Government of **Western Australia**
School Curriculum and Standards Authority

WACE
Western Australian Certificate of Education

Western Australian Certificate of Education
Sample Examination, 2016

Question/Answer Booklet

CHEMISTRY

Please place your student identification label in this box

Student Number: In figures | | | | | | | | | |

In words _____

_____

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
Chemistry Data Sheet

Number of additional answer booklets used (if applicable):

To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: up to three 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.

2013/42055

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Multiple-choice	25	25	50	25	25
Section Two: Short answer	12	12	60	75	35
Section Three: Extended answer	5	5	70	83	40
				Total	100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2016*. Sitting this examination implies that you agree to abide by these rules.

2. 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 that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

   Sections Two and Three: Write your answers in this Question/Answer Booklet.

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

4. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

5. 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 that you are continuing to answer at the top of the page.

6. The Chemistry Data Sheet is **not** to be handed in with your Question/Answer Booklet.

See next page

Section One: Multiple-choice **25% (25 Marks)**

This section has **25** questions. 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 that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 50 minutes.

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1. The reaction of iron(III) oxide with carbon monoxide gas is shown below:

$$Fe_2O_3(s) + 3\,CO(g) \rightleftharpoons 2\,Fe(\ell) + 3\,CO_2(g)$$

Which one of the following changes to the system will initially decrease the rate of the forward reaction?

(a) decreasing the volume of the reaction vessel
(b) decreasing the pressure of CO(g) in the vessel
(c) decreasing the $Fe_2O_3(s)$ particle size
(d) decreasing the concentration of $CO_2(g)$ in the system

2. An enzyme is a biological catalyst. Esters can be hydrolysed, as represented below by an esterase enzyme.

$$\text{ester} + \text{water} \overset{\text{esterase}}{\rightleftharpoons} \text{carboxylic acid} + \text{alcohol}$$

In the presence of esterase, which one of the following statements is true for this process?

(a) The position of equilibrium for this reaction is shifted to the right.
(b) The rate of forward reaction and the rate of reverse reaction both increase equally.
(c) The rate of forward reaction increases more than the rate of reverse reaction.
(d) The rate of forward reaction increases and the rate of reverse reaction decreases.

3. Hydrogen can be produced by the reaction

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\,H_2(g) \qquad \Delta H > 0$$

Which one of the following will increase the equilibrium yield of hydrogen?

(a) increasing the total pressure of the reaction system
(b) decreasing the partial pressure of the water vapour
(c) removing carbon monoxide from the system as it is produced
(d) decreasing the temperature of the system

See next page

4. Which one of the following reactions does **not** represent the Brønsted-Lowry model?

(a) $HSO_4^-(aq) + H_2O(\ell) \rightarrow SO_4^{2-}(aq) + H_3O^+(aq)$
(b) $CH_3COOH(aq) + NaOH(aq) \rightarrow NaCH_3COO(aq) + H_2O(\ell)$
(c) $HCO_3^-(aq) + H_2O(\ell) \rightarrow H_2CO_3(aq) + OH^-(aq)$
(d) $CaCO_3(s) + 2\,HC\ell(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + 2\,H_2O(\ell)$

5. Consider the following equation:

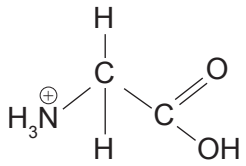
$$HS^-(aq) + CO_3^{2-}(aq) \rightleftharpoons S^{2-}(aq) + HCO_3^-(aq)$$

Which one of the following is **not** true of this equation?

(a) HCO_3^- is acting as a Brønsted-Lowry acid.
(b) CO_3^{2-} is acting as a conjugate base.
(c) HS^- is acting as a conjugate base.
(d) S^{2-} is acting as a Brønsted-Lowry base.

6. Consider the list below:

i PO_4^{3-}

ii 

iii $NH_2CH_2COO^-$
iv Na_2HPO_4

Which one of the following combinations, when mixed together in water, will form a buffer solution?

(a) i and ii
(b) iii and iv
(c) i and iv
(d) ii and iii

7. Which one of the following describes the acidity/basicity of a solution of the following compounds when dissolved in distilled water?

	Ammonium chloride	**Potassium carbonate**	**Sodium nitrate**	**Sodium ethanoate**
(a)	acidic	basic	neutral	basic
(b)	acidic	basic	acidic	basic
(c)	basic	acidic	neutral	acidic
(d)	basic	basic	basic	acidic

See next page

8. Hydrochloric acid (HCℓ) is a stronger acid than the ammonium ion (NH_4^+). Which one of the statements below is **true**?

(a) The equilibrium constant for the hydrolysis of HCℓ is smaller than that for NH_4^+.
(b) $C\ell^-(aq)$ is a weaker base than $NH_3(aq)$.
(c) Solutions of HCℓ will always have more hydrogen ions than solutions of NH_3.
(d) The pH of a 0.1 mol L^{-1} solution of HCℓ will be greater than the pH of a 0.1 mol L^{-1} solution of NH_3.

9. Bromophenol blue is an acid-base indicator that has a colour change from yellow to blue between pH 3.0 and 4.6. A sodium hydroxide solution (in a conical flask) is titrated with an acetic (ethanoic) acid solution (in a burette), using bromophenol blue indicator.

Which one of the following statements about this titration is true?

(a) The end point and the equivalence point occur at the same time.
(b) The end point occurs after the equivalence point.
(c) The end point occurs before the equivalence point.
(d) The indicator will be yellow at the equivalence point of the titration.

10. Over the last 200 years, the pH of oceans has dropped from 8.2 to 8.1. A drop of 0.1 pH units represents an

(a) approximate 20% increase in the concentration of hydrogen ions.
(b) increase of the hydrogen ion concentration by a factor of 10.
(c) approximate 20% increase in pH.
(d) insignificant change in hydrogen ion concentration, due to the large volume of the ocean.

11. 20.0 mL of 0.10 mol L^{-1} hydrochloric acid is mixed with 20.0 mL of 0.10 mol L^{-1} sodium hydroxide in a glass beaker. The volumes are measured using a 50.0 mL measuring cylinder. The temperature rise that occurred is measured and used to calculate the enthalpy change for the reaction. Which one of the following statements is correct?

