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

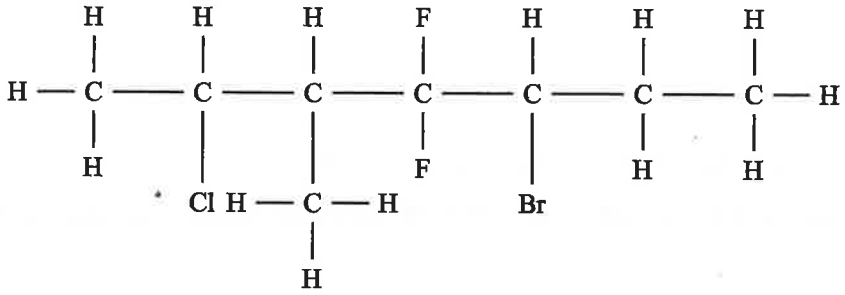
(D) The overall enthalpy is reduced

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?

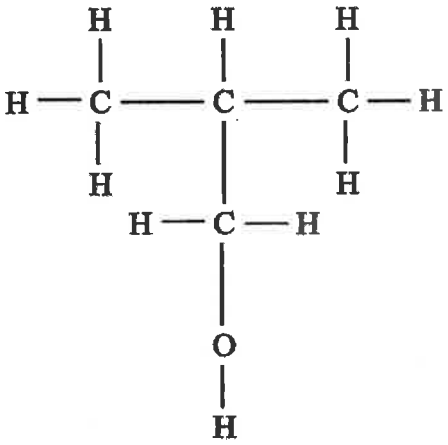
(A) $HNO_3(aq) + NH_3(g) \rightarrow NH_4^+(aq) + Cl^-(aq)$

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

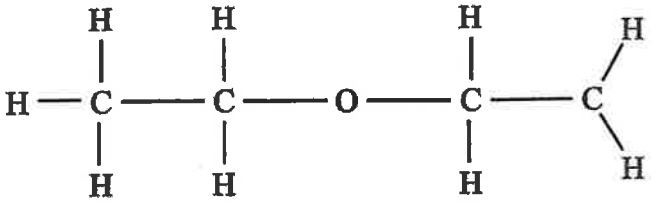
(C) $NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$

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

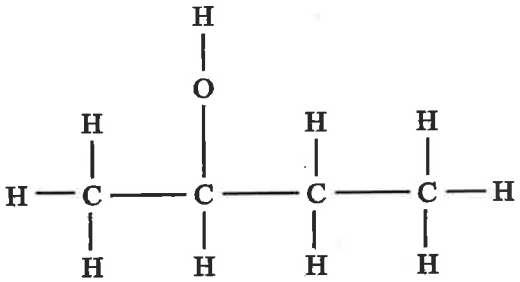
7 Which of the following are functional group isomers of $C_4H_{10}O$?



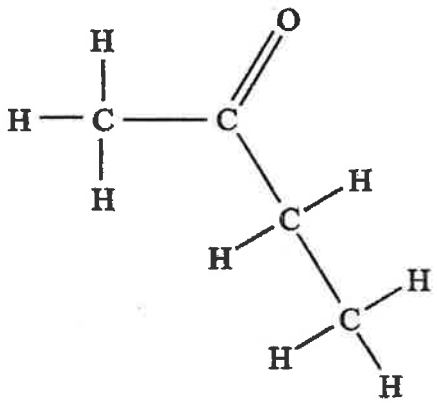
I



II



III



IV

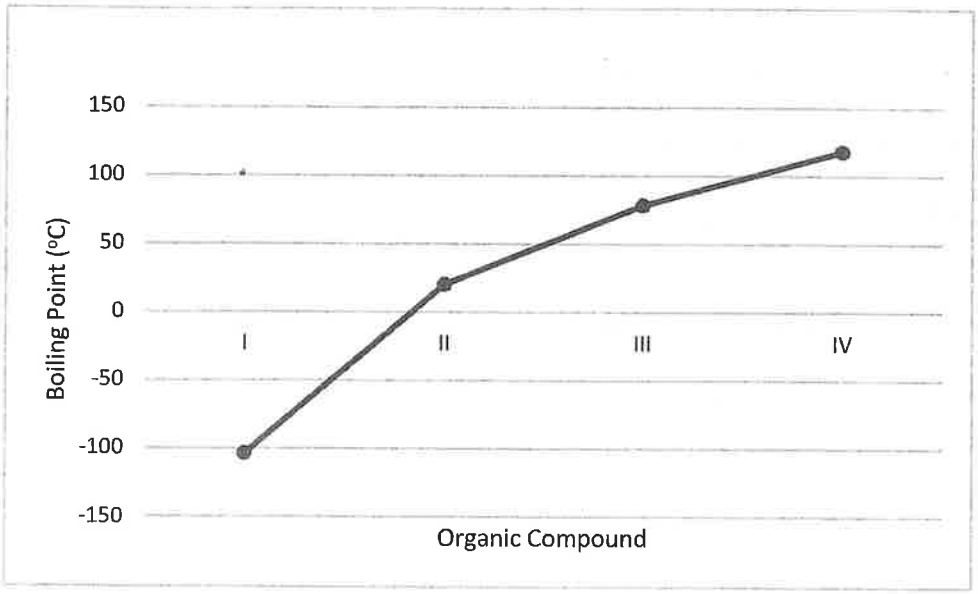
(A) I and II

(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?

