



Parramatta High School

2023

TRIAL EXAMINATION

Chemistry

General

- Reading time – 5 minutes
- Working time – 3 hours

Instructions

- Write using a black/blue pen.
- Draw diagrams using a pencil.
- NESA-approved calculators may be used.
- A formula sheet and data sheet, and Periodic Table are provided at the back of this paper.
- For questions in Section II, **show all relevant working** in questions involving calculations.

Total marks 100

Section I -20 marks (pages 2-7)

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

Section II -80 marks (pages 9 -26)

- Attempt Questions 21–33
- Allow about 2 hours and 25 minutes for this part

This paper MUST NOT be removed from the examination room.

Section I

20 marks

Attempt questions 1 – 20

Allow about 35 minutes for this part.

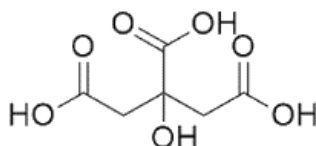
Use the multiple-choice answer sheet for Questions 1-20.

1. Two solutions sodium chloride and silver nitrate are mixed. A solid has formed at the bottom. Which substance would be the precipitate?

- (A) Sodium nitrate
- (B) Sodium chloride
- (C) Silver nitrate
- (D) Silver chloride

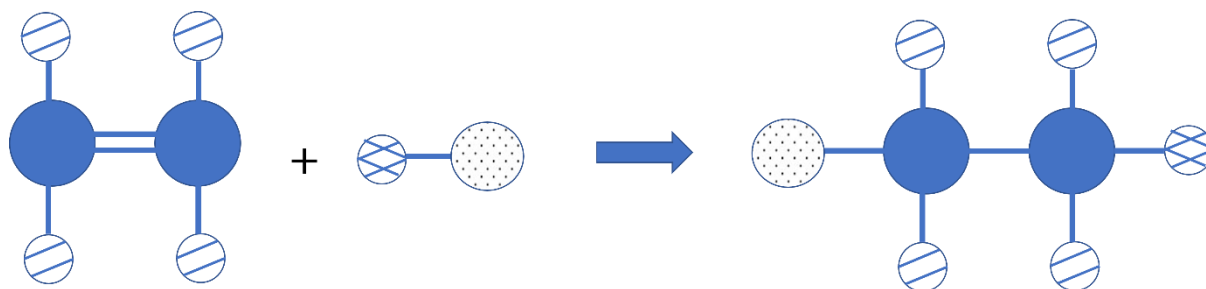
2. In an experiment, sodium hydroxide is reacted completely with citric acid.

The chemical structure of citric acid is shown below.



Which of the following equations correctly represents the reaction between citric acid and sodium hydroxide?

- (A) $\text{NaOH(aq)} + \text{C}_6\text{H}_8\text{O}_7\text{(aq)} \rightarrow \text{NaC}_6\text{H}_7\text{O}_7\text{(aq)} + \text{H}_2\text{O(l)}$
 - (B) $2\text{NaOH(aq)} + \text{C}_6\text{H}_8\text{O}_7\text{(aq)} \rightarrow \text{Na}_2\text{C}_6\text{H}_6\text{O}_7\text{(aq)} + 2\text{H}_2\text{O(l)}$
 - (C) $3\text{NaOH(aq)} + \text{C}_6\text{H}_8\text{O}_7\text{(aq)} \rightarrow \text{Na}_3\text{C}_6\text{H}_5\text{O}_7\text{(aq)} + 3\text{H}_2\text{O(l)}$
 - (D) $4\text{NaOH(aq)} + \text{C}_6\text{H}_8\text{O}_7\text{(aq)} \rightarrow \text{Na}_4\text{C}_6\text{H}_4\text{O}_7\text{(aq)} + 4\text{H}_2\text{O(l)}$
3. The picture shows a chemical reaction.

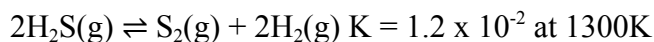


What type of reaction is shown in the diagram above?

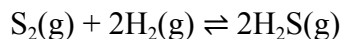
- (A) Addition
- (B) Dehydration

- (C) Hydration
(D) Substitution

4. Given the following information:



What would the numerical value for the equilibrium constant at the same temperature?



- (A) 1.2×10^{-2}
(B) 2.4×10^{-2}
(C) 4.2×10^2
(D) 8.3×10^2

5. Calcium carbonate can decompose to form carbon dioxide and calcium oxide.

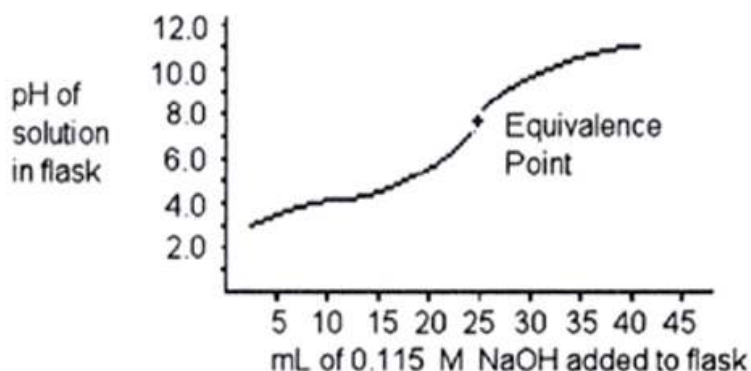


The diagram on the right shows two reaction vessels where calcium carbonate is decomposing.



Which vessel could the decomposition of calcium carbonate be considered completed?

- (A) Vessel B because equilibrium reactions can only occur in this type of vessel.
(B) Vessel A because the lid provided means the carbon dioxide cannot leave the vessel.
(C) Vessel B because there is no lid provided so that the carbon dioxide can leave the vessel.
(D) Vessel A because it is an isolated system so that the carbon dioxide cannot leave the vessel.
6. A 25.0 sample of a solution of a monoprotic acid is titrated with a 0.115 M NaOH solution. The titration curve below was obtained.



Indicator	pK _a
methyl orange	3.46
methyl red	5.00
bromocresol purple	6.12
bromthymol blue	7.10
thymol blue	8.90
phenolphthalein	9.10

Which of the following indicators would be best for this titration?

- (A) bromthymol blue
(B) methyl orange

(C) phenolphthalein

(D) thymol blue

7. The name 2-ethylbutan-3-one does not follow IUPAC naming conventions.

What is the correct IUPAC naming for this organic compound?

(A) 3-ethylbutan-2-one

(B) 2-ethylbutan-4-one

(C) 2-methylpentan-3-one

(D) 3-methylpentan-2-one

8. A student was asked to qualitatively test for the presence of carboxylic acid.

Which row correctly identifies the test reagent added and the result to confirm the presence of a carboxylic acid?

	<i>Reagent</i>	<i>Result</i>
(A)	Red litmus paper	Turn blue
(B)	Sodium bicarbonate	Effervescence
(C)	Bromine water	Decolourise
(D)	$\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$	Decolourise

9. Hydrogen peroxide decomposes to form oxygen and water.



What is the correct expression for K_{eq} ?

(A) $K = \frac{[\text{H}_2\text{O}_2][\text{O}_2]}{[\text{H}_2\text{O}]^2}$

(B) $K = \frac{[\text{H}_2\text{O}_2]^2}{[\text{H}_2\text{O}]^2[\text{O}_2]}$

(C) $K = \frac{[\text{H}_2\text{O}_2]^2}{[\text{O}_2]}$

(D) $K = \frac{[\text{H}_2\text{O}]^2[\text{O}_2]}{[\text{H}_2\text{O}_2]^2}$

10. The following table shows the value of the ionisation constant of pure water at various temperatures and at a constant pressure.

<i>Temperature (°C)</i>	0	25	50	75	100
K_{w}	1.1×10^{-15}	1.0×10^{-14}	5.5×10^{-14}	2.0×10^{-13}	5.6×10^{-13}

Which of the following statements about pure water is correct based on the above data?

- (A) Its pH will increase with increasing temperature.
- (B) Its pH will always be exactly 7 at any temperature.
- (C) The $[\text{OH}^-]$ will decrease with increasing temperature.
- (D) The $[\text{H}_3\text{O}^+]$ will increase with increasing temperature.

11. Which of the following is a secondary alcohol?

- (A) Pentan-1-ol
- (B) 2-methylpentan-2-ol
- (C) 2-methylpentan-3-ol
- (D) 3-methylpentan-3-ol

12. The amount of calcium carbonate (CaCO_3) in the ore of dolomite can be determined by gravimetric analysis. The dolomite sample is dissolved in acid and the calcium ions are precipitated as calcium oxalate (CaC_2O_4). The calcium oxalate is filtered, dried and heated strongly to form calcium oxide (CaO). 5.32g of dolomite was used and the mass of calcium oxide was 2.41g.

What is the percentage of calcium carbonate in the dolomite sample?

- (A) 87.2
- (B) 80.1
- (C) 45.3
- (D) 36.8

13. Which of the following statements about equilibrium are true?

- I. $\Delta S_{\text{sys}} = 0$
- II. $\Delta S_{\text{universe}} = 0$
- III. $\Delta G_{\text{sys}} = 0$

- (A) III only
- (B) Both I and II
- (C) Both II and III
- (D) All of them

14. A student was given an unknown inorganic compound. She made the following observations when she conducted a series of tests to identify the compound.

Observation 1: Produced a green flame with the flame test

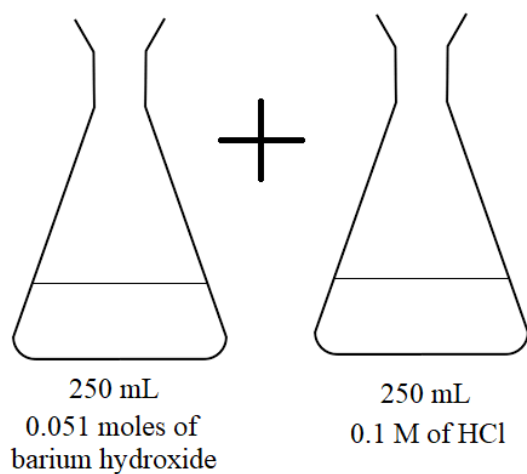
Observation 2: Produced a white precipitate with silver nitrate

What is the compound?

- (A) BaCl_2
- (B) BaF_2
- (C) CaCl_2

(D) CaF_2

15. The diagram shows a beaker with barium hydroxide and another beaker with HCl.



The barium hydroxide solution is then added to the beaker with the HCl.

What is the pH of the final solution?

- (A) 1.292
- (B) 12.886
- (C) 13.017
- (D) 13.188

16. Which pair of molecules are chain isomers?

- (A) 2-methylbutane and pentane
- (B) 2,2-dimethylbutane and pentane
- (C) 2-methylbutane and 3-methylbutane
- (D) 2,3-dimethylbutane and 2-methylpentene

17. The Tiwi people from the Tiwi Islands eat bitter yam which contains toxic oxalates. To ensure their safety, they had several steps which must be followed.

Which part of the process does their knowledge of solution equilibria relate to?

- (A) Fermenting
- (B) Grinding
- (C) Leaching
- (D) Roasting

18. A standardized 0.125 mol/L potassium dichromate solution, $\text{K}_2\text{Cr}_2\text{O}_7$ (aq), was used to titrate 20.0 mL samples of acidified Sn^{2+} (aq). The data is represented in the following table.

Trial	1	2	3
Final burette volume (mL)	15.35	27.65	39.85
Initial burette volume (mL)	3.25	15.35	27.65

What is the concentration of Sn^{2+} (aq) in the sample?

- (A) 0.0254 mol/L
 (B) 0.0763 mol/L
 (C) 0.229 mol/L
 (D) 0.615 mol/L
19. A 2.000g sample of an organic molecule ($\text{MM} \approx 90 \text{ g/mol}$) containing carbon, hydrogen and oxygen only is reacted with oxygen under complete combustion to produce 2.931 g of carbon dioxide gas and 1.200 g of water. Determine the molecular formula of the organic molecule.

- (A) $\text{C}_3\text{H}_4\text{O}_3$
 (B) $\text{C}_3\text{H}_6\text{O}_3$
 (C) $\text{C}_4\text{H}_{12}\text{O}_3$
 (D) $\text{C}_6\text{H}_{12}\text{O}_6$

20. $\text{CaCl}_2(\text{s}) \rightleftharpoons \text{Ca}^{2+}(\text{aq}) + 2\text{Cl}^{-}(\text{aq}) -795.8\text{kJ/mol}$

$$\begin{aligned}\Delta G_f^\circ \text{CaCl}_2 &= -748.1 \text{ kJ/mol} \\ \Delta S^\circ \text{Ca}^{2+} &= -53.1 \text{ J/Kmol} \\ \Delta S^\circ \text{CaCl}_2 &= 104.6 \text{ J/Kmol} \\ \Delta S^\circ \text{Cl}^{-} &= -153.25 \text{ J/Kmol}\end{aligned}$$

What is the temperature of the dissolution of calcium chloride?

