CSSA

CATHOLIC SECONDARY SCHOOLS
ASSOCIATION OF NSW

Centre Number

Student Number

DO NOT REMOVE PAPER FROM EXAM ROOM

2020

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

Morning Session
Friday, 21 August 2020

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 data sheet and Periodic Table are provided SEPARATELY
- Write your Centre Number and Student Number on the top of this page

Total marks – 100

Section I Pages 2-13

20 marks

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

Section II Pages 14-30

80 marks

- Attempt Questions 21-34
- Allow about 2 hours and 25 minutes for this section

Section I

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

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

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1 What is the effect on the equilibrium position of a reaction when a catalyst is added?

(A) Equilibrium shifts to favour the products

(B) Equilibrium shifts to favour the reactants

(C) The equilibrium position will be unaffected

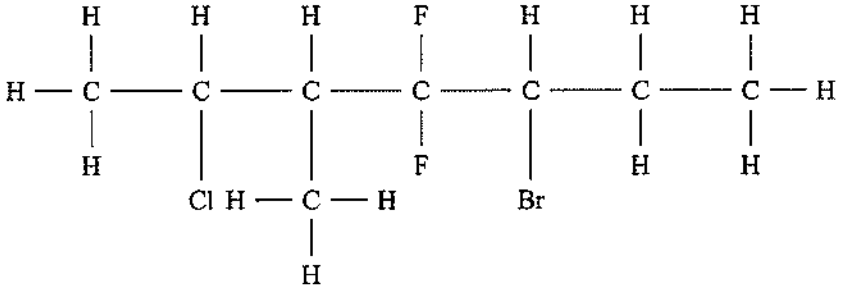
(D) The overall enthalpy is reduced

2 Aboriginal and Torres Strait Islander peoples have long been using the ideas of solubility to detoxify foods such as Cycads.

Which row of the table correctly identifies the purpose of these processes?

	Crushing The Cycad Seeds	**Soaking The Crushed Seeds In Water**
A.	Increases surface area	Leaches out water insoluble toxins
B.	Decreases surface area	Leaches out water insoluble toxins
C.	Decreases surface area	Leaches out water soluble toxins
D.	Increases surface area	Leaches out water soluble toxins

3 Name the following compound.



(A) 3-bromo-6-chloro-4,4-difluoro-5-methylheptane

(B) 2-chloro-3-methyl-4,4-difluoro-5-bromoheptane

(C) 5-bromo-2-chloro-4,4-difluoro-3- methylhexane

(D) 5-bromo-2-chloro-4,4-difluoro-3-methylheptane

4 Acids and bases vary in their ability to dissociate. A weak acid would have the following properties:

(A) A small value K_a and a high value pK_a

(B) A small value K_a and a small value pK_a

(C) A high K_a and a small value pK_a

(D) A high value K_a and a high value pK_a

5 A student was given a white powder. They wet a metal loop and dipped it in the powder, then put it in a Bunsen burner flame. The flame went reddish. Which metal ion could the white powder contain?

(A) Copper

(B) Barium

(C) Calcium

(D) Sodium

6 Which of the following reactions would be classified as an Arrhenius definition for an acid?

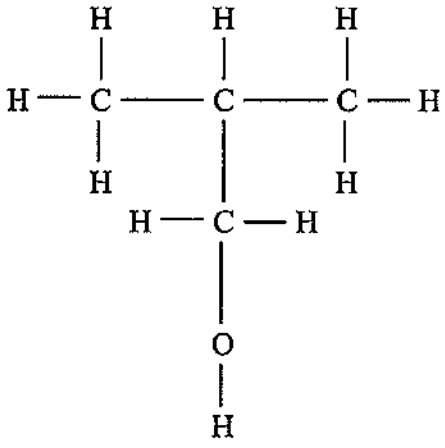
(A) $HNO_3(aq) + NH_3(g) \rightarrow NH_4^+(aq) + Cl^-(aq)$

(B) $HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$

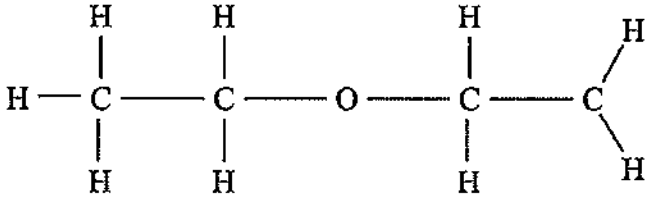
(C) $NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$

(D) $HBr(aq) \rightarrow H^+(aq) + Br^-(aq)$

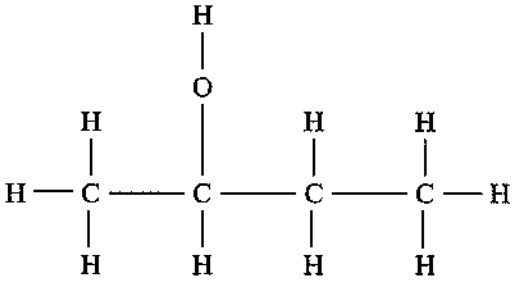
7 Which of the following are functional group isomers of $C_4H_{10}O$?



