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# CHEMISTRY

## UNIT 3 & 4

### 2018

Name: \_\_\_\_\_

Teacher: \_\_\_\_\_

#### TIME ALLOWED FOR THIS PAPER

Reading time before commencing work:	ten minutes
Working time for the 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 Book

##### To be provided by the candidate:

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, eraser, correction tape/fluid, 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.

**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	/50	/25
Section Two: Short answer	8	8	60	/70	/35
Section Three: Extended answer	5	5	70	/80	/40
					/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 questions 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.

2. 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.
3. 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.
4. 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.
5. The Chemistry Data Book is **not** handed in with your Question/Answer Booklet.

## Section One: Multiple-choice

25% (50 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.

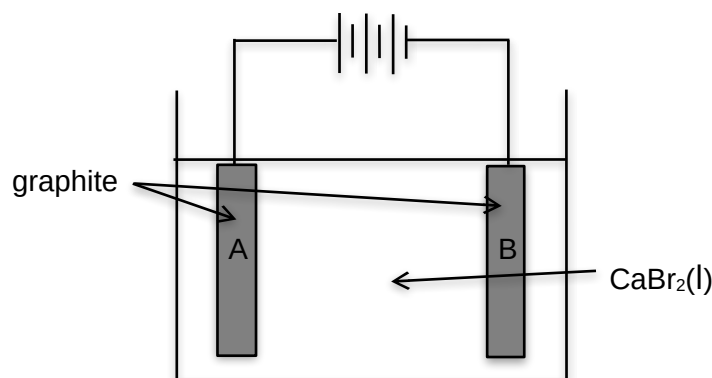
Suggested working time: 50 minutes.

1. The equilibrium constant expression for a particular reaction is as follows;

$$K = \frac{[\text{H}_2][\text{CO}]}{[\text{H}_2\text{O}]}$$

The reaction could be;

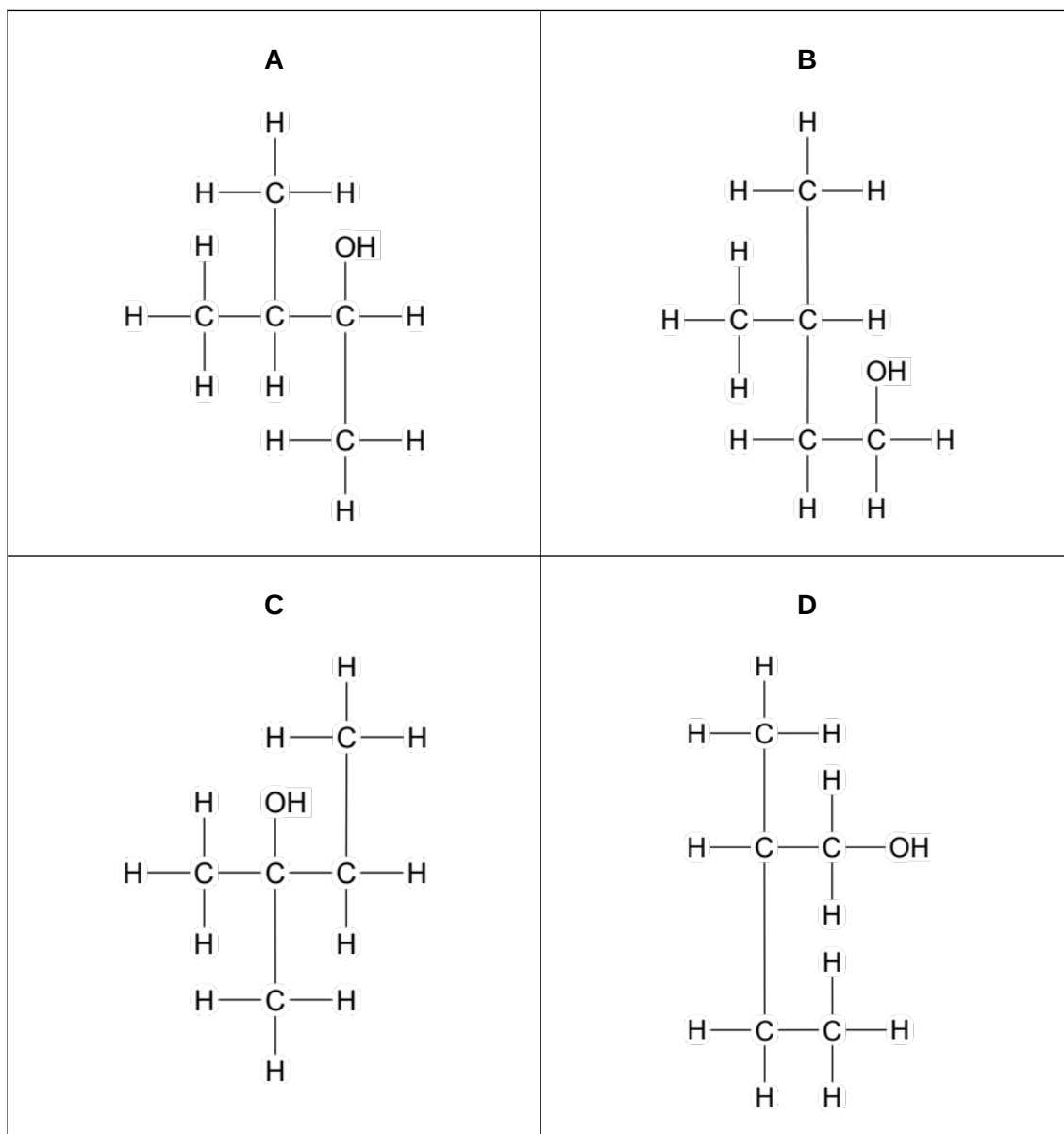
- (a)  $2 \text{CO(g)} + 2 \text{H}_2\text{(g)} \rightleftharpoons \text{CH}_4\text{(g)} + \text{CO}_2\text{(g)}$   
(b)  $\text{C(s)} + \text{H}_2\text{O(g)} \rightleftharpoons \text{CO(g)} + \text{H}_2\text{(g)}$   
(c)  $\text{H}_2\text{O(g)} + \text{CO(g)} \rightleftharpoons \text{CO}_2\text{(g)} + \text{H}_2\text{(g)}$   
(d)  $\text{CH}_4\text{(g)} + 2 \text{O}_2\text{(g)} \rightleftharpoons \text{CO}_2\text{(g)} + 2 \text{H}_2\text{O(g)}$
2. The cell diagram below represents the electrolysis of molten calcium bromide with inert graphite electrodes.



Which of the following statements are **correct** for this cell?

