ABBOTSLEIGH

2
Centre Number

Student Number

2024 **TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION**

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A formulae sheet, data sheet and Periodic Table are provided at the back of this paper

Total marks: 100

Section I – **20 marks** (pages 2 – 12)

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

Section II – **80 marks** (pages 13–40)

- Attempt Questions 21–37
- Allow about 2 hours and 25 minutes for this section

Section I

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

Use the multiple-choice answer sheet at the back of this paper for Questions 1–20.

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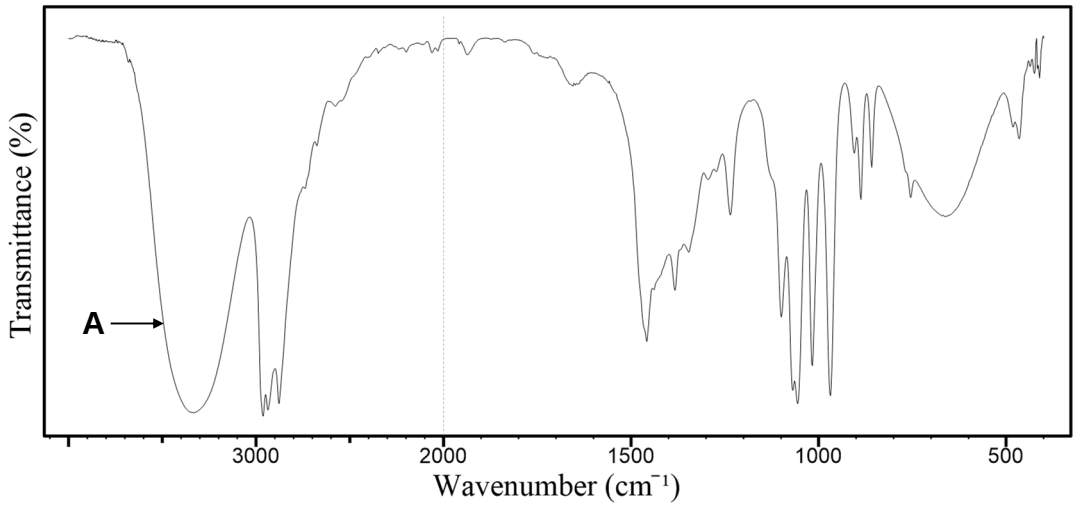
1 Identify the functional group associated with the absorption labelled **A** on the IR spectrum below.



A. −OH

B. −CH

C. −C=O

D. −COOH

2 Aboriginal and Torres Strait Islander peoples have long been using the ideas of solubility to detoxify foods such as the yellow walnut (*Beilschmiedia bancroftii*).

Identify the method that would best remove water soluble toxins from the yellow walnut.

A. Placing the nuts in a mesh bag in container of water.

B. Placing the nuts in a mesh bag in a creek with running water.

C. Crushing the nuts and placing them in a mesh bag in a container of water.

D. Crushing the nuts and placing them in a mesh bag in a creek with running water.

3 Magnesium ribbon was combusted in a crucible without a lid until no further reaction was observed. At this point all the shiny, silver coloured magnesium had been converted into magnesium oxide, a white powder.

Based on these observations, this reaction between magnesium and oxygen can be considered

A. a closed system that reached static equilibrium.

B. an open system that reached static equilibrium.

C. a closed system that reached dynamic equilibrium.

D. an open system that reached dynamic equilibrium.

4 Which of the following will a catalyst NOT do when added to an equilibrium reaction?

A. Change the value of the equilibrium constant for the reaction.

B. Increase the percentage of collisions that result in a reaction.

C. Increase the rates of both the forward and reverse reactions.

D. Provide an alternate reaction pathway with a lower activation energy.

5 The table below shows the pH range and colour changes of three indicators.

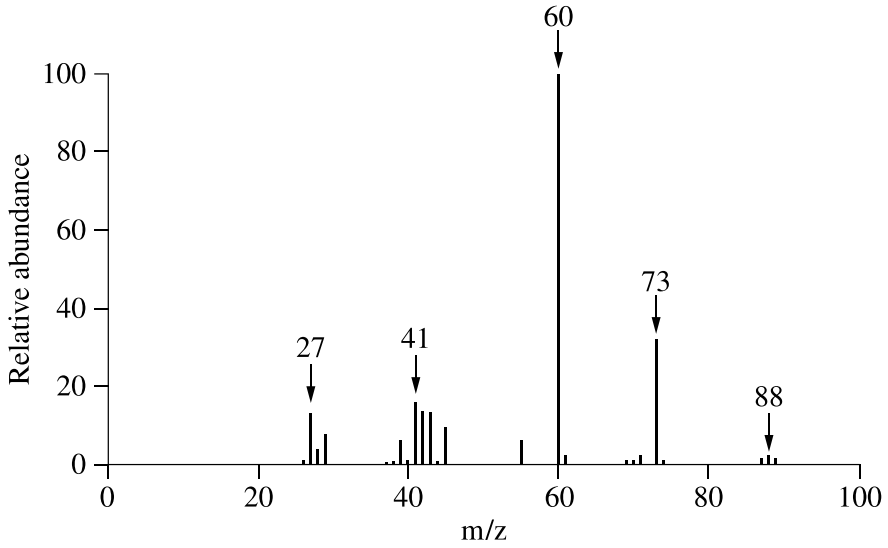
Indicator	*pH range*	*Colour range*
Methyl orange	3.3 – 4.4	Red to yellow
Bromothymol blue	6.0 – 7.6	Yellow to blue
Phenolphthalein	8.3 – 10.0	Colourless to pink

A student used a pH probe and determined that the pH of a clear, colourless solution was 4.3. She then added each indicator in turn to separate samples of the solution.

Which option below correctly identifies the colour of the indicators in the solution?

	Methyl orange	*Bromothymol blue*	*Phenolphthalein*
A.	Red	Yellow	Colourless
B.	Orange	Blue	Colourless
C.	Orange	Yellow	Colourless
D.	Yellow	Yellow	Colourless

6 The diagram shows the mass spectrum of butanoic acid.



Which of the following m/z corresponds to the base peak?

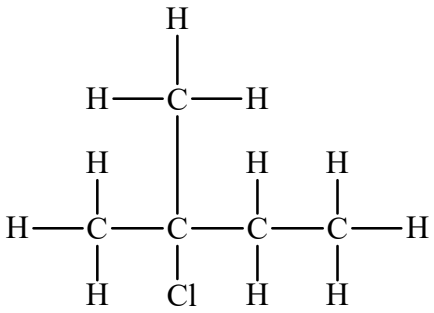
A. 41

B. 60

C. 73

D. 88

7 Consider the following molecule.



What is the systematic name for this compound?

A. 3-chloropentane

B. 2-chloro-2-methylbutane

C. 3-chloro-3-methylbutane

D. 1-chloro-1,1-dimethylpropane

8 A sodium hydroxide solution prepared from analytical-grade NaOH pellets is unsuitable to be used as a primary standard in acid-base titrations.

This is because

A. solutions of sodium hydroxide are colourless.

B. sodium hydroxide pellets have a low solubility.

C. sodium hydroxide solutions are caustic and can cause chemical burns.

D. the exact concentration of the NaOH solution made from the pellets is unknown.

9 Which equation for the reaction between sodium carbonate and dilute hydrochlroic acid is correct?

A. $Na_2CO_3(s) + HCl(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(l)$

B. $Na_2CO_3(s) + HCl(aq) \rightarrow Na_2Cl(aq) + CO_2(g) + H_2O(l)$

C. $Na_2CO_3(s) + 2HCl(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(l)$

D. $Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$

10 Which of the following combinations correctly identifies the molecular shape around a carbon atom within a carbon-carbon single, double and triple bond?

	Single	*Double*	*Triple*
A.	Trigonal pyramidal	Bent	Linear
B.	Trigonal pyramidal	Trigonal planar	Linear
C.	Tetrahedral	Trigonal planar	Linear
D.	Tetrahedral	Trigonal planar	Bent

11 Consider the following equilibrium system.

$$HS^-(aq) + H_2O(l) \rightleftharpoons S^{2-}(aq) + H_3O^+(aq)$$

Which of the following represents a conjugate acid-base pair in this system?

A. $HS^-(aq)$ / $H_3O^+(aq)$

B. $HS^-(aq)$ / $S^{2-}(aq)$

C. $S^{2-}(aq)$ / $H_2O(l)$

D. $S^{2-}(aq)$ / $H_3O^+(aq)$

12 A strong acid HA completely ionises in aqueous solutions.

1.0 mL of a 1.0 mol/L solution was diluted to 1.00 L with distilled water. 100 mL of this resulting solution was then diluted again to a 1.00 L with distilled water.

What is the pH of the final solution?

A. 2

B. 3

C. 4

D. 5

13 Which option correctly shows the compounds in order of increasing pH?

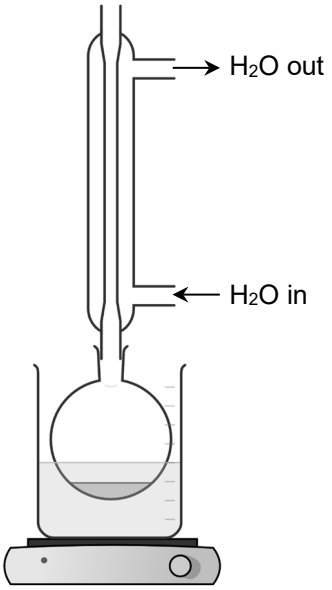
A. $NH_4Cl(aq)$, $NaNO_3(aq)$, $Na_2CO_3(aq)$

B. $Na_2CO_3(aq)$, $NaNO_3$ (aq), $NH_4Cl(aq)$

C. $NH_4Cl(aq)$, $Na_2CO_3(aq)$, $NaNO_3(aq)$

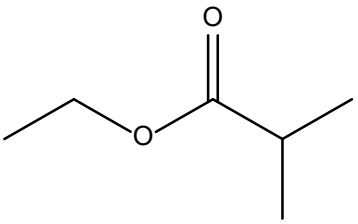
D. $Na_2CO_3(aq)$, $NH_4Cl(aq)$, $NaNO_3(aq)$

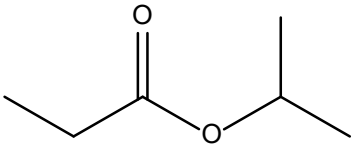
14 This apparatus was set up to produce an ester with molecular formula $C_6H_{12}O_2$.

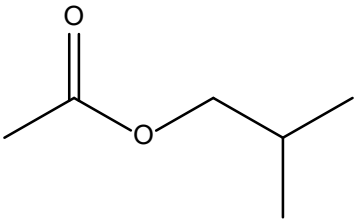


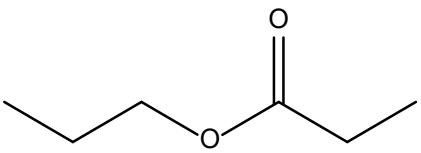
The ester was formed by refluxing propan-2-ol and a suitable carboxylic acid in the presence of an acid catalyst.

Identify the structure of this ester.

A. 

B. 

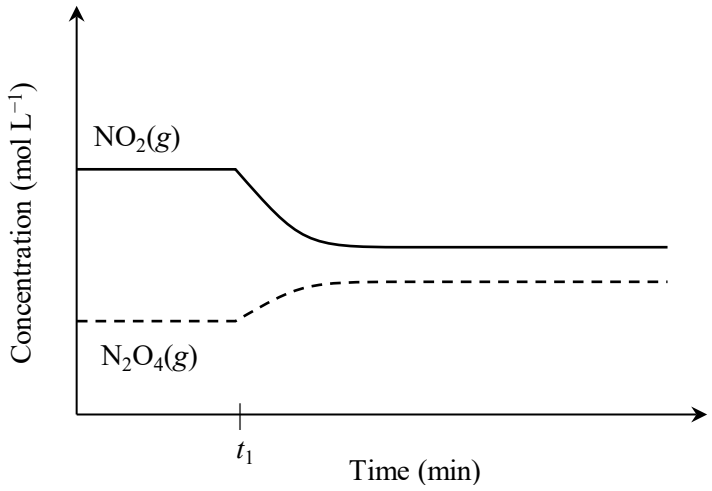
C. 

D. 

15 A sealed glass tube contains an equilibrium mixture of brown nitrogen dioxide gas, NO_2, and colourless dinitrogen tetroxide gas, N_2O_4.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

At time = t_1 the temperature of the mixture is increased. The graph below shows the gas concentrations over time.



Identify the correct statement.

A. The reaction as written is endothermic AND the K_{eq} increases after t_1.

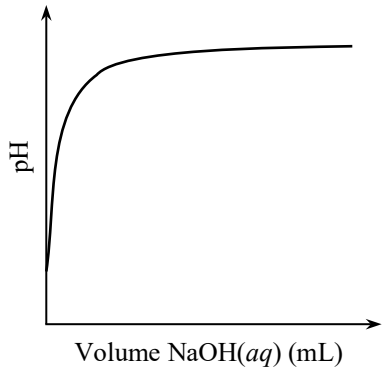
B. The reaction as written is exothermic AND the K_{eq} increases after t_1.