(a) Systematic error will be reduced by repeating the experiment several times and averaging the results.
(b) Random error will be reduced by using a 20.0 mL graduated pipette instead of the 50.0 mL measuring cylinder.
(c) Random error will be reduced by insulating the beaker.
(d) Systematic error will be increased by doubling the volume of solution.

12. How many moles of electrons must be exchanged to oxidise 1 mole of hypophosphorous acid, H_3PO_2, to phosphoric acid, H_3PO_4?

(a) 2
(b) 3
(c) 4
(d) 5

See next page

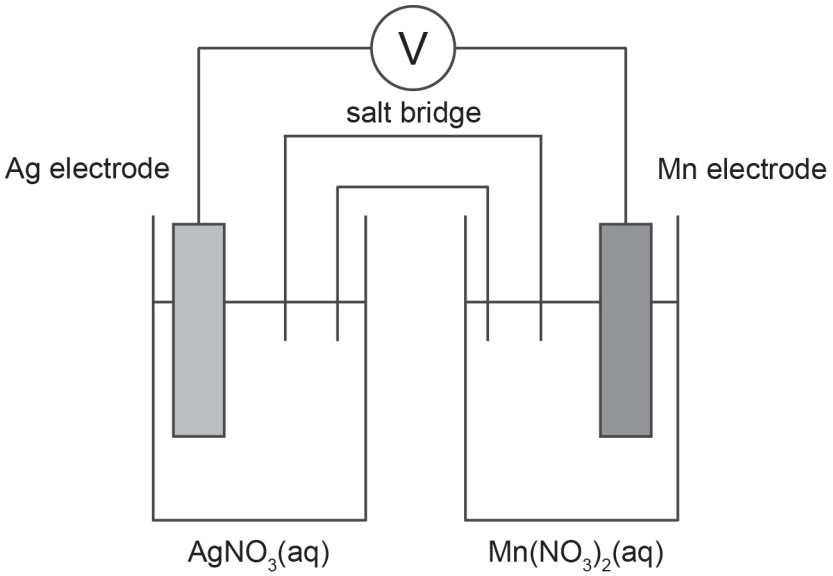
13. In which one of the following compounds is rhenium (Re) in the highest oxidation state?

(a) $NaReO_4$
(b) $ReC\ell O$
(c) Re_2O_3
(d) $ReC\ell_5$

14. In which one of the following will a metal displacement reaction occur?

(a) a zinc rod is dipped in a 1.0 mol L^{-1} solution of sodium sulfate
(b) a copper rod is dipped in a 1.0 mol L^{-1} solution of cobalt(II) nitrate
(c) a silver rod is dipped in a 1.0 mol L^{-1} solution of gold(III) nitrate
(d) a tin rod is dipped in a 1.0 mol L^{-1} solution of manganese(II) sulfate

15. An electrochemical cell consisting of $Ag//Ag^+$ and $Mn//Mn^{2+}$ couples is constructed as represented by the diagram below. All solutions are 1.0 mol L^{-1} and the temperature is 25 °C.



Which one of the following gives the predicted emf for this cell in volts?

(a) 0.42
(b) 0.80
(c) 1.98
(d) 2.78

See next page

16. Consider the following statements about fuel cells.

i A fuel cell is a device that converts chemical energy to electrical energy via a redox reaction.
ii Fuel cell technology involves the continuous supply of reactants to the cells and the continuous removal of the products.
iii A fuel cell can be recharged by reversing the direction of current flow through the cell.
iv Fuel cells are considered a low-emission technology.

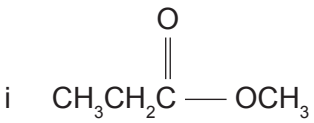
Which of the above statements about fuel cells are true?

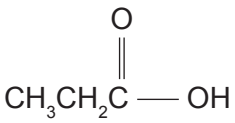
(a) i only
(b) i and ii
(c) i, iii and iv
(d) i, ii and iv

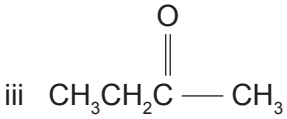
17. Which one of the following will react with acidified potassium dichromate solution to give a ketone?

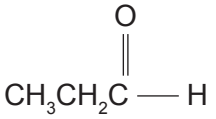
(a) $CH_3CH_2CH_2OH$
(b) CH_3CH_2CHO
(c) $CH_3CH(OH)CH_3$
(d) $(CH_3)_3COH$

Questions 18 and 19 refer to the compounds shown below.

i 

ii 

iii 

iv 

18. Which one of the following lists places the compounds in their correct class?

	i	ii	iii	iv
(a)	Ester	Aldehyde	Ketone	Carboxylic acid
(b)	Carboxylic acid	Ketone	Aldehyde	Ester
(c)	Ketone	Carboxylic acid	Ester	Aldehyde
(d)	Ester	Carboxylic acid	Ketone	Aldehyde

19. Which of the compounds can be prepared by oxidation of 1-propanol, $CH_3CH_2CH_2OH$?

(a) i only
(b) i and ii
(c) ii and iii
(d) ii and iv

See next page

20. Consider the following substances.

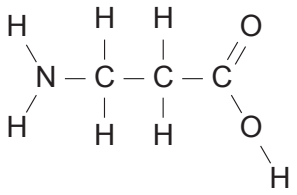
i	$BaSO_4$	ii	$CH_3CH_2CH_2CH_2OH$
iii	$CH_3CH_2COCH_3$	iv	H_2NCH_2COOH

Which one of the following lists the substances in order of **decreasing** solubility in water?