- (i) Electrons will flow from electrode A to electrode B.  
(ii) Calcium metal will form at electrode A.  
(iii) Anions will flow to electrode B.  
(iv) Calcium ions will become oxidised.  
(v) Electrode A is the cathode.
- (a) (i) only  
(b) (ii), (iii) and (iv) only  
(c) (ii) and (v) only  
(d) (i) and (iii) only

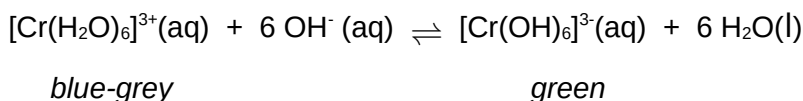
Questions 3 and 4 relate to the four isomers of  $C_5H_{11}OH$  shown below.



3. Which of the isomers would **not** react when mixed with acidified sodium permanganate solution?
- (a) A  
 (b) B  
 (c) C  
 (d) D
4. Which of the following is **not** a possible organic product resulting from oxidation of the isomers above?
- (a) 3-methylbutanoic acid  
 (b) 2-methylbutanoic acid  
 (c) 3-methylbutanone  
 (d) 2-methylbutanone

**Questions 5, 6 and 7 relate to the following information.**

Consider the following aqueous equilibrium system;



The following questions relate to the changes that would occur when a few drops of concentrated  $\text{HNO}_3(\text{aq})$  was added to the system.

5. Which of the following give the correct equilibrium shift and associated observations following this change?

	<b>Equilibrium shift</b>	<b>Observations</b>
(a)	forward favoured	solution becomes more green
(b)	forward favoured	solution becomes more blue-grey
(c)	reverse favoured	solution becomes more green
(d)	reverse favoured	solution becomes more blue-grey

6. Which statement is correct for the **instantaneous** change in rate of reaction?

- (a) The rate of the forward reaction increases.
- (b) The rate of the forward reaction remains unchanged.
- (c) The rate of the reverse reaction increases.
- (d) The rate of the reverse reaction remains unchanged.

7. Which statement is correct for the change in rate of reaction once a new equilibrium has been established?

- (a) The rate of the forward reaction is decreased.
- (b) The rate of the forward reaction is increased.
- (c) The rate of the forward reaction is unchanged.
- (d) There is not sufficient information to comment on the rate of forward reaction.

8. In the manufacture of ammonia there are three (3) key reactions, as shown in the equations below;

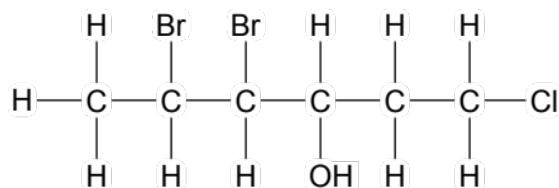
1.	Steam reforming	$\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + 3 \text{H}_2(\text{g})$	$\Delta H = +206 \text{ kJ}$
2.	Shift reaction	$\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{CO}_2(\text{g})$	$\Delta H = -41 \text{ kJ}$
3.	Haber process	$\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightleftharpoons 2 \text{NH}_3(\text{g})$	$\Delta H = -92 \text{ kJ}$

With the aim of increasing the yield, the factory operator decided to use a low temperature and a high pressure. Which reaction/s would **most benefit** from these conditions, in terms of an increased yield?

- (a) Steam reforming
- (b) Shift reaction
- (c) Haber process
- (d) Steam reforming and Shift reaction

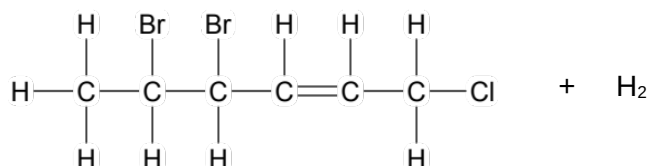


9. Consider the organic molecule shown below.

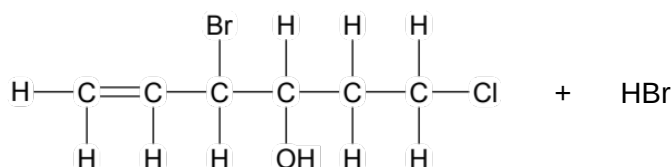


Which of the following reactions is **most likely** to produce this compound?

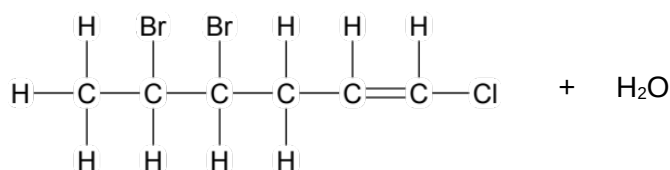
(a)



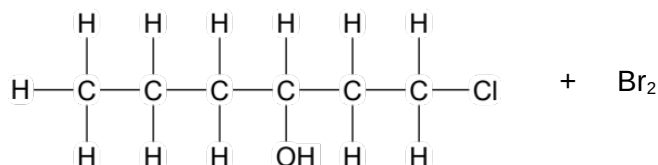
(b)



(c)



(d)



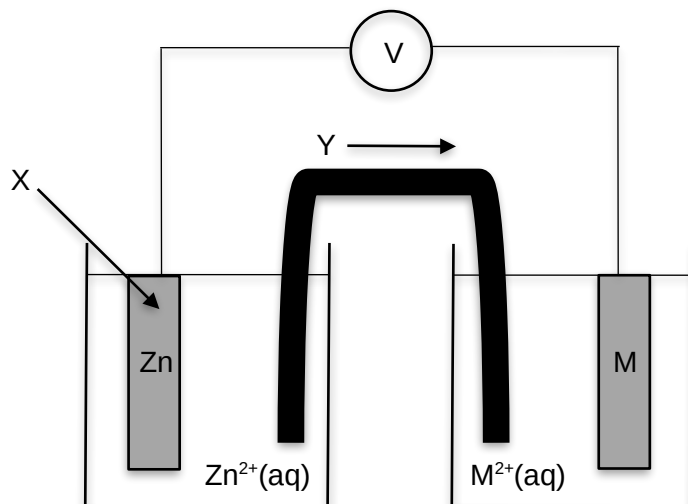
10. Which of the following changes, regarding the composition of sea water, are associated with ocean acidification?

