Christ Church Grammar School

Year 12 Chemistry
Mid-year Examination 2016

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten minutes
Working time for the paper: Three hours

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER
To be provided by the candidate

Pens, pencils, calculator satisfying the conditions set by the School Curriculum & Standards Authority

To be provided by the supervisor

This Question/Answer Booklet; Multiple-choice Answer Sheet; Chemistry Data Sheet.

Section 1		Section 2			Section 3			Totals		
No. Correct	Out of	Q	Mark	Out of	Q	Mark	Out of		Mark	Out of
	25	26	7		37	15		Section 1		50
		27	1		38	12		Section 2		70
		28	9		39	15		Section 3		80
		29	12		40	9		Total		200
		30	6		41	18				
		31	8		42	11		**Total**		**%**
		32	7							
		33	6							
		34	6							
		35	4							
		36	4							
		Total		70	Total		80			

STRUCTURE OF THE PAPER

Section	Format	No. of questions set	No. of questions to be attempted	Recommend time (minutes)	Marks Allocated	% of Exam
1	Multiple Choice	25	ALL	50	25	25%
2	Short Answer	11	ALL	60	70	35%
3	Extended Response	6	ALL	70	80	40%

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. Spare pages are included at the end of the booklet. They can be used for planning your responses and/ or as 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 an answer is to be 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.

Section One: Multiple Choice **25 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.

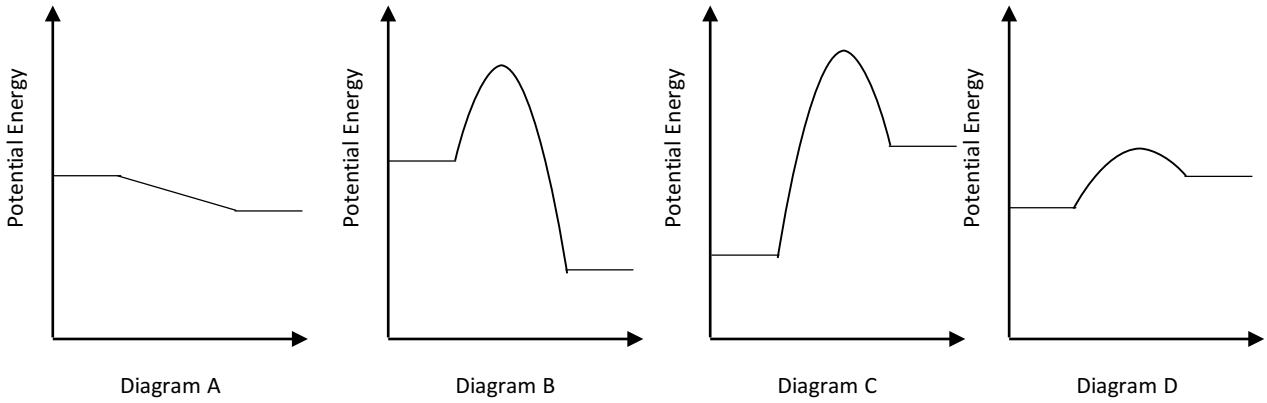
Suggested working time for this section is 50 minutes.

---

1. Consider the following reaction:

$$CH_4\,(g) + 2O_2\,(g) \rightarrow CO_2\,(g) + 2H_2O\,(\ell)$$

The following energy profile diagrams are all drawn on identical scales. Which energy profile diagram below would best correspond to this reaction?



A. Diagram A

B. Diagram B

C. Diagram C

D. Diagram D

2. In the laboratory iron(III) chloride solutions must be prepared just before use, as the following reaction occurs if left to stand:

$$Fe^{3+}\,(aq) + 3H_2O(\ell) \rightleftharpoons Fe(OH)_3(s) + 3\,H^+(aq)$$

To prevent the precipitation of $Fe(OH)_3$ you could:

A. add KOH(aq)

B. add Fe^{3+}(aq)

C. add $HC\ell$ (aq)

D. add $H_2O(\ell)$

3. In which of the following chemical equilibrium systems will the position of equilibrium be shifted to the LEFT by an INCREASE in PRESSURE?

(i) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$
(ii) $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$
(iii) $C_3H_8(g) + 5\ O_2(g) \rightleftharpoons 3CO_2(g) + 4\ H_2O(g)$
(iv) $C\ell_2(g) + 3F_2(g) \rightleftharpoons 2C\ell F_3(g)$

A. (i) only
B. (i) and (ii) only
C. (i) and (iii) only
D. (i), (iii) and (iv) only

4. A mixture of gases is in equilibrium at 500°C as represented by the equation:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92\ kJ$$

The magnitude of the equilibrium constant, K, at this temperature is 1.1×10^{-7}.

The temperature is increased to 650°C at constant volume. Which of the following statements is TRUE?

