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Student Number

NORTH SYDNEY GIRLS HIGH SCHOOL



2023

Higher School Certificate

Trial Examination

Chemistry

General Instructions

Reading Time – 5 mi

Working Time – 3 hours

Write using blue or black pen

Draw diagrams using pencil

Calculators approved by NESA may be used

A formulae sheet, data sheet and Periodic Ta
are provided

Write your student number at the top of thi
booklet and on the multiple choice answe
sheet.

Total Marks – 100

Weighting – 30%

Section I 20 Marks

Attempt Questions 1 - 20

Allow about 35 minutes for this section.

Section II 80 Marks

Attempt Questions 21 - 35

Allow about 2 hours and 25 minutes for this section.

Section I

20 marks

Attempt Questions 1–20

Allow about 35 minutes for this section

Use the multiple-choice answer sheet provided for Questions 1–20. If you must use blank paper instead, clearly indicate an answer of EITHER A, B, C or D for each question from 1–20.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ☐ B ☒ C ☐ D ☐

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

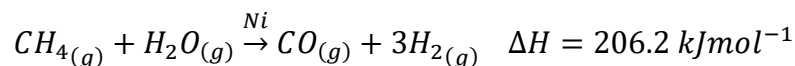
A ☒ B ☒ C ☐ D ☐

If you have changed your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:

A ☒ B ☒ C ☐ D ☐

correct ↖

- 1 The following reaction is carried out at standard temperature and pressure.



Which of the following statements is correct?

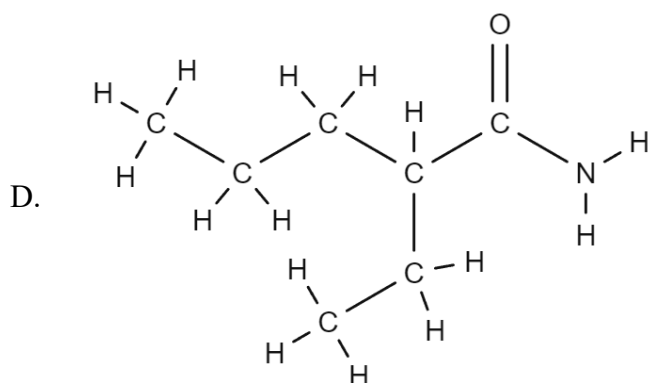
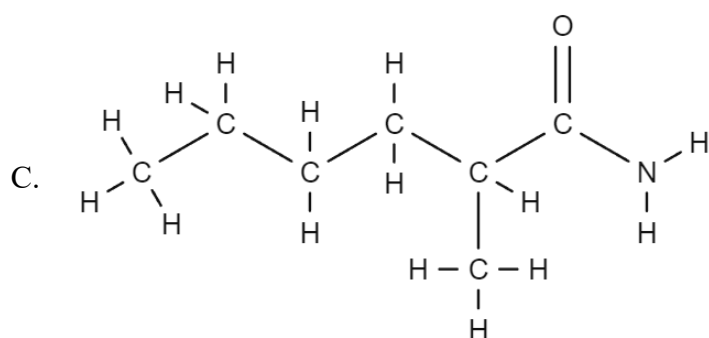
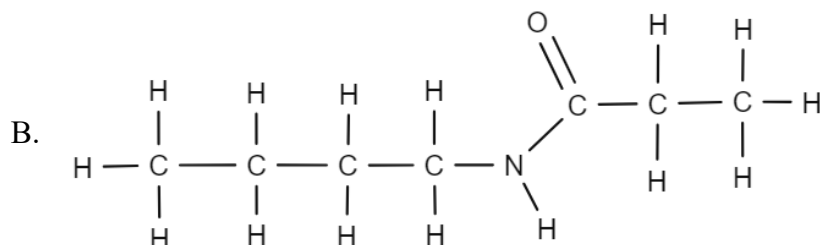
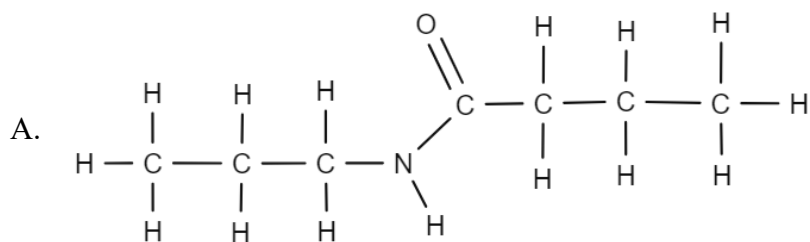
- A. Lowering the activation energy will cause the reaction to reach an equilibrium quickly.
 - B. Using a nickel catalyst will reduce the ΔH for the reaction.
 - C. The sum of the enthalpy of the products exceeds the sum of the enthalpy of the reactants.
 - D. The reaction is exothermic.
- 2 Which of the following sets of compounds show only acids and/or bases according to Arrhenius' definition?
- A. HCl, NH₃, CH₃COOH
 - B. NaOH, KOH, CH₃CH₂OH
 - C. HCl, KCl, NaCl, PbCl₂
 - D. HCl, NaOH, CH₃COOH
- 3 Which of the following is an example of a formula for a series of saturated organic compounds?
- A. C_nH_{2n+1}Cl
 - B. C_nH_{2n-1}Cl
 - C. C_nH_{2n-3}Cl
 - D. C_nH_{2n}
- 4 Which of the following is the molarity of a solution of saturated lead (II) chloride at 25 °C?
- A. 4.12 x 10⁻³ molL⁻¹
 - B. 1.62 x 10⁻² molL⁻¹
 - C. 2.04 x 10⁻² molL⁻¹
 - D. 2.57 x 10⁻² molL⁻¹