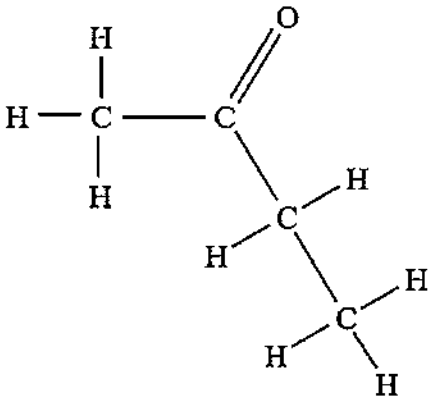
I



II



III



IV

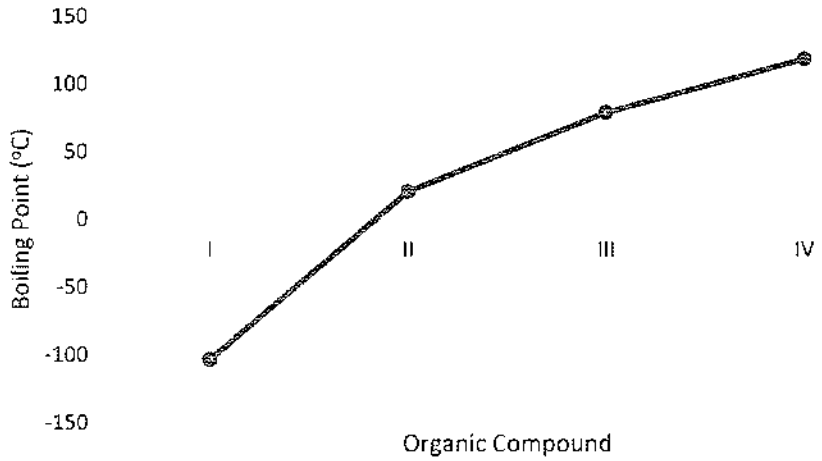
(A) I and II

(B) I and III

(C) II and III

(D) I, III and IV

8 The graph below shows the boiling points of four different organic compounds. Classify the following compounds based on their boiling point.



	I	II	III	IV
A.	Ethane	Ethanal	Ethanoic Acid	Ethanol
B.	Ethanal	Ethane	Ethanol	Ethanoic Acid
C.	Ethanal	Ethane	Ethanoic Acid	Ethanol
D.	Ethane	Ethanal	Ethanol	Ethanoic Acid

9 A student sets up a reaction flask that is sealed with a delivery tube to a delivery flask containing 120 mL of water. 2.00 g of sodium chloride is fully reacted with concentrated sulfuric acid, producing hydrogen chloride gas, which dissolves completely in water.

What is the concentration of the solution in the delivery flask?

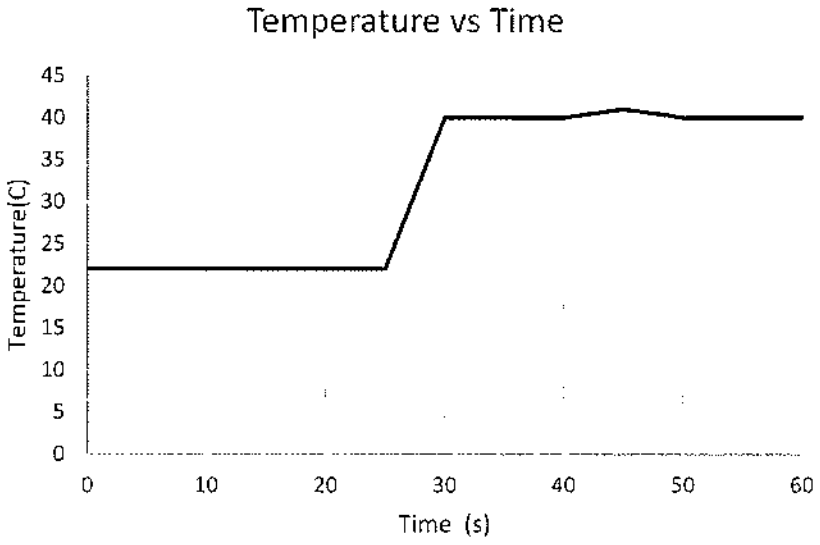
(A) 0.143 mol L^{-1}

(B) 0.285 mol L^{-1}

(C) 0.333 mol L^{-1}

(D) 0.570 mol L^{-1}

10 A student needed 24.0 mL of 0.208 M magnesium hydroxide to completely neutralise 55.0 mL of nitric acid. Assume the density of the final solution is the same as water.



The energy released in this reaction is closest to:

(A) 41.4 J

(B) 5.94×10^3 J

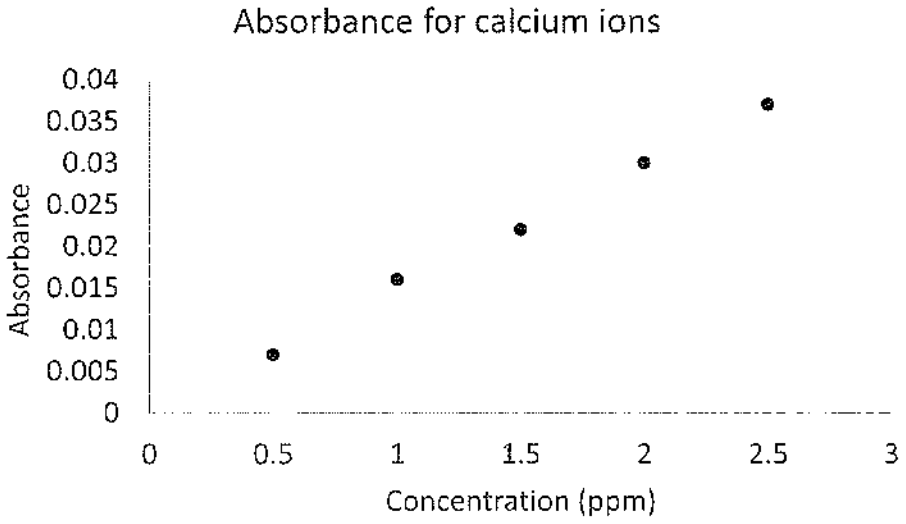
(C) 4.14×10^3 J

(D) 1.81×10^3 J

Questions 11 and 12 are based on the same information.

A solution of calcium chloride was mixed with a solution of sodium sulfate and a precipitate formed. A small sample of the solution above the precipitate was taken and diluted by a factor of 10. Atomic absorption spectroscopy (AAS) was used to measure the calcium ion concentration in the diluted solution.

11 After constructing the calibration graph below, the absorbance of the calcium in the diluted solution was found to be 0.018.



What is the concentration of the calcium ions in the *diluted* solution?

(A) 0.027 ppm

(B) 0.12 ppm

(C) 1.2 ppm

(D) 2.7 ppm

12 The concentration of the sulfate ions in the (undiluted) solution above the precipitate was

(A) 0.00411 mol L^{-1}

(B) 0.0411 mol L^{-1}

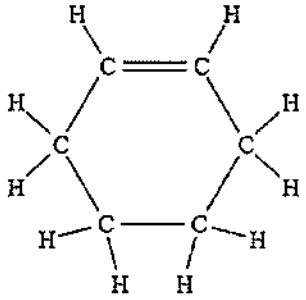
(C) 0.165 mol L^{-1}

(D) 0.330 mol L^{-1}

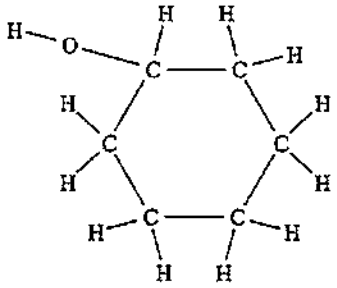
13 A student was given the task to identify a clear organic compound. The student found the organic compound to be insoluble with water and decolourised when tested with acidified $KMnO_4$. When the student reacted the compound with concentrated sulfuric acid, the product was flammable.

Which of the following structures could be the organic compound based on the student's results?

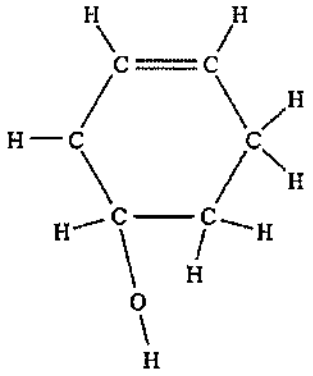
(A)



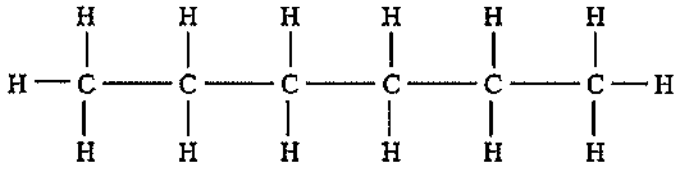
(B)



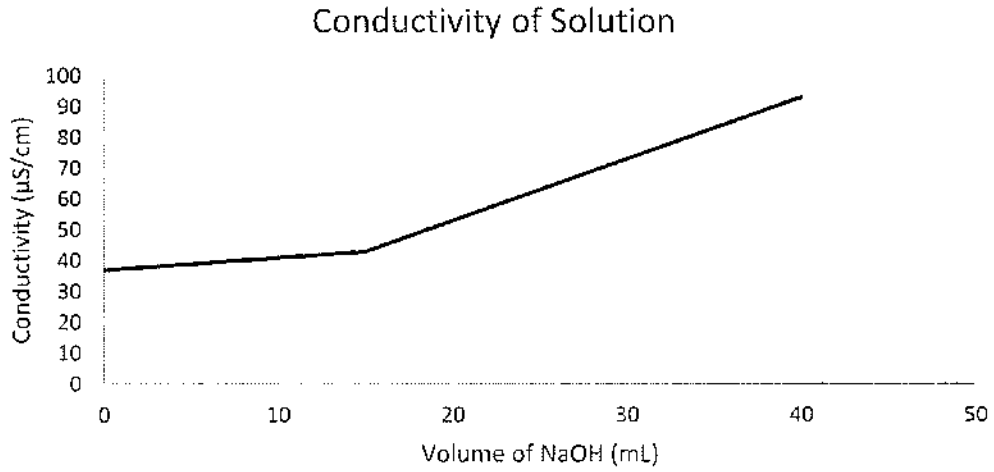
(C)



(D)



14 The conductivity graph below, shows the reaction of 30 mL of oxalic acid ($C_2O_4H_2$) a weak diprotic acid and 0.14 M sodium hydroxide.



Using this graph determine the concentration of the oxalic acid.