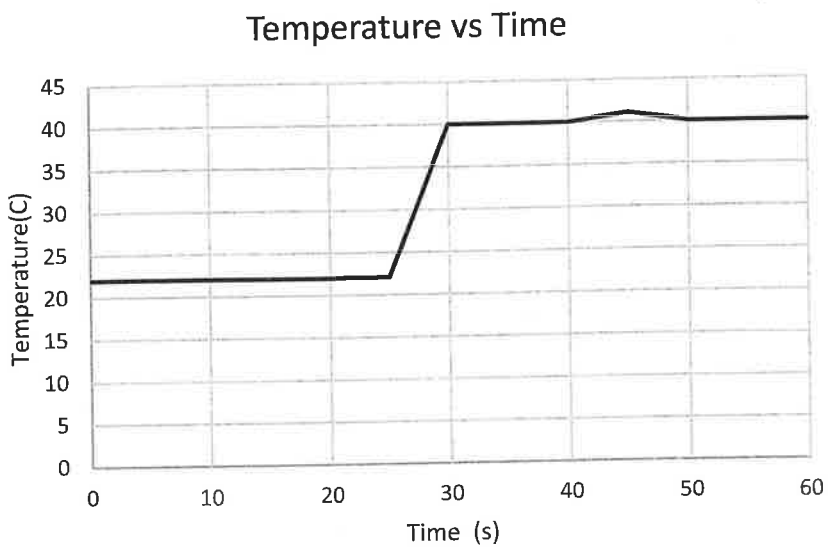
(A) 0.143 mol L^{-1}

(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

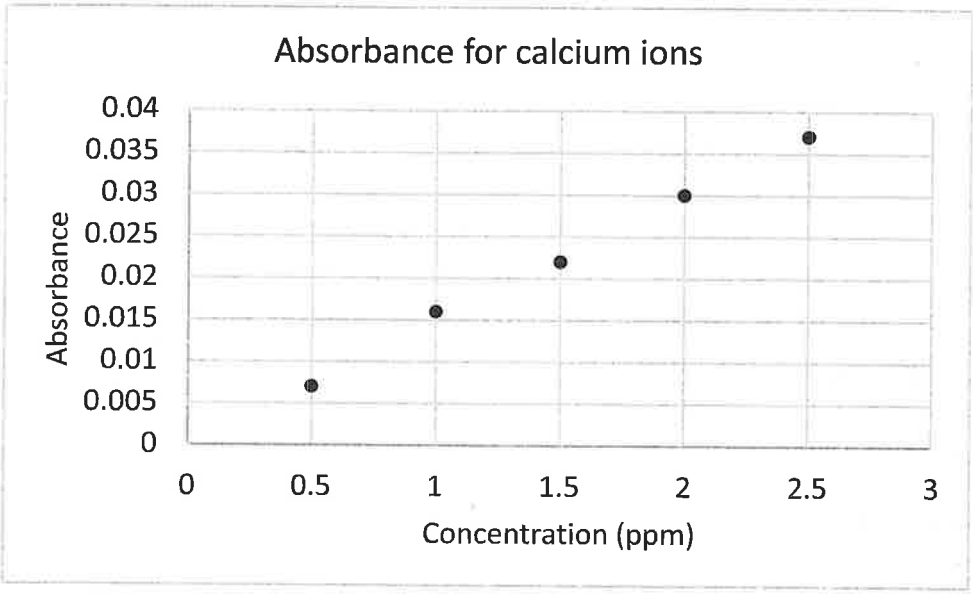
(C) 4.14×10^3 J

(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}

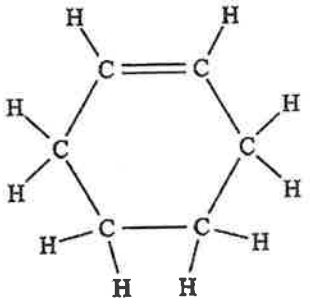
(C) 0.165 mol L^{-1}

(D) 0.330 mol L^{-1}

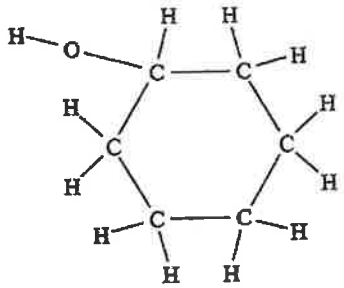
13 A student was given the task to identify a clear organic compound. The student found the organic compound to be insoluble with water and decolourised when tested with acidified $KMnO_4$. When the student reacted the compound with concentrated sulfuric acid, the product was flammable.

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

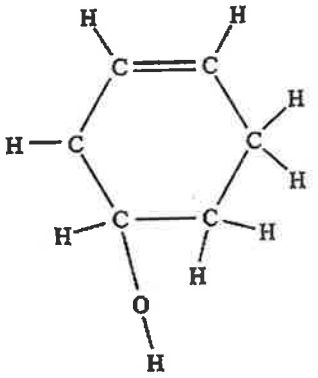
(A)



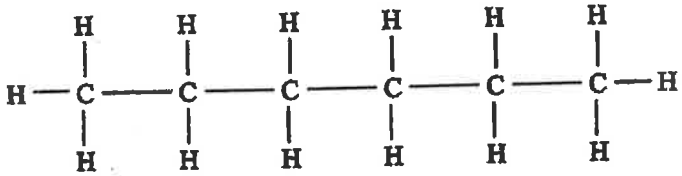
(B)



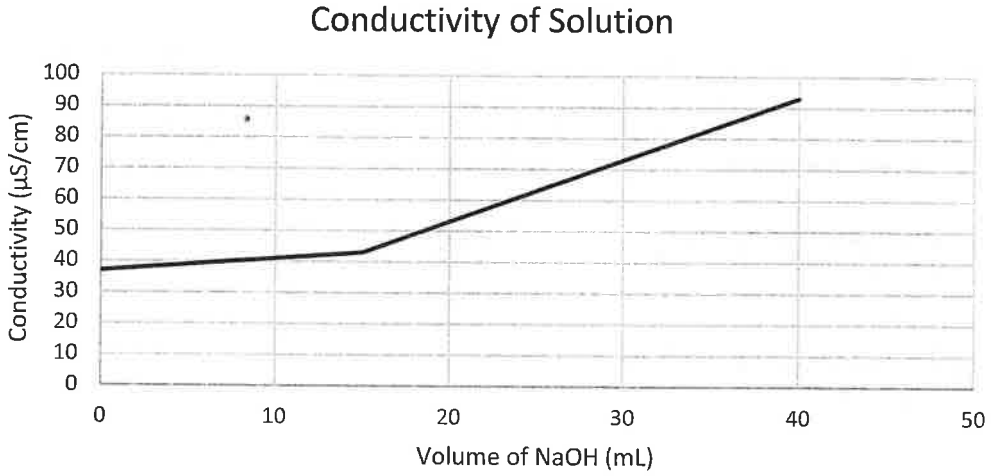
(C)



(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?

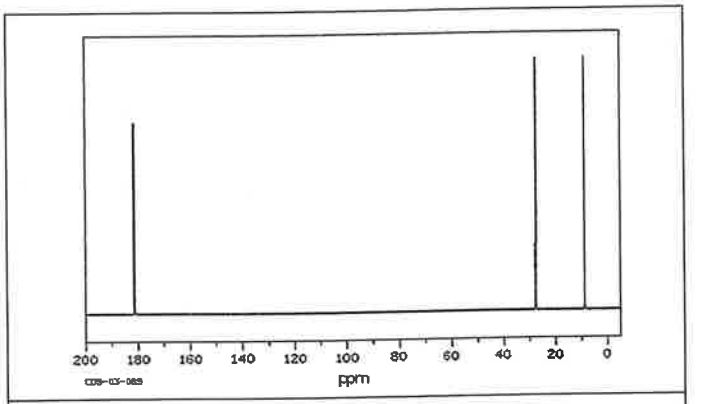
(A) I

(B) II

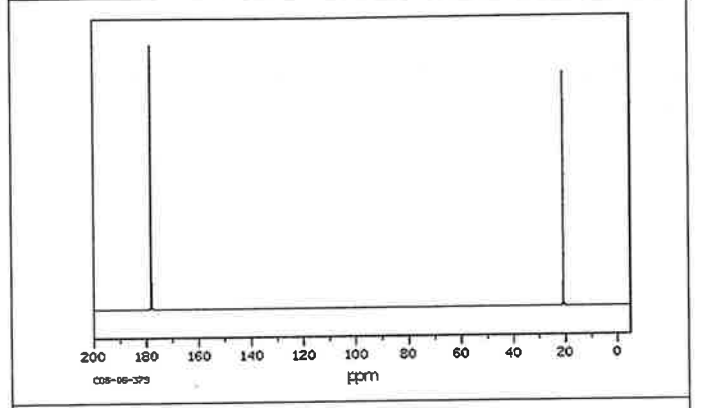
(C) III

(D) IV

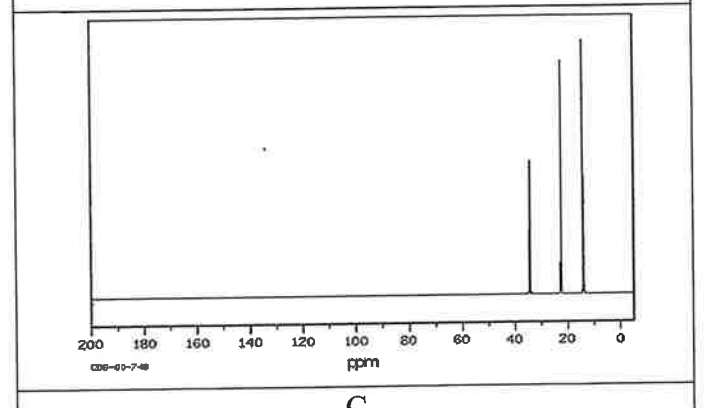
19 Which of the following carbon-13 NMR spectra belongs to propanoic acid?



