

**CHEMISTRY EXAM**

**12 ATCHE**

**SEMESTER 2, 2018**

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

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

# TIME ALLOWED FOR THIS PAPER

## Reading time before commencing work: ten (10) minutes

Working time for the paper: three (3) hours

# MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

**To be provided by the supervisor:**

This Question/Answer Booklet

A separate 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 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.

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** to be 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 the forward reaction of an equilibrium system is as follows;

K = [H2][CO]

[H2O]

The chemical equation could be;

1. 2 CO(g) + 2 H2(g) ⇌ CH4(g) + CO2(g)
2. C(s) + H2O(g) ⇌ CO(g) + H2(g)
3. H2O(g) + CO(g) ⇌ CO2(g) + H2(g)
4. CH4(g) + 2 O2(g) ⇌ CO2(g) + 2 H2O(g)

2. The cell diagram below represents an electroplating of gold experiment.



A B

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

1. Electrons will flow from electrode A to electrode B.
2. Gold metal will deposit at electrode A.
3. Negative ions (anions will flow to electrode B).
4. Gold ions (Au3+) will become oxidised.
5. Electrode A is the cathode.
6. (i) only
7. (ii), (iii) and (iv) only
8. (ii) and (v) only
9. (i) and (iii) only

**Questions 3 and 4 relate to the four isomers of C5H11OH shown below.**

|  |  |
| --- | --- |
| **A** | **B** |
| **C** | **D** |

3. Which of the four (4) isomers above would **not** react with acidified sodium permanganate solution?

1. A
2. B
3. C
4. D

4. Which of the following is **not** a possible organic product resulting from the oxidation of the isomers pictured above?

1. 3-methylbutanoic acid
2. 2-methylbutanoic acid
3. 3-methylbutanone
4. 2-methylbutanone

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

Consider the following aqueous equilibrium system;

[Cr(H2O)6]3+(aq) + 6 OH-(aq) ⇌ [Cr(OH)6]3-(aq) + 6 H2O(l)

*blue-grey green*

The following three (3) questions relate to the changes that would occur when a few drops of concentrated HNO3 (aq) was added to the system.

5. Which of the following gives the correct equilibrium shift and observable change after the addition of HNO3?

**Equilibrium shift Observations**

1. forward favoured solution becomes more green
2. forward favoured solution becomes more blue-grey
3. reverse favoured solution becomes more green
4. reverse favoured solution becomes more blue-grey

6. Which of the following statements correctly states the concentration of the hydroxide (OH-) ions after the addition of HNO3?

1. It increases.
2. It decreases.
3. It stays the same.
4. It increases then decreases.

7. Which of the following statements correctly describes the **overall** change in the rate of reaction once a new equilibrium has been re-established?

1. The rate of the forward reaction is decreased.
2. The rate of the forward reaction is increased.
3. The rate of the forward reaction is unchanged.
4. There is not sufficient information to comment on the rate of forward reaction.

8. There are three (3) key reactions in the manufacture of ammonia (NH3):

1. Steam reforming CH4(g)  + H2O(g) ⇌ CO(g) + 3 H2(g) ΔH = +206 kJ
2. Shift reaction CO(g) + H2O(g) ⇌ H2(g) + CO2(g) ΔH = -41 kJ
3. Haber process N2(g) + 3 H2(g) ⇌ 2 NH3(g) ΔH = -92 kJ

Which of the reactions above would show the highest increase in **yield** if the operating temperature was decreased and the pressure increased?

1. Steam reforming
2. Shift reaction
3. Haber process
4. Steam reforming and Shift reaction

9. Consider the organic molecule shown below.



Which of the following reactants would **most likely** produce the compound above?

