



2022

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

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Centre Number

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Student Number

Chemistry

Afternoon Session
Friday, 5 August 2022

**General
Instructions**

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- NESA-approved calculators may be used
- Use the Multiple-Choice Answer Sheet provided
- Draw diagrams using pencil
- A formulae sheet, data sheet and Periodic Table are provided
SEPARATELY
- Write your Centre Number and Student Number at the top of this page

**Total marks:
100**

Section I – 20 marks (pages 2 – 9)

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

Section II – 80 marks (pages 10 – 29)

- Attempt Questions 21 – 35
- Allow about 2 hours and 25 minutes for this section

Disclaimer

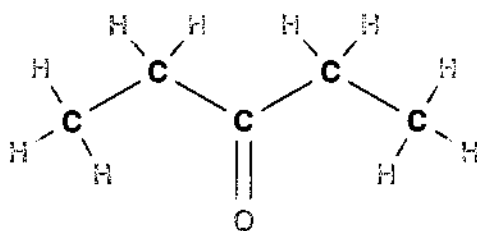
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Section I
20 marks

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

Use the Multiple-Choice Answer Sheet for Questions 1 – 20.

- 1 What is the preferred name for the following molecule?



- A. pentanal
B. pentanone
C. pentan-3-al
D. pentan-3-one
- 2 A student performed the following steps.
1. A piece of graphite was burnt in excess oxygen.
 2. The gas produced was collected and bubbled through limewater.
 3. The precipitate was filtered and dried.
 4. The precipitate was treated with phosphoric acid.
 5. The volume of gas produced was measured.

Which equation best represents one of the steps in the experiment?

- A. $\text{CO}_2(\text{g}) + \text{Ca}(\text{OH})_2(\text{aq}) \rightleftharpoons \text{CaCO}_3(\text{s}) + \text{H}_2\text{O}(\text{l})$
B. $2\text{CaCO}_3(\text{aq}) + 2\text{H}_3\text{PO}_4(\text{aq}) \rightleftharpoons \text{Ca}_2(\text{PO}_4)_2(\text{aq}) + 3\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$
C. $3\text{CaCO}_3(\text{aq}) + 2\text{H}_3\text{PO}_4(\text{aq}) \rightleftharpoons 2\text{Ca}(\text{PO}_4)_2(\text{s}) + 3\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$
D. $3\text{CaCO}_3(\text{aq}) + 2\text{H}_3\text{PO}_4(\text{aq}) \rightleftharpoons \text{Ca}_2(\text{PO}_4)_2(\text{aq}) + 3\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$

- 3 Chlorine gas is bubbled through hept-2-ene and a reaction occurs. What is the main product of this reaction?
- A. 1-chloroheptane
 - B. 2-chloroheptane
 - C. 1,2-dichloroheptane
 - D. 2,3-dichloroheptane

- 4 Using your data table, which of the following options shows the correct order of increasing solubility of Pb^{2+} ions in the following salt solutions?

A.	PbCl_2	PbBr_2	PbCO_3	$\text{Pb}_3(\text{PO}_4)_2$
B.	$\text{Pb}_3(\text{PO}_4)_2$	PbCO_3	PbBr_2	PbCl_2
C.	PbCO_3	$\text{Pb}_3(\text{PO}_4)_2$	PbCl_2	PbBr_2
D.	PbBr_2	PbCl_2	$\text{Pb}_3(\text{PO}_4)_2$	PbCO_3

- 5 Which statement is NOT true for a mixture of ice and water at equilibrium at a constant temperature?
- A. There are equal amounts of ice and water
 - B. The rates at which melting and freezing occur are equal
 - C. The system at equilibrium shows no macroscopic change
 - D. When the water is cooled, and the ice is heated, the same position of equilibrium can be achieved
- 6 Which of the following is amphiprotic?
- A. NH_4^+
 - B. HSO_3^{2-}
 - C. HPO_4^{2-}
 - D. H_3PO_4

- 7 Which of the following occurs when grease is mixed with soapy water?
- A. The hydrophilic tail of the soap bonds to the grease.
 - B. The hydrophobic head of the soap bonds to the grease.
 - C. The hydrophobic ends of the soap and the grease bond.
 - D. The head of the hydrophilic soap bonds to the hydrophilic grease.
- 8 The compound HCFC-123 has the molecular formula $C_2F_3Cl_2H$. It is an alternative to CFC-11 in low pressure refrigeration, as it is better for the ozone layer.
- How many isomers have the formula $C_2F_3Cl_2H$?
- A. 1
 - B. 2
 - C. 3
 - D. 4

Question 9 and Question 10 refer to the following information.

