

Aga Khan University Examination Board

Notes from E-Marking Centre on HSSC-II Chemistry Examination May 2018

Introduction:

This document has been produced for the teachers and candidates of Higher Secondary School Certificate (HSSC) Part II Chemistry. It contains comments on candidates' responses to the 2018 HSSC-II 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 which 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.

General Comments:

In Constructed Response Questions (CRQs), the candidates displayed better understanding of the concepts such as acid-base behaviour of oxides of group 4 elements, reactivity of Grignard's reagent, sources of organic compounds and infrared spectrum of carboxylic acid derivatives. On the other hand, they showed weak understanding and need more focus on concepts; like, reaction of KMnO_4 , IUPAC system for naming different phenols, reactions of alkyne carboxylic acid and precipitation of milk protein.

In Extended Response Questions (ERQs), they showed general understanding about the structure of benzene, but they need to study resonance in benzene with the help of Kekule and Dewar structures. Similarly, they showed good understanding of reactivity of aldehydes and ketones, but they need more focus on their reaction. They showed good performance in explaining the environmental problems related to oxides of sulphur or carbon, and polymerization reaction.

Detailed Comments:

Constructed Response Questions (CRQs)

Question 1a:

What is the trend of acidity of the oxides of group IVA elements?

Better responses mentioned that oxides of the elements at the top of group IVA are acidic and the acidity falls as you go down the group or decrease as we move from top to bottom in the group of periodic table.

Example:

a. What is the trend of acidity of the oxides of group IVA elements?	(1 Mark)
Acidity of oxides of group IVA elements decrease down the group.	

Weaker responses showed poor understanding of group trends of oxides of group IVA elements. Most of these candidates wrongly described that the acidity of oxides of group IVA elements increase as we move down the group or from top to bottom in the periodic table. Some of the candidates discussed about trend of oxides in the period which was not the demand of that question.

Example:

a. What is the trend of acidity of the oxides of group IVA elements?	(1 Mark)
Acidity of oxides increase down the group.	

Question 1b:

Compare the reactivity of carbon dioxide (CO_2) and silicon dioxide (SiO_2) with respect to their reaction with

- i. water.
- ii. sodium hydroxide.

Better responses compared the reactivity of carbon dioxide (CO_2) and silicon dioxide (SiO_2) with water and sodium hydroxide. They described that CO_2 reacts with water to form carbonic acid or hydrogen carbonate ions, while SiO_2 doesn't react with water. Similarly, they identified that CO_2 reacts with sodium hydroxide solution to form either sodium carbonate or sodium hydrogen carbonate solution, while SiO_2 does not react with sodium hydroxide solution under normal conditions.

Example:

b. Compare the reactivity of carbon dioxide (CO_2) and silicon dioxide (SiO_2) with respect to their reaction with

- i. water.

(2 Marks)

CO_2 readily reacts with water to give carbonic acid, while SiO_2 does not react with water. Hence CO_2 is more reactive than SiO_2 .

- ii. sodium hydroxide.

(2 Marks)

CO_2 readily reacts with ~~water~~ NaOH to give sodium bicarbonate salt, while SiO_2 does not react with NaOH . Hence CO_2 is more reactive than SiO_2 .

Weaker responses depicted lack of knowledge of acid-base behaviour of oxides of group VIA elements. They were not able to compare the reactivity of carbon dioxide (CO_2) and silicon dioxide (SiO_2) with water and sodium hydroxide. In most cases, these candidates illustrated that the reactivity of SiO_2 is higher with water and sodium hydroxide in comparison to reactivity of CO_2 . They further provided explanation for their wrong answer, and mentioned that because the size of silicon is larger compared to carbon, therefore; it can react more readily than carbon.

Example:

b. Compare the reactivity of carbon dioxide (CO_2) and silicon dioxide (SiO_2) with respect to their reaction with

i. water. (2 Marks)

SiO_2 is more soluble in water than the CO_2 because of its bigger size than CO_2 and that's why they are more reactive.

ii. sodium hydroxide. (2 Marks)

SiO_2 is more reactive than CO_2 because its Si is less crowded and atoms can easily attach to it.

Question 2

- a. Write a complete balanced chemical equation to show the reaction of KMnO_4 with
- iron sulphate (FeSO_4).
 - oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$).
- b. Identify the substance which is reduced in the reaction in part i.

Better responses provided complete and balanced chemical equation to show the reaction of KMnO_4 with both iron sulphate (FeSO_4) and oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$). In each case, they showed products formed during this reaction such as K_2SO_4 and MnSO_4 , while considering the oxidation reduction reaction, they balanced the number of hydrogen and oxygen using H_2SO_4 on the left hand side and H_2O on the right hand side of the equations. In part **b**, they further correctly identified that KMnO_4 is reduced in the reaction in sub part **i**.

Example:

i.	iron sulphate (FeSO_4).	(2 Marks)
$2\text{KMnO}_4 + 10\text{FeSO}_4 + 8\text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{MnSO}_4 + 5\text{Fe}_2(\text{SO}_4)_3 + 8\text{H}_2\text{O}$		
ii.	oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$).	(2 Marks)
$2\text{KMnO}_4 + 3\text{H}_2\text{SO}_4 + 5\text{H}_2\text{C}_2\text{O}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{MnSO}_4 + 10\text{CO}_2 + 8\text{H}_2\text{O}$		
b.	Identify the substance which is reduced in the reaction in part i.	(1 Mark)
<u>Manganese (Mn) is reduced from +7 to +2.</u>		

Weaker responses showed lack of grip on oxidation reduction reactions and were unable to write complete and balanced chemical equation to show the reaction of KMnO_4 with iron sulphate (FeSO_4) or oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$). Most of these candidates provided incomplete reaction with only one or two products i.e., K_2SO_4 , MnSO_4 , while some of these candidates even could not write these products as well and gave wrong formula of products; like, MnO_2 , KH_2C_2 and FeKO_4 . Furthermore, they did not mention the involvement of acid i.e., H_2SO_4 on left hand side of equation or water on the right hand side of equation. In part b, these candidates wrongly identified iron as substance which is reduced instead of manganese.

Example:

i.	iron sulphate (FeSO_4).	(2 Marks)
$\text{FeSO}_4 + \text{KMnO}_4 \longrightarrow \text{FeKO}_4 + \text{MnSO}_4$		
ii.	oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$).	(2 Marks)
$\text{C}_2\text{H}_2\text{O}_4 + \text{KMnO}_4 \longrightarrow \text{KH}_2\text{C}_2 + \text{MnO}_2 + \text{H}_2\text{O}$		
b.	Identify the substance which is reduced in the reaction in part i.	(1 Mark)
<u>Iron.</u>		

Question 3:

- a. Why are Grignard reagents more reactive as compared to most of the other organic compounds?
- b. Write a chemical equation to show the reaction of
 - i. propyl magnesium bromide with carbon dioxide.
 - ii. methyl magnesium bromide with propanone.
 - iii. ethyl magnesium bromide with ethanal.

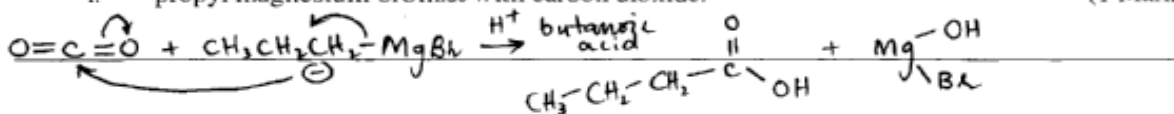
Better responses correctly described that Grignard reagents are more reactive as compared to most of the other organic compounds because of the nature of C-Mg bond which is highly polar. In part **b**, they were able to clearly write chemical equation to show the reaction of each given alkyl magnesium halide with the other reactant. For example, they showed reaction of propyl magnesium bromide with carbon dioxide which gives carboxylic acid, reaction of propanone with methyl magnesium bromide to form tertiary alcohol, and reaction of ethyl magnesium bromide with ethanal to yield secondary alcohol.