+ H2



+ HBr



+ H2O



+ Br2



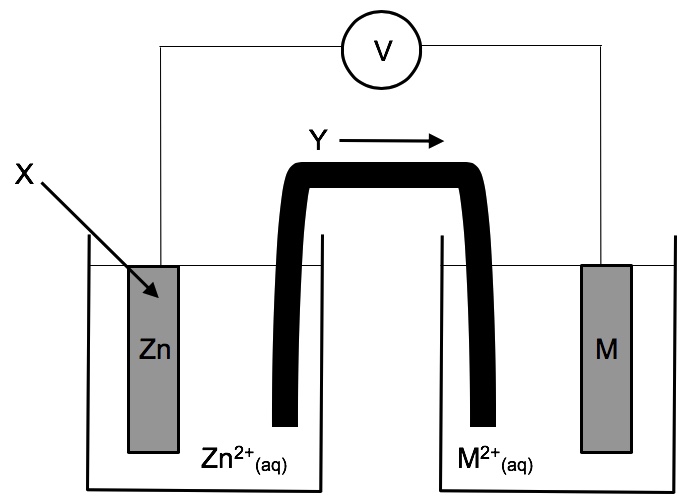
10. With reference to ocean chemistry, which of the following changes is/are associated with ocean acidification?

1. An increase in H2CO3(aq) concentration
2. An increase in CO32-(aq) concentration
3. An increase in H3O+(aq) concentration
4. An increase in CO2(aq) concentration
5. An increase in pH
6. (i), (ii) and (iii) only
7. (i), (iii) and (iv) only
8. (ii), (iv) and (v) only
9. (ii), (iii) and (v) only

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

The following **incomplete** diagram shows a Zn/Zn2+ half-cell which has been set up under standard conditions. This half-cell is connected to another half-cell that consists of an electrode M (a silver coloured metal) submerged in a colourless solution of M2+(aq).

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?

1. Fe
2. Cd
3. Sn
4. Pb

12. Which one 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. Which one of the following halogen displacement reactions would **not** occur under standard conditions?

(a) Br2(aq) + NaCl(aq)

(b) Br2(aq) + NaI(aq)

(c) Cl2(aq) + NaBr(aq)

(d) Cl­2(aq) + NaI(aq)

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

|  |  |
| --- | --- |
| (a) 4,5-dibromopentanamine | (b) propylmethanoate |
| (c) 2-chloro-3-methylhexanal | (d) 3-ethyl-4-methylheptane |

**Questions 15 and 16 refer to the information below.**

Liquid ethanol has a boiling point of 78.4 °C and liquid water has a boiling point of 100 °C. In an experiment, 20.0 mL of liquid ethanol and 20.0 mL of liquid water were both added to the same beaker and the contents thoroughly mixed at room temperature. The beaker was then sealed with an airtight lid.

15. Which of the following **best** describes the sealed beaker?

1. physical equilibrium, open system.
2. physical equilibrium, closed system.
3. chemical equilibrium, open system.
4. chemical equilibrium, closed system.

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

1. The non-polar region on an ethanol molecule is very small.
2. Ethanol molecules can form hydrogen bonds.
3. The intermolecular forces present in water are stronger than those in ethanol.
4. Ethanol molecules are highly polar.

**Questions 17, 18 and 19 relate to the information below.**

The chemical compound in litmus indicator that causes a colour change is called 7-hydroxyphenoxazone. Three (3) forms of this compound (I, II and III) are shown below. One shows the structure of 7-hydroxyphenoxazone in an acidic solution (appearing red in colour), one in a neutral solution (appearing purple in colour) and one in a basic solution (appearing blue in colour).

**I. II. III.**

17. Which of the following shows the structures of 7-hydroxyphenoxazone arranged in order of **increasing** pH (i.e. from low to high pH)?

1. I. II. III.
2. I. III. II.
3. II. I. III.
4. III. I. II.

18. Which of the following four (4) aqueous solutions below could be distinguished from the others using litmus indicator?

1. NaHCO3 (aq)
2. MgF2 (aq)
3. LiH2PO4 (aq)
4. Ca(OH)2 (aq)

19. Which of the following substances would have the same colour as its conjugate base, when tested with litmus indicator? Assume no other species that affect pH are present.