- (A) 442 K
 (B) 1010 K
 (C) 1067 K
 (D) 1436 K



3	7	8		
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Student Number

2023

Parramatta High School

HIGHER SCHOOL
CERTIFICATE
TRIAL EXAMINATION

Chemistry

Starting from the left, please
write your student number
NEATLY in the boxes.

Section I Part A - Multiple Choice

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

A ☒B ☒C ☐D ☐

Correct

Start	1	AO	BO	CO	DO	11	AO	BO	CO	DO
Here	2	AO	BO	CO	DO	12	AO	BO	CO	DO
	3	AO	BO	CO	DO	13	AO	BO	CO	DO
	4	AO	BO	CO	DO	14	AO	BO	CO	DO
	5	AO	BO	CO	DO	15	AO	BO	CO	DO
	6	AO	BO	CO	DO	16	AO	BO	CO	DO
	7	AO	BO	CO	DO	17	AO	BO	CO	DO
	8	AO	BO	CO	DO	18	AO	BO	CO	DO
	9	AO	BO	CO	DO	19	AO	BO	CO	DO

Do NOT write anything, or make any marks below this line.

Section II

80 marks

Attempt Questions 21-32

Allow about 2 hours and 25 minutes for this section.

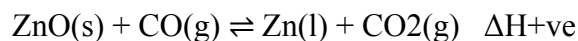
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working out in questions involving calculations.

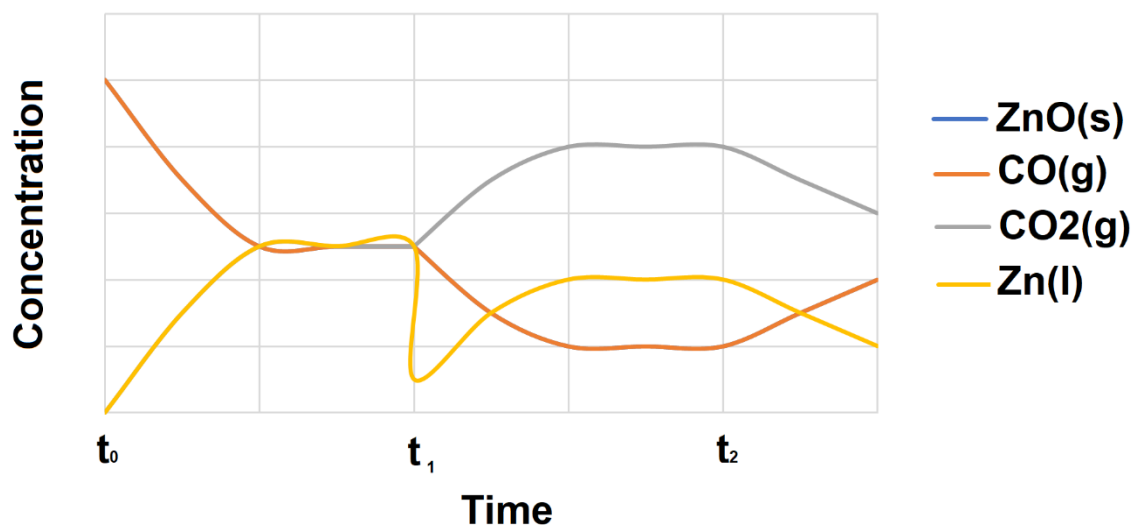
Extra writing space is provided in an extra writing booklet. If you use this space, clearly indicate which question you are answering.

Question 21 (8 marks)

To form zinc, zinc oxide is reduced during the following reaction.



The graph below shows the concentrations in a reaction vessel.



- a) Would changing the pressure of the vessel affect the reaction? Provide reasoning. (2)

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Question 21 continued

- b) Explain what happened in the reaction vessel during t_1 and t_2 . (3)

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- c) Explain the effect on the reaction if a catalyst is added at time t_1 and show the effect on the graph. (3)

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End of Question 21

Question 22 (7 marks)

Ethanol is considered the new fuel for cars and can be produced using fermentation.

- d) A bottle contains an unknown organic compound that is either an aldehyde, a primary alcohol or a tertiary alcohol.

Describe how you would identify the organic compound. (3)

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- e) Given that the yeast required during anaerobic fermentation becomes denatured at an alcohol percentage above 15%w/v, determine the mass of glucose that is required to achieve 15%w/v of ethanol in 1.00 L of water for fermentation (4)

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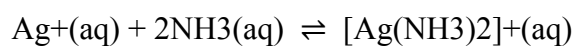
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The following reaction forms a complex ion $[\text{Ag}(\text{NH}_3)_2]^+$



The K_{eq} of the formation of $[Ag(NH_3)_2]^+$ is $K_{complex} = 2.0 \times 10^7 \text{ mol/L}$

Some aqueous NH_3 is added to an aqueous solution of silver bromide.

Calculate the solubility of AgBr(s) in $0.6\text{M NH}_3(\text{aq})$. (5)

This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings present.

Question 24 (6 marks)

Esters are organic compounds that can be produced in a school laboratory.

- a) Explain the precautions required to produce an ester in the school laboratory.

(3)

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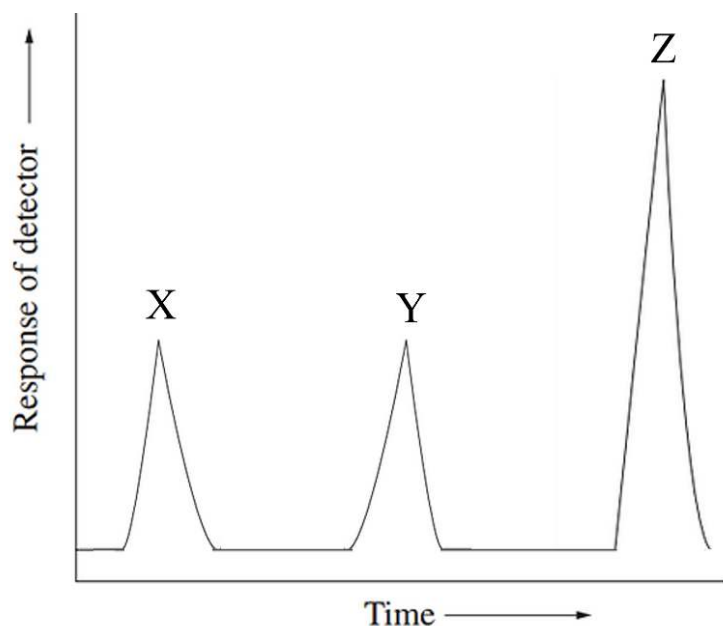
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- b) Gas chromatography can be used to separate compounds based on molecular weight. The smaller the molecule, the faster it gets detected. Gas chromatography can also be used to determine the percentage composition of a mixture as the area under each peak corresponds to the amount of substance by mass in the mixture.

The diagram below shows a gas chromatography spectrum performed on the mixture obtained after reflux between ethanol and butanoic acid. The table next to it shows the relative areas underneath each peak.

Peak	Relative area
X	1
Y	1
Z	2



Question 24 continued

Using the data provided, determine the number of moles of the ester produced given the mixture had a volume of 15.0 mL. Assume the density of all liquids in the reaction is 1g/mL. (3)

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End of Question 24

Question 25 (6 marks)

Ammonia, ethanol and hydrochloric acid are common chemicals used in the laboratory.

- a) Rank the three chemicals from most acidic to least acidic. Justify your answer (3)

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- b) Explain why ammonia is considered an amphoteric compound. Include relevant chemical equations. (3)

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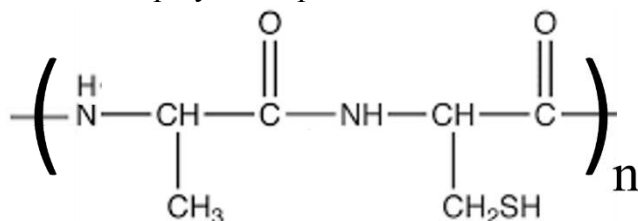
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Question 26 (5 marks)

Polymers are long molecules that are made of multiple smaller units called monomers and can be made via condensation polymerisation.

- a) The structure below shows the repeating unit of a protein, a type of polymer found in the body. Water is produced as a byproduct when this polymer is produced.

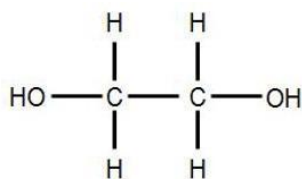


Draw the monomers that make up this protein.

(2)



- b) The monomer below is an ethylene glycol molecule. It can undergo condensation polymerisation to produce polyethylene glycol.



Calculate the mass of the polymer produced from reacting 1000 of these molecules together.

(3)

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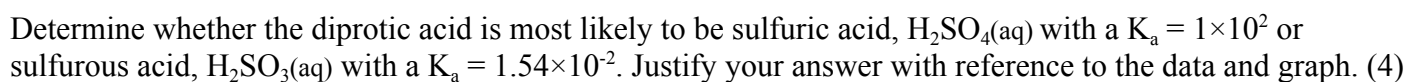
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Consider the following acid-base titration curve that is produced by adding 0.166 mol/L sodium hydroxide solution to 20.00 mL of an approximately 0.1 mol/L diprotic acid.

[illegible]

Question 28 (9 marks)

A student carries out an experiment to determine the pK_a value of ethanoic acid using vinegar.

- The concentration of ethanoic in vinegar is 0.870 mol/L.
- The pH of vinegar is 2.41.

a) Calculate the pK_a value of ethanoic acid in vinegar and the percentage dissociation of ethanoic acid in vinegar. (5)

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a) Explain the difference in properties of ethanoic acid as compared to its similar chain length hydrocarbon and alcohol. (4)

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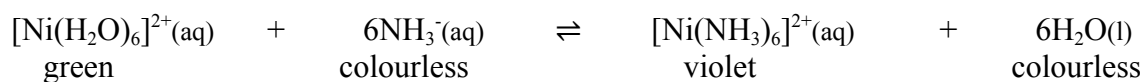
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Question 29 (6 marks)

Hexaaminenickel(II) is a purple coloured solution and can be formed through the following reaction.



Since nickel is expensive, small amounts of the ion are important. A colourimeter is used to calculate the concentration of each batch of solution made.

- a) For this reaction, why should a yellow filter be used in the colourimeter? (2)

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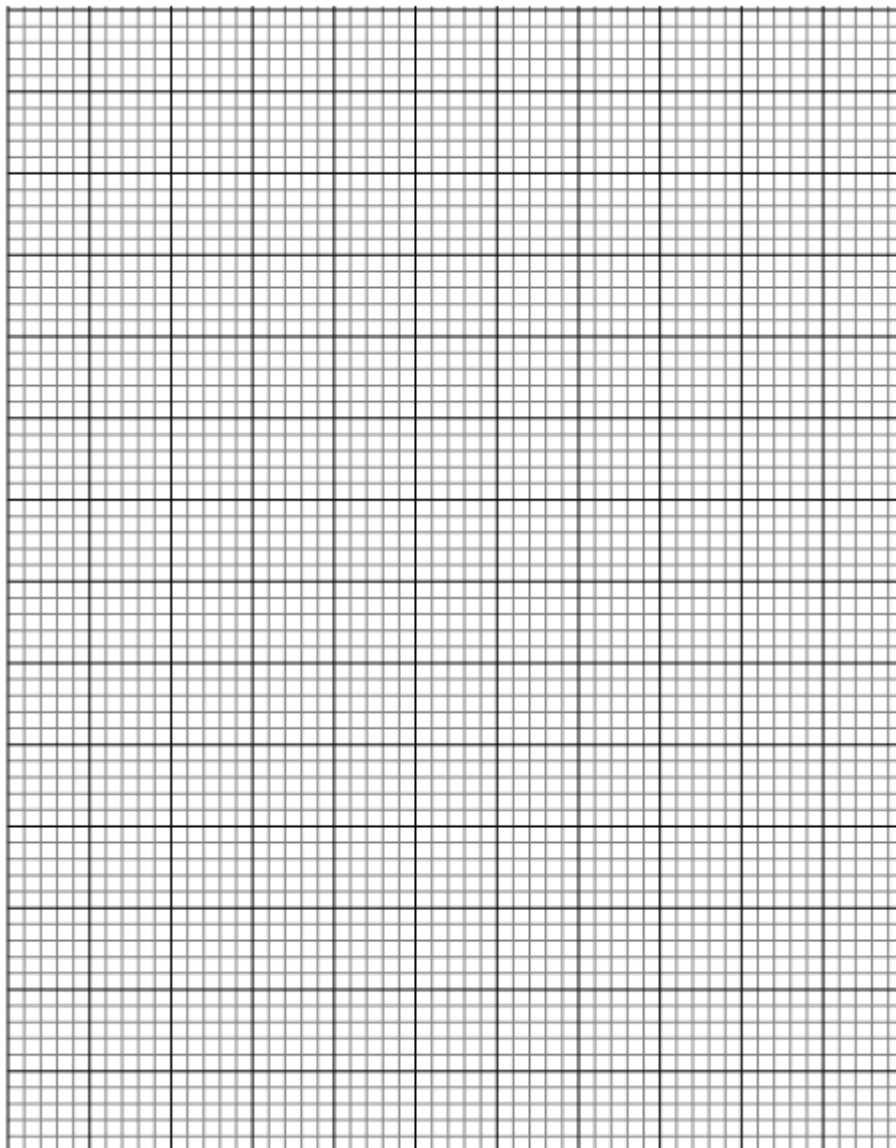
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- b) The table below shows the known concentrations of $[\text{Ni}(\text{NH}_3)_6]^{2+}$ ions and the absorbances.