Example:

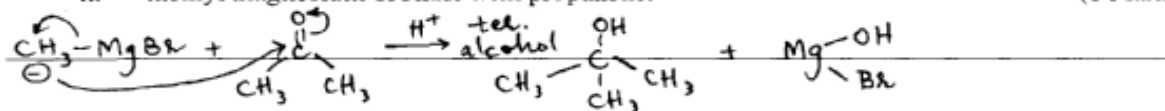
Mg is a very electropositive atom relative to Carbon, causing carbon to be very nucleophilic and hence reactive compound compared to others.

b. Write a chemical equation to show the reaction of

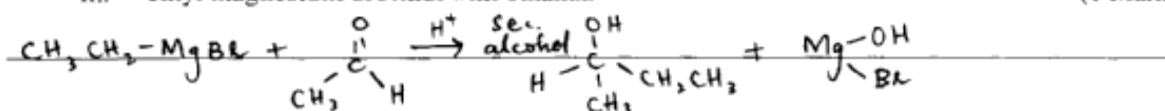
i. propyl magnesium bromide with carbon dioxide. (1 Mark)



ii. methyl magnesium bromide with propanone. (1 Mark)



iii. ethyl magnesium bromide with ethanal. (1 Mark)



Weaker responses exhibited poor understanding about the preparation and reactivity of Grignard's reagent with carbon dioxide, ketones and aldehydes. In part **a**, they were unable to provide correct reason for the high reactivity of Grignard reagents compared to other organic compounds. Most of these candidates wrote about the presence of magnesium or halide but did not write any description in relation to bond polarity or electronegativity/electropositivity. In part **b**, these candidates struggled to translate the names of given Grignard's reagent and other reactants to their correct structure, which lead to wrong identification of products. In some cases, out of two reactants, one of the structures was correct but again the product was inappropriate.

Example:

Grignard reagents are more reactive because of their instability and presence of a halide and magnesium

b. Write a chemical equation to show the reaction of

i. propyl magnesium bromide with carbon dioxide. (1 Mark)

$$\text{CO}_2 + \text{CH}_3 - \overset{\text{Mg}}{\underset{\text{Br}}{\text{CH}}} - \text{CH}_2 \longrightarrow \text{CH}_3 - \overset{\text{Mg}}{\text{CH}} - \overset{\text{Br}}{\text{CH}} - \overset{\text{Br}}{\text{CH}} - \overset{\text{O}}{\parallel} \text{C} - \text{OH}$$

ii. methyl magnesium bromide with propanone. (1 Mark)

$$\text{CH}_3 - \overset{\text{O}}{\parallel} - \text{CH}_2 - \text{CH}_3 + \text{Br} - \overset{\text{Mg}}{\underset{\text{Br}}{\text{CH}}} \longrightarrow \text{CH}_3 - \overset{\text{Mg}}{\text{CH}} - \overset{\text{Br}}{\text{CH}} - \text{CH}_2 + \text{H}_2\text{O} + \text{HBr}$$

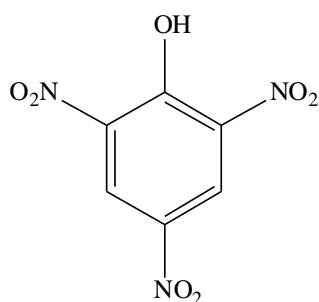
iii. ethyl magnesium bromide with ethanal. (1 Mark)

$$\text{CH}_3 - \overset{\text{O}}{\parallel} - \text{H} + \text{CH}_2 - \overset{\text{Mg}}{\underset{\text{Br}}{\text{CH}}} \longrightarrow \text{CH}_3 - \overset{\text{Br}}{\text{CH}} - \overset{\text{O}}{\parallel} - \text{H} + \text{CH}_3 - \overset{\text{Mg}}{\text{CH}}_2$$

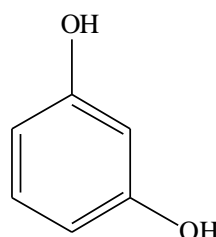
Question 4a:

Write the IUPAC names of the following phenols.

i.



ii.



Better responses correctly identified the IUPAC name of the given alcohols as 2,4,6-Trinitrophenol and 1,3-Dihydroxy benzene in part **i** and **ii** respectively.

Example:

i.	(1 Mark)
2,4,6-Trinitrophenol	
ii.	(1 Mark)
1,3-dihydroxybenzene	

Weaker responses depicted lack of knowledge about the IUPAC rules and provided wrong names of the given phenols. In part **i**, they used correct numbering, but gave incorrect names as 2,4,6-Trinitrocyclohexane. Similarly, in part **ii** they were unable to provide correct numbering, IUPAC name. In both cases, they showed confusion and wrongly identified the given structure as cyclohexane.

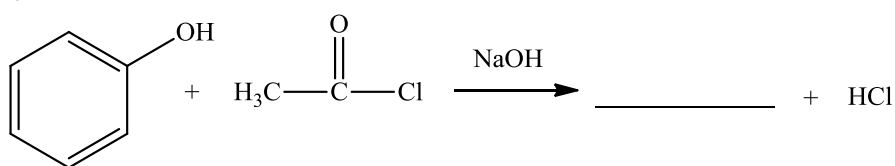
Example:

i.	(1 Mark)
<p>2,4,6-Trinitrophenol</p>	
ii.	(1 Mark)
<p>Cyclohexanol</p>	

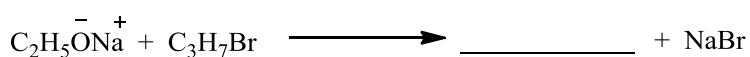
Question 4b:

Complete the given reactions by writing the missing products.

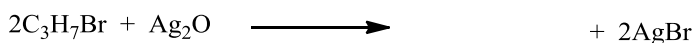
i.



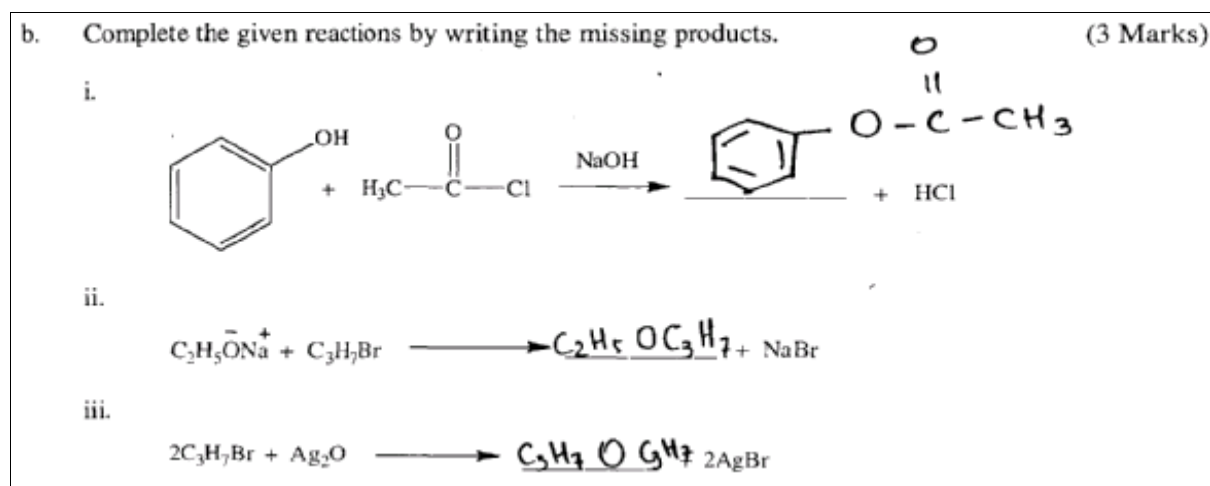
ii.



