

NORTH SYDNEY GIRLS HIGH SCHOOL



2021

Higher School Certificate

Practice HSC Examination

Chemistry

Total Marks – 100

General Instructions

- Reading Time – 5 minutes
- 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 Table are provided
- Write your student number at the top of your multiple choice answer sheet AND Sections 2-6

Section 1

20 Marks

- Attempt Questions 1- 20
- Allow about 35 minutes for this part

Sections 2-6

80 Marks

- Attempt question 21 – 37
- Allow about 2 hours and 25 minutes for this part

Section I

20 marks

Attempt Questions 1-20

Allow about 35 minutes for this part

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 ☐

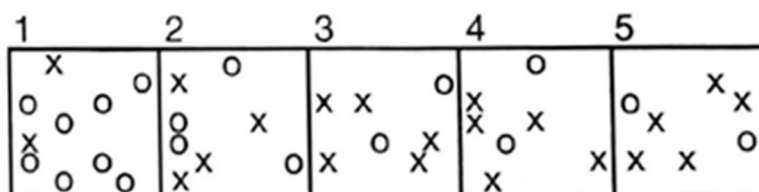
If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

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 ☐

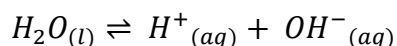
1. In the following series of diagrams, molecules of NO₂ are reacting to produce N₂O₄ and eventually the two gases reach equilibrium. O represents NO₂ and X represents N₂O₄.



Identify the stage at which this system reaches equilibrium.

- A. 2
- B. 3
- C. 4
- D. 5

2. Water ionizes according to the following equilibrium process:



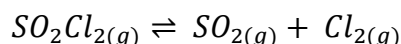
At any instant, only about 1 molecule of water in every 1.0×10^7 water molecules will be ionised. Which of the following is TRUE when the system is at equilibrium?

- A. The reverse rate is greater than the forward rate
- B. The forward rate is greater than the reverse rate
- C. Both the forward and reverse rates are the same
- D. Most water molecules are ions

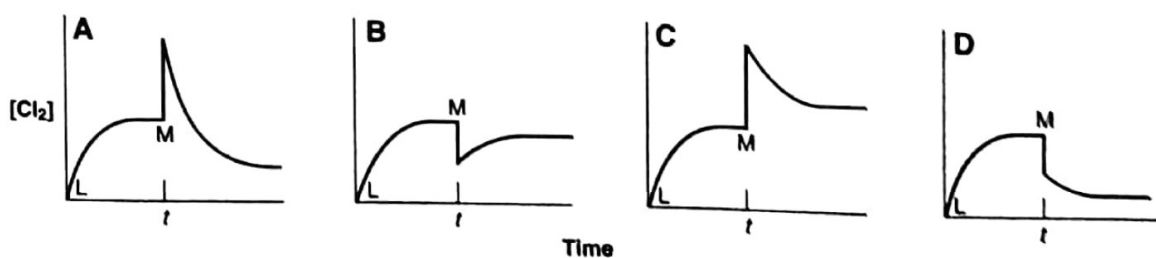
3. Which of the following lists contains reactions that are generally considered non-reversible?

- A. Combustion, photosynthesis, neutralisation, burning magnesium
- B. Dehydrating cobalt(II) chloride, combustion, neutralisation, dissociation of weak acid
- C. Combustion, burning steel wool, photosynthesis, dehydrating cobalt(II) chloride
- D. Precipitation, combustion, photosynthesis, decomposition of dinitrogen tetroxide

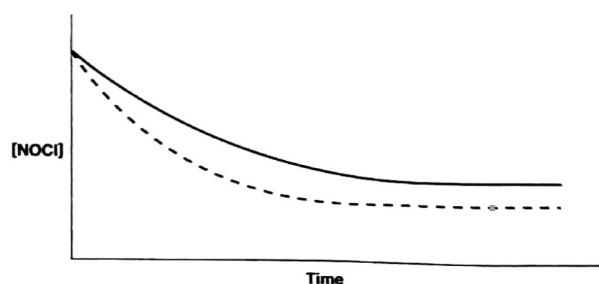
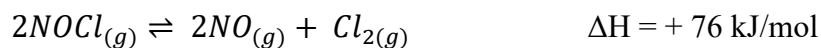
4. A quantity of SO_2Cl_2 was placed in a syringe at constant temperature to demonstrate the following equilibrium.