- 5 How many structural isomers have the formula $\text{C}_3\text{H}_6\text{Cl}_2$?
- A. 2
 - B. 3
 - C. 4
 - D. 5
- 6 A closed reaction system at equilibrium has an equilibrium constant of K . Keeping the temperature constant, the system is changed and has a reaction quotient Q . At this moment, $Q > K$.

Which of the following best describes the change that would subsequently occur?

- A. The reaction will form a new K value to match the Q value.
 - B. The reaction will favour the forward reaction to reach K again.
 - C. The reaction will favour the reverse reaction to reach K again.
 - D. The reaction system does not change as only temperature changes the K value.
- 7 What mass of purified sodium carbonate should be dissolved in a 100.00 mL volumetric flask to neutralise 250.00 mL of 0.200 mol L^{-1} HCl solution?
- A. 2.65 g
 - B. 4.15 g
 - C. 5.30 g
 - D. 5.30 kg
- 8 Which of the following has the lowest molar solubility at 25°C ?
- A. Silver phosphate
 - B. Silver iodide
 - C. Iron(II) hydroxide
 - D. Lead(II) hydroxide

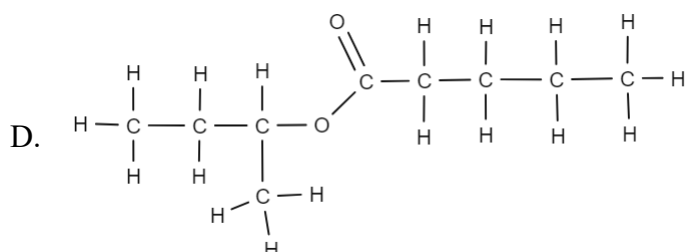
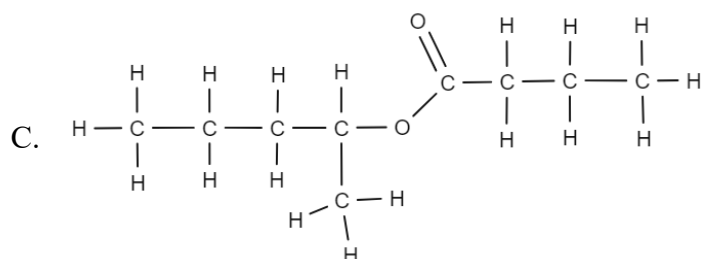
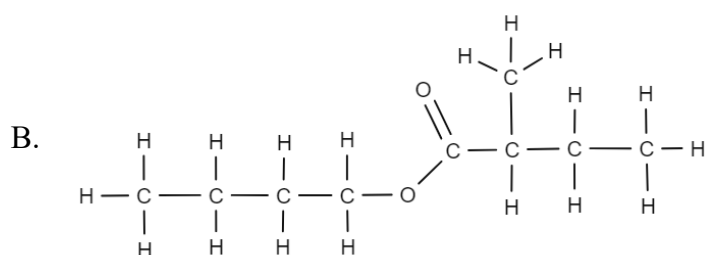
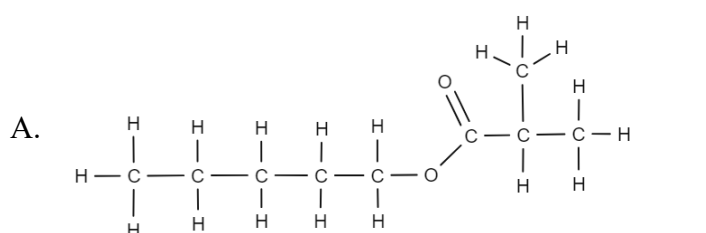
9 Which of the following compounds is N-butylpropanamide?