- 9 Butyl acetate can be synthesised and purified in the school laboratory. The initial step is usually to reflux the reactants.

Which of the following is NOT a suitable safety precaution for this initial step?

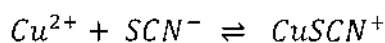
- A. Students should wear safety glasses and lab coats, to protect from any spills.
- B. The concentrated sulfuric acid should be handled with gloves, as it is very corrosive.
- C. A thermometer should be inserted in the top of the condenser, to monitor the temperature.
- D. Naked flames should be avoided near the reactants, as organic chemicals may be combustible.

10 The yield from the reaction is only 35%.

What is the maximum yield of the ester if 10.5 g of acetic acid is reacted with 9.5 g of 1-butanol?

- A. 5.2 g
- B. 7.0 g
- C. 7.1 g
- D. 20.0 g

11 Which K_{eq} expression is correct for the following reaction?



A.
$$\frac{[Cu^{2+}][SCN^{-}]}{[CuSCN^{+}]}$$

B.
$$\frac{[Cu]^2 [SCN^{-}]}{[CuSCN^{+}]}$$

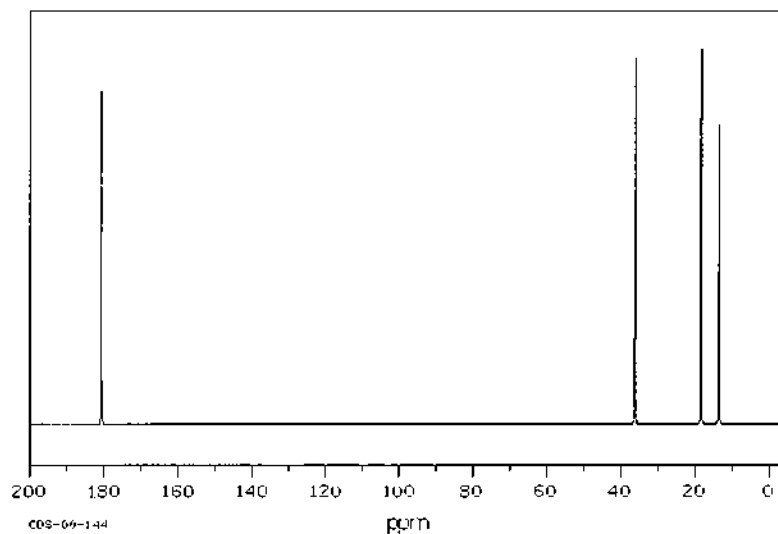
C.
$$\frac{[CuSCN^{+}]}{[Cu^{2+}][SCN^{-}]}$$

D.
$$\frac{[CuSCN^{+}]}{[Cu]^2 [SCN^{-}]}$$

12 Which of the following pairs of substances will NOT form an equilibrium?

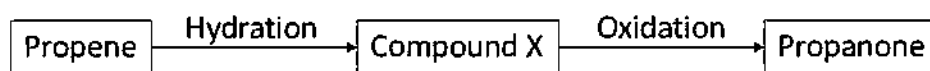
- A. $CH_3CH_2NH_2(aq) / CH_3CH_2NH_3^{+}(aq)$
- B. $NaH(aq) / H_2(g)$
- C. $SO_4^{2-}(aq) / H_2SO_4(aq)$
- D. $NH_3(aq) / NH_4^{+}(aq)$

13 The carbon-13 NMR spectrum of an organic molecule is shown below.



Which molecule could produce this spectrum?

