Christ Church Grammar School

Year 12 Chemistry
Trial WACE Examination, 2018

Question/Answer Booklet

CHEMISTRY ATAR

Fix student label here

Student Name: _____

Time allowed for this paper
Reading time before commencing work: ten minutes
Working time for paper: three hours

Materials required/recommended for this paper
To be provided by the supervisor
This Question/Answer Booklet; Multiple-choice Answer Sheet; Data Booklet; Results Table for Q 39

To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction tape/fluid, eraser, ruler, highlighters
Special items: non-programmable calculators approved for use in the WACE examinations

Important note to candidates
No other items may be taken into the examination room. It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Section 1		Section 2			Section 3			Totals		
No. Correct	Out of	Q	Mark	Out of	Q	Mark	Out of		Mark	Out of
	25	26		5	36		13	Section 1		50
		27		14	37		9	Section 2		70
		28		9	38		15	Section 3		80
		29		8	39		11	Total		200
		30		4	40		15			
		31		5	41		17	Total		%
		32		7						
		33		4						
		34		6						
		35		8						
		Total		70	Total		80			

Structure of this paper

Section	Number of questions set	Number of questions to be answered	Recommended time (minutes)	Marks Allocated	Percentage of Exam
Section One Multiple-choice	25	ALL	50	25	25
Section Two Short Answer	10	ALL	60	70	35
Section Three Extended Response	6	ALL	70	80	40
				Total	100

Instructions to candidates

1. Answer the questions according to the following instructions.
   Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through the square and shade a new answer. Do not erase or use correction fluid. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any one question.
   Sections Two and Three: Write answers in the Question/ Answer Booklet.

2. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to three significant figures and include appropriate units where applicable.

3. You must be careful to confine your answers to the specific question asked and to follow instructions that are specific to a particular question.

4. Supplementary pages for the use of planning/continuing your answer to a question have been provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.
   Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.

See next page

Section One: Multiple Choice **50 marks (25% of paper)**

This section contains 25 questions. Answer all questions on the Multiple–choice Answer Sheet provided. Use blue or black pen only. If you make a mistake, place a cross through that square. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is given for any question.

Suggested working time for this section is 50 minutes.

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1. In which of the following is nitrogen in the lowest oxidation state (oxidation number)?

   A. $N_2H_5^+$

   B. N_2H_4

   C. NH_2^-

   D. $N_2H_3^-$

2. Which of the following are redox reactions?

   I. $2O_3 \longrightarrow 3O_2$
   II. $2H_2O_2 \longrightarrow 2H_2O + O_2$
   III. $O^{2-} + H_2O \longrightarrow 2OH^-$
   IV. $2H_2 + O_2 \longrightarrow 2H_2O$

   A. II only

   B II, III and IV only

   C. I and IV only

   D. II and IV only

3. How many moles of electrons are consumed when 2 moles of dichromate ($Cr_2O_7^{2-}$) ions are reduced to chromium (II) ions, Cr^{2+}?

   A. 4

   B. 8

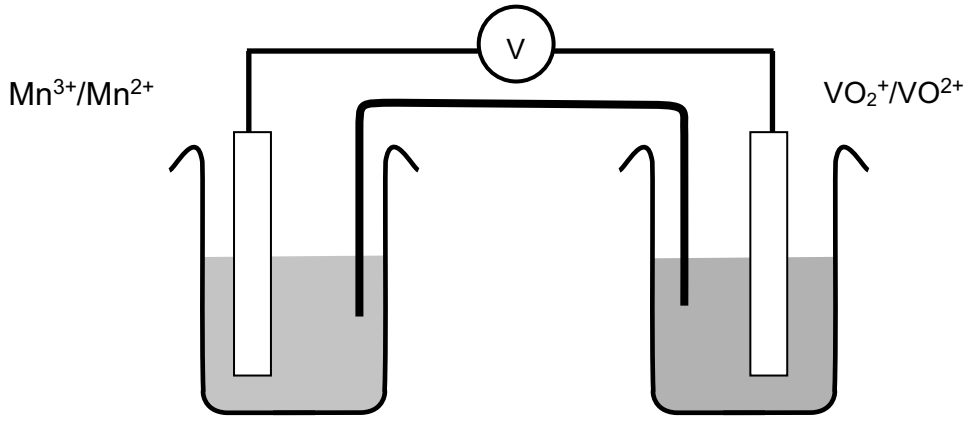
   C. 16

   D. 24

See next page

The following four questions refer to the galvanic cell drawn below.

A beaker containing a mixture of manganese (III) ions, $Mn^{3+}(aq)$, and manganese (II), $Mn^{2+}(aq)$, ions is connected to a beaker containing a mixture of vanadate (V) ions, $VO_2^+(aq)$, and vanadate (IV) ions, $VO^{2+}(aq)$. Both cells are under standard conditions with inert electrodes and a potassium nitrate salt bridge.



The colours of the four ions are as follows:

Ion	Colour
$VO_2^+(aq)$	yellow
$VO^{2+}(aq)$	blue
$Mn^{3+}(aq)$	brown
$Mn^{2+}(aq)$	pale pink

The standard electrode potentials of the two half cells are as follows:

$Mn^{3+}(aq) + e^- \rightleftharpoons Mn^{2+}(aq)$ +1.51 V
$VO_2^+(aq) + 2H^+ + 2e^- \rightleftharpoons VO^{2+}(aq) + H_2O$ +1.02 V

4. Which of the following best describes the electrode in the left-hand beaker?

   A. It is the positive anode.
   B. It is the negative anode.
   C. It is the positive cathode.
   D. It is the negative cathode.