<i>Concentration of $[\text{Ni}(\text{NH}_3)_6]^{2+}$</i>	<i>Absorbance $\lambda 590\text{nm}$</i>
0	0
0.01	0.28
0.02	0.56
0.03	0.84
0.04	1.12
0.05	1.4

Question 29 continued

Using this information, draw a calibration curve to calculate the concentration of a solution that has an absorbance of 0.95. (4)



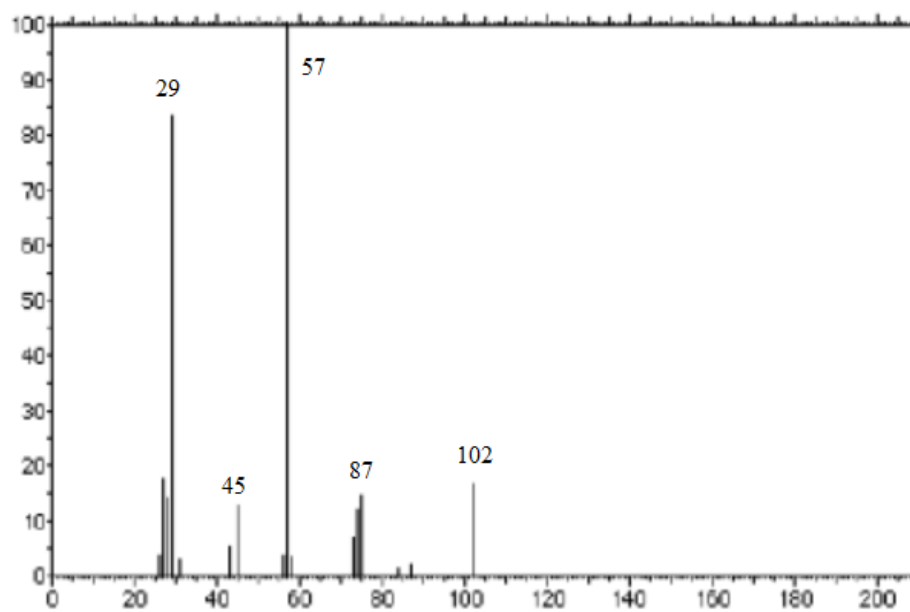
Concentration of solution:

End of Question 29

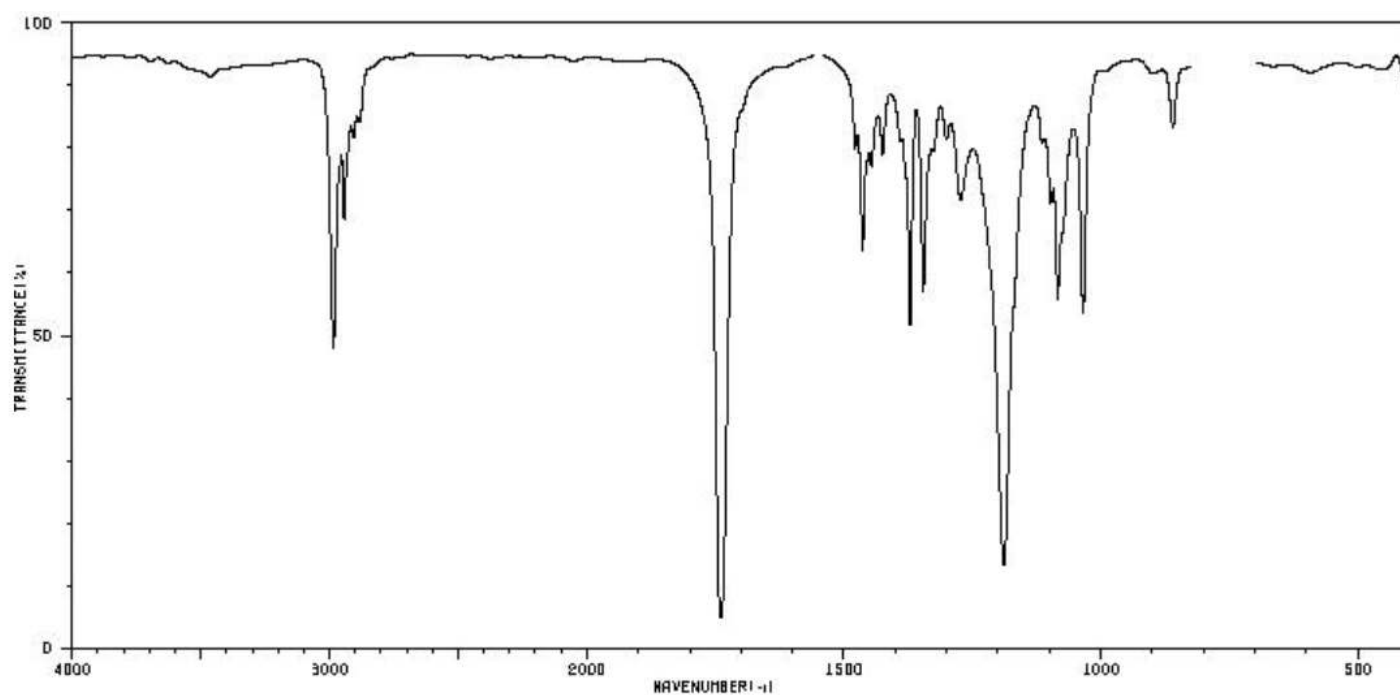
Question 30 (7 marks)

The following spectra were obtained for an unknown organic compound.

Mass spectrum

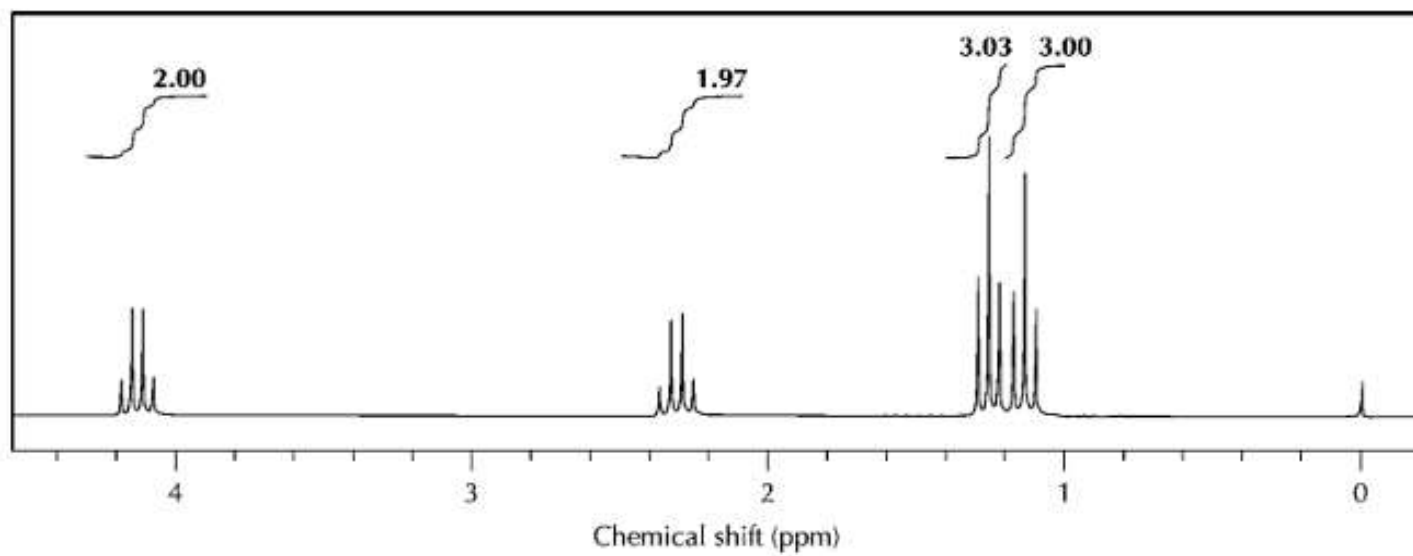


Infrared spectrum

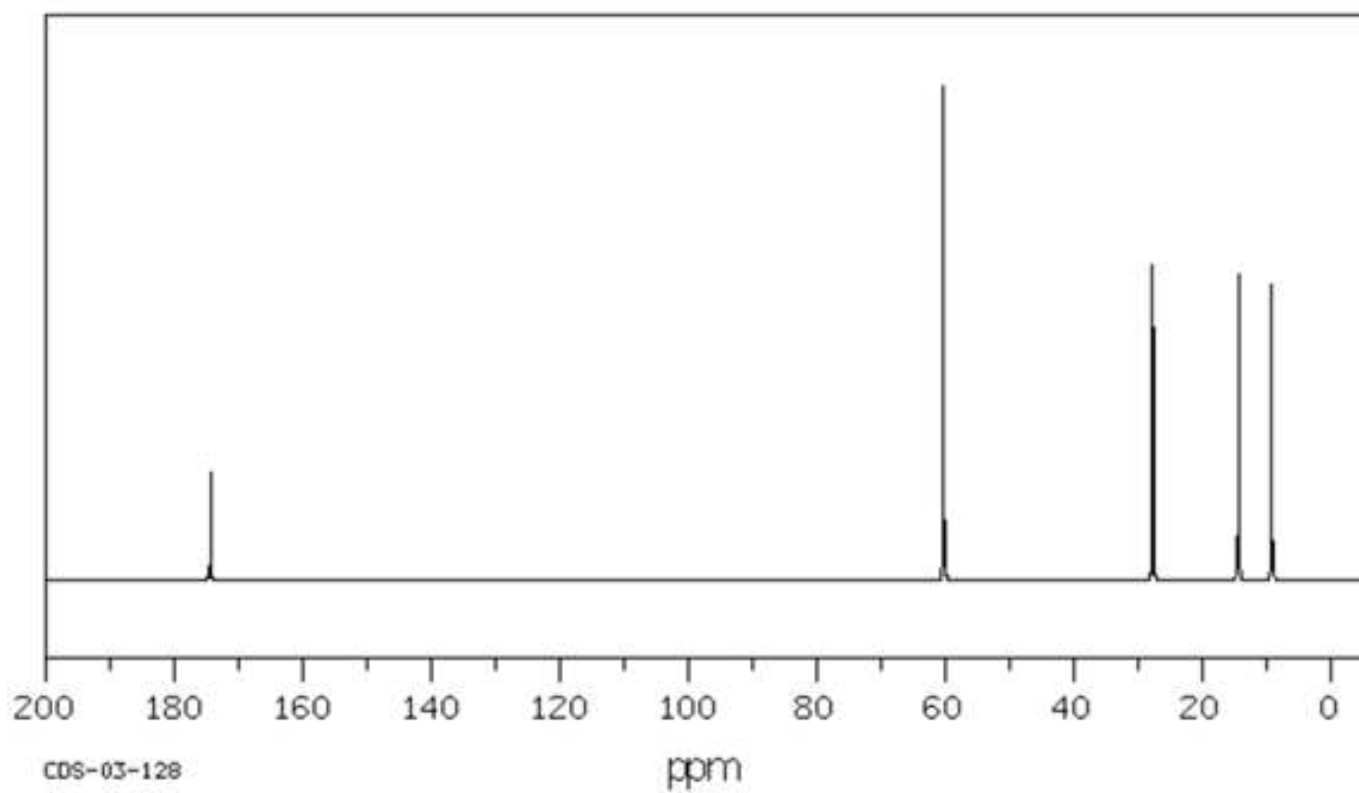


Question 30 continues page 22.

Proton NMR



Carbon-13 NMR



Question 30 continued

In the space provided, draw and name the unknown compound that is consistent with all the information provided. Justify your answer with reference to the information provided.

Structure:

Name:

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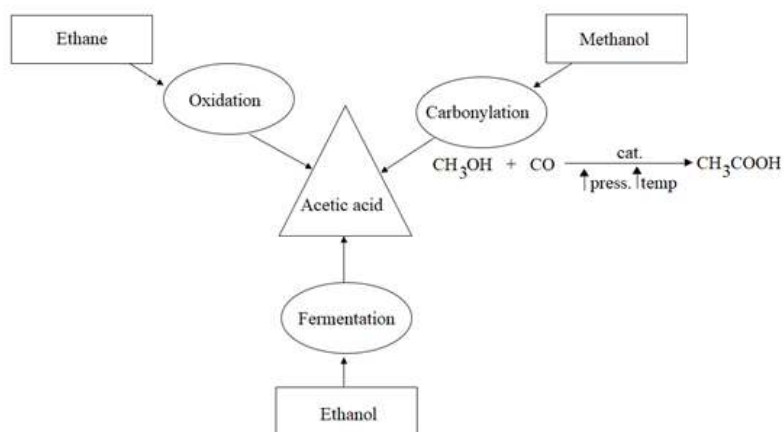
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End of Question 30

Question 31 (7 marks)

A new company wants to produce acetic acid using one of the following processes.