- A. Butane
 - B. Butanoic acid
 - C. Methyl butanoate
 - D. Propanoic acid
- 14 The flow chart below shows that propene undergoes a hydration reaction to form compound X. Compound X is then oxidised to form propanone.



Which of the following correctly identifies compound X?

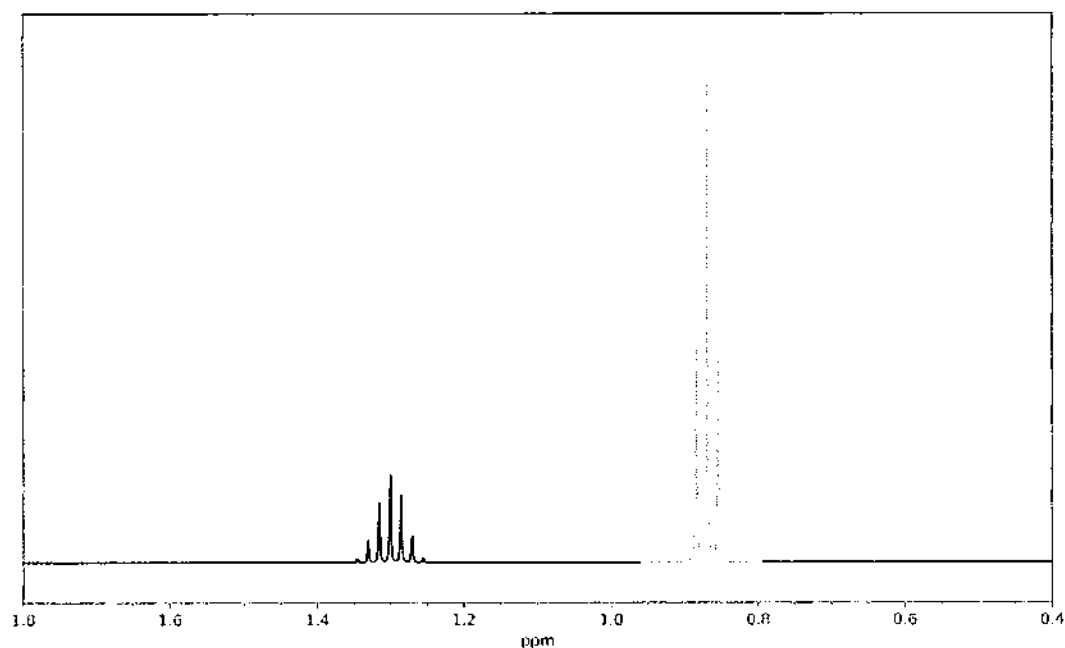
- A. Propan-1-ol
- B. Propan-2-ol
- C. 2-methylpropan-1-ol
- D. 2-methylpropan-2-ol

- 15 20.0 mL of 0.10 mol L⁻¹ sodium hydroxide was added to 10.0 mL of 0.20 mol L⁻¹ sulfuric acid and 10.0 mL of distilled water. Determine the temperature increase of the solution.

($\Delta H_{\text{neutralisation}} = -57 \text{ kJ mol}^{-1}$)

- A. 0.51°C
- B. 0.68°C
- C. 1.14°C
- D. 1.37°C

- 16 The proton NMR spectrum of propane is shown below.



What does the shaded part of the spectrum show?

- A. A triplet splitting pattern, indicating the presence of two hydrogens on the neighbouring carbons
- B. A quartet splitting pattern, indicating the presence of three hydrogens on the neighbouring carbons
- C. A quartet splitting pattern, indicating the presence of two hydrogens on the neighbouring carbons
- D. A triplet splitting pattern, indicating the presence of four hydrogens on the neighbouring carbons

17 What is the minimum amount of solid barium nitrate (M_r 271.3 g mol⁻¹) that needs to be added to 50.0 mL of sodium hydroxide (0.0500 mol L⁻¹) to cause precipitation?

A. 0.339 g.

B. 0.678 g.

C. 1.38 g.

D. 2.77 g.

18 Question 18 and 19 refer to the following information.

Propanoic acid (C₂H₅COOH) has pK_a of 4.87.

What is the pH of 0.010 mol L⁻¹ propanoic acid solution at 25°C?