- (i) An increase in  $\text{H}_2\text{CO}_3(\text{aq})$  concentration
- (ii) An increase in  $\text{CO}_3^{2-}(\text{aq})$  concentration
- (iii) An increase in  $\text{H}_3\text{O}^+(\text{aq})$  concentration
- (iv) An increase in  $\text{CO}_2(\text{aq})$  concentration
- (v) An increase in pH

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

**Questions 11 and 12 refer to the information below.**

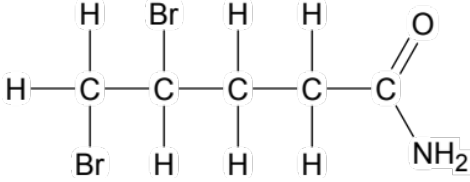
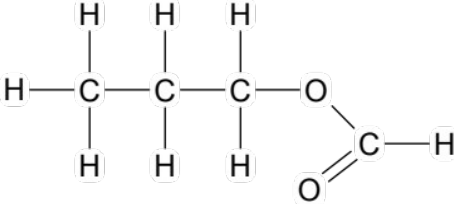
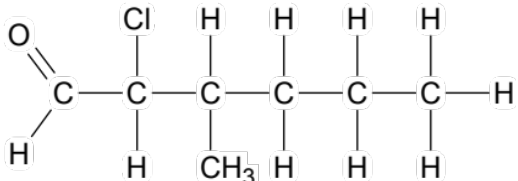
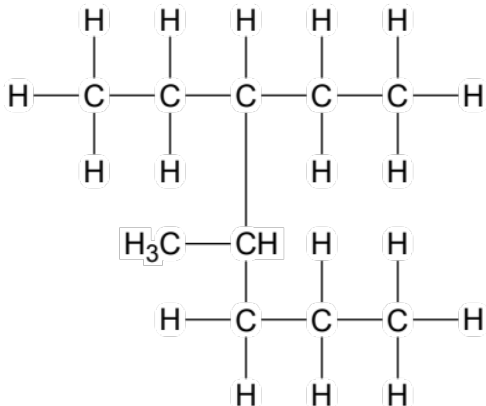
The following partially completed diagram shows a  $\text{Zn}/\text{Zn}^{2+}$  half-cell which has been set up under standard conditions. This is connected to electrode M, which is a silver metal, submerged in a colourless salt solution of  $\text{M}^{2+}(\text{aq})$ . The identity of M is known to be either iron (Fe), cadmium (Cd), tin (Sn) or lead (Pb).



11. If the EMF of the cell above was measured to be 0.36 V under standard conditions, what is the most likely identity of M?
- (a) Fe  
(b) Cd  
(c) Sn  
(d) Pb
12. Which of the following **correctly** identifies the letters X and Y in the diagram above?
- | X           | Y           |
|-------------|-------------|
| (a) anode   | cation flow |
| (b) anode   | anion flow  |
| (c) cathode | cation flow |
| (d) cathode | anion flow  |
13. In which of the following would no halogen displacement reaction occur?
- (a)  $\text{Br}_2(\text{aq}) + \text{NaCl}(\text{aq})$   
(b)  $\text{Br}_2(\text{aq}) + \text{NaI}(\text{aq})$   
(c)  $\text{Cl}_2(\text{aq}) + \text{NaBr}(\text{aq})$   
(d)  $\text{Cl}_2(\text{aq}) + \text{NaI}(\text{aq})$



14. Which of the following molecules has **not** been given the correct IUPAC name?

<p>(a) 4,5-dibromopentanamine</p> 	<p>(b) propylmethanoate</p> 
<p>(c) 2-chloro-3-methylhexanal</p> 	<p>(d) 3-ethyl-4-methylheptane</p> 

Questions 15 and 16 refer to the information below.

Ethanol and water are both liquids at room temperature. Ethanol has a boiling point of 78.4 °C, whereas water boils at 100 °C. A beaker was placed on a laboratory bench and 20 mL of ethanol and 20 mL of water were added to the beaker and mixed. The beaker was covered with an airtight lid and left for several hours until a constant vapour pressure formed. Both gaseous water and gaseous ethanol contributed to the vapour pressure.

15. Which of the following **best** describes this system?

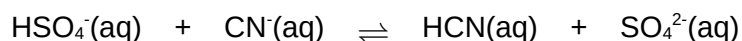
- (a) physical equilibrium, open system.
- (b) physical equilibrium, closed system.
- (c) chemical equilibrium, open system.
- (d) chemical equilibrium, closed system.

16. Which of the following statements **does not** relate to an explanation of why ethanol and water are miscible (i.e. form a homogeneous mixture)?

- (a) The non-polar region on an ethanol molecule is very small.
- (b) Ethanol molecules can form hydrogen bonds.
- (c) The intermolecular forces present in water are stronger than those in ethanol.
- (d) Ethanol molecules are highly polar.

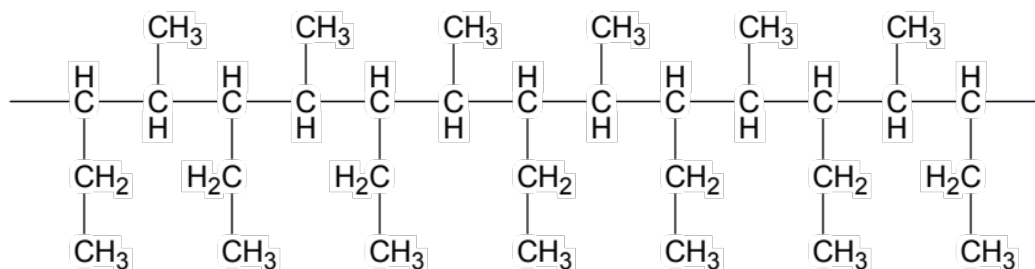


21. Using the Bronsted-Lowry theory, a student was asked to identify the acid, base, conjugate acid and conjugate base in the following reaction.



Which of the following statements are **correct**?

- (i)  $\text{HSO}_4^-(\text{aq})$  is the acid.
  - (ii)  $\text{CN}^-(\text{aq})$  is the conjugate acid.
  - (iii)  $\text{HCN}(\text{aq})$  is the conjugate base.
  - (iv)  $\text{HCN}(\text{aq})$  is the acid.
  - (v)  $\text{SO}_4^{2-}(\text{aq})$  is the conjugate base.
- (a) (i) and (iii) only  
 (b) (ii) and (iv) only  
 (c) (i) and (v) only  
 (d) (iv) and (v) only
22. Consider the fragment of polymer strand shown below.

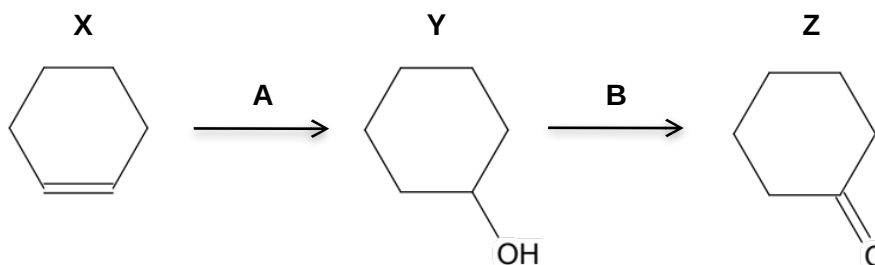


Which of the monomers below was used to make this polymer?