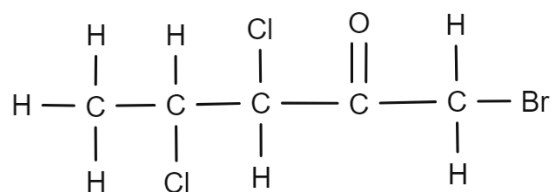
10 Which of the following tests would allow a scientist to distinguish between dilute aqueous solutions of ethanamine and ethanoic acid?

- A. Measuring Enthalpy of Combustion
- B. Reaction with acidified potassium dichromate
- C. Reaction under UV light
- D. Addition of universal indicator

- 11 What will be the first response of a system at equilibrium when the reactant concentration is increased?
- Drive the reaction forwards
 - Drive the reaction backwards
 - Drive the reaction forwards and backwards equally
 - Will not change the system as only temperature will do this
- 12 An ester is made in a laboratory using pentan-2-ol and butanoic acid. Which of the following esters would be produced?



- 13** Which of the following statements about titration is correct?
- A. The equivalence point is the point at which the indicator changes colour.
 - B. The equivalence point is the point at which the acid has completely neutralised the base.
 - C. The end point is the volume at which the acid has completely neutralised the base.
 - D. The end point is the volume at which the pH curve plateaus.
- 14** What is the concentration of H^+ ions in a 2.0 L solution of $\text{Mg}(\text{OH})_2$ at pOH 5.6 and 25 °C?
- A. $2.5 \times 10^{-6} \text{ molL}^{-1}$
 - B. $4.0 \times 10^{-9} \text{ molL}^{-1}$
 - C. $5.0 \times 10^{-6} \text{ molL}^{-1}$
 - D. $8.0 \times 10^{-9} \text{ molL}^{-1}$
- 15** The structure of a compound is shown below.



What is the correct IUPAC name for this compound?

- A. 1-bromo-3,4-chloropentan-2-one
 - B. 5-bromo-2,3-dichloropentan-4-one
 - C. 1-bromo-3,4-dichloropentan-2-one
 - D. 5-bromo-2,3-chloropentan-4-one
- 16** Which of the following biofuels is primarily produced from the fermentation of sugars?
- A. Biodiesel
 - B. Biogas
 - C. Ethanol
 - D. Hydrogen