A. 2.00

B. 3.44

C. 4.87

D. 5.87

19 What is the percent dissociation for this solution of propanoic acid?

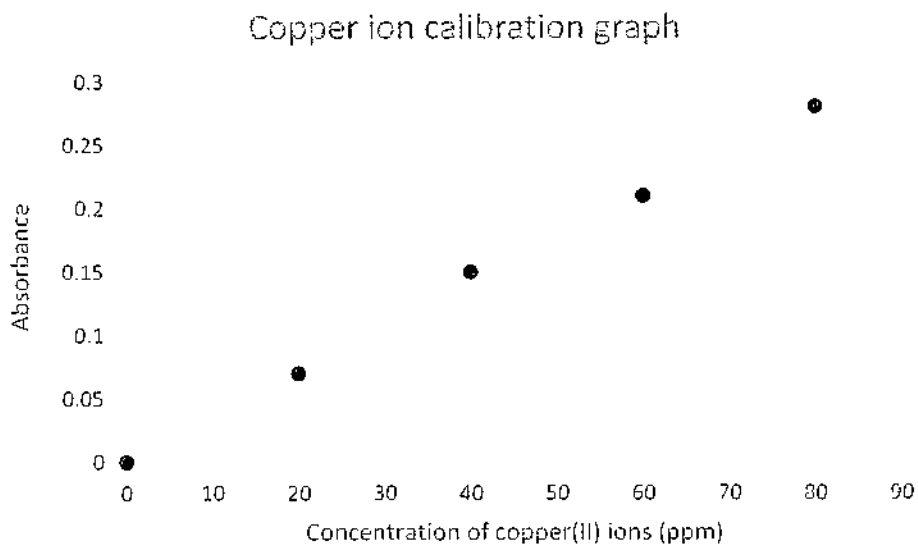
A. 0.01

B. 0.13

C. 0.36

D. 3.67

- 20 A student was analysing two solutions of copper(II) chloride with unknown concentration. The student's calibration curve for this analysis is shown below.



The student measured the absorbances of the two solutions of unknown concentration.

Absorbance of Solution 1	0.25
Absorbance of Solution 2	0.15

What was the chloride ion concentration in Solution 2 (in mol L⁻¹)?

- A. 2.98×10^{-4}
- B. 4.00×10^{-4}
- C. 6.29×10^{-4}
- D. 1.26×10^{-3}

Section II
80 marks

Attempt Questions 21 – 35
Allow about 2 hours and 25 minutes for this section

-
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
 - Show all relevant working in questions involving calculations.
 - Extra writing space is provided on page 30 – 31. If you use this space, clearly indicate which question you are answering.
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Question 21 (4 marks)

Determine if a precipitate forms when 150 mL of 0.10 M $\text{Pb}(\text{NO}_3)_2$ is combined with 100 mL of 0.20 M NaCl. **4**

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Question 22 (5 marks)

- (a) Outline two advantages of using biofuel compared to fossil fuels. **2**

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- (b) Ethanol's use as a biofuel is becoming increasingly common. **3**

The table below shows various properties of ethanol.

Properties of Ethanol	
Heat of Combustion (kJ mol^{-1})	1370
Density (g mL^{-1})	0.78
Average molar mass (g mol^{-1})	46

A vehicle has a 60 L fuel tank.

Calculate the energy released by the complete combustion of one full tank of ethanol.

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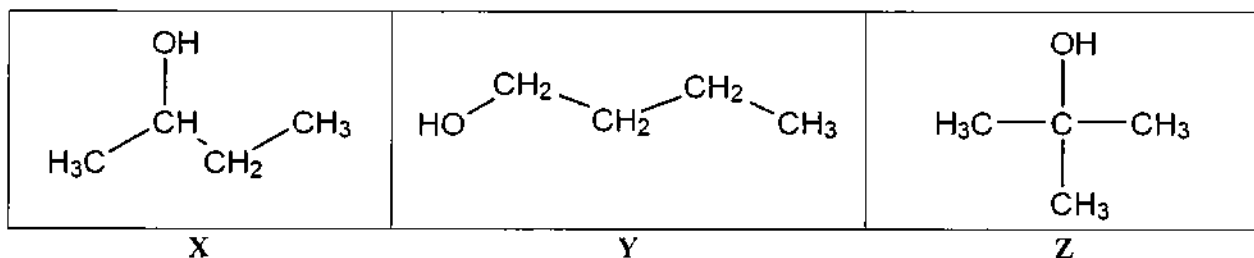
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Question 23 (9 marks)

Below are three different compounds.