- (a)  $\text{H}_2\text{C}=\text{CH}-\text{CH}_2-\text{CH}_2-\text{CH}_3$
- (b)
- (c)  $\text{H}_3\text{C}-\text{CH}=\text{CH}-\text{CH}_2-\text{CH}_3$
- (d)

Questions 23 and 24 relate to the following information.

An overview of a particular reaction sequence is shown below.



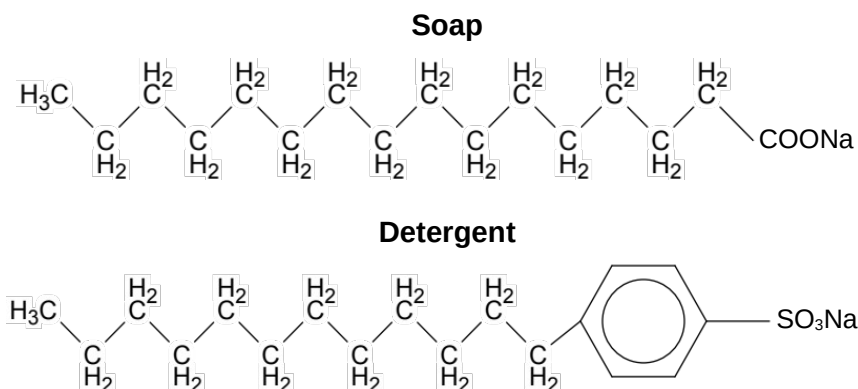
23. What functional group is present in each of the substances?

	<b>X</b>	<b>Y</b>	<b>Z</b>
(a)	alkene	alcohol	aldehyde
(b)	alkene	aldehyde	carboxylic acid
(c)	alkene	alcohol	ketone
(d)	alkane	ketone	ester

24. What reagents were **most likely** added at steps A and B?

	<b>A</b>	<b>B</b>
(a)	$\text{O}_2(\text{g})$	$\text{H}_2(\text{g})$
(b)	$\text{H}_2\text{O}(\text{l})$	$\text{O}_2(\text{g})$
(c)	$\text{NaOH}(\text{aq})$	$\text{H}^+/\text{MnO}_4^-(\text{aq})$
(d)	$\text{H}_2\text{O}(\text{l})$	$\text{H}^+/\text{Cr}_2\text{O}_7^{2-}(\text{aq})$

25. A sample of soap and a sample of detergent were both added to a beaker of hard water, containing a **low** concentration of  $\text{Ca}^{2+}(\text{aq})$ . The soap and detergent are shown below;



Which of the following species is **not likely** to be present in the beaker after mixing?

- (a)  $\text{CH}_3(\text{CH}_2)_{14}\text{COO}^-(\text{aq})$
- (b)  $\text{CH}_3(\text{CH}_2)_{11}\text{C}_6\text{H}_4\text{SO}_3^-(\text{aq})$
- (c)  $\text{Ca}(\text{CH}_3(\text{CH}_2)_{14}\text{COO})_2(\text{s})$
- (d)  $\text{Ca}(\text{CH}_3(\text{CH}_2)_{11}\text{C}_6\text{H}_4\text{SO}_3)_2(\text{s})$

End of Section One

See Next Page

**Section Two: Short answer****35% (70 marks)**

This section has **8** 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(s) that you are continuing to answer at the top of the page.

Suggested working time: 60 minutes.

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**Question 26****(6 marks)**

Consider the lead-acid accumulator battery used in most common vehicles. The lead-acid accumulator provides the energy required to start the vehicle's engine, as well as having the ability to recharge itself whilst the vehicle is being driven. Explain (noting that chemical equations are not required in your answer) how this cell can be classified as both;

(a) a galvanic cell.

(3 marks)

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(b) an electrolytic cell.

(3 marks)

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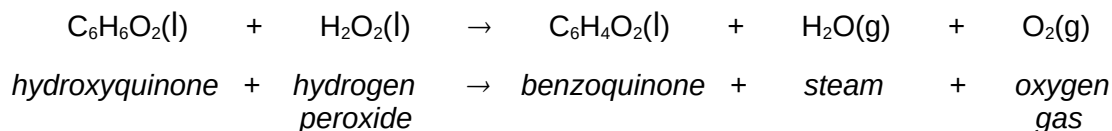
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**Question 27****(9 marks)**

The bombardier beetle produces a 'chemical bomb' from the reaction between hydroxyquinone and hydrogen peroxide. The beetle produces and stores these chemicals, as well as the *peroxidase* enzyme required to catalyse the reaction. As the chemicals combine and react, heat and gas is produced and the resulting pressure forces the chemical products out of the beetle's abdomen with a loud bang. The beetle uses this as a defence mechanism.

The relevant chemical equation is;



- (a) Sketch a labelled energy profile diagram for this reaction. Label the heat of reaction and the activation energy. (3 marks)



- (b) Add to the energy profile diagram above, the effect of the *peroxidase* enzyme. (1 mark)
- (c) Determine whether hydroxyquinone is reduced or oxidised in this reaction. Use oxidation numbers to support your answer. (2 marks)

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- (d) The structure of hydroxyquinone is shown below. Classify hydroxyquinone as a primary, secondary or tertiary alcohol. Justify your answer. (2 marks)

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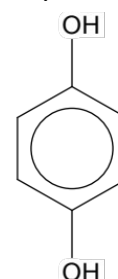
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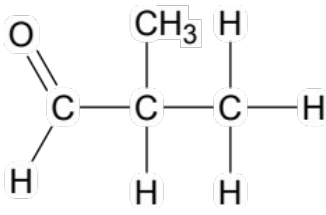
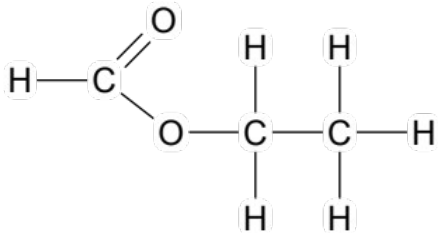
- (e) What functional group do you predict will be present in benzoquinone? (1 mark)

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**Question 28****(10 marks)**

- (a) Give the IUPAC name for each of the organic molecules below. (2 marks)

	
IUPAC Name:	IUPAC Name:

Acidified sodium dichromate solution was added to a sample of each of the substances in (a).

- (b) Explain, with the use of an appropriate chemical equation, how this test would allow the substances to be distinguished. (4 marks)

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- (c) Draw the structures of the organic molecules named below. (2 marks)

1,1-dibromobutan-2-amine	1,4,5-trifluoro- <i>cis</i> -pent-2-ene
Structural diagram:	Structural diagram:

A few drops of green universal indicator were added to a sample of each of the substances in (c).

