (STP), where 1 mole of any gas occupies 22.4 dm^3. Candidates correctly applied this concept to calculate the number of moles of each gas by dividing the given volume by 22.4. From these mole values, they deduced the simplest whole-number ratio of nitrogen to hydrogen to ammonia and used it to write the correct balanced chemical equation: $N_2 + 3H_2 \rightarrow 2NH_3$. These responses reflected strong grasp of stoichiometry, showing that gas volumes at STP can be used to infer mole ratios directly without needing mass or molar mass. Additionally, many candidates explained how their balanced equation obeyed the Law of Conservation of Mass, and some even verified their result by recalculating the expected volumes from the mole ratios. Such responses demonstrated not only procedural accuracy but also deeper conceptual understanding of gaseous reactions and chemical balancing.

Image of Better Response



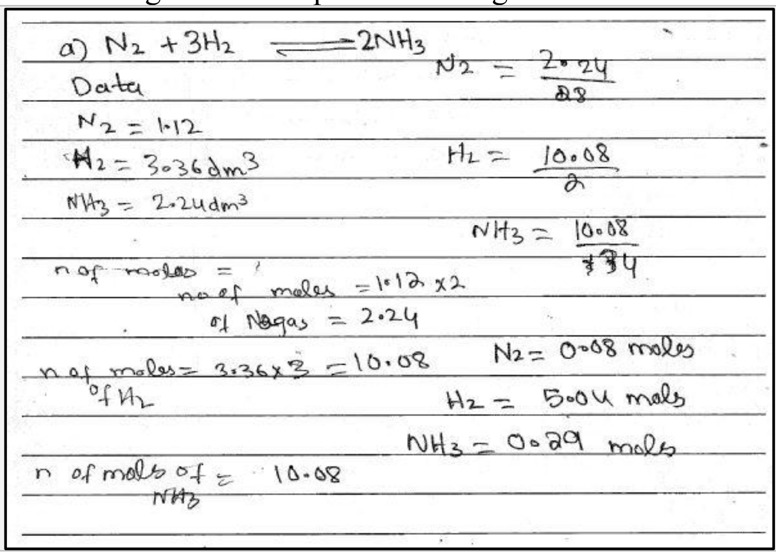
Data
Volume of N_2 = 1·2dm³
Volume of H_2 = 3·36dm³
Volume of NH_3 = 2·24

To calculate th number of moles of N_2 :
$n = \frac{1{\cdot}2dm^3}{22{\cdot}4dm^3} = 0{\cdot}05$
Number of moles of H_2 :
$n = \frac{3{\cdot}36}{22{\cdot}4} = 0{\cdot}15$
Number of moles of NH_3:
$n = \frac{2{\cdot}24}{22{\cdot}4} = 0{\cdot}1$
~~0·05~~ N_2 : H_2 : NH_3 (simplest ratio)
0·05 : 0·15 : 0·1
1 : 3 : 2
from that we calculated the coefficents of the substances.
1 mol· of N_2 reacts with 3 mol of H_2 to produce 2 mol of NH_3 so the given balanced equation is:
$N_2 + 3H_2 \longrightarrow 2NH_3$

Description of Weaker Responses

Weaker responses revealed persistent conceptual and procedural misunderstandings. Many candidates incorrectly applied mass–mole formulas despite being given only gas volumes, showing confusion between volume-based and mass-based mole calculations. Unit errors were also common, particularly mixing up cm^3 and dm^3, or failing to convert appropriately. Some candidates made incorrect assumptions about gas volumes at STP, using arbitrary or incorrect values instead of 22.4 dm^3 per mole. Several responses skipped key steps in deriving mole ratios, leading to unbalanced or chemically invalid equations. Others presented equations without verifying if they aligned with the Law of Conservation of Mass. These mistakes indicated a lack of clarity in applying the molar volume concept and in constructing balanced equations from gaseous data.