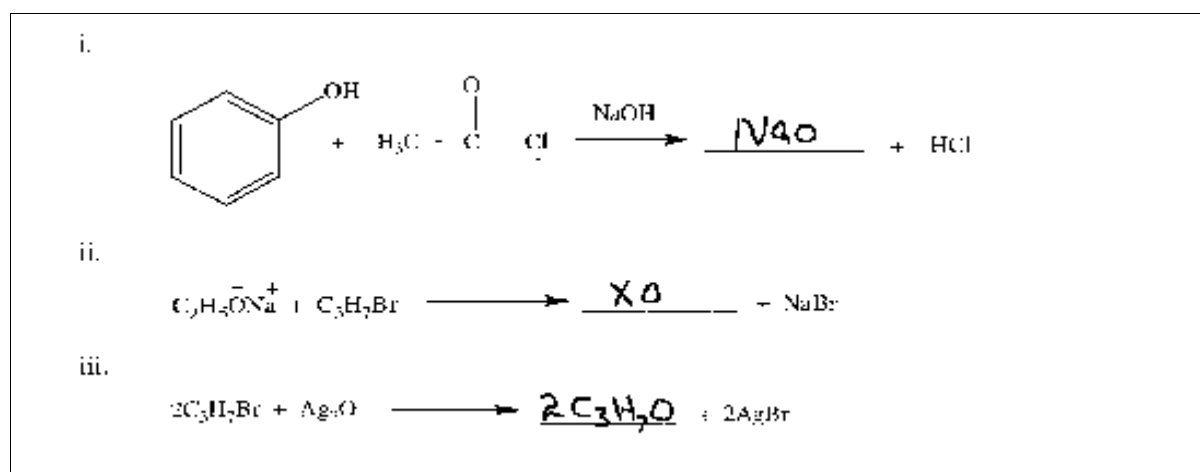
iii.



Better responses completed the given reactions with missing products. They represented correct product as ester for the reaction when phenol reacts with acetyl chloride in the presence of a base. On the other hand, the other two reactions were related to the preparation of ethers, where they showed correct structure of ether formed by the reaction of alkoxide with alkyl halide or by reaction of alkyl halide with silver oxide.

Example:

Weaker responses exhibited lack of understanding of organic reactions related to reactivity of phenols or preparation of ether through Williamson synthesis. They were unable to identify correct structure of product in each case. In part i, instead of reacting hydroxyl group of phenol with acetyl chloride most of the candidates showed electrophilic aromatic substitution reaction of phenol and represented acetylation over aromatic ring. Some of these candidates showed the structure of phenoxide ion. In part ii and iii, they showed irrelevant structure with less or more number of carbon atom with variety of other functional groups such as aldehyde, ketone, alkyl halide and alcohol.

Example:

Question 5a:

Write the IUPAC names of the given organic compounds following the rules of nomenclature.

Organic Compound	IUPAC Name
$\begin{array}{ccccccc} & \text{CH}_3 & & & \text{CH}_3 & & \\ & & & & & & \\ \text{H}_3\text{C} & -\text{C} & =\text{CH} & -\text{CH}_2 & -\text{C} & -\text{CH}_3 & \\ & & & & & & \\ & & & & \text{CH}_3 & & \end{array}$	
$\begin{array}{ccccccc} & \text{CH}_3 & & \text{CH}_3 & & & \\ & & & & & & \\ \text{CH}_3 & -\text{C} & - & \text{C} & -\text{CH}_3 & & \\ & & & & & & \\ & \text{CH}_3 & & \text{CH}_3 & & & \end{array}$	

Better responses correctly identified the IUPAC name of the given organic compounds as 2,5,5-Trimethyl-2-hexene and 2,2,3,3-Tetramethyl butane.

Example:

Organic Compound	IUPAC Name
$\begin{array}{ccccccc} & \text{CH}_3 & & & \text{CH}_3 & & \\ & & & & & & \\ \text{H}_3\text{C} & -\text{C} & =\text{CH} & -\text{CH}_2 & -\text{C} & -\text{CH}_3 & \\ & & & & & & \\ & & & & \text{CH}_3 & & \end{array}$	2,5,5-Trimethyl-2-hexene
$\begin{array}{ccccccc} & \text{CH}_3 & & \text{CH}_3 & & & \\ & & & & & & \\ \text{CH}_3 & -\text{C} & - & \text{C} & -\text{CH}_3 & & \\ & & & & & & \\ & \text{CH}_3 & & \text{CH}_3 & & & \end{array}$	2,2,3,3-Tetramethylbutane

Weaker responses showed poor understanding about nomenclature of organic molecules focusing on sigma and pi carbon-carbon bonds such as alkane and alkene. In case of given alkene, most of these candidates selected the long chain of carbon atom, but were unable to do correct numbering. Some of these candidates had correct numbering, but did not mention position of alkene and an additional methyl group present. Similarly, in case of alkane they again selected long chain of carbon and provided correct numbering, but were unable to mention two additional methyl groups present.

Example:

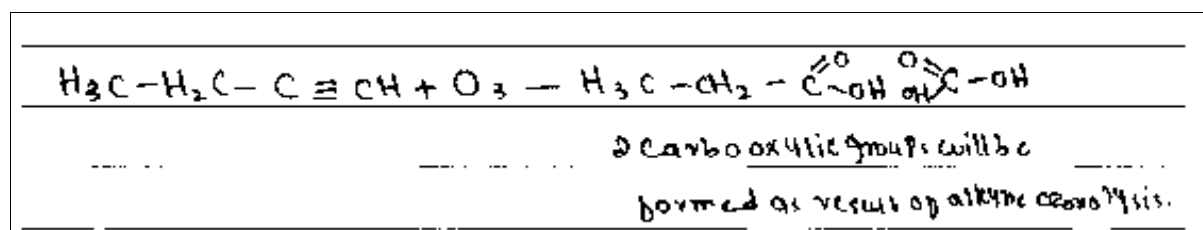
Organic Compound	IUPAC Name
$\begin{array}{ccccccc} & \text{CH}_3 & & & \text{CH}_3 & & \\ & & & & & & \\ \text{H}_3\text{C} & -\text{C} & = & \text{CH} & - & \text{CH}_2 & - & \text{C} & - & \text{CH}_3 \\ & & & & & & & & & \\ & & & & & & & \text{CH}_3 & & \end{array}$	2,5 di methyl hexene
$\begin{array}{ccccccc} & \text{CH}_3 & & \text{CH}_3 & & & \\ & & & & & & \\ \text{CH}_3 & - & \text{C} & - & \text{C} & - & \text{CH}_3 \\ & & & & & & \\ & \text{CH}_3 & & \text{CH}_3 & & & \end{array}$	2,4 di methyl butane

Question 5b:

Write a chemical equation to show the reaction of 1-butyne with ozone (O₃).

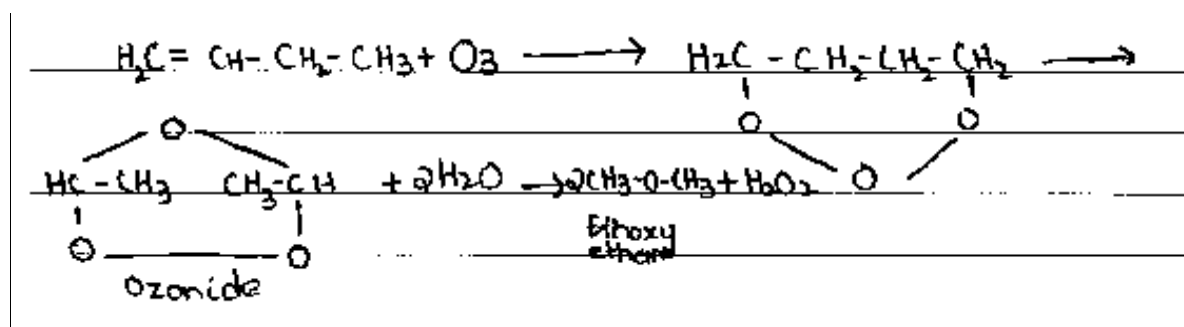
Better responses depicted in-depth understanding of reaction of alkyne with ozone and identified correct structure of two products i.e. propanoic acid and carbonic acid or CO₂.