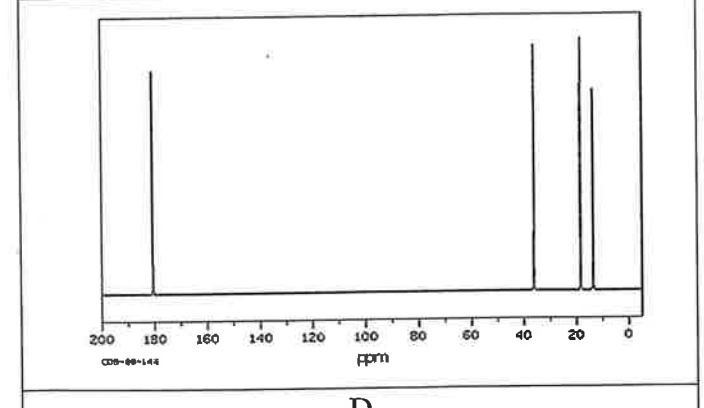
A



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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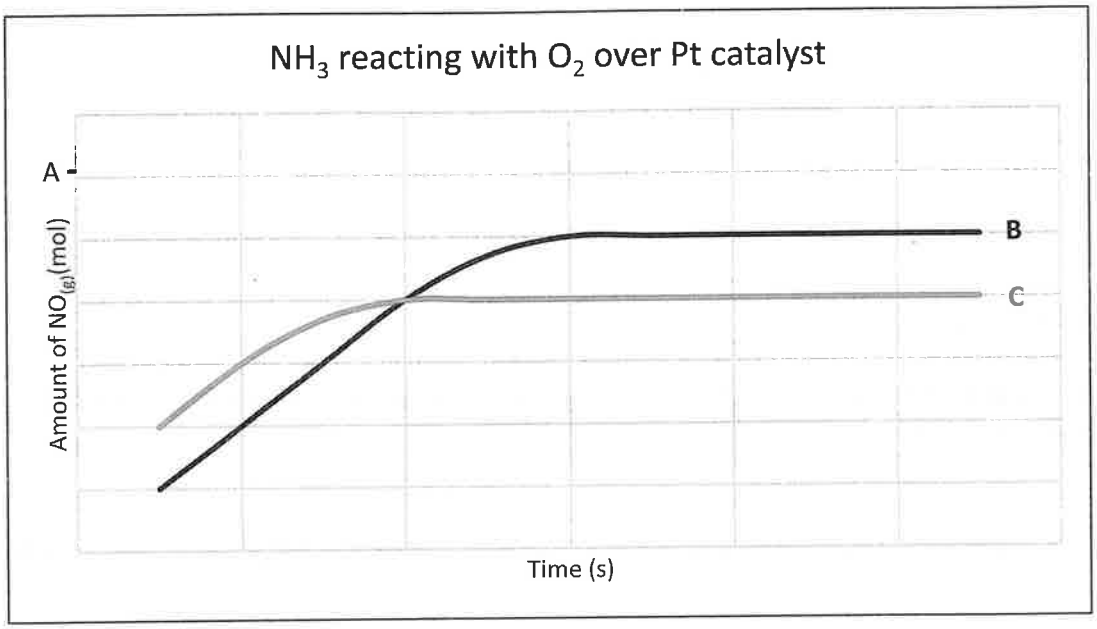
Question 22 (5 marks)

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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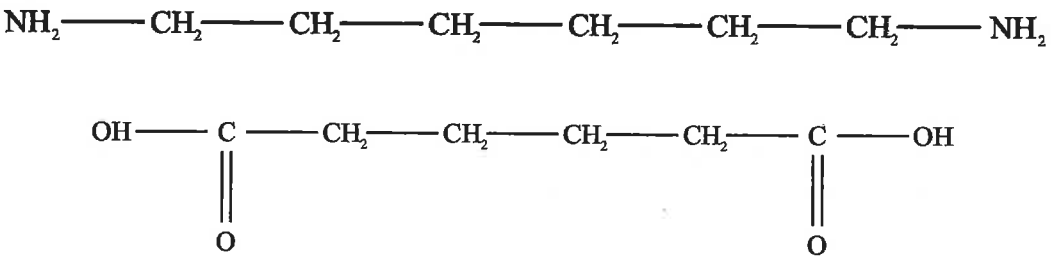
Question 24 (4 marks)

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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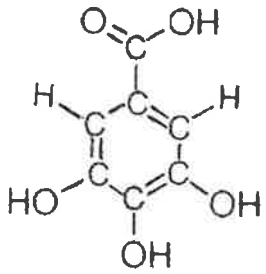
Question 26 (7 marks)