5. What would be the voltage of the cell?

   A. 2.53 V
   B. 0.49 V
   C. 0.16 V
   D. 0.33 V

See next page

6. What changes in colour would you expect to see in the two beakers during cell operation?

	Left hand beaker	**Right hand beaker**
A.	more brown	more yellow
B.	more brown	more blue
C.	more pink	more yellow
D.	more pink	more blue

7. If the the $Mn^{3+}(aq)/ Mn^{2+}(aq)$ mixture in the left-hand beaker was replaced with a $Fe^{3+}(aq)/ Fe^{2+}(aq)$ mixture, which of the following would occur?

A. The direction of flow of electrons would reverse.

B. The voltage of the cell will increase.

C. The mass of the left-hand electrode will increase.

D. A precipitate would form in the left-hand beaker.

8. A reversible reaction has a ΔH value for the forwards reaction of +60 kJ and an activation energy for the backwards reaction of 220 kJ. If a catalyst is added that decreases the activation energy of the forwards reaction to one quarter of its original value, what is the activation energy of the catalysed backwards reaction?

A. 10 kJ

B. 55 kJ

C. 70 kJ

D. 110 kJ

9. Consider the following reversible reactions:

Reaction 1 $\mathbf{H_2(g) + I_2(g) \rightleftharpoons 2HI(g)}$ **ΔH = -10 kJ, K= 49 at 730 K**

Reaction 2 $\mathbf{HI(g) \rightleftharpoons \frac{1}{2} H_2(g) + \frac{1}{2} I_2(g)}$

Which of the following represents the values for ΔH and K at 730 K for reaction 2?

	ΔH	**K**
A.	-10	-0.143
B.	-5	0.143
C.	+10	-0.143
D.	+5	0.143

See next page

10. The Haber Process involves the reaction between nitrogen and hydrogen according to the equation:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad K = 40.7 \text{ at } 400 \text{ K}$$

If 1 mole of nitrogen, 3 moles of hydrogen and 2 moles of ammonia were introduced to a 1.0L vessel at 400K, which of the following statements is correct?

A. The system is at equilibrium because the amounts of each substance are present in the correct ratios, according to the balanced chemical equation.

B. The system is not at equilibrium and, once equilibrium is reached, there will be more than 2 moles of ammonia present.

C. The system is not at equilibrium and, once equilibrium is reached, there will be more than 3 moles of hydrogen present.

D. The system is not at equilibrium and, once equilibrium is reached, there will equal concentrations of all three substances present.

The following two questions relate to the manufacture of methanol according to the equation:

$$CO(g) + H_2O(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -360 \text{ kJ}$$

11. In a particular process, CO(g) and $H_2O(g)$ were added to a vessel and it took 2 minutes for equilibrium to be reached. If the process was repeated at a higher temperature and with a suitable catalyst, which of the following statements would be true?

A. Equilibrium will be reached in less than 2 minutes, and the equilibrium concentration of methanol will be increased.

B. Equilibrium will be reached in less than 2 minutes, and the equilibrium concentration of methanol will be unchanged.

C. Equilibrium will be reached in less than 2 minutes, and the equilibrium concentration of methanol will be decreased.

D. Equilibrium will still be reached in 2 minutes, but the equilibrium concentration of methanol will be decreased.

12. Once the system has reached equilibrium, an inert gas such as argon was added, firstly at constant volume, and then at constant pressure. What effects would these two changes have on the mass of methanol formed?

	Addition of argon at constant volume	**Addition of argon at constant pressure**
A.	no change	no change
B.	increase	no change
C.	no change	increase
D.	no change	decrease

See next page

13. Consider the equilibrium that exists between chromate ions and dichromate ions

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(\ell)$$

Which of the following would result in a decrease in the rate of the backwards reaction, once equilibrium is re-established?

I. Decreasing the temperature.
II. Addition of a small amount of solid NaOH.
III. Addition of water.
IV. Addition of a small amount of solid $NaNO_3$.

A. I only

B. I and II

C. I, II and III

D. II, III and IV

14. Which option would not form a buffer system?

A. $H_2O/NaC\ell$

B. $CH_3CH_2COOH/CH_3CH_2COONa$

C. $H_2PO_4^-/HPO_4^{2-}$

D. H_2NCH_2COOH

15. Which one of the following pairs of reagents would give no evidence of a chemical reaction when mixed?

A. Sodium hydroxide solution and warm ammonium chloride solution

B. Sodium carbonate solution and potassium hydroxide solution

C. Silver nitrate solution and hydrochloric acid

D. Calcium chloride solution and phosphoric acid solution

16. Which of the following statements is true about equal volumes of nitric acid and ethanoic acid of the same concentration?