Discuss the factors that the company needs to consider in selecting the best process to use in the production of acetic acid.

Question 32 (10 marks)

In swimming pools, a buffer solution of carbonic acid (H_2CO_3) and sodium bicarbonate (NaHCO_3) is used to maintain the pH.

- a) Explain how the buffer works. Support your answer with balanced chemical equations. (5)

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Question 32 continues on page 25.

Question 32 continued

- b) A buffer solution is prepared using carbonic acid and sodium bicarbonate. In the buffer solution, the concentration of carbonic acid is 0.251 M, and the concentration of sodium bicarbonate is 0.140 M.

A sample of hydrochloric acid containing 0.015 moles of HCl is added to 1.00L of the buffer solution.

The value of K_a for carbonic acid is 4.30×10^{-7} mol/L at 25°C.

Calculate the pH of the buffer solution after the HCl has been added. Ignore any change in total volume.

(5)

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End of Question 32

End of Test

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2023

Parramatta High School

Student Number

HIGHER SCHOOL
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TRIAL EXAMINATION

Chemistry

Starting from the left, please
write your student number
NEATLY in the boxes.

Section I Part A - Multiple Choice

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

A ☒

B ☒

C ☐

D ☐

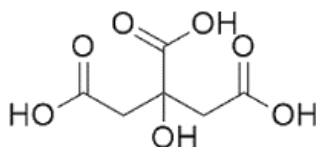
Correct

Start	1	AO	BO	CO	DO	11	AO	BO	CO	DO
Here	2	AO	BO	CO	DO	12	AO	BO	CO	DO
	3	AO	BO	CO	DO	13	AO	BO	CO	DO
	4	AO	BO	CO	DO	14	AO	BO	CO	DO
	5	AO	BO	CO	DO	15	AO	BO	CO	DO
	6	AO	BO	CO	DO	16	AO	BO	CO	DO
	7	AO	BO	CO	DO	17	AO	BO	CO	DO
	8	AO	BO	CO	DO	18	AO	BO	CO	DO
	9	AO	BO	CO	DO	19	AO	BO	CO	DO
	10	AO	BO	CO	DO	20	AO	BO	CO	DO

Do NOT write anything, or make any marks below this line.

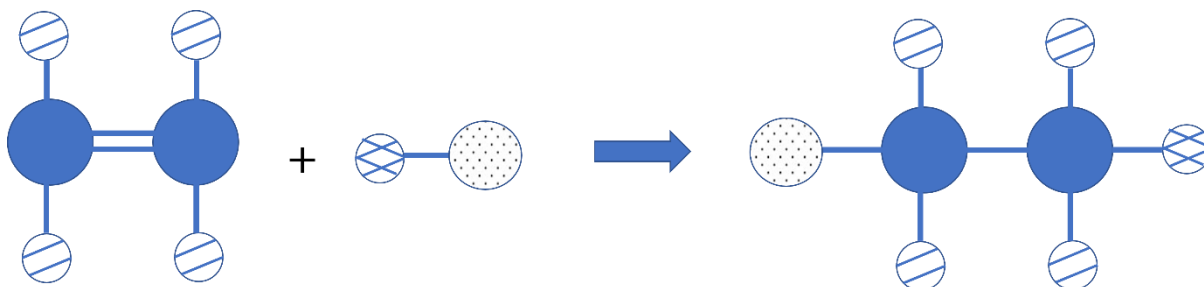
- Two solutions sodium chloride and silver nitrate are mixed. A solid has formed at the bottom. Which substance would be the precipitate?
 (A) Sodium nitrate
 (B) Sodium chloride
 (C) Silver nitrate
 (D) Silver chloride

- In an experiment, sodium hydroxide in reacted completely with citric acid.
 The chemical structure of citric acid is shown below.



Which of the following equations correctly represents the reaction between citric acid and sodium hydroxide?

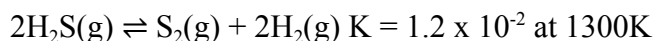
- $\text{NaOH(aq)} + \text{C}_6\text{H}_8\text{O}_7\text{(aq)} \rightarrow \text{NaC}_6\text{H}_7\text{O}_7\text{(aq)} + \text{H}_2\text{O(l)}$
 $2\text{NaOH(aq)} + \text{C}_6\text{H}_8\text{O}_7\text{(aq)} \rightarrow \text{Na}_2\text{C}_6\text{H}_6\text{O}_7\text{(aq)} + 2\text{H}_2\text{O(l)}$
 $3\text{NaOH(aq)} + \text{C}_6\text{H}_8\text{O}_7\text{(aq)} \rightarrow \text{Na}_3\text{C}_6\text{H}_5\text{O}_7\text{(aq)} + 3\text{H}_2\text{O(l)}$
 $4\text{NaOH(aq)} + \text{C}_6\text{H}_8\text{O}_7\text{(aq)} \rightarrow \text{Na}_4\text{C}_6\text{H}_4\text{O}_7\text{(aq)} + 4\text{H}_2\text{O(l)}$
- The picture shows a chemical reaction.



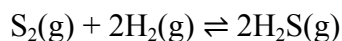
What type of reaction is shown in the diagram above?

- (A) Addition
 (B) Dehydration
 (C) Hydration
 (D) Substitution

4. Given the following information:



What would the numerical value for the equilibrium constant at the same temperature?



(A) 1.2×10^{-2}

(B) 2.4×10^{-2}

(C) 4.2×10^2

(D) 8.3×10^2

5. Calcium carbonate can decompose to form carbon dioxide and calcium oxide.



The diagram on the right shows two reaction vessels where calcium carbonate is decomposing.



Which vessel could the decomposition of calcium carbonate be considered completed?

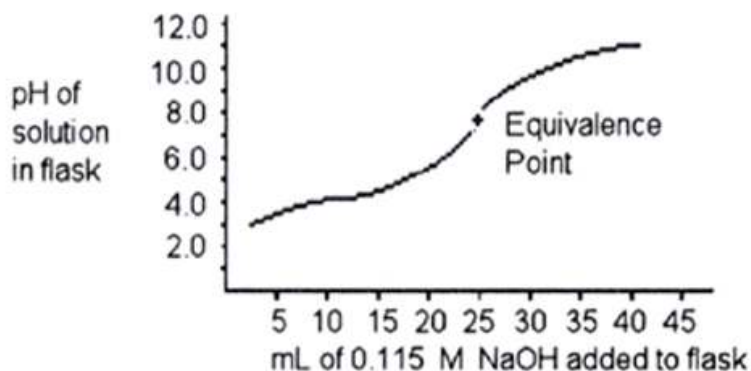
(A) Vessel B because equilibrium reactions can only occur in this type of vessel.

(B) Vessel A because the lid provided means the carbon dioxide cannot leave the vessel.

(C) Vessel B because there is no lid provided so that the carbon dioxide can leave the vessel.

(D) Vessel A because it is an isolated system so that the carbon dioxide cannot leave the vessel.

6. A 25.0 sample of a solution of a monoprotic acid is titrated with a 0.115 M NaOH solution. The titration curve below was obtained.



Indicator	pK _a
methyl orange	3.46
methyl red	5.00
bromocresol purple	6.12
bromthymol blue	7.10
thymol blue	8.90
phenolphthalein	9.10

Which of the following indicators would be best for this titration?

(A) bromthymol blue

(B) methyl orange

(C) phenolphthalein

(D) thymol blue

7. The name 2-ethylbutan-3-one does not follow IUPAC naming conventions.

What is the correct IUPAC naming for this organic compound?

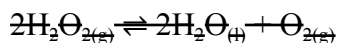
- (A) 3-ethylbutan-2-one
 (B) 2-ethylbutan-4-one
 (C) 2-methylpentan-3-one
 (D) 3-methylpentan-2-one

8. A student was asked to qualitatively test for the presence of carboxylic acid.

Which row correctly identifies the test reagent added and the result to confirm the presence of a carboxylic acid?

	<i>Reagent</i>	<i>Result</i>
(A)	Red litmus paper	Turn blue
(B)	Sodium bicarbonate	Effervescence
(C)	Bromine water	Decolourise
(D)	$\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$	Decolourise

9. ~~Hydrogen peroxide decomposes to form oxygen and water.~~



~~What is the correct expression for K_{eq} ?~~

(E) $K = \frac{[\text{H}_2\text{O}_2][\text{O}_2]}{[\text{H}_2\text{O}]^2}$

(F) $K = \frac{[\text{H}_2\text{O}_2]^2}{[\text{H}_2\text{O}]^2[\text{O}_2]}$

(G) $K = \frac{[\text{H}_2\text{O}_2]^2}{[\text{O}_2]}$

(H) $K = \frac{[\text{H}_2\text{O}]^2[\text{O}_2]}{[\text{H}_2\text{O}_2]^2}$

10. The following table shows the value of the ionisation constant of pure water at various temperatures and at a constant pressure.

<i>Temperature (°C)</i>	0	25	50	75	100
K_w	1.1×10^{-15}	1.0×10^{-14}	5.5×10^{-14}	2.0×10^{-13}	5.6×10^{-13}

Which of the following statements about pure water is correct based on the above data?

- (E) Its pH will increase with increasing temperature.
 (F) Its pH will always be exactly 7 at any temperature.

(G) The $[\text{OH}^-]$ will decrease with increasing temperature.

(H) The $[\text{H}_3\text{O}^+]$ will increase with increasing temperature.

11. Which of the following is a secondary alcohol?

(A) Pentan-1-ol

(B) 2-methylpentan-2-ol

(C) 2-methylpentan-3-ol

(D) 3-methylpentan-3-ol

12. The amount of calcium carbonate (CaCO_3) in the ore of dolomite can be determined by gravimetric analysis. The dolomite sample is dissolved in acid and the calcium ions are precipitated as calcium oxalate (CaC_2O_4). The calcium oxalate is filtered, dried and heated strongly to form calcium oxide (CaO). 5.32g of dolomite was used and the mass of calcium oxide was 2.41g.

What is the percentage of calcium carbonate in the dolomite sample?

(A) 87.2

(B) 80.1

(C) 45.3

(D) 36.8

13. Which of the following statements about equilibrium are true?

IV. $\Delta S_{\text{sys}} = 0$

V. $\Delta S_{\text{universe}} = 0$

VI. $\Delta G_{\text{sys}} = 0$

(A) III only

(B) Both I and II

(C) Both II and III

(D) All of them

14. A student was given an unknown inorganic compound. She made the following observations when she conducted a series of tests to identify the compound.

Observation 1: Produced a green flame with the flame test

Observation 2: Produced a white precipitate with silver nitrate

What is the compound?

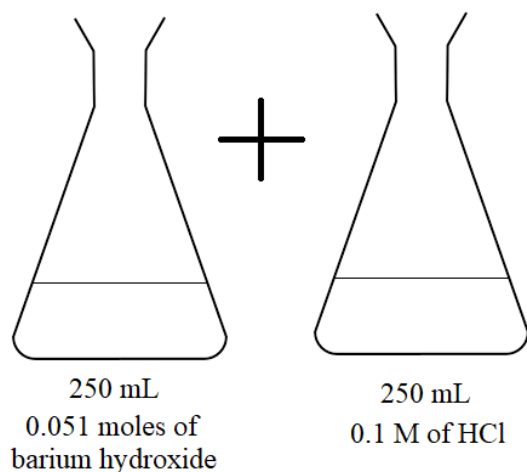
(A) BaCl_2

(B) BaF_2

(C) CaCl_2

(D) CaF_2

15. The diagram shows a beaker with barium hydroxide and another beaker with HCl.



The barium hydroxide solution is then added to the beaker with the HCl.

What is the pH of the final solution?

- (A) 1.292
- (B) 12.886
- (C) 13.017
- (D) 13.188



$$n(\text{Ba(OH)}_2) = 0.051 \text{ (given)}$$

$$n(\text{HCl}) = 0.25 \times 0.1 = 0.025 \text{ moles (LIMITING)}$$

$$n(\text{Ba(OH)}_2) \text{ used} = 0.025/2 = 0.0125$$

$$\text{excess } n(\text{Ba(OH)}_2) = 0.051 - 0.0125 = 0.0385$$

$$n(\text{OH}^-) = 0.0385 \times 2 = 0.077$$

$$c(\text{OH}^-) = 0.077/0.5 = 0.154$$

$$\text{pOH} = -\log(0.154) = 0.8124$$

$$\text{pH} = 14 - \text{pOH} = 14 - 0.8124 = 13.1875$$

16. Which pair of molecules are chain isomers?

- (A) 2-methylbutane and pentane
- (B) 2,2-dimethylbutane and pentane
- (C) 2-methylbutane and 3-methylbutane
- (D) 2,3-dimethylbutane and 2-methylpentene

17. The Tiwi people from the Tiwi Islands eat bitter yam which contains toxic oxalates. To ensure their safety, they had several steps which must be followed.

Which part of the process does their knowledge of solution equilibria relate to?