(A) 0.035 mol L^{-1}

(B) 0.07 mol L^{-1}

(C) 0.35 mol L^{-1}

(D) 0.7 mol L^{-1}

15 At equilibrium, a 1.00 L vessel contains 0.0540 mol of SO_2, 0.0630 mol of O_2, and 0.102 mol of SO_3. The system is represented by the following equation:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Which of the following is closest to the value of the equilibrium constant, K_{eq}, for this reaction?

(A) 0.0177

(B) 0.0334

(C) 30.0

(D) 56.6

16 An organic liquid was tested using the following method:

i. two drops of bromine water were added to 5 mL of the organic;
ii. one drop of the organic was added to 10 mL of water and stirred;
iii. the pH of the solution from part (ii) was determined.

The results were:

Bromine water	Added to water	pH of water
Did not change colour	Dissolved	3.2

The organic liquid could have been

(A) Ethanoic acid

(B) Ethylene

(C) Ethanol

(D) Pentane

17 The reaction below occurs in a closed system:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Predict the shift in the equilibrium position and the effect on the amount of NH_3 when the volume is halved at a constant temperature.

(A) The equilibrium position shifts to the right, NH_3 production is increased.

(B) The equilibrium position shifts to the left, NH_3 production is increased.

(C) The equilibrium position shifts to the right, NH_3 production is decreased.

(D) The equilibrium position shifts to the left, NH_3 production is decreased.

18 The table below shows the heat of combustion for four compounds.

Compound	Molar Mass ($g\ mol^{-1}$)	Heat of Combustion ($kJ\ mol^{-1}$)
I	28.01	233
II	76.01	890
III	26.04	1300
IV	30.07	1560

Which of these would produce the greatest amount of energy if 10 g of each fuel was burnt?

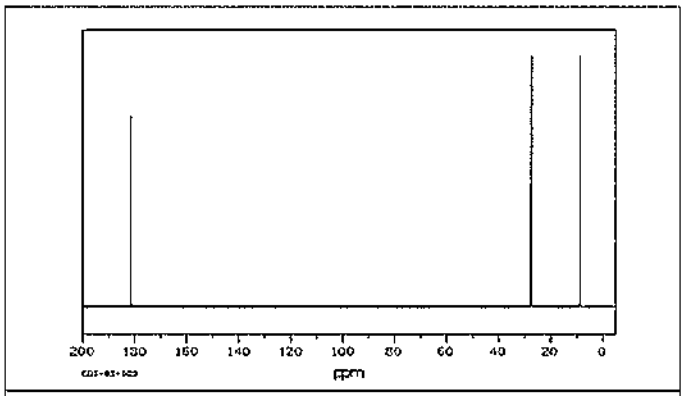
(A) I

(B) II

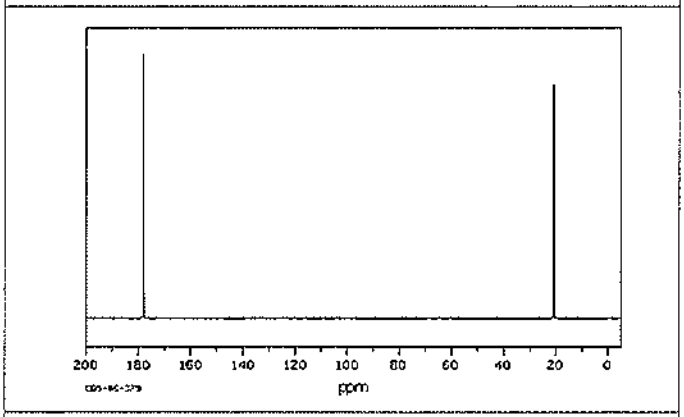
(C) III

(D) IV

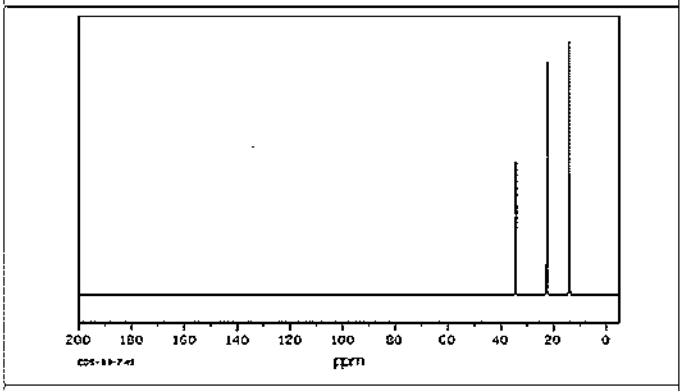
19 Which of the following carbon-13 NMR spectra belongs to propanoic acid?



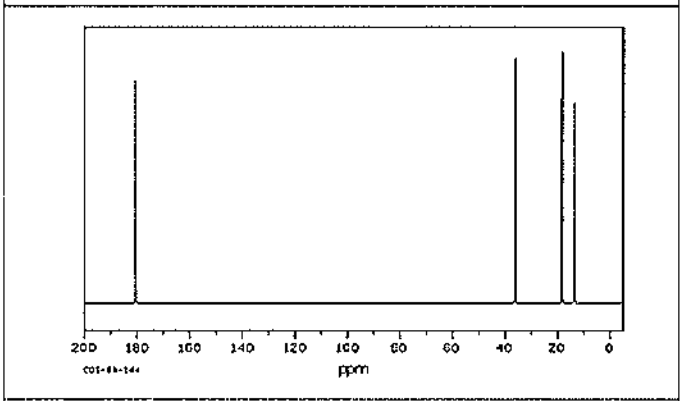
A



B



C



D

20 Photosynthesis is an endothermic chemical process occurring in the cells of plants, algae and some bacteria.

Photosynthesis has a ΔG value of $+2866 kJ\ mol^{-1}$

What does this information indicate about the photosynthesis reaction?