A. The number of molecules of NH_3 increases.
B. The equilibrium constant increases.
C. No effect on the equilibrium position is observed.
D. The concentration of H_2 increases.

5. Under certain conditions cyclohexane, C_6H_{12}, can react to form benzene, C_6H_6 and hydrogen according to the equation below. A mixture of the gases was placed in a container with a movable piston and allowed to come to equilibrium.

$$C_6H_{12}(g) \rightleftharpoons C_6H_6(g) + 3\ H_2(g) \qquad \Delta H = +206\ kJ$$

Which of the following changes would increase the mass of benzene at equilibrium?

A. Adding a catalyst
B. Decreasing the volume of the container.
C. Decreasing the external pressure.
D. Adding hydrogen at constant volume.

6. An important reaction that occurs in the atmosphere during thunderstorms can be studied in the laboratory by mixing NO and O_2 gas. The gases react according to the following equation:

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

1 mole of NO and 1 mole of O_2 were mixed in a 1 L container and the reaction was allowed to reach equilibrium at 200^{O}C.

At equilibrium the concentrations of the reactants and products were:
$[NO] = 0.5\ molL^{-1}$ $[O_2] = 0.75\ molL^{-1}$ $[NO_2] = 0.5\ molL^{-1}$

The container was heated to 500^{O}C and it was found that once equilibrium had been reestablished the $[O_2]$ had decreased to $0.6\ molL^{-1}$.
From this information we can conclude:

A. The reaction is exothermic and the concentration of NO_2 will be $0.65\ molL^{-1}$

B. The reaction is exothermic and the concentration of NO_2 will be $0.8\ molL^{-1}$

C. The reaction is endothermic and the concentration of NO_2 will be $0.65\ molL^{-1}$

D. The reaction is endothermic and the concentration of NO_2 will be $0.8\ molL^{-1}$

7. Cobalt (II) salts generally appear pink due to the presence of $Co(H_2O)_6^{2+}(aq)$ but the ion $CoC\ell_4^{2-}(aq)$ is blue in colour. For the reaction

$$Co(H_2O)_6^{2+}(aq) + 4C\ell^-(aq) \rightleftharpoons CoC\ell_4^{2-}(aq) + 6\,H_2O(l) \quad \Delta H = +12.4kJ$$

Which of the following would cause the reaction mixture to take on a stronger BLUE colour?

(i) adding water
(ii) adding concentrated hydrochloric acid
(iii) adding silver nitrate solution
(iv) heating
(v) cooling

A. (i), (ii) and (iv) only

B. (ii) and (iv) only

C. (ii) and (v) only

D. (i), (iii) and (iv) only

8. A closed system reaches equilibrium, as shown by the equation, at a temperature of 473K

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

Which of the following would occur if a small quantity of calcium carbonate is introduced into the system at equilibrium?

A. a reaction will occur to produce more carbon dioxide

B. the mass of both calcium carbonate and calcium oxide will have increased at re-establishment of equilibrium

C. the equilibrium constant, K will increase

D. the gas pressure will remain constant

9. Which of the following would not be suitable to make a buffer solution

A. the amino acid isoleucine

B. H_2CO_3 and $NaHCO_3$

C. nitric acid and potassium nitrate

D. potassium hydrogenphosphate and potassium dihydrogenphosphate

10. Which of the following equations best represents the change taking place when aqueous ammonia reacts with nitric acid?

A. $HNO_3 + NH_3 \rightarrow NO_3^- + NH_4^+$

B. $HNO_3 + NH_3 \rightarrow + NH_4 NO_3$

C. $H^+ + NH_3 \rightarrow NH_4^+$

D. $HNO_3 + H_2O \rightarrow NO_3^- + H_3O^+$

11. Which of the following is a possible pH of 1.0 $molL^{-1}$ sulfuric acid at 25°C?

A. -0.2

B. 0.0

C. 0.2

D. -0.4

12. Which of the following pairs of substances are conjugate acid-base pairs?

(i) H^+ and OH^-
(ii) H_2CO_3 and CO_3^{2-}
(iii) $H_2PO_4^-$ and HPO_4^{2-}
(iv) NH_3 and NH_4^+

A. (i), (ii) and (iv) only

B. (ii) and (iii) only

C. (iii) and (iv) only

D. all of the above

13. Propanoic acid is a weak organic acid that ionises in aqueous solution according to the following equation:

$$CH_3CH_2COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3CH_2COO^-_{(aq)} + H_3O^+_{(aq)}$$

If the pH of a 0.100 mol L^{-1} propanoic acid solution is 2.43 at 25°C, then the percentage of propanoic acid molecules that have ionised is:

A. 2.43%

B. 3.72%

C. 4.57%

D. 41.2%

14. The pH of 125 mL of 0.025 mol L^{-1} nitric acid at 25°C will be approximately

A. 1.60

B. 1.30

C. 0.90

D. 2.51

15. Propanoic acid and benzoic acid are both monoprotic weak acids whose equilibrium constants are listed below:

Propanoic acid $C_3H_7COOH \rightleftharpoons H^+ + C_3H_7COO^-$; $K = 1.35 \times 10^{-5}$

Benzoic acid $C_6H_5COOH \rightleftharpoons H^+ + C_6H_5COO^-$; $K = 6.31 \times 10^{-5}$

Which of the following statements is true?