- (A) Fermenting
- (B) Grinding
- (C) Leaching
- (D) Roasting

18. A standardized 0.125 mol/L potassium dichromate solution, $\text{K}_2\text{Cr}_2\text{O}_7$ (aq), was used to titrate 20.0 mL samples of acidified Sn^{2+} (aq). The data is represented in the following table.

Trial	1	2	3
Final burette volume (mL)	15.35	27.65	39.85
Initial burette volume (mL)	3.25	15.35	27.65

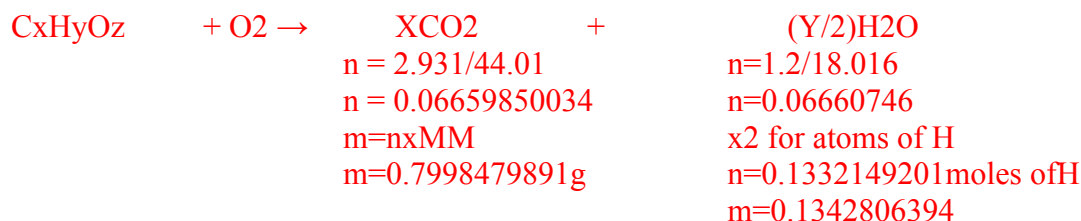
What is the concentration of Sn^{2+} (aq) in the sample?

- (A) 0.0254 mol/L
- (B) 0.0763 mol/L
- (C) 0.229 mol/L
- (D) 0.615 mol/L

trial 1 = $15.35 - 3.25 = 12.1$
trial 2 = $27.65 - 15.35 = 12.3$
trial 3 = $39.85 - 27.65 = 12.2$
average = 12.2 mL

$\text{K}_2\text{Cr}_2\text{O}_7 + \text{Sn}^{2+} \rightarrow \text{SnCr}_2\text{O}_7 + 2\text{K}^+$
 $c = 0.125$ $v = 0.02$
 $v = 0.0122$
 $n = 0.001525$ $n = 0.001525$ (1:1)
 $c = 0.001525 / 0.02$

19. A 2.000g sample of an organic molecule (MM \approx 90 g/mol) containing carbon, hydrogen and oxygen only is reacted with oxygen under complete combustion to produce 2.931 g of carbon dioxide gas and 1.200 g of water. Determine the molecular formula of the organic molecule.



mass of C and H = 0.9341286285

mass of O = 2 - 0.9341286285 = 1.065871371

n of O = 0.0666169

n of H = 0.1332149201

n of C = 0.06659850034

EF = CH_2O = molar mass = 30

$\times 3$ to get molecular formula

$C_3H_6O_3$

20. $CaCl_2(s) \rightleftharpoons Ca^{2+}(aq) + 2Cl^{-}(aq) - 795.8 kJ/mol$

$$\Delta G_f^\circ CaCl_2 = -748.1 kJ/mol$$

$$\Delta S^\circ Ca^{2+} = -53.1 J/Kmol$$

$$\Delta S^\circ CaCl_2 = 104.6 J/Kmol$$

$$\Delta S^\circ Cl^{-} = -153.25 J/Kmol$$

What is the temperature of the dissolution of calcium chloride?

(A) 442 K

(B) 1010 K

(C) 1067 K

(D) 1436 K

102K?

$$\Delta G = \Delta H - T\Delta S$$

$$T = (\Delta H - \Delta G) / \Delta S$$

$$\Delta G = -748.1 kJ/mol$$

$$\Delta H = -795.8 kJ/mol$$

$$\Delta S = \text{products} - \text{reactants}$$

$$\Delta S = (2 \times \text{Cl}^- + \text{Ca}^{2+}) - \text{CaCl}_2$$

$$\Delta S = [(2 \times 56.5) + (-53.1)] - (104.6)$$

$$\Delta S = -44.7$$

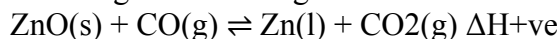
$$\Delta S \text{ needs to be converted to kJ (divide by 1000)} = -0.0447$$

$$T = -795.8 - -748.1 - 0.0447$$

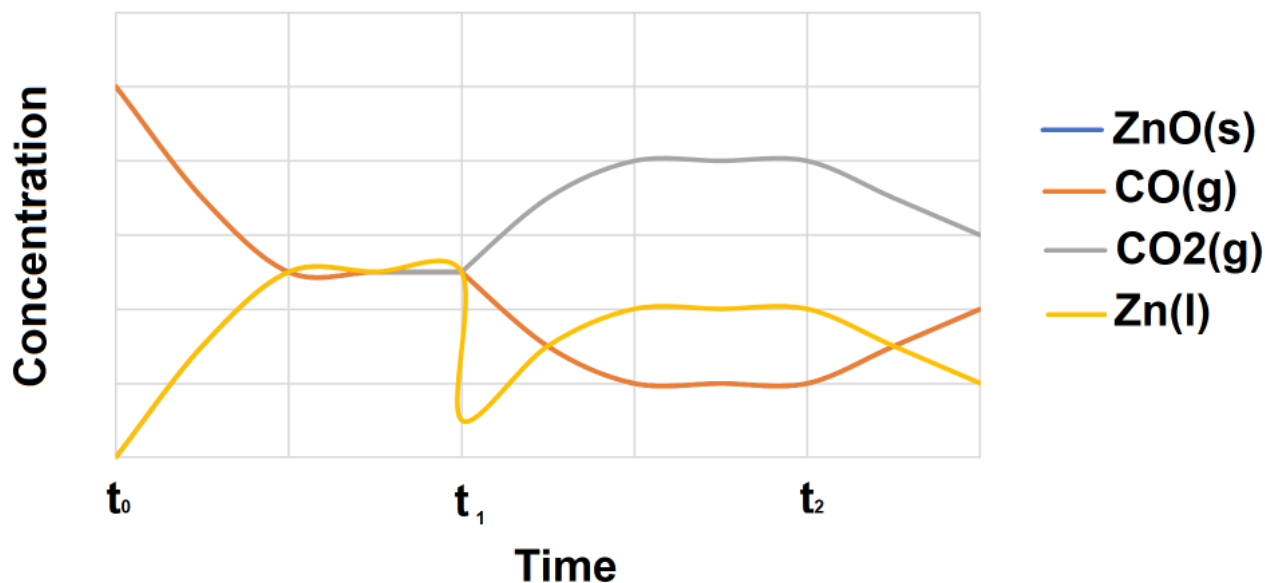
$$T = 1067\text{K}$$

Question 21 (marks)

To form zinc, zinc oxide is reduced during the following reaction.



The graph below shows the concentrations in a reaction vessel.



- a) Would changing the pressure of the vessel influence the reaction? Provide reasoning. (2)

Marking Criteria	Marks
• Correct answer with appropriate reasoning	2
• Something relevant	1

Sample Answer Changing the pressure would have no effect on the reaction. Pressure effects gases since there are equal moles of gases on the reactant and products then pressure changes will affect both sides equally and so no change will be detected.

- b) Explain what had happened in the reaction vessel during t_1 and t_2 . (3) **Marked against labels on your graph**

Marking Criteria	Marks
• Identifies t_1 – Zn removed, t_2 – decrease in temp with explanation	3
• Identifies t_1 – Zn removed, t_2 – decrease in temp with description and/or error in one explanation	2
• Identifies t_1 – Zn removed, t_2 – increase in temp	1

Sample Answer The system was at equilibrium until at t_1 where Zn(l) was removed from the system (seen by the straight line). According to Le Chatelier's Principle (LCP) the system will favour the production of more Zn(l). At t_2 the temperature was decreased, shown by the increase in the concentration of Zn and CO₂. The reverse reaction is exothermic and so will release heat the system.

- c) **Explain** the effect on the reaction if a catalyst is added at time t_1 and show the effect on the graph. (3)

Biggest issue: not explaining increasing collisions (which can be caused by decreasing activation energy) leads to increase in forward/reverse reactions.

Marking Criteria	Marks
• Lines correct and explanation of effect of catalyst	3
• Lines correct and description of effect of catalyst OR Explanation of catalyst with no/incorrect line	2
• Some relevant information	1

Sample Answer A catalyst speeds up both the forward and reverse reactions because it allows collisions between reactants and products easily. This means that equilibrium is reached faster and so the lines are steeper.

Question 22 (7 marks)

Ethanol is considered the new fuel for cars and can be produced using fermentation.

- a) A bottle contains an unknown organic compound that is either an aldehyde, a primary alcohol or a tertiary alcohol.

Describe how you would identify the organic compound.

(3)

Marking Criteria	Marks
<ul style="list-style-type: none">• Accurate and detailed description of 2 tests with appropriate reagents and expected observations	3
<ul style="list-style-type: none">• Description of 2 tests with appropriate reagents and expected observations• Accurate and detailed description of 2 tests with appropriate reagents but no observations• Accurate and detailed description of 1 test with appropriate reagents and expected observations	2
<ul style="list-style-type: none">• Identifies two tests	1

Sample answer:

To test for an aldehyde, add benedict's solution to a sample. If the compound is an aldehyde, then a red precipitate will form. (other options include Schiff's reagent - turns pink with aldehydes, Tollen's reagent turns silver)

To test for primary alcohol, obtain a new sample and acidified potassium permanganate or acidified dichromate ions. The primary alcohol is present if the colour changes from purple to colourless (for potassium permanganate) or from orange to clear (for dichromate ions). If the reagent does not decolourise, then it is the tertiary alcohol.

Notes:

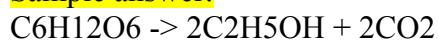
Students did well with identifying tests, but were unable to be specific and describe the colour and expected observations. Some students misunderstood the question or mixed up the reagents with the incorrect functional group.

Bromine water is for carbon carbon double bonds

- b) Given that the yeast required during anaerobic fermentation become denatured at an alcohol percentage above 15%w/v, calculate the (maximum?) mass of glucose needed to add to 1.00 L of water for fermentation (without wasting any glucose?) (4marks)

Marking Criteria	Marks
• Shows all relevant calculations and correct answer	4
• Shows most of the relevant calculations with correct answer	3
Or	
• Shows all relevant steps with incorrect answer	
• Shows some relevant calculations	2
• Shows minimal relevant calculations	1

Sample answer:



15%w/v in 1L = 150g/1L

Moles of ethanol = $150\text{g} / 46.068\text{g/mol} = 3.256056265$ moles

Mole ratio to ethanol divide by 2

Moles of ethanol needed = 1.628028132 moles

Mass = moles x MM

= 1.628028132 moles x 180.156g/mol

= 293.2990361g

= 293 g

Question 23 (marks)

23. Some $\text{NH}_3(\text{aq})$ is added to an aqueous solution of silver bromide. Silver ions react with ammonia to form the complex ion $\text{Ag}(\text{NH}_3)_2^+$ $K_{\text{complex}} = 2.0 \times 10^7$
Calculate the solubility of $\text{AgBr}(\text{s})$ in 0.6M $\text{NH}_3(\text{aq})$. (5)

Marking Criteria	Marks
<ul style="list-style-type: none"> Correct calculation of solubility of AgBr in NH_3 with no errors 	5
<ul style="list-style-type: none"> Links K to the K_{sp} and K_{complex} so that calculation of solubility of AgBr in NH_3 with minor errors Correct Calculation of $[\text{Ag}^+]$ at equilibrium of NH_3 and $\text{Ag}(\text{NH}_3)_2^+$ 3 or more steps correct (more than a rice table) 	3 - 4
<ul style="list-style-type: none"> correct rice table or more correct steps than relevant information 	2
<ul style="list-style-type: none"> Some relevant information 	1

Sample Answer



$$K = K_{\text{sp}}K_{\text{comp}}$$

$$K = 5.35 \times 10^{-13} \times 2.0 \times 10^7$$

$$K = 1.07 \times 10^{-5}$$

K is much larger than K_{sp} it can be assumed that $\text{Ag}(\text{NH}_3)_2^+$ will be formed.



	AgBr	NH_3	$\text{Ag}(\text{NH}_3)_2^+$	Br^-
I	-	0.6M	0	0
C	-	-2x	+x	+x
E	-	$0.6 - 2x$	x	x

$$K = \frac{x^2}{(0.6 - 2x)^2}$$

$$1.07 \times 10^{-5} = \frac{x^2}{(0.6 - 2x)^2}$$

$$\pm 3.27 \times 10^{-3} = \frac{x}{(0.6 - 2x)}$$

Since x can not be -ve taking the positive value

$$x = 3.27 \times 10^{-3}(0.6 - 2x)$$

$$x = 1.96 \times 10^{-3} - 6.54 \times 10^{-3}x$$

$$1.0065x = 1.96 \times 10^{-3}$$

$$x = \frac{1.96 \times 10^{-3}}{1.0065}$$

$$x = 0.00194989\text{M OR } 1.95 \times 10^{-3}\text{M}$$

$$[\text{Ag}(\text{NH}_3)_2^+] = 1.95 \times 10^{-3}\text{M}$$

$$[\text{NH}_3] = 0.6 - 1.95 \times 10^{-3}$$

$$[\text{NH}_3] = 0.598\text{M}$$

$$\frac{[\text{Ag}(\text{NH}_3)_2^+]}{[\text{Ag}^+][\text{NH}_3]^2} = 2.0 \times 10^7$$

$$[\text{Ag}^+] = \frac{[\text{Ag}(\text{NH}_3)_2^+]}{(2.0 \times 10^7)[\text{NH}_3]^2}$$

$$[\text{Ag}^+] = \frac{1.95 \times 10^{-3}}{(2.0 \times 10^7)[0.598]^2}$$

$$[\text{Ag}^+] = 2.73 \times 10^{-9}\text{M}$$

Total solubility of AgBr is given by:

$$s = [\text{Ag}^+] + [\text{Ag}(\text{NH}_3)_2^+]$$

$$s = 2.73 \times 10^{-9}\text{M} + 1.95 \times 10^{-3}\text{M}$$

$$s \approx 1.95 \times 10^{-3}\text{M}$$

The solubility of AgBr in 0.6M NH_3 is $1.95 \times 10^{-3}\text{M}$ and is significantly bigger than its solubility in water 5.35×10^{-13} .