Example:



Weaker responses displayed two major mistakes in their answers. First, they were not able to translate 1-butyne to its correct structure and drawn structure of alkene. Secondly, instead of writing the structure of carboxylic acid and carbonic acid, they tried to show the mechanism involved in the ozonolysis of alkene using the structure of molozonide or ozonide.

Example:



Question 6a:

Which of the following carboxylic acids is more acidic? Give reason for your selection.

- FCH_2COOH
- ClCH_2COOH

Better responses were able to identify FCH_2COOH as more acidic carboxylic acid and provided correct reason for their selection. They mentioned that fluorine has high electronegativity as compared to chlorine atom, therefore; it stabilises the carboxylate ion formed after removal of proton and makes it more acidic.

Example:

FCH_2COOH is more acidic than ClCH_2COOH because the electron-withdrawing effect of fluorine is higher than chlorine substituent group as the electronegativity of fluorine is the highest which makes the removal / deprotonation of carboxylic acid easier and stabilizes the carboxylate ion.

Weaker responses were unable to recognise acidic behaviour of carboxylic acid on the basis of substituent attached at alpha carbon atom. They identified ClCH_2COOH as more acidic carboxylic acid and provided illogical reasoning considering high electronegativity of fluorine or low electronegativity of chlorine atom.

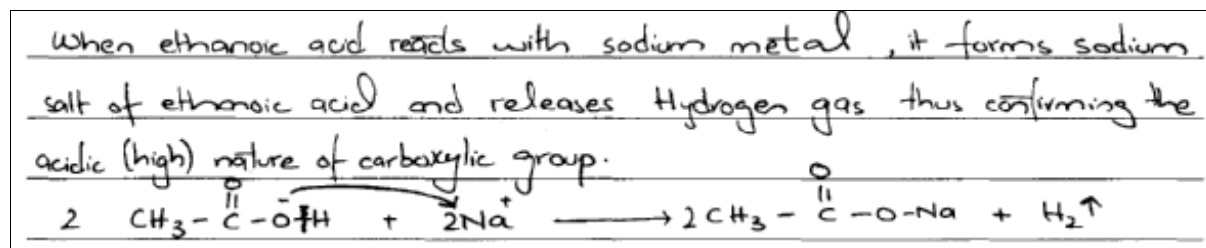
Example:

ClCH_2COOH is more acidic due to low electronegativity difference. H^+ & Cl^- ions can be easily removed.

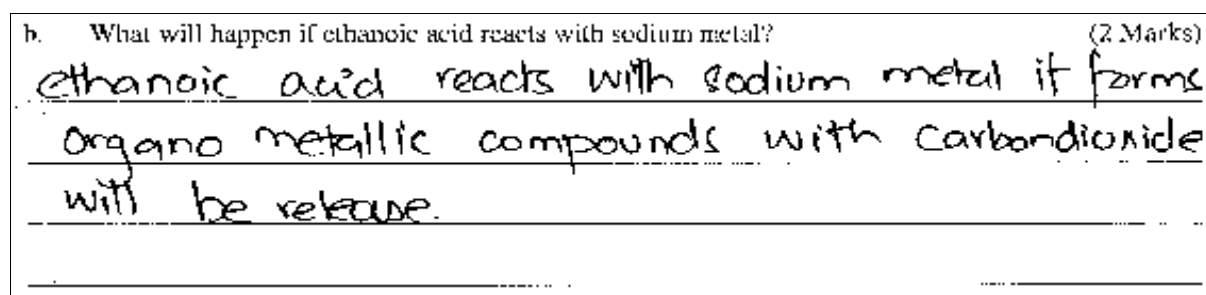
Question 6b:

What will happen if ethanoic acid reacts with sodium metal?

Better responses illustrated good knowledge of reactions of carboxylic acid and mentioned that when ethanoic acid reacts with sodium metal it forms sodium acetate with release of hydrogen gas. Some of these candidates wrote complete and balanced chemical equation mentioning both the reactants and products.

Example:

Weaker responses were not able to predict the outcome of that reaction due to poor understanding of reactions of carboxylic acid. Some of these candidates tried to write a chemical equation to show that reaction, but they were not able to translate ethanoic acid to its correct structure. Majority of these candidates suggested the formation of organometallic compound while few candidates showed reaction of sodium with carbonyl carbon of ethanoic acid.

Example:**Question 7:**

Name and describe any TWO sources of organic compounds.

Better responses mentioned and described two sources of organic compounds. In most cases, they mentioned coal and petroleum as major source of organic compounds and provided appropriate description. Some of these candidates mentioned natural gas and natural products including plants and animals as source of organic compound with their descriptions.

Example:

- Plants: plants are natural source of organic compounds like terpenes from trees, aromatic hydrocarbons from herbs like fennel seeds and tea plant are obtained
- Coal: By destructive distillation of coal coal tar, coke, coal gas is obtained which on further dist. fractional distillation and processes gives benzene, toluene, phenol, methane and many other useful organic compounds.

Weaker responses failed to identify and describe two sources of organic compounds. Majority of these responses tried to describe organic compound rather than providing their sources. Some of these candidates discussed about isomerism and their types while few of these provided description about catenation or hydrocarbons.

Example:

Name and describe any TWO sources of organic compounds.

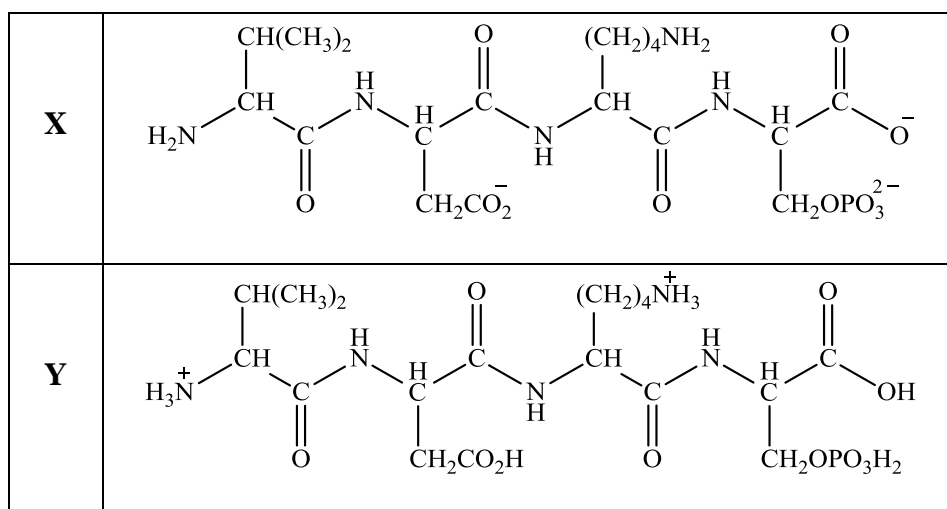
Organic compound exist in a really great number all around us.

1) Due to the catenation of organic compound and their link between each other, new organic compounds can be formed.

2) Organic compounds can also be found out in the old ~~comp.~~ compounds of organic compounds

Question 8:

Casein, a milk protein, contains a large number of phosphate groups attached to the amino acid side chains in its polypeptide structure. The effect of pH on the solubility of casein reflects the ionisation of the acidic and basic groups in its structure.