- (a) Name **Compound Y**. **1**

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- (b) Define the term "*homologous series*" using one or more of the compounds as an example. **2**

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- (c) Define the term "*position isomers*" using one or more of the compounds as an example. **2**

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- (d) Each of the compounds is mixed with acidified potassium permanganate. Outline any reactions that may occur and identify any products that may form. **4**

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Question 24 (4 marks)

Describe how to prepare 250.0 mL of a 0.150 mol L⁻¹ sodium borate octahydrate solution, (Na₂[B₄O₅(OH)₄].8H₂O), and also how hydrochloric acid can be used to verify its concentration. **4**

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Question 25 (4 marks)

A pharmaceutical company states that consuming two of their tablets provides 50% of the daily intake of calcium. The average daily intake of calcium is 1450 mg. The tablets contain soluble calcium in the form of calcium citrate ($\text{Ca}_3(\text{C}_6\text{H}_5\text{O}_7)_2$). Citric acid is a weak triprotic acid.

4

One tablet was crushed, dissolved into 25.0 mL of distilled water and made up to 100.0 mL. A 10.0 mL sample required 37.0 mL of $0.160 \text{ mol L}^{-1} \text{ H}_3\text{PO}_4$ to precipitate the calcium.

Evaluate the company's claim.

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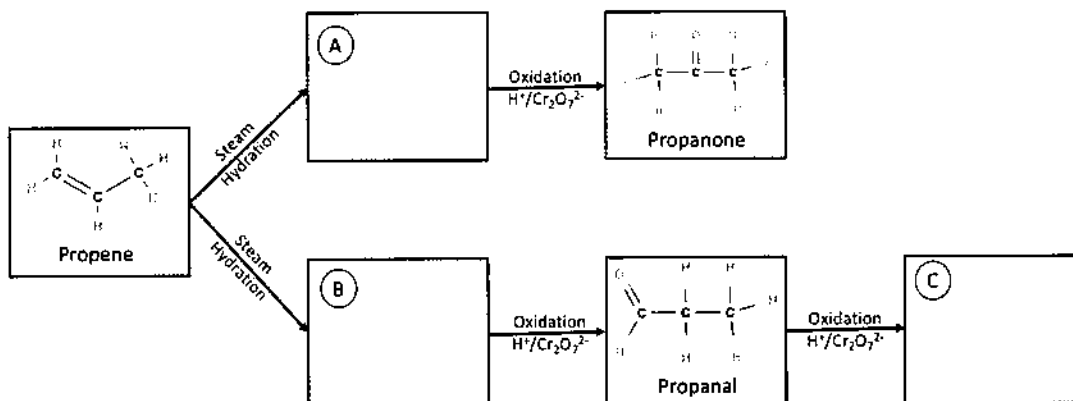
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Question 26 (5 marks)

- (a) Propene, in the presence of a strong acid catalyst and high temperatures, undergoes a hydration reaction with steam. 3



Complete the reaction pathway diagram above by providing structural formulae and naming compounds A, B and C.

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- (b) Butanoic acid was placed in a reflux apparatus with compound B and concentrated sulfuric acid. The mixture was heated until a sweet fruity odour was observed. 2

Write a balanced chemical equation for the reaction and name the products formed.

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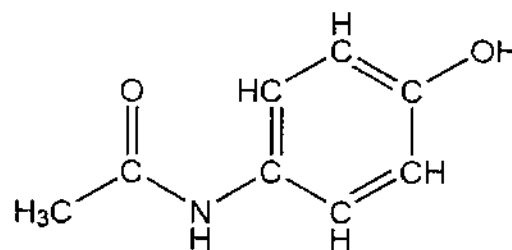
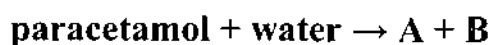
Question 27 (8 marks)

Paracetamol is a compound that is commonly used in pain relief.