- (d) Explain how this test would allow the substances to be distinguished. (2 marks)

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**Question 29****(8 marks)**

A student had five (5) small pieces of iron and placed one piece into each of the solutions listed below.

- tap water,  $\text{H}_2\text{O}(\text{l})$
- calcium chloride,  $\text{CaCl}_2(\text{aq})$
- acidified potassium permanganate,  $\text{KMnO}_4(\text{aq}) / \text{H}^+(\text{aq})$
- silver nitrate,  $\text{AgNO}_3(\text{aq})$
- zinc fluoride,  $\text{ZnF}_2(\text{aq})$

- (a) Name one solution with which no reaction would occur. (1 mark)

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- (b) In one solution a metal displacement reaction would occur. Name this solution and write full observations for the reaction that would take place. (3 marks)

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- (c) Which reaction has the potential to produce the largest EMF if it was set up as an electrochemical cell? State this EMF, assuming standard conditions. (2 marks)

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- (d) When the piece of iron was placed in the tap water and left for a few days, a chemical change was observed. Write the oxidation and reduction half-equations for the process that was occurring. (2 marks)

oxidation: 

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reduction: 

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**Question 30****(10 marks)**

Lipase enzymes can be used to catalyse the transesterification reaction that produces biodiesel. Like all proteins, lipases have a specific shape which allows them to function properly. The shape of a lipase enzyme is determined by the secondary and tertiary structures present.

(a) Classify the following types of interactions as secondary or tertiary structures. (3 marks)

- disulfide bridge
- $\alpha$ -helix
- $\beta$ -pleated sheet
- dipole-dipole forces
- ionic bond

Secondary	Tertiary

(b) In general, lipases function best at a temperature of approximately 25-35 °C. Explain why a temperature higher than this range can result in the loss of enzyme function. (2 marks)

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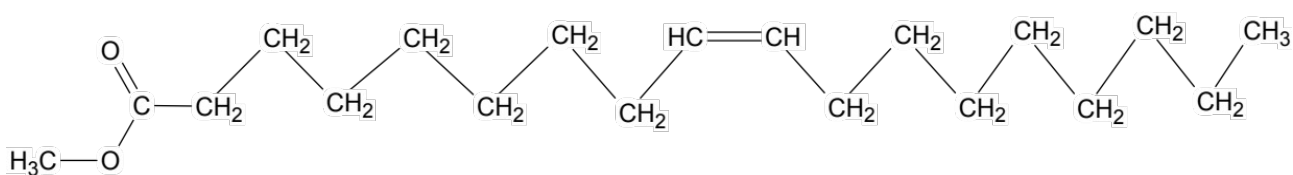
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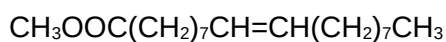
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Consider a sample of biodiesel comprising the compound shown below.



OR



- (c) Draw the structures of the two (2) substances that have reacted, in the presence of lipase, to produce the biodiesel shown. (2 marks)

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- (d) Name the other substance produced in the reaction referred to in (c), in addition to the biodiesel. (1 mark)

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An alternate catalyst for this reaction is sodium hydroxide, NaOH(aq).

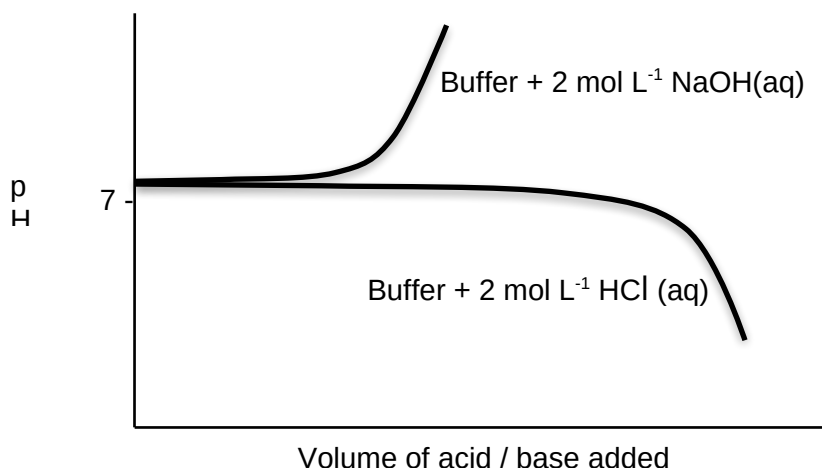
- (e) State one (1) advantage and one (1) disadvantage of using a base catalyst instead of a lipase catalyst. (2 marks)

Advantage	
Disadvantage	

**Question 31****(6 marks)**

A dihydrogenphosphate / hydrogenphosphate buffer, prepared by mixing  $\text{NaH}_2\text{PO}_4(\text{aq})$  and  $\text{Na}_2\text{HPO}_4(\text{aq})$ , was tested to investigate its buffering capacity. The buffer sample was split evenly into two (2) beakers. One of the buffer samples had  $2 \text{ mol L}^{-1} \text{NaOH}(\text{aq})$  added dropwise while the pH was measured. The second sample had  $2 \text{ mol L}^{-1} \text{HCl}(\text{aq})$  added dropwise while the pH was measured.

The results of this investigation are shown in the graph below.



- (a) Write an equation for the buffering system that was prepared. (1 mark)

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- (b) Which of the following is the most likely composition of the buffer that was being investigated? (tick your choice) (1 mark)

- ☐  $0.15 \text{ mol L}^{-1} \text{NaH}_2\text{PO}_4(\text{aq}) + 0.15 \text{ mol L}^{-1} \text{Na}_2\text{HPO}_4(\text{aq})$
- ☐  $0.15 \text{ mol L}^{-1} \text{NaH}_2\text{PO}_4(\text{aq}) + 0.30 \text{ mol L}^{-1} \text{Na}_2\text{HPO}_4(\text{aq})$
- ☐  $0.30 \text{ mol L}^{-1} \text{NaH}_2\text{PO}_4(\text{aq}) + 0.15 \text{ mol L}^{-1} \text{Na}_2\text{HPO}_4(\text{aq})$
- ☐  $0.30 \text{ mol L}^{-1} \text{NaH}_2\text{PO}_4(\text{aq}) + 0.30 \text{ mol L}^{-1} \text{Na}_2\text{HPO}_4(\text{aq})$

- (c) Justify your choice of buffer in part (b). Include a definition of buffering capacity in your answer. (4 marks)

