Student Number……

Hornsby Girls' High School 2020

Year 12
Trial Examination

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using blue or black pen
- Draw diagrams using a pencil
- Board-approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper and may be detached for your convenience
- Write your student number at the top of each page
- Attempt all questions
- The multiple choice answer sheet may be detached for convenience.
- Marks are as indicated in brackets

Total marks – 100

- Section I - Multiple Choice 20 marks
- Section II – Written Response 80 marks

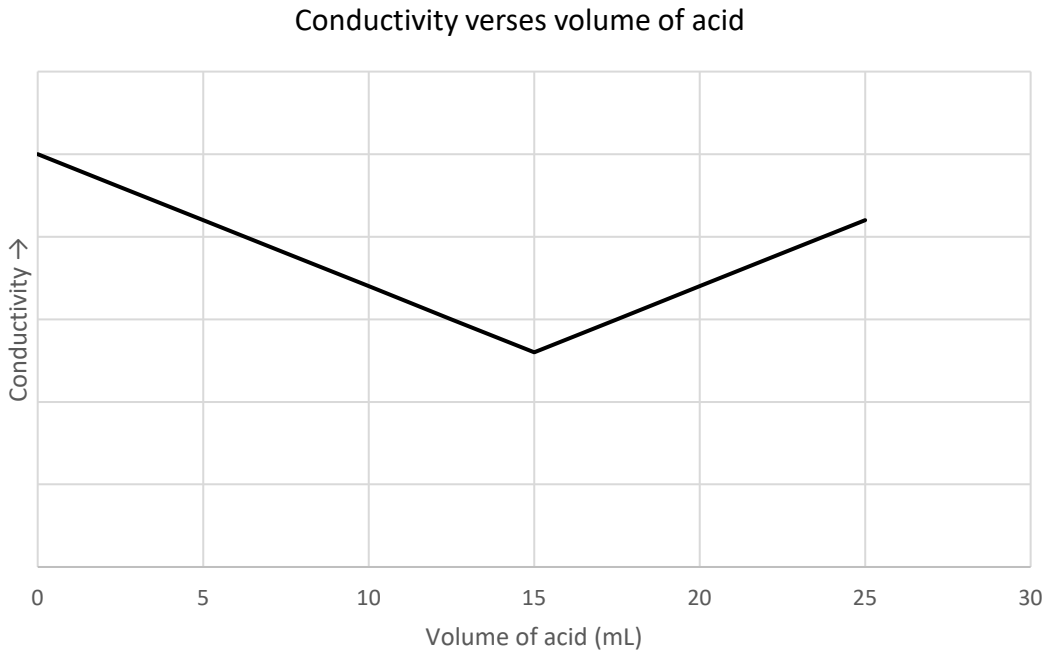
Section I

20 marks

Attempt Questions 1–20

Use the multiple-choice answer sheet for Questions 1 – 20.

1 The graph is used for Questions 1 and 2. It shows changes to conductivity as hydrochloric acid is added to 25 mL of sodium hydroxide.



Which statement about this titration is correct?

(A) The equivalence point occurred when 15 mL of acid was added.

(B) The equivalence point occurred when 25 mL of acid was added.

(C) Neutralisation is incomplete as the conductivity has not reached zero.

(D) The end point occurred when 15 mL of acid was added, and the equivalence point occurred when 25 mL of acid was added.

2 Given that the concentration of the sodium hydroxide was 0.12 M, what is the concentration of the hydrochloric acid solution?

(A) 0.0072 M

(B) 0.12 M

(C) 0.20 M

(D) 1.70 M

3 How many different structural isomers are there for C_3H_6BrCl?

(A) 2

(B) 3

(C) 4

(D) 5

4 A 250.0 mL sample of 0.40M hydrochloric acid is added to 750.0 ml of 0.60M potassium hydroxide solution.

What is the final concentration of hydroxide ions?

(A) 0.30 M

(B) 0.35 M

(C) 0.40 M

(D) 0.45 M

5 How many products are possible when but-2-ene reacts with $HCl_{(g)}$?

(A) 1

(B) 2

(C) 3

(D) 4

6 For the reaction:

$$Br_{2\,(g)} + I_{2\,(g)} \rightleftharpoons 2IBr_{\,(g)} \qquad K_{eq} = 1.2 \times 10^2 \text{ at } 150°C$$

Given this reaction above, what is the Kc for the reaction shown below?

$$4IBr_{(g)} \rightleftharpoons 2Br_{2(g)} + 2I_{2(g)} \text{ at } 150°C$$

(A) 1.6×10^{-2}

(B) 4.1×10^{-3}

(C) 6.9×10^{-5}

(D) 8.0×10^{-5}

7 Jennie wants to use a physical property to distinguish between two alcohols, octan-1-ol and propan-1-ol. Both alcohols are colourless liquids at standard laboratory conditions. The student should use:

(A) density because propan-1-ol has a much higher density than octan-1-ol.

(B) boiling point because octan-1-ol has a higher boiling point than propan-1-ol.

(C) electrical conductivity because octan-1-ol has a higher conductivity than propan-1-ol.

(D) spectroscopy because it is not possible to distinguish between the alcohols using their other physical properties.

8 The equilibrium expression for a reaction is

$$K_{eq} = \frac{[H^+]^6}{[Bi^{3+}]^2[H_2S]^3}$$

The reaction could be:

(A) $6H^+ + BiS_{(s)} \rightleftharpoons 2Bi^{3+}(aq) + 3H_2S_{(g)}$

(B) $6H^+_{(aq)} + Bi_2S_{3\,(s)} \rightleftharpoons 2Bi^{3+}_{(aq)} + 3H_2S_{(g)}$

(C) $2Bi^{3+}_{(aq)} + 3H_2S_{(aq)} \rightleftharpoons Bi_2S_{3(s)} + 6H^+_{(aq)}$

(D) $2Bi^{3+}_{(aq)} + 3H_2S_{(aq)} \rightleftharpoons Bi_2S_{3\,(aq)} + 6H^+_{(aq)}$

9 The indicator HIn is used in a titration between hydrochloric acid and magnesium hydroxide solutions. The following equation represents how the indicator works.

$$\underset{\text{green}}{HIn(aq)} \leftrightharpoons H^+(aq) + \underset{\text{purple}}{In^-(aq)}$$

The indicator is added to 20.0 ml of magnesium hydroxide solution in a conical flask and the hydrochloric acid is added via a burette until the endpoint is observed. The acidic and basic solutions are of similar concentrations and the flask is swirled continuously as the acid is added. Which of the following statements describe the expected observations for the colour of the solution in the conical flask?

(A) The solution starts green and turns purple after the addition of approximately 10ml.

(B) The solution starts green and turns purple after the addition of approximately 40ml.

(C) The solution starts purple and turns green after the addition of approximately 10ml.

(D) The solution starts purple and turns green after the addition of approximately 40ml.

10 The pH of a solution of HCOOH is 3.0. What is the concentration of the acid if pKa = 3.75? (Assume negligible dissociation)

(A) 5.6×10^{-3} mol L^{-1}

(B) 6.6×10^{-3} mol L^{-1}

(C) 5.6×10^{-2} mol L^{-1}

(D) 5.6 mol L^{-1}

11 Rose set up a spirit burner containing an alcohol (molar mass 74.1 g mol^{-1}) to heat 200.0 g of water, at 23.0ºC, in a conical flask. The initial mass of the spirit burner was 350.75 g. After the water temperature reached 45.0ºC, the spirit burner was extinguished, and its mass was found to be 350.01 g.

What is the molar heat of combustion of this alcohol?

(A) 68.1 kJ mol^{-1}

(B) 1840 kJ mol^{-1}

(C) 6810 kJ mol^{-1}

(D) 32200 kJ mol^{-1}

12 The conjugate base of the ammonium ion is

(A) NH_3

(B) NH_4^+

(C) NH_2^-

(D) NH_3^+

13 Nitric acid completely dissociates in aqueous solutions. 1.0 mL of 10 mol L^{-1} solution was diluted to 1 L with distilled water. 100 mL of this resulting solution was then further diluted to 1 L using distilled water.

What pH is the final solution closest to?

(A) 1

(B) 2

(C) 3

(D) 4

14 The oxidation of sulfur dioxide, SO_2, to sulfur trioxide, SO_3, can be represented by the following equation:

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \qquad K_{eq} = 1.75 \text{ at } 1000°C$$

An equilibrium mixture has a concentration of 0.12 M SO_2 and 0.16 M oxygen gas, O_2.

The temperature of the container is 1000°C.

The equilibrium concentration of SO_3 at 1000°C is

(A) 1.5×10^{-4} M

(B) 4.0×10^{-3} M

(C) 1.2×10^{-2} M

(D) 6.3×10^{-2} M

15 Which mixture would produce a buffer solution when dissolved in 1.0L of water?

(A) 0.50 mol of CH_3COOH and 0.50 mol of NaOH

(B) 0.50 mol of CH_3COOH and 0.25 mol of NaOH

(C) 0.50 mol of CH_3COOH and 1.00 mol of NaOH

(D) 0.50 mol of CH_3COOH and 0.25 mol of $Ba(OH)_2$

16 Separate 25.0 mL samples of 0.10 mol L^{-1} ethanoic acid solution and 0.10 mol L^{-1} hydrochloric acid solution, are prepared.

Which one of the following statements about the samples is correct?

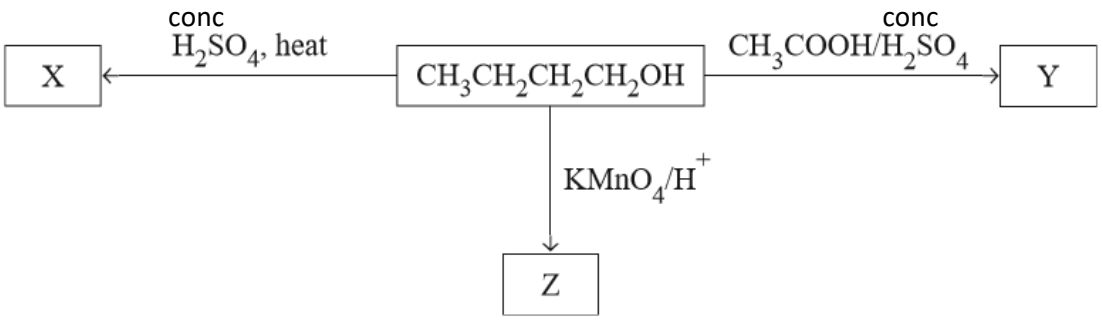
(A) Both samples will react with 1.00 g of magnesium ribbon at the same rate.

(B) Both samples have the same electrical conductivity.

(C) The concentration of H_3O^+ ions is greater in the ethanoic acid solution.

(D) Both samples will react completely with 25.0 mL of 0.10 mol L^{-1} sodium hydroxide solution.

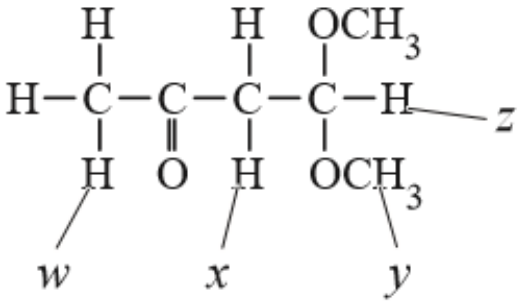
17 Consider the reaction sequence below.



Which row of the table correctly identifies X, Y and Z?

	X	*Y*	*Z*
(A)	but-1-ene	(1-butyl) ethanoate	butanoic acid
(B)	butane	hexanoic acid	butan-1-ol
(C)	but-2-ene	ethyl butanoate	butanoate
(D)	cyclobutane	butyl acetate	butanal

18 Consider the following molecule.



Which one of the labelled hydrogens gives a triplet signal in a ^{1}H NMR spectrum?