(A) This is a spontaneous system that requires a continual supply of external energy for the reaction to occur.

(B) This is a non-spontaneous system that produces a continual supply of energy for the reaction to occur.

(C) This is a non-spontaneous system that requires a continual supply of external energy for the reaction to occur.

(D) This is a spontaneous system that produces a continual supply of energy for the reaction to occur.

Section II

80 marks
Attempt Questions 21-34
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 pages 31 and 32. If you use this space, clearly indicate which question you are answering.

Question 21 (7 marks)

During a practical test, students were given four unknown organic chemicals (**A, B, C** and **D**) and told that they were, in no particular order, propanol, hexane, 1-hexene and acetic acid.

(a) The students were given the following information. **3**

	A	B	C	D
Solubility in water	Yes	No	No	Yes
Acidic/neutral/basic (if soluble in water)	Acidic			Neutral

Identify **A** and **D**. Justify your answer.

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Question 21 continues on page 15

(b) Describe a method, including suitable safety precautions and expected results, to identify **B** and **C**. **4**

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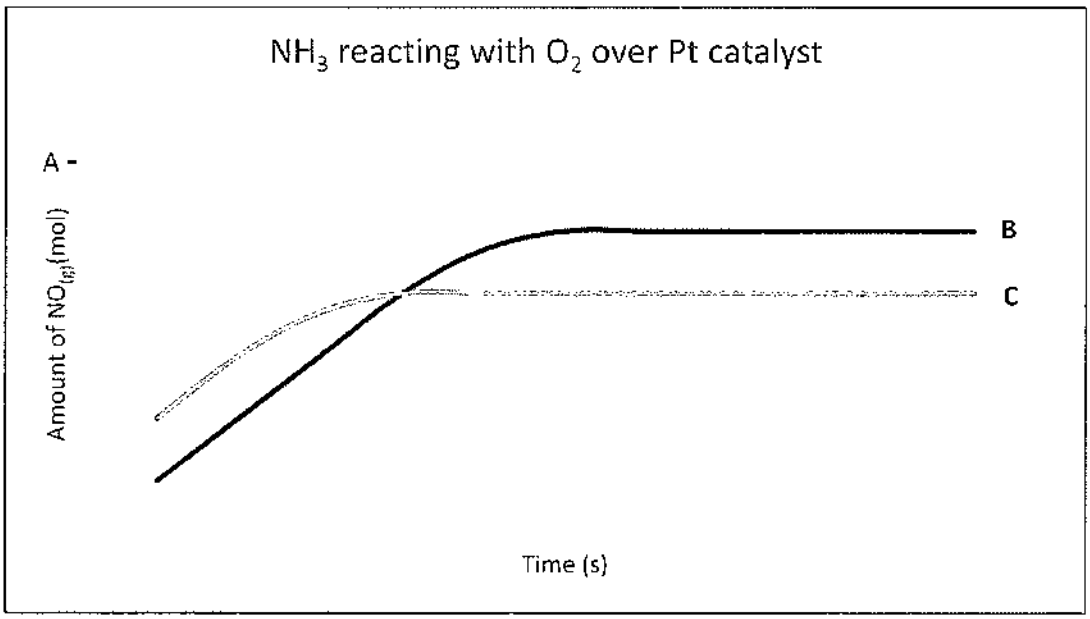
Question 22 (5 marks)

Ammonia reacts with oxygen gas using a platinum gauze catalyst according to the following equilibrium:

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO_{(g)} + 6H_2O(g) \qquad \Delta H = -908kJ$$

The graph below shows a given amount of ammonia being reacted with excess oxygen in a closed system. Label 'A' on the graph is the calculated maximum theoretical amount of $NO_{(g)}$ that should be produced. Label B is the amount of $NO_{(g)}$ produced when the reaction is carried out at 250°C and Label C is the amount of $NO_{(g)}$ produced when the reaction is carried out at 350°C.



(a) Using your knowledge of equilibrium theory, provide a valid reason why the maximum theoretical amount of NO(g) was not produced. **2**

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(b) The gradient of curves B and C are different. Explain the difference in these gradients. **3**

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Question 23 (4 marks)

Determine the final pH when combining 30.0 mL of 0.15 M sulfuric acid and 25.0 mL of 0.39 M potassium hydroxide. **4**

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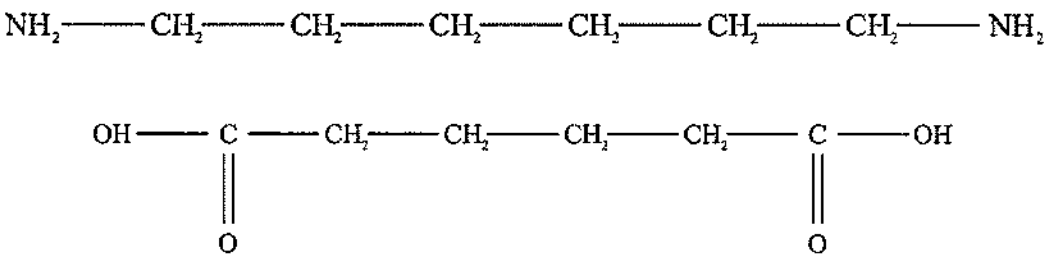
Question 24 (4 marks)

Wallace Carothers first made nylon in 1935 using condensation polymerisation. The structure of the monomers is shown below.