A. Each contains the same number of H_3O^+ ions in solution.

B. Each has the same pH.

C. Each will require the same amount of sodium hydroxide in order to reach the equivalence point.

D. When each is titrated to equivalence with sodium hydroxide, the pH of the resulting solution is the same.

See next page

17. Which one of the following reagents produces ammonia when mixed with ammonium sulfate and heated?

A. a solution containing potassium permanganate and dilute sulfuric acid.

B. dilute hydrochloric acid

C. limewater (saturated calcium hydroxide solution)

D. water

18. Which is the strongest acid in the equilibrium shown below:

$$\mathbf{H_2CO_3(aq) + S^{2-}(aq) \rightleftharpoons HCO_3^-(aq) + HS^-(aq); \quad K>1}$$

A. S^{2-}

B. H_2CO_3

C. H_3O^+

D. HS^-

19. In pure water at 5°C the hydroxide ion concentration is measured to be 4.0×10^{-8} molL^{-1}. The K_w and pH of pure water at this temperature will be:

	K_w	pH
A.	1.0×10^{-14}	7.0
B.	1.6×10^{-13}	7.6
C.	1.6×10^{-15}	7.0
D.	1.6×10^{-15}	7.4

20. Which one of the following correctly arranges 1.0 molL^{-1} solutions of the substances in the order of increasing pH?

A. $HC\ell < H_2SO_4 < CH_3COONa < CH_3COOH < NH_4CH_3COO$

B. $H_2SO_4 < HC\ell < CH_3COOH < NH_4CH_3COO < CH_3COONa$

C. $H_2SO_4 < HC\ell < CH_3COOH < CH_3COONa < NH_4CH_3COO$

D. $HC\ell < H_2SO_4 < NH_4CH_3COO < CH_3COOH < CH_3COONa$

See next page

21. Which of the following reactions would have the lowest atom economy?

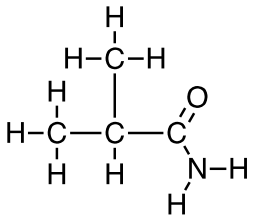
A. The hydration of ethene

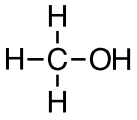
B. The chlorination of prop-1-ene

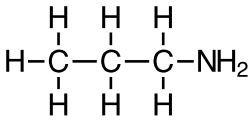
C. Condensation polymerisation

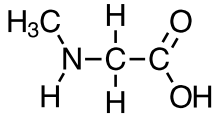
D. Addition polymerisation

22. Which of the following structures could not be classified as being primary?

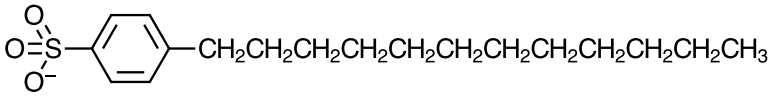
A. 

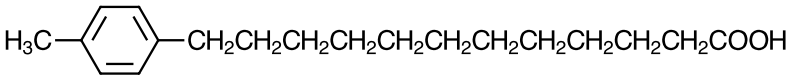
B. 

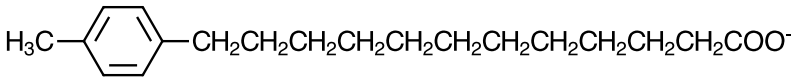
C. 

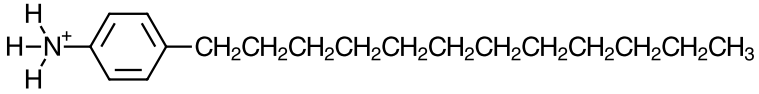
D. 

23. Which of the following structures best represents the structure of an anionic detergent?

A. 

B. 

C. 

D. 

24. How many primary alcohols have the molecular formula C_4H_9OH?

    A. 1

    B. 2

    C. 3

    D. 4

25. When one mole of substance Q was burned completely in oxygen, 3.5 moles of oxygen were consumed and the only products were 3.0 moles each of CO_2 and H_2O. Which of the following could be the name of substance Q?

    A. Propene

    B. Propanoic acid

    C. Propanone

    D. Propanol

End of Section One

See next page

Section Two: Short Answer **70 marks (35% of paper)**

This section has ten (10) questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to an appropriate number of significant figures and include appropriate units where applicable.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page
- Continuing an answer. If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested time for working for this section is 60 minutes.

Question 26 **(5 marks)**

Concentrated sulfuric acid can be used to oxidise halide ions, the sulfur atom in sulfuric acid being reduced. When doing so it can be reduced to a range of different sulfur-containing compounds, including SO_2, S and H_2S.

When reacting with chloride ions, sulfur dioxide is the dominant product. When reacting with bromide ions, sulfur (S) is the dominant product. When reacting with iodide ions, hydrogen sulfide is the dominant product.

Complete the full redox equations for the second and third of these reactions in the boxes provided below; the first one has been done for you.

Reaction	Full redox equation
concentrated sulfuric acid and chloride ions	$H_2SO_4 + 2\,C\ell^- + 2H^+ \rightarrow SO_2 + C\ell_2 + 2\,H_2O$
concentrated sulfuric acid and bromide ions	$H_2SO_4 + Br^- \rightarrow S + Br_2$
concentrated sulfuric acid and iodide ions	$H_2SO_4 + I^- \rightarrow H_2S + I_2$

(4 marks)

Make a statement below about the how the strength of reducing agent affects the change in oxidation number of sulfur.