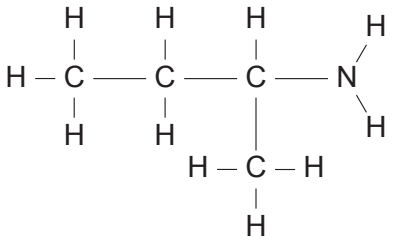
(a)	i	iv	ii	iii
(b)	i	iii	ii	iv
(c)	iv	ii	iii	i
(d)	ii	iv	iii	i

21. Which one of the following compounds is an α-amino acid?

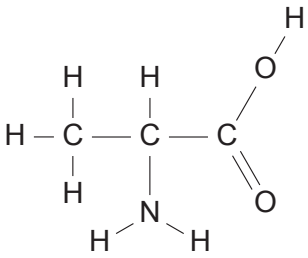
(a)



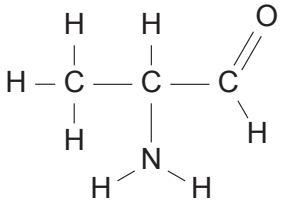
(b)



(c)



(d)



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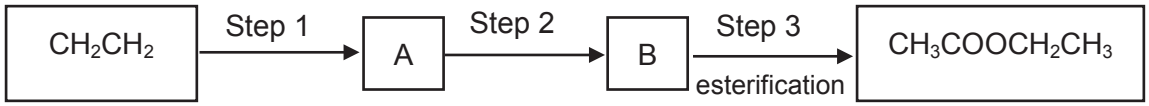
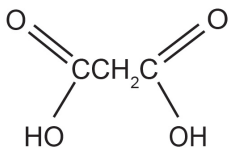
22. Ethene (CH_2CH_2) can be used to manufacture ethyl ethanoate, $CH_3COOCH_2CH_3$, in three steps, as indicated below:

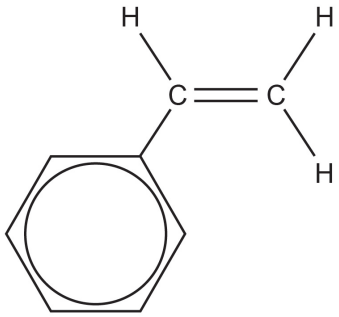


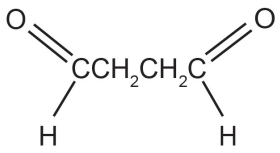
Which one of the following is the correct sequence of Steps 1 and 2?

	Step 1	**Step 2**
(a)	substitution with water	oxidation
(b)	addition of water	oxidation
(c)	oxidation	addition of water
(d)	oxidation	substitution with water

23. Which one of the following pairs represent monomers that could react together to form a polymer?

i 

ii 

iii 

iv HO — $CH_2CH_2CH_2CH_2$ — OH

(a) i and iv
(b) i and iii
(c) ii and iii
(d) iii and iv

See next page

24. Proteins that show a high degree of similarity in their primary structure in the Protein Data Bank are most likely to have

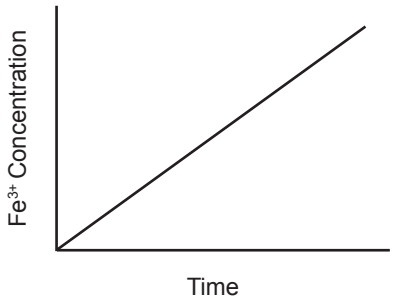
(a) similar function.
(b) identical tertiary structure.
(c) been isolated from the same species.
(d) the same amino acid composition.

25. When aqueous solutions of Ag^+ and Fe^{2+} are mixed, Ag and Fe^{3+} form according to the following equilibrium:

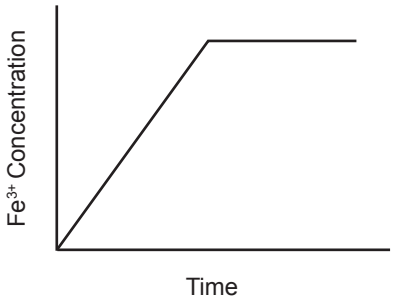
$$Ag^+(aq) + Fe^{2+}(aq) \rightleftharpoons Ag(s) + Fe^{3+}(aq)$$

Which one of the following concentration versus time graphs best represents the way in which the Fe^{3+} concentration varies as the reaction proceeds to equilibrium?

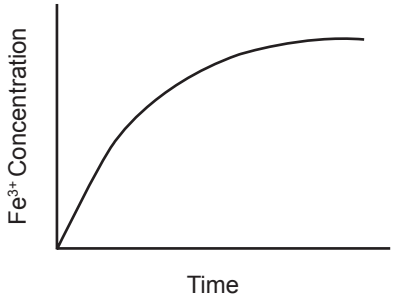
(a)



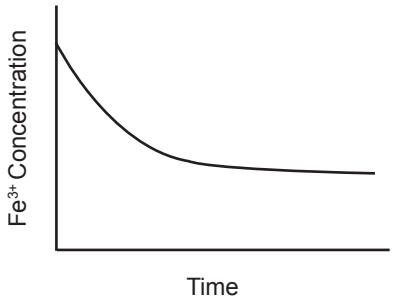
(b)



(c)



(d)



End of Section One

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Section Two: Short answer **35% (75 Marks)**

This section has **12** 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 the 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 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 that you are continuing to answer at the top of the page.

Suggested working time: 60 minutes.