(a) **1**

Draw the resulting polymer.

Question 24 continues on page 18

(b) Describe the properties and uses of a named condensation polymer. **3**

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Question 25 (3 marks)

Calculate the K_a for a 0.001 mol L^{-1} solution of propanoic acid (CH_3CH_2COOH) which has a pH of 3.9. **3**

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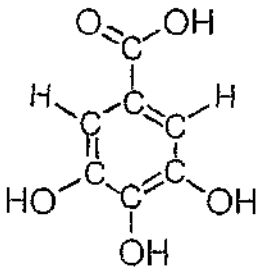
Question 26 (7 marks)

The Bush Raisin (also known as Kampurarpa) has a multitude of uses within Indigenous culture. The Bush Raisin is a very rich source of gallic acid (shown below), which has powerful anti-oxidant and anti-viral properties. Gallic acid is a monoprotic acid derived from the hydrolysis of tannic acid.

Solanum centrale
(Bush Raisin)



Gallic acid

1.0 g of the Bush Raisin was crushed and the tannic acid was extracted and hydrolysed to produce gallic acid, $C_6H_2(OH)_3COOH$, which was made up to 250 mL. 25.0 mL aliquots were titrated against 0.012 M NaOH.

The results are a follows.

Titration	Volume of NaOH (mL)
1	11.9
2	9.1
3	9.0
4	9.2

(a) Determine the concentration of the gallic acid. **5**

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(b) Tannic acid is a straight chain condensation polymer composed of five monomers of gallic acid. Determine the mass of tannic acid in the original sample. **2**

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Question 27 (4 marks)

Esters are synthesised to create flavours and scents. The flavour of blackberry is due to the chemical compound propyl hexanoate. Draw a flowchart and use an appropriate equation to describe the synthesis of blackberry flavour in a school laboratory. **4**

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Question 28 (6 marks)

A student adds a volume of silver bromide to a 0.20 $molL^{-1}$ solution of sodium bromide.

(a) Calculate the molar solubility of silver bromide at 25°C. **3**

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(b) Explain the effect of adding some sodium bromide on the solubility of silver bromide in this solution. Reference Le Chatelier's Principle in your answer. **3**

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Question 29 (5 marks)

C_4H_9OH can be a primary, secondary or tertiary alcohol. Use equations and diagrams to describe a basic chemical test that would determine if the structure of butanol is a primary or secondary alcohol. **5**

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Question 30 (7 marks)

During an experiment looking at the identification of both anions and cations, a student found a small beaker containing some unknown white solid. None of her group could confidently remember what the solid was. The other students in the group said that they had been using magnesium nitrate, barium sulfate, barium chloride and copper (II) sulfate.

(a) Some of the unknown white solid was put into a flame and it gave a yellow-green flame. One student suggested this indicated the presence of copper. Evaluate their suggestion based on the solid colour and the colour of the flame. **2**

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(b) A spatula of the unknown solid was placed into a test tube and the test tube was mostly filled with water and stirred, leaving a clear, colourless solution. Some of the solution in the test tube was transferred to another test tube and mixed with three drops of silver nitrate solution. A thick, white precipitate formed. With the use of a balanced equation, explain how this test helped in identifying the solid. **2**

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(c) One of the students was concerned that it might have been a mixture of some of the chemicals that the students had been using. The student added some of the solution that they had made up to another test tube then added five drops of 0.1 M sodium hydroxide solution, causing a precipitate to form. Based on each of the chemical tests outlined in parts (a), (b) and (c) of this question, what conclusions should the student make about the composition of the solid? **3**

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Question 31 (5 marks)

Hard water is water that has high mineral content, specifically calcium and magnesium ions. **5**

A student carried out an experiment to test the effectiveness of soap and detergents on removing oil from hard water.

The student placed 50 mL of a 0.1 M solution of $MgSO_4$ into 2 beakers, A and B. A fabric soaked in oil was added to each beaker. 50 mL of a 5% soap solution was added to beaker A and 50 mL of a 5% detergent solution was added to beaker B.

The results of the experiment are shown below.

Beaker	Observation
A	• Oily stains remain on cloth • Grey precipitate formed in solution
B	• Oily stains disappear

Describe the differences in structure between soaps and detergents to explain the student's results.