_____

_____

_____

(1 mark)

See next page

Question 27 **(14 marks)**

The Ostwald Process is an important stage in the manufacture of nitric acid. The equation for the process is:

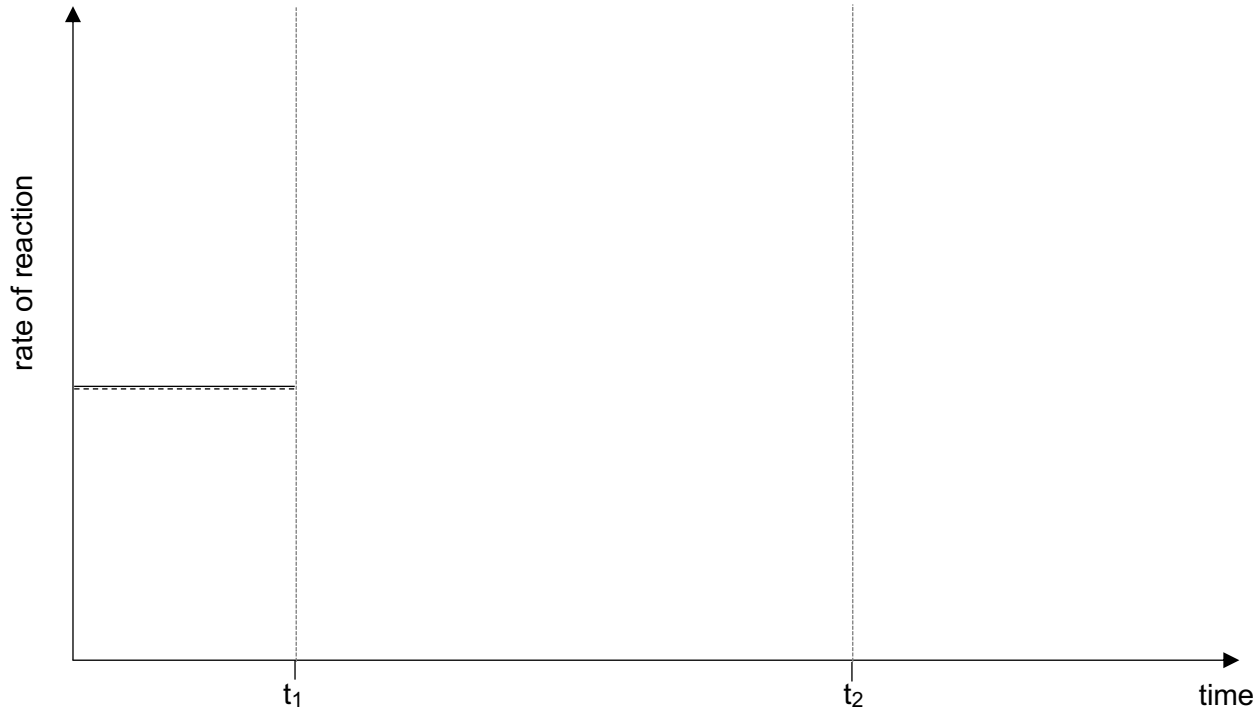
$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -950 \text{ kJ}$$

This system had reached equilibrium at 400 K. The temperature of the system was then increased to 500 K.

(a) Use collision theory to explain the effect of increasing the temperature on the yield of nitrogen monoxide.

(5 marks)

(b) If the volume of the system is decreased at time t_1 and equilibrium is re-established at time t_2, sketch a graph of how the rates of the forwards (——) and backwards (-----) reactions vary with time.



(3 marks)

In a second experiment, the volume of a system at equilibrium was suddenly doubled from 5.00 L to 10.00 L. The concentrations of oxygen and nitrogen monoxide were measured before the change and the concentration of oxygen was measured after the change, once equilibrium had been re-established.

(c) Use the date below and the working space given to fill in the gaps in the table:

	$[O_2]$ ($molL^{-1}$)	**[NO] ($molL^{-1}$)**	**amount of NO (mol)**
before change	0.214	0.326	
after change	0.092		

(6 marks)

Space for working

Question 28 **(9 marks)**

Consider the following equilibrium;

$$3MnO_4^{2-}(aq) + 2H_2O(\ell) \rightleftharpoons 2MnO_4^{-}(aq) + MnO_2(s) + 4OH^{-}(aq)$$

Various changes were imposed on this equilibrium mixture. Use your knowledge of equilibrium to complete the table below, showing the changes in the quantities shown once equilibrium has been re-established. Write **increase**, **decrease** or **no change** in each of the boxes.

Change imposed	Effect on rate of forward reaction	Effect on mass of solid manganese dioxide	Effect on pH
The system is diluted with water			
A small volume of concentrated nitric acid is added			
A small volume of concentrated potassium permanganate ($KMnO_4$) is added			

See next page

Question 29 **(8 marks)**

1.80 g of indium(III) nitrate is dissolved in 20.0 mL of distilled water and then added to 40.0 mL of 0.502 $molL^{-1}$ potassium hydroxide solution. A precipitate of insoluble indium(III) hydroxide forms.

Calculate the pH of the resulting solution.

See next page

Question 30 **(4 marks)**

Sodium benzoate dissociates to form the benzoate ion, $C_6H_5COO^-$ which when added to acidic food, acts as a preservative. When added, it produces benzoic acid, C_6H_5COOH and an equilibrium between benzoate ions and the benzoic acid is established. Part of its preservative action is due to it acting as a buffer.
(K_a of benzoic acid = 6.5×10^{-5})

(a) Give an equation showing the buffer system.

_____

(1 mark)

(b) Explain how the buffer system produced in the food would respond to the addition of an alkaline ingredient, including equations where possible.

_____

_____

_____

_____

_____

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_____

_____

(3 marks)

Question 31 **(5 marks)**

Citric acid is a weak, triprotic acid found in citrus fruits and is used in many processed foods as an additive. The citric acid present in fruit juice was determined using volumetric analysis. A suitable procedure is outlined below. You may assume that citric acid is the only acid present in the juice.