Image of Weaker Response



a) $N_2 + 3H_2 \rightleftharpoons 2NH_3$
Data
N_2 = 1·12
H_2 = 3·36dm³
NH_3 = 2·24dm³
~~n of moles =~~
n of moles of N_2 gas = 1·12 x2 = 2·24
n of moles of H_2 = 3·36x3 = 10·08
n of mols of NH_3 = 10·08
$N_2 = \frac{2{\cdot}24}{28}$
$H_2 = \frac{10{\cdot}08}{2}$
$NH_3 = \frac{10{\cdot}08}{34}$
N_2 = 0·08 moles
H_2 = 5·04 mols
NH_3 = 0·29 mols

Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	Preferred Pedagogy Used for this SLO	Assessment Strategies
• Identify the expectation of command words (use Command Word Guide) • Ensure the content is taught at the relevant cognitive level • Identify necessary content required (skills + concepts) • Review past paper questions on the concept • Utilise the resource guide for additional materials	• 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 candidate performance in applying mole–volume relationships and balancing chemical equations—particularly in gaseous reactions—teachers should adopt targeted strategies that strengthen both conceptual clarity and procedural accuracy. Problem taxonomy exercises can help candidates identify known and required quantities (e.g., volume, mass, moles, or ratios) before attempting a solution, fostering structured thinking. Focused unit conversion drills between cm^3, dm^3, and m^3 reinforce the importance of consistent metric usage in gas calculations. Step-by-step solution checklists can further support candidates by guiding them through a logical sequence from volume to moles to balanced equations, reducing the likelihood of skipped or incorrect steps. In addition, teaching verification techniques, such as checking for mass and charge balance, promotes analytical thinking and accuracy. To enhance relevance and engagement, incorporating real-world contexts—such as airbag inflation using nitrogen gas or ammonia production in industry—helps candidates see the practical value of stoichiometric gas relationships. Together, these strategies support deeper understanding and more precise problem-solving, equipping candidates to handle gas-based stoichiometry with greater confidence.		

Question No. 7b	
Question Text	In 1833, Michael Faraday proposed the first law of electrolysis. i. Provide the statement of the law and derive corresponding mathematical expression. ii. Determine the mass of sodium produced when a current of 5 amperes is passed through molten sodium chloride for a duration of 3 hours.
SLO No.	12.4.1 (12.4.3)
SLO Text	Explain Faraday's first and second law of electrolysis; (calculate the mass or volume of substance produced during electrolysis.)
Max Marks	7
Cognitive Level	U
Checking Hints	a. 1 mark for writing the statement of Faraday's first law of electrolysis 1 mark each for showing the given expressions (4 required) $m \alpha Q$ $Q = I \times t$ $m \alpha I \times t$ $m = Z \times I \times t$ b. 1 mark for substitution of values/ working 1 mark for the correct answer

	(Note: Any other alternate and valid method of solving numerical problems will be awarded marks accordingly.)
Overall Performance	Only a minority of candidates attempted this part of the extended response question. Among those who did, performance was mixed, reflecting uneven understanding of electrolysis and the quantitative relationships in Faraday's law. While there were responses that demonstrated confident application of core formulas with accurate derivations and unit conversions, many candidates struggled with conceptual clarity, inconsistent use of units, and poor problem-solving structure. Greater emphasis is needed on foundational principles and stepwise calculation strategies to improve future performance.
Description of Better Responses	*Better responses* demonstrated a comprehensive understanding of Faraday's First Law of Electrolysis and the quantitative relationship between current, time, and the mass of a substance deposited during electrolysis. Candidates began by clearly stating the law: 'The mass (m) of a substance liberated at an electrode during electrolysis is directly proportional to the quantity of electricity (Q = It) passed through the electrolyte.' They then derived the formula: m = Zit. Some candidates extended the derivation using molar mass (*M*), Faraday's constant ($F \approx 96500\ \mathrm{C\ mol^{-1}}$), and number of electrons involved (*n*): $m = \frac{M.I.t}{n.F}$. For part (ii), they correctly converted 3 hours into 10,800 seconds and substituted values into the formula: $m = \frac{23.5.10800}{1.96500}$ = 12.87 g (assuming sodium with molar mass 23 g/mol and *n* = 1). These responses were characterised by precise use of constants, unit consistency, and logical reasoning, with many also verifying units through dimensional analysis to ensure the correctness of their final answer.
Image of Better Response	Image i: Faraday's First law: • First law of electrolysis by faraday states that the amount of substance deposited, liberated or produced at electrodes (anode / cathode) is directly proportional to charge supplied during electrolysis. • It can be predicted that if more charge is supplied more amount of substance can be gained at electrodes during electrolysis. The mathematical equation for this is: $W \propto Q$ = $W = ZQ$ where W = mass/amount of substance formed and Q is charge passed. and Z equivalent weight • It can also be written as: $W = ZIt$ [$Q = It$] charge = current x time The two formula /forms of Farday first law are: $W = ZIt$ —(i) and $W = ZQ$ —(ii) (b) Mass of Na produced = ? Current = 5 Amperes = I Time = 3 hours = 180 mins = 10800 sec charge, Q = It = Q = 5x 10800 = 54000 Columbs Using the relation;