Question 26 **(6 marks)**

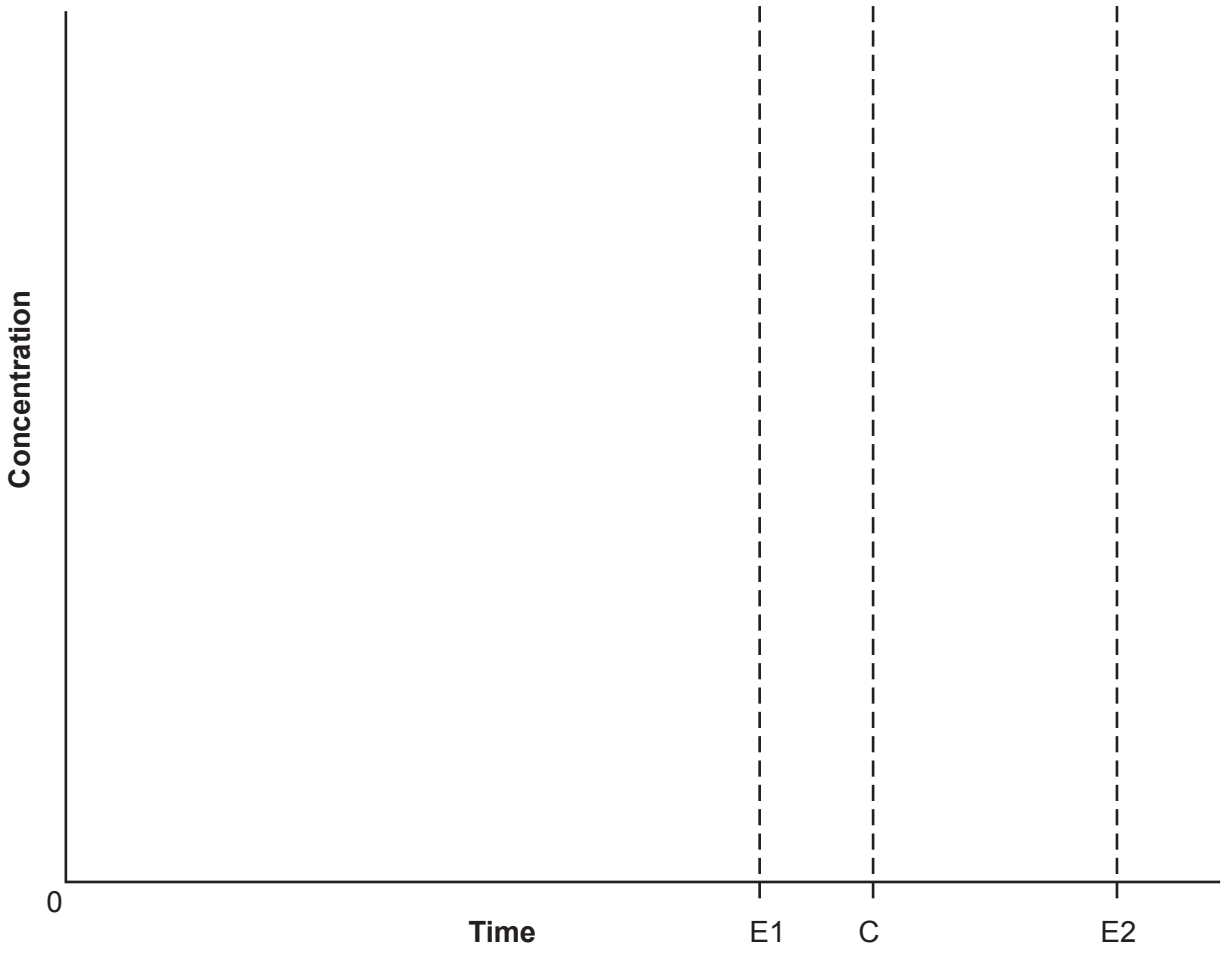
Silver chloride, AgCℓ(s), is very sparingly soluble in water. However, it is soluble in ammonia solutions, due to the formation of the $[Ag(NH_3)_2]^+$ ion as shown in the equilibrium below:

$$AgC\ell(s) + 2\ NH_3(aq) \rightleftharpoons [Ag(NH_3)_2]^+(aq) + C\ell^-(aq)$$

The equilibrium constant, K, for this system is greater than 1 (>1).

A student mixes the reactants at time t = 0.

(a) On the axes below, draw separate curves to show how the concentrations of $NH_3(aq)$ and $[Ag(NH_3)_2]^+(aq)$ change with time as the system approaches, and finally reaches, equilibrium (Time E1). Label clearly your curve for $NH_3(aq)$ and your curve for $[Ag(NH_3)_2]^+(aq)$. Continue your curves from Time E1 to Time C. (3 marks)

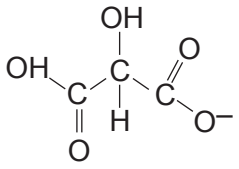


(b) At Time C, as shown on the axis, a small quantity of concentrated NaCℓ solution is added to the system, and the system is then again allowed to reach equilibrium at Time E2.
On the same axes above, show how the concentrations of $NH_3(aq)$ and $[Ag(NH_3)_2]^+(aq)$ would change in response to the addition of NaCℓ solution from Time C until equilibrium is reached at Time E2. (3 marks)

See next page

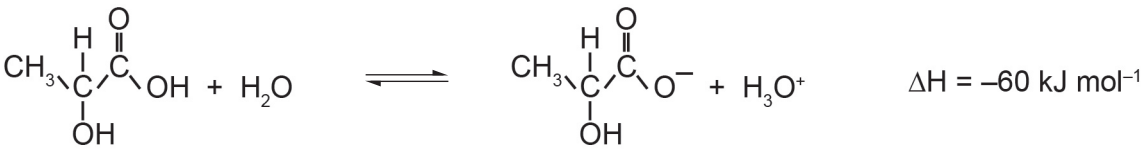
Question 27 **(10 marks)**

(a) Complete the table by writing the formula or drawing the structure for the conjugate base, species X or conjugate acid in each blank space as appropriate. Species X is the species that is able to form both a conjugate base and a conjugate acid. (6 marks)

Conjugate base	Species X	Conjugate acid
		$CH_3NH_3^+$
$C_2O_4^{2-}$		
		

Lactic acid produced by muscles during exercise, is found in many milk products and is used in the brewing of beer. It is also added to a number of canned food items as a buffer.

The equation for the reaction of lactic acid with water is shown below:



$\Delta H = -60$ kJ mol^{-1}

The value of the equilibrium constant (K) for the above reaction, at 25 °C, is approximately 7.9×10^{-5}.

(b) State whether the ratio of organic products to organic reactants will be equal to one, less than one (< 1) or greater than one (> 1) for this system at equilibrium at 25 °C. (1 mark)

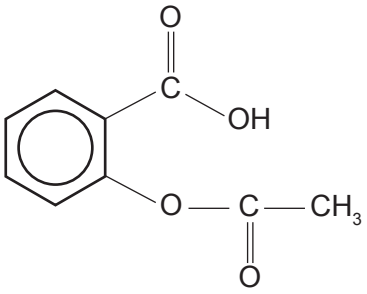
(c) Predict the direction in which the equilibrium will shift immediately after the changes indicated in the table below. Write 'left', 'right' or 'no change'. (3 marks)

Change	Direction of initial equilibrium shift
decreasing the temperature	
adding hydrochloric acid	
adding sodium hydroxide	

See next page

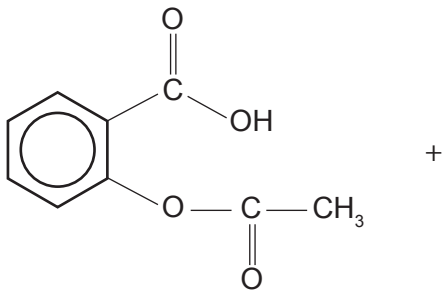
Question 28 **(6 marks)**

The active ingredient in aspirin tablets (acetylsalicylic acid) has the structure shown below:



When acetylsalicylic acid is placed in water, some of it dissolves and ionises to form its conjugate base.