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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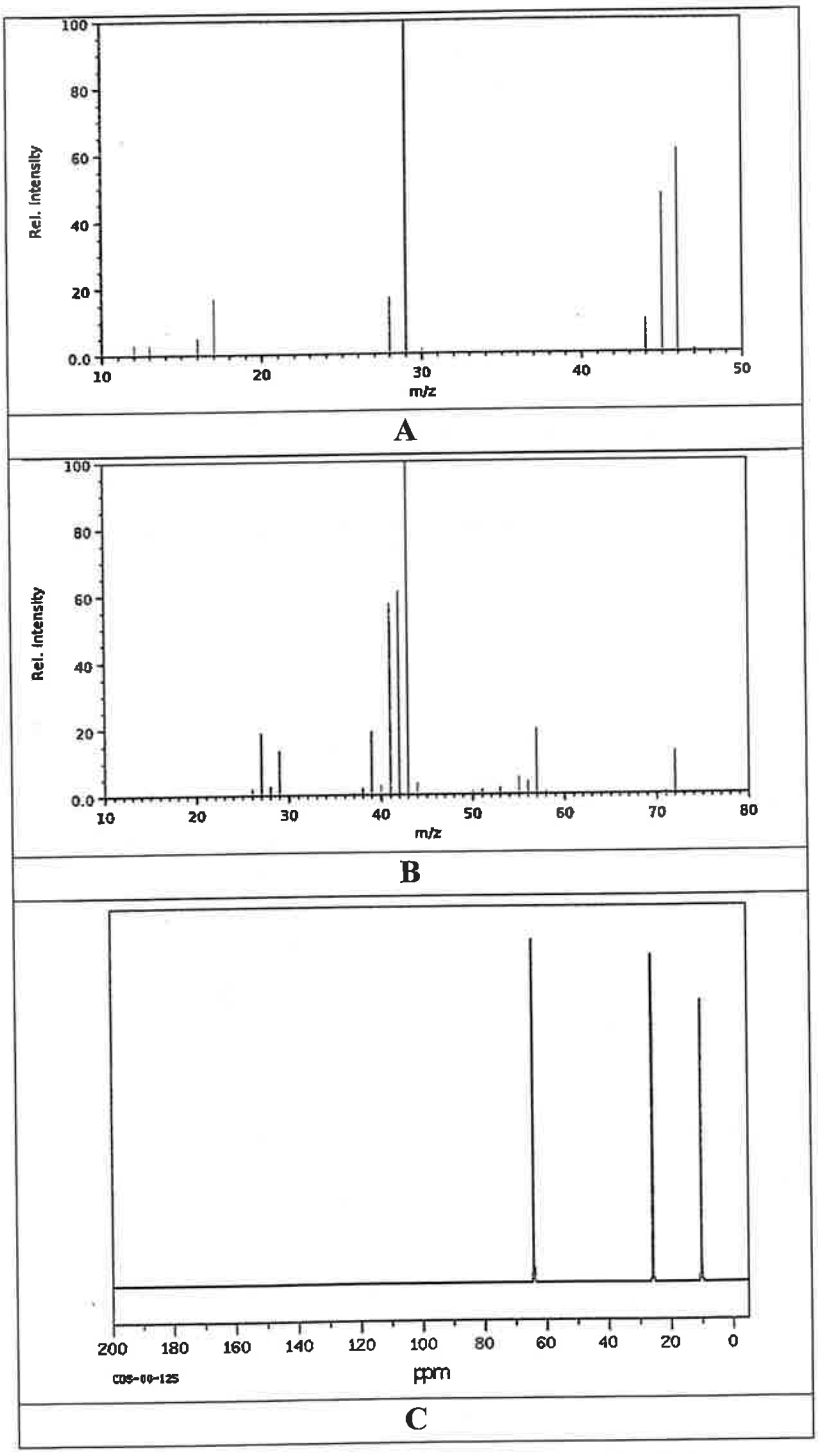
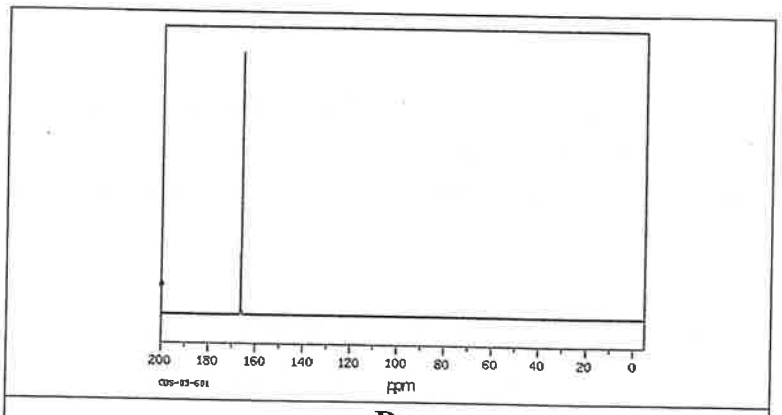
Question 33 (6 marks)

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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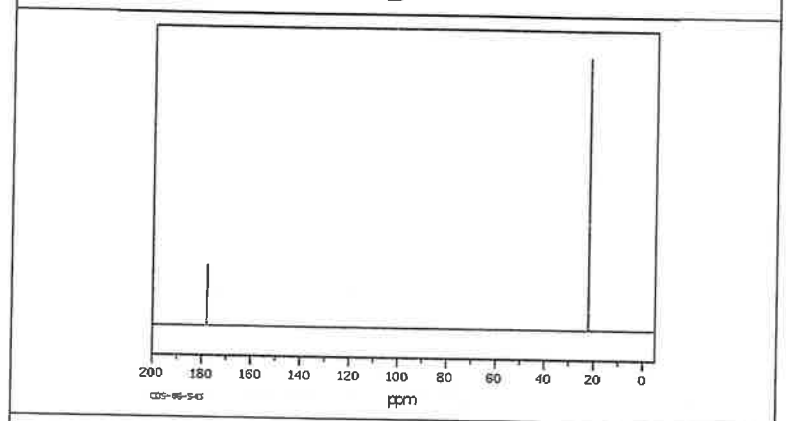

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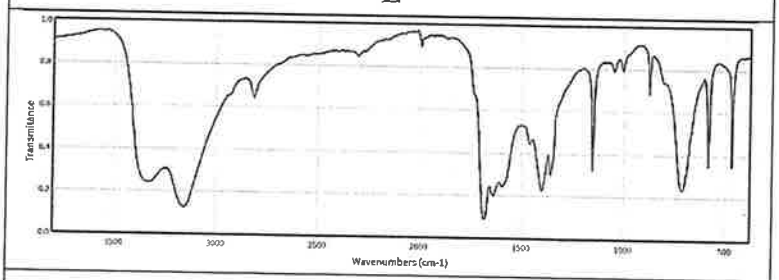

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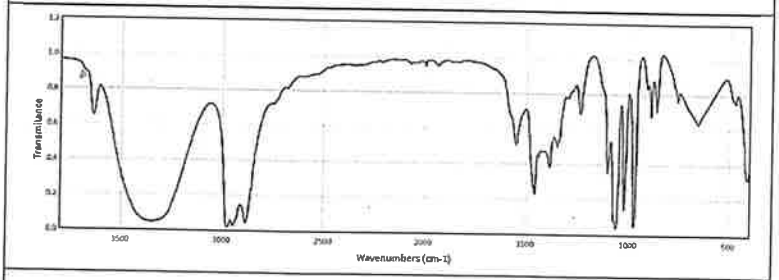
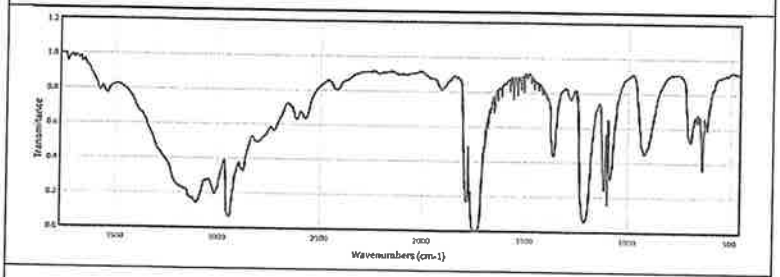


G



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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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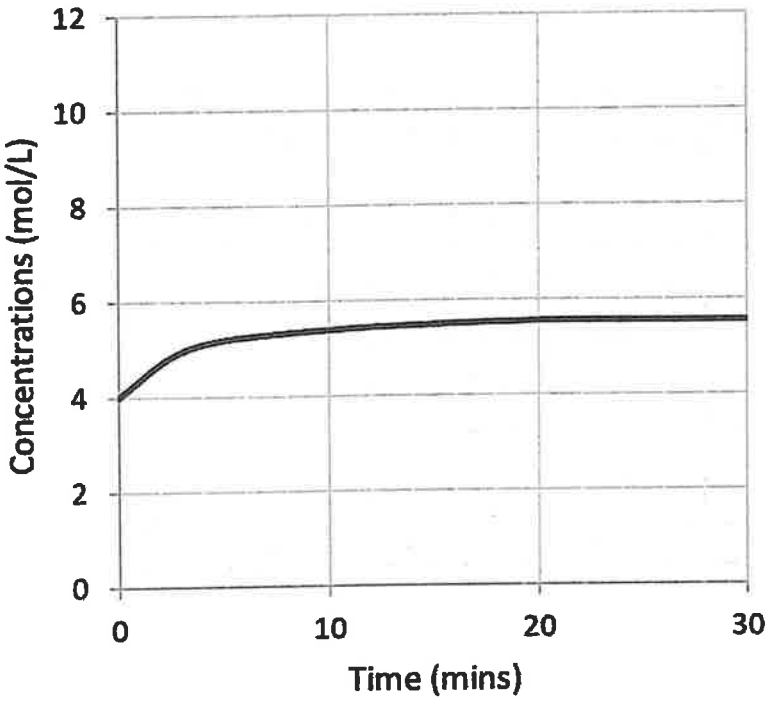
Question 34 continues on page 30