96500 Coloumbs = 1 Farad = 1mole electron = molar mass

96500 C (charge) : 23g Na produced

$Na^+ + 1\bar{e} \longrightarrow Na^\circ$ (as 1mole $\bar{e}$ is involved)

then amount when 54000C charge is supplied

96500 C = 23 g

54000 C = x g

$x = \frac{54000C \times 23g}{96500C}$

x = 12.87g

So 12.87 g of Na is produced when 5 Ampere current for 3 hours is passed during electrolysis of NaCl

Image ii:

(b)

Faraday First law of electrolysis states that the amount of Substance deposited or mass of gas Liberated at particular electrode is directly proportional to the charge passing through the solution.

According to 1st law of faraday

$m \propto Q$

$m = zQ$ ∵ z = Electrochemical equivalent

From the Formula of ∵ $z = \frac{E}{F}$ = Equivalent weight / charge

current $I = \frac{Q}{t}$ ⇒ $Q = I \times t$

$m = zIt$

$m = \frac{E}{F} \times I \times t$

$m = E \times \frac{1}{F} \times I \times t$

$m = \frac{\text{Molar mass}}{\text{Electron transfer}} \times \frac{1}{F} \times I \times t$

Given Data

mass of sodium = unknown.

current = 5 amperes.

Time = 3hours.

Time in Seconds.

3hr = 10800 secs

1 hr = 60 min

3hr = 180 mins.

1min = 60 sec

Write equation.

$Na + 1e \longrightarrow Na^+$

As 1F = 96500 columbs.

using Formula.

$m = \frac{M.m}{\text{Electron transfer}} \times \frac{1}{F} \times I \times t$

$m = \frac{23g}{1} \times \frac{1}{96500C} \times 5A \times 10800 secs$

$m = \frac{1242000}{96500C}$ ⇒ m = 12.8 g of Na

Description of Weaker Responses	*Weaker responses* revealed a range of conceptual and procedural misconceptions regarding Faraday's First Law of Electrolysis. Many candidates either misstated the law or confused it with unrelated concepts such as reaction rates or general laws of electrochemistry. In several cases, candidates omitted critical steps in the derivation, failing to establish the proportionality between mass, current, and time, or used incorrect or undefined symbols—for example, using unfamiliar notation for electrochemical equivalent (Z). A common procedural error involved neglecting unit conversions, especially failing to convert time from hours to seconds, leading to inflated or incorrect mass calculations. Some candidates substituted incorrect values for Faraday's constant or misapplied the molar mass and number of electrons involved (n) in the reaction. Others confused Z with molar mass or atomic number, showing poor understanding of the formula's components. Additionally, a number of responses demonstrated sign errors or confusion in interpreting the half-equation for sodium deposition, indicating weak foundational knowledge in electrochemical reactions. Overall, these responses lacked coherence, accuracy, and a clear grasp of the law's practical and theoretical underpinnings.
Image of Weaker Response	b. i) In 1833, Michael Faraday proposed first law of electrolysis. Statement of the Law "The amount of reaction of current at electrode is directly proportional to the sum of current flowing through electrode." Mathematically = m x I x t ii) Data: mass of sodium = ? current = I = 5 amperes t = 3 hours formula m = I x t Solution = 5 x 3 = 15 g