1. The fruit juice was diluted by taking a 25.0 mL of fruit juice, accurately pipetting this volume into a 250 mL volumetric flask and making to volume with distilled water.

2. A 25.0 mL aliquot of the diluted fruit juice was placed in a conical flask.

3. A standardised, freshly prepared sodium hydroxide solution was placed into a burette.

4. A few drops of phenolphthalein, which changes colour in the pH range 8.0 to 10.0, were added to the conical flask and the titration was carried out.

5. The procedure was repeated using a clean, dry conical flask for each additional analysis until concordant results were obtained.

Complete the table below indicating how the titre volume and the citric acid concentration calculated for the fruit juice would be affected by the changes listed. Use the terms **increase**, **decrease** or **no change**.

Difference from outlined procedure	Effect on titre volume	Effect on calculated citric acid concentration
Burette was rinsed with water		
Bromocresol green was used as an indicator (pH colour change range: 4.0 – 5.6)		
The volumetric flask was overfilled		

See next page

Question 32 **(7 marks)**

Two different saturated alcohols, each with the molecular formula C_4H_8O, were reacted with acidified $K_2Cr_2O_7$. An excess of the alcohol was used in each case.

Reaction 1: $C_4H_8O \longrightarrow$ **Product A**
Reaction 2: $C_4H_8O \longrightarrow$ **Product B** $\longrightarrow$ **Product C**

(a) Draw full structural formula for the alcohols used in the Reaction1 and 2 in the table below.

Structure of alcohol in Reaction 1	Structure of alcohol in Reaction 2

(2 marks)

(b) The boiling point of **Product A** is lower than the alcohol used in Reaction 1. Give an explanation for this.

_____

_____

_____

_____

_____

(3 marks)

(c) Give a chemical test that could be used to distinguish between **Products A** and **C**.

Test:_____

Observations for **A**	Observations for **C**

(2 marks)

Question 33 **(4 marks)**

0.1 mol L^{-1} concentrations of two acids, nitric acid (HNO_3) and nitrous acid (HNO_2) were prepared and their pH measured. The following results were obtained:

$HNO_3 = 1$ $HNO_2 = 2.13$

Explain the difference in pH using chemical equations and calculations where possible.

(4 marks)

Question 34 **(6 marks)**

Complete the tables below, drawing full structural formulae for the substances described.

(a) (i) The reactants that produce the ester, 2-butylpropanoate.

Reactant 1	Reactant 2
Name: _____	Name: _____

(4 marks)

See next page

(b) (i) An unsaturated hydrocarbon capable of producing 2,3-dibromopentane when reacted with bromine.

Reactant 1
Name: _____

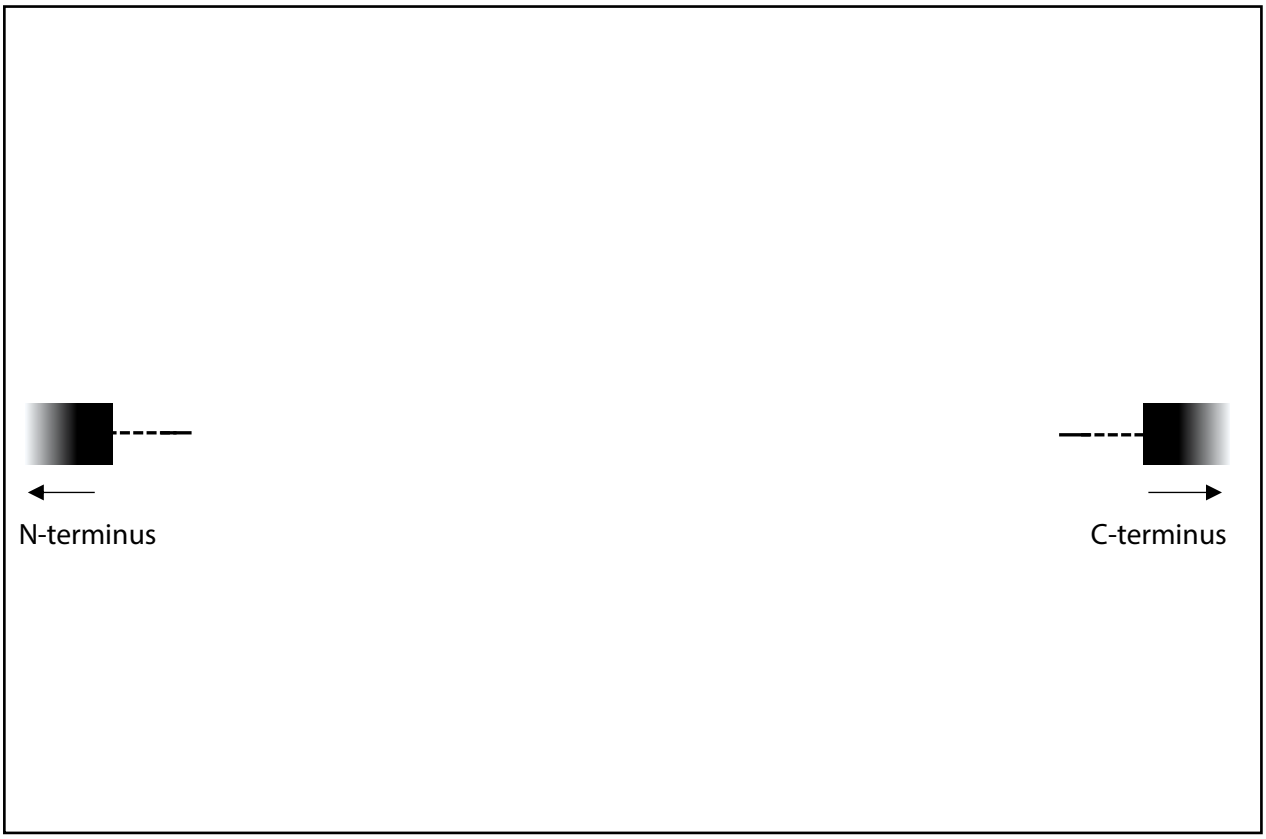
(2 marks)