- a. Identify the structure (**X** or **Y**) which shows the existence of casein protein at
- low pH.
 - high pH.
- b. At what pH, precipitation of casein occurs? Explain your answer with reasoning.

Better responses were able to correctly distinguish both the structures X and Y and identified the existence of casein protein at different pH. In part b, they mentioned that the isoelectric point (IEP) for casein is approximately 4.6 and it is the pH value at which casein is precipitated. They further explained that originally casein possess a net negative charge, but during the addition of acid to milk, this negative charge on the outer surface of the micelle neutralised/ phosphate groups are protonated, and the neutral protein precipitates.

Example:

a.	Identify the structure (X or Y) which shows the existence of casein protein at	
i.	low pH.	(1 Mark)
	Y	
ii.	high pH.	(1 Mark)
	X	
b.	At what pH precipitation of casein occurs? Explain your answer with reasoning.	(3 Marks)
	Precipitation of casein occurs at 4.5 pH when pH of milk drops from 6 to 4.5 pH. This pH is the isoelectric point of casein that means its net charge becomes zero and it starts to precipitate causing the milk to curd.	

Weaker responses demonstrated poor understanding about structures of casein protein at different pH. These candidates wrongly identified the existence of casein protein at low pH with structure X and at high pH with structure Y. In part b, they were unable to discuss about isoelectric point of casein and failed to explain how casein gets precipitated. Majority of these responses generally discussed about the denaturation of protein and described that at low pH, casein gets denature and the structure of casein breaks apart due to that solubility of casein is decreased and it appeared as clumps.

Example:

a. Identify the structure (X or Y) which shows the existence of casein protein at

i. low pH. (1 Mark)

X

ii. high pH. (1 Mark)

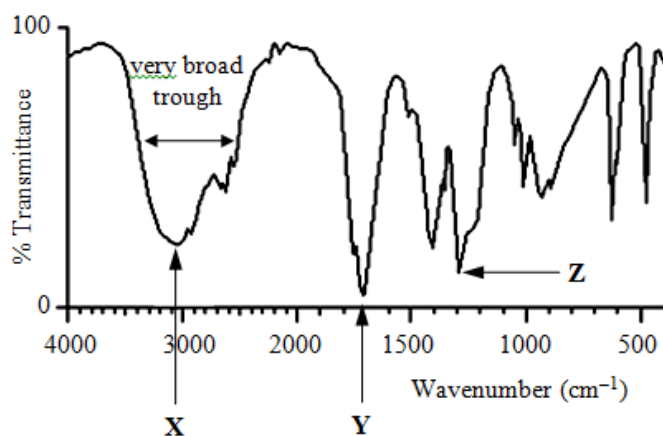
Y

b. At what pH precipitation of casein occurs? Explain your answer with reasoning. (3 Marks)

Acidic pH is lower than 7 eg pH of citric acid causes the precipitation of casein in milk. When the pH decreases it denatures the protein causing its structure to break and unfold. These then combine and cluster together to form clumps

Question 9:

Given below is an infrared spectrum showing peaks X, Y and Z.



Bond	Range (cm ⁻¹)
O-H (alcohols)	3230 – 3550
O-H (acids)	2500 – 3000
C=C	1620 – 1680
C=O	1680 – 1750
C-O	1000 – 1300
C-H	2850 – 3300

- a. Match the peaks X, Y and Z with the CORRECT type of bonds in the given table.
b. Based on the information given, encircle the compound to which the spectrum belongs.

- Acetone
- Ethanoic acid
- Benzene
- Ethanol

Better responses managed to clearly recognise the infrared spectrum of the given compound and mentioned each peak with correct type of bonds in the given table. They correctly identified very broad peak **X** as O-H (acid) at 2500 cm⁻¹ to 3000 cm⁻¹, peak **Y** as C=O at 1680 cm⁻¹ to 1750 cm⁻¹, and peak **Z** as C-O at 1000 cm⁻¹ to 1300 cm⁻¹. In part b, based on the information in part a, they showed that the given spectrum belongs to ethanoic acid.

Example:

a.	Match the peaks X , Y and Z with the CORRECT type of bonds in the given table.	(3 Marks)
	X = <u>O-H (acids)</u>	
	Y = <u>C=O</u>	
	Z = <u>C-O</u>	
b.	Based on the information given, encircle the compound to which the spectrum belongs.	(1 Mark)
i.	Acetone	
ii.	<u>Ethanoic acid</u>	
iii.	Benzene	
iv.	Ethanol	

Weaker responses made the wrong judgments about the peaks highlighted in the infrared spectrum of the given compound and were not able to match each peak with correct type of bonds in the given table. Instead of selecting hydroxyl group of carboxylic acid (O-H acid) as peak **X** they identified hydroxyl group of alcohol (O-H alcohol). Similarly, they selected C=C and C-H bonds as **Y** and **Z** instead of C=O and C-O respectively. Some of these candidates were able to correctly identify O-H of carboxylic acid, but wrongly recognised aldehyde or alcohol at other two positions. Finally, based on information in part **a**, they encircled wrong compound in part **b**.

Example:

a.	Match the peaks X , Y and Z with the CORRECT type of bonds in the given table.	(3 Marks)
	X = <u>Carboxylic acid</u>	
	Y = <u>aldehyde</u>	
	Z = <u>alcohol</u>	
b.	Based on the information given, encircle the compound to which the spectrum belongs.	(1 Mark)
i.	Acetone	
ii.	Ethanoic acid	
iii.	Benzene	
iv.	<u>Ethanol</u>	

Extended Response Questions (ERQs)

These questions offered a choice between part **a** and **b**

Most of the candidates attempted **10a** and performed better compared to **10b**.

Question 10a:

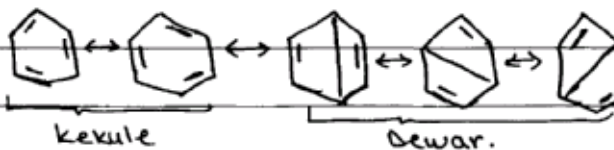
- What is resonance?
- Explain the resonance in benzene with the help of Kekule and Dewar structures.

Better responses correctly defined resonance as the possibility of different pairing schemes of valence electrons of atom. They further explained the resonance in benzene with the help of Kekule and Dewar structures. They showed Kekule and Dewar structures and mentioned that the stability of benzene molecule increases with increase in the number of its resonance structures. They discussed about the major and minor contribution of Kekule and Dewar structures, respectively, in the actual structure of benzene. Finally, these candidates mentioned about resonance hybrid and alternating pi bonds present in benzene molecule.

Example:

- Resonance is defined as the different pairing schemes of the electrons of valance shell, to form a stable configuration.
- Benzene also exhibits the Phenomena of resonance proposed by ke kule and Dewar. Resonance is responsible for the stability of benzene ring. In early years, chemists were finding difficulties to propose the structure of benzene, straight chain ruled out because of the cyclic nature of benzene ring and its formula - C_6H_6 doesn't fit in any of The series like

alkanes, alkenes or alkynes. Finally benzene is defined to have a compound with alternating double and single bonds which can be proved by The hydrogenation reaction. kekule on this basis proposed following structures:



- Due to more bond lengths

of carbons in Dewar structure, it's energetically unfavourable and hence contributes very less in original ring structure. whereas the Kekule structure are energetically favourable and hence contribute more in finding original structure.

When we calculated the hydrogenation energy of hypothetical ring and compared it with the observed hydrogenation energy, it proved that the actual benzene ring is more stable by an energy of -150kJ which is known as resonance energy.

• Hence the stability of benzene ring is due to these resonance hybrid structures, alternating with each other.