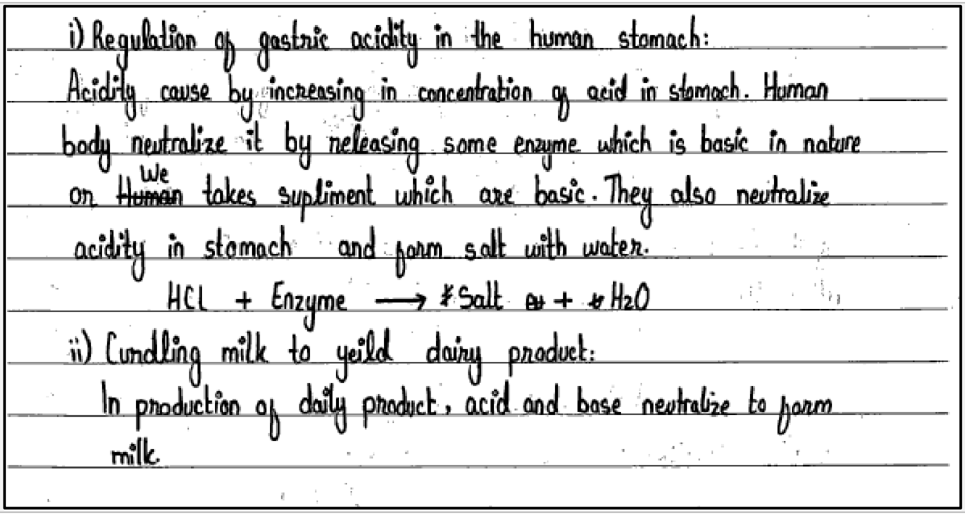
Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	Preferred Pedagogy Used for this SLO	Assessment Strategies
• Identify the expectation of command words (use Command Word Guide) • Ensure the content is taught at the relevant cognitive level	• Story Board • Cause and Effect • Fish and Bone • Concept Mapping • Audio Visual Resources • Think, Pair and Share • Knowledge Platform videos	• Past paper questions • Discussion on E-Marking Notes • AKU-EB Digital Learning Solution powered by Knowledge Platform https://akueb.knowledgeplatform.com/login

• Identify necessary content required (skills + concepts) • Review past paper questions on the concept • Utilise the resource guide for additional materials	• Questioning Technique (Socratic approach) • Practical Demonstration	
Any Additional Suggestion: To enhance candidates' understanding and application of Faraday's First Law of Electrolysis—particularly in derivations and quantitative calculations—teachers can implement strategies that develop both conceptual clarity and computational accuracy. Emphasising half-reactions as the starting point helps candidates identify and balance the number of electrons involved, reinforcing the redox changes at electrodes and supporting accurate use of the formula $m = \frac{M.I.t}{n.F}$. A prominently displayed unit conversion wall, featuring common transformations such as hours to seconds and coulombs to faradays, serves as a constant visual aid, helping candidates apply the correct units and avoid basic errors in calculations. Additionally, providing reference cards that list essential constants—such as Faraday's constant, molar masses, and the elementary charge—ensures consistency in problem-solving and builds familiarity with standard scientific values. Together, these strategies equip candidates with the procedural fluency and confidence needed to accurately tackle electrolysis questions in assessments.		

Question No. 8a	
Question Text	Explain the acid-base reactions involved in the following situations: i. Regulation of gastric acidity in the human stomach ii. Curdling of milk to yield dairy products Support your answer with a suitable example and/ or an equation where required.
SLO No.	8.1.3
SLO Text	Explain the significance of acid base reactions in daily life (food preservation, allergic reactions, gastric acidity, curdling of milk);
Max Marks	7
Cognitive Level	U
Checking Hints	i. 1 mark for writing each point about the role of acid base reactions in gastric acidity including examples or equations (any 4 required) ii. 1 mark for writing each point about the role of acid base reactions in curdling of milk including examples or equations (any 3 required)
Overall Performance	Though many candidates attempted this part of the extended response questions, but their performance on this question was mixed. While a fair number of candidates demonstrated sound understanding of acid-base reactions in real-life contexts, including well-written chemical equations and biological relevance, others showed confusion or failed to apply basic principles correctly. Part (i) was generally better attempted than part (ii), which many candidates struggled to link explicitly with acid-base chemistry. Greater emphasis on integrating real-life applications with chemical concepts would help improve performance on such contextual questions.
Description of Better Responses	In part (i) of *better responses*, candidates demonstrated a solid grasp of acid-base neutralisation in the digestive system. They identified hydrochloric acid (HCl) as the source of gastric acidity and explained that excess acid leads to symptoms such as heartburn or indigestion. They listed commonly used antacids like magnesium hydroxide ($Mg(OH)_2$) or calcium carbonate ($CaCO_3$) and supported their explanations with appropriate neutralisation equations. Candidates also referred to the role of bicarbonate in buffering stomach acid and mentioned that antacids relieve discomfort by neutralising excess HCl, showcasing both chemical and physiological understanding. In part (ii), better responses accurately described