C. The reaction as written is endothermic AND the K_{eq} decreases after t_1.

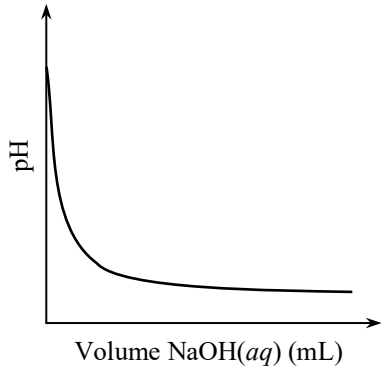
D. The reaction as written is exothermic AND the K_{eq} decreases after t_1.

16 Which of the following titration curves represents a volume of NaOH added to an acidic buffer solution?

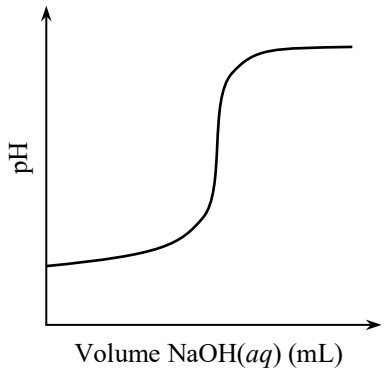
A.



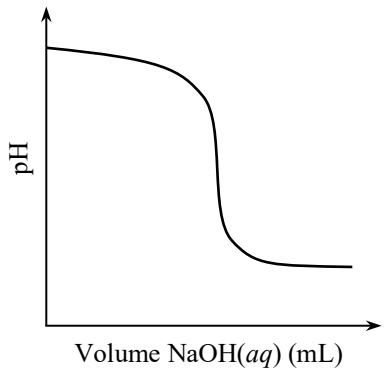
B.



C.



D.



17 In the upper atmosphere, oxygen gas (O_2) and ozone gas (O_3) are in equilibrium at a particular temperature with $K_{eq} = 8 \times 10^{-24}$.

$$3O_2(g) \rightleftharpoons 2O_3(g)$$

If $[O_2(g)]$ at this temperature is 2×10^{-3} M and $[O_3(g)]$ is 4×10^{-6} M, the reaction would be

A. at equilibrium.

B. at completion.

C. moving in the reverse direction.

D. moving in the forward direction.

18 Which of the following pair of solutions, upon mixing will produce the solution with the highest temperature change?

A.	200 mL 0.10 M NaOH(*aq*)	100 mL 0.25 M HNO_3(*aq*)
B.	100 mL 0.10 M NaOH(*aq*)	100 mL 0.10 M CH_3COOH(*aq*)
C.	50 mL 0.20 M NaOH(*aq*)	100 mL 0.10 M H_2SO_4(*aq*)
D.	100 mL 0.40 M NaOH(*aq*)	50 mL 1.0 M HNO_3(*aq*)

19 How many alcohols are structural isomers with the formula C_4H_9OH?

A. 4

B. 5

C. 6

D. 7

20 The table lists some properties of the carbon compounds **W**, **X**, **Y** and **Z**.

Compound	*Reactivity with* $K_2Cr_2O_7/H^+$	*Solubility in water*
W	Solution turns green	Insoluble
X	Orange colour remains	Insoluble
Y	Solution turns green	Soluble
Z	Orange colour remains	Soluble

Which row of the table below best identifies the compounds **W**, **X**, **Y** and **Z**.

	W	**X**	**Y**	**Z**
A.	C_2H_6	$CH_3(CH_2)_5OH$	$(CH_3)_3COH$	$(CH_3)_2CHOH$
B.	$CH_3(CH_2)_5OH$	C_2H_6	$(CH_3)_2CHOH$	$(CH_3)_3COH$
C.	$(CH_3)_3COH$	$(CH_3)_2CHOH$	C_2H_6	$CH_3(CH_2)_5OH$
D.	$(CH_3)_2CHOH$	$(CH_3)_3COH$	$CH_3(CH_2)_5OH$	C_2H_6

End of Section I

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2024 **TRIAL HSC EXAMINATION**

2
Centre Number

Student Number

Chemistry

Section II Answer Booklet

80 marks
Attempt Questions 21–37
Allow about 2 hours and 25 minutes for this section

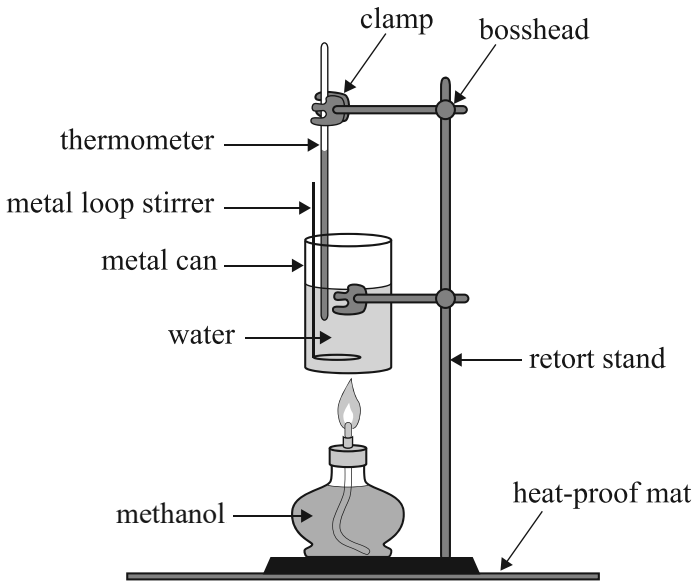
Instructions

- Write your Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (4 marks)

The apparatus below was set up. **4**



Assuming complete combustion and that there is no heat loss to the surroundings calculate the final temperature of the water using the data provided in the table.

Mass of water heated (g)	200.0
Initial temperature of water (°C)	17.5
Molar heat of combustion of methanol (kJ/mol)	−726
Mass of methanol used (g)	2.82

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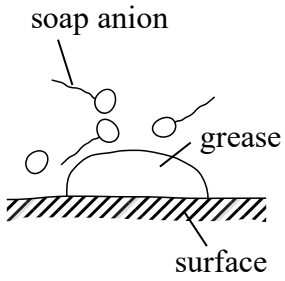
Question 22 (4 marks)

Soap is used to clean a range of items in our everyday life. **4**

Below is a diagram which shows the first step in the removal of grease from a surface using soapy water.

Construct diagrams to show the remaining steps in this process and explain how soap removes grease from a surface.

Step 1	*Step 2*	*Step 3*
		

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Question 23 (3 marks)

According to the Arrhenius theory of acids and bases sodium acetate (CH_3COONa) is an example of a salt, yet according to the more modern Bronsted-Lowry theory it is an example of a base. **3**

Justify the above statement, supporting your response with a relevant balanced equation.

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Question 24 (4 marks)

A student has discovered four unlabelled bottles in the laboratory. The bottles contain aqueous solutions of any ONE of the following: **4**

- barium nitrate
- calcium nitrate
- magnesium nitrate
- silver nitrate

Draw a flow chart to show a sequence of tests that could be performed in a school laboratory to distinguish the cation present within each solution.

The available materials are: 1 M NaOH(*aq*), 1 M HCl(*aq*), 1 M H_2SO_4(*aq*), wire loop and Bunsen burner.

Include expected observations and ONE net ionic equation.

Question 25 (4 marks)

As the effects of the uses of fossil fuels becomes more apparent, there has been a move to use renewable fuels such as bioethanol. **4**

The equations below show the complete combustion of octane and bioethanol:

Complete combustion of octane, the main component of petrol:

$$C_8H_{18}(l) + \frac{25}{2}O_2(g) \rightarrow 8CO_2(g) + 9H_2O(g) \qquad \Delta H_c = -5470 \text{ kJ mol}^{-1}$$

Complete combustion of ethanol:

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g) \qquad \Delta H_c = -1370 \text{ kJ mol}^{-1}$$

Compare the use of petrol and bioethanol as fuels, including the environmental impacts of each. Make use of the information above in your response.

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Question 26 (5 marks)

The table lists the pH of 0.10 mol L^{-1} solutions of four different acids at 25°C.

Acid	*pH*
A	1.0
B	2.9
C	0.7
D	2.1

Three of the acids are monoprotic, the fourth contains more than one acidic hydrogen.

(a) Which of *A*, *B*, *C* or *D* must be the acid with more than one acidic hydrogen? Justify your choice. **2**

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(b) Methanoic acid (HCOOH) is a monoprotic acid. Calculate the K_a of methanoic acid with the same concentration and pH as Acid *D*. **3**

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Question 27 (3 marks)

Consider the solubility in water of the following organic compounds. **3**

Compound	*Molecular mass* (g/mol)	*Solubility in water* (g/ 100 mL)
Propan-2-ol $CH_3CHOHCH_3$	60.10	100
Propanal CH_3CH_2CHO	58.08	5
Butane C_4H_{10}	58.12	0.0061

Explain the difference in the solubility in water of the three organic compounds. Include one relevant diagram as part of your response.

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Question 28 (3 marks)

When solid sodium hydrogen carbonate is added to a solution of acetic acid (ethanoic acid) in the laboratory an immediate reaction occurs that goes to completion and the temperature of the reaction mixture decreases. **3**

$$NaHCO_3(s) + CH_3COOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l) + CO_2(g)$$

Justify the spontaneity of this process with reference to changes in both enthalpy and entropy.

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Question 29 (4 marks)

A student mixes 25.0 mL of 0.020 mol L^{-1} sodium carbonate with 125.0 mL of 3.0×10^{-4} mol L^{-1} barium nitrate solution.

(a) Write the balanced chemical equation for this reaction. **1**

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(b) Determine whether the student will observe a precipitate form when the two solutions are mixed together. **3**

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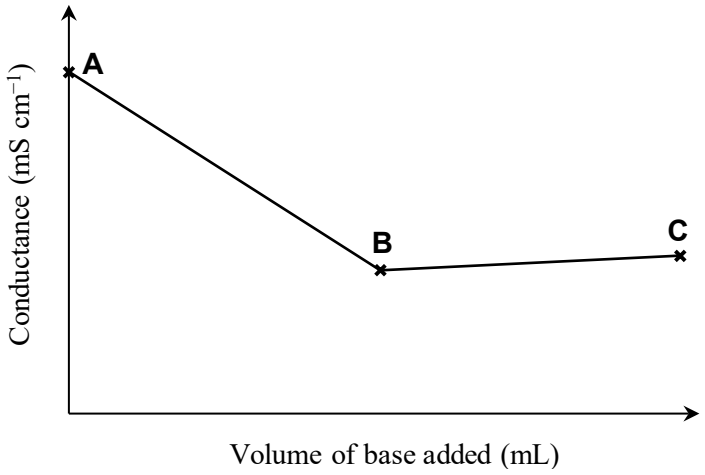
Question 30 (4 marks)

Conductivity curves show the change in the electrical conductivity during a titration and can be used to determine the equivalence point of a reaction.

The curve below represents the change in conductivity upon the addition of aqueous ammonia solution to nitric acid.



(a) Which letter A – C most closely shows the equivalence point for the reaction? **1**

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(b) Account for the shape of the curve, using all the letters in your response. **3**

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Question 31 (9 marks)

When hydrogen and carbon monoxide are added to a container at 430°C the following equilibrium system is obtained.

$$2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$$

(a) Write the equilibrium expression for this reaction. **1**

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(b) 0.045 mol hydrogen and 0.080 mol carbon monoxide are added to a 1.00 L container at 430°C and allowed to reach equilibrium. At equilibrium the concentration of methanol is 0.011 mol. **2**

Calculate the equilibrium constant for the system.

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Question 31 continues on page 25

(c) Using Le Chatelier's Principle, explain the effect of decreasing the volume of the container on the methanol concentration. **3**

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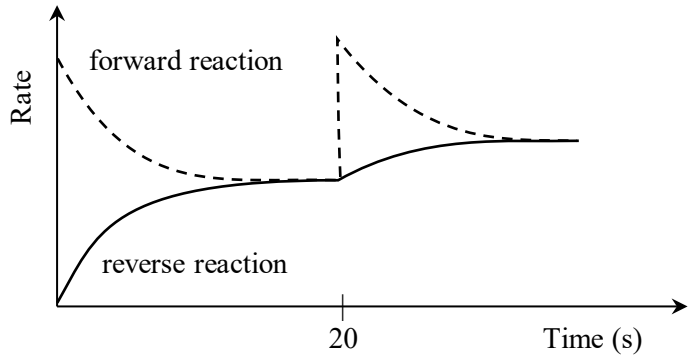
(d) At time = 20 seconds hydrogen was added to the equilibrium mixture. Using collision theory, account for the shape of the rate-time graph below for the forward reaction, from 20 seconds until equilibrium is re-established. **3**



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End of Question 31

Question 32 (4 marks)

A student adds 75.0 mL of 0.15 M sodium hydroxide to 50.0 mL of 0.10 M sulfuric acid. **4**

Calculate the pH of the solution after the chemical reaction has occurred.