A. Benzoic acid is a weaker acid than propanoic acid.

B. The pH of a 0.100 $molL^{-1}$ solution of benzoic acid will be higher than that of a 0.100 $molL^{-1}$ solution of propanoic acid.

C. The benzoate ion is a stronger base than the propanoate ion.

D. A 0.100$molL^{-1}$ solution of benzoic acid will react faster with a piece of magnesium metal than will a 0.100$molL^{-1}$ solution of propanoic acid with an identical piece of magnesium.

16. Ionisation of ethanoic acid can be represented by the following equation:

$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$$

When added to an aqueous solution of sodium ethanoate, which of the following would **increase** the concentration of ethanoate ions?

A. Solid sodium hydroxide

B. A few drops of concentrated hydrochloric acid

C. A few drops of silver nitrate

D. Distilled water.

17. Which of the following solutions will have the lowest pH at 25°C?

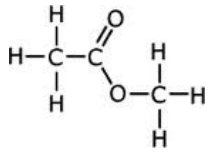
A. 0.10 mol L^{-1} H_2SO_4

B. 0.05 mol L^{-1} H_3PO_4

C. 0.20 mol L^{-1} HNO_3

D. 0.20 mol L^{-1} CH_3COOH

Questions 18, 19 and 20 refer to the following six substances

I	Ethanoic acid		IV	CH_3CH_2CHO
II	CH_3COCH_3		V	ethyl methanoate
III	$CH_3CH(OH)CH_2CH_2CH_3$		VI	

18. Which of the substances can be oxidized by acidified potassium dichromate?

A. III and IV

B. I, III and IV

C. I, II and IV

D. II, III and IV

19. What would be the correct name of the organic product formed when I is reacted with III?

A. 2-ethylpentanoate

B. 2-pentylethanoate

C. 1-ethylpentanoate

D. 1-pentylethanoate

20. Which of the following is true?

A. The dominant intermolecular forces between molecules of V and VI are hydrogen bonds.

B. When V is hydrolysed in acidic conditions, I is one of the products.

C. III and IV have the same empirical formula.

D. When VI is hydrolysed in acidic conditions, I is one of the products.

21. Consider the acids, ethanoic acid and hexanoic acid. Compared to ethanoic acid, hexanoic acid would have:

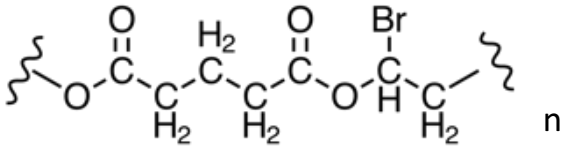
A. a higher boiling point and greater solubility in water.

B. a higher boiling point and lower solubility in water.

C. a lower boiling point and greater solubility in water.

D. a lower boiling point and lower solubility in water.

22. A particular polymer can be represented by this repeating unit:



Which of the following pairs of monomers would be required to prepare this polymer?

A. $HOOCCH_2CH_2CH_2COOH$ and $HOCH_2CHBrCH_2OH$

B. $HOOCCH_2CH_2CH_2OH$ and $HOOCCHBrCH_2OH$

C. $HOOCCH_2CH_2CH_2COOH$ and $HOCHBrCH_2OH$

D. $HOOCCH_2CH_2CH_2OH$ and $HOCHBrCH_2COOH$

23. Which of the following statements is true?

A. Leucine, isoleucine and methionine all have non-polar side chains

B. Serine, threonine and proline all have side chains that can form hydrogen bonds with each other.

C. Tyrosine and tryptophan contain delocalised electrons.

D. Lysine, asparagine and alanine all have basic amino acids

24. One mole of an alkane requires 6.5 moles of oxygen for complete combustion. The molecular formula of the alkane is:

A. C_3H_8

B. C_4H_{10}

C. C_5H_{12}

D. C_6H_{14}

25. Which of the following can exhibit cis-trans isomerism?

(i) But-2-ene
(ii) $CH_2C\ell CH_2C\ell$
(iii) But-1-ene
(iv) $CH_2{=}CC\ell_2$

A. (i), (ii) and (iv)

B. (i), (iii) and (iv)

C. (i) only

D. All of the above

END OF SECTION ONE

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

This section has **eleven** 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 three 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 **(7 marks)**

Write balanced equations and observation in part (for the following reactions:

(a) Solid potassium oxide and methanoic acid

_____

(2 marks)

(b) Glycine and sodium hydroxide solution

_____

(2 marks)