(a) Write the equation for the ionisation of acetylsalicylic acid in the space below, and identify the conjugate acid and base pairs in the reaction. Connect each acid-base pair with a line, and label the conjugate acid in the pair 'A', and the conjugate base 'B'. (3 marks)

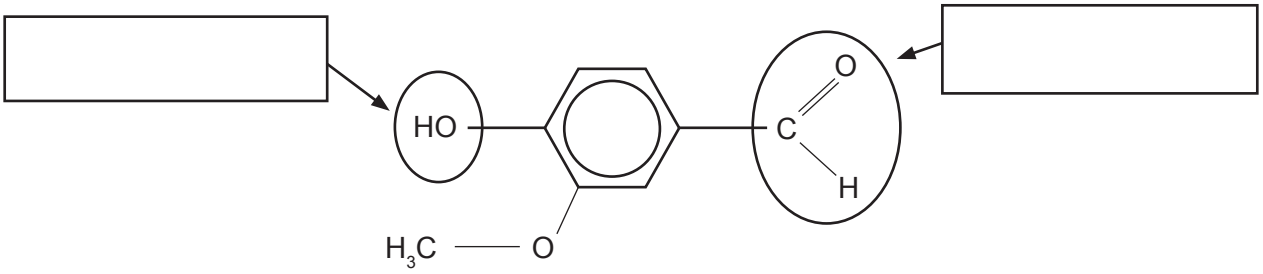


(b) Acetylsalicylic acid is a weak acid, and only partly ionises in water. It is poorly soluble in water, and far less soluble than a related compound, acetic acid (CH_3COOH). Explain why the water solubility of molecular acetylsalicylic acid is less than that of CH_3COOH. (3 marks)

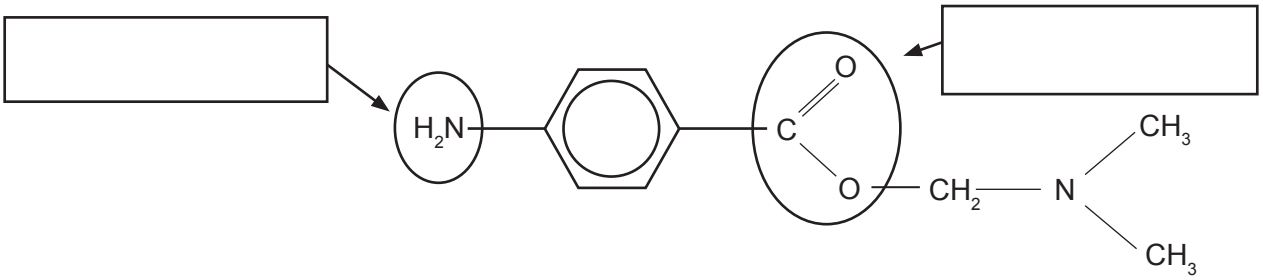
See next page

Question 29 **(4 marks)**

Examine the two compounds below. Compound 1 is the naturally-occurring flavouring agent vanillin. Compound 2 is the local anaesthetic procaine. Name the functional groups circled in these two compounds.



Compound 1: Vanillin



Compound 2: Procaine

Question 30 **(8 marks)**

Chloromethane can be produced industrially by the reaction of methanol and hydrogen chloride at high temperature in the presence of a catalyst. The equation for this reaction is shown below:

$$CH_3OH + HC\ell \rightleftharpoons CH_3C\ell + H_2O$$

The boiling points and melting points for each of the species involved in the reaction are shown below.

Species	Melting point (°C)	Boiling point (°C)
CH_3OH	–98	65
$HC\ell$	–114	–85
$CH_3C\ell$	–98	–24
H_2O	0	100

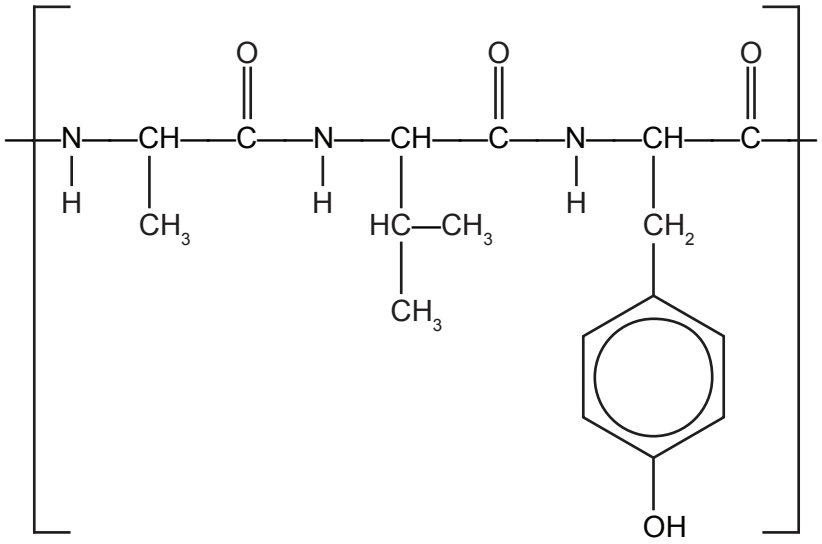
Write the phase, i.e. solid (s), liquid (ℓ) or gas (g), of each species in this system at the temperatures shown in the table below, and predict the effect of an increase in total pressure on this equilibrium at each of the temperatures.

Temperature (°C)	Phase (s, ℓ or g)				Shift in equilbrium (right, left or no change)
	CH_3OH	$HC\ell$	$CH_3C\ell$	H_2O	
–50					
40					
70					
110					

See next page

Question 31 **(6 marks)**

Examine the structure below that represents a segment of the primary structure of insulin to answer the questions that follow.