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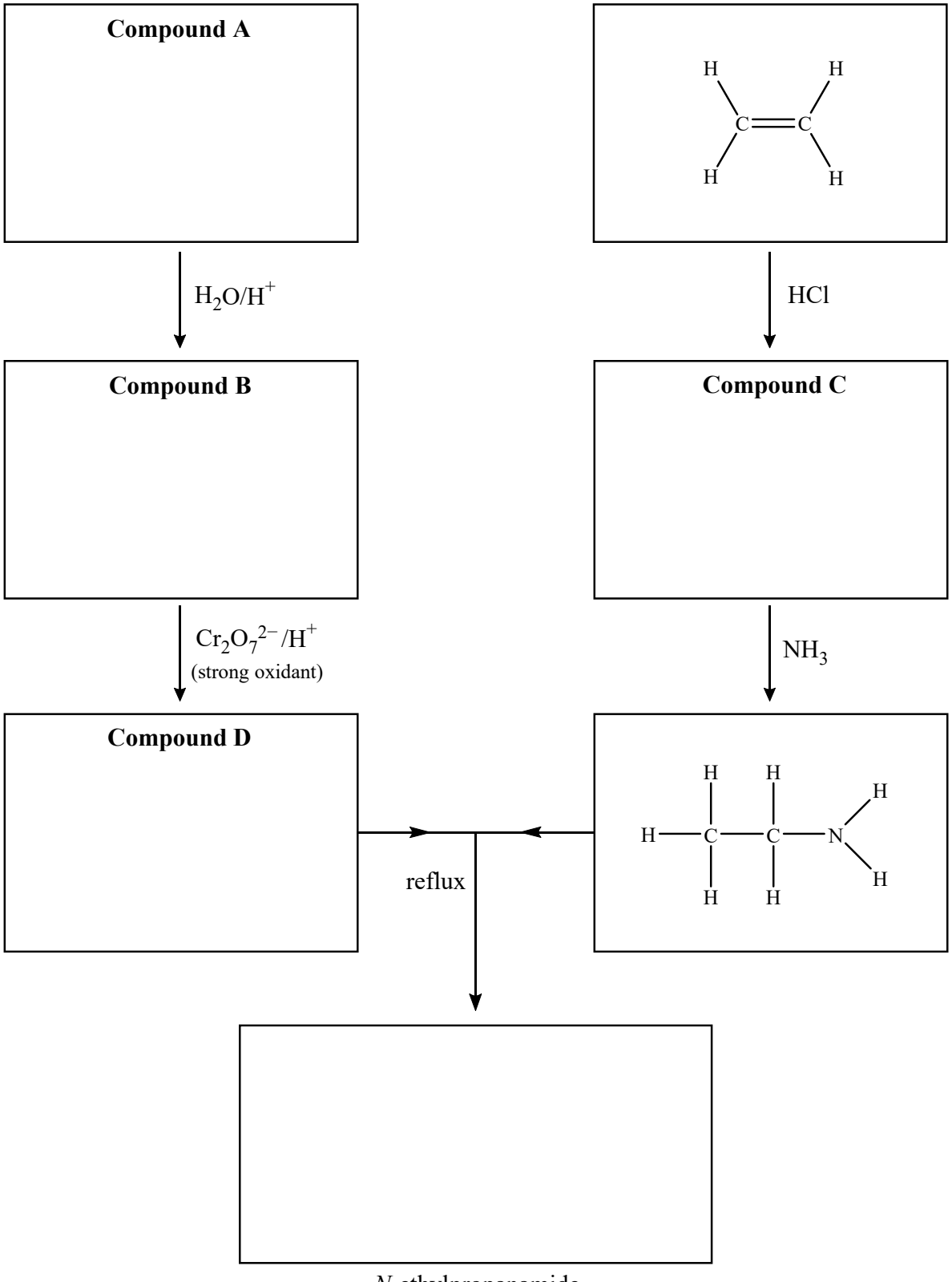
Question 33 (5 marks)

A reaction pathway to synthesise *N*-ethylpropanamide is shown in the flow chart. **5**

Complete the flow chart by drawing the structural formulae for *N*-ethylpropanamide and compounds A, B, C and D.



N-ethylpropanamide

Question 34 (4 marks)

A 1.32 g sample of impure magnesium metal was analysed by allowing it to react with 100.0 mL of 0.750 mol/L HCl(*aq*). The remaining solution is titrated with 0.250 mol/L NaOH(*aq*), and the average titre volume is 45.00 mL. **4**

Assuming the impurities do not react with the acid, calculate the percentage by mass of magnesium in the sample.

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Question 35 (5 marks)

A textbook states that 'the molar solubility of silver carbonate is higher in water than it is in a 0.100 M silver nitrate solution'. **5**

Justify the statement is correct using calculations AND Le Chatelier's Principle.

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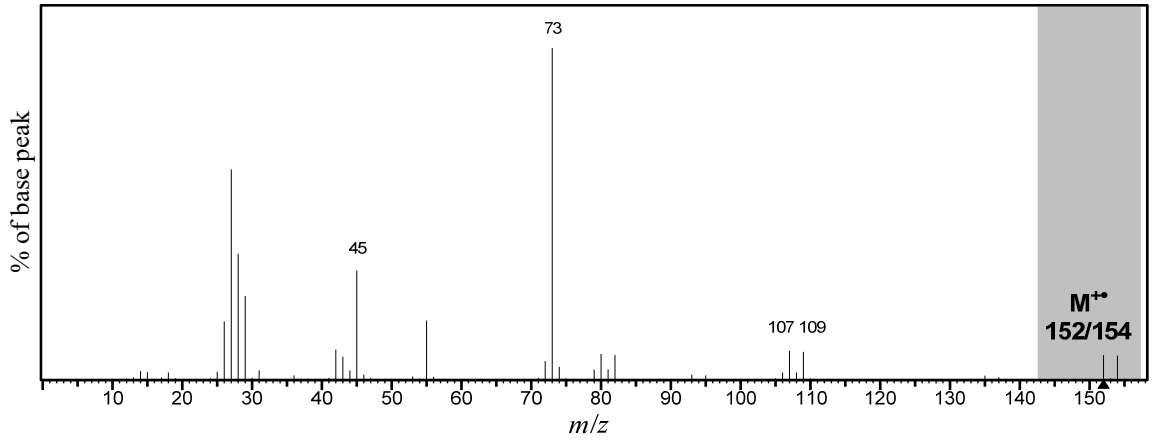
Question 36 (7 marks)

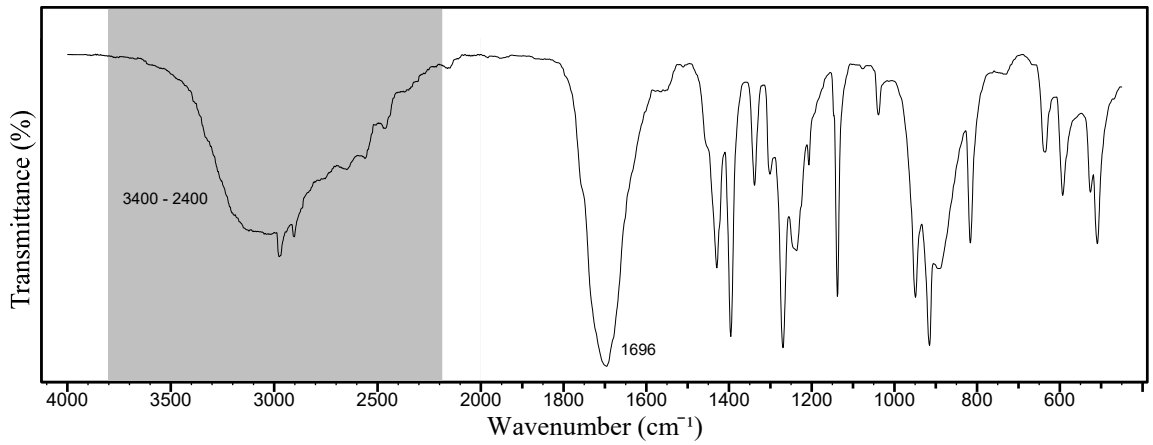
A synthetic medicinal chemist isolated and purified an organic product from a series of reactions which had been designed to produce a brominated organic compound. Bromine can be present as ^{79}Br and ^{81}Br. **7**

The organic chemist obtained the following spectral data of the purified product to determine the structure of the molecule.

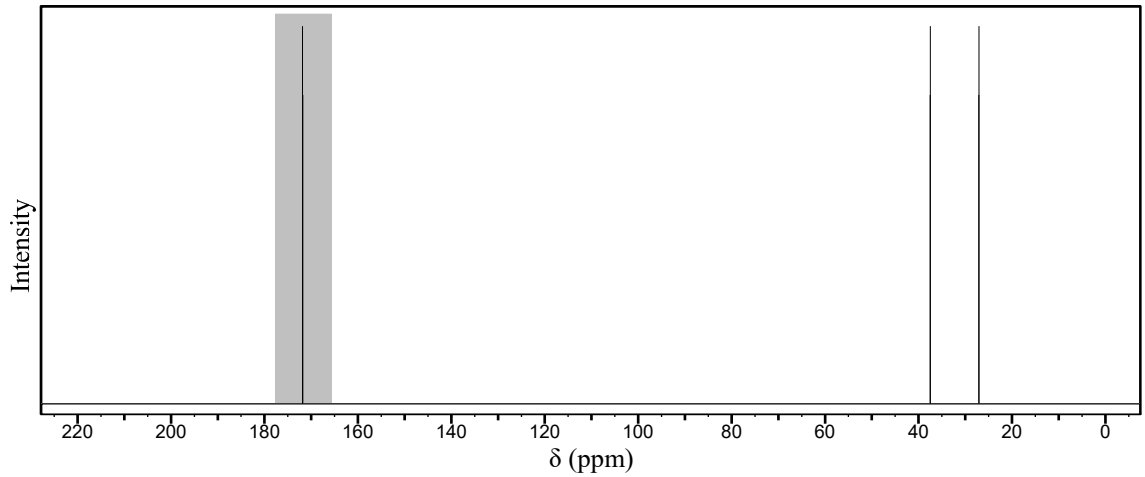
Mass Spectrum



IR Spectrum

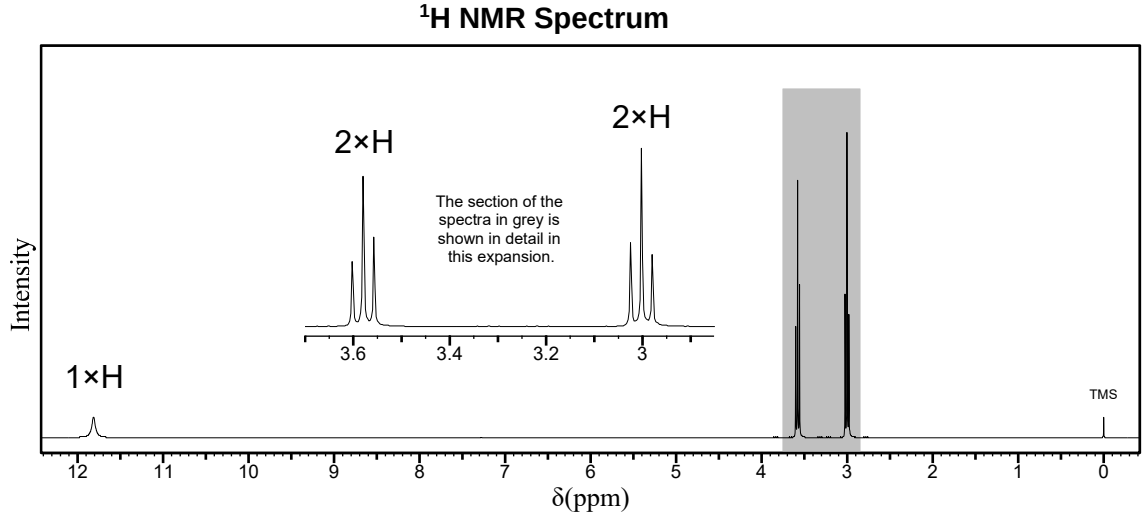


^{13}C NMR Spectrum



Question 36 continues on page 31

Question 36 (continued)



Deduce the structural formula of the molecule consistent with the spectra provided. Identify the IUPAC name of the proposed structure and relate the highlighted features of the spectra to the structure.

Structure:

IUPAC Name: .....

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Question 36 continues on page 32

Question 36 (continued)

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End of Question 36

Question 37 (8 marks)

AbbPharm produces a multivitamin which includes a range of vitamins and minerals. Each multivitamin tablet contains the following minerals:

Mineral	Mass in tablet (mg)
Calcium (394 mg as calcium carbonate and 6 mg as calcium hydrogen phosphate)	400
Magnesium (as magnesium oxide)	64.0
Iron (as ferrous fumarate)	6.8
Zinc (as zinc oxide)	0.21
Chromium (as chromic chloride hexahydrate)	0.025
Copper (as cupric sulfate)	0.900
Iodine (as potassium iodide)	0.150

A laboratory was asked to determine the mass of zinc in the *AbbPharm* multivitamin. A chemist carried out two methods to determine the mass of zinc in the multivitamin. Evaluate the TWO methods below in their validity of determining the mass of zinc in the tablets. **8**

Include at least one relevant equation and one calculation in your answer.

Method 1: Using Gravimetric Analysis

The chemist took 4 multivitamin tablets, ground them up individually, dissolving them in 10% nitric acid. Excess 1.0 M NaOH was added to each tablet. The resulting precipitates were dried to constant mass and then weighed.

The mean mass of the precipitate formed was 9.20 mg.