- 17 Which of the following shows the base and conjugate base in the reaction that occurs when phosphoric acid (H_3PO_4) is added to water?
- A. H_2O , H_2PO_4^-
B. OH^- , H_2PO_4^-
C. H_3PO_4 , PO_4^{3-}
D. H_3PO_4 , H_2PO_4^-
- 18 A 50.0 mL solution of 0.86 mol L^{-1} ammonia is completely neutralised by 20.0 mL of nitric acid. If each solution starts at 22.0°C , what is the maximum temperature reached by the mixture? ($\Delta H_{\text{neut}} = -57 \text{ kJ mol}^{-1}$). Assume the density of the solution is 1.00 g/mL .
- A. 8.4°C
B. 22.1°C
C. 30.4°C
D. 33.7°C
- 19 A 15.00 mL sample of a monoprotic acid is placed in a volumetric flask, then diluted up to the mark. A 15.00 mL aliquot of this diluted solution is then titrated against a 0.050 mol L^{-1} solution of barium hydroxide using an appropriate indicator. If the undiluted sample of the monoprotic acid has a concentration of 3.88% m/v and a molar mass of 88.11 g mol^{-1} , which volumetric flask should be used in the original dilution in order to obtain titres of approximately 20 mL?
- A. 50 mL
B. 100 mL
C. 200 mL
D. 250 mL

Question 20 begins on the next page.

- 20 The relationship between the acid dissociation constant, K_a , and the corresponding conjugate base dissociation constant, K_b , is given by:

$$K_a \times K_b = K_w$$

Acetic acid has a pK_a value of 4.8. What is the pH of a 750 mL solution containing 4.7 g of sodium acetate at 25 °C?

- A. 5.2
- B. 8.8
- C. 10
- D. 11

Section II begins on the next page

Section II

80 marks

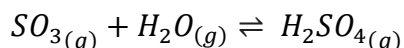
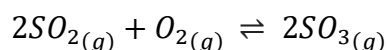
Attempt Questions 21–34

Allow about 2 hours and 25 minutes for this section.

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response. Show all relevant working in questions involving calculations.

Question 21 (4 Marks)

The industrial process for sulfuric acid production begins with the extraction of sulfur solid, followed by its combustion with oxygen to form sulfur dioxide. The sulfur dioxide is then reacted with oxygen to form sulfur trioxide and then further reacted with water to form sulfuric acid, according to the following equations.



A 2.0 L chamber at high temperature contains 3.0 mol of sulfur dioxide, 2.0 mol of oxygen gas and 1.7 mol of water vapor before the reaction begins. After the system has been allowed to reach equilibrium, the amount of gaseous sulfuric acid present is 0.90 mol.

Write the equilibrium expression for the reaction of SO_2 to produce H_2SO_4 and hence calculate the equilibrium constant for this reaction.

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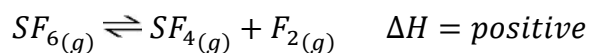
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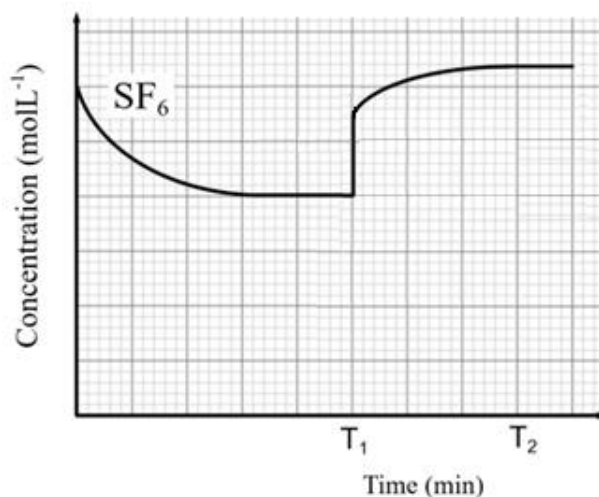
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Question 22 (9 Marks)

Sulfur hexafluoride decomposes according to the following equation:



The graph below shows the concentration of SF_6 in a sealed reaction vessel over time.



- (a) Given that the reaction vessel must remain sealed, identify the change to the system which occurred at T_1 and explain the shape of the graph between T_1 and T_2 .

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- (b) At T_2 , the volume of the vessel is doubled and the system is left to establish equilibrium. Describe the changes that would occur to the equilibrium constant for this reaction and how the system will change.

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(c) Explain, using collision theory, the effect of increasing the temperature on the equilibrium position.

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Question 23 (4 Marks)

The pHs of three equimolar aqueous salt solutions are given below.