(c) Bromine water is added to cyclohexene

_____

Observation:_____

_____

(3 marks)

Question 27 **(1 mark)**

Write an expression for the equilibrium constant, K, for the following reaction

$$Fe_3O_4(s) + 4\,H_2(g) \rightleftharpoons 3\,Fe(s) + 4\,H_2O(g)$$

Question 28 **(9 marks)**

Consider the following reaction:

$$C_5H_{12} + Br_2 \rightleftharpoons C_5H_{11}Br + HBr \qquad \Delta H = +ve$$

The melting points and boiling points of each of the species in the process are given in the table below:

Species	Melting point (^{0}C)	Boiling point (^{0}C)
C_5H_{12}	-129	36
Br_2	-7.2	58.5
$C_5H_{11}Br$	-95	130
HBr	-87	-67

a) Four identical reaction vessels were set up containing 1 mole of C_5H_{12} and 1 mole of Br_2 at 200°C.

Vessel 1 the mixture was allowed to reach equilibrium
Vessel 2 the temperature was decreased to 50°C and the mixture was allowed to reach equilibrium
Vessel 3 1 mole of xenon gas was added and the mixture was allowed to reach equilibrium
Vessel 4 a catalyst was added and the mixture was allowed to reach equilibrium

Compare the rate of attainment of equilibrium and the mass HBr produced in containers 2, 3 and 4 to that in Container 1 (increase, decrease, remain the same).

	Effect on the rate of attainment of equilibrium	Effect on the mass of HBr(g)
Vessel 2		
Vessel 3		
Vessel 4		

(6 marks)

(b) Predict the effect of the following changes on the position of the equilibrium.

Change	Effect on the equilibrium (left, right, no change)
The volume of the container is increased at 100^{O}C	
HBr is added at constant temperature at 25^{O}C	
Bromine is added at constant temperature at 25^{O}C	

(3 marks)

Question 29 **(12 marks)**

Consider the equilibrium:

$$4\,NH_3(g) + 5\,O_2(g) \rightleftharpoons 4\,NO(g) + 6\,H_2O(g) \quad \Delta H = -908\ kJ$$

a) When the following changes are imposed on the system at equilibrium, describe the change in the concentration of NO(g) and the rate of the forward reaction after equilibrium is reestablished. (Use the terms increase, decrease or no change)

Change	Effect on [NO]	Effect on forward rate of reaction
The volume of the vessel is decreased		
The temperature is decreased		
Addition of a suitable catalyst		
Addition of H_2O at constant volume		

(8 marks)

(b) What conditions of temperature and pressure would be most suitable to optimise the production of NO? Give an explanation for your answer.

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4 marks)

Question 30 **(6 marks)**

(a) Write an equation to represent the ionisation of water

_____

(1 mark)

The following table shows the pH of water at three different temperatures

Temperature (°C)	pH
10	7.27
30	
50	6.63

(b) Given that the value of K_w is 1.47×10^{-14} at 30°C, calculate the pH of water at this temperature and enter your value in the table above

_____

_____

_____

_____

(2 marks)

(c) Considering water at 10°C, would you expect it to be acidic, basic or neutral. Circle your answer below:

acidic **basic** **neutral**

(1 mark)

(d) Explain your answer to (c)

_____

_____

_____

(2 marks)

Question 31 **(8 marks)**

(a) The following ionic salts were all dissolved separately in equal volumes of water at 25°C. The approximate pH of the solutions formed was measured and recorded as being either neutral ('7'), acidic ('5') or basic ('9'). Complete the table below.

salt dissolved	**approximate pH ('5','7' or '9')**
potassium nitrate	
ammonium chloride	
sodium phosphate	
potassium hydrogensulfate	

(4 marks)

(b) One further ionic salt, phosphonium ethanoate, PH_4CH_3COO was dissolved in water and was found to have a pH of below 7. Use your knowledge of acid/base chemistry to account for this observation. Use equations to support your answer.

_____

_____

_____

_____

_____

_____

(4 marks)

Question 32 **(7 marks)**

Calculate the pH of the solution formed when 43.0mL of 0.200molL^{-1} nitric acid is added to 15.0mL of 0.300molL^{-1} barium hydroxide (at 25°C).

Question 33 **(6 marks)**

A sweet smelling liquid, **A**, has a molecular formula $C_3H_6O_2$. **A** was prepared from reacting liquids **B** and **C** in the presence of concentrated H_2SO_4.

Liquid **B** produces a colourless, odourless gas when added to solid sodium carbonate.

Liquid **B** has a higher molar mass than liquid **C**.

Identify possible structures for liquids **A**, **B** and **C**.