Question 37 continues on page 34

Question 37 (continued)

Method 2: Using Atomic Absorption Spectroscopy

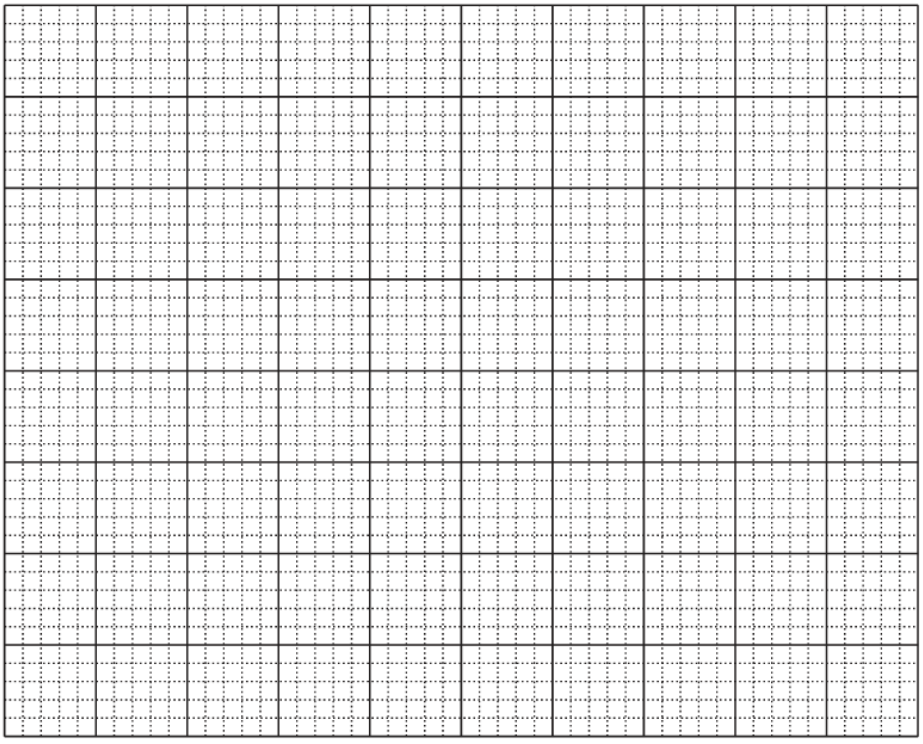
The chemist prepared 4 tablet samples for analysis by dissolving the tablets individually in 10% nitric acid. Each tablet solution was made up to a final volume of 100.0 mL. Five standard solutions of zinc were also prepared. The absorbances of the standard and sample solutions were determined by atomic absorption spectroscopy at 213.9 nm.

The results are shown in the table:

Standard Zn^{2+} solutions (mg L^{-1})	*Absorbance*
0.00	0.000
1.00	0.170
2.00	0.330
3.00	0.503
4.00	0.680

The mean absorbance of the tablet solution was 0.280.

Zn^{2+} Calibration Graph



Question 37 continues on page 35

Question 37 (continued)

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End of Paper

Section II Extra writing space

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HSC Chemistry Task 4

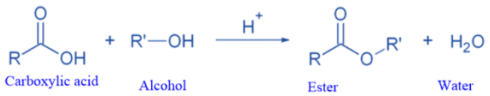
Marking Guidelines, Sample Answers and Marker's Feedback

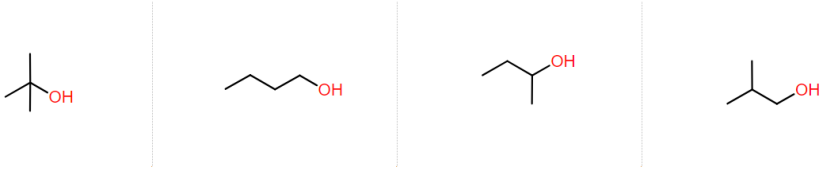
General feedback:

- Avoid writing outside of the lines, particularly avoid writing close to the edge of the page → use extra writing space.
- Clearly state if extra writing space is used (you want the marker to find your answer!)
- Think through explanations before starting to write (especially longer responses), as you want your answer to have a logical flow.
- Answer the question clearly – this might mean a writing a short sentence in a calculation question.
- Either when checking the paper or before you go to the next question double check that your response matches the verb in the question.
- Show all working in calculation questions → including stating equations, giving explanatory statements and being clear what you are calculating.
- In calculation questions check the significant figures and units.

Section 1 (20 marks)

Question 1-20 Multiple Choice

Question	Answer	
1	A	No absorption at about 1700 so C and D eliminated. The CH bond is not broad.
2	D	Crushing increases surface area; running water prevents solution saturation.
3	B	No lid = open system; no Mg remaining = static equilibrium.
4	A	Catalyst will NOT change the Keq.
5	C	B or C from the MO, B eliminated as BB is blue above 7.6
6	B	Base peak has relative absorbance of 100.
7	B	A & D are well off, C is numbering from wrong end giving higher locant values
8	D	Have to have an exact concentration to be used as a primary standard
9	D	Others are incorrect with balancing
10	C	C or D based on single bond, triple bond linear so D eliminated
11	B	HS^- acid gives proton to water, forming conjugate base S^{2-}
12	C	1 to 1000 is 3 ten fold changes in pH then 100 to 1000 a further ten fold
13	A	NH_4Cl is acidic salt, NaCl is a neutral salt, Na_2CO_3 is a basic salt
14	B	An ester linkage is formed on reaction of a carboxylic acid and an alcohol. The general equation for this reaction is:  If the alcohol used in propan-2-ol $(CH_3)_2CHOH$, then R' = $CH(CH_3)_2$. The only option with this structure is (B).
15	D	Temp increase causes shift left (conc reactant increases) so reverse reaction is endo and forward reaction is exo; [reactant] increases and [product] decreases which causes Keq to decrease.
16	C	A strong base is added to an acidic buffer solution, so the curve needs to look like a weak acid – strong base titration curve. Thus C is the answer.

17	C	$Q = [O_3]^2/[O_2]^3 = (4x10^{-6})^2/(2x10^{-3})^3 = 0.002 > 8x10^{-24}$. Q>Keq so reverse reaction is favoured to decrease [product] and increase [reactant] which will lower Q so it reaches Keq.
18	D	Find the moles of acid and base for each pair, considering the limiting reagent.
19	A	The isomers of C_4H_9OH that are alcohols are shown:  There are 4 isomers so (A) is the answer.
20	B	The two tests shown are oxidation with potassium dichromate and solubility in water. The compounds in question are C_2H_6 (an alkane), $CH_3(CH_2)_5OH$ (a long primary alcohol), $(CH_3)_3COH$ (a tertiary alcohol), and $(CH_3)_2CHOH$ (a secondary alcohol). Of these molecules, the tertiary alcohol and the alkane do not undergo oxidation reaction with potassium dichromate so the orange colour for these should remain, while for the primary and secondary alcohol the solution turns green. So X and Z are the tertiary alcohol and the alkane. Alcohols are highly soluble in water while alkanes are not, thus X is the alkane and Z is the tertiary alcohol. The only option with these selections is (B).

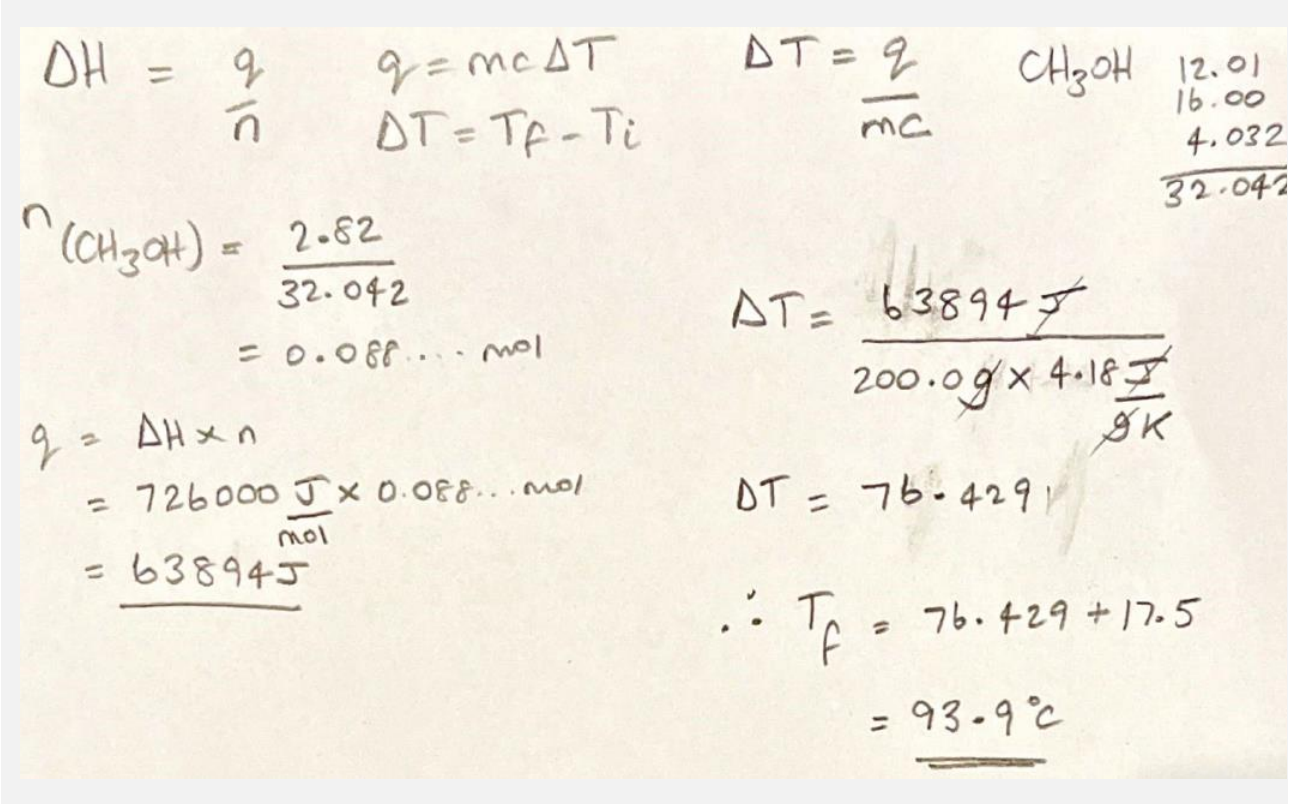
Section 2 (80 marks)

Question 21 (4 marks) Marker: ER

Marking guidelines

Criteria	Marks
• Correct value calculated with all steps shown • Correct units included and used throughout the response	4
• Correct calculation with no units OR • Mostly correct calculation with single error with correct units • Correct calculation with inconsistent units	3
• Two steps correct	2
• A relevant and correct calculation	1

Sample response:



Marker feedback:

Too many responses manipulated units incorrectly. The HSC marking process has penalised this in the past. If mass of water heated is in g then c has the value of 4.18 J/g/K. If the mass of water is converted to kg then c has the value of 4.18 x 10^3 J/kg/K. The unit of energy is J in the unit of c. It is tempting to manipulate and combine steps. This is ill advised as it leads to errors, as has happened with several girls. 1 mark was deducted if there was inconsistency in units as the calculation was worked through.

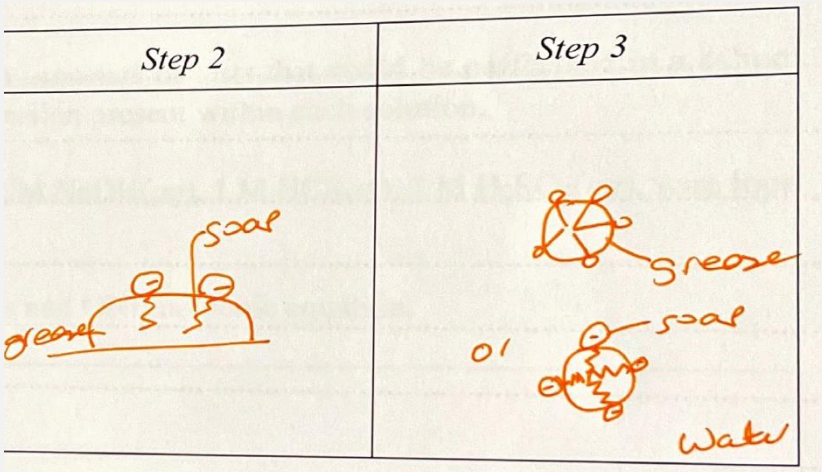
Show all steps in the calculation to be clear in your working**.**

Question 22 (4 marks) Marker: ER

Marking guidelines

Criteria	Marks
• Two diagrams completed with labels/text to clearly show main features of soaps anions removing grease from surfaces • Precise and correct terminology used in explanation • Thorough explanation of how soap anions remove grease from surface. • IMF between soap anion and water and soap anion and grease used in the explanation	4
• Three of the above	3
• Two of the above	2
• One piece of relevant information or something correct in the diagram	1

Sample response:



Step 1: the soap anions are dissolved in water. In Step 2, the hydrophobic/non-polar tails of the soap anions form dispersion forces with the grease on the surface. As more soap anions attach to the grease (or as agitation occurs), the soap anions form small spheres with the grease called micelles. The micelles consist of grease in the middle, with the non-polar soap anion tails attached to the grease and the hydrophilic/polar heads of the soap anions facing outwards to the water and forming ion-dipole IMF with the water. Step 3: As more water is added, the micelles are rinsed away and therefore the grease is removed from the surface.