At time t the plunger of the syringe was pushed in until the volume of the reaction mixture was half its original value. Select the graph that correctly shows the variation of chlorine concentration after time, t .



5. Nitrosyl chloride decomposes according to the below equation.



The graph above shows the concentration of nitrosyl chloride in two different experiments. Experiment 1 is shown with a solid line and Experiment 2 is shown with a dashed line.

How did the reaction conditions differ in Experiment 2 compared to Experiment 1?

- A. A catalyst was present
- B. A lower temperature was used
- C. An inert gas was present
- D. A higher temperature was used

6. The K_{sp} values for four salts are given below. Which salt will be the poorest conductor of electricity?

- A. 4.1×10^3
- B. 2.3×10^{-2}
- C. 3.7×10^{-4}
- D. 5.1×10^{-1}

7. Neutralisation reactions occur when an acid is combined with a base. Which of the following pairs of substances would result in a neutralisation reaction when combined?

I	H_3O^+ and OH^-
II	Sulfuric acid and calcium hydroxide
III	Nitric acid and sodium carbonate
IV	Hydrochloric acid and magnesium oxide

- A. I and II only
- B. I, II and IV only
- C. I,III and IV only
- D. I,II, III and IV

8. The pH values and concentrations of four acids are given in the table below.

Acid	pH	Concentration
I	2.84	0.20
II	2.15	0.10
III	3.45	2.00
IV	4.56	0.75

Which acid is the strongest?

- A. Acid I
- B. Acid II
- C. Acid III
- D. Acid IV

9. Which of the following mixtures below would NOT produce a buffer solution?

- A. $\text{HNO}_{3(\text{aq})}$ and $\text{NaNO}_{3(\text{aq})}$
- B. $\text{NaH}_2\text{PO}_{4(\text{aq})}$ and $\text{Na}_2\text{HPO}_{4(\text{aq})}$
- C. $\text{NH}_4\text{Cl}_{(\text{aq})}$ and $\text{NH}_{3(\text{aq})}$
- D. Sodium citrate_(aq) and citric acid_(aq)

10. A student prepared a standard solution using the following method.

Step 1: 4.5g of pure sodium hydrogen carbonate was dissolved in a clean, dry beaker using distilled water.

Step 2: The solution was poured into a volumetric flask using a funnel and the beaker and funnel were set to one side without washing.

Step 3: The volumetric flask was filled with distilled water to just above the calibration line. To compensate, the student quickly removed some of the solution.

Step 4: The volumetric flask was shaken to ensure consistency.

The student then calculated the concentration of the solution. The standard solution is most likely to be:

- A. Weaker than calculated
- B. Stronger than calculated
- C. Less concentrated than calculated
- D. More concentrated than calculated

11. A 50.0 mL sample of a 0.100 mol L^{-1} nitric acid solution completely reacted with 46.8 mL of potassium hydroxide solution. What volume of the same potassium hydroxide solution would be required to completely react with 50.0 mL of a 0.100 mol L^{-1} acetic acid solution?

- A. Less than 46.8 mL
- B. 46.8 mL
- C. More than 46.8 mL
- D. Unable to calculate unless the concentration of the potassium hydroxide solution is also known

12. 25.0 mL of a 1.00 mol L^{-1} acid was titrated against a sodium hydroxide solution. Which of the following acids, if used in the titration, would require the greatest volume of sodium hydroxide to reach the equivalence point?