Name of Liquid **A**	Structure of Liquid **A**
Name of Liquid **B**	Structure of Liquid **B**
Name of Liquid **C**	Structure of Liquid **C**

(6 marks)

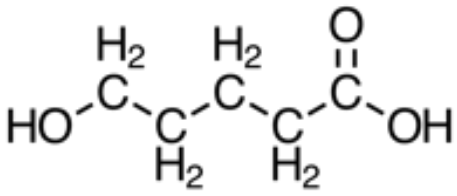
Question 34 **(6 marks)**

Complete the following table, drawing the full structural formula and giving the name of each substance.

Substance	Full structural formula
An ester that is a structural isomer of ethyl ethanoate	IUPAC Name: _____
An oxidation product of pentan-2-ol with acidified sodium dichromate	IUPAC Name: _____
The dipeptide Gly-Ser, as it exists in basic conditions	No name required.

Question 35 **(4 marks)**

The following molecule (M = 118.08 $gmol^{-1}$) can be used to produce a polymer when it is heated under acidic conditions.



(a) Draw the structure of the polymer, showing two repeating units. (2 marks)

(b) What class of polymer is this an example of? (1 mark)

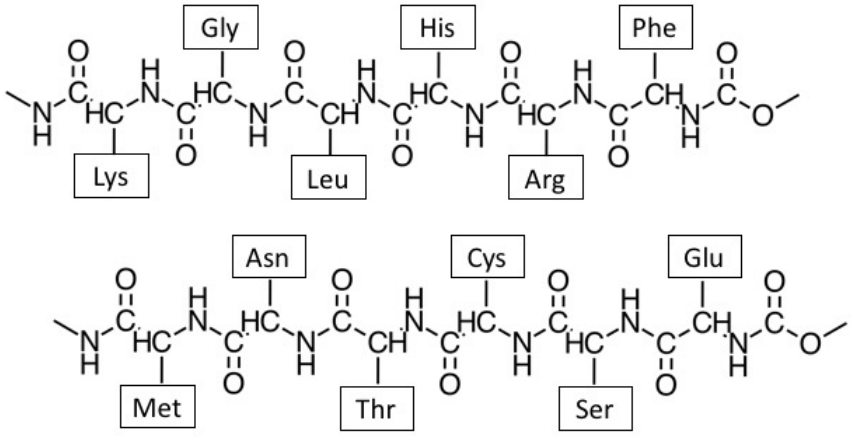
_____

(c) Under these reaction conditions, a small amount of a cyclic compound (M = 100.114 $gmol^{-1}$) was also found to be produced. Draw the structure of this cyclic compound.

(1 mark)

Question 36 **(4 marks)**

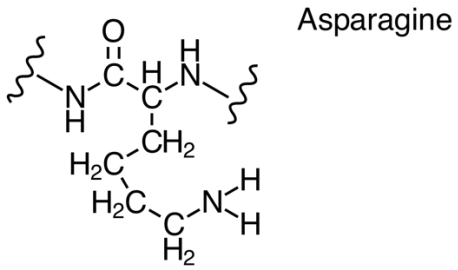
Below is a section of a protein showing 2 parallel strands of the same polypeptide chain.
The side chains of each amino acid are abbreviated, using their 3-letter abbreviation.

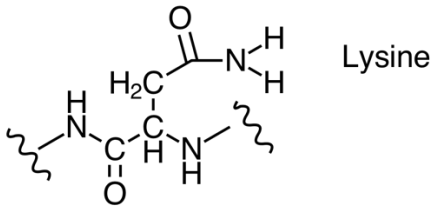


(a) The primary structure of a protein involves the sequence of amino acids, each joined by amide (peptide) bonds. Circle an amide (peptide) bond in the diagram above – labelling it with the letter A. (1 mark)

(b) The secondary structure of a protein includes β-pleated sheets and α-helices. Draw one of the bonds responsible for these secondary structures on the diagram above. Label it with the letter B. (1 mark)

(c) Asparagine (Asn) and Lysine (Lys) are two amino acids in close proximity in the protein structure above. Their structures are shown in full below.





(i) What type of intermolecular force is responsible for the attraction between these two amino acids?

_____

(1 mark)

(ii) Draw a dashed line showing this interaction on the diagram above. (1 mark)

END OF SECTION TWO

THIS PAGE IS INTENTIONALLY BLANK

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 three significant figures.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as 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.