Weaker responses exhibited poor understanding of structure of benzene molecule and were failed to explain the phenomenon of resonance and stability of benzene with the help of Kekule and Dewar structures. Some of these candidates gave actual definition of resonance but were unable to describe resonance in benzene in terms of its resonating structure. Majority of these candidates tried to write the mechanism of electrophilic substitution reaction in benzene with appropriate structure showing attack of electrophile, shifting of pi bonds/ stability of carbocation. They provided wrong description about Kekule and Dewar structures and did not mention about major or minor contribution of each structure. Moreover, they did not discuss about conjugated bonds and resonance hybrid in benzene.

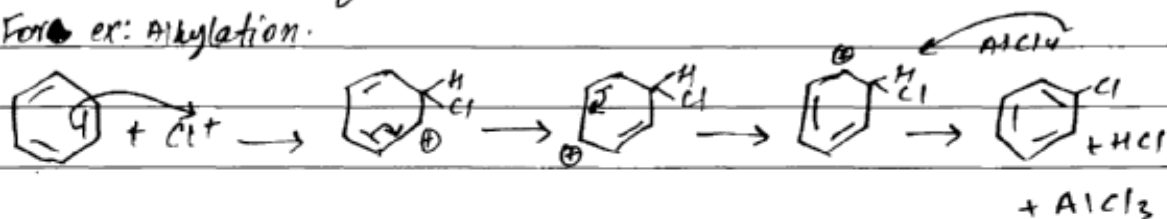
Example:

a) i) The phenomenon that usually occurs in those compounds having alternate double bonds due to conjugation or delocalization is called resonance. and the molecules that exhibit resonance are called resonating structures. It is usually the shifting of pi bonds that creates resonance.

ii) Benzene is a molecule having alternate double bonds that takes part in creating resonance. In benzene the pi bonds are delocalized and hence resonance

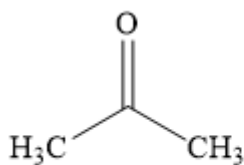
occurs. This resonance can be seen in nucleophilic substitution reactions of benzene.

For ex: Alkylation.

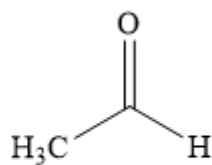


The property of resonance makes a molecule more reactive due to delocalization of π electrons and hence it is less stable and more active towards any chemical reaction.

Question 10b:



A

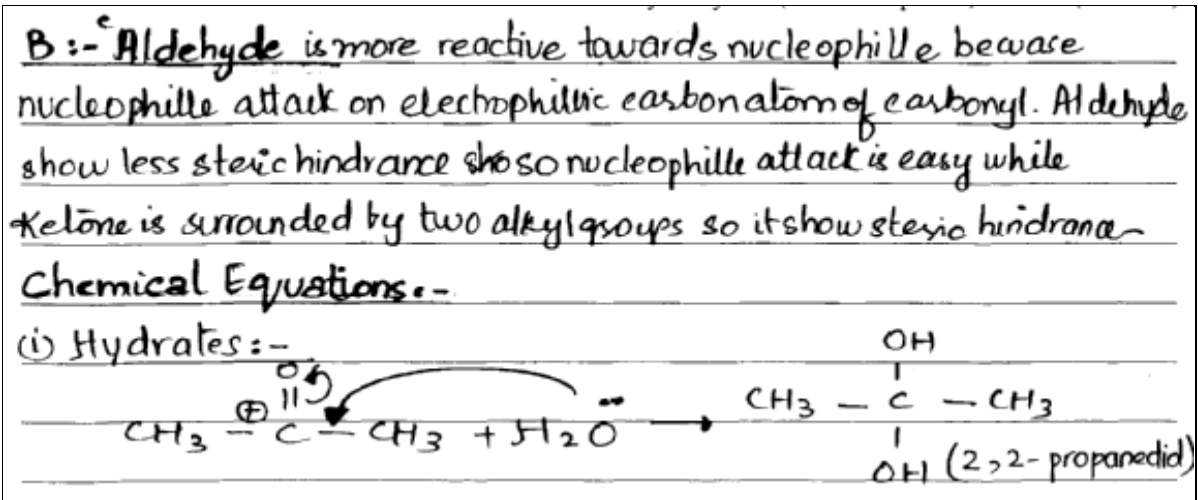


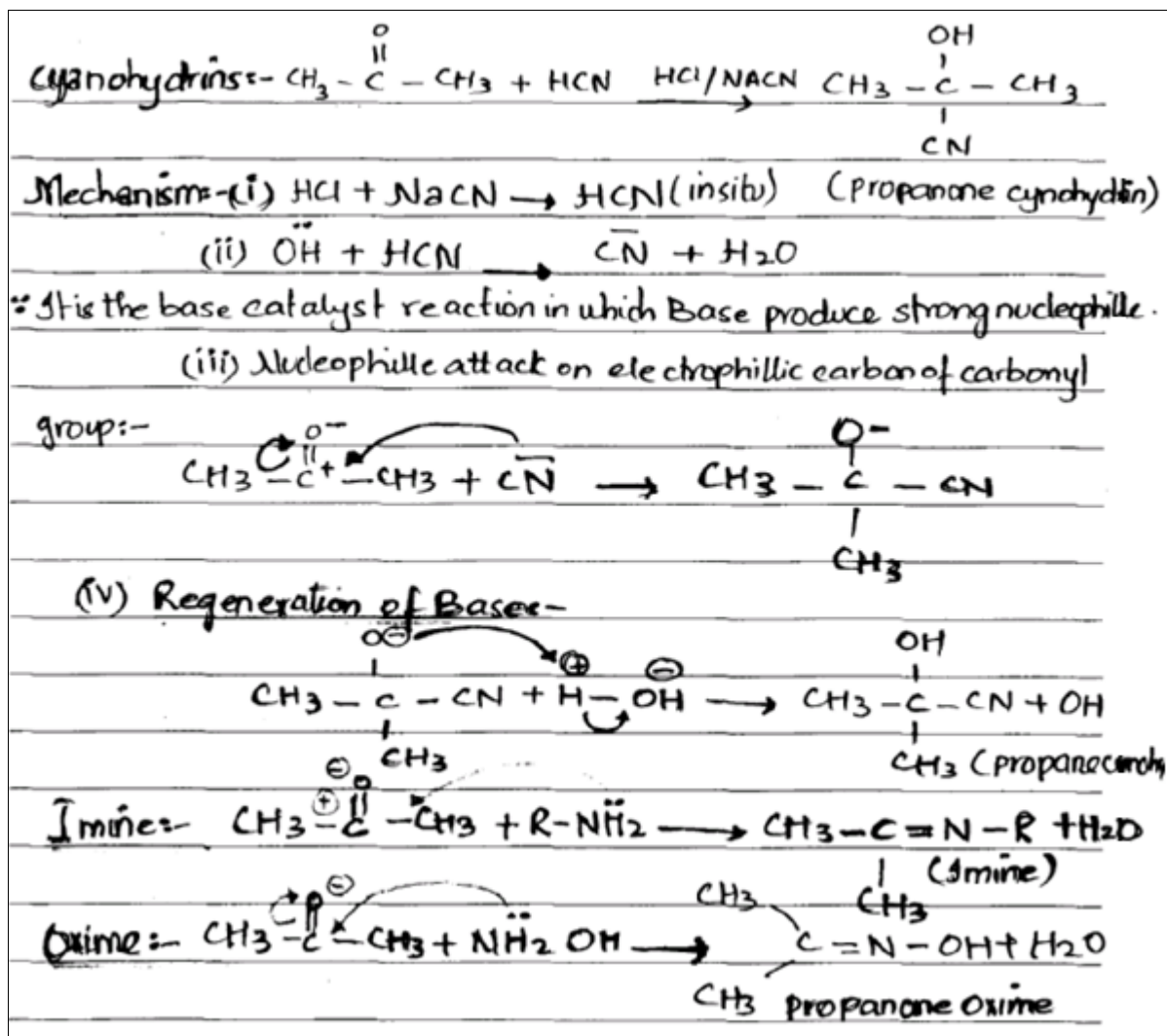
B

- i. Which of the given carbonyl compounds (**A** or **B**) is more reactive towards nucleophile. Give a reason for your answer.
- ii. Write a chemical equation using carbonyl compound **A** to show the formation of
 - I. hydrate.
 - II. cyanohydrin.
 - III. imine.
 - IV. oxime.
- iii. Write the mechanism for the formation of cyanohydrin (formed in part II).