- A. Acetic acid
- B. Citric acid
- C. Hydrochloric acid
- D. Sulfuric acid

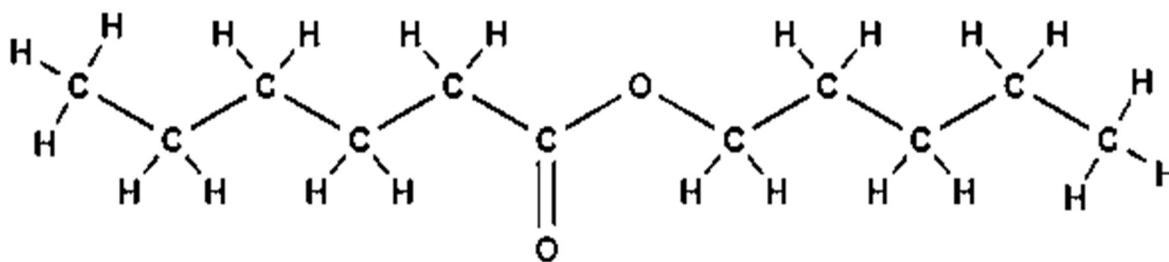
13. A strong base is used to titrate a solution of weak diprotic acid. The equivalence point is reached when:

- A. The indicator changes colour
- B. Equal moles of the base and acid have reacted
- C. The molar ratio of acid to base is the same as that required by the chemical equation
- D. The pH is 7.0

14. Which of the following statements about organic compounds is CORRECT?

- A. Hydrocarbons must be extracted from beneath the Earth's surface.
- B. Ethanol can be produced from the hydration of ethene with dilute sulfuric acid.
- C. Ethanol can be produced through an addition reaction between a haloalkane and water.
- D. Alkanes react readily with aqueous bromine to form a haloalkane.

15. The correct systematic name for the below compound is:



- A. hexyl pentanoate
- B. pentyl hexanoate
- C. N-pentyl hexanamide
- D. N-hexyl pentanamide

16. Which of the following compounds would you expect to have the highest boiling point?

- A. butan-1-ol
- B. 2-methylbutane
- C. propanoic acid
- D. butan-2-amine

17. Vinegar can be made from wine. In this reaction ethanol is converted into ethanoic (acetic) acid. This reaction can best be described as what type?

- A. Fermentation
- B. Addition
- C. Substitution
- D. Oxidation

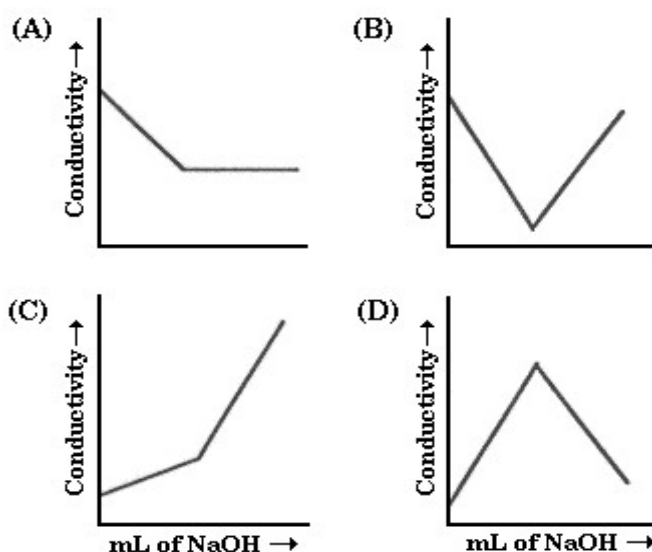
18. What two molecules are members of the same homologous series?

- A. C_6H_{12} and C_6H_{10}
- B. $C_6H_{11}OH$ and $C_{16}H_{31}OH$
- C. $C_6H_{11}Cl$ and $C_7H_{12}Cl_2$
- D. $C_4H_{10}O$ and C_4H_8O

19. C_3H_7OH is reacted with HCl . Which of the following best describes this type of reaction and the expected product?

	Type of Reaction	Product
A.	Dehydration	C_3H_6
B.	Addition	C_3H_7Cl
C.	Substitution	C_3H_7Cl
D.	Halogenation	C_3H_7OCl

20. Which of the following graphs best represents the conductivity changes that occur when an aqueous solution of HCl is titrated with an aqueous solution of ammonia?