Solution	pH
NaH_2PO_4	6.5
NaNO_3	7.0
Na_2CO_3	8.6

Using relevant equations, account for the differing pH values measured.

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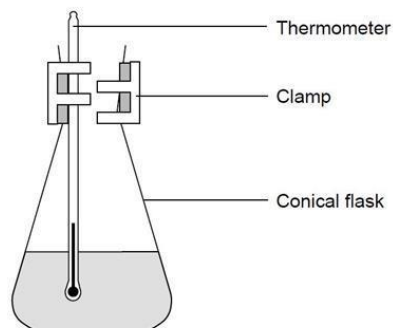
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Question 24 (7 marks)

An investigation was conducted to measure the enthalpy of combustion of propan-1-ol. The figures below show the apparatus used and the data gathered from the investigation. The theoretical enthalpy of combustion of propan-1-ol is -2017 kJmol^{-1} .



Volume of water (mL)	70.0
Water temperature (initial) ($^{\circ}\text{C}$)	24.0
Mass of spirit burner (initial) (g)	345.68
Water temperature (final) ($^{\circ}\text{C}$)	50.4
Mass of spirit burner (final) (g)	345.28

(a) Calculate the percentage error in the investigation.

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(b) Identify two possible reasons which could account for your answer to a).

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(c) Describe one safety precaution that should be taken when carrying out this investigation.

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Question 25 (4 marks)

The enthalpy of neutralisation for methanoic acid (HCOOH), nitrous acid (HNO_2) and nitric acid (HNO_3) when reacted with potassium hydroxide is given below.

Acid	Enthalpy of neutralisation (kJ mol^{-1})
$\text{HCOOH}_{(\text{aq})}$	-14
$\text{HNO}_{2(\text{aq})}$	-14
$\text{HNO}_{3(\text{aq})}$	-57.6

Explain why the enthalpy of neutralisation for nitric acid is higher than that of nitrous and methanoic acid.

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Question 26 (3 Marks)

Compare and contrast the reaction(s) involved in the production of bromoethane from ethene versus production from ethane.

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Question 27 (7 Marks)

A student carried out a titration using a 2.00 mol L^{-1} standard solution of the weak monoprotic acid potassium hydrogen phthalate (KHP). The aim was to determine the concentration of an unknown base, MOH. The volume of base used to reach the end point when titrating a 25.00 mL aliquot of KHP was recorded below.

Titre	Volume of Base (mL)
1	22.5
2	23.5
3	23.6
4	23.4

(a) Assuming M is a Group I metal, calculate the concentration of the unknown base solution.

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(b) KHP has a pK_a of 5.4 at 25°C . Calculate the pH of a 2.0 mol L^{-1} KHP solution at 25°C .

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Question 28 (4 Marks)

Certain groups of halogenated hydrocarbons have been used in the past as fire-retardant material. An example of one fire-retardant compound has the formula $\text{C}_2\text{H}_3\text{BrClF}$.

(a) Draw four isomers which share this molecular formula.

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(b) Name the isomer of $\text{C}_2\text{H}_3\text{BrClF}$ which would be likely to have the highest boiling point.

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Question 29 (3 marks)

Explain the application of solubility equilibria to the removal of toxicity from a named food by Aboriginal and Torres Strait Islander Peoples.