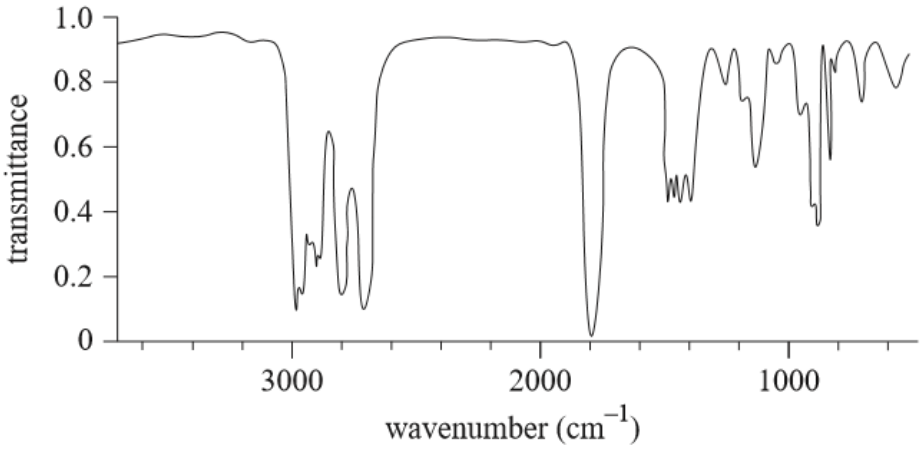
(A) hydrogen w

(B) hydrogen x

(C) hydrogen y

(D) hydrogen z

19 The infrared spectrum of an unknown sample is shown below.



What is the unknown sample most likely to be?

(A) Butanal

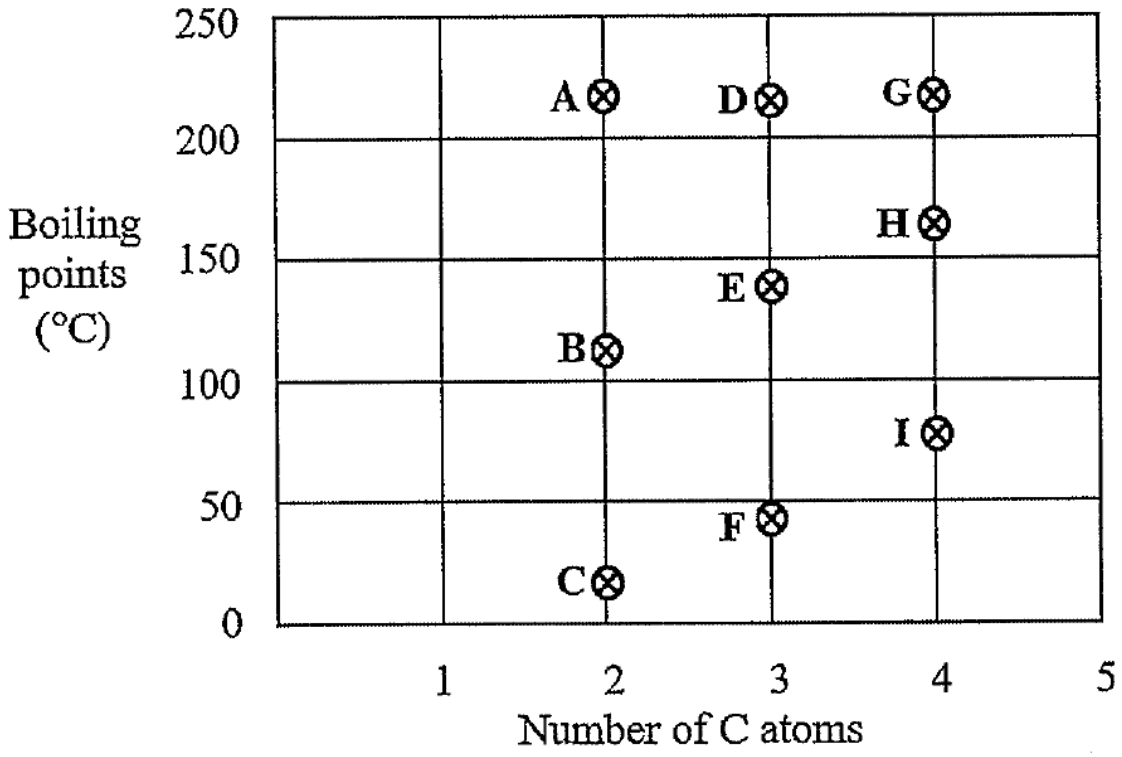
(B) Butanoic acid

(C) Hex-3-ene

(D) Propanol

20 The graph below shows the boiling points and carbon chain lengths of nine different organic compounds that are represented by the letters A to I.

Three of these compounds are carboxylic acids, three are alkylamines and three are amides.



Which of the follow correctly identifies the groups to which each of the compounds (A to I) belongs?

	Carboxylic acid	Alkylamine	Amide
(A)	D, E, F	A, B, C	G, H, I
(B)	A, D, G	B, E, H	C, F, I
(C)	B, E, H	C, F, I	A, D, G
(D)	C, E, G	A, F, H	B, D, I

Section II

80 marks

Answer questions in the space provided.

Show all relevant working in questions involving calculations.

Question 21 (6 marks)

The reaction to produce hydrogen from carbon monoxide and steam is shown.

$$H_2O_{(g)} + CO_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$$

Use the data supplied in the table to answer the following questions.

	ΔH_f° kJ mol^{-1}	S° J K^{-1} mol^{-1}
$CO_{(g)}$	-111	198
$H_2O_{(g)}$	-242	189
$CO_{2(g)}$	-393	214
$H_{2(g)}$	0	131

(a) Calculate the enthalpy change for this reaction. (1)

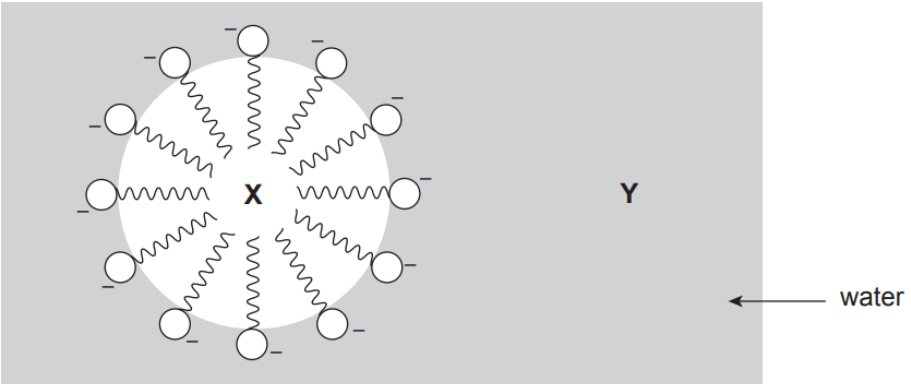
(b) Calculate the entropy change for this reaction. (1)

(c) Determine whether this reaction is spontaneous at 600K under standard conditions. (2)

(d) Given that when a reaction has reached equilibrium $\Delta G = 0$, calculate the minimum temperature required for this reaction to reach equilibrium under standard conditions AND state when the reaction will be spontaneous. (2)

Question 22 (3 marks)
Soaps are commonly used cleaning agents.

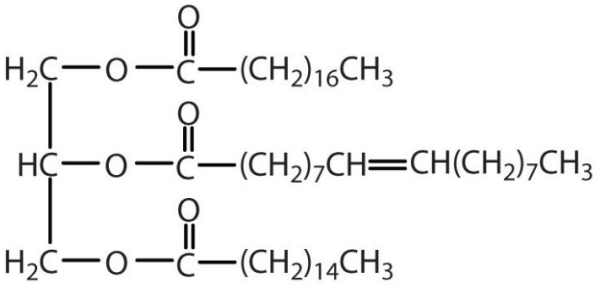
Soap anions remove grease by forming micelles in water. A diagram of a micelle in water is shown below.



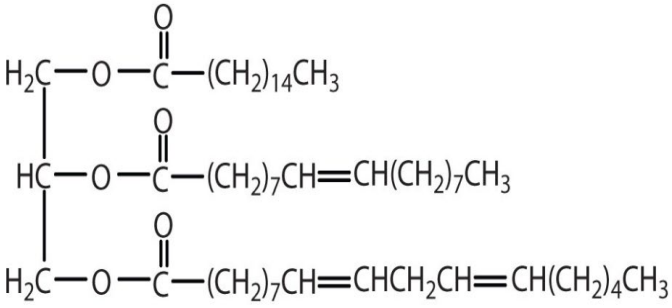
(a) Identify which region X or Y is more polar. (1)

(b) Fats are solid at room temperature and oils are generally liquids. Which triglyceride A or B is more likely to be in oils and which in fats? Justify your choice. (2)

triglyceride - A



triglyceride – B



SGS note: The dot point says, "investigate the structure and action of soaps and detergents". This question is beyond this scope but could be considered to be part of molecular shape and BP links.

Question 23 (5 marks)

The effectiveness of a soap can be measured by its ability to froth in water. Trials were conducted, using one piece of glassware, to compare the effectiveness of one soap in samples of water taken from three different sources. In each trial, 1.0 mL of soap solution was added to 80.0 mL samples of water. The glassware was sealed and then shaken vigorously for 10 seconds. The total volume including the froth formed, was recorded.

Three trials were conducted for each water source. The results obtained from this experiment are shown in the table below.

	Total volume (mL)			
Water source	Trial 1	Trial 2	Trial 3	Average
1	91.0	93.0	92.0	92.0
2	89.0	86.0	86.0	87.0
3	82.0	82.0	84.0	82.7

(a) State the independent variable for this experiment. (1)

(b) State the benefit of obtaining an average volume from three trials for each water source. (1)

(c) What piece of glassware would be used for these trials? (1)

(d) From which water source is the soap least able to froth? Explain why. (2)

Question 24 (4 marks)

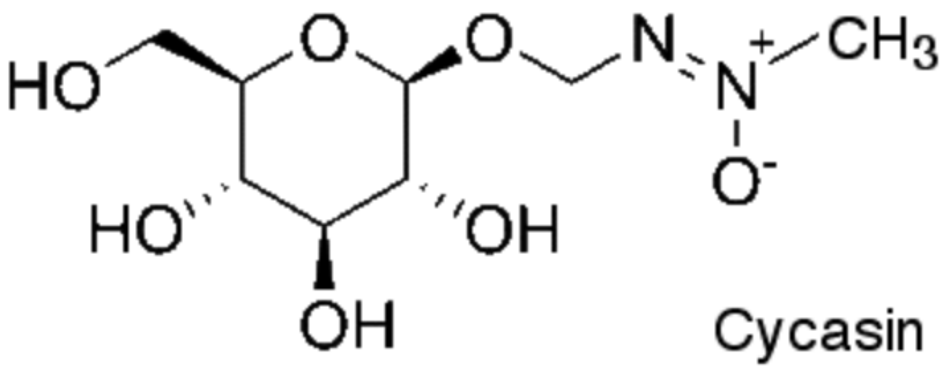
An investigation into the solubility product of silver bromate was conducted by reacting equal volumes of varying concentrations of two solutions, silver nitrate and sodium bromate. The solutions reacted at 25°C. The observations are recorded below.

Test	$[Ag^+]$ mol L^{-1}	$[BrO_3^-]$ mol L^{-1}	*Observations*
1	0.05	0.05	thick white precipitate
2	0.025	0.05	white precipitate
3	0.005	0.05	fine white precipitate settles on standing
4	0.0025	0.05	fine white precipitate settles on standing
5	0.00125	0.05	fine white precipitate settles on standing
6	0.0005	0.05	no precipitate
7	0.00025	0.05	no precipitate

(a) Analyse the data to determine the range of values where the solubility product at 25 °C must lie. (2)

(b) Using the range of values from part (a) calculate the average to estimate the K_{sp} and then calculate the solubility of silver bromate at equilibrium. (2)

Question 25 (5 marks)
Below is the structural formula for cycasin the toxin in cycads.