(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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CATHOLIC SECONDARY SCHOOLS ASSOCIATION OF NSW
2020 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION
CHEMISTRY – MARKING GUIDELINES

Section I
20 marks

Questions 1-20 (1 mark each)

Question	Answer	Outcomes Assessed	Targeted Performance Band
1	C	CH11/12-12	2-3
2	D	CH12-12	2-3
3	D	CH12-14	2-3
4	A	CH12-5	3
5	C	CH11/12-6, CH12-15	2-3
6	D	CH12-13	3-4
7	B	CH12-7	3-4
8	D	CH12-6, CH12-14	3-4
9	B	CH12-5, CH12-13	4
10	B	CH12-13	4
11	C	CH12-15	3-4
12	C	CH12-12, CH12-15	4-5
13	A	CH12-5	5-6
14	A	CH12-5, CH12-13	4-5
15	D	CH12-12	4-5
16	A	CH11/12-5, CH11/12-6, CH12-14	4-5
17	A	CH12-6, CH12-12	4-5
18	B	CH12-6	4-5
19	A	CH12-14, CH12-15	4-5
20	C	CH12-12, CH11-11	5-6

Section II

80 marks

Question 21 (a)(3 marks)
Outcomes Assessed: **CH11/12-5, CH11/12-6, CH12-14, CH12-15**
Targeted Performance Bands: **2-5**

Criteria	Marks
• Correctly identifies both compounds • Explains the solubility of both compounds • Identifies the acidity of the acid	3
• Correctly identifies BOTH compounds	2
• Identifies ONE of the compounds that is water soluble	1

Sample Answer:

Propanol, which contains the hydrophilic –OH group, and acetic acid, which contains the hydrophilic –COOH group, are both soluble in water. When acetic acid dissolves in water, the acidic hydrogen on the –COOH group ionises, making the solution acidic. So **A** is acetic acid and **D** is propanol.

Question 21 (b)(4 marks)
Outcomes Assessed: **CH11/12-2, CH11/12-3, CH11/12-5, CH11/12-6, CH12-14, CH12-15**
Targeted Performance Bands: **3-5**

Criteria	Marks
• Outlines a suitable method, with approximate quantities • Identifies suitable safety precautions, including one beyond PPE • Identifies the expected results	4
• Outlines a suitable method, with approximate quantities • Identifies a suitable safety precaution (may include PPE) • Identifies the expected results	3
• Any TWO of the above points (may include PPE)	2
• Any ONE of the above points (may include PPE)	1

Sample Answer:

The simplest method to distinguish between hexane and 1-hexene is to conduct a bromine water test:

1. Conduct the experiment in a fumehood (probably best to ask your teacher to conduct the experiment). They should be wearing safety glasses, a labcoat and using gloves.
2. Pour **B** and **C** into separate test tube to a height of 3 cm.
3. Add 1 cm of the orange bromine water and stir vigorously.
4. The test tube with hexane will still have orange, whereas the test tube containing 1-hexene should go completely clear.
5. Dispose of both solutions in an appropriate container for organic waste.

Question 22 (a) (2 marks)
Outcomes Assessed: **CH11/12-5, CH11/12-7, CH12-12**
Targeted Performance Bands: **2-3**

Criteria	Marks
• Uses LCP and the reaction equation to provide a valid reason	2
• Provides a valid reason	1

Sample Answer:

The theoretical yield assumes complete reaction has occurred. This is an equilibrium system, so completion does not occur. As the system achieves equilibrium, the rate of the forward and reverse reactions will be equal and concentrations of all species will be constant, as predicted by Le Chatelier's Principle.

Question 22(b) (3 marks)
Outcomes Assessed: **CH11/12-5, CH11/12-6, CH12-12**
Targeted Performance Bands: **3-5**

Criteria	Marks
• Explains differences in terms of increased rate for C AND lower yield for C due to reverse reaction being favoured at higher temperature	3
• Explains differences in terms of increased rate for C OR lower yield for C due to reverse reaction being favoured at higher temperature	2
• Makes a comparison statement	1

Sample Answer:

The reaction is exothermic in the forward direction. If the temperature of the system is increased it will favour the reverse reaction, resulting in a decreased yield, as is shown in the graph with line C. Increasing the temperature also increases the rate of reaction, so equilibrium will be achieved more quickly, as is also shown on the graph for line C.

Question 23 (4 marks)
Outcomes Assessed: CH11/12-6, CH12-13
***Targeted Performance Bands:* 3-5**

Criteria	Marks
• Correct equation, with states • Correct calculation of mol of H^+ and OH^- • Correct mol of excess converted to concentration • Correct pH	4
• As above, with one major calculation error • As above, but calculates pOH	3
• Correct equation • Correct calculation of mol of H^+ and OH^-	2
• Correct equation OR • Correct calculation of mol of H^+ and OH^-	1

Sample Answer:

Eqn: H_2SO_4 (aq) + 2KOH (aq) → K_2SO_4 (aq) + $2H_2O$ (l)

Total Volume = 0.055 L

Moles of H^+ = 2 x 0.15 x 030 = 0.0090 mol

Moles of OH^- = 0.39 x 0.025 = 0.00975 mol

Excess moles OH^- = $7.5x10^{-4}$ mol

$[OH^-]$ = $7.5x10^{-4}$ mol/0.055 = 0.0136 mol L^{-1}

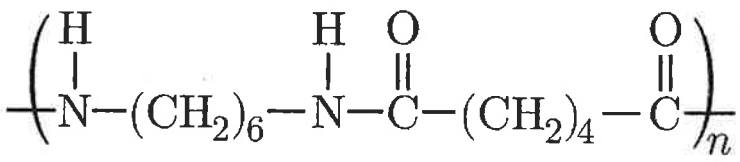
pOH = -log0.0136 = 1.865

pH = (14 – 1.8653..) = 12.13

Question 24(a) (1 mark)
Outcomes Assessed: **CH11/12-6, CH12-14**
Targeted Performance Bands: **3-4**

Criteria	Mark
• Correctly draws the structure for the polymer	1

Sample Answer:



Question 24(b) (3 marks)
Outcomes Assessed: **CH12-14**
Targeted Performance Bands: **3-4**

Criteria	Marks
• Describes structure and relates to properties	3
• Describes structure OR properties	2
• Provides relevant information	1

Sample Answer:

Nylon can be moulded or drawn into fibres to make fabric. It is strong, waterproof and resistant to attack by fungi and bacteria. Can be used for umbrellas, rope, fishing lines, dental floss, tents, carpet. Nylon is used when mechanical strength, rigidity and stability to heat and chemicals are required for example, pipes and machine parts.