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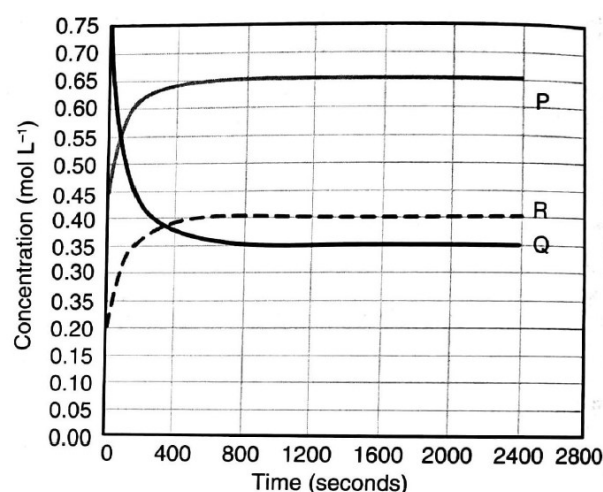
Student Number

Section 2

Answer the questions in the space provided or on a similar amount of separate paper. Clearly indicate which answer addresses which question if using separate paper. Show all relevant working for questions involving calculations.

Question 21 (4 marks)

The graph below shows changes in concentration of three species involved in a chemical equilibrium.



a) Calculate the change in concentration of EACH of the chemical species involved.

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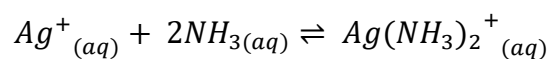
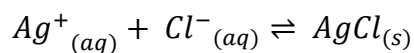
b) Determine the equation for the reaction shown by the graph.

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Question 22 (3 marks)

Aqueous silver ions are involved in the following equilibria:



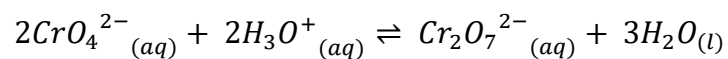
If sodium chloride and silver nitrate solutions are mixed, a white precipitate forms. If ammonia is then added, the reaction mixture becomes a clear solution.

Explain the above observation using Le Chatelier's principle.

[illegible]

Question 23 (4 marks)

Yellow chromate (CrO_4^{2-}) and orange dichromate ($Cr_2O_7^{2-}$) are in equilibrium with each other in aqueous solution.



Predict the colour change when adding concentrated sodium hydroxide to this system at equilibrium. Account for this change using collision theory.

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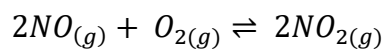
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Question 24 (5 marks)

The following equilibrium exists at high temperatures.



The equilibrium constant is 2.1 at 1000K. A mixture contained these four gases at the following concentrations.

$$[\text{NO}] = 0.55 \text{ mol L}^{-1}$$

$$[\text{O}_2] = 0.105 \text{ mol L}^{-1}$$

$$[\text{NO}_2] = 0.065 \text{ mol L}^{-1}$$

a) Demonstrate that the mixture is not at equilibrium.

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b) Using your answer to part a, suggest how the concentration of NO will change as the reaction moves towards equilibrium.

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END OF SECTION 2

Question 26 (6 marks)

A buffer was prepared using equal volumes and concentrations of acetic acid and sodium acetate. A few drops of indicator were added to the buffer solution.

- a) Explain, with the use of equations, why the salt sodium acetate forms a basic solution when dissolved in water. 3

This image shows a single sheet of white paper with ten horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and extend across the width of the page. There is no handwriting or other markings on the paper.

- b) When small amounts of $0.1 \text{ mol L}^{-1} \text{ HNO}_3$ or $0.1 \text{ mol L}^{-1} \text{ NaOH}$ were added to the buffer, no change in the colour of the solution was observed. Explain why this observation occurred and support your answer with a relevant chemical equation.

This image shows a full page of white paper with ten horizontal dashed lines, typical of primary school handwriting practice paper. The lines are evenly spaced and extend across the entire width of the page. There is no text or other markings on the paper.

Question 27 (5 marks)

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

$$K_a \times K_b = K_w$$

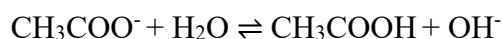
Assume the temperature is 25 °C.

- a) The K_a of acetic acid CH_3COOH is 1.8×10^{-5} . Calculate the K_b of the acetate ion CH_3COO^- . 1

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- b) The conjugate base dissociation constant K_b is the equilibrium constant for the following reaction:



Calculate the pH of a 0.16 mol L^{-1} solution of sodium acetate (NaCH_3COO).