Cycasin

(a) Write the molecular formulae of the compound. (2)

(b) Explain using Le Chatelier's principle why leaving it in running water for several days can remove this toxin. (3)

Refer to its structure and the following equation:

$$\text{cycasin(s)} + H_2O_{(l)} \rightleftharpoons \text{cycasin(aq)}$$

Question 26 (5 marks)

(a) Draw a functional group isomer of cyclopentene. (1)

(b) Write the chemical equation (using structural formulae) for cyclopentene and bromine water. (2)

(c) Write down a risk assessment for either cyclopentene or bromine water. (2)

Question 27 (4 marks)

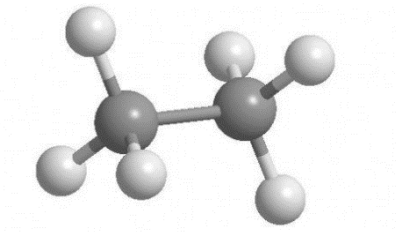
Hydrocyanic acid (HCN) is a weak acid. A 2.2M solution of HCN at 25°C has a $K_b = 1.62 \times 10^{-5}$

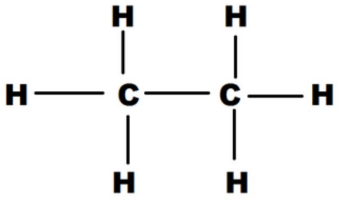
(a) Write the equation of HCN dissociation in water. (1)

(b) Use an ICE table and the information above to find the concentration of all of the species at equilibrium (assuming negligible dissociation). (3)

Question 28 (4 marks)

The models below both represent ethane.

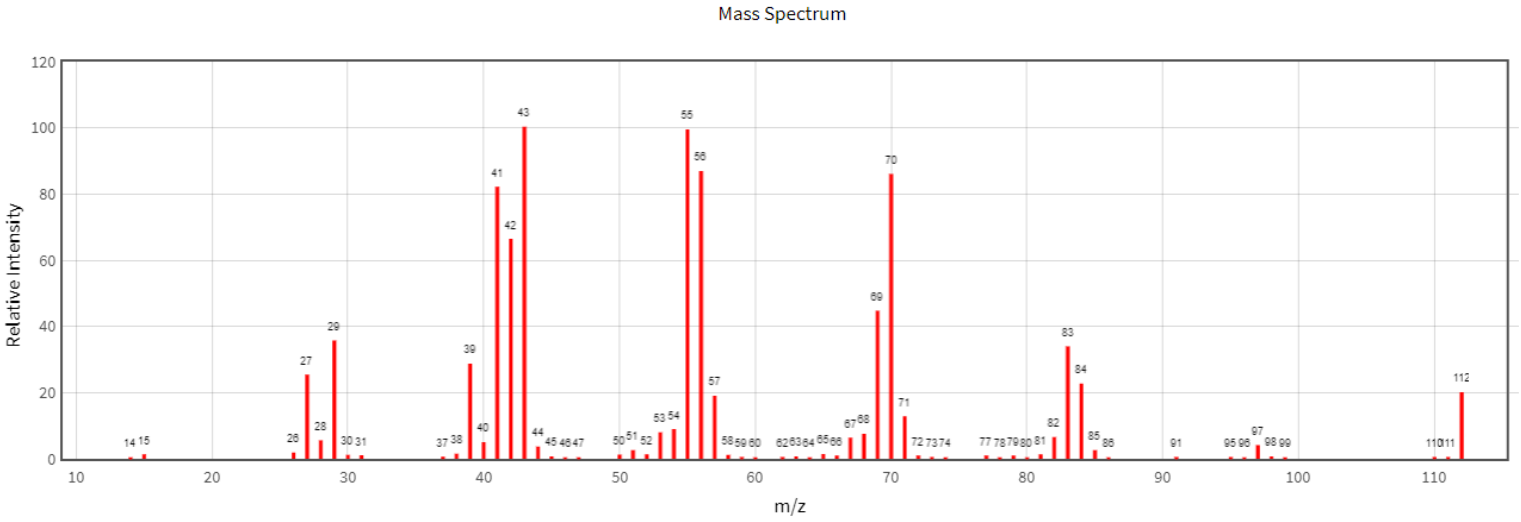




Discuss the advantages and disadvantages of each models representing ethane. (4)

Question 29 (2 marks)

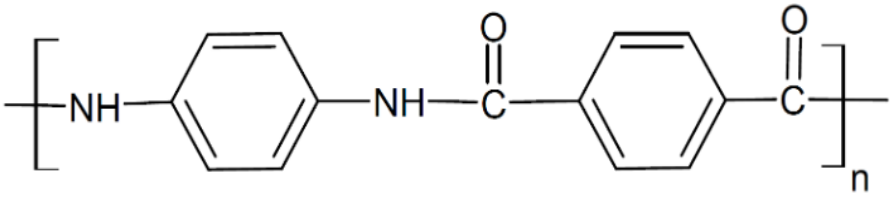
The mass spectrum of a hydrocarbon is shown below.



The hydrocarbon contains 85.7% C and 14.3% H. Determine the molecular formula of the hydrocarbon. (2)

Question 30 (4 marks)

The image below represents a polymer.



(a) Draw the two monomers that make up this polymer. (1)

(b) What type of polymer is this? (1)

(c) This is a strong polymer explain why referring to its structure. (2)

Question 31 (6 marks)

As part of the Chemistry course, you have carried out a practical investigation to measure the enthalpy of neutralisation.

(a) Outline the steps carried out this investigation. (3)

(b) Calculate the enthalpy of neutralisation of acetic acid if 25.0 ml of 1.0 M acetic acid and 25.0 ml of 1.0 M NaOH are mixed together and the temperature rise is 6.2 ºC. (Assume the density of the mixture is 1g/mL) (3)

Question 32 (7 marks)

The concentration of a sample of nitric acid was determined using 1.01 mol L^{-1} ammonia solution. A 25.00 mL aliquot (portion) of the ammonia solution was added to a conical flask and a few drops of methyl orange were added. The mixture was shaken, giving a pale-yellow colour. The end points of four titrations are shown in the table.

Titration number	*Volume of HNO_3 (mL)*
1	37.8
2	36.1
3	36.2
4	36.0

(a) 'Equivalence point' and 'end point' are terms often used regarding titrations. Using the titrations described above, explain the difference between the two terms. (2)

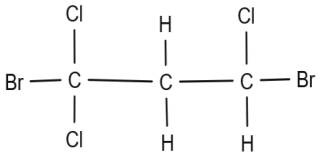
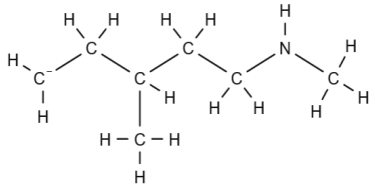
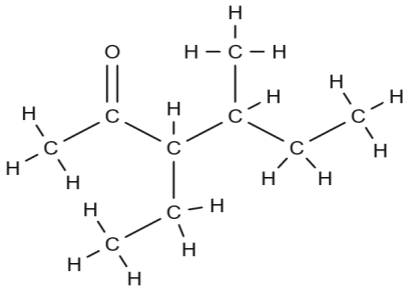
(b) Write a balanced equation for the reaction. (1)

(c) Calculate the concentration of the acid. Show your working. (2)

(d) Using the axes provided, sketch the shape of the expected titration curve for this titration. Label the axes appropriately. (2)

Question 33 (3 marks)

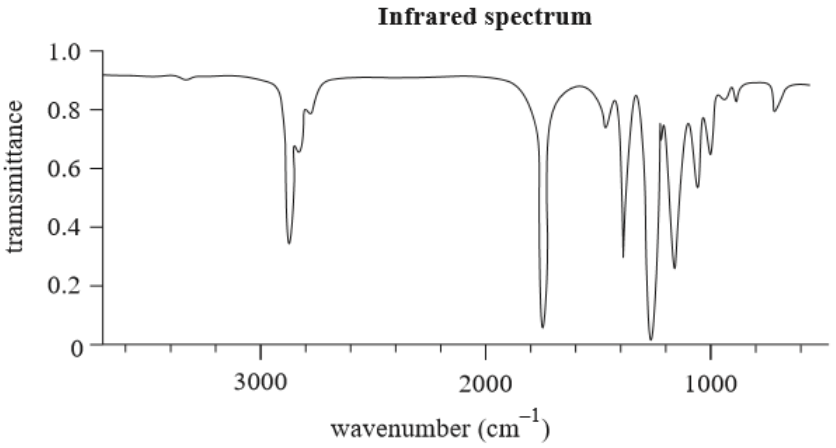
Name the following compounds. (3)

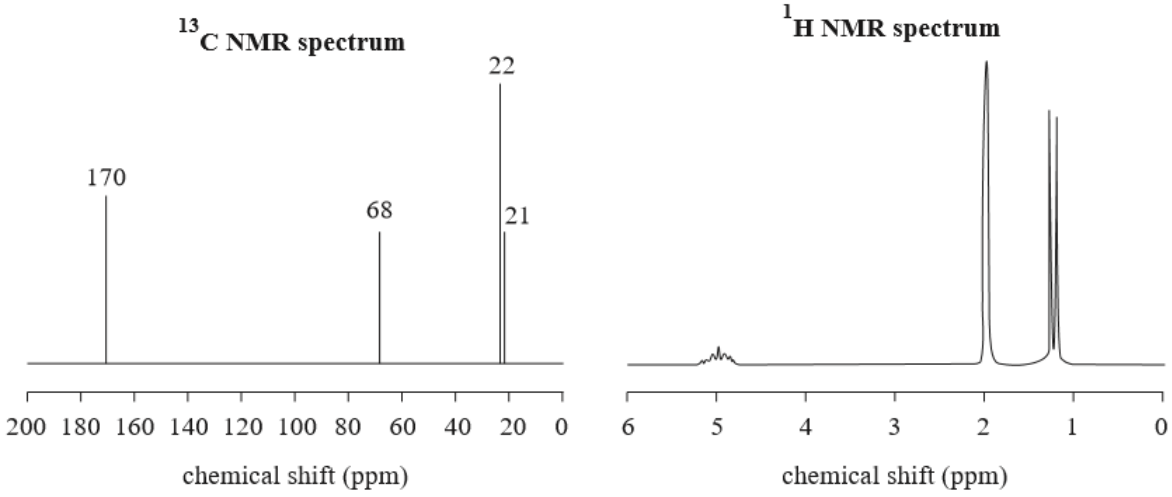
	
	
	

Question 34 (6 marks)

A chemist finds an unlabelled bottle containing a large quantity of compound Y, a colourless liquid. Elemental analysis gives a molecular formula of $C_5H_{10}O_2$. Compound Y does not decolourise bromine water, nor does it produce CO_2 when added to $NaHCO_3$ solution.

To identify the molecular structure of compound Y, a sample is submitted for spectroscopic analysis. The following data were obtained.