Marker feedback:

Better responses included labelled diagrams and clear link between the IMF involved. Diagrams not well drawn, and labelling was often missing or unclear. Several responses indicated that the polar head of the soap anion interacted with the grease as opposed to the non-polar tail. Responses could be easily improved with explicit reference to the IMF formed between the soap anion and the grease and the soap anion and the water. There is some confusion on what a micelle is**.**

Question 23 (3 marks) Marker: LD

Marking guidelines

Criteria	Marks
• Statement justified with 1 relevant balanced equation	3
• Partial justification covering one aspect of the acid/base theory correctly and an equation OR • Some justification for both theories with one correct equation	2
• Any one piece of relevant information	1

Sample response:

The Arrhenius model is that an Arrhenius acid reacts with an Arrhenius base to form a salt and water. Sodium acetate is the salt formed following the reaction of sodium hydroxide (Arrhenius base) and acetic acid (Arrhenius acid). The two products of this reaction are the salt + water. Equation needed to show this reaction.
$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$. [state symbols not required].
A B-L base is one which accepts a proton. Sodium acetate dissolves in water forming sodium ions and acetate ions. The acetate ions hydrolyse in water to produce hydroxide ions as the acetate ion accepts a proton from a water molecule. Equation needed to show acetate reacting with water forming hydroxide ions.
$CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$

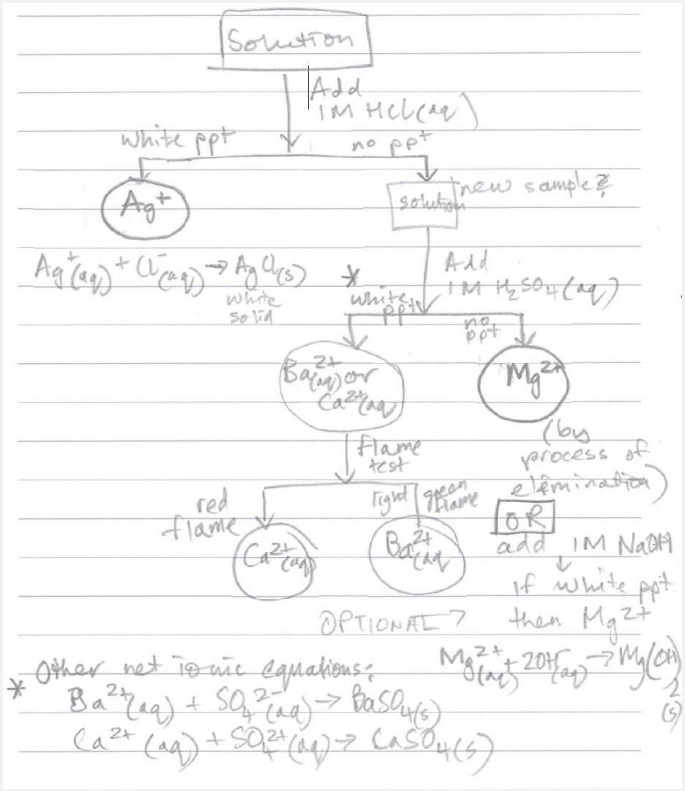
Marker feedback:
This was tricky for some. There needed to be a clear understanding shown of WHY Arrhenius classified CH_3COONa is a salt, which is that it is the result of neutralisation. Some students were incorrectly saying that it is not a salt because it does not produce OH^- ions in solutions. This does not explain why it is a salt under the Arrhenius definition.

Question 24 (4 marks) Marker: LD

Marking guidelines

Criteria	Marks
• Clear flow chart drawn which correctly identifies all cations present in the solution. • Expected observations listed for each step in the flow chart, including colours of any precipitates formed or flame colours produced • One correct net ionic equation with correct arrow →, (states should be there)	4
• Three of the above	3
• Two of the above	2
• One relevant step	1

Sample response:



Marker feedback:
Well done by most. A reminder to always state the COLOUR of precipitates formed, as this is part of the outline of observations. Also, ensure that the balanced net ionic equation has a forward arrow and not a reversible arrow.

Question 25 (4 marks) LD compare fuels

Marking guidelines

Criteria	Marks
• Thorough comparison made of octane and petrol as fuels (clear link to use as fuel shown), using at least two criteria, including environmental impacts. • Clear comparative language made • Refers to information provided (equations and/or heats of combustion)	4
• Sound comparison made of octane and petrol as fuels, using at least two criteria, including environmental impacts. • Refers to information provided (equations and/or heats of combustion)	3
• Basic comparison made of octane and petrol as fuels, using at least two criteria, including environmental impacts. • Some reference to information provided	2
• Some relevant information provided	1

Sample response:

Petrol (octane) has a higher heat of combustion (-5470 kJ mol^{-1}) than ethanol (-1370 kJ mol^{-1}), so less petrol is needed than ethanol to get the same energy released, as stated in the equations. Therefore, petrol is more efficient than ethanol, which means less petrol is required to be refined, less impact on the environment.

Bioethanol will undergo complete combustion more readily than octane in petrol because less moles of oxygen is needed (3 mol) compared with that of octane (25/2 moles) (or as stated in the equation). This means that ethanol will produce less soot (C) and less CO, which means less harmful pollution released into the environment.

Bioethanol produces less CO_2 per mole burnt (2 mol) than petrol (8 mol), which means less greenhouse gases are produced by burning ethanol. Less greenhouse gases means less effect on the enhanced greenhouse effect and therefore climate change. (can also bring in the idea of ethanol being sourced from growing sugar cane or other crops, which absorbs and therefore offsets CO_2)

Can also talk about:
Bioethanol is a renewable resource (comes from sugar cane which grows quickly), whereas octane comes from crude oil which is non-renewable. Therefore, Bioethanol has less of an environmental impact than octane. (or can talk about less CO_2 produced by ethanol overall compared with octane.

Marker feedback:

Mostly done well, but I suggest strongly that you use the information in front of you to stick to the question. Many going off in different directions, rather than relating the information in front of you and relating back the environmental effects. Also, make sure you link your comparison of each fuel back to the EFFECT on the environment. (see sample answer)

Question 26a (2 marks) Marker: ER

Marking guidelines

Criteria	Marks
• C identified with justification	2
• One relevant piece of information	1

Sample response:

pH of acid C is the lowest (most acidic value). Using pH = -log[H^+]. A 0.10M solution of a monoprotic strong acid would be 1.0, a weak monoprotic acid will be higher than this. As C has the lowest pH it must have more than one acidic hydrogen to have pH less than 1.

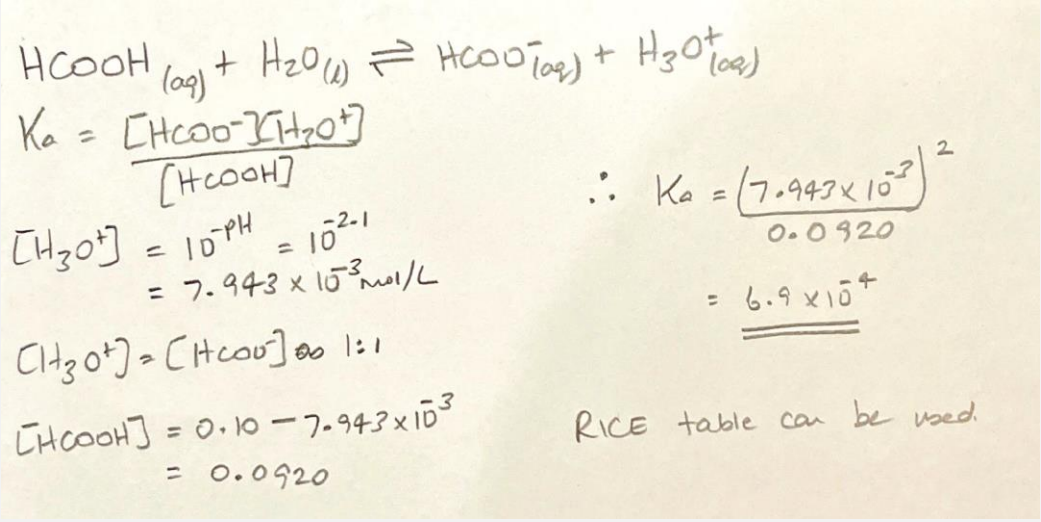
Marker feedback:
The identification of C was done well. However, the justification was not as well done. It is insufficient to simply say that it was the lowest value of pH. Better responses converted the pH to concentration of hydrogen ions and stated that as this was greater than 0.1 mol/L there must be more than one acidic hydrogen or that with single hydrogen a concentration of 0.10M produced a pH of 1.0 at the lowest.

Question 26b (3 marks) Marker: ER

Marking guidelines

Criteria	Marks
• Ka calculated with all working including equation and ratio of methanoate to hydronium clear and equilibrium concentration of methanoic acid.	3
• Mostly correct but either a mistake or working missing or used 0.10 as concentration of methanoic acid	2
• A relevant step in the calculation	1

Sample response:



Marker feedback:
Generally done well. Important to remember if pH is given then [H^+] can be determined and from that the equilibrium concentration of the acid can be determined. Good responses explicitly indicated that the concentration of hydrogen ion = concentration of the methanoate ion. Do not skip steps.

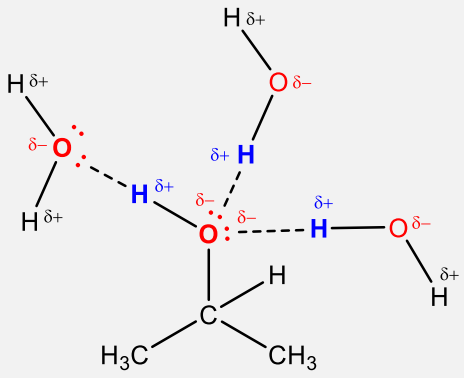
Question 27 (3 marks) Marker: LT

Marking guidelines

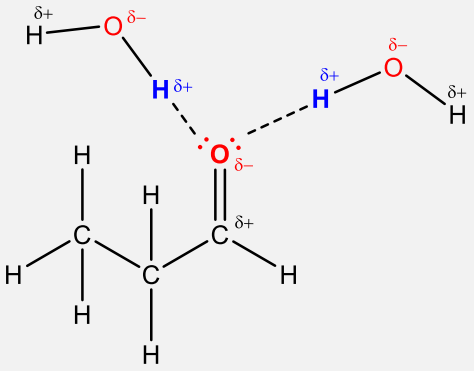
Criteria	Marks
• Identifies the difference in the solubility of ALL three organic molecules in water. • Uses cause and effect terminology to relate the trend in solubility to the strength of a present IMF between ALL organic molecules and water. • Includes a diagram to show an interaction between organic molecules and water.	3
• Any TWO of the above.	2
• One piece of relevant information	1

Sample response:

Propan-2-ol has the highest solubility of all the organic molecules presented (100 g/100 mL). This is due to an extensive network of strong H-bonds that form between molecules of propan-2-ol and water. The diagram below shows a molecule of propan-2-ol and the three possible sites of H-bonding with water. Propan-2-ol is also a branched secondary alcohol. This molecule has short carbon side chains (methyl groups) that minimise repulsions between the non-polar region of the molecule and water.



propan-2-ol



propanal

Propanal has the next highest solubility (5 g/100 mL). This molecule forms H-bonds with water, however the extensiveness of the H-bonding is less than that of the alcohol. The diagram shows the reduced number of sites on the molecule for H-bonding to occur compared to the alcohol. Propanal also has a longer non-polar region (ethyl group) which would see greater repulsion between the polar water molecules, further reducing its solubility comparatively to the alcohol.

Butane has the lowest solubility in water of all three organic molecules (0.0061g/100 mL). This is due to the absence of H-bonding as the large non-polar alkane chain is only capable of forming weak dispersion forces with water.

Marker feedback:

Lots of discussion about like dissolving like with no reference to the relative strength of IMF.

Teaching point: identifying that both propanal and proan-2-ol can both undergo H bonding. But the extent of H bonding is much greater in the alcohol due the great number of sites for H bonding to occur.
Some students only identified dipole-dipole being present in propanal and failed to identify these as H bonds, but still alluded to the IMF being weaker than in the alcohol. This was permissible. However, despite this being a teaching point, students who incorrectly stated that propanal was not capable of H bonding would have lost a mark as this statement is incorrect. Lots of confusion over the nature of H bonding. Please explain. Better answered referred to the extent of H bonding; and the size of the branched 2 alcohol.

Lots of students didn't provide any diagram at all.
Many diagrams didn't feature water. This was imperative as you were trying to show the interactions between H_2O and the organic molecule.
This question was done poorly.

Question 28 (3 marks) Marker: LT

Marking guidelines

Criteria	**Marks**
• Identifies that a spontaneous reaction requires a negative ΔG. Uses a knowledge of $\Delta G = \Delta H - T\Delta S$ and entropy to justify how this is possible with a positive ΔH AND links entropy change to the substances in the reaction.	3
• Justification of spontaneity omits reference to ONE of: - Gib's energy - entropy OR - enthalpy.	2
• One piece of relevant information provided.	1

Sample response:

The process is spontaneous so will have a negative ΔG, the temperature decreases so the process has a positive ΔH.
Considering the equation $\Delta G = \Delta H - T\Delta S$, for ΔG to be negative with a positive value of ΔH at laboratory temperature, entropy must increase (positive ΔS) and be large enough that $T\Delta S$ is greater than ΔH.
In this reaction gas is produced from a solid and a solution which will provide a significant increase in the entropy of the system as gases have a far higher entropy than solids, liquids and solutions.