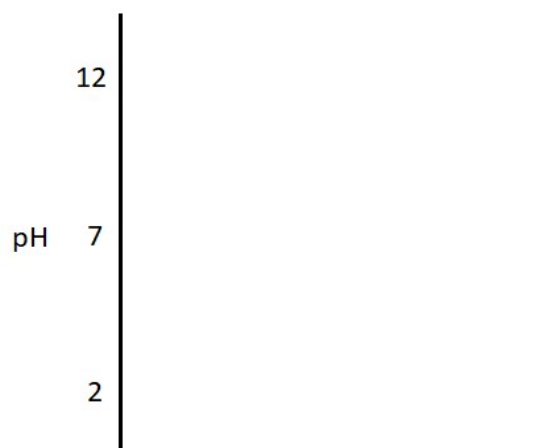
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END OF SECTION 3

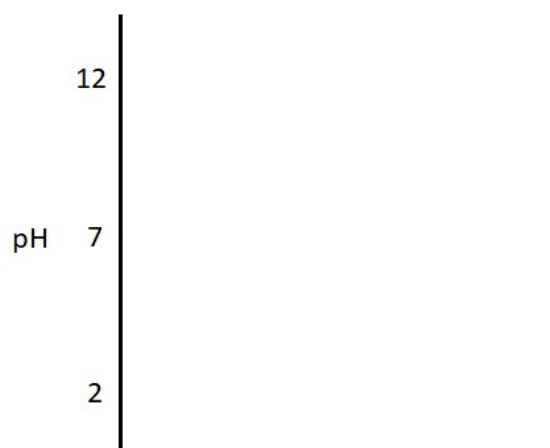
Question 29 (3 marks)

Using the axes below, draw three separate approximate “model” titration curves to fit the descriptors provided. (You may draw your own CLEARLY LABELLED axes if answering on separate paper.)

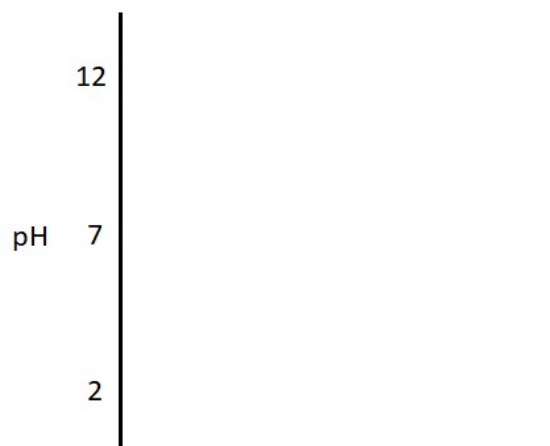
Addition of a strong acid to a weak base



Addition of a weak base to a strong acid



Addition of a strong base to a weak acid



Question 30 (4 marks)

30.00 mL of a NaHCO_3 solution was titrated with a 0.354 mol L^{-1} standard solution of the monoprotic acid potassium hydrogen phthalate, $\text{C}_8\text{H}_5\text{KO}_4$. Potassium hydrogen phthalate is sometimes called KHP. The results from 4 titrations are shown in the table below.

Titration number	Volume of KHP added (mL)
1	43.30
2	42.85
3	42.95
4	42.90

a) Write a balanced chemical equation for the reaction between the $\text{C}_8\text{H}_5\text{KO}_4$ and the NaHCO_3 . **1**

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b) Calculate the concentration of the sodium hydrogen carbonate solution. **3**