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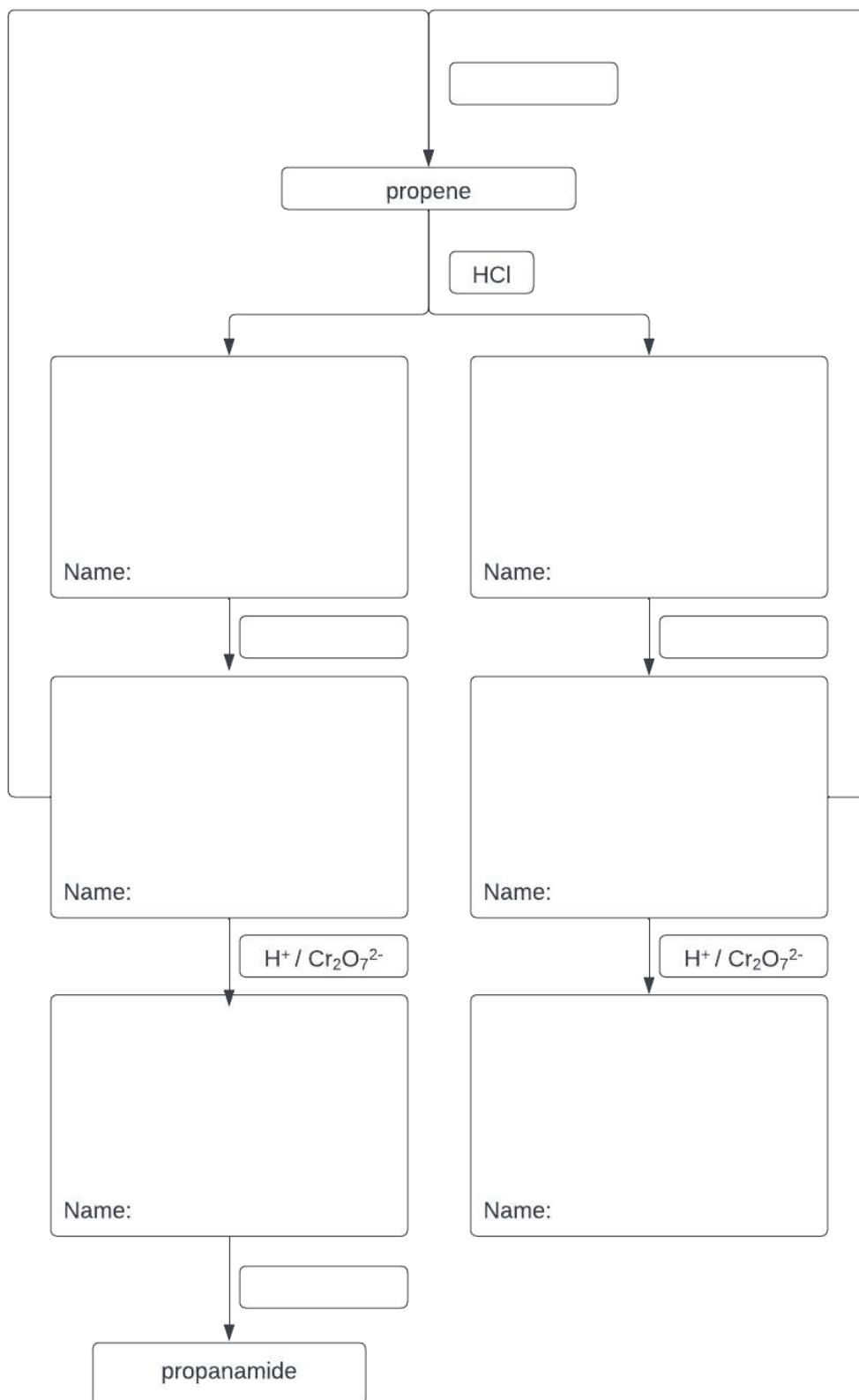
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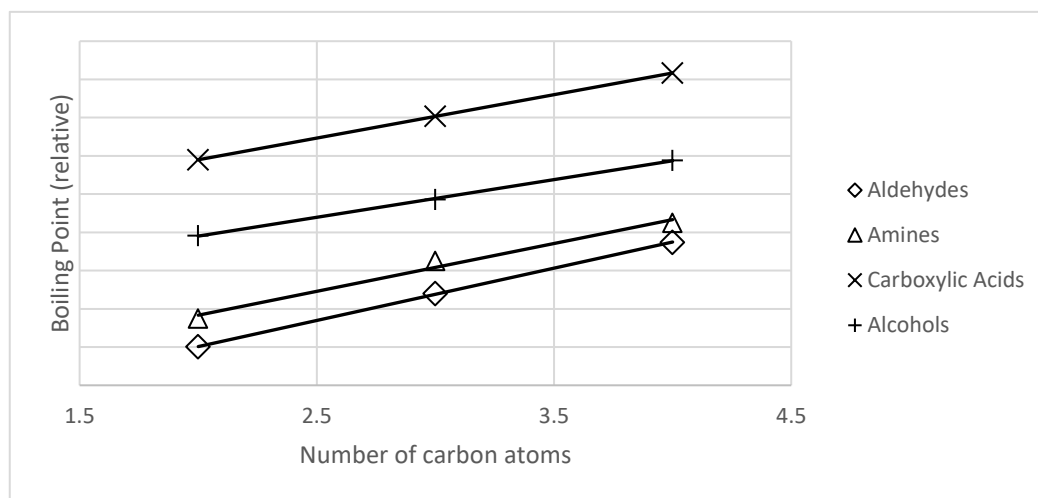
Question 30 (8 Marks)