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Question 32 (7 marks)

Describe how a primary standard solution is made and justify the effect the use of a standard solution has on validity, reliability and accuracy for a titration. 7

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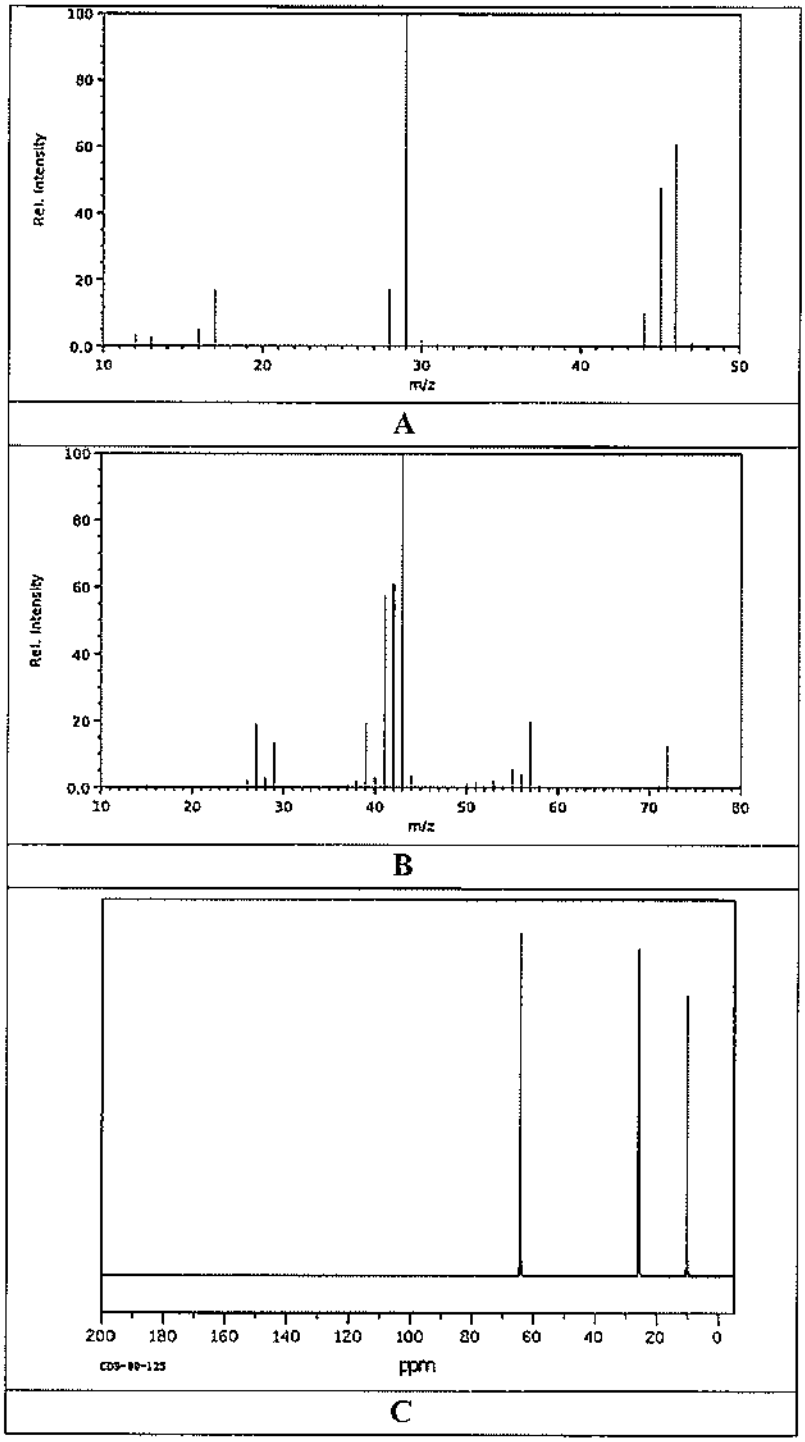
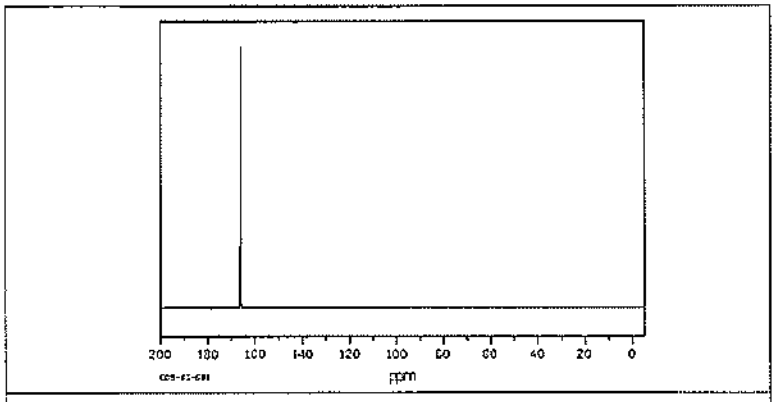
Question 33 (6 marks)

A student had been studying the mass, carbon-13 NMR and infrared spectra of four different organic chemicals: pentane, 1-propanol, ethanamide and methanoic acid. She was outside when a gust of wind blew some of the spectra away. She was able to collect eight of the spectra, shown below (labelled **A** to **H**). **6**

Identify which spectra belong to each compound, with justification.