Better responses correctly identified carbonyl compound **B** as more reactive compared to carbonyl compound **A**. They gave appropriate reason for their selection by mentioning that it is an aldehyde in which carbonyl carbon is more electrophilic as it contains only one alkyl group with less steric hindrance. In subpart **ii**, they wrote chemical equation with correct structures showing the formation of each product. In subpart **iii**, they provided correct mechanism for the formation of cyanohydrin including formation of CN^- ion, its attack as nucleophile and protonation.

Example:



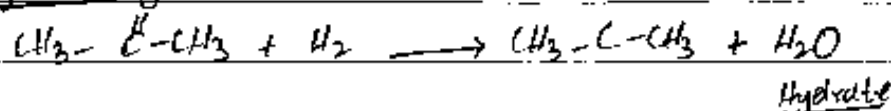


Weaker responses showed confusion in relation to stability and reactivity of a compound **A** and **B**. They had a wrong understanding that if a compound is more stable, it would be more reactive. They wrongly identified carbonyl compound **A** (ketone) as more reactive and gave reason that it is due to its high stability. In subpart **ii**, they showed lack of understanding of reaction of carbonyl compounds. They did not provide chemical equation to show the reaction of different reactants (water, HCN, amine and hydroxylamine) with carbonyl compound **A**. They were even not able to translate hydrate, cyanohydrin, imine and oxime to their correct structures to show atleast final product. In subpart **iii**, these candidates gave wrong mechanism for the formation of cyanohydrin and few candidates tried to represent hydrolysis of cyanohydrin through water molecule and mentioned removal of hydroxyl group of cyanohydrin and hydrogen of water.

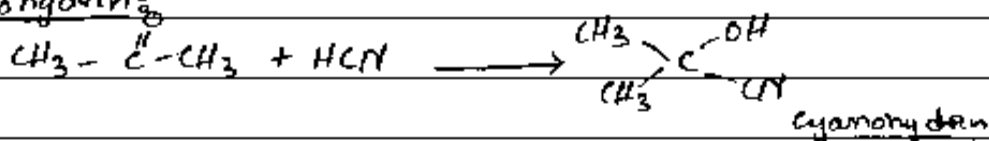
Example:

(i) The β Carbonyl Compound is more reactive towards nucleophile, because Aldehyde (β Carbonyl Compound) is more stable, its H molecule easily escape out (as a leaving group) from the mechanism.

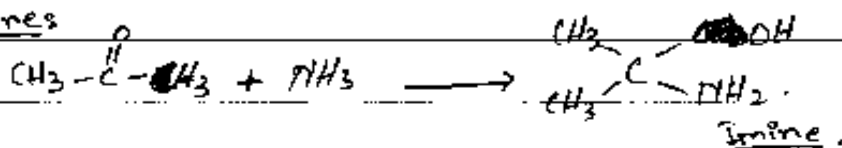
(ii) • Hydrates



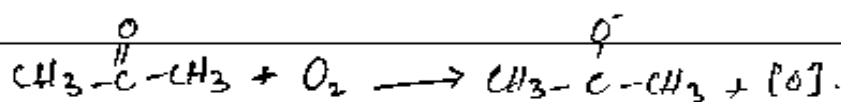
• Cyanohydrins



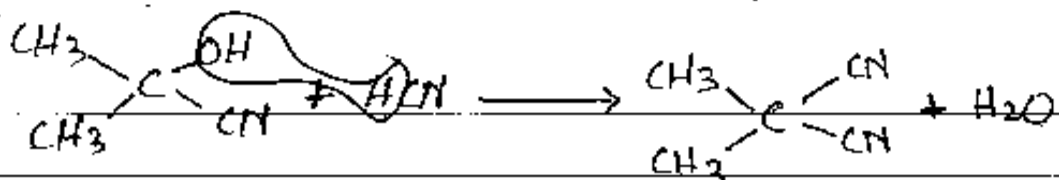
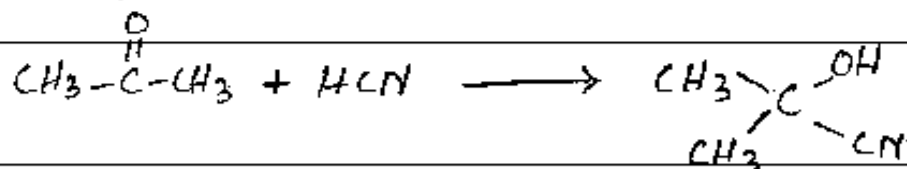
• Imines



• Oximes



(iii) • Cyanohydrins



Most of the candidates attempted **11a** and performed better compared to **11b**.

Question 11a:

- i. Explain any ONE environmental problem caused by the emission of each of the following.
- I. Oxides of sulphur
 - II. Oxides of carbon
- (Note: Write chemical equations where necessary to support your answer.)
- ii. Write any TWO negative impacts on the environment of any one of the problems described above.

Better responses correctly identified acid rain as one of the major environmental problem caused by the emission of oxides of sulphur, while global warming as another potential environmental problem associated with the emission of oxides of carbon. They further explained that how acid rain is formed using chemical equation. Similarly, they discussed about the greenhouse effect and global warming including the description of carbon dioxide as a greenhouse gas. In subpart **ii**, these responses further described the negative impacts of environmental problems identified in subpart **i**, such as acid rain damage building material, paint and plastic.

Example:

a i) I. oxides of sulphur: when oxides of sulphur are released in the atmosphere they react with water vapours to form sulphurous acid that then reacts with H_2O to form sulphuric acid.

$$SO_2 + H_2O \rightarrow HSO_3 \text{ (sulphurous acid)}$$
$$HSO_3 + H_2O \rightarrow H_2SO_4 \text{ (sulphuric acid)}$$
$$SO_2 + H_2O \rightarrow H_2SO_4$$

these then together with nitric acid fall as acid rain on buildings and road. Acid rain is caused when PH of rain water becomes slightly acidic due to various reaction of Sulphur in atmosphere.

II. oxides of carbon = normally there are gases present in

atmosphere that traps heat such as CO_2 . Increase amount of CO_2 in atmosphere traps more heat causing green-house effect but a major problem, ^{is caused} called global warming this, increases the overall temperature of atmosphere making the climate more hot. Gradual increase of CO_2 will cause high temperature effecting arctic and cold regions of Earth destroying habitat.

ii) oxides of sulphur has negative impacts; acid rain.

- 1) It damages monuments, statues, plastic and buildings.
- 2) It causes damage to plants and marine environment clearing essential minerals and making prone to disease

Weaker responses were unable to identify environmental problems associated with the emission of oxides of sulphur and carbon. Rather mentioning the environmental problem caused by oxides of sulphur, i.e. acid rain, they generally described the formation and source of oxides of sulphur in the atmosphere. Some of these candidates wrongly identified acid rain as one of the environmental problem caused by the oxides of carbon. Few candidates correctly identified acid rain as one of the environmental problem caused due to oxides of sulphur, but were unable to explain the formation of acid rain with chemical equations or had no discussion about pH. Similarly, they did not identify global warming and greenhouse effect associated with oxides of carbon and gave no information about increase in the earth's average temperature due to excessive release of several greenhouse gases. On the other hand, many candidates mixed up the concepts of acid rain, greenhouse effect and ozone layer together, and wrongly identified ozone layer depletion as one of the environmental cause due to oxides of sulphur. In subpart **ii**, they did not discuss negative impacts of environmental problems highlighted in part **i**, but gave general description about the negative impact of any environmental problems.