(a) Circle **all** the peptide linkages (functional groups that link the monomers) represented in the above structure. (1 mark)

(b) Draw the molecular structures of the **three** α-amino acids that form this segment of insulin. (3 marks)

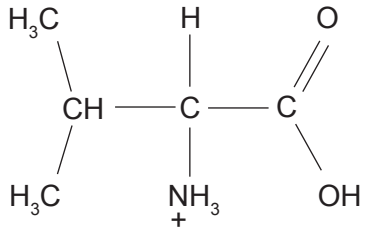
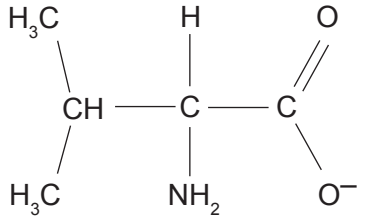
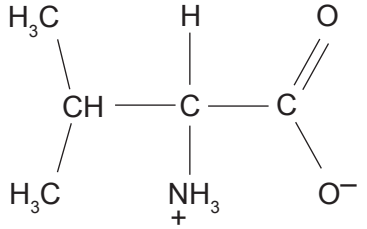
(c) The active form of insulin is made up of two polypeptide chains that contain five alpha helices. State the type of interactions that stabilises these secondary structures and the functional groups involved. (2 marks)

Type of interaction	Functional groups

See next page

Question 32 **(3 marks)**

Below are the structures for the amino acid valine under different pH conditions. In the spaces provided, give the approximate pH range (acidic, basic or neutral) under which each valine structure would exist.

Valine structure	pH range
	
	
	

See next page

Question 33 **(6 marks)**

Consider the following reactions and complete the tables that follow.

(a) An excess of 2-butanol is oxidised by acidified $Na_2Cr_2O_7$ solution. (3 marks)

Observations	
Structural formula of organic product **(show all atoms)**	
Name of organic product	

(b) Butanoic acid reacts with methanol in the presence of H_2SO_4 solution. (3 marks)

Observations	
Structural formula of organic product **(show all atoms)**	
Name of organic product	

See next page

Question 34 **(6 marks)**

Ocean acidification results from carbon dioxide dissolving in water and an equilibrium being established between the water and carbon dioxide to produce carbonic acid, (H_2CO_3).

(a) Write a balanced equation for this equilibrium. (2 marks)

(b) The formation of carbonic acid leads to an increase in the hydronium ion (H_3O^+) concentration in water. Show the equilibrium that results in the formation of hydronium ions when carbonic acid reacts with water. (1 mark)

(c) State **one** problem ocean acidification is causing for marine organisms. Explain how this problem arises and support your answer with an appropriate balanced equation. (3 marks)

Question 35 **(9 marks)**

Complete the table below, which relates to the properties and uses of plastics.

Select from the list below to complete the 'Property' column of the table. A property may only be used **once.** State a different use for each polymer.

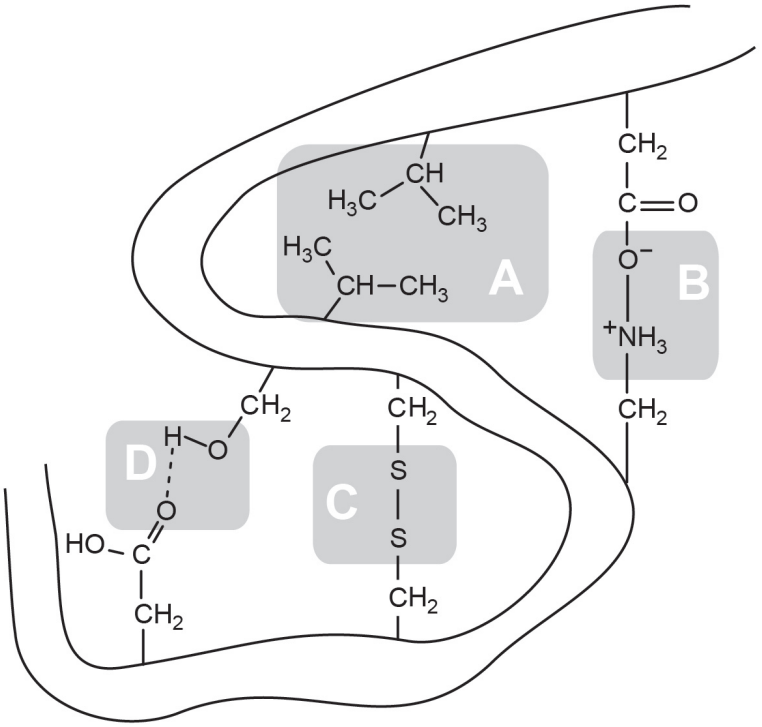
- hydrophobic
- high tensile strength
- biodegradable
- rigid
- chemically inert
- heat resistant

Plastic	Type of polymer (addition or condensation)	Property	Use related to property
High density polyethene (HDPE)			
Polytetrafluoroethene (Teflon)			
Polyethylene terephthalate (PET)			

See next page

Question 36 **(5 marks)**

The diagram below represents a segment of protein, showing the types of interactions that can occur between amino acid side chains to form the tertiary structure.



(a) Identify these types of interactions, labelled **A, B, C and D**, by completing the table below. (4 marks)

Label	Type of interaction
A	
B	
C	
D	

(b) State what is meant by the 'tertiary structure' of a protein. (1 mark)

See next page

Question 37 **(6 marks)**

Ethanol may be produced by fermentation or the hydrolysis of ethene. Conditions are indicated in the table below.

	Temperature (°C)	Pressure (kPa)	Raw material
fermentation	60	101.3	
hydrolysis of ethene	300	7000	

(a) Complete the table above to indicate the raw materials for each process. (2 marks)

(b) Explain the lower temperature conditions of the fermentation process. (2 marks)

(c) In addition to lower temperature conditions, state **two** other advantages of the fermentation process compared with the hydrolysis of ethene. (2 marks)

End of Section Two

See next page

Section Three: Extended answer **40% (83 Marks)**

This section contains **five (5)** 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 the appropriate number of 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 that you are continuing to answer at the top of the page.

Suggested working time: 70 minutes.