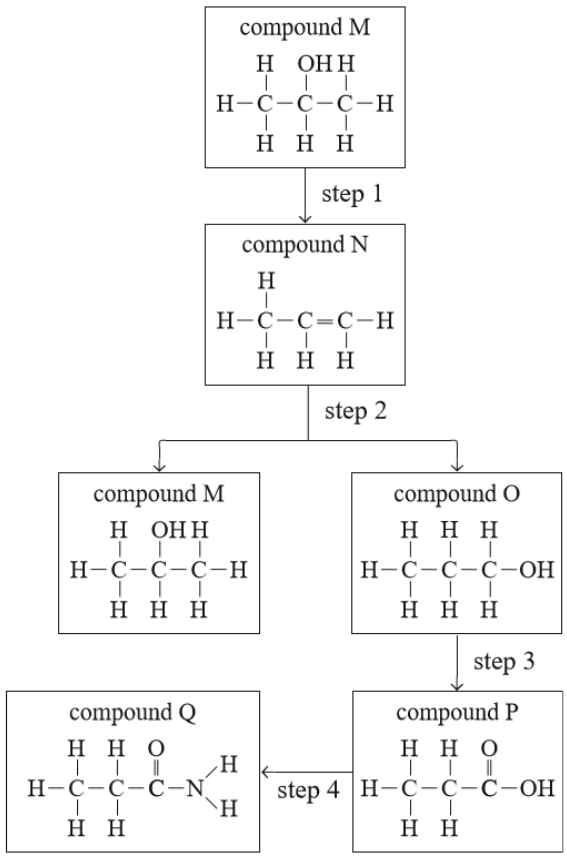


^{1}H NMR data		
Chemical shift (ppm)	*Relative peak area*	*Peak splitting*
1.2	6	doublet (2)
2.0	3	singlet (1)
5.0	1	septet (7)

Draw the structural formula of compound Y. Justify your answer with reference to all THREE of the provided spectra. (6)

Question 35 (10 marks)

The diagram shows a reaction scheme that can be used to synthesise propanamide.



(a) Identify the reagents and conditions needed to achieve step 1-3 of this synthetic scheme and explain how ^{1}HNMR and mass spectroscopic techniques could be used to identify compounds M and O. (5)

(b) Write the structural formula for the organic product of compound P reacting with compound M. (1)

(c) How will this new product differ in boiling point compared to the reactants? Explain why. (2)

(d) Justify what equipment and conditions you need for this reaction to occur. (2)

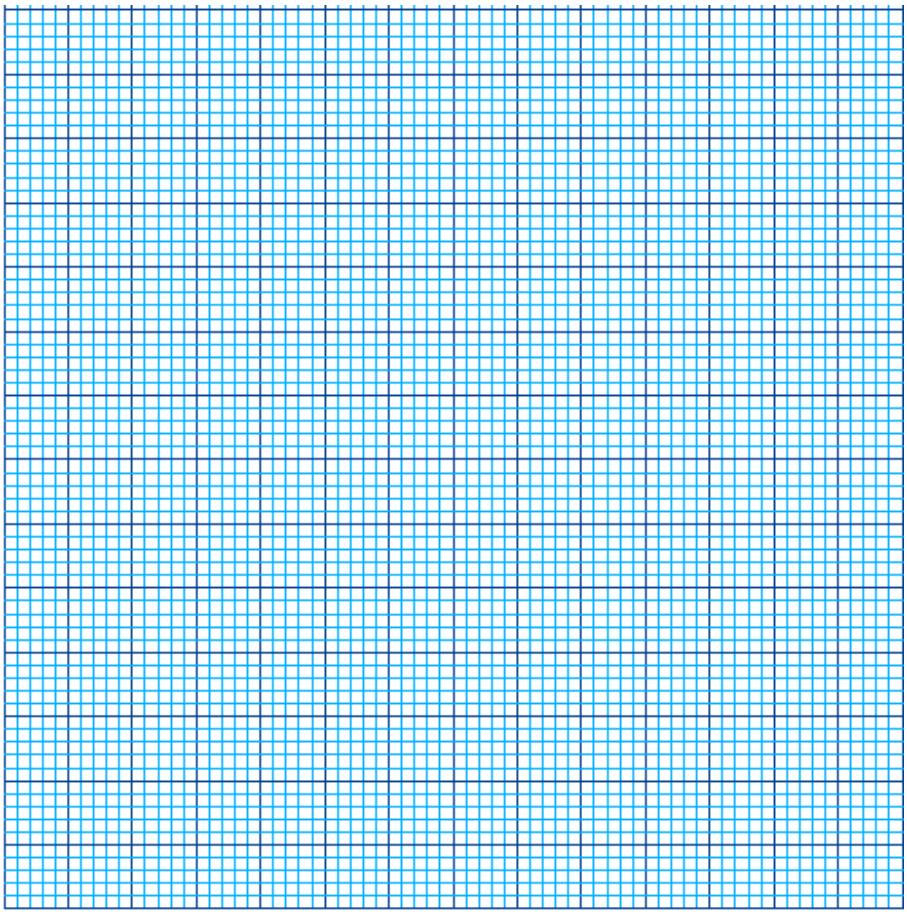
Question 36 (6 marks)

Brass is an alloy of copper and zinc.

To determine the percentage of copper in a particular sample of brass, an analyst prepared a number of standard solutions of copper (II) ions and measured their absorbance using an atomic absorption spectrometer (AAS). The results are given in the table.

Cu^{2+} concentration ($mg\ L^{-1}$)	Absorbance
0	0
50.00	0.060
100.0	0.120
200.0	0.240
300.0	0.360
400.0	0.480
500.0	0.600

(a) Draw and label the absorbance versus concentration calibration curve for Cu^{2+}. (3)



(b) A 19.8 mg sample of the brass was dissolved in acid, and the solution was made up to 100 mL in a volumetric flask. The absorbance of this test solution was found to be 0.150.

Calculate the percentage by mass of copper in the brass sample. (3)

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Trial Examination

Chemistry
Answers

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Section I

20 marks

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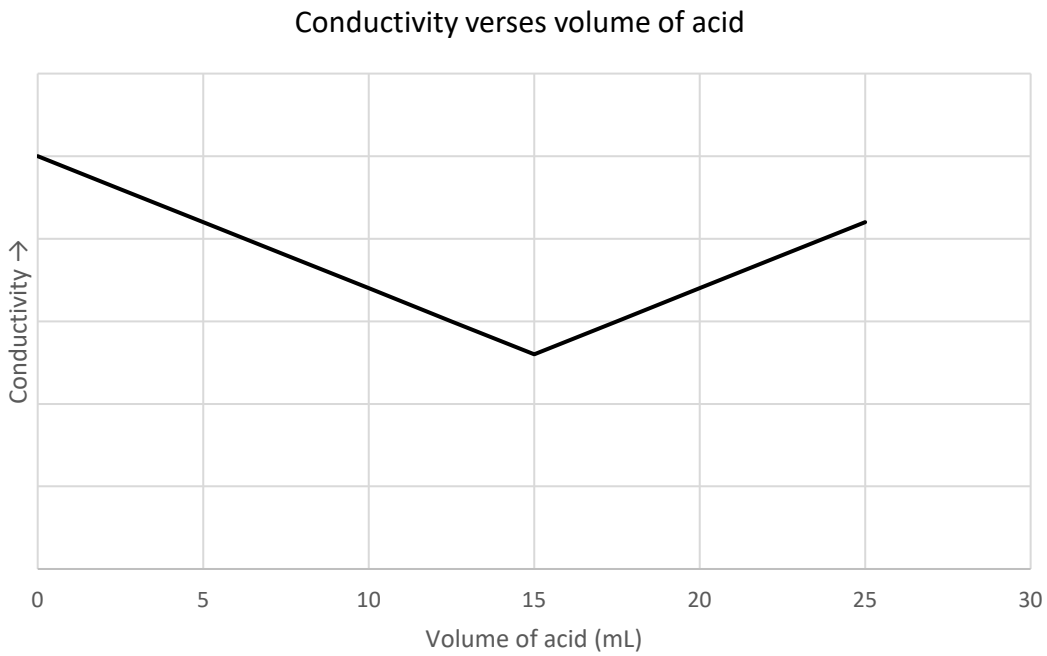

Which statement about this titration is correct?

(A) The equivalence point occurred when 15 mL of acid was added.

(B) The equivalence point occurred when 25 mL of acid was added.

(C) Neutralisation is incomplete as the conductivity has not reached zero.

(D) The end point occurred when 15 mL of acid was added, and the equivalence point occurred when 25 mL of acid was added.

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(A) 2

(B) 3

(C) 4

(D) 5

4 A 250.0 mL sample of 0.40M hydrochloric acid is added to 750.0 ml of 0.60M potassium hydroxide solution.

What is the final concentration of hydroxide ions?

(A) 0.30 M

(B) 0.35 M

(C) 0.40 M

(D) 0.45 M

5 How many products are possible when but-2-ene reacts with $HCl_{(g)}$?

(A) 1

(B) 2

(C) 3

(D) 4

6 For the reaction:

$$Br_{2\,(g)} + I_{2\,(g)} \rightleftharpoons 2IBr_{\,(g)} \qquad K_{eq} = 1.2 \times 10^{2} \text{ at } 150°C$$

Given this reaction above, what is the Kc for the reaction shown below?

$$4IBr_{(g)} \rightleftharpoons 2Br_{2(g)} + 2I_{2(g)} \text{ at } 150°C$$

(A) 1.6×10^{-2}

(B) 4.1×10^{-3}

(C) 6.9×10^{-5}

(D) 8.0×10^{-5}

7 Jennie wants to use a physical property to distinguish between two alcohols, octan-1-ol and propan-1-ol. Both alcohols are colourless liquids at standard laboratory conditions. The student should use:

(A) density because propan-1-ol has a much higher density than octan-1-ol.

(B) boiling point because octan-1-ol has a higher boiling point than propan-1-ol.

(C) electrical conductivity because octan-1-ol has a higher conductivity than propan-1-ol.

(D) spectroscopy because it is not possible to distinguish between the alcohols using their other physical properties.

8 The equilibrium expression for a reaction is

$$Keq = \frac{[H^+]^6}{[Bi^{3+}]^2[H_2S]^3}$$

The reaction could be:

(A) $6H^+ + BiS_{(s)} \rightleftharpoons 2Bi^{3+}(aq) + 3H_2S_{(g)}$

(B) $6H^+_{(aq)} + Bi_2S_{3\,(s)} \rightleftharpoons 2Bi^{3+}_{(aq)} + 3H_2S_{(g)}$

(C) $2Bi^{3+}_{(aq)} + 3H_2S_{(aq)} \rightleftharpoons Bi_2S_{3(s)} + 6H^+_{(aq)}$

(D) $2Bi^{3+}_{(aq)} + 3H_2S_{(aq)} \rightleftharpoons Bi_2S_{3\,(aq)} + 6H^+_{(aq)}$

9 The indicator HIn is used in a titration between hydrochloric acid and magnesium hydroxide solutions. The following equation represents how the indicator works.

$$HIn(aq) \leftrightharpoons H^+(aq) + In^-(aq)$$

green purple

The indicator is added to 20.0 ml of magnesium hydroxide solution in a conical flask and the hydrochloric acid is added via a burette until the endpoint is observed. The acidic and basic solutions are of similar concentrations and the flask is swirled continuously as the acid is added. Which of the following statements describe the expected observations for the colour of the solution in the conical flask?

(A) The solution starts green and turns purple after the addition of approximately 10ml.

(B) The solution starts green and turns purple after the addition of approximately 40ml.

(C) The solution starts purple and turns green after the addition of approximately 10ml.

(D) The solution starts purple and turns green after the addition of approximately 40ml.

10 The pH of a solution of HCOOH is 3.0. What is the concentration of the acid if pKa = 3.75? (Assume negligible dissociation)

(A) 5.6×10^{-3} mol L^{-1}

(B) 6.6×10^{-3} mol L^{-1}

(C) 5.6×10^{-2} mol L^{-1}

(D) 5.6 mol L^{-1}

11 Rose set up a spirit burner containing an alcohol (molar mass 74.1 g mol^{-1}) to heat 200.0 g of water, at 23.0ºC, in a conical flask. The initial mass of the spirit burner was 350.75 g. After the water temperature reached 45.0ºC, the spirit burner was extinguished, and its mass was found to be 350.01 g.