Question 35 **(8 marks)**

Silk is a naturally occurring fibre consisting of two main proteins. One of these called fibroin contains the recurrent sequence shown below and provides the high strength associated with the silk fibre.

$$(\text{Gly-Ser-Gly-Ala-Gly-Ala})_n$$

(a) Draw the full structure of the **Ser-Gly-Ala** portion of fibroin in the space provided below:



(3 marks)

(b) The strength of silk is largely due to the presence of intermolecular forces between parts of the protein chain. Name and explain the origin of the predominant intermolecular force present between sections of the peptide backbone of the fibroin.

Name of intermolecular force:

_____ (1 mark)

Explanation of origin of the intermolecular force:

_____

_____

_____

_____

_____

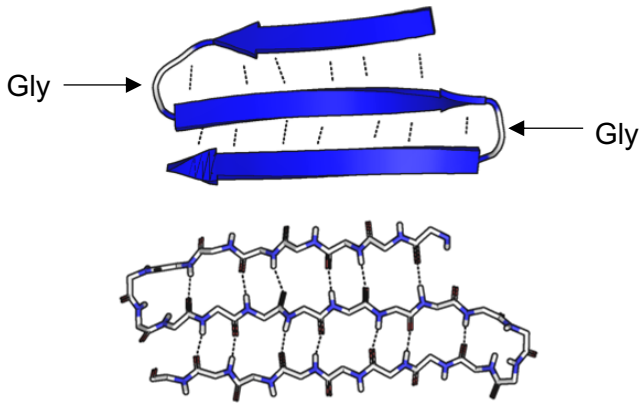
_____

_____

_____

(3 marks)

(c) The presence of glycine residues enables the protein chain to fold back on itself. This is shown in the schematic diagram below:



What is the name given to the structure shown above?

_____

(1 mark)

End of Section Two

See next page

Section Three: Extended answer **80 marks (40% of paper)**

This section contains **six** questions. You must answer **all** questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to an appropriate number of significant figures.

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- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
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Suggested working time for this section is 70 minutes.

Question 36 **(13 marks)**

Natural gas is a naturally occurring hydrocarbon gas consisting primarily of methane. Other hydrocarbons are also present, as are many other substances. One such substance is hydrogen sulfide, H_2S. Natural gas containing high levels of hydrogen sulfide (typically above about 4ppm) is often called 'sour gas'. Hydrogen sulfide is corrosive and extremely poisonous, so its presence in sour gas needs to be decreased.

There are several methods of hydrogen sulfide removal. One of these is the Claus process.

Reaction 1 $\mathbf{8H_2S + 4O_2 \longrightarrow S_8 + 8H_2O}$

(a) In a particular process, Reaction 1 is known to be only 61.4% efficient. If the treatment of 10 tonnes of sour gas yielded 79.2 g of elemental sulfur, calculate the ppm level of hydrogen sulfide in the sour gas.

(4 marks)

See next page

In the laboratory, the hydrogen sulfide level in a sample of sour gas can instead be determined as follows:

1. Passing the gas through an excess of an oxidising agent such as potassium dichromate to react all of the hydrogen sulfide.

$$4Cr_2O_7^{2-} + 3H_2S + 26H^+ \longrightarrow 8Cr^{3+} + 3SO_4^{2-} + 16H_2O$$

2. Reacting the excess dichromate ions with a solution of hydrogen peroxide.

$$Cr_2O_7^{2-} + 3H_2O_2 + 8H^+ \longrightarrow 2Cr^{3+} + 3O_2 + 7H_2O$$

(b) In a laboratory experiment, it was found that when 987 L of sour gas was analysed in this way and passed through 100 mL of 0.0104 $molL^{-1}$ potassium dichromate, 23.2 mL of 0.0482 $molL^{-1}$ hydrogen peroxide was required to react with the excess dichromate ions. Calculate the concentration (in $molL^{-1}$) of hydrogen sulfide in the sour gas sample.