Question 38 **(22 marks)**

A student set out to compare the effectiveness of a given quantity of two antacid preparations, one containing $Mg(OH)_2$ and the other $A\ell(OH)_3$, purchased from his local pharmacy.

He titrated each preparation against a hydrochloric acid solution to determine how much acid each could neutralise and to determine the concentration of active ingredient in each preparation. He first standardised the hydrochloric acid solution available in the laboratory against a primary standard, and chose anhydrous sodium carbonate as the primary standard.

(a) Give **two** reasons why anhydrous sodium carbonate is an appropriate standard. (2 marks)

See next page

The student prepared 1.00 L of a 0.0248 mol L^{-1} Na_2CO_3 solution. He titrated three 25.0 mL aliquots of this solution against the HCℓ and found an average titre of 24.35 mL.

(b) Calculate the concentration of the standardised HCℓ solution. (4 marks)

(c) Below is a list of common errors that can occur in titrations. From this list select **one** source of random error and **one** source of systematic error and explain your choice in the tables below. (4 marks)

- reading of burette
- bubbles in the pipette
- not drying Na_2CO_3 in an oven prior to its use as a primary standard
- rinsing all glassware with distilled water
- incorrect indicator
- perception of colour change at the end point

Random error	Why error is classified as random

Systematic error	Why error is classified as systematic

See next page

Question 38 (continued)

The antacid suspensions were thoroughly shaken and 20.0 mL of each transferred to separate 250.0 mL volumetric flasks. Both were made up to the mark with distilled water and shaken vigorously. 10.0 mL aliquots of the diluted suspensions were transferred to conical flasks for titration and an appropriate indicator added.

The titre values obtained for the $A\ell(OH)_3$ suspension are shown in the table below:

Titre volume HCℓ (mL)				Average titre volume (mL)
Trials				
1	2	3	4	
22.62	21.98	21.94	21.90	21.94

(d) Account for the need for four trials in the titration. (1 mark)

(e) (i) Calculate the concentration, in moles per litre (mol L^{-1}), of $A\ell(OH)_3$, in the original $A\ell(OH)_3$ suspension. (5 marks)

See next page

(ii) From his titration of the $Mg(OH)_2$ diluted suspension, the student found the mass of $Mg(OH)_2$ in the 250 mL **diluted** suspension to be 1.13 g. Determine the concentration of $Mg(OH)_2$ in the original **undiluted** suspension and express your answer in moles per litre (mol L^{-1}). (2 marks)

(f) Which of the preparations would be more effective (neutralise more HCℓ) for a given volume? Show your workings. (4 marks)

See next page

Question 39 **(19 marks)**

Qualitative analysis of an organic compound showed that it contained only carbon, hydrogen and oxygen. A quantitative study of the same compound was performed, in which a 0.5096 g sample was burnt in excess oxygen to produce 0.4160 g of water and 700.7 mL of carbon dioxide, collected at 100.0 °C and 102.8 kPa.

(a) Determine the empirical formula of the compound. (10 marks)

See next page

(b) A second 0.4832 g sample of the compound was heated to 261 °C. The vaporised sample was found to exert a pressure of 241 kPa in a 100.0 mL container. Use this information to determine the molecular formula of the compound. (5 marks)

(c) When the original compound was reacted with acidified ethanol, it produced a fruity-smelling liquid. Infer the structure of the original compound, and draw its structure in the box below. Name the original compound. (2 marks)