What is the molar heat of combustion of this alcohol?

(A) 68.1 kJ mol^{-1}

(B) 1840 kJ mol^{-1}

(C) 6810 kJ mol^{-1}

(D) 32200 kJ mol^{-1}

12 The conjugate base of the ammonium ion is

(A) NH_3

(B) NH_4^+

(C) NH_2^-

(D) NH_3^+

13 Nitric acid completely dissociates in aqueous solutions. 1.0 mL of 10 mol L^{-1} solution was diluted to 1 L with distilled water. 100 mL of this resulting solution was then further diluted to 1 L using distilled water.

What pH is the final solution closest to?

(A) 1

(B) 2

(C) 3

(D) 4

14 The oxidation of sulfur dioxide, SO_2, to sulfur trioxide, SO_3, can be represented by the following equation:

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \qquad K_{eq} = 1.75 \text{ at } 1000°C$$

An equilibrium mixture has a concentration of 0.12 M SO_2 and 0.16 M oxygen gas, O_2.

The temperature of the container is 1000°C.

The equilibrium concentration of SO_3 at 1000°C is

(A) 1.5×10^{-4} M

(B) 4.0×10^{-3} M

(C) 1.2×10^{-2} M

(D) 6.3×10^{-2} M

15 Which mixture would produce a buffer solution when dissolved in 1.0L of water?

(A) 0.50 mol of CH_3COOH and 0.50 mol of NaOH

(B) 0.50 mol of CH_3COOH and 0.25 mol of NaOH

(C) 0.50 mol of CH_3COOH and 1.00 mol of NaOH

(D) 0.50 mol of CH_3COOH and 0.25 mol of $Ba(OH)_2$

16 Separate 25.0 mL samples of 0.10 mol L^{-1} ethanoic acid solution and 0.10 mol L^{-1} hydrochloric acid solution, are prepared.

Which one of the following statements about the samples is correct?

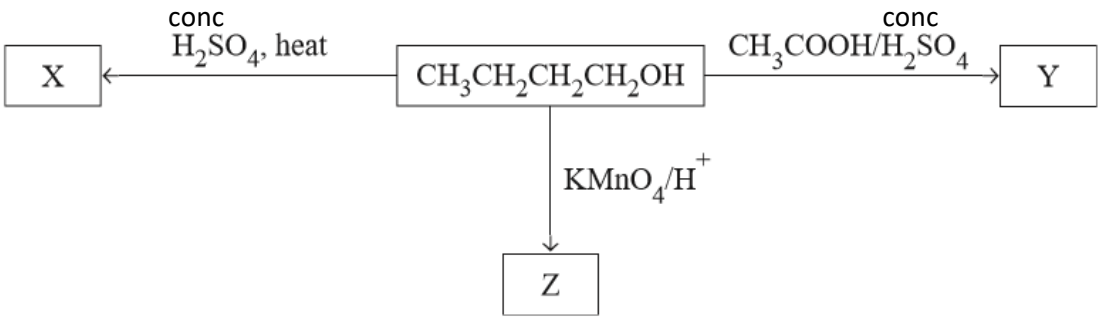
(A) Both samples will react with 1.00 g of magnesium ribbon at the same rate.

(B) Both samples have the same electrical conductivity.

(C) The concentration of H_3O^+ ions is greater in the ethanoic acid solution.

(D) Both samples will react completely with 25.0 mL of 0.10 mol L^{-1} sodium hydroxide solution.

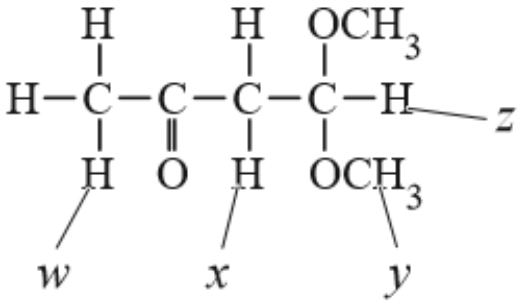
17 Consider the reaction sequence below.



Which row of the table correctly identifies X, Y and Z? A

	X	Y	Z
(A)	but-1-ene	(1-butyl) ethanoate	butanoic acid
(B)	butane	hexanoic acid	butan-1-ol
(C)	but-2-ene	ethyl butanoate	butanoate
(D)	cyclobutane	butyl acetate	butanal

18 Consider the following molecule.



Which one of the labelled hydrogens gives a triplet signal in a ^{1}H NMR spectrum?

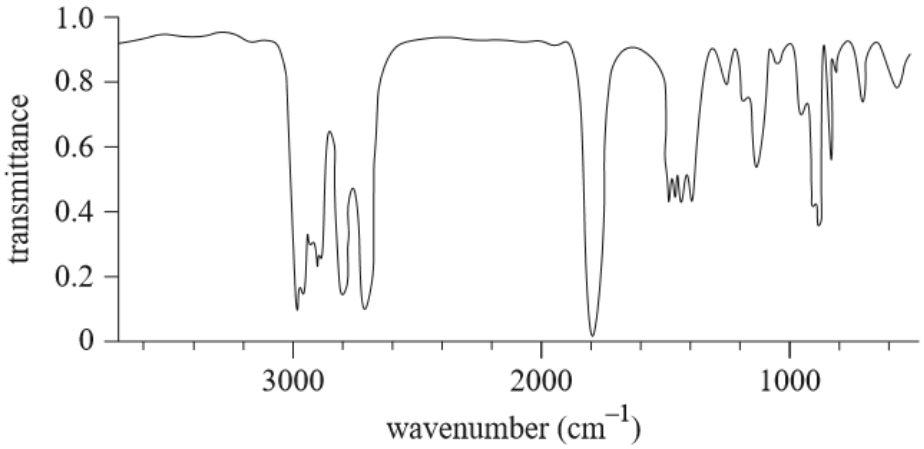
(A) hydrogen w

(B) hydrogen x

(C) hydrogen y

(D) hydrogen z

19 The infrared spectrum of an unknown sample is shown below.



What is the unknown sample most likely to be?

(A) Butanal

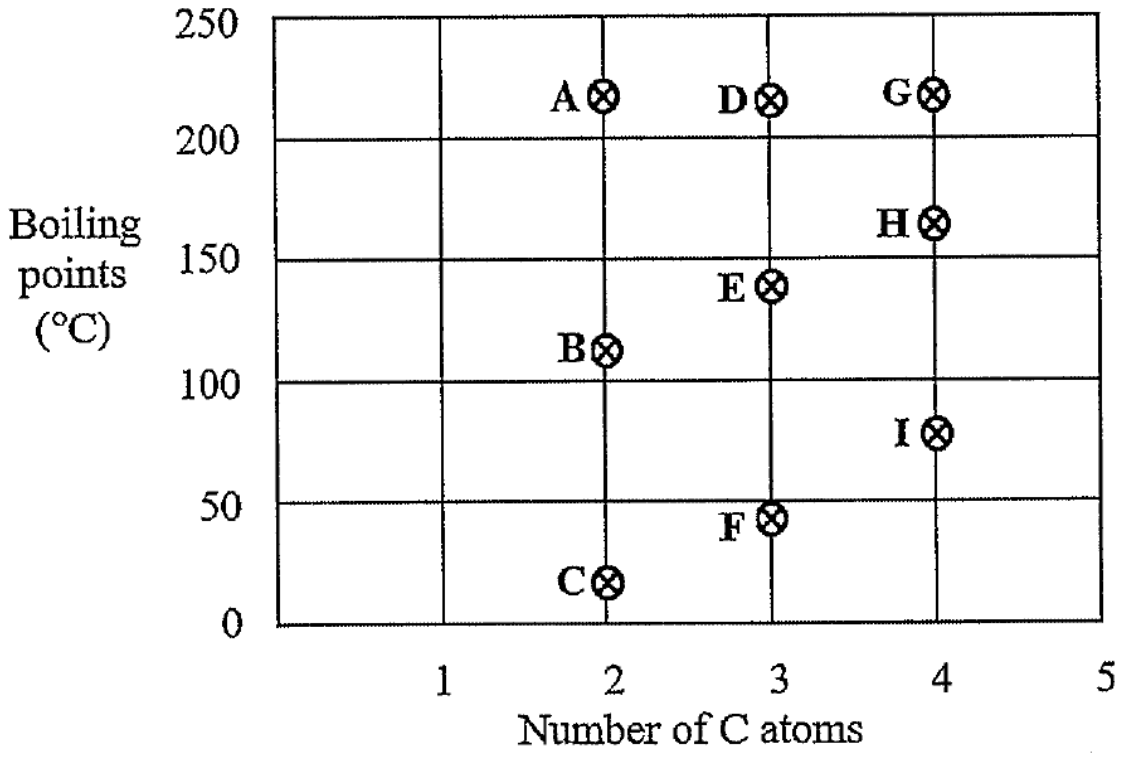
(B) Butanoic acid

(C) Hex-3-ene

(D) Propanol

20 The graph below shows the boiling points and carbon chain lengths of nine different organic compounds that are represented by the letters A to I.

Three of these compounds are carboxylic acids, three are alkylamines and three are amides.



Which of the follow correctly identifies the groups to which each of the compounds (A to I) belongs?

	Carboxylic acid	Alkylamine	Amide
(A)	D, E, F	A, B, C	G, H, I
(B)	A, D, G	B, E, H	C, F, I
(C)	B, E, H	C, F, I	A, D, G
(D)	C, E, G	A, F, H	B, D, I

Section II

80 marks

Answer questions in the space provided.

Show all relevant working in questions involving calculations.

Question 21 (6 marks)

The reaction to produce hydrogen from carbon monoxide and steam is shown.

$$H_2O_{(g)} + CO_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$$

Use the data supplied in the table to answer the following questions.

	ΔH_f° kJ mol^{-1}	S° J K^{-1} mol^{-1}
$CO_{(g)}$	-111	198
$H_2O_{(g)}$	-242	189
$CO_{2(g)}$	-393	214
$H_{2(g)}$	0	131

(a) Calculate the enthalpy change for this reaction. (1)

ΔH = -40 kJ/mol

(b) Calculate the entropy change for this reaction. (1)

ΔS = -42 J/K/mol

(c) Determine whether this reaction is spontaneous at 600K under standard conditions. (2)

ΔG = ΔH - TΔS

= -14.8 kJ/mol

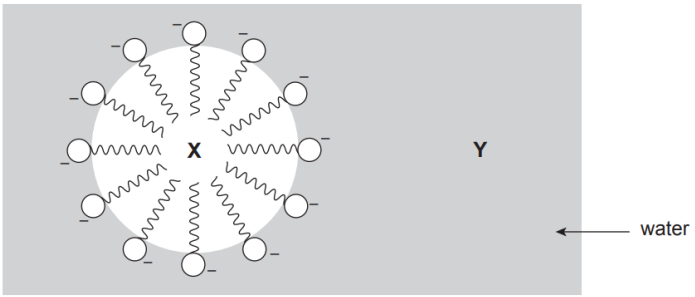
(d) Given that when a reaction has reached equilibrium ΔG = 0, calculate the minimum temperature required for this reaction to reach equilibrium under standard conditions AND state when the reaction will be spontaneous. (2)

ΔG = 0

T = 952.38K

Question 22 (3 marks)
Soaps are commonly used cleaning agents.

Soap anions remove grease by forming micelles in water. A diagram of a micelle in water is shown below.