(6 marks)

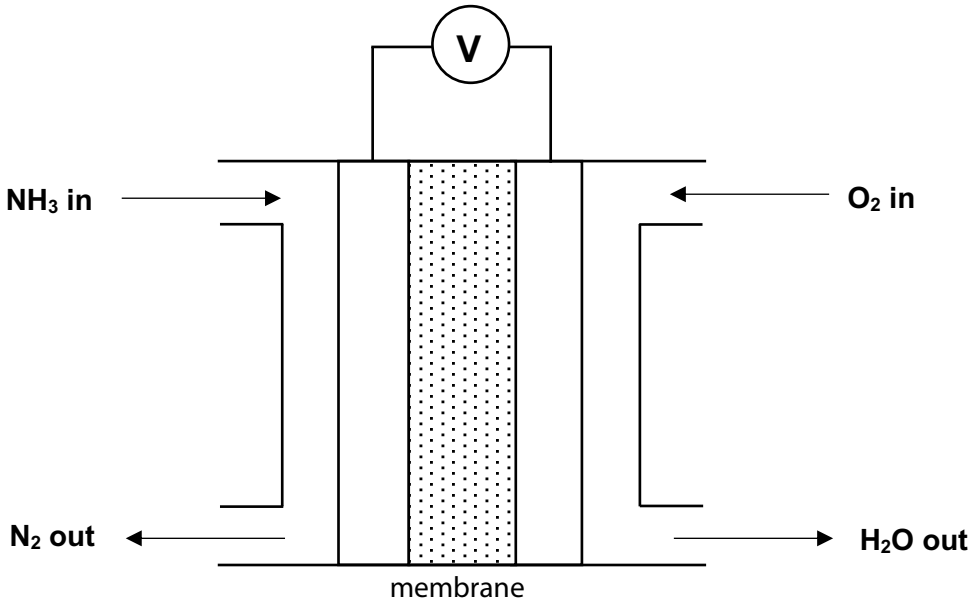
(c) Given that the density of the sour gas was 0.739 gL^{-1}, calculate the ppm level of the hydrogen sulfide in the laboratory sample.

(3 marks)

See next page

Question 37 **(9 marks)**

There is much interest in fuel cell technology as scientists look for alternative green energy sources. One such cell is the ammonia fuel cell. A simplified diagram of such a cell is shown below:



(a) Construct half-equations for the oxidation and reduction reactions and combine them into an overall redox equation.

Oxidation half equation	
Reduction half equation	
Overall redox equation	

(6 marks)

(b) On the diagram for the fuel cell given above, indicate the direction of electron flow in the external circuit, and identify the direction of flow of cations across the membrane.

(2 marks)

(c) Suggest why the ammonia fuel cell is considered a clean energy source.

_____

_____

_____

(1 mark)

See next page

Question 38 **(15 marks)**

(a) Western Australia has very large underground reserves of lithium, mostly in the form of lithium chloride. The lithium is extracted by the electrolysis of molten lithium chloride.

(i) At which electrode will the lithium metal be formed?

_____

(1 mark)

(ii) Write an equation for the reaction at the anode.

_____

(1 mark)

(b) One use of lithium metal is in the lithium-ion galvanic cell. The anode reaction involves the oxidation of lithium metal, which is bound on to graphite (represented by C_6)

$$LiC_6 \longrightarrow Li^+ + C_6 + e^-$$

The cathode reaction is as follows:

$$CoO_2 + Li^+ + e^- \longrightarrow LiCoO_2$$

(i) Identify the element that is reduced at the cathode and give its change in oxidation number.

The _____ is reduced from _____ to _____.

(2 marks)

(ii) Write the combined redox reaction for the overall cell.

Overall redox equation	

(1 mark)

See next page

(c) A useful laboratory chemical containing lithium is lithium aluminium tetrahydride, $LiA\ell H_4$. It is a powerful reducing agent and can be used to reduce a wide range of organic substances.

(i) What is the oxidation number of hydrogen in $LiA\ell H_4$? _____

(1 mark)

Butanal can be reduced by reaction with lithium aluminium tetrahydride according to the following equation:

$$8C_4H_8O + 2LiA\ell H_4 + 8H^+ \rightarrow 8\ C_4H_{10}O + 2A\ell^{3+} + 2Li^+$$

(ii) Draw the structure of butanal and the most likely structure of the organic product of the reaction.

Full structural formula for butanal	Full structural formula of the product

(2 marks)

Lithium aluminium tetrahydride reacts violently in water, and so it is important that the other reactants are in excess.

(iii) What is the maximum mass of lithium aluminium tetrahydride that could be safely used to reduce 20.0 mL of butanal, which has a density of 0.817 gmL^{-1}?

_____

_____

_____

_____

_____

(4 marks)

(iv) There is some concern about the effects of aluminium ions on health. K_3PO_4 (aq) is added in order to ensure that all the aluminium ions are removed by precipitation before disposing of the reaction mixture. Assuming that all the $LiA\ell H_4$ reacts, what volume of 0.12 $molL^{-1}$ potassium phosphate solution would need to be added?

_____

_____

_____

_____

(3 marks)

See next page

Question 39 **(11 marks)**

Much can be learned about chemical reactions by a study of kinetics (reaction rates). One such study is the Harcourt-Essen reaction, which is the acid-catalysed iodination of propanone, the equation for which is given below

$$C_3H_6O + I_2 \longrightarrow C_3H_5OI + HI$$

(a) Draw the full structural formula of iodopropanone in the box below

(1 mark)

A series of reactions was performed in which the concentrations of propanone, iodine and hydrogen ions were varied and the initial rate of formation of iodopropanone (CH_3COCH_2I) was monitored. A summary is given of eight individual experiments is given in the table below.

For your convenience this table is also provided on a separate sheet.