Marker feedback:

Many students incorrectly classified the reaction as exothermic rather than endothermic.

Students who did this were still able to justify spontaneity with reference to entropy and Gibbs energy.

This question was done well.

Question 29a (1 mark) Marker: ER

Marking guidelines

Criteria	Marks
• Correct balanced chemical equation provides, including STATES.	1

Sample response:

Na_2CO_3 *(aq)* + $Ba(NO_3)_2$ *(aq)* → $BaCO_3$ *(s)* + $2NaNO_3$ *(aq)*

Marker feedback:
Mostly done well. A few balancing issues.

Question 29b (3 marks) Marker: ER

Marking guidelines

Criteria	Marks
• Correctly calculates Q with working shown and determines that a precipitate will be observed by comparing Q and K_{sp}.	3
• Two pieces of relevant information provided – eg. chemical equation, K_{sp} expression, calculation step, conclusion based on data.	2
• One piece of relevant information provided – eg. chemical equation, K_{sp} expression, calculation step, conclusion based on data.	1

Sample response:

$BaCO_3$ *(s)* ⇌ Ba^{2+} *(aq)* + CO_3^{2-} *(aq)* $K_{sp} = 2.58 \times 10^{-9}$ (from data sheet)

Total volume = 150.0 mL

$[CO_3^{2-}]$ $c_1V_1 = c_2V_2$ $\therefore c_2 = \frac{0.020 \times 0.0250}{0.1500} = 0.0033$ mol/L

$[Ba^{2+}]$ $c_1V_1 = c_2V_2$ $\therefore c_2 = \frac{3.0 \times 10^{-4} \times 0.1250}{0.1500} = 0.00025$ mol/L

$\therefore Q_{sp} = [Ba^{2+}]\,[CO_3^{2-}] = 0.00025 \times 0.0033 = 8.3 \times 10^{-7}$ (this is larger than K_{sp})

$\therefore Q_{sp} > K_{sp}$ so the student will observe a precipitate as precipitation will occur.

Marker feedback:
Not an easy question. Biggest source of error was not calculating the concentration of the barium and carbonate ions and instead using the moles in the calculation.
Teaching point – when writing equation use equilibrium arrow.

Question 30a (1 mark) Marker: ER

Marking guidelines

Criteria	Marks
• B	1

Sample response:

B represents the equivalence point.

Marker feedback:
Done very well.

Question 30b (3 marks) Marker: ER

Marking guidelines

Criteria	Marks
• Correct reason given for A, B and C	3
• Two points of curve covered correctly OR • Partially correct for three parts	2
• A relevant piece of information	1

Sample response:

A – relatively high initial conductivity as HNO_3 is strong acid, fully ionised and exists as mobile hydrogen and nitrate ions.
B – conductivity drops from A to being at lowest point at B as all the hydrogen ions present from the acid have been neutralised by the ammonia which has been added.
C – after the equivalence point there is excess ammonia which only increases the conductivity slightly as it is a weak base which partially ionises in water. A small concentration of ammonium and hydroxide ions are formed which are able to act as conductors. The conductivity does not rise a lot as there is an equilibrium between molecular ammonia and ammonium and the resulting common ion effect from the ammonium nitrate works against the dissociation.

Marker feedback:
Generally done well. However, some very imprecise language which made tracking thought processes pretty challenging. Given that there were multiple ions present it is important to specify which one/s is impacting the conductivity. Better responses were able to identify that nitric acid is a strong acid and ionises to form hydrogen and nitrate ions as well as the weak nature of ammonia as a base.

Question 31a (1 mark) Marker: RT

Marking guidelines

Criteria	Marks
• Correct equilibrium expression provided.	1

Sample response:

$K_{eq} = \frac{[CH_3OH]}{[H_2]^2\,[CO]}$ $K_{eq} = \frac{[HI]^2}{[H_2]\,[I_2]}$ Alternate

Marker feedback:
Done very well.

Question 31b (2 marks) – RT

Marking guidelines

Criteria	Marks
• Correctly calculates equilibrium concentrations and K_{eq} with working shown.	2
• One correct calculation step provided.	1

Sample response:

	H_2	CO	CH_3OH
R	2	1	1
I (mol/L)	0.045	0.080	0
C (mol/L)	-0.011 x 2 = -0.022	-0.011	+0.011
E (mol/L)	0.023	0.069	0.011

$\therefore K_{eq} = \frac{0.011}{(0.023)^2 \times 0.069} = 301 = 3.0 \times 10^2$ (2sf)

Alternate

	H_2	I_2	HI
R	1	1	2
I (mol/L)	0.045	0.080	0
C (mol/L)	=0.038-0.045= -0.007	= -0.007	= +0.007x2= +0.014
E (mol/L)	0.038	=0.080-0.007=0.073	=0.014

$\therefore$ [HI] = 0.014 mol/L (2sf)

Marker feedback:

Generally done well with RICE tables used effectively.
Ecf from (a) if Keq expression was incorrect.

Question 31c (3 marks) – RT

Marking guidelines

Criteria	Marks
• Identifies that pressure increases, determines the effect on the methanol concentration (increase) and provides a thorough explanation using LCP with reference to the gas mole ratio (reactants **:** products = 3:1).	3
• TWO of – identifies that pressure increases; identifies shift is to the side with less moles of gas; determines shift is to the right; determines that [CH_3OH] increases.	2
• One piece of relevant information provided.	1

Sample response:

Decreasing the volume of the system increases the pressure. According to Le Chatelier's principle the system will shift right towards the products to counteract the change and reduce the pressure. The shift is towards the products as this is the side of the reaction with less moles of gas – 1 mole compared to 3 moles on the reactant side. The shift right increases the [CH_3OH].

Alternate
Decreasing the volume of the system increases the concentration of all substances, including HI, and increases the pressure. According to Le Chatelier's principle the system will shift towards the side of the reaction with the least gaseous moles to counteract the change and decrease the pressure. As there are 2 moles of gas on both sides of the reaction there is no shift and the system remains at equilibrium.

Marker feedback:
A good understanding of equilibrium and LCP was shown.
Mark(s) were mostly lost for a lack of detail:
- volume decrease not linked to effect on pressure
- values for gas mole ratio not included
- effect on methanol concentration not included

Be clear when writing a ratio what the numbers relate to eg. mole ratio of gases 3:1 (reactants **:** products).
Teaching points
- be clear that gases are what's important eg. mole ratio of GASES; shift to side with the least moles OF GAS
- note that when volume decreases it is the increase in concentration of all the substances that causes the pressure to increase, not the pressure increase causing the concentrations to increase *(not needed in the answer but some wrote it and showed a misconception)*

Question 31d (3 marks) – RT

Marking guidelines

Criteria	Marks

• Uses collision theory to provide an extensive account for the shape of the rate-time graph of the forward reaction from t=20s until equilibrium is reached:
  ○ initial increase
  ○ decrease, including why a decrease occurs as opposed to an increase
  ○ plateau
• Clearly links rate, frequency of collisions and substance concentrations.
	3

• Uses collision theory to provide a thorough account for the shape of part of the rate-time graph. OR • Accounts for the shape of the rate-time graph from t=20s until equilibrium is reached with required detail missing. Some use of collision theory required.	2
• One piece of relevant information provided.	1

Sample response:

Adding H_2 increases the $[H_2]$ which increases the frequency/number of collisions between reactant particles and therefore the frequency/number of successful collisions and immediately increases the rate of the forward reaction as shown by the **sharp increase in the graph** at t=20s.

The equilibrium then shifts right as rate forward reaction > rate reverse reaction. Therefore, after t=20s the $[H_2]$ and [CO] decrease causing less collisions, less successful collisions and the rate of the forward reaction to decrease as shown by the **decreasing curve**.

This continues until equilibrium is reached when the rate forward reaction becomes constant *(frequency of successful collisions between reactant particles become constant)*, and the **curve becomes horizontal**.

Alternate
Same answer as above.

Marker feedback:
Not many responses achieved full marks, the main reason was not accounting for why the forward rate decreased (as opposed to increased) after t=20s.
Good detail using collision theory was generally given for the sharp increase, but this needed to be kept up for the rest of the curve. Teaching point = when equilibrium was re-established include why in terms of concentrations/collisions remaining constant (this was not penalised for).
Overall a good understanding of collision theory and rate of reaction was shown.
Teaching point:

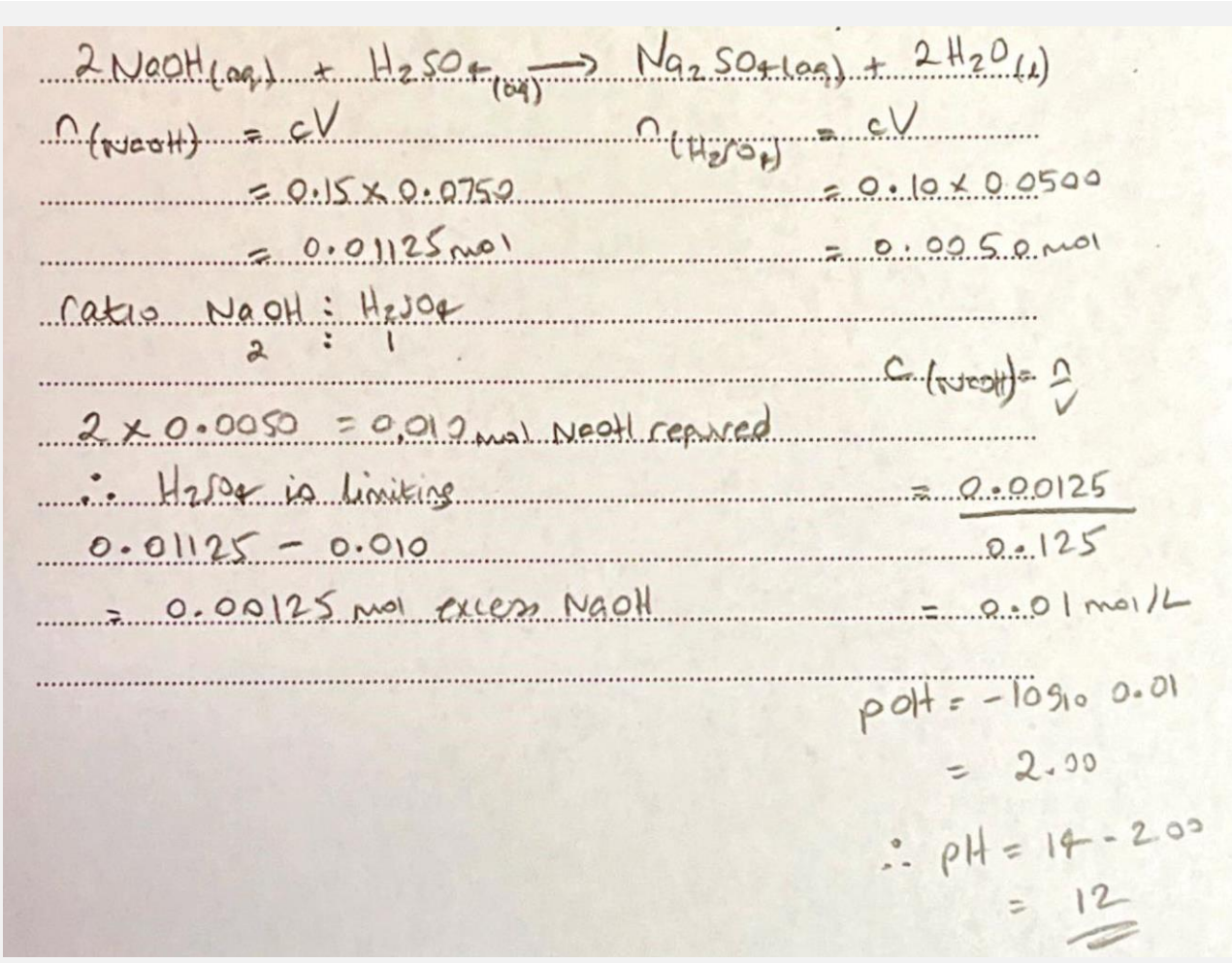
- no need to include explanation for the reverse reaction curve – Q only asked for the forward reaction curve, don't waste time/writing space here.