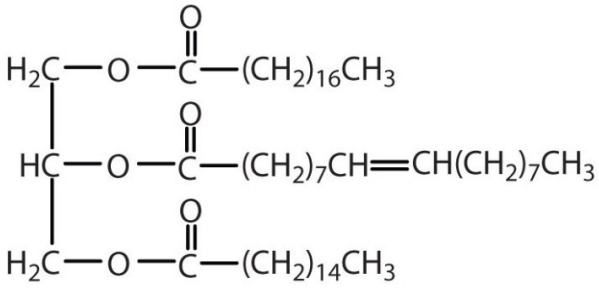


(a) Identify which region X or Y is more polar. (1)

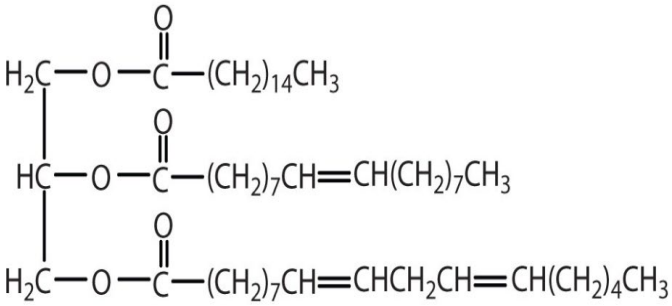
Y

(b) Fats are solid at room temperature and oils are generally liquids. Which triglyceride A or B is more likely to be in oils and which in fats? Justify your choice. (2)

triglyceride - A



triglyceride – B



A = Fat, B = Oil

B has multiple unsaturated bonds causing 'bends' or 'kinks' in the carbon chains.

Molecules cannot pack as closely together, reduced intermolecular dispersion forces,

---

lower melting point and hence liquid at room temperature.

SGS note: The dot point says "investigate the structure and action of soaps and detergents". This question is beyond this scope, but could be considered to be part of molecular shape and BP links.

Question 23 (5 marks)

The effectiveness of a soap can be measured by its ability to froth in water. Trials were conducted, using one piece of glassware, to compare the effectiveness of one soap in samples of water taken from three different sources. In each trial, 1.0 mL of soap solution was added to 80.0 mL samples of water. The glassware was sealed and then shaken vigorously for 10 seconds. The total volume including the froth formed, was recorded.

Three trials were conducted for each water source. The results obtained from this experiment are shown in the table below.

	Total volume (mL)			
Water source	Trial 1	Trial 2	Trial 3	Average
1	91.0	93.0	92.0	92.0
2	89.0	86.0	86.0	87.0
3	82.0	82.0	84.0	82.7

(a) State the independent variable for this experiment. (1)

Water source

(b) State the benefit of obtaining an average volume from three trials for each water source. (1)

Improves reliability

(c) What piece of glassware would be used for these trials? (1)

Measuring cylinder (not test tube)

(d) From which water source is the soap least able to froth? Explain why. (2)

3

Possibly hard water containing Ca2+ and Mg2+ ions

These ions react with soap anions and form a precipitate, soap scum

Question 24 (4 marks)

An investigation into the solubility product of silver bromate was conducted by reacting equal volumes of varying concentrations of two solutions, silver nitrate and sodium bromate. The solutions reacted at 25°C. The observations are recorded below.

Test	$[Ag^+]$ mol L^{-1}	$[BrO_3^-]$ mol L^{-1}	*Observations*
1	0.05	0.05	thick white precipitate
2	0.025	0.05	white precipitate
3	0.005	0.05	fine white precipitate settles on standing
4	0.0025	0.05	fine white precipitate settles on standing
5	0.00125	0.05	fine white precipitate settles on standing
6	0.0005	0.05	no precipitate
7	0.00025	0.05	no precipitate

(a) Analyse the data to determine the range of values where the solubility product at 25 °C must lie. (2)

Ksp between test 5 and 6

Ksp test 5 = [Ag+][BrO3-] = 0.00125 x 0.05 = 6.25 x 10-5

Ksp test 6 = 0.0005 x 0.05 = 2.5 x 10-5

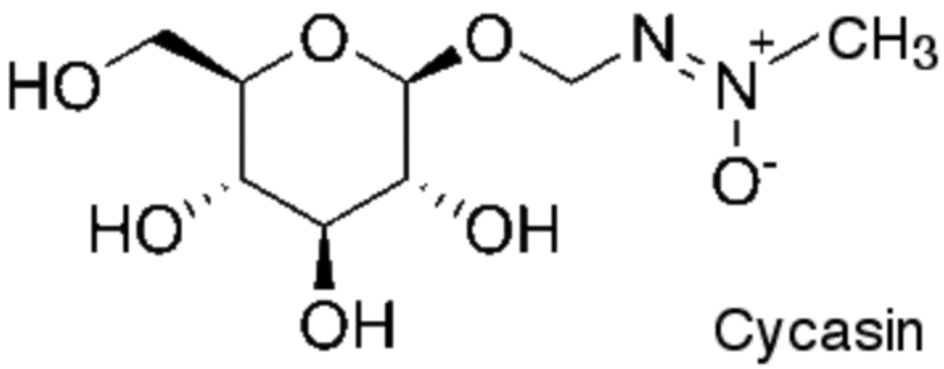
Note: concentrations are actually halved as equal volumes were added, not seen by any student.

(b) Using the range of values from part (a) calculate the average to estimate the K_{sp} and then calculate the solubility of silver bromate at equilibrium. (2)

Avg Ksp = Ksp test 5 + Ksp test 6/2 = 4.5 x 10-5

[AgBrO3] = 6.6 x 10-3 M

Question 25 (5 marks)
Below is the structural formula for cycasin the toxin in cycads.



Cycasin

(a) Write the molecular formulae of the compound. (2)

$C_8H_{16}O_7N_2$

(b) Explain using Le Chatelier's principle why leaving it in running water for several days can remove this toxin. (3)

Refer to its structure and the following equation:

$$\text{cycasin(s)} + H_2O_{(l)} \rightleftharpoons \text{cycasin(aq)}$$

Cycasin is polar, has hydroxyl groups and polar N-O part, hence soluble in water

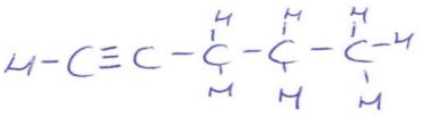
Equilibrium shifts right due to continuous removal of cycasin (aq) by running water.

Water is continuously added to the equilibrium.

Question 26 (5 marks)

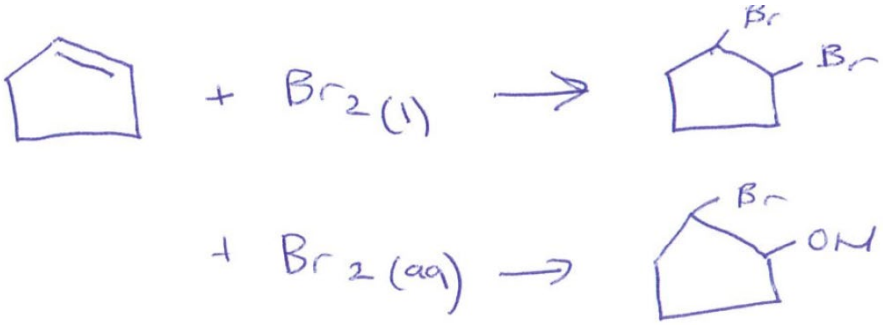
(a) Draw a functional group isomer of cyclopentene. (1)

C_5H_8



- any isomer of pentyne

(b) Write the chemical equation (using structural formulae) for cyclopentene and bromine water. (2)



To be awarded all 2 mark the following needs to be done:

- correct structural formula for reactants
- correct structural formula for products

(c) Write down a risk assessment for either cyclopentene or bromine water. (2)

(1) Cyclopentene - flammable | harmful to skin eyes | inhalation → toxic
- fume cupboard, goggles, gloves

or

(1) $Br_{2(aq)}$: harmful to eye - skin inhalation - toxic
- fume cupboard | goggles | glove >

Question 27 (4 marks)

Hydrocyanic acid (HCN) is a weak acid. A 2.2M solution of HCN at 25°C has a $K_b = 1.62 \times 10^{-5}$

(a) Write the equation of HCN dissociation in water. (1)

$+ H_2O(l) \quad HCN_{(aq)} \rightleftharpoons H_3O^+_{(aq)} + CN^-_{(aq)}$

(b) Use an ICE table and the information above to find the concentration of all of the species at equilibrium (assuming negligible dissociation). (3)

$K_b \times K_a = 10^{-14}$

$K_a = \frac{10^{-14}}{1.62 \times 10^{-5}} = 6.17 \times 10^{-10}$

	HCN	H_3O^+	CN^-
I	2.2	0	0
C	$-x$	$+x$	$+x$
E	$2.2-x$	x	x

Let x = Amount of dissociation

$K_a = 6.17 \times 10^{-10} = \frac{[H_3O^+][CN^-]}{[HCN]}$

$6.17 \times 10^{-10} = \frac{x^2}{(2.2-x)}$

$6.17 \times 10^{-10} = \frac{x^2}{2.2}$

$x = 3.69 \times 10^{-5}$

$= 3.7 \times 10^{-5} M$

$[H_3O^+] = 3.7 \times 10^{-5} M = [CN^-]$

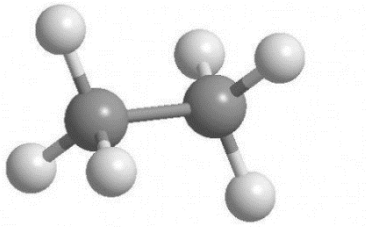
$[HCN] = 2.2 M$

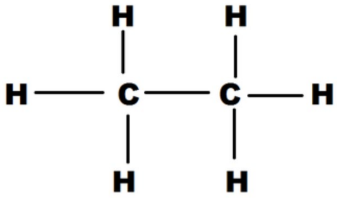
To be awarded all 3 mark the following needs to be done:

- Calculate Ka from the Kb value
- Constructed an ICE table and have the values filled in correctly
- Correct final concentration of HCN, H3O+, CN-

Question 28 (4 marks)

The models below both represent ethane.





Discuss the advantages and disadvantages of each models representing ethane. (4)

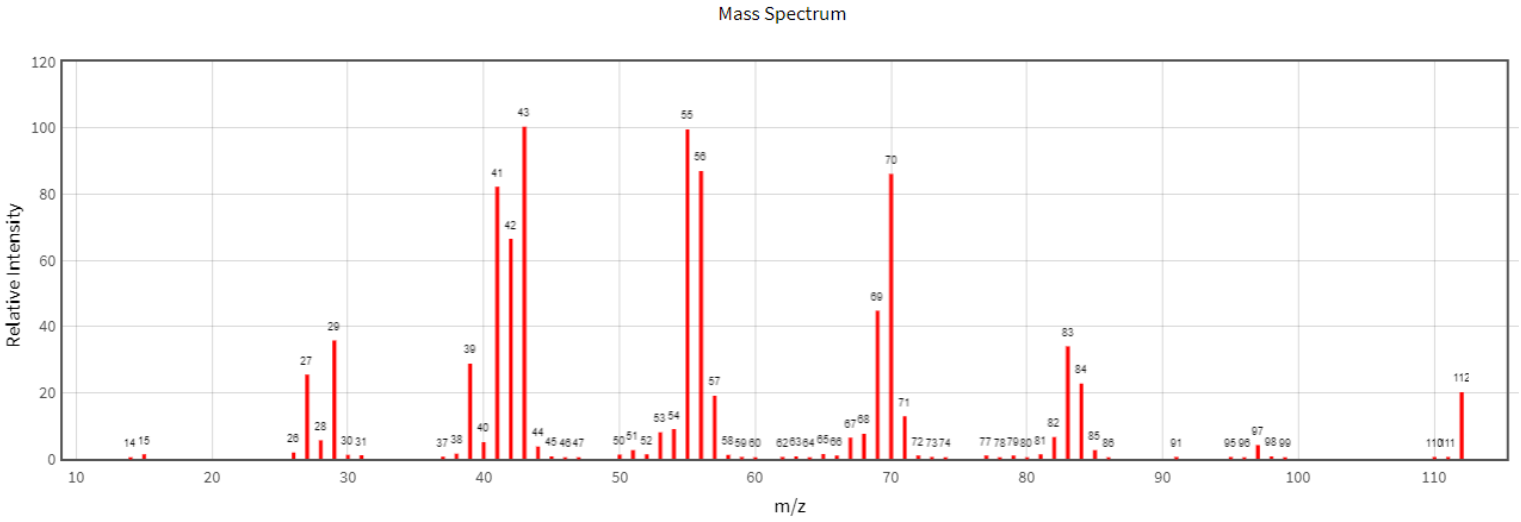
To be awarded all 4 mark the following needs to be done:

- ONE advantages of the ball and stick model + structural formula
- ONE disadvantage of the ball and stick model + structural formula

If you did an advantages i.e. the ball and stick model you can also do it as a disadvantage of the structural formula model

Question 29 (2 marks)

The mass spectrum of a hydrocarbon is shown below.