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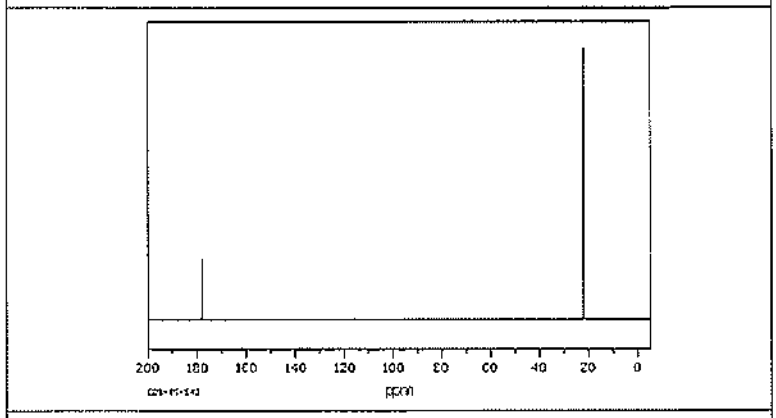

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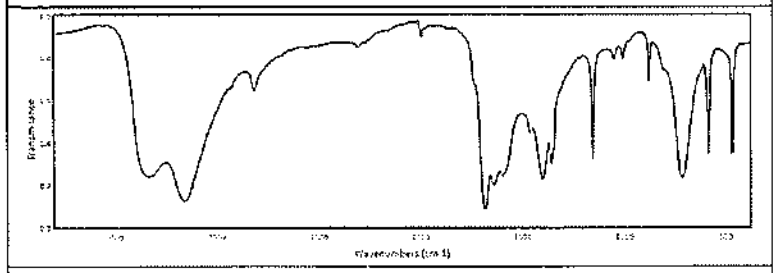

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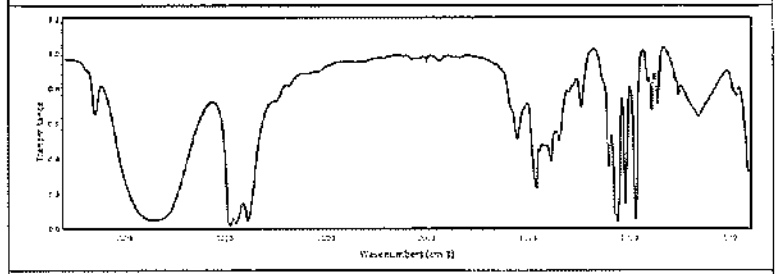
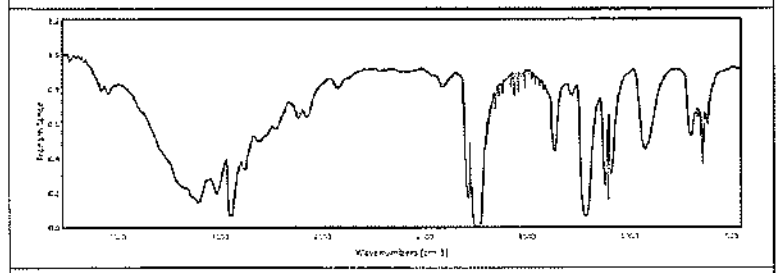


G



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Question 33 continues on page 28

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Question 34 (10 marks)

An industrial chemist is investigating the following equilibrium reaction.

$$A_{(g)} + 2B_{(g)} \rightleftharpoons C_{(g)} + 4D_{(g)}$$

In this experiment, 1.00 mol of *A*, 2.00 mol of *B*, 1.00 mol of *C* and 2.00 mol of *D* are mixed in a 250 mL vessel at 700°C. At this temperature, $K_{eq} = 0.034$.

(a) Determine the direction of the equilibrium. Support your response with appropriate calculations. **3**

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(b) The concentration of substance *A* is 5.56 $molL^{-1}$ at equilibrium. Calculate the equilibrium concentration of the other substances in the equilibrium equation. **4**

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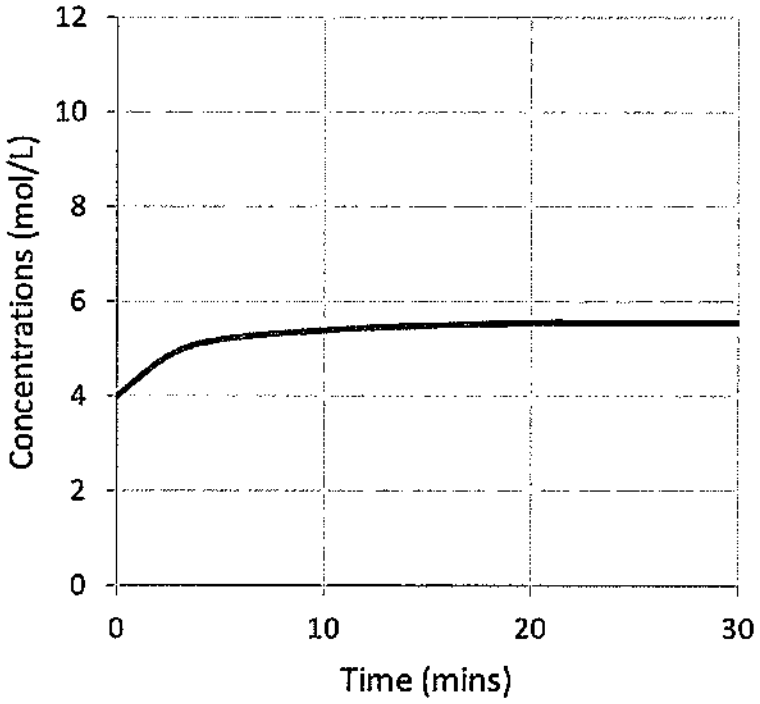
Question 34 continues on page 30

(c) Using your answers from (b), complete the concentration/time graph below for substance B, C and D with clear labels for each substance. Substance *A* has been drawn for you already. **3**



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