Question 24 (marks)

Esters are organic compounds that can be produced in a school laboratory.

- c) Explain the precautions required to produce an ester in the school laboratory. (3)

Marking Criteria	Marks
• Explains 2 conditions and relates both these conditions to safety in the lab	3
• Explains 2 condition but only relates 1 to safety in the lab	2
• Describes 2 conditions but no reference to safety	1
• Describes 1 condition with reference to safety	

Sample answer:

Esterification requires high temperatures. However, the alcohol reactant is flammable. Therefore, a heating mantle is used instead of a Bunsen Burner that has an open flame in order to decrease the chances of a fire. Esterification also requires reflux under a longer period of time. To avoid build up of pressure in the reaction vessel, the top of the condenser is opened. This will decrease the chances of cracks or explosions.

Other answers also include

- Use of high concentration of H_2SO_4 as a dehydrating agent and shift eqb— teacher adds the acid

Note:

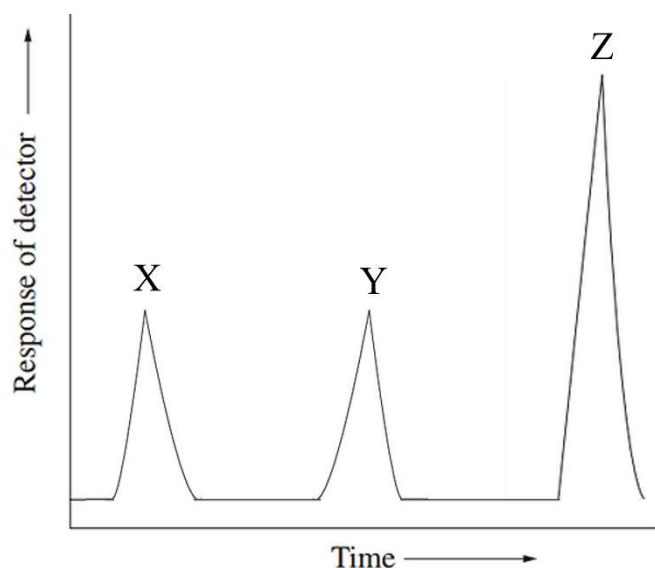
Responses needed to LINK TO ESTERIFICATION AND WHY THAT PRECAUTION IS REQUIRED FOR THAT HARM THAT IS NEEDED FOR THE ESTERIFICATION

Students that wrote precautions that were not specific to esterification did not get marks (ie safety glasses, tie hair up etc)

- c) Gas chromatography can be used to separate compounds based on molecular weight. The smaller the molecule, the faster it gets detected. Gas chromatography can also be used to determine the percentage composition of a mixture as the area under each peak corresponds to the amount of substance by mass in the mixture.

The diagram below shows a gas chromatography spectrum performed on the mixture obtained after reflux between ethanol and butanoic acid. The table next to it shows the relative areas underneath each peak.

Peak	Relative area
X	1
Y	1
Z	2



Using the data provided, determine the number of moles of the ester produced given the mixture had a volume of 15.0 mL.

Marking Criteria	Marks
• Provides all relevant calculations	3
• Provides most of the calculations	2
• Some relevant information	1

Sample answer:

Z is the ester ethyl butanoate as it is the largest molecule hence it has the longest retention time. With the data provided from the table, the mass of the ester is 2:4, or 50 % w/v of the whole mixture. This means that 7.5 g of the mixture is ethyl butanoate.

MM of ethyl butanoate = 116.156 g/mol

Number of moles = $7.5\text{g}/116.156\text{ g/mol} = 0.06456833\text{ moles} = 0.0646\text{ moles (3sf)}$

Question 25 (marks)

Ammonia, ethanol and hydrochloric acid are common chemicals used in the laboratory.

- a) Rank the three chemicals from most acidic to least acidic. Justify your answer (3)

Marking Criteria	Marks
<ul style="list-style-type: none"> Provides a correct order. Provides an explanation referring to stability of anions form in solution 	3
<ul style="list-style-type: none"> Provides a correct order. Provides an explanation 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer

Most acidic HCl>ethanol>ammonia least acidic

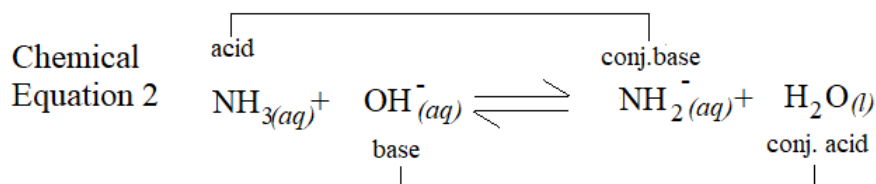
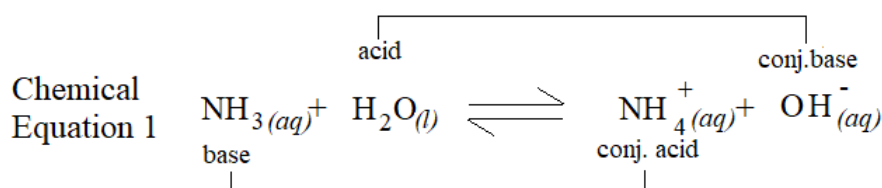
HCL in solution forms stable Cl⁻ ions it maximum dissociation of the cation and anion, ethanol is next stable with the O attached and ammonia is the least stable anion in solution so it is not 100% dissociation like Cl.

- b) Explain why ammonia is considered as an amphoteric compound. Include relevant chemical equations. (3)

Marking Criteria	Marks
<ul style="list-style-type: none"> Use equations to explain ammonia as a proton donor and a proton acceptor. 	3
<ul style="list-style-type: none"> Use an equation to explain ammonia as a proton donor or proton acceptor. 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer

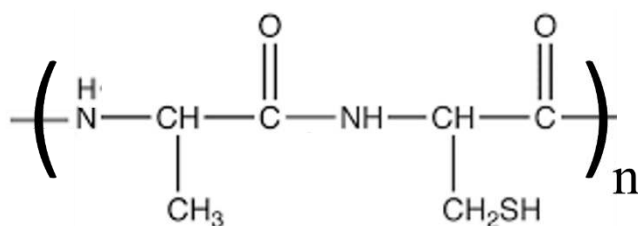
Amphoteric means the compound can act as a base that is a proton acceptor (equation 1) and an acid that is a proton donor (equation 2).



Question 26 (9 marks)

Polymers are long molecules that are made of multiple smaller units called monomers and can be made via condensation polymerisation.

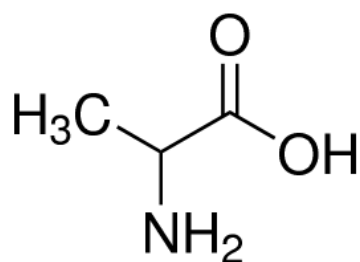
- a) The structure below shows the repeating unit of a protein, a type of polymer found in the body. Draw the monomers that make up this protein. (2 marks)



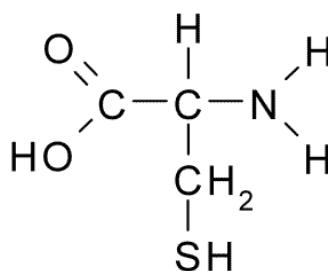
Marking Criteria	Marks
• Accurately draws both monomers	2
• Some relevant structures provided	1

Sample answer

Alanine:

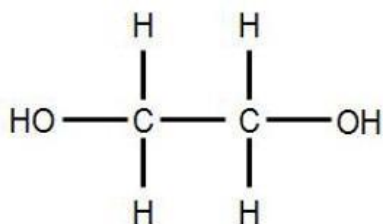


Cysteine:



Note: cut at NH-CH was also accepted

- b) The monomer below is an ethylene glycol molecule. It can undergo condensation polymerisation to produce polyethylene glycol.



Calculate the mass of the polymer produced from reacting 1000 of these molecule together. (3marks)

Marking Criteria	Marks
• Provides all relevant calculations	3
• Provides most of the calculations	2
• Some relevant information	1

Sample answer:

MM ethylene glycol = 62.068 g/mol

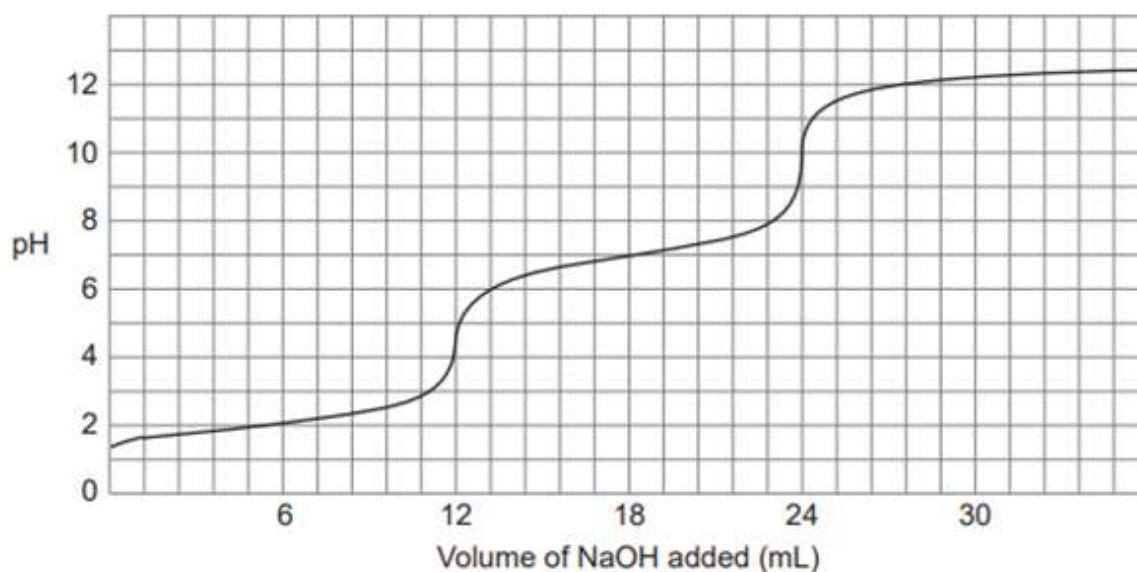
X 1000 = 62068 – 999waters

62068 – 17997.984 =

44070.016g /mol

Question 27 (4 marks)

Consider the following acid-base titration curve that is produced by adding 0.166 mol/L sodium hydroxide solution to 20.00 mL of an approximately 0.1 mol/L diprotic acid.



Determine whether the diprotic acid is most likely to be sulfuric acid, $\text{H}_2\text{SO}_4(\text{aq})$ with a $K_a = 1 \times 10^2$ or sulfurous acid, $\text{H}_2\text{SO}_3(\text{aq})$ with a $K_a = 1.54 \times 10^{-2}$. Justify your answer with reference to the data and graph. (4)

Marking Criteria	Marks
• Correctly identify the acid and provides thorough justification with specific reference to data and graph.	4
• Correctly identify the acid and provides justification with reference to data and graph.	3
• Correctly identify the acid and provides justification with reference to data or graph.	2
• Provides some relevant information	1

Sample answer

From the starting point of the graph, from 0-1 mL of NaOH added, there is a slight curve which indicates a weak acid titration with a strong base, so it is H_2SO_3 as it has the lower K_a meaning it's a weaker base.

Since 20 mL of 0.1 mol of diprotic was titrated with 0.166 mol of NaOH, if it was sulfuric acid which completely dissociates, you would need approx. 0.2 moles of OH^- ions to reach the first end point which is approx. $= \frac{0.166}{0.2} \times 20 = 16 \text{ mL}$ but the graph shows 12 mL of NaOH it must less H^+ ions so the diprotic acid must be sulfurous acid.

Question 28 (marks)

Hexaaminenickel(II) is a purple coloured solution and can be formed through the following reaction.



Since nickel is expensive, small amounts of the ion are important. A colourimeter is used to calculate the concentration of each batch of solution made.

- a) For this reaction, **why** should a yellow filter be used in the colourimeter?