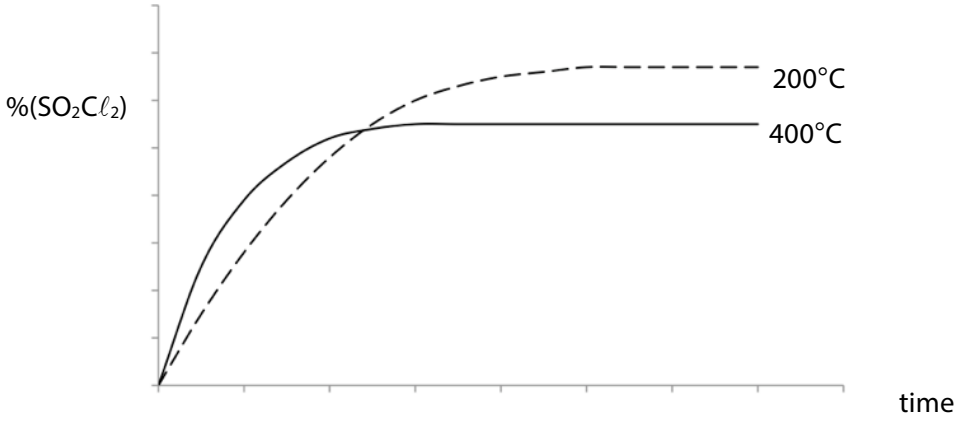
Suggested working time for this section is 70 minutes.

Question 37 **(15 marks)**

Consider the reaction below :

$$SO_2(g) + C\ell_2(g) \rightleftharpoons SO_2C\ell_2(g)$$

The following graph shows the change in percentage of $SO_2C\ell_2$ in the reaction mixture during its preparation at different temperatures:



(a) Explain why the slope of the graph for 400°C is steeper than for 200°C?

_____

_____

_____

(3 marks)

(b) Is the forward reaction endothermic or exothermic? Explain.

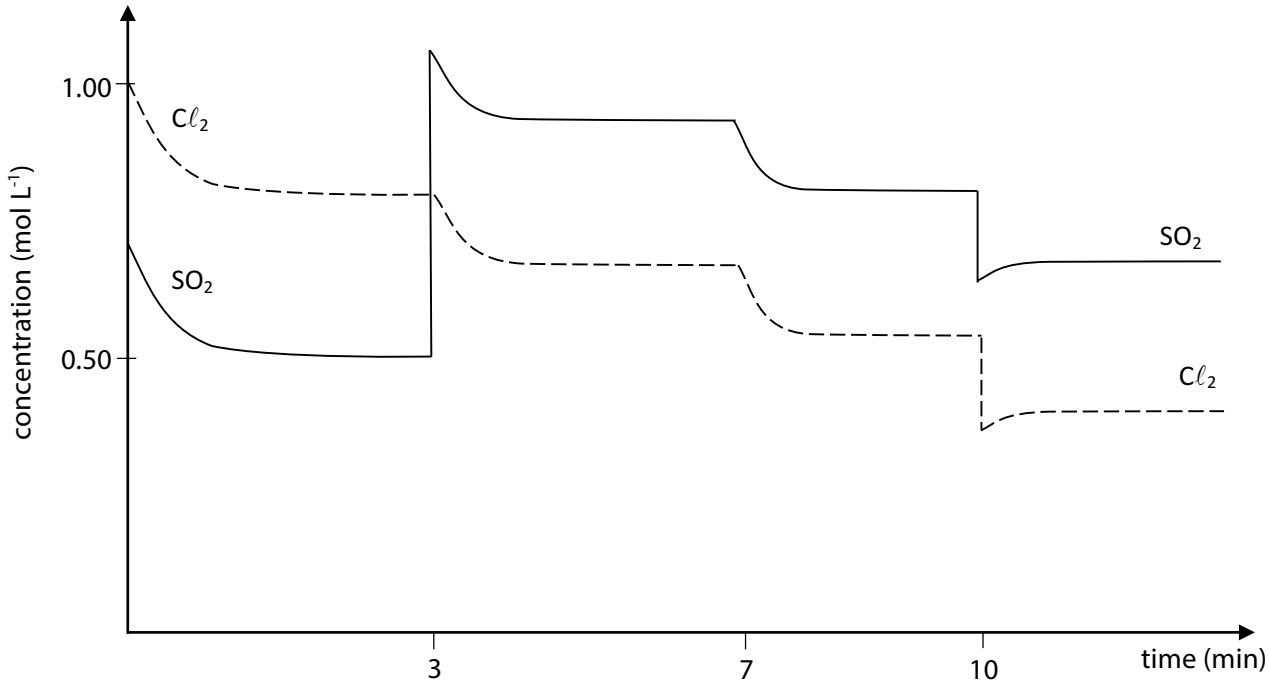
_____

_____

_____

(3 marks)

In a particular experiment the reactants were mixed in a 1 L container and the mixture was allowed to come to equilibrium. Changes were made to the system at 3, 7 and 10 minutes. The concentrations of the reactants are plotted against time in the graph below:



(c) What different events happened at the 3 minute, 7 minute and 10 minute marks? Explain the effect of the change on the system.

Time	What change occurred	Explanation
3 minutes		
7 minutes		
10 minutes		

(9 marks)

Question 38 **(12 marks)**

Oxalic acid (HOOCCOOH) is a weak, diprotic acid that can be used as a primary standard in acid/base titrations.

In a particular experiment, 4.78g of oxalic acid was dissolved in water and made up to 500mL in a volumetric flask.