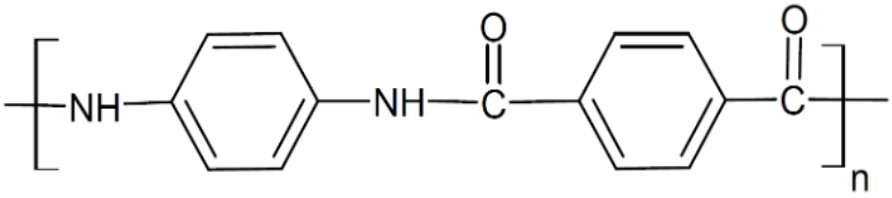
The hydrocarbon contains 85.7% C and 14.3% H. Determine the molecular formula of the hydrocarbon. (2)

To be awarded all 2 mark the following needs to be done:

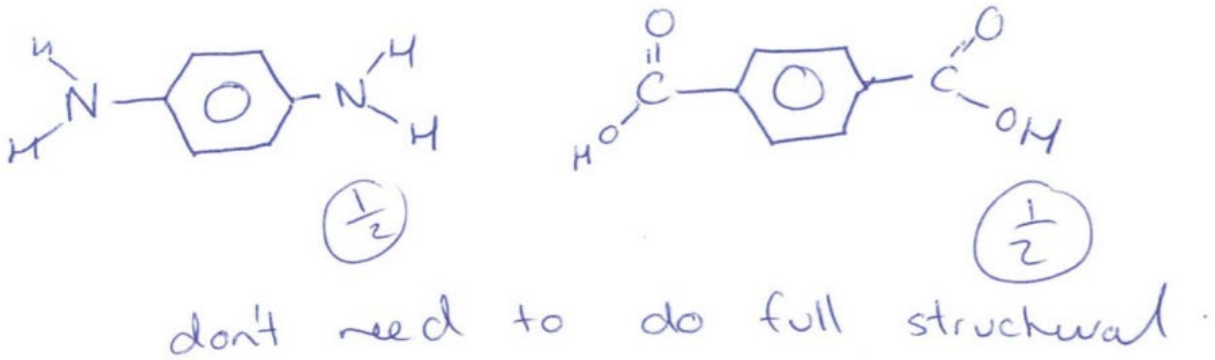
- Determined what the molecular ion peak is
- Deduced the molecular formula of the Mass Spectrum to be C8H16

Question 30 (4 marks)

The image below represents a polymer.



(a) Draw the two monomers that make up this polymer. (1)



(b) What type of polymer is this? (1)

To be awarded 1 mark the following needs to be done:

- Condensation or polyamide

(c) This is a strong polymer explain why referring to its structure. (2)

To be awarded all 2 mark the following needs to be done:

- Refer to structure of where the polar bond N-H and how it can form hydrogen bonding with itself which means it is going to have a high m.p/b.p
- Refer to the benzene ring and discuss how the bulky structure either adds to increase intermolecular forces or makes it more rigid

General Concerns

1. Most people go confused as to where the H-bond was occuring or only discussed about dipole-dipole forces which is not correct as it is not the dominant force in the polymer…
2. Only mentioned H-bond but haven't actually **referred to its structure**
3. Only did it on either benzene ring or N-H bonds

Question 31 (6 marks)

As part of the Chemistry course, you have carried out a practical investigation to measure the enthalpy of neutralisation.

(a) Outline the steps carried out this investigation. (3)

o be awarded all 3 mark the following needs to be done:

- Use correct concentration + volume of acid and base
- Outline each step by step with a verb and sufficient detail
- Include the lid and how the dependent variable was measured

General Concerns

1. Used the wrong acid/base for this experiment (does not work with weak acid and base) as enthalpy of neutralisation is for the amount of energy per mole of water formed. If you used a weak acid/base it would include other enthalpy changes in the final results as opposed to just H+ with OH- to form water.
2. Forgot to record the maximum temperature change as this is very important…
3. volume or concentration of acid/base was ridiculous

(b) Calculate the enthalpy of neutralisation of acetic acid if 25.0 ml of 1.0 M acetic acid and 25.0 ml of 1.0 M NaOH are mixed together and the temperature rise is 6.2 ºC. (Assume the density of the mixture is 1g/mL) (3)

(1) $q = 0.05 \times 4.18 \times 10^3 \times 6.2$

$= 1295.8\ J$

$= 1.2958\ kJ$

$n\ H_2O = 0.025$ (1)

$\Delta H = \frac{1.2958}{0.025} = 52\ kJ/mol$

Question 32 (7 marks)

The concentration of a sample of nitric acid was determined using 1.01 mol L^{-1} ammonia solution. A 25.00 mL aliquot (portion) of the ammonia solution was added to a conical flask and a few drops of methyl orange were added. The mixture was shaken, giving a pale-yellow colour. The end points of four titrations are shown in the table.

Titration number	*Volume of HNO_3 (mL)*
1	37.8
2	36.1
3	36.2
4	36.0

(a) 'Equivalence point' and 'end point' are terms often used regarding titrations. Using the titrations described above, explain the difference between the two terms. (2)

To be awarded all 2 mark the following needs to be done:

- Explained the term equivalence (equivalent moles of acid and base)
- Explain the term end-points (refers to when the indicator changes colour)

General Concerns

1. Either didn't know what the terms mean or had it mixed up

(b) Write a balanced equation for the reaction. (1)

(b) Write a balanced equation for the reaction. (1)

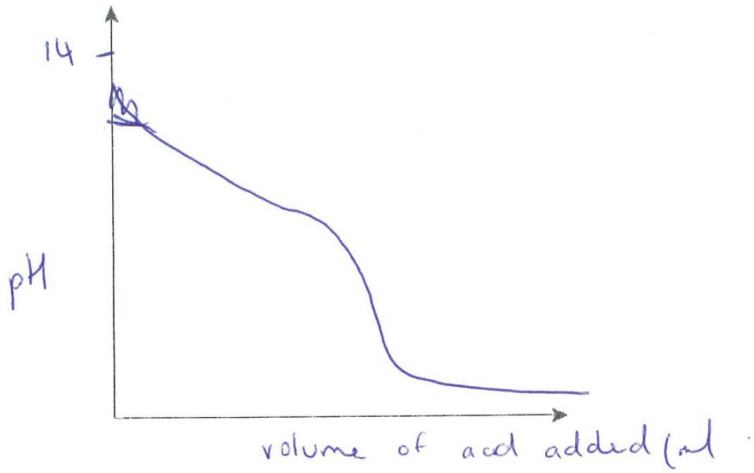
$HNO_{3(aq)} + NH_{3(aq)} \rightarrow NH_4NO_{3(aq)}$

(c) Calculate the concentration of the acid. Show your working. (2)

Ignore 1 average of titrates 2-4
= 36.1 mL
1:1 stoichiometry
$n = c \cdot V$
$= 1.01 \times \frac{25}{1000}$
$= 0.02525$ mol
$0.02525 = x \times \frac{36.1}{1000}$
$x = 0.6994 \text{ mol L}^{-1}$
$= 0.699$ M

(d) Using the axes provided, sketch the shape of the expected titration curve for this titration. Label the axes appropriately. (2)

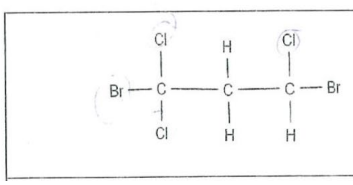
(d) Using the axes provided, sketch the shape of the expected titration curve for this titration. Label the axes appropriately. (2)



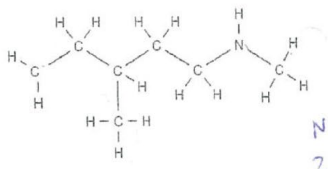
Question 33 (3 marks)

Name the following compounds. (3)

Name the following compounds. (3)

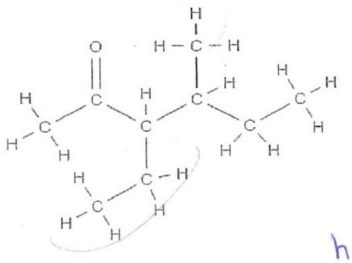


1,3-dibromo-1,1,3-trichloropropane (1)



N-methyl
3-methyl

N,3-dimethylpenta-1-amine (1)



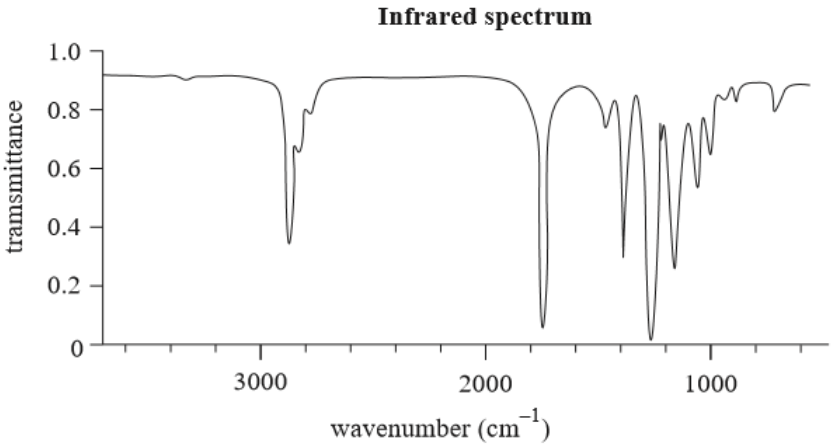
hexa-2-one
2-hexanone

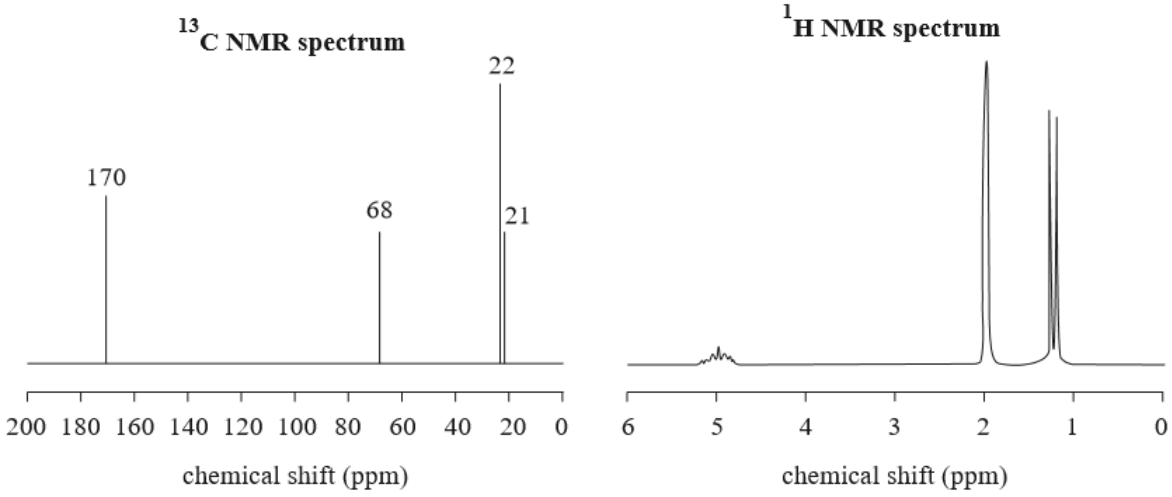
3-ethyl-4-methyl-2-hexanone
or
hexa-2-one (1)

Question 34 (6 marks)

A chemist finds an unlabelled bottle containing a large quantity of compound Y, a colourless liquid. Elemental analysis gives a molecular formula of $C_5H_{10}O_2$. Compound Y does not decolourise bromine water, nor does it produce CO_2 when added to $NaHCO_3$ solution.