Experiment	$[CH_3COCH_3]$ ($molL^{-1}$)	$[I_2]$ ($molL^{-1}$)	$[H^+]$ ($molL^{-1}$)	Initial rate of formation of iodopropanone ($molL^{-1}s^{-1}$)
1	0.0200	0.0100	0.00300	3.68×10^{-6}
2	0.0400	0.0100	0.00300	7.35×10^{-6}
3	0.0600	0.0100	0.00300	1.11×10^{-5}
4	0.0800	0.0100	0.00300	1.47×10^{-5}
5	0.0400	0.0200	0.00300	7.36×10^{-6}
6	0.0400	0.0300	0.00300	7.34×10^{-6}
7	0.0800	0.0100	0.00500	2.45×10^{-5}
8	0.0800	0.0100	0.00100	4.81×10^{-6}

(b)(i) On the graph provided, plot how the initial rate of reaction varies with the concentration of propanone, using the results of **Experiments 1,2,3** and **4**.

See next page

(3 marks)

See next page

(ii) What would be a suitable conclusion to draw from these results?

_____

_____

(1 mark)

(c) Now consider experiments **4, 7** and **8**.

(i) Identify the independent variable, dependent variable and two explicitly controlled variables for these experiments.

Independent variable _____

Dependent variable _____

Controlled variables

1._____

2._____

(3 marks)

(ii) Identify one other variable that would also need to be controlled to ensure the validity of the results.

_____

(1 mark)

(d) Finally, considering all the data in the table, what would you conclude about the effect of iodine on the initial rate of reaction?

_____

_____

(2 marks)

Question 40 **(15 marks)**

A protein present in silk is called sericin. The structure of sericin is not fully known but it is a sticky substance which is present in large amounts in spider silk. As part of attempts to determine the structure of sericin, analyses were carried out to determine the quantities of the elements present, namely carbon, hydrogen, nitrogen and oxygen.

Complete combustion of an 800 mg sample of sericin produced 1.33 g of carbon dioxide. When a 2.41 g of sericin was combusted, 1.09 g of water were produced.

A further 1.69 g sample of the sericin was treated to produce a solution of ammonia. When this solution was titrated with 1.0 $molL^{-1}$ hydrochloric acid, 21.1 mL of the acid was required to fully react with the ammonia present.

(a) Determine the empirical formula of sericin.

(11 marks)

See next page

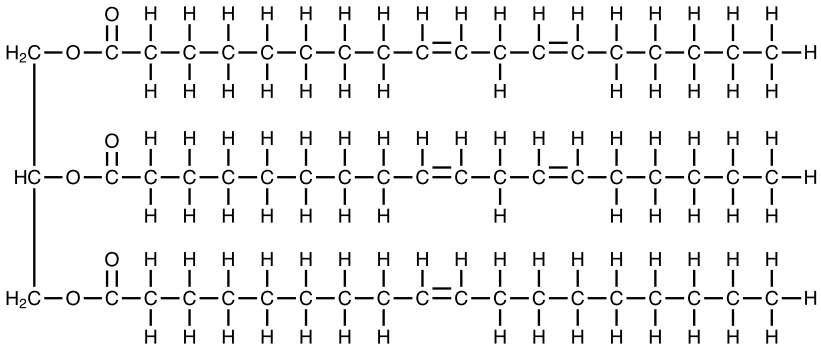
(b) At a temperature of 600°C, a sample of 7.35 g was found to occupy a volume of 930 mL at 72 kPa. From this information determine the molecular formula of sericin.

(4 marks)

Question 41 **(17 marks)**

Sunflower oil is used widely in the food industry. The used oil is often sold on to make biodiesel. The process uses a suitable base but the quantity of it that is used needs to be carefully controlled and varies from batch to batch.

(a) The structure of sunflower oil is shown below. The amount of base used varies due to the free fatty acid content of the oil.



(i) Draw the structure of the monounsaturated free fatty acid that would originate from sunflower oil in the box below.

(2 marks)

(b) To determine the amount of base that needs to be added, a titration is carried out between a sample of the oil and potassium hydroxide to determine the free fatty acid content (FFA).

From the table below, select an appropriate indicator for the titration and justify your answer using equations where appropriate. You may refer to the free fatty acids as R-COOH.

Indicator	pH range
Bromocresol green	3.8 (yellow) – 5.4 (blue)
Phenolphthalein	8.0 (colourless) – 10.0 (pink)

Chosen indicator: _____

Justification including a relevant equation:

_____

_____

_____

_____

_____

_____

(4 marks)

(c) When 0.217 $molL^{-1}$ potassium hydroxide was titrated with a 20.0 mL sample of oil, the following titres were obtained. Complete the table below and determine the average titre.

	Rough	1	2	3	4
Initial volume / mL	0.95	4.35	2.35	2.10	3.75
Final volume / mL	19.40	21.60	19.55	20.40	20.95
Titre volume / mL					

(i) Average titre: _____

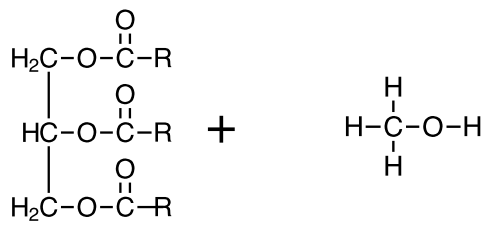
(2 marks)

See next page

(ii) From this data determine the % by mass of free fatty acid content of the oil. You may assume the free fatty acid is all linoleic acid, $C_{18}H_{32}O_2$. The average density of sunflower is 0.93 gmL^{-1}.

(5 marks)

(d) Using the space below, complete and balance the reaction for producing biodiesel using a suitable catalyst. For simplicity, the structure of the oil is shown with R- groups denoting parts of the oil molecule.



(4 marks)

End of questions

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