(a) Calculate the concentration of the oxalic acid solution.

_____

_____

_____

(2 marks)

'Lye' is a solid that consists of potassium hydroxide contaminated with some impurities. A 2.27g pellet of lye was dissolved in water and made up to 250mL.

20mL aliquots (samples) of this solution were titrated against the oxalic acid prepared earlier.

The colours of two indicators are shown below, along with the pH range at which they change colour.

Indicator	pH change range	Colour at low pH	Colour at high pH
Methyl orange	4-6	red	yellow
Phenolphthalein	8-10	colourless	pink

(b)(i) Which indicator would you choose for this titration? Circle your chosen answer

Methyl orange **Phenolphthalein**

(ii) What colour change would you expect to see at the end point for your chosen indicator?

Colour changes from _____ to _____

(3 marks)

The table of results used in the titration is shown below. Complete the table and calculate the average titre

	1	2	3	4
Final reading (mL)	14.95	29.25	43.65	15.15
Initial reading (mL)	0.00	14.95	29.25	0.80
Titre (mL)				

The average titre is _____ mL

(1 mark)

(c) Use this average titre and the concentration of oxalic acid from (a) to calculate the percentage purity of potassium hydroxide in the lye. You may assume that the impurities in the lye have no acidic or basic properties

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5 marks)

(d) If the burette had been rinsed with distilled water before filling it with the oxalic acid, what effect would would this have had on the calculated purity of the lye?

Decreased **Unchanged** **Increased**

(1 mark)

Question 39 **(15 marks)**

Most of Australia's copper deposits are in the form of the mineral chalcopyrite ($CuFeS_2$). Copper is extracted from this ore by roasting the powdered mineral in air. The chemical reactions for the roasting process are shown below.

Reaction 1 $2CuFeS_2(s) + 4O_2(g) \rightarrow Cu_2S(s) + 2FeO(s) + 3SO_2(g)$

Reaction 2 $Cu_2S(s) + O_2(g) \rightarrow 2Cu(l) + SO_2(g)$

A particular ore body contains 13.6% chalcopyrite by mass. In order to extract the copper it is first crushed and the mineral component, chalcopyrite is then roasted according to the chemical reactions above.

(a) What mass of ore is required to produce 1 tonne of Cu metal.

_____

_____

_____

_____

_____

_____

(4 marks)

Generally, these industries have an on-site sulphuric acid plant where the by-product of the copper extraction (SO_2) is reacted with oxygen to from sulfur trioxide (SO_3). The sulfur trioxide is then reacted with water to produce sulphuric acid.

(b) Write balanced chemical equations for the reactions of sulfur dioxide with oxygen and subsequently the reaction of the product with water.

_____

_____

(2 marks)

(c) Determine the volume of sulphur dioxide produced during reactions 1 and 2 that would result from the treatment of one tonne of chalcopyrite ore. The gas is released at atmospheric conditions of 101kPa and 27ºC and the process has a 100% yield.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6 marks)

(d) Determine the mass of sulphuric acid produced per tonne of chalcopyrite ore if the reaction of sulphur dioxide with oxygen is 93% efficient. Assume the reaction of the product with water gives a 100% yield.

_____

_____

_____

_____

_____

(3 marks)

SEE NEXT PAGE FOR QUESTION 40

Question 40 **(9 marks)**

One of the more common buffer solutions is that formed between benzoic acid and sodium benzoate.

$$C_6H_5COOH \rightleftharpoons C_6H_5COO^- + H^+$$

In order to prepare such a buffer, the chemist performed the following steps

1. He measured 100.0mL of 1.00molL^{-1} benzoic acid into a beaker
2. To this solution, he added 144g of sodium benzoate and stirred until it had all dissolved
3. He made the solution up to exactly 500mL in a volumetric flask
4. He measured the pH of this buffer solution and it was found to be 5.2.

(a) Calculate the concentration of benzoic acid in the buffer solution

_____

_____

_____

_____

(2 marks)

(b) Calculate the concentration of benzoate ions in the buffer solution

_____

_____

_____

_____

(2 marks)

(c) Calculate the concentration of hydrogen ions ions in the buffer solution

_____

_____

(1 mark)

(d) He tested his buffer solution by adding concentrated (10.0molL^{-1}) sodium hydroxide solution. He was pleased that a large volume could be added before there was any significant change in pH. Explain how this buffer minimised the change in pH, using equations as necessary.

_____

_____

_____

_____

(2 marks)

(e) He also tested the buffer by adding concentrated ($10.0 mol L^{-1}$) hydrochloric acid and found that an even greater volume could be added before there was a significant change in pH. Give an equation for the reaction that is occurring and explain why the volume that could be added was greater than when he added the sodium hydroxide solution.