It has the chemical structure shown on the right.

If paracetamol is hydrolysed in the presence of an acid, it forms two compounds, **A** and **B**.

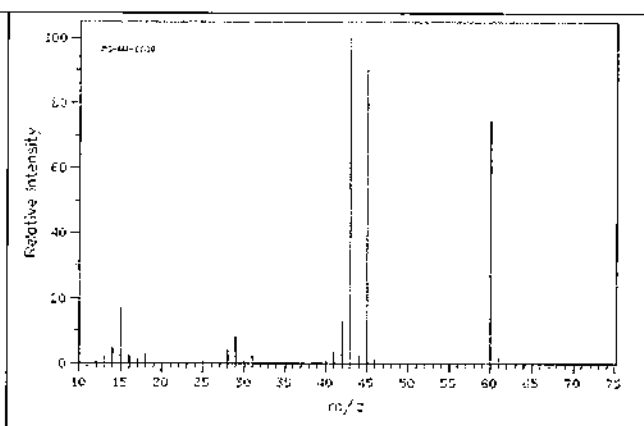
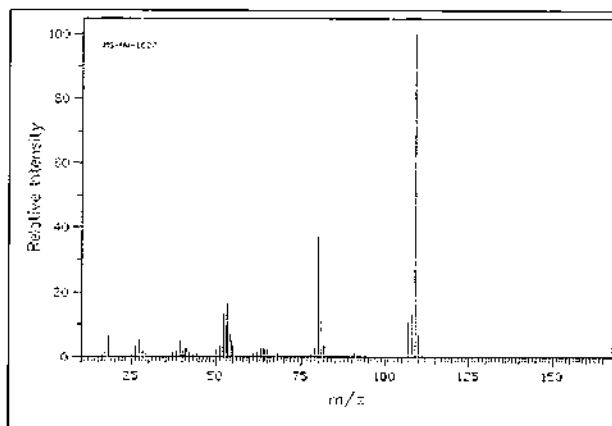
The unbalanced reaction can be represented by:



The following data was collected for both products.

A	B
66.0% carbon	39.9% carbon
6.5% hydrogen	6.7% hydrogen
12.8% nitrogen	53.4% oxygen
14.7% oxygen	