Example:

i) ~~Explain~~ → Environmental Problem by Sulphur.
 $S + O_2 \rightarrow SO_2$ (sulphur dioxide)
 $S + O_3 \rightarrow SO_3$ (sulphur trioxide).
When sulphur is emitted in the environment it combines with oxygen to form sulphur dioxide and combines with ozone to form sulphur trioxide. These both are ~~the~~ are harmful gases and are dangerous to human life.
→ Environmental Problems by Carbon.

$C + O_2 \rightarrow CO_2$ (Carbon dioxide)
When carbon meets ^{with} oxygen it produces carbon dioxide ~~with~~ which is dangerous ^{gas} ~~for~~ ^{for} animal/human life.

ii) IMPACTS.

i) Due to sulphur dioxide in environment it combines with water and produces acidic rain.

ii) By more carbon dioxide gas in environment it would be difficult ~~for~~ human being to breathe and aquatic life to survive.

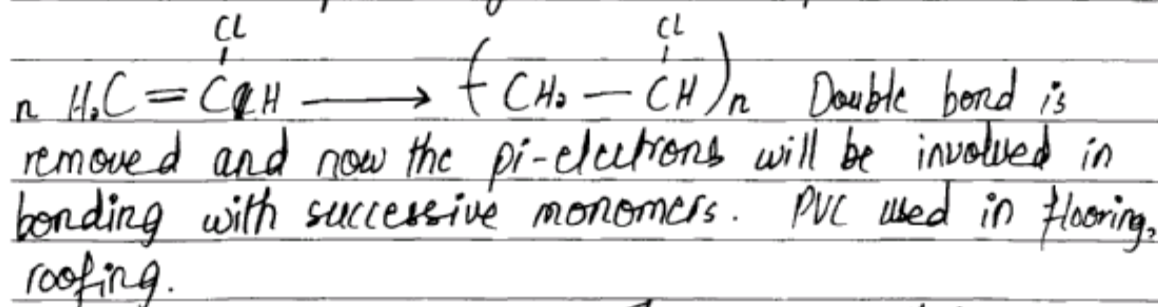
Question 11b:

- i. Describe the synthesis of polyvinyl chloride (PVC) and Nylon-6,6 using chemical equations.
- ii. Identify the type of polymerisation involved in the synthesis of EACH polymer in part i.

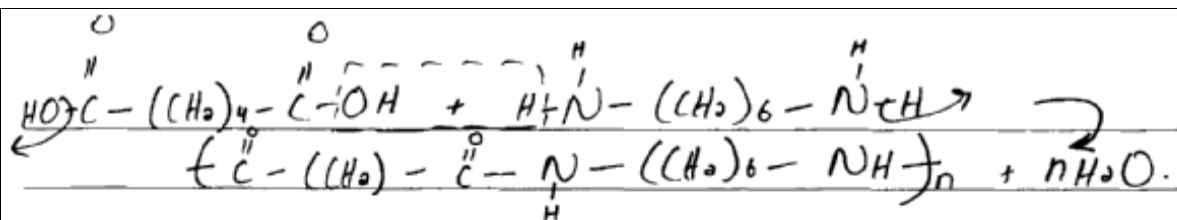
Better responses were able to describe the synthesis of polyvinyl chloride (PVC) and Nylon-6,6 using appropriate chemical equations. They represented correct structure of vinyl chloride and transformation of double bond to a single bond to form PVC. Similarly, they provided correct structure of hexamethylenediamine and adipic acid to show the formation of Nylon-6,6 with removal of water molecule. In subpart **ii**, they correctly identified the type of polymerisation involved in the synthesis of each polymer such as addition polymerisation for PVC and condensation polymerisation for Nylon-6,6.

Example:

i) Synthesis of PolyVinyl Chloride (PVC): The monomers that constitutes PVC is are Vinyl Chloride, whose repeating units makes up a larger molecule of PVC.



Synthesis of Nylon-6,6. The monomers that constitutes Nylon-6,6 are Adipic Acid (hexandioic Acid) and hexamethylene diamine molecules:



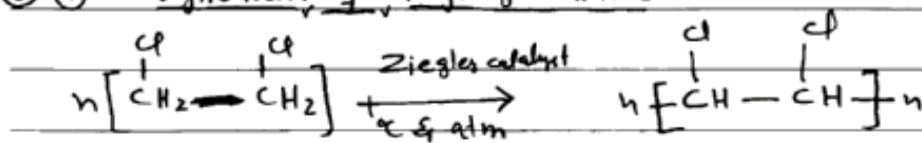
ii) PVC, formed by Addition polymerization, in which monomer units joined to form larger molecule that is polymer only and double bond removed.

Nylon 6-6, it is an example of condensation polymerization in which small repeating units that are monomers joined to form ~~large~~ polymers by the removal of some small molecule like H_2O or $\text{CH}_2\text{-OH}$.

Weaker responses exhibited poor understanding about the formation of PVC and Nylon-6,6 and were failed to describe the synthesis of these polymers. Majority of these candidates had knowledge that PVC is formed by vinyl chloride but they were unable to represent correct structure of vinyl chloride. As a result, they could not show correct structure of PVC. Similarly, these candidates showed wrong structure of adipic acid and hexamethylenediamine. In most cases, they mentioned $-(\text{CH}_2)_6-$ in adipic acid structure rather than mentioning it in the structure of hexamethylenediamine. Similarly, they mentioned $-(\text{CH}_2)_4-$ in hexamethylenediamine structure instead of mentioning it in adipic acid structure. Some of these candidates showed correct structure of adipic acid and hexamethylenediamine but were unable to join them properly with peptide linkage. Few of these candidates incorrectly identified the type of polymerisation involved in the synthesis of these polymers. For example, condensation polymerisation for PVC and addition polymerisation for Nylon-6,6.

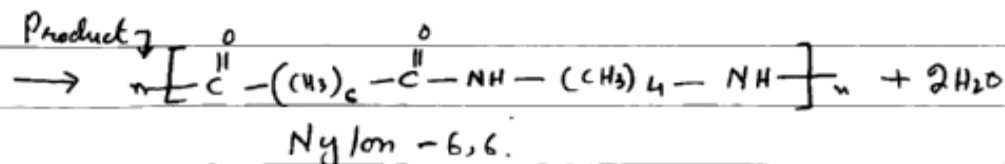
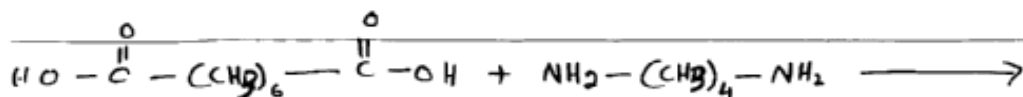
Example:

(b) (i) Synthesis of Polyvinyl chloride.



* Synthesis of Nylon-6,6

It is synthesised by polymerizing adipic acid and tetra methyl diamine.



(ii)

⇒ In the synthesis of PVC addition polymerization is involved. We used Ziegler catalyst and low temperature ~~and~~ ~~at~~ ~~and~~ ~~pressure~~, If we do not use Ziegler catalyst we must provide 4000 atm, 100°C.

⇒ In synthesis of Nylon-6,6 condensation polymerization is involved because ~~the~~ ^{one} ~~two~~ molecules of water are eliminated in this ~~type~~ synthesis.