_____

_____

_____

_____

(2 marks)

SEE NEXT PAGE FOR QUESTION 41

Question 41 **(18 marks)**

An organic compound **X** is known to contain carbon, hydrogen, nitrogen and oxygen. When burnt in excess oxygen, a 2.45 g sample of X produced 1.35 g of water and 3.66 g of carbon dioxide.

A second sample of **X,** of mass 1.60 g, was treated to convert all of the nitrogen present to N_2 gas. At 25 °C and 105 kPa, the N_2 produced had a volume of 128 mL.

a) Calculate the empirical formula of compound **X**. (10 marks)

b) A second 1.98 g sample of compound **X** was found to occupy 0.231 L at 40° C and 150 kPa. Determine the molecular formula of compound **X**.

(4 marks)

c) X is known to be an alpha amino acid containing 2 acidic hydrogen atoms per molecule. Draw a possible structure for **X**.

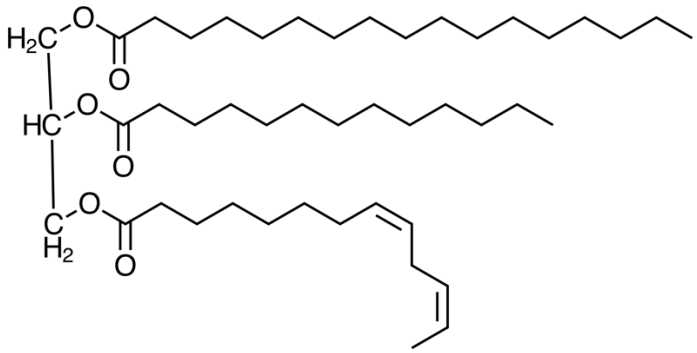
(2 marks)

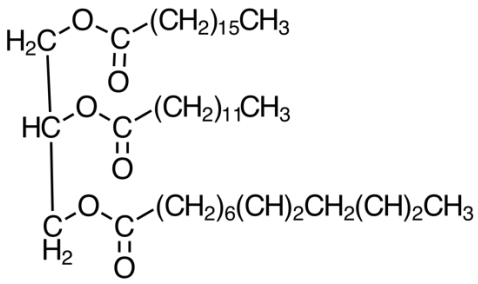
d) Determine the volume of 0.12 $molL^{-1}$ NaOH needed to completely react with a solution containing 12 g of compound **X**.

(2 marks)

Question 42 **(11 marks)**

Fatty acids are stored in the human body in the form of triglycerides. One such triglyceride is shown below, using two different notations.

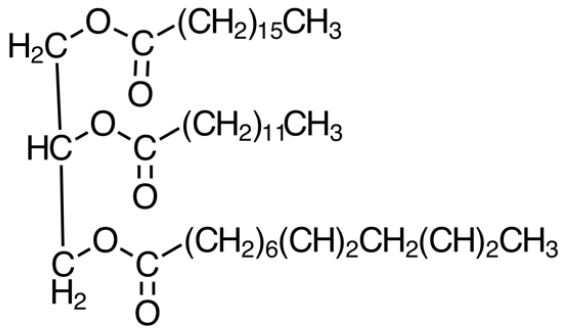




a) Write an equation to represent the hydrolysis of the triglyceride above in acidic conditions. Use the boxes provided to draw the reactants and products respectively.

(5 marks)

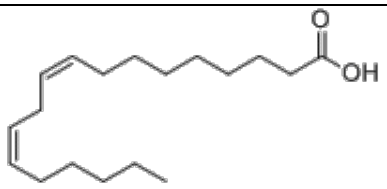
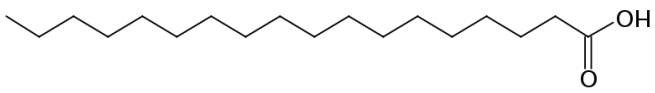
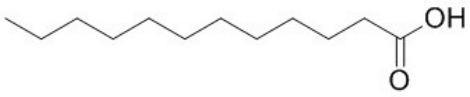
Reactants



+ ……

Products

b) Three of the common fatty acids found in mammals are linoleic acid, stearic acid and lauric acid

	Structure	MW	Melting point (°C)
Linoleic acid $C_{18}H_{32}O_2$		280.45 $gmol^{-1}$	-5 °C
Stearic acid $C_{18}H_{36}O_2$		284.47 $gmol^{-1}$	69 °C
Lauric acid $C_{12}H_{24}O_2$		200.32 $gmol^{-1}$	43 °C

i) Explain why stearic acid has a higher melting point than lauric acid.

_____

_____

_____

_____

_____

_____

_____

(3 marks)

ii) Hibernating animals possess enzymes called *desaturases* that convert saturated fatty acids into unsaturated fatty acids during winter. This lowers the melting point of the fats and prevents them from freezing. Explain why unsaturated linoleic acid has a lower melting point than stearic acid, which is saturated.

_____

_____

_____

_____

_____

_____

(3 marks)

END OF EXAMINATION

Additional working space