	curdling as a result of lactic acid fermentation. They explained that lactose in milk is converted into lactic acid by bacteria, lowering the pH and causing milk proteins (especially casein) to denature and coagulate, forming curds. Some cited yogurt or paneer production as examples, demonstrating clear understanding of the acid-induced coagulation process.
Image of Better Response	(a)(i) Regulation of gastric acidity by acid base reactions: when stomach produces so much HCl due to spicy food consumption, pH of stomach decreases, to neutralize the ~~the~~ effect of acid, antacids are consumed. Antacids are basic in nature. Examples of such antacids include $Mg(OH)_2$ and $CaCO_3$ $2HCl + Mg(OH)_2 \longrightarrow MgCl_2 + 4H_2O$ → Neutralisation reaction shows that Acid and base form Neutral salt and water, Hence pH of stomach is maintained. (ii) curdling of milk to yield dairy products: when any acidic substance is added to milk, ~~like~~ when ~~the~~ lactose gets converted to lactic acid, pH of milk decrease (acidic) which denature the protein (caesin) present in milk, hence coagulation occurs which result in seperation of curd from whey. The liquid part obtained from curdling of milk is termed as whey where as the solid part that remains ~~to~~ ~~the~~ form curd. From these process of acid base reaction dairy products like butter, whey curd, and yogurt are obtained Both these situations involve acid base reaction. first situation involves the reaction between an acid and a base, during this ~~pro~~ Neutralization occurs which treat the gastric acidity in the human stomach. without this process acid of stomach can damage stomach walls resulting in many stomach infections such as ulcer. Basic play vital role in maintaining the pH of ~~a~~ stomach. ~~substance~~ second situation involves the effect of acid on milk. Milk has protein, ~~in~~ change in pH denatures the protein, adding lemon or any other acid result in decrease in pH due to which proteins in milk are coagulated.
Description of Weaker Responses	*Weaker responses* often misidentified antacids or acids in part (i), sometimes listing unrelated substances like soft drinks or fruit juices. Many failed to describe the role of acids and bases or omitted any mention of chemical reactions. Some responses lacked clarity or focused on symptoms without linking them to chemical processes, showing poor conceptual linkage between theory and application. In part (ii), weaker responses showed confusion about the cause of milk coagulation. Some attributed curdling to high temperature or pressure or incorrectly linked it to butyric acid. Others confused lactic acid with added bases or failed to explain the role of pH and protein denaturation. These responses lacked chemical accuracy and failed to connect the phenomenon with acid-base principles.

Image of Weaker Response	
	

i) Regulation of gastric acidity in the human stomach:
Acidity cause by increasing in concentration of acid in stomach. Human body neutralize it by releasing some enzyme which is basic in nature or We takes supliment which are basic. They also neutralize acidity in stomach and form salt with water.
HCL + Enzyme ⟶ Salt + H_2O
ii) Curdling milk to yeild dairy product:
In production of daily product, acid and base neutralize to form milk.

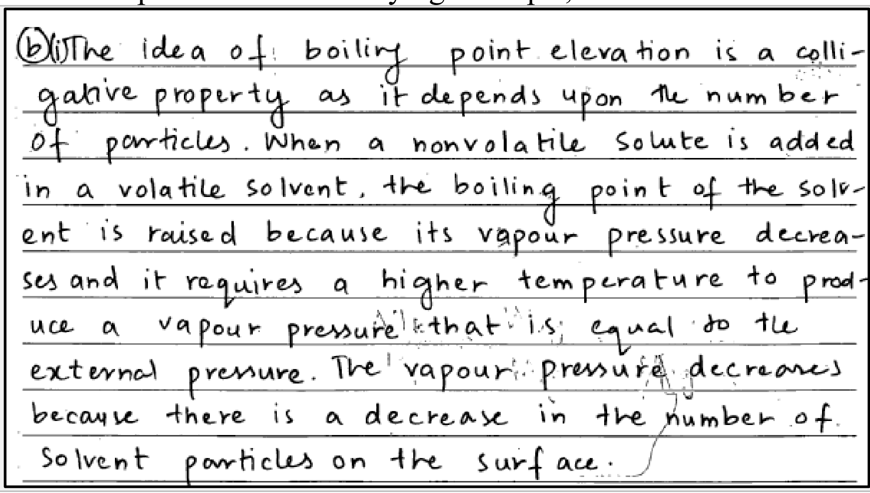
Suggestions for improvement (Highlight all that apply)