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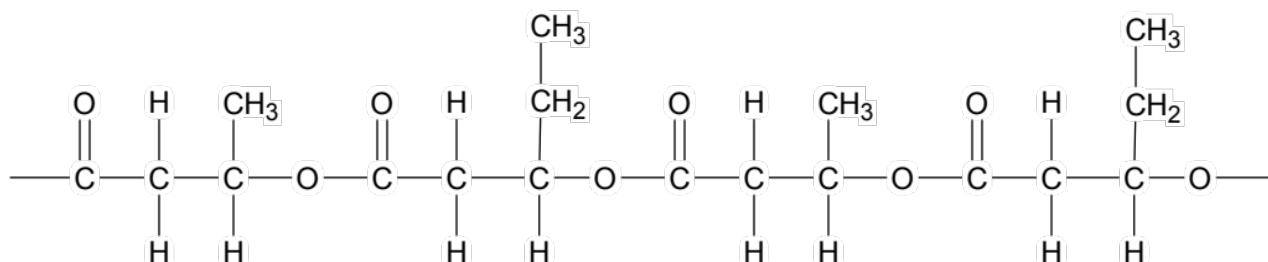
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**Question 32**

**(8 marks)**

PHBV is a biodegradable, non-toxic plastic that is produced naturally by some types of bacteria. A fragment of the PHBV polymer is shown below.



- (a) Draw the two (2) monomers from which this copolymer is formed and give the IUPAC name for each. (4 marks)

Structural diagram:	Structural diagram:
IUPAC name:	IUPAC name:

- (b) Is this polymer a 'polyester' or a 'polyamide'? State your answer below, then circle the ester or amide links in the polymer fragment above. (2 marks)

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PHBV is a thermoplastic, which means it melts easily when heat is applied, and lacks the strength of a polymer such as nylon.

- (c) Briefly account for the different physical properties of PHBV and nylon. (2 marks)

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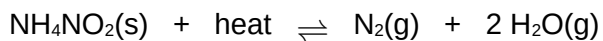
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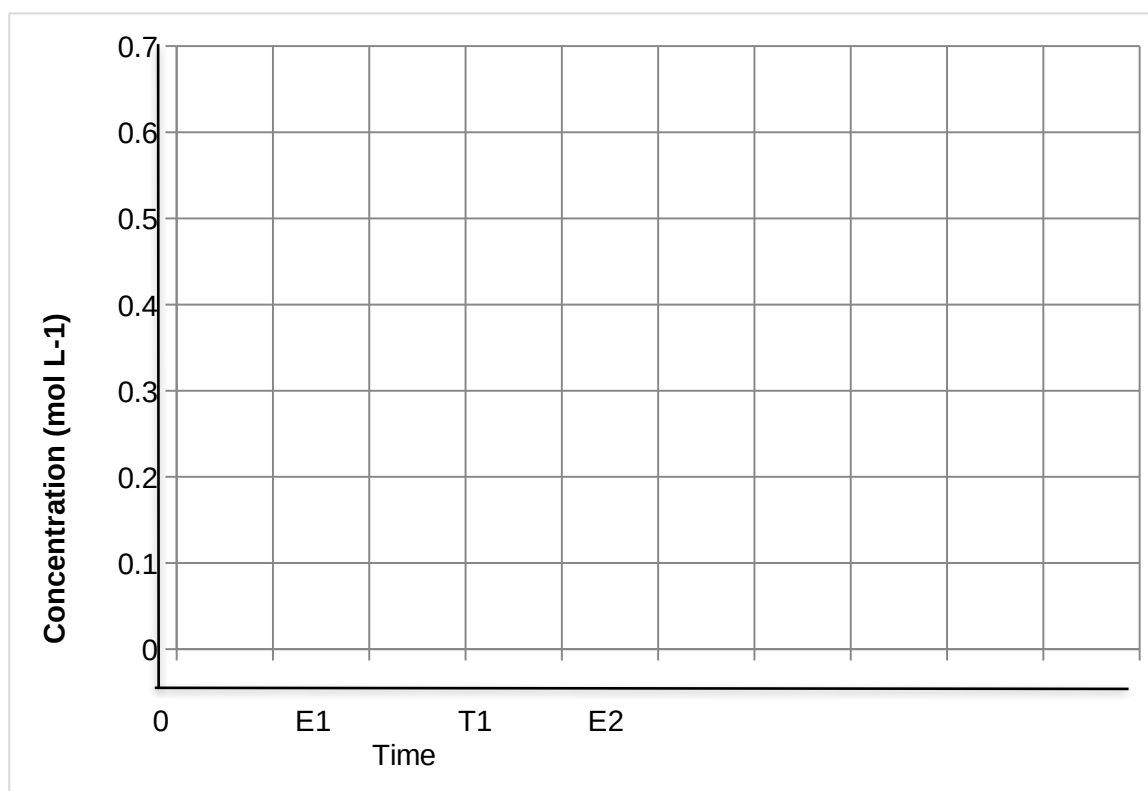
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**Question 33****(13 marks)**

Some pale yellow crystals of ammonium nitrite ( $\text{NH}_4\text{NO}_2$ ) were placed in an empty, sealed flask at Time 0. The ammonium nitrite crystals began to decompose according to the chemical equation shown below.



Equilibrium was first established at Time E1. At this time, the concentration of nitrogen gas in the flask was  $0.2 \text{ mol L}^{-1}$ .



- (a) On the axes above, sketch (and label) the concentration of all appropriate species involved in the equilibrium from Time 0 until Time E1. Continue your graph from Time E1 to Time T1, where the system maintained equilibrium. (3 marks)

At Time T1, the temperature of the system was decreased, and equilibrium was then allowed to re-establish. The new equilibrium was established at Time E2.

- (b) On the same axes above, continue your sketch from Time T1 until Time E2. (2 marks)

- (c) How would the value of the equilibrium constant (K) at E2 compare to the value at E1?  
Explain your answer. (3 marks)

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- (d) Explain, in terms of collision theory, the effect of the temperature decrease on the rate of both the forward and reverse reactions, from T1 to E2. (3 marks)

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- (e) State the effect on the equilibrium position if the following changes were made to the system. (2 marks)

	Effect on equilibrium position (forward favoured, reverse favoured, no change)
More $\text{NH}_4\text{NO}_2(\text{s})$ crystals were added into the flask	
The flask was opened, reducing the pressure of the system	

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

This section contains **five (5)** questions. You must answer **all** questions. Write your answers in the spaces provided below.

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(s) that you are continuing to answer at the top of the page.

Suggested working time: 70 minutes.

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**Question 34****(13 marks)**

Fuel cells have several differences when compared to other primary and secondary cells. They require a continuous input of oxidant and reductant, and this allows them to produce a continuous and constant supply of electricity.