The flowchart below shows a chemical synthesis process. Fill in the empty boxes to identify the appropriate product or reagent for each stage of the process. Provide names AND structures for organic compounds.



Question 31 (6 Marks)

The graph below shows the relative boiling points of 4 different straight-chain homologous series.

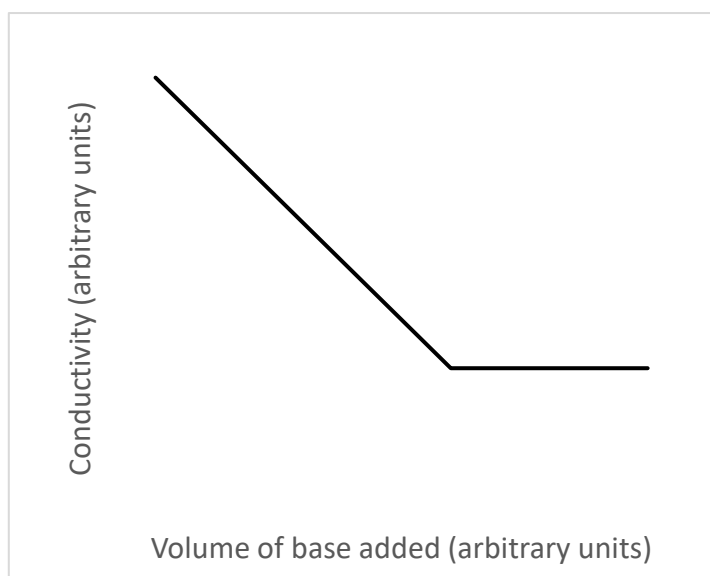


Explain the trend(s) shown in the graph above.

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

Question 32 (4 marks)

The curve below shows the change in conductivity of a mixture when a base is gradually added to an acid.



Explain the trend in the conductivity curve with reference to the change in chemical species present in the mixture.

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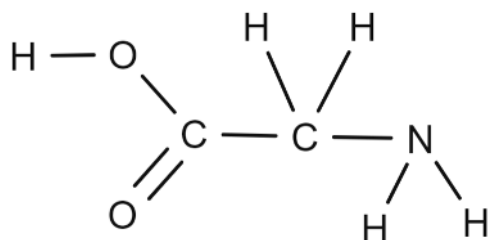
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Question 33 (3 marks)

The following diagram shows the structure of glycine, an amphotropic compound.



With reference to the functional group(s) in glycine's structure, account for its ability to act as both a Bronsted-Lowry acid and base.

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Question 34 (6 Marks)

Hydrocarbons have been vital to society's advancement in terms of economic development; however, obtaining and using hydrocarbons from the Earth also has environmental and sociocultural implications.

Using relevant examples, discuss the statement above.

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Question 35 (8 Marks)

7.5 mL of a calcium nitrate solution was added to 25.00 mL of 0.105 mol L^{-1} sodium hydroxide solution to form a saturated solution at 25°C .

a) Determine the minimum concentration of the calcium nitrate solution.

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b) A 10.0 mL sample of a $4.0 \times 10^{-3} \text{ mol L}^{-1}$ calcium nitrate solution was added to 15.0 mL of 0.010 mol L^{-1} sodium phosphate solution. Determine whether a precipitate will form at 25°C .

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END OF EXAM