Question 25 (3 marks)
Outcomes Assessed: CH11/12-6, CH11/12-7, CH12-13
***Targeted Performance Bands:* 4-5**

Criteria	Marks
• Correct equilibrium expression • Correctly substituted values • Correct answer	3
• Correct equilibrium expression • Correctly substituted values • Incorrect answer	2
• Correct equilibrium expression	1

Sample Answer:

$K_a = [H_3O^+]\ [CH_3CH_2COO^-] / [CH_3CH_2COOH]$

$[H_3O^+] = 10^{-pH}$

$[H_3O^+] = 0.00012589 \text{ mol } L^{-1} = [CH_3CH_2COO^-]$

$[CH_3CH_2COOH] = 0.001 - 0.000126 = 0.000874 \text{ mol } L^{-1}$

$K_a = 1.82 \times 10^{-5}$

Question 26 (a) (5 marks)
***Outcomes Assessed:* CH11/12-5, CH11/12-6, CH12-13**
***Targeted Performance Bands:* 3-6**

Criteria	Marks
• Identifies mol ratio of gallic acid to NaOH (1:1) from equation • Correct moles of NaOH • Correct moles of gallic acid • Correct substitution and calculates concentration of gallic acid to 2 sig fig.	5
• As above but included outlier when calculating average volume	4
• As above with no equation and one error	3
• As above with two errors	2
• Identifies mol ratio of gallic acid to NaOH	1

Sample Answer:

Eqn: $C_6H_2(OH)_3COOH(aq) + NaOH(aq) \rightarrow C_6H_2(OH)_3COONa(aq) + H_2O(l)$

Mol ratio of Gallic acid : NaOH is 1:1

Average titre = 9.1 mL (do not include the outlier)

Mole of NaOH = $0.0091 \times 0.012 = 0.00010920$ mol

Mole of Gallic = 0.0001092 mol

[gallic acid] = $0.000109210.25 = 0.004368 \text{ mol } L^{-1} = 0.0044 \text{ mol } L^{-1}$

Question 26(b) (2 marks)
Outcomes Assessed: **CH11/12-6**
Targeted Performance Bands: **4-5**

Criteria	Marks
• Correct molar mass of tannic acid • Correct mass of tannic acid in raisin	2
• Correct process with one error	1

Sample Answer:

MM of Gallic acid = 170.118 g mol^{-1}

Tannic acid contains 5 monomers. Four molecules of water are eliminated.

Molar mass = (170.118 x 5) – (18.016x4) = 778.526 g mol^{-1}

Mass of tannic acid present = 778.526 x (0.001092/5) = 0.017 g.

Question 27 (4 marks)
Outcomes Assessed: **CH12-7, CH12-14**
Targeted Performance Bands: **3-5**

Criteria	Marks
• Uses a flowchart showing all correct reagents and processes • Writes an appropriate chemical equation showing the production of the ester	4
• Uses a flowchart showing all correct reagents and processes	3
• Uses a flowchart showing some correct reagents and processes	2
• Provides relevant information	1

Sample Answer:

Reagents (see below)	Refluxed for 30-45 minutes	Ester mixture	Sodium carbonate and volume of water added	Ester + aqueous solution after escape of CO_2	Aqueous layer removed using separating funnel	Mainly ester	Distill, optional	Purified ester
	STEP 1		**STEP 2**		**STEP 3**		**STEP 4**	

Propan-1-ol + hexanoic acid (using conc. sulfuric acid) is heated in reflux apparatus → ester is insoluble in water and can be separated using a separating funnel.

$CH_3CH_2CH_2OH + CH_3CH_2CH_2CH_2CH_2COOH \rightleftharpoons CH_3CH_2CH_2OOCCH_2CH_2CH_2CH_2CH_3 + H_2O$

Question 28(a) (3 marks)
Outcomes Assessed: **CH12-12**
Targeted Performance Bands: **3-6**

Criteria	Marks
• Correctly calculates the molar solubility of silver bromide and shows all correct working	3
• As above with one error	2
• Showed some relevant understanding	1

Sample Answer:

Reaction	***AgBr***	⇌	Ag^+	+	Br^-
Initial			0		0.2
Change			$+x$		$+x$
Equilibrium			x		0.2

$K_{sp} = [Ag^+]\,[Br^-]$

$5.35 \times 10^{-13} = [\,x\,]\,[0.2]$

$x = 5.35 \times 10^{-13}/0.20$

$x = 2.67 \times 10^{-12}\ molL^{-1}$

Question 28(b) (3 marks)
Outcomes Assessed: **CH12-12**
Targeted Performance Bands: **4-6**

Criteria	Marks
• Correctly used Le Chatelier's Principle to explain the decrease in solubility AND • References the 'Common Ion' effect	3
• Correctly used Le Chatelier's Principle to explain the decrease in solubility	2
• Showed some relevant understandings	1

Sample Answer:

According to LCP a system in equilibrium will shift to minimise a change. The solution of sodium bromide already contains bromide ions (common ion) therefore if the concentration of bromide ions is increased, the reverse reaction will be favoured. This will result in the solubility of silver bromide decreasing.

Question 29 (5 marks)
Outcomes Assessed: **CH12-6, CH12-14**
Targeted Performance Bands: **4-5**

Criteria	Marks
• Uses correct equations to show the production of aldehydes and ketones from primary and secondary alcohols respectively • Describes how carboxylic acid can be produced from primary alcohols using structural diagrams for primary and secondary alcohols • Explains how to differentiate between a primary and secondary alcohol	5
• Uses correct equations to show the production of aldehydes and ketones from primary and secondary alcohols respectively • Describes how carboxylic acid can be produced from primary alcohols using structural diagrams for primary and secondary alcohols	4
• Describes oxidation of primary AND secondary alcohols	3
• Describes oxidation of primary OR secondary alcohols	2
• Provides relevant information	1

Sample Answer:

If the butanol was a primary alcohol it would have the following structure

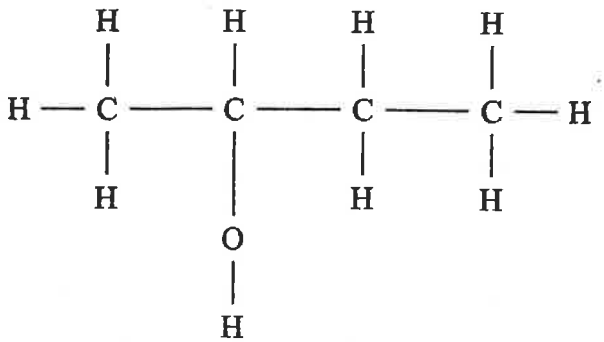
HO ——— CH_2 ——— CH_2 ——— CH_2 ——— CH_3

Butanol can be oxidised by heating excess ethanol in acidified permanganate or dichromate. This forms an aldehyde (butanal) with the C=O bond on the first C. The aldehyde can be further oxidised to produce butanoic acid by heating under reflux. This can be distilled to separate the acid from the reaction mixture and can be tested using universal indicator or a pH probe or litmus. A pH <7 would be expected)

$CH_2OHCH_2CH_2CH_3 + MnO_4^-/H^+ \rightarrow CH{=}OCH_2CH_2CH_3$

$CH{=}OCH_2CH_2CH_3 + MnO_4^-/H^+ \rightarrow CH_3CH_2CH_2COOH$

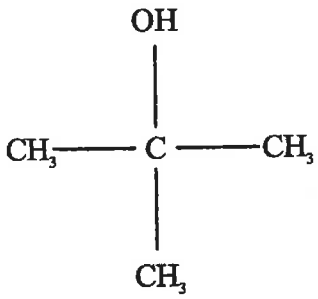
If butanol was a secondary alcohol it would have the following structure



The secondary alcohol can be oxidised by heating excess ethanol in acidified permanganate or dichromate this forms a ketone (butanone) with the C=O bond on the second C. This reaction cannot proceed further and can be tested using a pH probe or litmus. The pH should be higher than that of the products of a primary alcohol. (pH ~7)

$CH_3CHOHCH_2CH_3 + MnO_4^-/H^+ \rightarrow CH_3C{=}OCH_2CH_3 + H_2O$

A tertiary alcohol will have the following structure and will not readily undergo oxidation reactions.