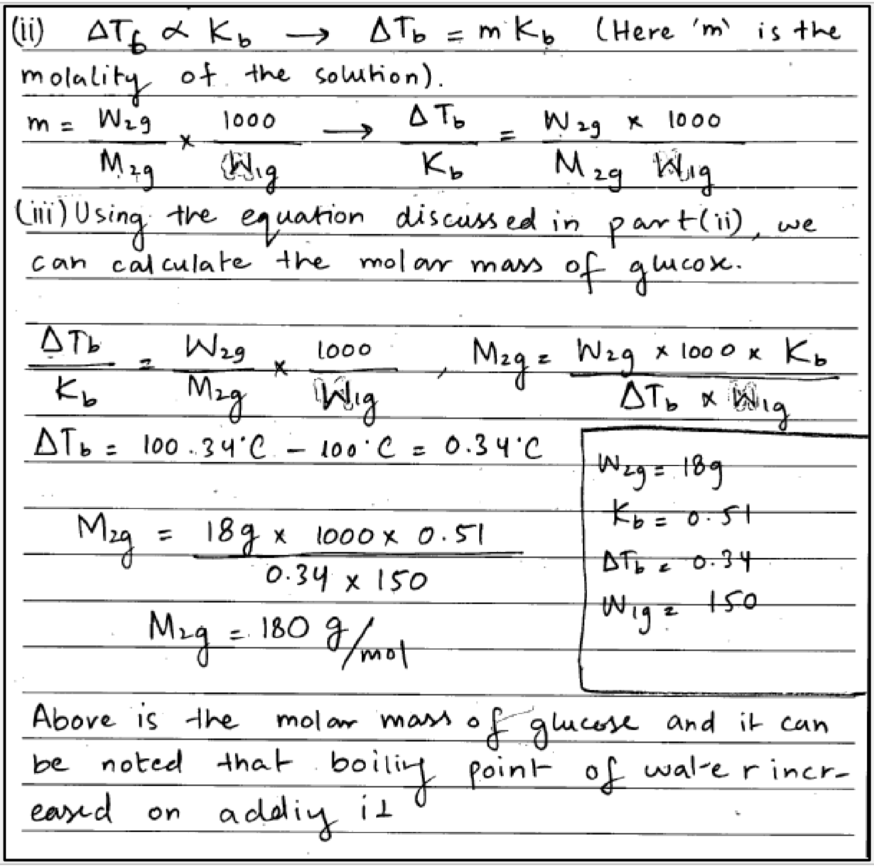
Maximising SLO Achievement	Pedagogy Used for that SLO	Assessment Strategies
• Identify the expectation of command words (use Command Word Guide) • Ensure the content is taught at the relevant cognitive level • Identify necessary content required (skills + concepts) • Review past paper questions on the concept • Utilise the resource guide for additional materials	• 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 candidates' conceptual understanding and application of acid-base reactions—particularly in biological and domestic contexts—teachers can adopt focused, real-life strategies that make learning more engaging and meaningful. Medical case analyses, such as exploring acidity or heartburn, provide opportunities for candidates to examine how compounds like $Mg(OH)_2$ or $CaCO_3$ function as antacids. Through role-plays or guided case studies, candidates can write balanced chemical equations and understand the specific role each compound plays in neutralisation. Cultural food demonstrations, such as curdling milk with lemon juice or vinegar, can illustrate acid-induced protein denaturation and link to lactic acid production in yogurt-making, helping candidates connect everyday processes with underlying acid-base reactions. Additionally, interactive household labs using natural indicators like red cabbage or turmeric allow candidates to test and classify common substances as acids or bases. Predicting and recording observations encourages hands-on exploration and reinforces theoretical concepts. Together, these strategies support deeper learning by making acid-base chemistry relevant, observable, and directly connected to real-life experiences.