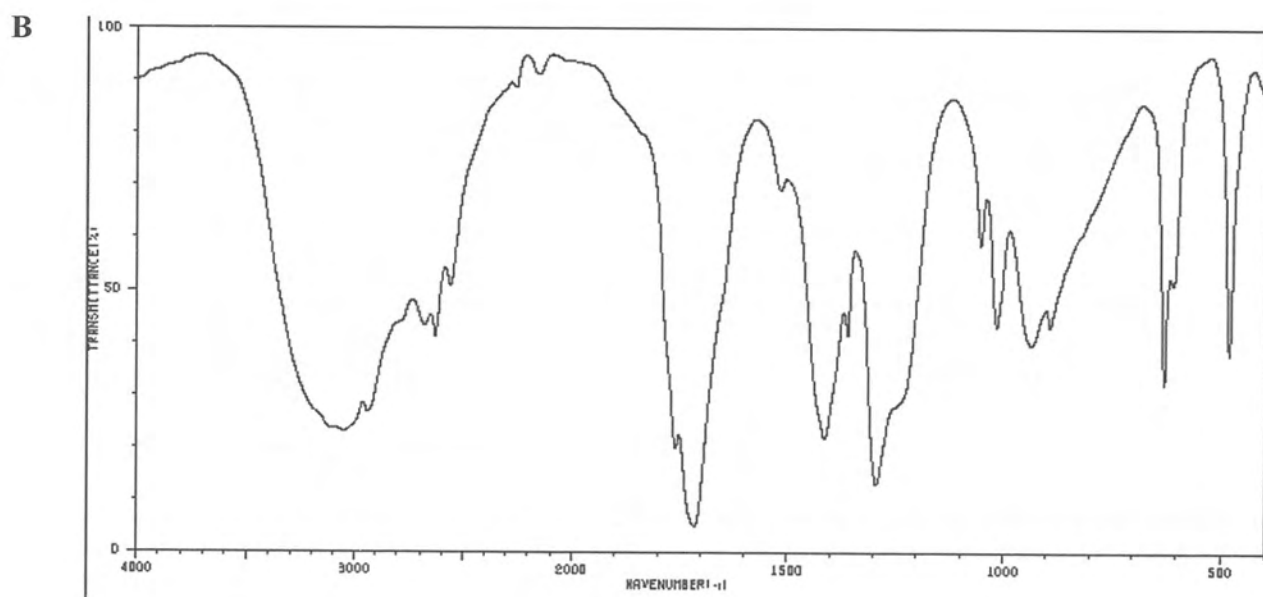
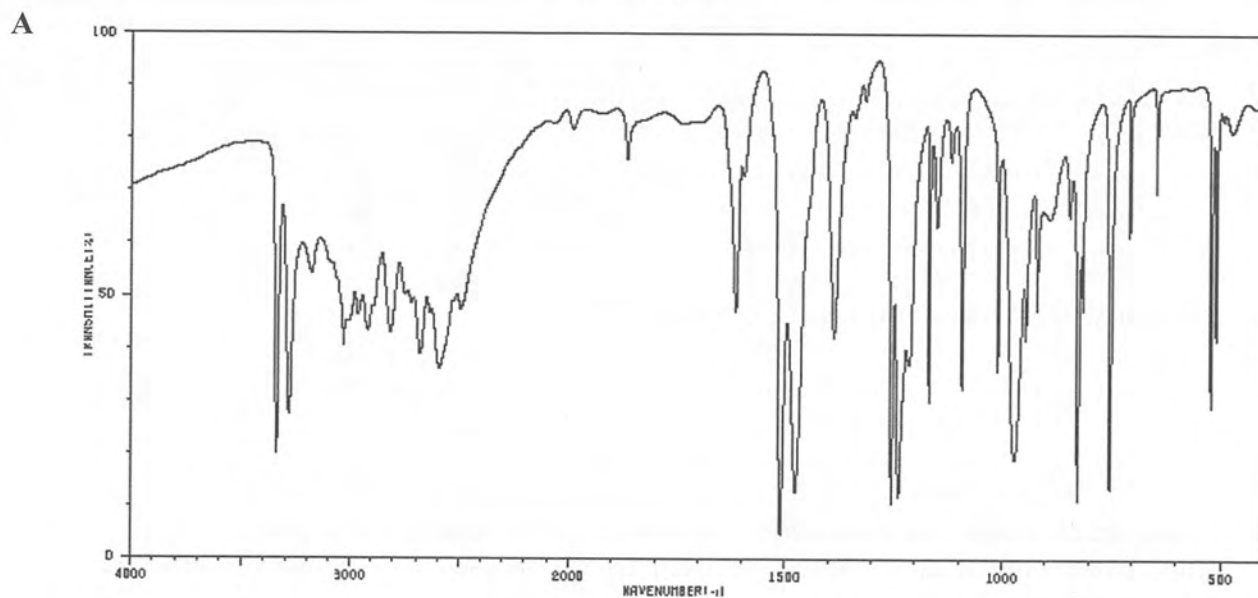
Elemental analyses



Question 27 continues on page 17

Question 27 (continued)

Infrared spectra



Question 27 continues on the page 18

Question 34 (6 marks)

Compare and account for any differences in the molar solubility of lead (II) iodide in
(i) water, (ii) 0.1 M lead (II) nitrate and (iii) 0.1 M magnesium iodide.

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Question 35 (3 marks)

Consider a solution of propanoic acid, pK_a 4.88, in water at 25°C.

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Describe, using a suitable equation, what happens to the K_a and degree of ionisation if the solution evaporates to half its volume at 25°C.

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End of Examination

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Section II extra writing space

If you use this space, clearly indicate which question you are answering by writing the question number before beginning the response.

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EXAMINERS

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