(2)

Marking Criteria	Marks
• Correct answer with appropriate reasoning	2
• Something relevant	1

Sample Answer

Colourimeters work by emitting a coloured light source through a cuvette and collecting the amount of light that is transmitted or absorbed by the coloured mixture. The light source should be the opposite colour on the colour wheel from the coloured solution to ensure that the coloured compound will absorb the light. Since the solution is purple then yellow is opposite colour.

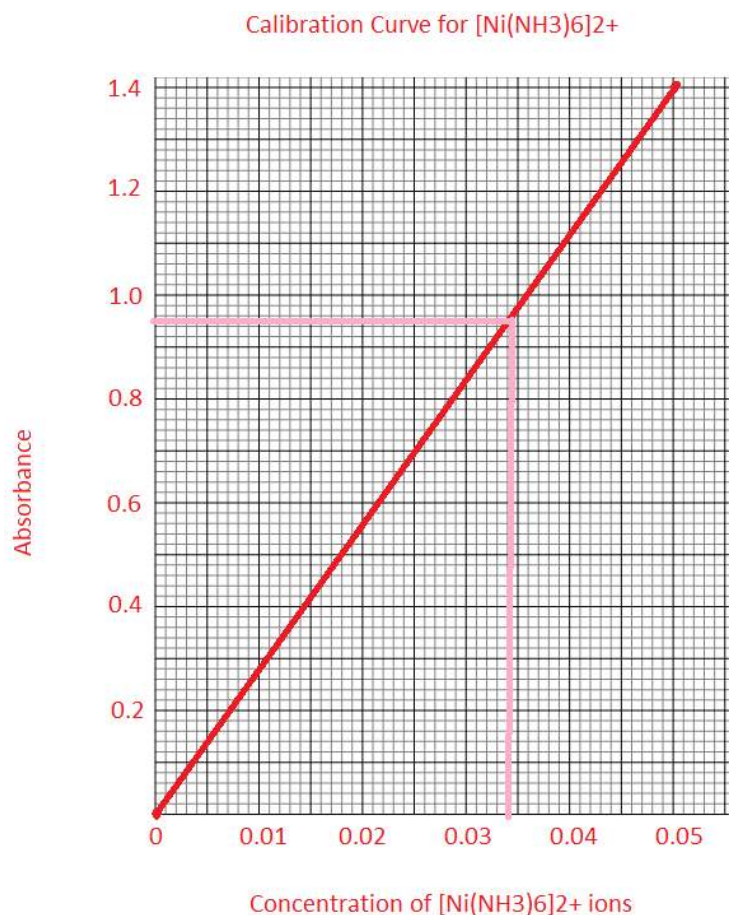
- b) The table below shows the known concentrations of $[\text{Ni}(\text{NH}_3)_6]^{2+}$ ions and the absorbances. Using this information create a calibration curve to calculate the concentration of a solution that has an absorbance of 0.95.

(4)

Concentration of $[\text{Ni}(\text{NH}_3)_6]^{2+}$	Absorbance $\lambda 590\text{nm}$
0	0
0.01	0.28
0.02	0.56
0.03	0.84
0.04	1.12
0.05	1.4

Marking Criteria	Marks
• [Unknown] correct, graph correct with unknown marked	4
• Concentration of unknown attempted, graph correct or not marked on graph	3
• Graph attempted, unknown attempted	2
• Some relevant Information	1

Sample Answer unknown marked from your graph



The unknown solution has a concentration of $[\text{Ni}(\text{NH}_3)_6]^{2+}$ 0.034.

32. Evaluate the factors of chemical synthesis process of ONE chemical that is mass produced. (5)

Marking Criteria	Marks
<ul style="list-style-type: none"> Named chemical, factors (social, economic, yield, purity, reaction conditions, uses) through explained and overall judgement on why the chemical should be mass produced. 	5
<ul style="list-style-type: none"> Named chemical, factors (social, economic, yield, purity, reaction conditions, uses) explained and no judgement on why the chemical should be mass produced. Or explanation is not thorough 	3 - 4
<ul style="list-style-type: none"> Some factors explained 	2
<ul style="list-style-type: none"> Some relevant information 	1

Chemicals may include:

Production of Ammonia, Sulfuric acid – any chemical that is relevant.

Question 29 (9 marks)

A student carries out an experiment to determine the pK_a value of ethanoic acid using vinegar.

- The concentration of ethanoic in vinegar is 0.870 mol/L.
- The pH of vinegar is 2.41.

a) Calculate the pK_a value of ethanoic acid in vinegar and the percentage dissociation of ethanoic acid in vinegar. (5)

Marking Criteria	Marks
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• Provides steps to correctly calculate pK_a and % dissociation with correct sig fig	5
• Provides steps to correctly calculate pK_a and % dissociation	4
• Provides steps to calculate pK_a and % dissociation	3
• Provides steps to calculate pK_a OR % dissociation	2
• Provide some relevant information	1

Sample answer

$$[H^+] = 10^{-2.41} = 3.89 \times 10^{-3}$$

$$K_a = \frac{[H^+]^2}{[CH_3COOH]} = \frac{[3.89 \times 10^{-3}]^2}{0.870} = 1.74 \times 10^{-5}, \text{ thus } pK_a = -\log(1.74 \times 10^{-5}) = 4.76$$

$$\% \text{ dissociation} = \frac{3.89 \times 10^{-3}}{0.870} \times 100 = 0.45\%$$

- b) Explain the difference in properties of ethanoic acid as compared to it similar chain length hydrocarbon and alcohol.

(4)

Marking Criteria	Marks
• Provides an explanation for ethanoic acid to having a higher boiling point as compared to ethane AND as compared to ethanol	4
• Provides an explanation for ethanoic acid to having a higher boiling point than ethane and ethanol	3
• Provides a thorough explanation for ethanoic acid to having a higher boiling point than ethane or ethanol	2
• Provide some relevant information	1

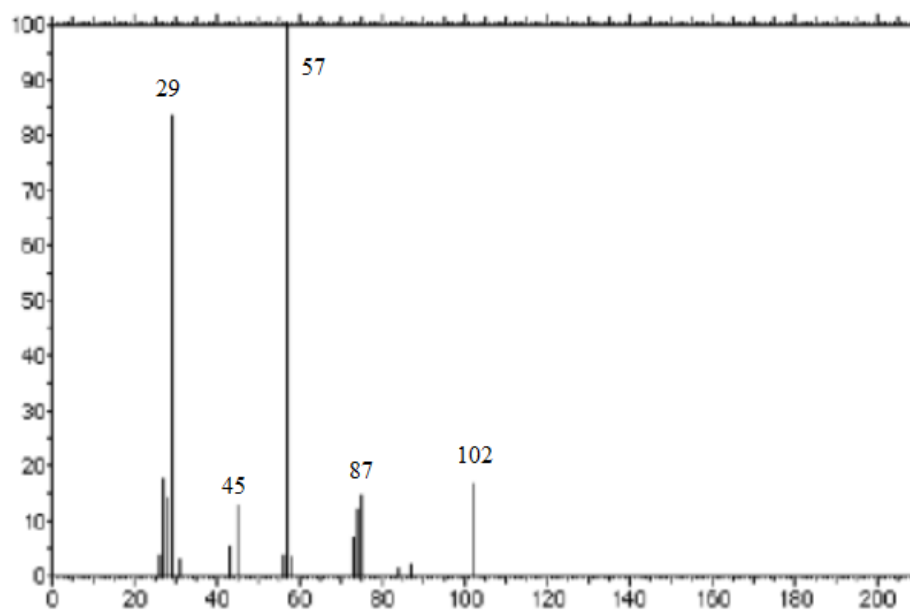
Sample answer

Ethanoic acid is more soluble and has a higher boiling point than ethane. Ethanoic has a carbonyl group (C=O) and hydroxyl group (OH) this make the bond polar and thus ethanoic acid can form strong hydrogen bond with water making it more soluble with these stronger bonds with water it also means that more energy is required to overcome thus it has a higher boiling point. Similar explanation for ethanoic acid and ethanol, even though ethanol also contains a hydroxyl group it doesn't have the carbonyl group like ethanoic acid, as the carbonyl group is also slight polar and thus ethanoic acid forms more hydrogen bond with water making it the highest boiling point and more soluble.

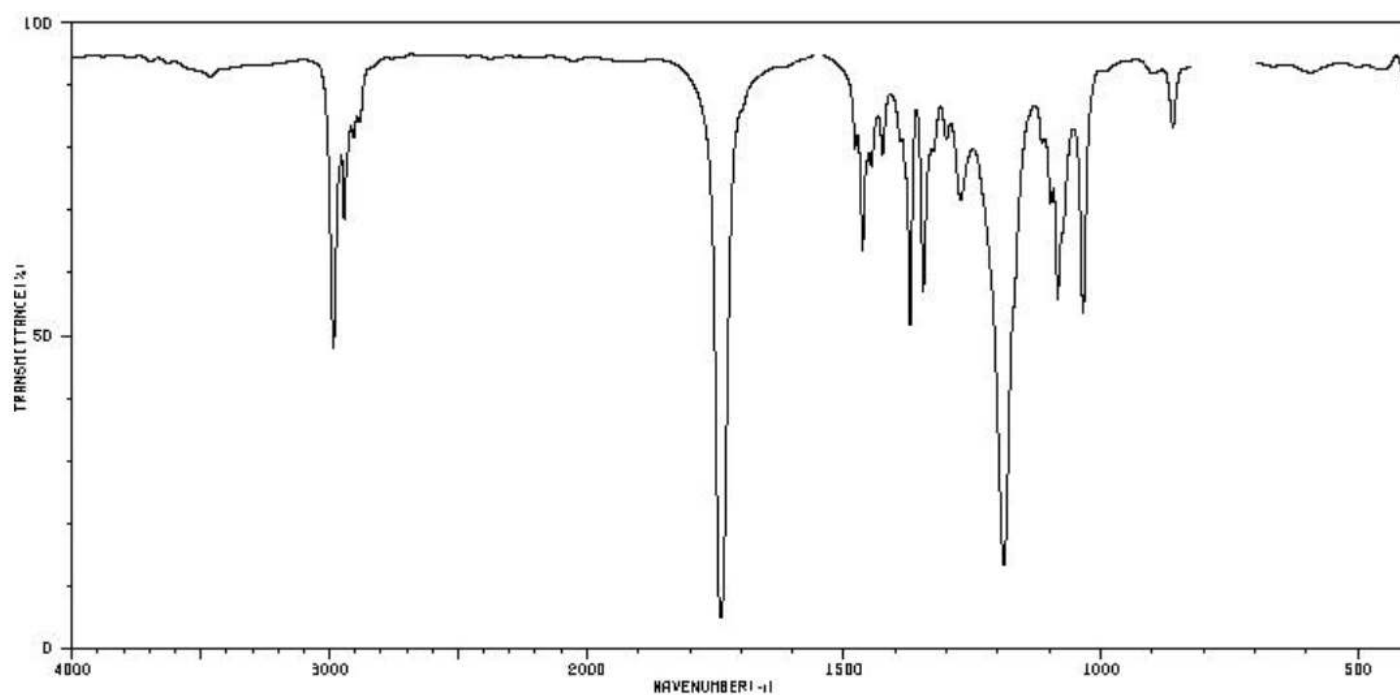
Question 30 (7 marks)

The following spectra were obtained for an unknown organic compound.