1. CH3COOH(aq)
2. NH4+(aq)
3. HSO4- (aq)
4. HPO42- (aq)

20. The key equilibrium reaction in the Contact process is the conversion of SO2(g) to SO3(g) as shown in the equation below.

2 SO2(g) + O2(g) ⇌ 2 SO3(g) ΔH = -198 kJ

Which of the following conditions would **not** increase the rate of the forward reaction?

(a) Use of high pressure.

(b) Use of low temperature.

(c) Presence of a V2O5 catalyst.

(d) Use of a high concentration of O2(g).

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

HSO4-(aq) + CN-(aq) ⇌ HCN(aq) + SO42-(aq)

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

1. HSO4-(aq) is the acid.
2. CN- (aq) is the conjugate acid.
3. HCN(aq) is the conjugate base.
4. HCN(aq) is the acid.
5. SO42-(aq) is the conjugate base.
6. (i) and (iii) only
7. (ii) and (iv) only
8. (i) and (v) only
9. (iv) and (v) only

22. Consider the fragment of polymer shown below.



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

(a)



(b)



(c)

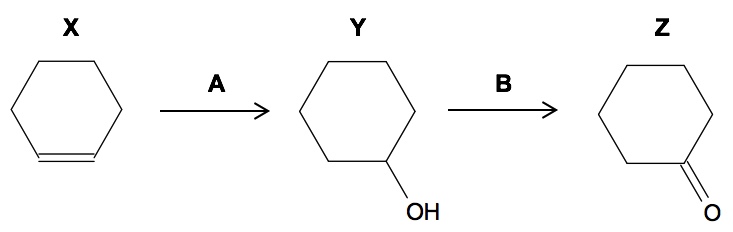


(d)



**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?

**X Y Z**

1. alkene alcohol aldehyde
2. alkene aldehyde carboxylic acid
3. alkene alcohol ketone
4. alkane ketone ester

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

**A B**

1. O2(g) H2(g)
2. H2O(l) O2(g)
3. NaOH(aq) H+/MnO4-(aq)
4. H2O(l) H+/MnO4-(aq)

25. A sample of soap and a sample of detergent were both added to a beaker of hard water that was known to have a **low** concentration of Ca2+(aq). The structures of the soap and the detergent are shown below;

**Soap**

COO- Na+



**Detergent**

SO3-Na+



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

1. CH3(CH2)14COO-(aq)
2. CH3(CH2)11C6H4SO3-(aq)
3. Ca(CH3(CH2)14COO)2(s)
4. Ca(CH3(CH2)11C6H4SO3)2(s)

**End of Section One**

**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.

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Suggested working time: 60 minutes.

**Question 26 (6 marks)**

The lead-acid accumulator battery is widely used in vehicles today. It 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. For each of the following, provide at least two (2) reasons (noting that chemical equations are **not** required in your answer) as to how this cell can be classified as both;

(a) an electrochemical (galvanic) cell. (3 marks)

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(b) an electrolytic cell. (3 marks)

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**Question 27 (9 marks)**

The bombardier beetle produces a ‘chemical bomb’ as a defence mechanism. This ability comes from the reaction between hydroxyquinone and hydrogen peroxide, a strong oxidising agent. These chemicals and the *peroxidase* enzyme required to catalyse the reaction are stored in the body of the beetle. When disturbed, all he chemicals combine and react to produce heat and gas. The resulting pressure forces the chemical products out of the beetle’s abdomen with a loud explosion.