The alkaline hydrogen-oxygen fuel cell was one of the earliest fuel cells to be developed. The cell consists of porous nickel electrodes that are coated in a catalyst such as platinum. The electrodes are porous to allow maximum contact between the reactants, the catalyst and the electrodes. It is called the 'alkaline' fuel cell, due to the presence of hot concentrated potassium hydroxide solution (KOH). These cells were first used in the Apollo space shuttles.

- (a) Briefly describe the chemistry of the alkaline hydrogen-oxygen fuel cell. Your answer should identify the oxidant (oxidising agent) and the reductant (reducing agent), in addition to stating the function of the potassium hydroxide solution. Include an overall equation for the chemical reaction occurring in the fuel cell. (4 marks)

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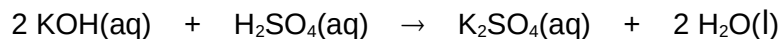
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An engineer working on the Apollo missions noticed that one of the fuel cells that was to be used in the space shuttles was leaking potassium hydroxide. The potassium hydroxide was dripping from the cell and forming a puddle on the warehouse floor. He knew the concentration of potassium hydroxide used in the cell should be  $400 \text{ g L}^{-1}$  and he estimated the size of the puddle to be 1.5 L in volume. The engineer found some  $2.75 \text{ mol L}^{-1}$  sulfuric acid solution,  $\text{H}_2\text{SO}_4(\text{aq})$ , in the storeroom and poured 1.9 L of this onto the  $\text{KOH}(\text{aq})$  in order to neutralise the spill.

The neutralisation reaction that took place is as follows;

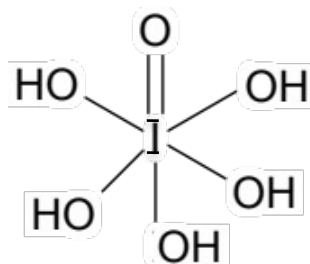


- (b) Based on the engineer's estimations, determine the limiting reagent. (5 marks)

- (c) Based on the engineer's estimations, calculate the final pH of the puddle and state whether the spill has been effectively neutralised. (4 marks)

**Question 35****(12 marks)**

Periodic acid was discovered in 1833 and comes in two forms; orthoperiodic acid ( $\text{H}_5\text{IO}_6$ ) and metaperiodic acid ( $\text{HIO}_4$ ). Orthoperiodic acid is a weak acid, that has a melting point of  $128.5^\circ\text{C}$  and is soluble in both water and alcohol. The orthoperiodic acid molecule has 5 ionisable (acidic) hydrogens, as shown in the diagram below;



- (a) In the table below, write Bronsted-Lowry equations for the first three (3) ionisation steps of orthoperiodic acid. (3 marks)

	Ionisation equation	Ka value
1.		
2.		
3.		

In no particular order, the values of  $K_{a1}$ ,  $K_{a2}$  and  $K_{a3}$  are given as;

$$2.45 \times 10^{-12}$$

$$5.13 \times 10^{-4}$$

$$4.90 \times 10^{-9}$$

- (b) Place these values in the table above, next to the corresponding ionisation step. Explain your choice below. (3 marks)

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Orthoperiodic acid is an oxidising agent (oxidant) of moderate strength. It can be produced from the electrochemical oxidation of iodic acid ( $\text{HIO}_3$ ) using a lead(II) oxide anode.

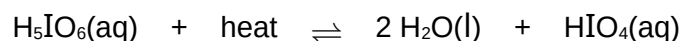
- (c) Write the balanced half-equation for the production of orthoperiodic acid from iodic acid, assuming acidic conditions. (2 marks)

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When heated sufficiently, orthoperiodic acid can be converted to metaperiodic acid, according to the following reaction;



- (d) Use oxidation numbers to demonstrate that this is **not** a redox reaction. (2 marks)

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When metaperiodic acid is heated further, the compound diiodine pentoxide ( $\text{I}_2\text{O}_5$ ) is formed. Diiodine pentoxide is a water soluble, white crystalline solid which has a melting point of  $300^\circ\text{C}$ .

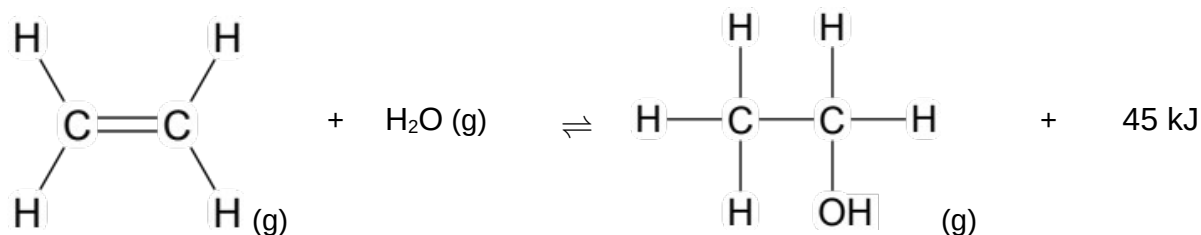
- (e) Write the balanced half-equation for the formation of diiodine pentoxide from metaperiodic acid, assuming acidic conditions. Include phase symbols in your equation. (2 marks)

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**Question 36****(20 marks)**

Ethanol ( $\text{C}_2\text{H}_5\text{OH}$ ) is commonly manufactured by the hydrolysis of ethene. The reaction for this exothermic process is shown below.



This reaction is carried out at a temperature of  $300^\circ\text{C}$  and a pressure of 6-7 MPa, in the presence of a phosphoric acid catalyst. The ethene is present **in excess**, with a 1:0.6 ratio of ethene:steam being introduced into the reaction chamber.

Using these conditions, a 5% yield of ethanol is achieved per pass. However, by collecting the unreacted ethene and steam, and cycling them back through the reaction chamber, an overall yield of 95% can be obtained.

If 385 kg of ethene was added to the reaction chamber;

- (a) Calculate the volume of steam, stored at  $300^\circ\text{C}$  and 6.00 MPa, that should be added to the reaction chamber to produce the desired 1:0.6 ratio of reactants? (5 marks)

- (b) If the yield is only 5.0 % per pass, what mass of ethanol would be produced in the reaction chamber initially? (3 marks)

As stated previously, this reaction is carried out at a temperature of 300 °C. This can be referred to as a 'compromise in conditions'.

- (c) Explain why a 'compromise temperature' is used. (5 marks)

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A moderate pressure is used in the reaction chamber because at high pressures there is an increased risk that polyethene will form instead of ethanol.

- (d) Write an equation or draw appropriate structural diagrams to illustrate how this could happen. (2 marks)

The common alternate method for ethanol synthesis is via the fermentation of glucose. The ethanol formed is referred to as 'bioethanol', to indicate the more sustainable production approach used.