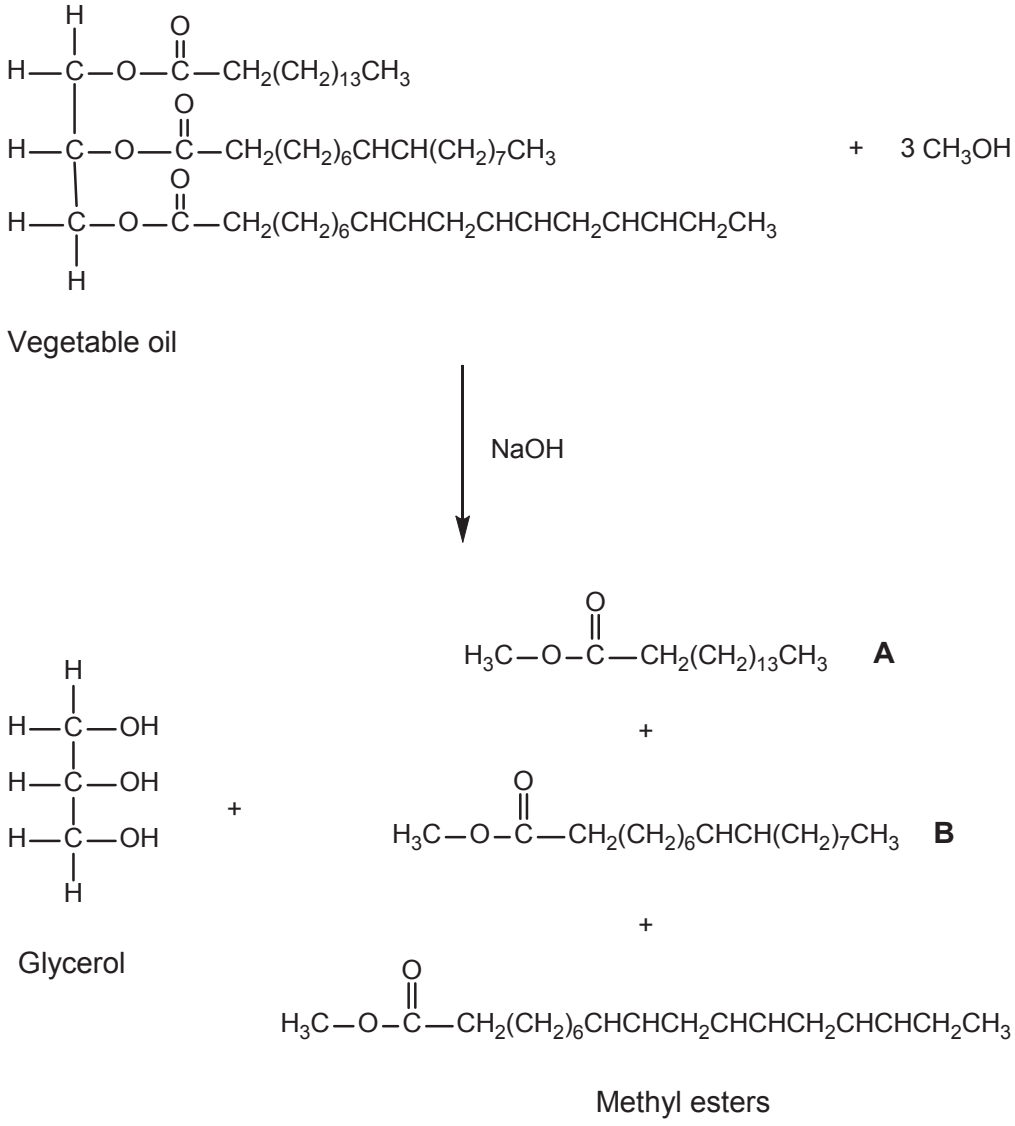
Name: _____

(d) Describe briefly and give observations for an additional chemical test to confirm the identity of the functional group in the original compound. (2 marks)

See next page

Question 40 **(16 marks)**

Biodiesel can be produced by a trans-esterification reaction between vegetable oil and an alcohol in the presence of sodium hydroxide catalyst. A typical trans-esterification reaction is shown below. The products are glycerol and three methyl esters.



(a) State another catalyst that can be used in the production of biodiesel. (1 mark)

See next page

(b) The vegetable oil in the reaction has a molar mass of 855.334 g mol^{-1}. If 1.50 tonnes of vegetable oil is reacted, what mass of methanol will be required to react with this amount of oil? (1 tonne = 1×10^6 g) (3 marks)

(c) Three different methyl esters, denoted by **A**, **B** and **C**, are produced from this reaction. What is the mass of Ester **A** produced in this process if the reaction is 78% efficient in production of this ester? Express your final answer to the appropriate number of significant figures. (5 marks)

See next page

Question 40 (continued)

(d) The glycerol produced can be used as anti-freeze due to its high water solubility. Explain, with the aid of a diagram, why glycerol has water solubility. (5 marks)

(e) To prevent different products forming in an alternative synthesis pathway, the quantity of sodium hydroxide present in the reaction must be kept low, compared with the vegetable oil. If the mole ratio of NaOH to vegetable oil approaches the ratio 3:1, the alternative pathway becomes significant.

(i) What type of organic product forms in this alternative pathway? (1 mark)

(ii) Draw the structure for **one** organic product that forms in the alternative synthesis pathway from this vegetable oil. (1 mark)

See next page

Question 41 **(10 marks)**

You are supplied with strips of three unknown metals, **A**, **B** and **C**, and are required to determine the order in which they are reduced, from most easily to least easily.

Using a voltmeter, electrical leads and clips, standard laboratory glassware and the typical range of chemicals found in most laboratories, design an investigation and describe the procedures to be followed to determine the order of reduction for the metals. Use a labelled diagram to support your description. Ensure that you explain the purposes of substances or equipment (excluding beakers or other glassware) used.

Indicate the data you will collect and explain how these data give the order of reduction.

See next page

See next page

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See next page

Question 42 **(16 marks)**

Use the following information about bleaching to answer the questions that follow.

Many chlorine-based compounds, such as sodium hypochlorite (NaOCℓ), chlorine ($C\ell_2$) and chlorine dioxide ($C\ell O_2$), are used as bleaches in household cleaning products and for industrial processes.

Their uses include:

- removing colour (for example, stain removal from clothes)
- whitening paper pulp in the process of making paper
- sterilising substances (for example, swimming pool water).

These compounds act by oxidising the compounds with which they come into contact. When chlorine gas is used for bleaching, the active ingredient is hypochlorous acid (HOCℓ). This is produced by reaction of the chlorine gas with water. Hydrochloric acid is also produced in the reaction.

To increase the amount of hypochlorous acid produced in this reaction, the water through which the chlorine is bubbled is usually made alkaline by the addition of a small amount of hydroxide ions. Chlorine-based bleaches react well at room temperatures.

A disadvantage of chlorine bleaches is the potential for highly poisonous dioxins to be produced by reaction with organic compounds. Peroxide bleaches are environmentally more acceptable because they produce only oxygen and water.

Hydrogen peroxide is a liquid, but sodium percarbonate ($2Na_2CO_3 \cdot 3H_2O_2$) and sodium perborate ($NaBO_3 \cdot H_2O$) are solid peroxide bleaches that release hydrogen peroxide when dissolved in water. A disadvantage of peroxide bleaches is the need for high temperatures for them to react.

The development of molecules known as tetra-amido macrocyclic ligand-activators (TAMLs) that function as catalysts has enabled the hydrogen peroxide bleaching reaction to occur at much lower temperatures.

(a) Write the balanced equation for the reaction of chlorine gas with water. (1 mark)

(b) Explain briefly how the addition of hydroxide ions to the water through which the chlorine is bubbled will increase the amount of hypochlorous acid produced. (3 marks)

See next page

(c) Give the oxidation state of chlorine in hypochlorous acid and the oxidation state of chlorine in hydrochloric acid. (2 marks)

Oxidation state of Cℓ in hypochlorous acid	Oxidation state of Cℓ in hydrochloric acid

(d) Identify the species oxidised and the species reduced when chlorine gas reacts with water. (2 marks)

Species oxidised	Species reduced

(e) Write the half-equation for the reduction of hypochlorous acid to chloride ion. (1 mark)

(f) For every one mole of formula units of sodium percarbonate, how many mole of hydrogen peroxide are released when it is dissolved in water? (1 mark)

(g) Compare the activation energy for oxidation reactions involving chlorine-based bleaches to those using peroxide-based bleaches (in the absence of catalysts). Explain the reasons for your answer. (2 marks)

See next page

Question 42 (continued)

(h) Draw a fully labelled energy profile diagram showing the progress of the decomposition of hydrogen peroxide with and without TAML molecules. (4 marks)

The equation for the reaction is $2H_2O_2 \rightarrow 2H_2O + O_2 + \text{energy}$.

End of questions

Spare answer page

Question number: _____

Spare answer page

Question number: _____

Spare answer page

Question number: _____

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