Question No. 8b

Question Text	Elaborate upon the concept of boiling-point elevation by: i. defining it as a colligative property. ii. writing its equation that articulates the concept with respect to solution concentration. iii. calculating the molar mass of glucose when 18 g of it are dissolved in 150 g of water, resulting in a boiling point of 100.34°C under 1 atmosphere. The molal boiling point

	elevation constant for water is 0.51℃ kg/mol. It's important to note that glucose, as a molecular solid, exists as discrete molecules within the solution.
SLO No.	10.5.3 (10.5.2)
SLO Text	Calculate molar mass of a substance using ebullioscopic and cryoscopic methods. (Explain the colligative properties of liquids, i.e. a. lowering of vapour pressure,b. elevation of boiling point, c. depression of freezing point, d. osmotic pressure;)
Max Marks	7
Cognitive Level	A
Checking Hints	1 mark for the definition 1 mark for showing the correct relationship through equation 1 mark for each step of working (5 required)
Overall Performance	Less than half of the candidates attempted this extended response question, and among them, performance was bifurcated. Moreover, some responses reflected strong understanding of colligative properties, correct use of equations, and careful calculations with proper units. However, many responses were brief and lacked conceptual backing, indicating that while the topic was somewhat familiar, the application to real data (such as glucose in solution) was poorly understood by many.
Description of Better Responses	*Better responses* demonstrated a thorough understanding of boiling-point elevation as a colligative property. Candidates clearly defined it as the rise in the boiling point of a solvent upon the addition of a non-volatile solute, emphasising that it depends solely on the number of solute particles rather than their chemical identity. These responses accurately applied the mathematical expression $\Delta T_b = K_b \cdot m$, where ΔT_b is the boiling point elevation, K_b is the ebullioscopic constant, and m is the molality of the solution. To calculate the molality, candidates correctly divided the number of moles of glucose by the mass of water in kilograms, and they handled all unit conversions appropriately—such as converting 150 g of water to 0.150 kg and identifying the temperature elevation as 0.34°C (from 100.34°C – 100.00°C). From this, they determined the molality of the solution as approximately 0.6667 mol/kg. Recognising that molality equals moles of solute divided by mass of solvent, they then calculated the number of moles of glucose and used it to accurately determine the molar mass by dividing the given 18 g of glucose by the number of moles, arriving at a final value of 180 g/mol, consistent with the known molar mass of glucose ($C_6H_{12}O_6$). These candidates not only demonstrated sound mathematical fluency but also clearly explained each step, linked the procedure to underlying concepts, and verified their results logically.
Images of Better Responses	 (b)(i) The idea of boiling point elevation is a colligative property as it depends upon the number of particles. When a nonvolatile solute is added in a volatile solvent, the boiling point of the solvent is raised because its vapour pressure decreases and it requires a higher temperature to produce a vapour pressure that is equal to the external pressure. The vapour pressure decreases because there is a decrease in the number of solvent particles on the surface.


(ii) $\Delta T_b \propto K_b \rightarrow \Delta T_b = m K_b$ (Here 'm' is the molality of the solution).

$m = \frac{W_{2g}}{M_{2g}} \times \frac{1000}{W_{1g}} \rightarrow \frac{\Delta T_b}{K_b} = \frac{W_{2g} \times 1000}{M_{2g}\, W_{1g}}$

(iii) Using the equation discussed in part (ii), we can calculate the molar mass of glucose.

$\frac{\Delta T_b}{K_b} = \frac{W_{2g}}{M_{2g}} \times \frac{1000}{W_{1g}}$, $M_{2g} = \frac{W_{2g} \times 1000 \times K_b}{\Delta T_b \times W_{1g}}$