Mass spectrum

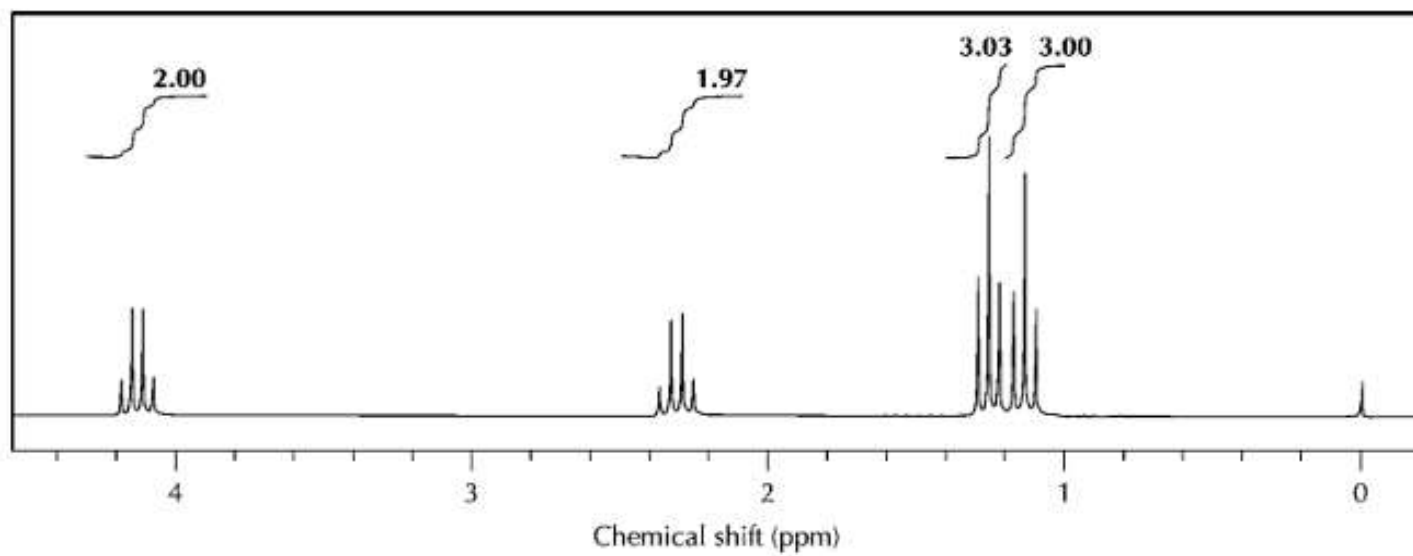


Infrared spectrum

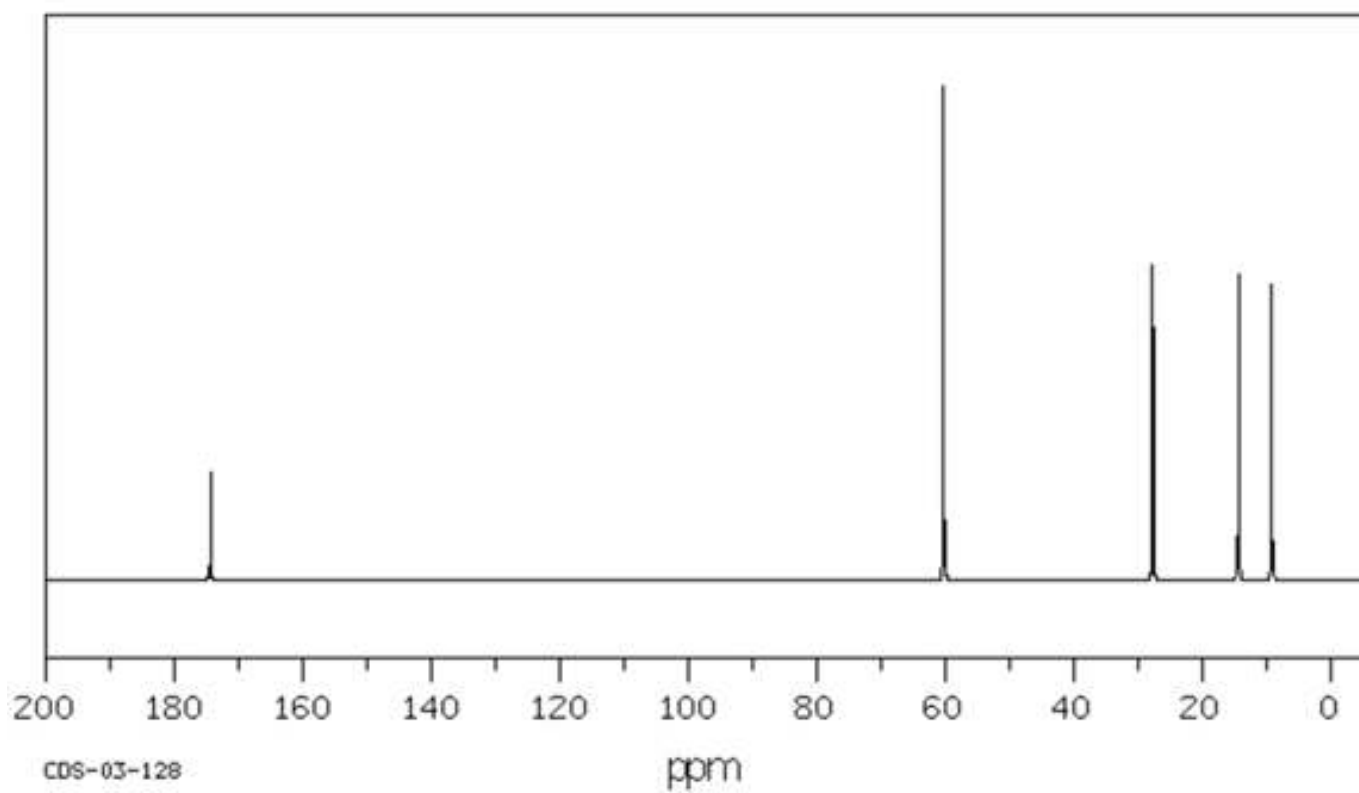


Question 30 continues on page 22.

Proton NMR



Carbon-13 NMR



Question 30 continued

In the space provided, draw and name the unknown compound that is consistent with all the information provided. Justify your answer with reference to the information provided.

Marking Criteria	Marks
<ul style="list-style-type: none"> Correctly identifies the compound and justifies with reference to all relevant parts of each spectrum 	7
<ul style="list-style-type: none"> Correctly identifies the compound and justifies with reference to parts of each spectrum 	6
<ul style="list-style-type: none"> Correctly identifies the compound and justifies with reference to parts of most of the spectrums 	5
<ul style="list-style-type: none"> Correctly identifies the compound and justifies with reference to parts of the spectrums 	4
<ul style="list-style-type: none"> Identifies the compound with reference and justifies with reference to relevant parts of each spectrum 	3-4
<ul style="list-style-type: none"> Provide some relevant information 	1-2

Sample answer

Looking at infrared, you can see a peak at approx. 1700, 3000 and 1200. So 1700 implies C=O, 3000 implies C-H and 1200 as C-O. No OH so it's not an alcohol or a carboxylic acid. For it to have both C=O and C-O most likely an ester.

Looking at H NMR 4 H environment, the one at 4.2 is a quartet which implies a -CH₃ there is another -CH₃ at 2.5 shifted so there are different amounts of shielding for the two -CH₃. There are two triplets implying two -CH₂

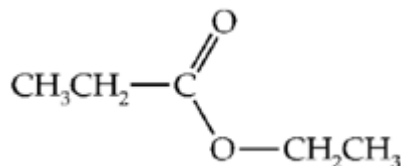
Looking at C NMR 5 carbon environment, peak at 175 suggest ester or acid, no -OH so it's an ester with 5 carbon environment and a total of 4 H environment.

Looking at the mass spec, the fragment at 57 implies three carbon and the oxygen branch of an ester, and the 27 implies the ethyl group of the ester.

So three on the main branch and two on the functional branch,

Thus

Structure



Name: Ethyl propanoate

Question 31 (marks)

In swimming pools, a buffer solution of carbonic acid (H_2CO_3) and sodium bicarbonate (NaHCO_3) is used to maintain the pH. The value of K_a for carbonic acid is $4.30 \times 10^{-7} \text{ mol/L}$ at 25°C .

- a. Explain how the buffer works. Support your answer with balanced chemical equations. (5)

Marking Criteria	Marks
<ul style="list-style-type: none"> Provides an explanation of buffers Provides two balanced equations showing the buffering of an acid and a base 	5
<ul style="list-style-type: none"> Provides an explanation of buffers Provides equations showing the buffering of an acid and a base 	4
<ul style="list-style-type: none"> Provides an explanation of buffers Provides equations showing the buffering of an acid and/or a base 	3
<ul style="list-style-type: none"> Provides an explanation of buffers OR <ul style="list-style-type: none"> Provides equations showing the buffering of an acid and a base 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer

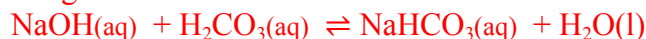
A buffer consists of a weak acid mixed conjugate base or a weak base and conjugate acid. An equilibrium system is formed since they are both weak and not completely dissociate.

So if HCl is added, $[\text{H}^+]$ increases the reaction rate $\text{H}^+ + \text{salt} \Rightarrow \text{weak acid}$ and takes some H^+ out of circulation.



As it does so, it increases weak acid concentration, so the reverse reaction rate starts to increase until you get a new equilibrium. Thus, the pH changes less.

Similarly, titration with a strong base



Decreases the $\text{H}^+ + \text{salt} \Rightarrow \text{weak acid}$ rate, and so since the weak acid dissociation is still happening, the weak acid $\Rightarrow \text{H}^+ + \text{salt}$ adds some H^+ to the solution. Thus, the pH changes less.

- b. A buffer solution is prepared using carbonic acid and sodium bicarbonate. In the buffer solution, the concentration of carbonic acid is 0.251 M, and the concentration of sodium bicarbonate is 0.140 M.

A sample of hydrochloric acid containing 0.015 moles of HCl is added to 1.00L of the buffer solution.

Calculate the pH of the buffer solution after the HCl has been added. Ignore any change in total volume.

(5)

Marking Criteria	Marks
<ul style="list-style-type: none"> Provides correct steps and correctly calculate pH Correct moles of H_2CO_3 and HCO_3^- 	5
<ul style="list-style-type: none"> Provides correct steps to calculate pH Correct moles of H_2CO_3 and HCO_3^- 	4
<ul style="list-style-type: none"> Provides correct steps to calculate pH Correct moles of H_2CO_3 OR <ul style="list-style-type: none"> Provides steps to calculate pH Correct moles of H_2CO_3 and HCO_3^- 	3
<ul style="list-style-type: none"> Provides step to calculate pH 	2
<ul style="list-style-type: none"> Provide some relevant information 	1

Sample answer

Moles of H_2CO_3 after addition = $0.251 + 0.015 = 0.266$

Moles of $HCO_3^- = 0.14 - 0.015 = 0.125$

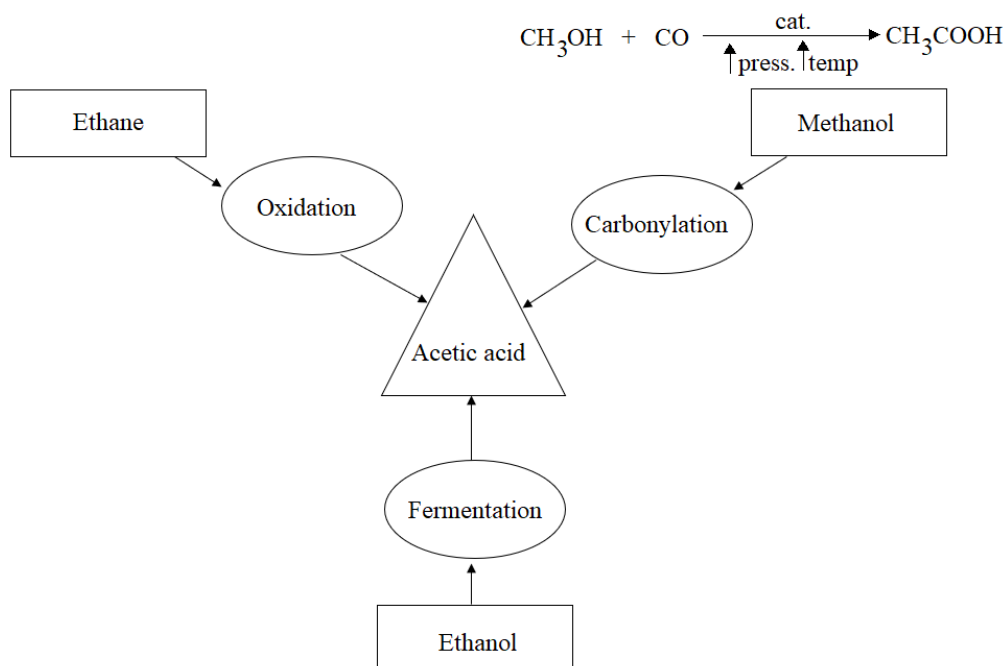
$$K_a = \frac{[H^+][HCO_3^-]}{[H_2CO_3]}, \quad 4.30 \times 10^{-7} = \frac{[H^+][0.125]}{[0.266]}$$

$$[H^+] = \frac{4.30 \times 10^{-7} \times 0.266}{0.125} = 9.1504 \times 10^{-7}$$

$$pH = -\log(9.1504 \times 10^{-7}) = 6.04$$

Question 32 (7 marks)

A new company wants to produce acetic acid using one of the following processes.



Discuss the factors that the company need to consider in selecting the best process to use in the production of acetic acid.

Marking Criteria	Marks
• Provides a thorough discussion of factors for all three processes	7
• Provides a sound discussion of factors for all three processed	6
• Provides a sound discussion of factors for two processed	5
• Provides a discussion of factors for the processes	3-4
• Provide some relevant information	1-2

Sample Answer:

In producing acetic acid using ethane, the company needs to consider the availability of the raw product, which is ethane. Ethane comes from fossil fuels and is limited in its availability and sustainability even though the extraction process is well established. Ethane is a gas and is volatile, so the safety of ethane storage for oxidation needs to be considered for workers and local residents near the manufacturing company.

Carbonylation of methanol using a catalyst, high pressure, and high temp can create a high yield. However, a reaction vessel for a reaction under high pressure and high temperature needs to meet strict safety requirements. The use of carbon monoxide is also can cause a problem. The process of getting methanol from other chemical reactions might slow down the process of the production of acetic acid.

Using ethanol and fermentation is a good process, as ethanol production is renewable from natural glucose, such as corn. This process will be more sustainable. However, getting ethanol needs large areas of farming,

which might be affected by the weather and climate. The extraction process through fermentation has less environmental impact than using ethane from fossil fuel.