Question 30(a)(2 marks)
Outcomes Assessed: **CH12-15**
Targeted Performance Bands: **2-3**

Criteria	Marks
• Correctly identifies barium as the cation based on flame colour AND • Correctly identifies that copper(II) sulfate would probably not be a white solid	2
• Correctly identifies barium as the cation based on flame colour OR • Correctly identifies that copper(II) sulfate would not be a white solid	1

Sample Answer:

The yellow-green flame probably indicates the presence of barium. Copper(II) sulfate is normally blue, not white (unless dehydrated, but it would then have turned the solution blue in (b)).

Question 30(b) (2 marks)
Outcomes Assessed: **CH11/12-5, CH11/12-6, CH12-15**
Targeted Performance Bands: **3-4**

Criteria	Marks
• Correctly identifies that the white solid contained chloride ions AND • Provides a correct equation	2
• Correctly identifies that the white solid contained chloride ions OR • Provides a relevant equation	1

Sample Answer:

Silver nitrate solution is often used to show the presence of chloride ions in a solution, because it forms a thick, white precipitate.

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

Question 30(c) (3 marks)
Outcomes Assessed: **CH11/12-5, CH11/12-6, CH12-15**
Targeted Performance Bands: **3-6**

Criteria	Marks
• Identifies that the mixture contains both magnesium chloride and barium chloride • Identifies that the mixture does not contain copper(II) sulfate or barium sulfate	3
• Identifies that the mixture contains both magnesium chloride and barium chloride OR • Identifies that the mixture contains magnesium chloride OR barium chloride, AND that barium sulfate is not present	2
• Identifies that the mixture contains magnesium chloride OR barium chloride OR that barium sulfate is not present	1

Sample Answer:

The colour showed that the solid did not contain copper(II) sulfate.

The flame test showed that the solid contained barium but the solid was soluble so the solid did not contain barium sulfate. The silver nitrate test showed that the solid contained chloride ions, so barium chloride was present.

Adding sodium hydroxide and forming a precipitate showed that magnesium ions were present (barium hydroxide should be soluble at those concentrations). Therefore, the mixture probably contained magnesium nitrate as well.

Question 31 (5 marks)
Outcomes Assessed: **CH12-6, CH12-14**
Targeted Performance Bands: **5-6**

Criteria	Marks
• Describes the structure of soaps AND detergents using diagrams • Explains all observations of the student's experiment • Explains the action of detergents to remove the oil stain	5
• Describes the structure of soaps AND detergents using diagrams • Explains some observations of the student's experiment • Explains the action of detergents to remove the oil stain	4
• Describes the structure of soaps OR detergents using diagram • Describes observations of the student's experiment • Describes the action of detergents to remove the oil stain	3
• Describes the structure of soaps OR detergents using diagrams • Describes the action of detergents to remove the oils stains	2
• Provides relevant information	1

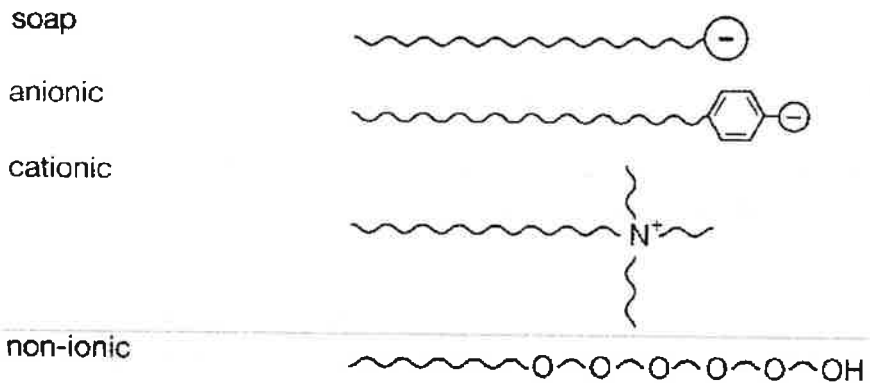
Sample Answer:

Soap has a negative tail – this is attracted to the positive Mg^{2+} ions in the water – forming a precipitate.

$2RCOONa^{-} + Mg^{2+}_{(aq)} \rightarrow (RCOO)_2Mg_{(s)} + 2Na^{+}_{(aq)}$

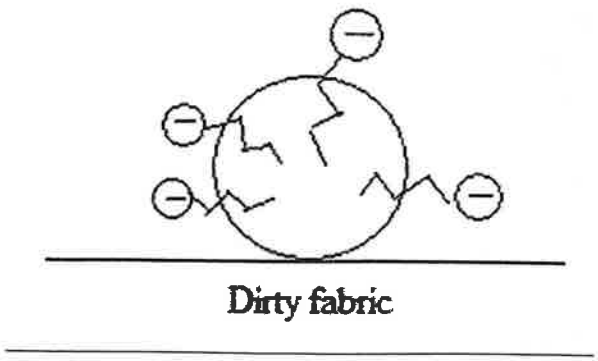
The formation of the precipitate reduces the amount of soap available for cleaning – hence the oil stain is not removed.

Detergents can be anionic, cationic or non-ionic. An anionic detergent will have similar effects as a soap due to the negative head. However, cationic and non-ionic detergents will not precipitate with the Mg^{2+} and be more effective in removing the oil stain.



The detergent removes the oil stain through the production of micelles. Detergent has a hydrophobic tail and a hydrophilic head. The hydrophobic tail attaches to the non-polar oil molecules and the hydrophilic head is soluble in water. The soap molecules surround the oil.

The intermolecular attraction between the long hydrocarbon tails with the oil droplet and the hydrophilic head with the water molecules are strong enough to remove the oil droplet from fabric, leaving the oil droplet (micelles) suspended in the water.



Question 32 (7 marks)
Outcomes Assessed: CH12-7, CH12-13
***Targeted Performance Bands:* 2-6**

Criteria	Marks
• Extensive understanding of properties of a named primary standard AND • Describes correct preparation of a standard solution AND • Defines validity, reliability and accuracy AND • Justifies the use of a primary standard by linking to these definitions	7
• Thorough understanding of properties of primary standards AND • Describes correct preparation of a standard solution AND • Defines validity, reliability and accuracy AND • Justifies the use of a primary standard but no obvious link to these definitions OR • One of the definitions is not linked	5-6
• Good understanding of properties of primary standards AND/OR • Describes correct preparation of a standard solution AND • Defines validity, reliability and accuracy AND • Justifies the use of a primary standard but no obvious link to these definitions	4
• Good understanding of properties of primary standards OR • Describes correct preparation of a standard solution AND • Defines validity, reliability and accuracy	3
• Identifies a standard solution AND states a property of primary Standard	2
• Identifies a standard solution OR states a property of primary Standard	1

Sample Answer:

A primary standard (eg Oxalic Acid) is a solid, with high purity, high molar mass, and is highly soluble. A known mass is dissolved in a beaker with a small volume of distilled/deionised water and transferred to a volumetric flask, washing the beaker several times and then filling the volumetric flask to the graduation line. The solution is mixed by inverting the stoppered flask several times.