$\Delta T_b = 100.34°C - 100°C = 0.34°C$

$W_{2g} = 18g$
$K_b = 0.51$
$\Delta T_b = 0.34$
$W_{1g} = 150$

$M_{2g} = \frac{18g \times 1000 \times 0.51}{0.34 \times 150}$

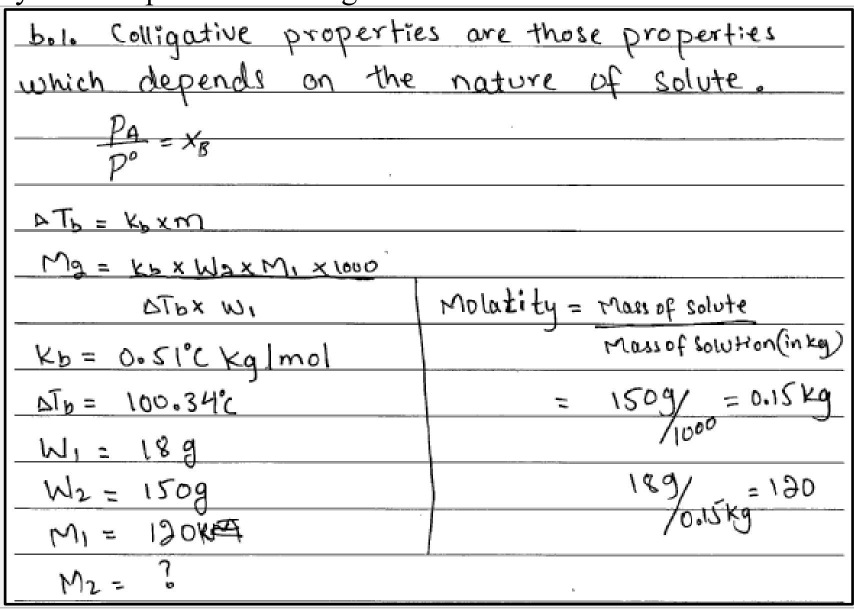
$M_{2g} = 180\ g/mol$

Above is the molar mass of glucose and it can be noted that boiling point of water increased on adding it

Description of Weaker Responses

Weaker responses revealed numerous conceptual and procedural flaws. Many candidates were unable to distinguish boiling-point elevation from other colligative properties or mistakenly associated the question with Raoult's law or vapour pressure lowering without directly addressing how boiling point is affected. A significant number failed to subtract the correct temperatures to obtain ΔT_b, omitted the use of molality altogether, or incorrectly calculated it by swapping the solute and solvent values. Some responses showed a lack of familiarity with unit conversions, treating 150 g of water as 150 kg or using molar masses in place of moles. Others incorrectly attempted to calculate the molar mass by adding the atomic masses of carbon, hydrogen, and oxygen, rather than solving it through colligative property data. In several cases, formulas were misapplied or left incomplete, and final answers lacked justification or consistency in units. These responses generally reflected a superficial understanding of colligative properties, confusion between related concepts, and a lack of systematic problem-solving skills.

Image of Weaker Response


b.i. Colligative properties are those properties which depends on the nature of solute.

$\frac{P_A}{P^o} = x_B$

$\Delta T_b = K_b \times m$

$M_2 = \frac{K_b \times W_2 \times M_1 \times 1000}{\Delta T_b \times W_1}$

$K_b = 0.51°C\ kg/mol$
$\Delta T_b = 100.34°C$
$W_1 = 18\ g$
$W_2 = 150g$
$M_1 = 120$
$M_2 = ?$

Molality = $\frac{\text{Mass of solute}}{\text{Mass of solution (in kg)}}$

$= 150g/1000 = 0.15kg$

$18g / 0.15kg = 120$

$$Mg = \frac{0.51 \times 150 \times 120 \times 1000}{100.34 \times 18}$$

$$Mg = \frac{9180000}{1806.12}$$

$$Mg = 5082.71$$

Suggestions for improvement (Highlight all that apply)

Maximising SLO Achievement	**Preferred Pedagogy Used for this SLO**	**Assessment Strategies**
• Identify the expectation of command words (use Command Word Guide) • Ensure the content is taught at the relevant cognitive level • Identify necessary content required (skills + concepts) • Review past paper questions on the concept • Utilise the resource guide for additional materials	• 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 candidates' understanding of boiling-point elevation and related colligative property calculations, teachers can implement targeted strategies that promote logical reasoning, error detection, and real-world relevance. Using graphical organisers—such as flowcharts or step-by-step diagrams—can help candidates navigate through the problem-solving process in a structured manner. These visuals guide them from identifying known quantities (e.g., solute mass, boiling point elevation) to selecting the appropriate formula, converting units, calculating molality, and ultimately deriving molar mass, thereby reducing the risk of missed steps. To develop analytical skills, teachers can introduce error-spotting exercises featuring worked examples with deliberate mistakes, such as incorrect unit conversions or swapped solute and solvent values and ask candidates to critique and correct them. This practice reinforces correct procedures while drawing attention to common pitfalls. Additionally, incorporating real-life applications—such as the use of antifreeze in car radiators—can enhance engagement. By examining how ethylene glycol elevates the boiling point of water and walking through sample calculations, candidates can better appreciate the practical significance of colligative properties. Collectively, these strategies move candidates beyond rote learning and foster a deeper, applied understanding of the topic.

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, candidates 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, candidates 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, candidates 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 candidates' interest and understanding of space.

Pedagogy: Think, Pair, and Share
Description: A collaborative learning technique where candidates 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. Candidates 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 candidates 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. Candidates 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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