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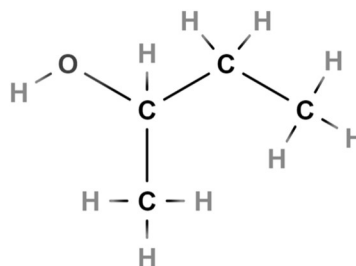
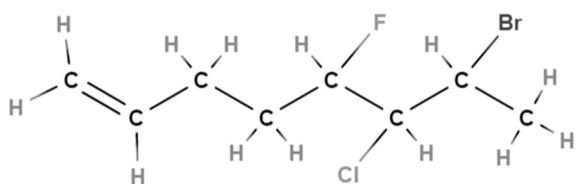
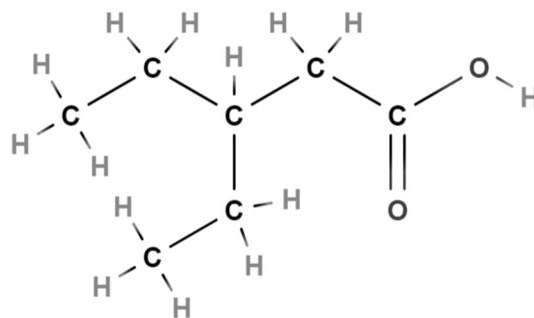
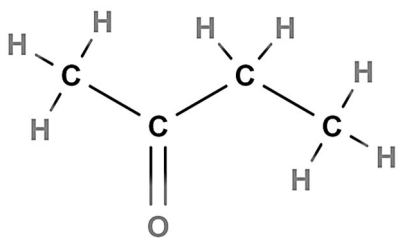
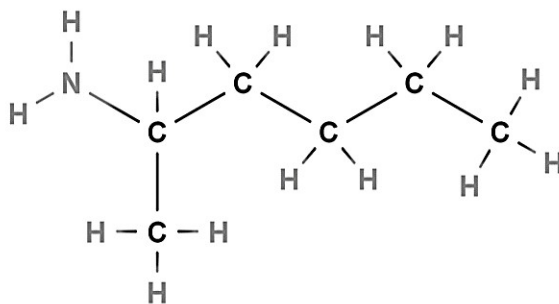
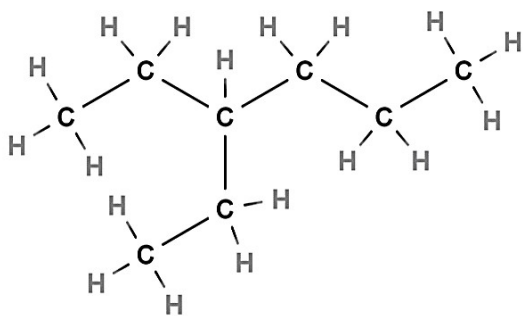
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Question 31 (6 marks)

Name the organic compounds below in the spaces provided. (If answering on separate paper, clearly indicate which name you are attributing to each structure.)



END OF SECTION 4

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Student Number

Section 5

Answer the questions in the space provided or on a similar amount of separate paper. Clearly indicate which answer addresses which question if using separate paper. Show all relevant working for questions involving calculations.

Question 32 (5 marks)

The molecular formula $C_6H_{14}O$ can be used to describe a number of different organic compounds.

a) Draw three of these compounds in the spaces below or on separate paper.

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b) Compare and contrast *functional group isomers* with *position isomers*.

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Question 33 (5 marks)

A student is tasked with comparing two liquid hydrocarbons with the formula C_6H_{14} and C_6H_{12} respectively. She finds that the two have very similar physical properties. However, one reacts readily when combined with Cl_2 while the other does not.

a) Identify which of the two compounds will react readily with Cl_2 and justify your answer. **3**

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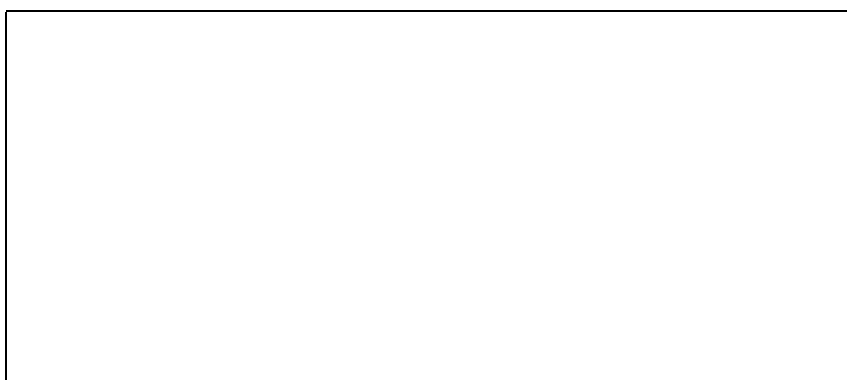
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b) What could the student do to cause the other compound to react with Cl_2 ? **1**