Question 32 (4 marks) Marker: ER

Marking guidelines

Criteria	Marks
• Correct calculation with correct solution	4
• One mistake	3
• Two correct steps	2
• One relevant calculation step	1

Sample response:



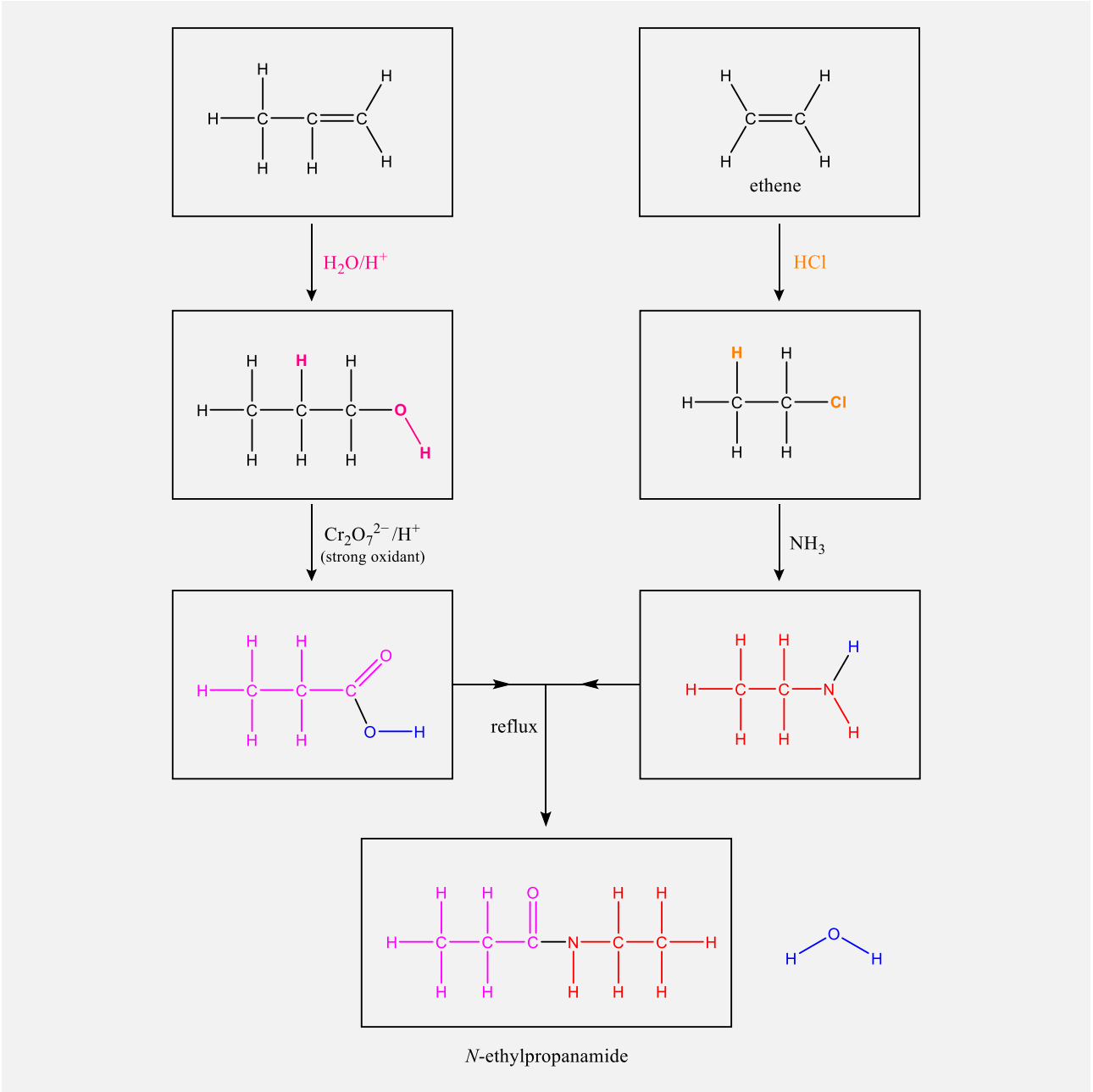
Marker feedback:
This was found to be a challenging question by many but most attempted it well. It is crucial to have a balanced equation because it is from the equation that the ratio of acid:base can be determined to then have the ratio. Better responses showed logical structure to their responses and showed all working. A mark was deducted for numbers simply appearing. All values need to be explicitly accounted for.

Question 33 (5 marks) - LT

Marking guidelines

Criteria	Marks
• Provides a correct structural diagram for *N*-ethylpropanamide. • Provides a correct structural diagram for Compound A. • Provides a correct structural diagram for Compound B. • Provides a correct structural diagram for Compound C. • Provides a correct structural diagram for Compound D.	5
• ANY ONE to FOUR of the above.	1 - 4

Sample response:



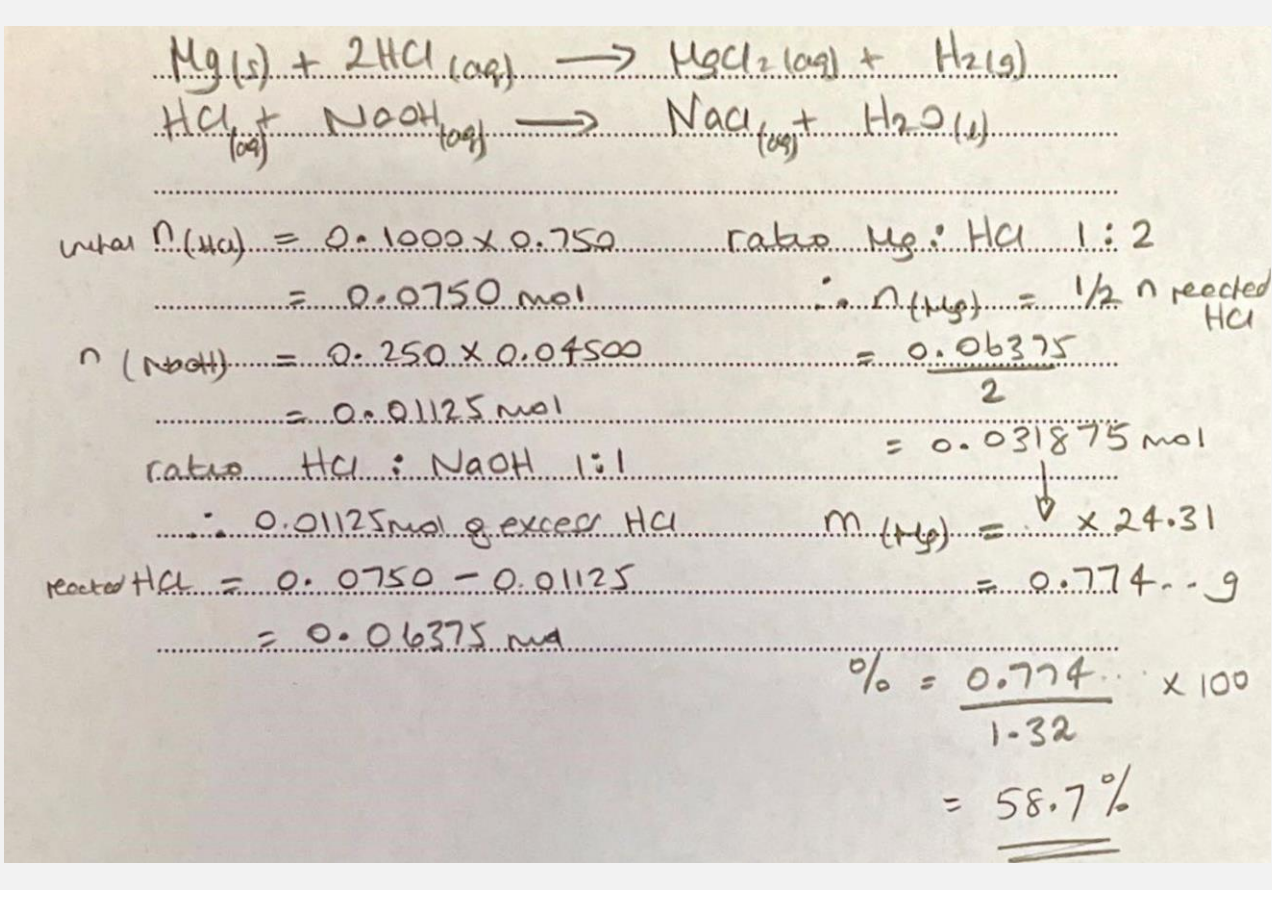
Marker feedback:

Question 34 (4 marks) Marker: ER

Marking guidelines

Criteria	Marks
• Correct calculation to determine %. • All steps shown with two correct balanced equations. • Ratios used in the calculation process. • Correct sig figs (3).	4
• One minor error or omission	3
• 2 correct steps (equation + calculation OR 2 calculation)	2
• 1 correct step (equation or calculation)	1

Sample response:

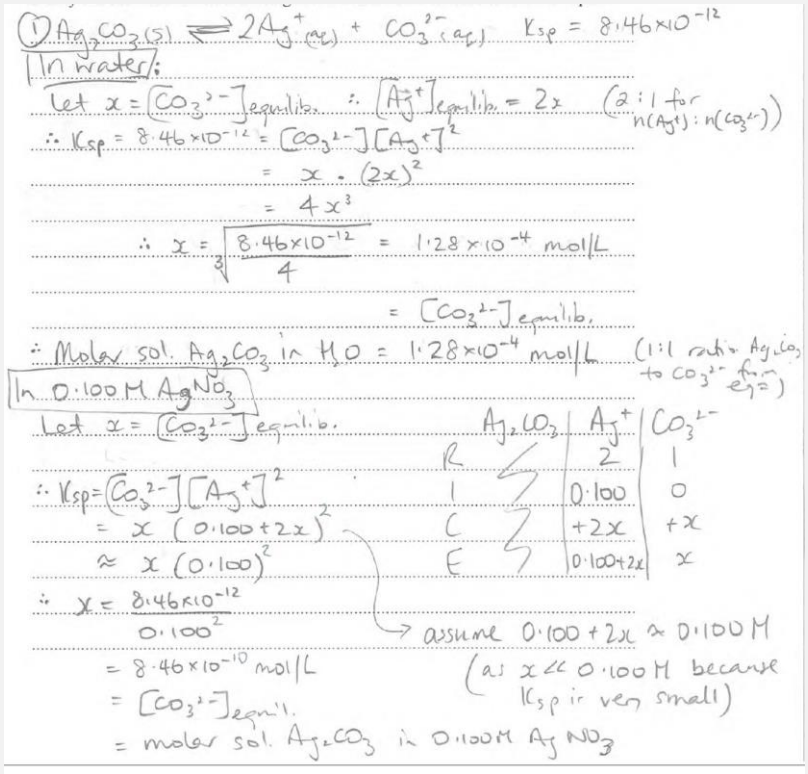


Marker feedback:
Generally done well, although concerning how many equations had acid reacting with Mg to produce hydrogen ions. Both equations were to be correct and the use of the ratios. State symbols not marked but they should be included as they could be marked for. Better responses laid out the working very clearly with the ratios explicitly referenced.

Question 35 (5 marks) – RT
Marking guidelines

Criteria	Marks
• Extensive justification provided using both calculations and LCP: o clear understanding of molar solubility and common ion effect shown o calculation of molar solubility in water with clear, detailed working shown o common ion calculation of molar solubility with clear, detailed working shown o comparison of molar solubilities and conclusion that the statement is correct o LCP used to confirm statement is correct based on direction of shift and linked to molar solubility o clear, logical progression shown in response	5
• Thorough justification provided including: o clear understanding of molar solubility and the common ion effect shown o both calculations mostly correct including working o LCP explanation containing most required detail o clear, logical progression shown in response	4
• Sound justification provided including: o some understanding of molar solubility and the common ion effect shown o one mostly correct calculation OR both calculations attempted o LCP explanation containing most required detail	3
• Some relevant information provided, no calculations required.	2
• One piece of relevant information provided.	1

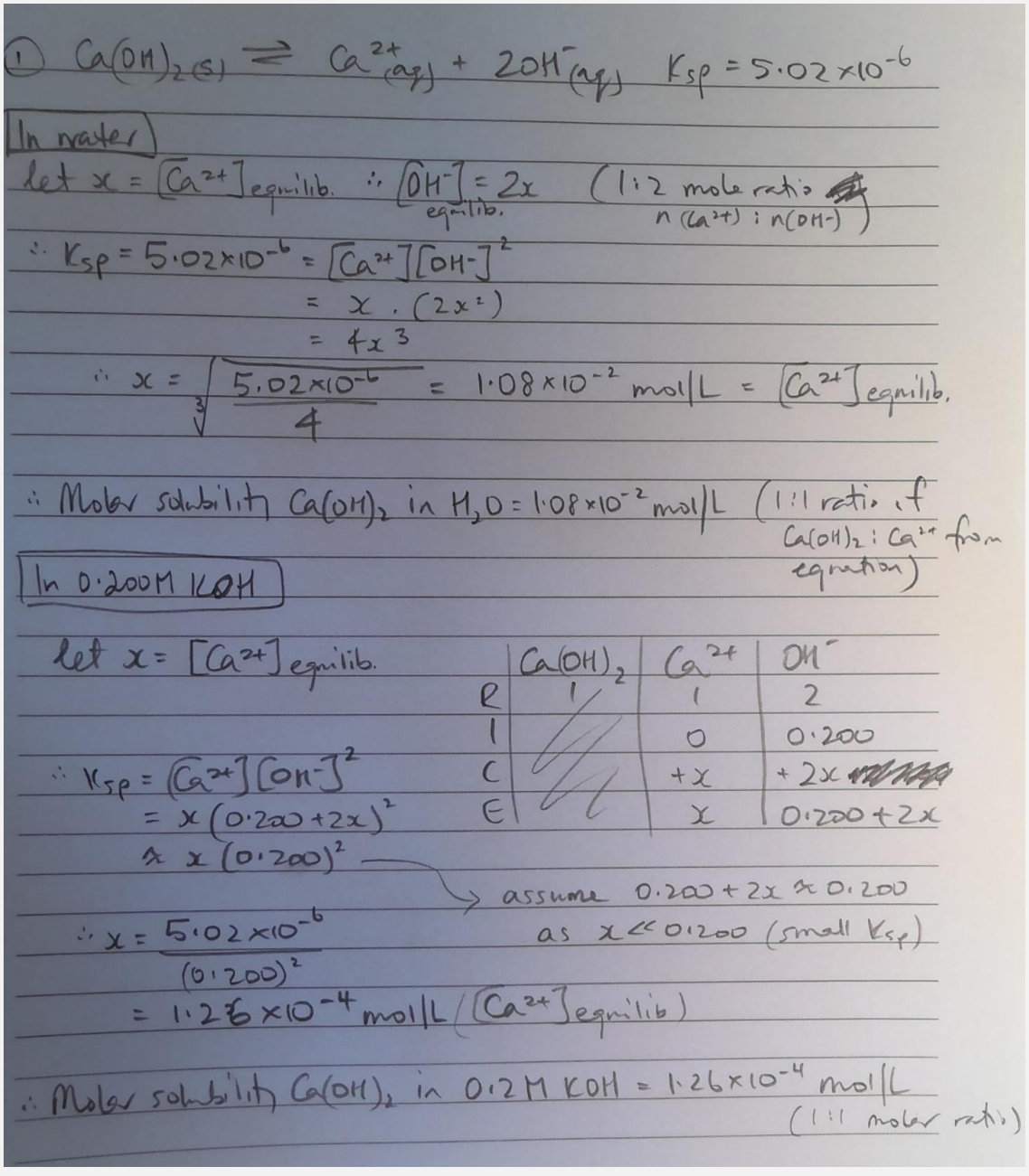
Sample response:



Calculations confirm the statement is correct as the molar solubility in 0.100M $AgNO_3$ is lower (8.46 x 10^{-10} M) than the molar solubility in water (1.28 x 10^{-4} M).

Le Chatelier's principle also confirms the statement is correct as it predicts that with a higher $[Ag^+]$ the equilibrium above will shift left to lower the $[Ag^+]$, causing more precipitate to form and a hence lower molar solubility in the $AgNO_3$ solution as compared to in water.

Alternate



Calculations confirm the statement is correct as the molar solubility in 0.200M KOH is lower (1.26 x 10^{-4} M) than the molar solubility in water (1.08 x 10^{-2} M).

Le Chatelier's principle also confirms the statement is correct as it predicts that with a higher $[OH^-]$ the equilibrium above will shift left to lower the $[OH^-]$, causing more precipitate to form and a hence lower molar solubility in the KOH solution as compared to in water.

Marker feedback:

Challenging question in terms of it not being broken down into parts to make which calculations to do more obvious.

Showing detailed working was an issue in this question especially:

- use of molar ratios
- detailing what 'x' is and that it is the concentration at equilibrium (as opposed to initially)
- linking 'x' to molar solubility using molar ratio
- assumption that $0.100-2x = 0.100$ (reasoning is needed)
- RICE table(s)

Taking care with working was also an issue in this question:

- $x = [CO_3^{2-}]$ not $[Ag^+]$, what you let 'x' be needs to match up to working in RICE table
- losing squared from $[Ag^+]^2$ in Ksp expression when putting in values

Remember to include states in the equilibrium equation.

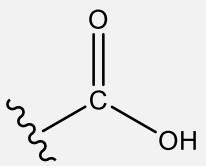
Misconception that molar solubility = Ksp.

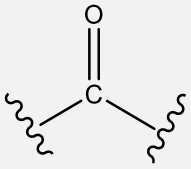
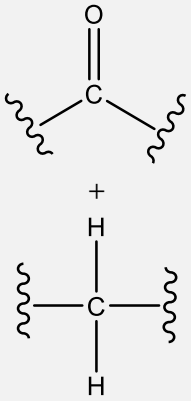
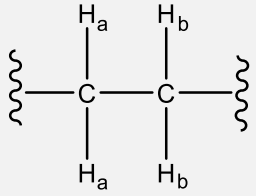
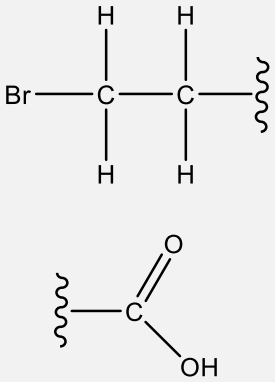
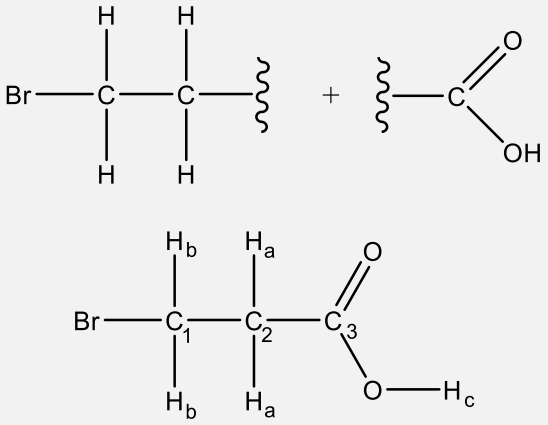
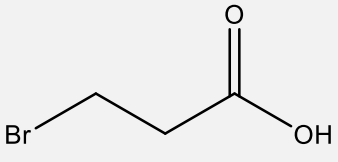
Question 36 (7 marks) - LT

Marking guidelines

Criteria	Marks
• Provides a correct structural formula (full traditional representation, skeletal or condensed structure) of 3-bromopropanoic acid. • Provides the correct IUPAC name of the molecule. • Justifies the correct structure showing an extensive understanding of the interpretation of all necessary spectral features, including (but not limited to): o the two molecular ion peaks (M+) that arise because of the two isotopes of bromine OR uses the m/z of M^+ to show evidence of one Br atom within the molecule by deducing molecular weight of compound. o the absorption at $\tilde{\nu}$ 3400 – 2400 cm^{-1} indicating the presence of the O-H stretch of the carboxylic acid functional group. o Identifies the presence of THREE distinct carbon environments within the molecule. o Uses the chemical shift of δ172 ppm as evidence of the presence of a C=O carbon environment. o Identifies the presence of TWO triplets giving evidence of the two shaded H environments being adjacent methylene groups and a terminal Br • Refers explicitly to the relevant spectral data.	7
• Provides a correct structural formula for an isomer of 3-bromopropanoic acid. OR Provides the correct structure of 3-bromopropanioic acid but incorrectly names it as 1-bromopropanoic acid. • Justifies the correct structure showing a thorough understanding of the interpretation of all necessary spectral features. • Refers to relevant spectral data.	6
• Shows a sound understanding of the interpretation of spectroscopic data. • Uses relevant information presented in the question to justify the structure of the chemical. • Provides a structural formula consistent with analysis.	4 - 5
• Shows some understanding of the interpretation of spectroscopic data.	2 - 3
• Provides some relevant information.	1

Sample response:

Spectra	*Feature*	*Conclusion*
IR	Broad absorption at $\tilde{\nu}$ 3400 – 2400 cm^{-1} indicating the presence of the O-H stretch of the carboxylic acid functional group	

	Strong absorption evident at $\tilde{\nu}$ 1696 cm^{-1} indicating C=O stretch, consistent with determination of carboxylic acid functional group	
^{13}CNMR	3 carbon environments: - 1×C_3 δ 172 ppm consistent with C=O present - 1×C_2 δ 45 ppm chemical shift indicative of possible -CH_2 - 1×C_1 δ 35 ppm chemical shift indicative of possible -CH_2	
^{1}HNMR	5 H total in 3 distinct chemical environments: - 2 H_a at δ 3.0 ppm triplet = next to -CH_2- - 2 H_b at δ 3.6 ppm triplet = next to -CH_2- = two adjacent methylene groups - 1 H_c at δ 11.8 ppm singlet = carboxylic acid proton	
MS	2 × M^+ ions confirms the presence of ONE bromine atom: - $M^{+\bullet}$ at *m/z* 152 = evidence of ^{79}Br - $M^{+\bullet}$ at *m/z* 154 = evidence of ^{81}Br - *m/z* 109 = $[CH_2CH_2{}^{81}Br]^+$ - *m/z* 107 = $[CH_2CH_2{}^{79}Br]^+$ - *m/z* 73 = $[CH_2CH_2COOH]^+$ - *m/z* 45 = $[COOH]^+$	
Putting it all together		 3-bromopropanoic acid

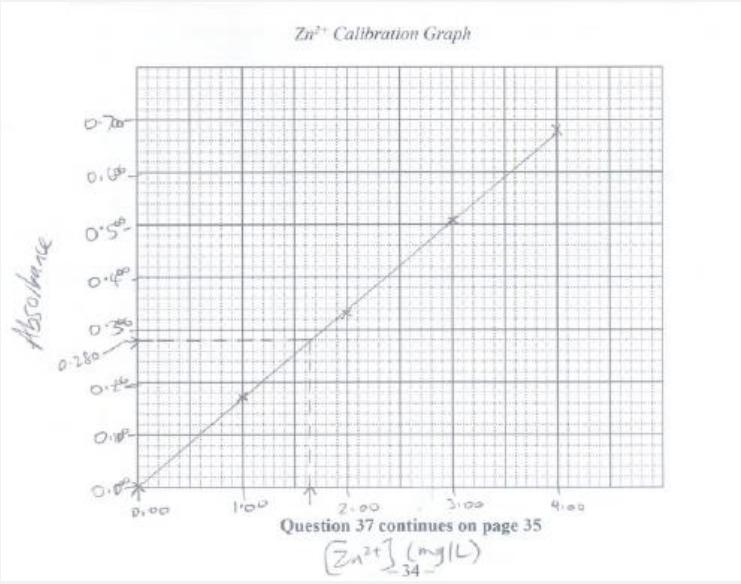
Marker feedback:

Question 37 (8 marks) LD Zinc

Marking guidelines

Criteria	Marks
• Draws correct calibration graph. • Provides interpolation from calibration graph to correctly calculate the mass of zinc in tablet using AAS. • Provides a relevant balanced chemical equation • Recognises that AAS is valid and gravimetric analysis is not valid because the addition of sodium hydroxide precipitates additional cations, giving examples • Provides extensive evaluation of both methods.	7-8
• Draws substantially correct calibration graph AND • Provides interpolation from calibration graph to correctly calculate the mass of zinc in tablet using AAS AND/OR • Provides a relevant balanced chemical equation AND/OR • Provides a thorough evalulation of both AAS and gravimetric analysis	5-6
• Draws substantially correct calibration graph AND • Interpolation OR • Draws substantially correct calibration graph AND makes a link to validity of one method	3-4
• Provides some relevant information	1-2

Sample response:



Graph:

Question 37 continues on page 35

AAS: Using absorbance from graph $[Zn^{2+}]$ = 1.65 mg/L
Therefore in 100 mL $[Zn^{2+}]$ = 0.165 mg (This was enough for the relevant calculation)

OR Zn as ZnO can be calculated as:
$n(Zn^{2+}) = \frac{0.165 \times 10^{-3}}{65.38}$ = 2.52 x 10^{-6} mol
$n(ZnO)$ = 2.52 x 10^{-6} mol
$n(ZnO)$ = 2.52 x 10^{-6} mol x MM(ZnO)
$n(ZnO)$ = 0. 205 mg
(Both 0.165 mg and 0.205 mg are close to the stated value in the table which was 0.21 mg)

Relevant equation for gravimetric analysis is:
$Zn^{2+}(aq) + 2OH^{-}(aq) \rightarrow Zn(OH)_2(s)$

Since the addition of NaOH will also react with cations in the tablet such as Cu^{2+}(aq), Fe^{3+}(aq), Cr^{2+}, Ca^{2+} forming precipitates such as $Cu(OH)_2$(s) and $Fe(OH)_3$(s), gravimetric analysis is NOT a valid method to determine the mass of Zn in the tablet. The precipitate formed in gravimetric analysis cannot be assumed to be just $Zn(OH)_2$(s) because it contains other precipitates and hence it is much higher than expected. Gravimetric analysis is not valid in this case because it is not measuring what was in intended.

(As part of this explanation, a calculation may be done for the [Zn] using gravimetric analysis, but it was not necessary:
$Zn^{2+}(aq) + 2OH^{-}(aq) \rightarrow Zn(OH)_2(s)$
$n(Zn(OH)_2) = 0.0920/99.396 = 9.26 \times 10^{-5}$ mol = n(ZnO) in the tablet
$m(ZnO) = n \times MM = 9.26 \times 10^{-5} \times 81.38$
$m(ZnO) = 7.53$ mg)

AAS is a valid method because it uses a specific Zn lamp and emits a specific wavelength which only Zn^{2+} absorbs and therefore only measures the concentration of Zn^{2+} ions, and no other cations from the tablet.

Marker feedback:
This was attempted fairly well. The graph was well done by most. The biggest error/omission was recognising that the gravimetric analysis method was not valid because of the additional precipitation of other cations. If this was not recognised, the maximum they could score was 6 marks.