To identify the molecular structure of compound Y, a sample is submitted for spectroscopic analysis. The following data were obtained.





^{1}H NMR data		
Chemical shift (ppm)	*Relative peak area*	*Peak splitting*
1.2	6	doublet (2)
2.0	3	singlet (1)
5.0	1	septet (7)

Draw the structural formula of compound Y. Justify your answer with reference to all THREE of the provided spectra. (6)

34 (6 marks)

Had to mention all 3 spectra and give formula ..would not be possible if you had wrong compound to get 5 most you could

get was 4

1 mark IR peaks linked to functional group C=O at 1780.. Could mention C-O and that does not have broad OH band (or

Explain that cant be acid because it doesn't react with carbonate)

1 mark C-13 should have mentioned 4 environments and peak 170ppm C=O and C-O 68ppm

Should have realised it was an ester from these bits of info

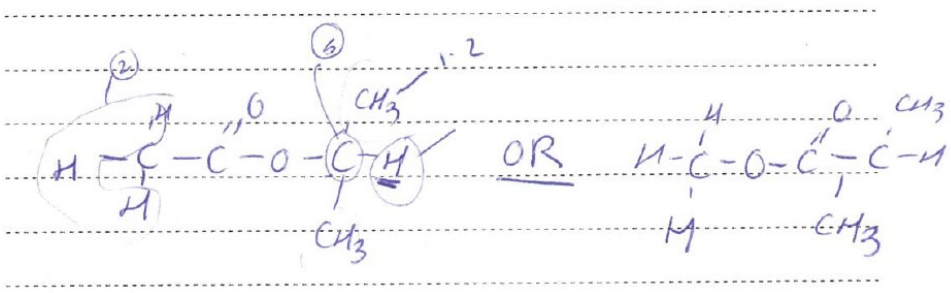
3 marks for H nmr (but if detailed from others in terms of chemical reactions still got 3)

Should mention there were 3 peaks meaning 3 environments

And describe some information eg at 5 –CH attached to CH3CH3 (it has 6 neighbouring H atoms as it is a septet

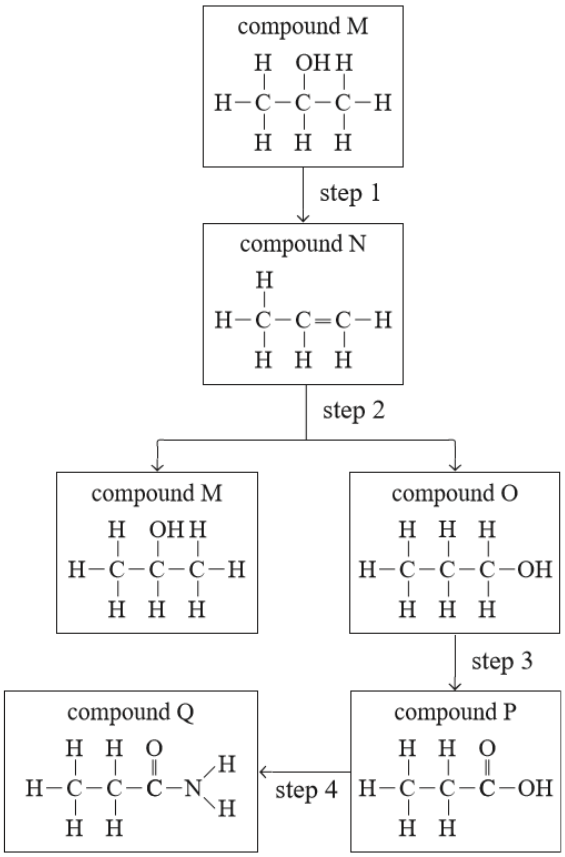
At 2 –suggests 3 H as CH3 attached to C=O as shifted

At 1.2 CH3 attached to C with no H attached …(6 means CH3 CH3) 10H atoms (6+3+1)



Question 35 (10 marks)

The diagram shows a reaction scheme that can be used to synthesise propanamide.



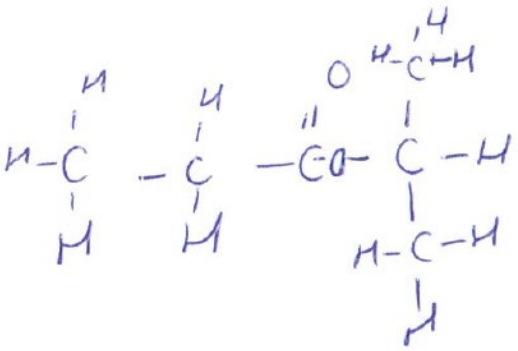
(a) Identify the reagents and conditions needed to achieve step 1-3 of this synthetic scheme and explain how ^{1}HNMR and mass spectroscopic techniques could be used to identify compounds M and O. (5)

Step 1 conc sulfuric acid ½ mark heat
Step 2 dilute sulfuric acid (can add water but not just water itself) heat ½ mark
Step 3 KMnO4/H+ or K2Cr2O7/H+ 1 mark include the H+

Mass Sec –both molecular ion at 60 but splitting pattern would be different 31 vs 45
45-CH3CHOH------(2-propanol) 31 –CH2OH 1 mark

HNmr –M -3 enviromments and O- 4 enviroments and explain why 2 marks

(b) Write the structural formula for the organic product of compound P reacting with compound M. (1)



(c) How will this new product differ in boiling point compared to the reactants? Explain why. (2)

Ester lower Bp than alcohol or acid 1 mark … Alcohol and acid have higher bp due to H bonding bwn molecules ½ …ester between molecules dipole-dipole bonding ½ mark

(d) Justify what equipment and conditions you need for this reaction to occur. (2)

Equipment….reflux equipment (round bottom flask) heat mantle condenser ½ mark
Must mention reflux

Justify---it's a slow reaction and you need to heat reaction for long period of time/ volatile reactants and products / no build up of pressure ½ mark

Concentrated H2 SO4 as a catalyst (dehydrating reagent) justify -to shift eq to right by removing H2O 1 mark

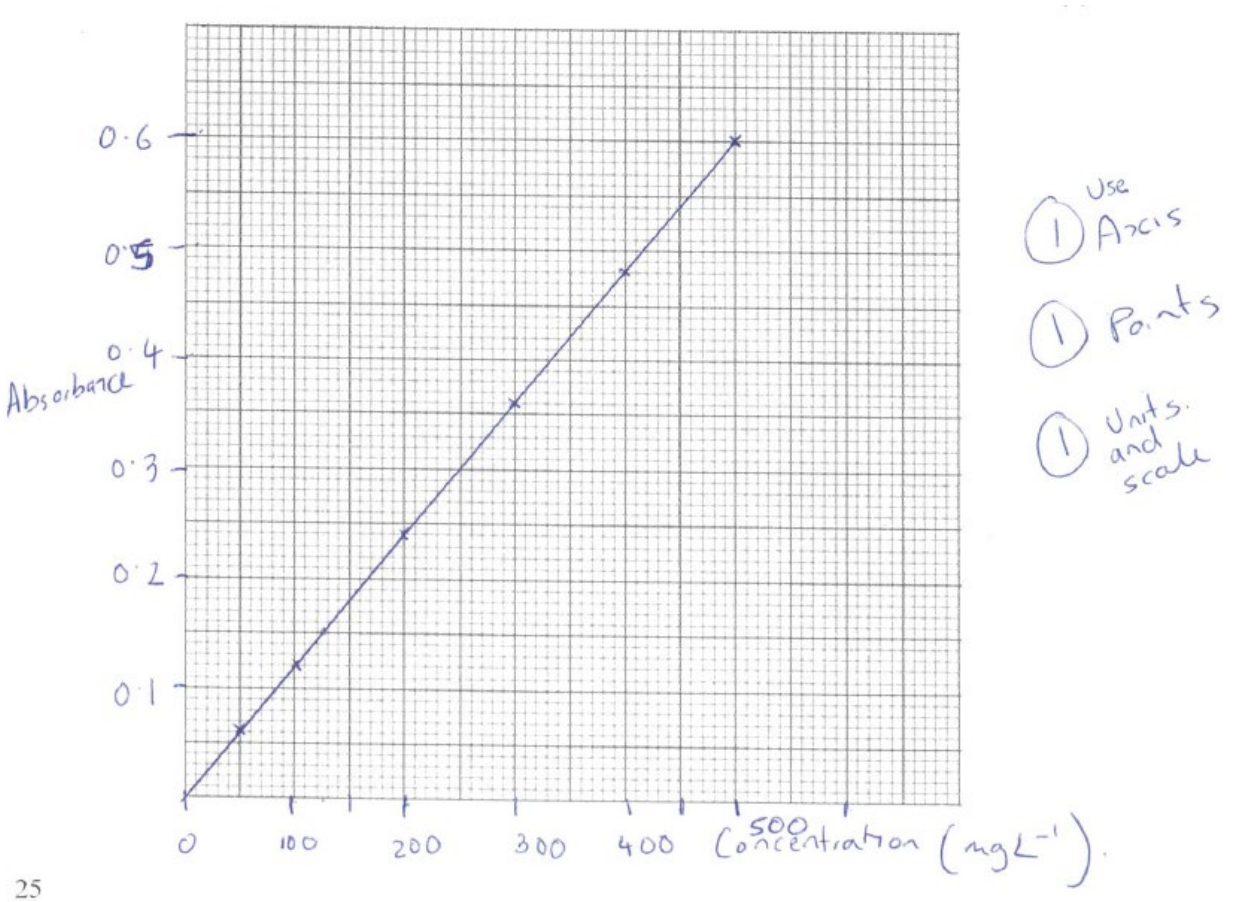
Question 36 (6 marks)

Brass is an alloy of copper and zinc.

To determine the percentage of copper in a particular sample of brass, an analyst prepared a number of standard solutions of copper (II) ions and measured their absorbance using an atomic absorption spectrometer (AAS). The results are given in the table.

Cu^{2+} concentration ($mg\ L^{-1}$)	Absorbance
0	0
50.00	0.060
100.0	0.120
200.0	0.240
300.0	0.360
400.0	0.480
500.0	0.600

(a) Draw and label the absorbance versus concentration calibration curve for Cu^{2+}. (3)



25

(b) A 19.8 mg sample of the brass was dissolved in acid, and the solution was made up to 100 mL in a volumetric flask. The absorbance of this test solution was found to be 0.150.

Calculate the percentage by mass of copper in the brass sample. (3)

125 mg (Except 120 - 130

12.5mg in 100ml

$\%Cu = \frac{12.5}{19.8} \times 100$

$= 63.1\%$