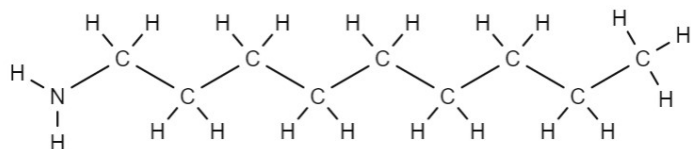
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c) Draw the full structural formula for a potential product of the reaction in part b) in the space below or on separate paper. **1**

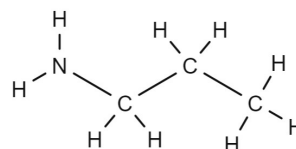


Question 34 (4 marks)

The solubility in water of two organic compounds was investigated in a series of experiments. The structures of the two compounds are given below.



Compound A



Compound B

With reference to the structure of each compound, explain which of the two compounds would be expected to have a higher solubility in water.

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END OF SECTION 5

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Student Number

Section 6

Answer the questions in the space provided or on a similar amount of separate paper. Clearly indicate which answer addresses which question if using separate paper. Show all relevant working for questions involving calculations.

Question 35 (4 marks)

A scientist attempted to produce an ester from a sugar cane starting material.

- a) Outline how bioethanol can be produced from plant material. Include a chemical equation in your answer. 2

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- b) Ethanol produced from the sugar cane was oxidised in acidic conditions and heated. Give the systematic name of the product. 1

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- c) The product from part b) was then reacted with butan-1-ol under suitable conditions. Draw the full structural formula for the product of this reaction below or on separate paper. 1

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Question 36 (2 marks)

Write a number of balanced equations to show a sequence of reactions that would allow an ethanol starting material to be converted to ethanamide.

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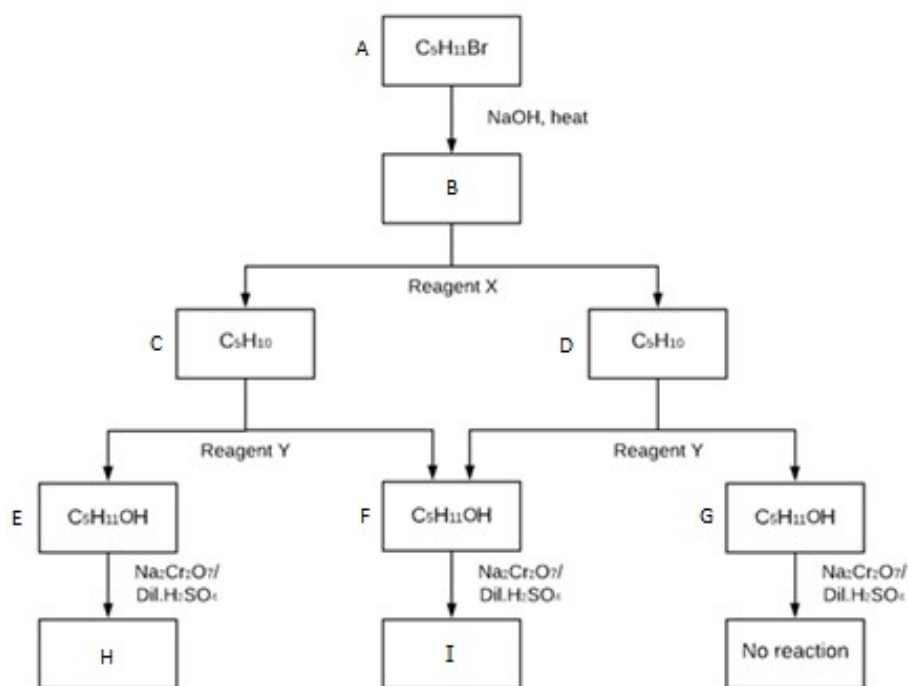
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Question 37 (10 marks)

The flow chart below shows a number of possible reaction pathways for a single starting material, A.



a) Identify reagent X.

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b) Draw a full chemical structure for EVERY chemical compound in the flow chart and justify your conclusions. **9**

	Structure	Justification
A		
B		
C		
D		
E		
F		

G		
H		
I		

END OF SECTION 6