Validity refers to the controlling of variables in the method and hence answering the Aim.

Accuracy is how close the results are to published or accepted results within the scientific community.

Reliability relates to obtaining similar results for multiple trials (concordance.)

Impact on validity. This method of producing a standard solution is a tested and accepted process for determining an unknown acid or base. If an incorrect standard is chosen, such as a partially insoluble salt, this will make the process and result invalid, as the calculated concentration of the standard solution will be incorrect. The correct procedure should be followed for a valid experiment

Impact on accuracy: If the mass of the primary standard is not correct, accuracy of the experiment is decreased. For a mass that is recorded too low, the analysed sample will be incorrectly high, if too much is added then analysed sample will be incorrectly low.

Impact on reliability. Reliability refers to recording consistent results when repeat trials are performed. The preparation of the standard solution has no effect on reliability. A titration should use the same solution batch, so there is enough for repeat trials.

Question 33 (6 marks)
Outcomes Assessed: **CH11/12-5, CH11/12-6, CH12-14, CH12-15**
Targeted Performance Bands: **2-6**

Criteria	Marks
• Identifies all spectra, with justification	5-6
• Identifies TWO spectra of the different types, with justification	3-4
• Identifies TWO spectra of the same type, with justification	2
• Correctly identifies ONE spectrum OR • Provides ONE piece of relevant information	1

Sample Answer:

A and **B** are mass spectra. **A** has its largest mass peak at 46, corresponding to the molar mass of methanoic acid. **B** has its largest peak at 72, corresponding to the molar mass of pentane.

C, D and **E** are all carbon-13 spectra. **C** has 3 peaks, indicating 3 carbons with different environments. This could indicate pentane or 1-propanol. However, the peaks are spread out, as high as about 60 ppm (indicative of C-O), indicating that the structure is probably not an alkane but 1-propanol. **D** has only one peak, corresponding to one carbon or identical carbons. Only methanoic acid has one carbon, and no other compound has all identical carbons. So **D** is methanoic acid. **E** has two peaks, very widely split, indicating probably 2 carbons with very different environments, one is a low shift which is indicative of an alkane and the other is a large shift, probably similar to the C=O of an acid or ester. So **E** must be ethanamide.

F, G and **H** are infrared spectra. **H** has a very broad band at about 3000 cm^{-1}, indicative of an –OH group on an acid, so **H** is methanoic acid. **F** has a typical C=O peak at about 1700 cm^{-1}. Given that it isn't methanoic acid, this indicates **F** is ethanamide. **G** has a broad peak at about 3300 cm^{-1}, indicating a –OH bond of an alcohol, so **G** is 1-propanol.

Question 34 (a)(3 marks)
Outcomes Assessed: **CH12-12**
Targeted Performance Bands: **3-6**

Criteria	Marks
• Correctly justifies the direction of equilibrium AND • Correctly calculates the concentrations for each substance AND • Substitutes correctly to calculate Q	3
• Correctly calculates the concentrations for each substance AND • Substitutes correctly to calculate Q	2
• Correctly calculates one concentration OR • Some relevant information	1

Sample Answer:

$[A]=\frac{1.00}{0.250}=4.00\ molL^{-1}$

$[B]=\frac{2.00}{0.250}=8.00\ molL^{-1}$

$[C]=\frac{1.00}{0.250}=4.00\ molL^{-1}$

$[D]=\frac{2.00}{0.250}=8.00\ molL^{-1}$

$Q=\frac{(4)\times(8)^4}{(4)\times(8)^2}=64$

$Q > K_{eq}$ therefore the reaction will go towards left, favouring the reactant side.

Question 34 (b) (4 marks)
Outcomes Assessed: **CH12-12**
Targeted Performance Bands: **4-6**

Criteria	Marks
• Correctly calculates the Keq and showing all working out AND • Used reference in the stimulus to justify their answer	4
• Provided substantially correct working out towards calculating K_{eq}	3
• Provided some correct steps	2
• Showed some relevant understanding	1

Sample Answer:

Reaction	***A***	+	***2B***	⇌	***C***	+	***4D***
Initial	4.00		8.00		4.00		8.00
Change	$+x$		$+2x$		$-x$		$-4x$
Equilibrium	$4.00+x$		$8.00+2x$		$4.00-x$		$8.00-4x$

To solve for x:

$[A]$ at equilibrium = 5.56 $molL^{-1}$ = 4.00 + x

x = 5.56−4.00 = 1.56 $molL^{-1}$

Therefore,

[B] = 8.00 + 2x = 8.00 + 2(1.56) = 11.12 $molL^{-1}$

[C] = 4.00 − x = 4.00 −1.56 = 2.44 $molL^{-1}$

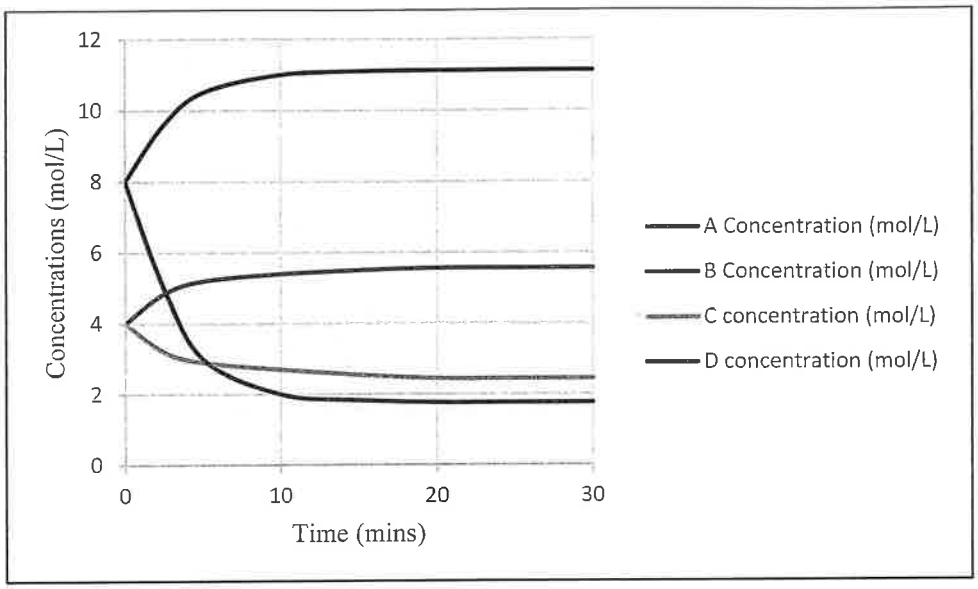
[D] = 8.00 − 4x = 8.00 − 4(1.56) = 1.76 $molL^{-1}$

$K_{eq}=\frac{(2.44)(1.76)^4}{(5.56)(11.12)^2}$ = 0.034, which matches the K_{eq} given at the start.

Question 34 (c) (3 marks)
Outcomes Assessed: **CH12-12**
Targeted Performance Bands: **4-6**

Criteria	Marks
• Correctly drawn THREE concentration/time graphs	3
• Correctly drawn TWO concentration/time graphs	2
• Correctly drawn ONE concentration/time graph	1

Sample answer:



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