- (e) Briefly describe why the fermentation method is a more 'green' and sustainable process in terms of the temperature, pressure and starting materials used. (5 marks)

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**Question 37****(16 marks)**

A useful piece of data regarding fats and oils is their 'saponification value'. Saponification value is defined as '**the number of milligrams of potassium hydroxide (KOH) required to saponify 1 gram of fat**'. The saponification value provides information about the molecular weight of the fat; a lower saponification value indicates a higher molecular weight fat with a longer hydrocarbon chain.

Knowledge of saponification value is important in soap making. Soap can be produced from many different fats and each has a different saponification value. This value will affect the quantities of chemical used in the reaction to produce the soap. Some examples of fats and their saponification values are shown in the table below.

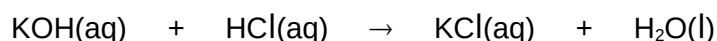
	Saponification value
Olive oil	185-196
Linseed oil	192-195
Palm oil	196-205
Butter	220-233
Coconut oil	246-260

The saponification value of a fat is determined experimentally by a back titration, according to the following procedure.

1. Dissolve 1.00 g of fat in 10.00 mL of ethanol-ether-solvent.
2. Add 25.00 mL of 0.5 mol L<sup>-1</sup> KOH solution. This ensures the KOH is in excess. The general saponification reaction that takes place is shown in the following equation.



3. Place the sample in a water bath at 100 °C for 30 minutes to ensure all the fat has reacted. Cool the sample.
4. Add several drops of phenolphthalein to the saponified sample. A pink colour should be observed, confirming excess KOH(aq).
5. Back titrate the sample with 0.5 mol L<sup>-1</sup> HCl(aq) until the end point is reached. This allows the amount of KOH(aq) remaining to be determined.



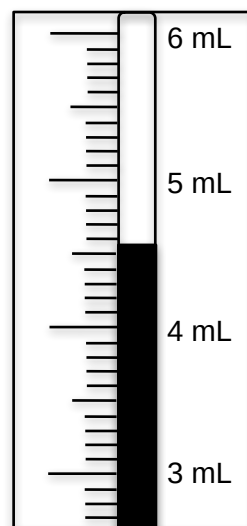
Some chemistry students carried out this procedure on a sample of unknown fat. They repeated the process five (5) times. Their incomplete titration data is shown in the table below.

	1	2	3	4	5
Initial reading (mL)	47.25	29.60	48.50	31.75	20.95
Final reading (mL)	29.60	12.80	31.75	14.90	
Titre (mL)					



The final burette reading for **Trial 5** is shown below right.

- (a) Read the final burette value to the appropriate degree of accuracy and record it in the table. Then calculate the average titre that should be used. (2 marks)



- (b) Use the titration data, as well as the initial data on KOH(aq) given in Step 2, to calculate the number of moles of KOH(aq) that reacted with the fat. (4 marks)

- (c) Calculate the saponification value for this fat and identify the fat using the values given in the saponification table. (3 marks)

- (d) Calculate the molecular weight of this fat. (2 marks)

The students decided to use the data from this experiment to make some small bars of soap, which they sold at the school fete to raise money for their school.

- (e) Explain why soap molecules have a slightly basic pH. (2 marks)

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- (f) Briefly explain how soap is able to clean oily food particles off hands. (3 marks)

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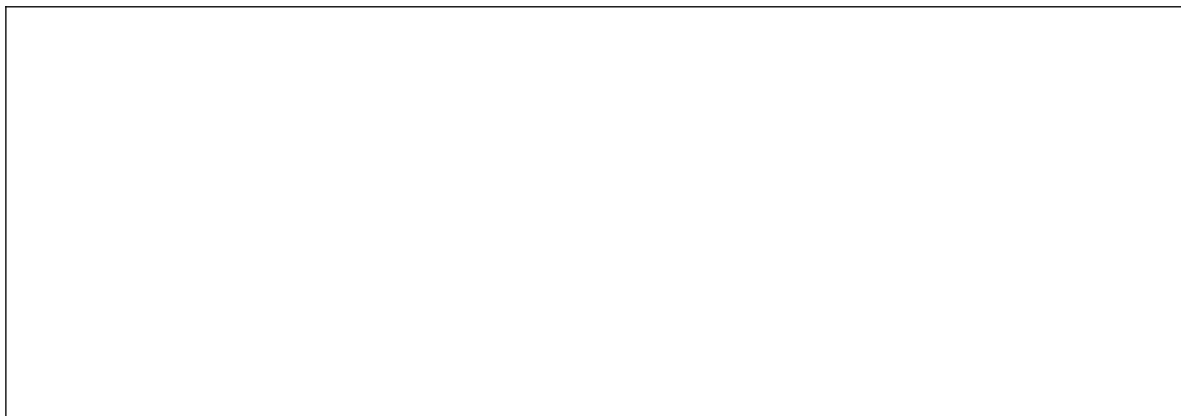
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**Question 38****(19 marks)**

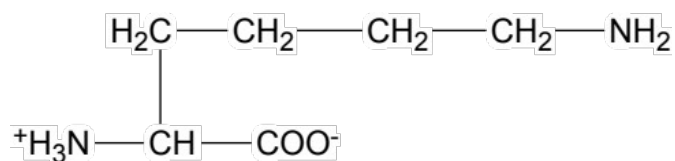
'Copper peptide GHK' (also written GHK-Cu) is a tripeptide composed of the amino acids glycine, histidine and lysine (gly-his-lys). GHK-Cu is found in blood plasma, urine and saliva. Studies have shown that GHK-Cu plays an important role in healing wounds. In one animal study, it was observed that the presence of GHK-Cu increased the rate of healing threefold.

- (a) Draw a structural diagram of the GHK-Cu tripeptide.

(3 marks)



The GHK-Cu tripeptide functions due to the ability of the amino acid lysine to interact with copper(II) ions. A diagram of lysine, at physiological pH, is shown below.



- (b) Define a 'zwitterion'. Circle and label the acidic and basic groups on the diagram of lysine shown above.

(3 marks)

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In the GHK-Cu tripeptide, the lysine residue is only able to interact with copper(II) ions at an alkaline pH.

- (c) Draw the structure of lysine at pH 14 (i.e. strongly alkaline).

(1 mark)



One of the amino acid residues from GHK-Cu was isolated and analysed by combustion. A 2.73 g sample of the amino acid was burnt in oxygen, and this produced 4.92 g of carbon dioxide and 2.35 g of water vapour. A volume of 440 mL of nitrogen gas ( $\text{N}_2$ ) was also captured, at 220 °C and 174 kPa.

- (d) Determine the empirical formula of this amino acid. (10 marks)

- (e) Identify which of the amino acids in GHK-Cu had been isolated and analysed. Justify your answer. (2 marks)

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End of questions

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