The relevant chemical equation is;

**C6H6O2(l)  + 3H2O2(l) → C6H4O2(l) + 4H2O(g) + O2(g)**

*hydroxyquinone + hydrogen → benzoquinone + steam + oxygen*

*peroxide gas*

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



(b) Draw a dotted line (- - -) to show the effect of the *peroxidase* enzyme on the energy profile diagram above. (1 mark)

(c) Use the oxidation numbers method to determine whether hydroxyquinone (C6H6O2) is reduced or oxidised in this reaction. (2 marks)

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



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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: |

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

Explain, with the use of an appropriate chemical equation, how this procedure would allow the two substances above to be identified. (4 marks)

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(c) Draw the structural formula of the organic molecules below. (2 marks)

|  |  |
| --- | --- |
| 1,1-dibromobutan-2-amine | 1,4,5-trifluoro-*cis*-pent-2-ene |
| Structural diagram: | Structural diagram: |

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

State the **resultant** colour of universal indicator observed in each of the substances and provide a brief reason for your answers. (2 marks)

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**Question 29 (8 marks)**

In an experiment, a student placed a small piece of iron metal into each of the samples listed below.

Sample A: tap water, H2O(l)

Sample B: calcium chloride, CaCl2(aq)

Sample C: acidified potassium permanganate, KMnO4(aq) / H+(aq)

Sample D: silver nitrate, AgNO3(aq)

Sample E: zinc fluoride, ZnF2(aq)

(a) Name **one** sample where no visible change would be observed. (1 mark)

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(b) Name one sample where a metal displacement reaction would occur **and** write all observations for this reaction. Note: A chemical equation is not required. (3 marks)

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(c) i. Which sample would produce the largest theoretical EMF with iron metal? (1 mark)

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ii. Assuming standard conditions, calculate the maximum EMF that can be obtained from the reaction sample stated in part (i) above. (1 mark)

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

oxidation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

reduction: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**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) Write each of the following types of interactions under the appropriate headings below.

(3 marks)

* + - disulfide bridge
    - α-helix
    - β-pleated sheet
    - dipole-dipole forces
    - ionic bond

|  |  |
| --- | --- |
| Secondary Structure | Tertiary Structure |
|  |  |

(b) In general, lipase enzymes 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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The following diagram shows a biodiesel structure.



**OR**

CH3OOC(CH2)7CH=CH(CH2)7CH3

(c) Draw the structural formulas of the two (2) substances needed, in the presence of lipase enzyme, to produce the biodiesel structure shown above. (2 marks)

|  |  |
| --- | --- |
| Monomer 1 | Monomer 2 |
|  |  |

(d) Apart from the biodiesel, the reaction referred to in (c) also produces a new substance. Name this substance. (1 mark)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

An alternative catalyst for the biodiesel making process is sodium hydroxide, NaOH(aq).

(e) State one (1) advantage and one (1) disadvantage of using NaOH as a catalyst instead of lipase enzyme. (2 marks)

|  |  |
| --- | --- |
| Advantage |  |
| Disadvantage |  |

**Question 31 (6 marks)**

A dihydrogenphosphate / hydrogenphosphate buffer, prepared by mixing NaH2PO4(aq) and Na2HPO4(aq), was tested to investigate its buffering capacity.

(a) Write a Lowry-Bronsted equation for the buffer equilibrium above. (1 mark)

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The buffer solution was divided evenly into two (2) samples. The first buffer sample had 2 mol L-1 NaOH(aq) added dropwise and its pH was recorded. The second buffer sample had 2 mol L-1 HCl(aq) added dropwise and its pH was also recorded.

The results of **both** procedures are shown in the graph below.



(b) With reference to the graph above, which of the following is the most likely composition of the buffer that was being investigated? (**Circle** your choice). (1 mark)

A. 0.15 mol L-1 NaH2PO4(aq) + 0.15 mol L-1 Na2HPO4(aq)

B. 0.15 mol L-1 NaH2PO4(aq) + 0.30 mol L-1 Na2HPO4(aq)

C. 0.30 mol L-1 NaH2PO4(aq) + 0.15 mol L-1 Na2HPO4(aq)

D. 0.30 mol L-1 NaH2PO4(aq) + 0.30 mol L-1 Na2HPO4(aq)

(c) With **reference to the graph** above, justify your answer in part (b). Include in your explanation a definition of buffering capacity. (4 marks)

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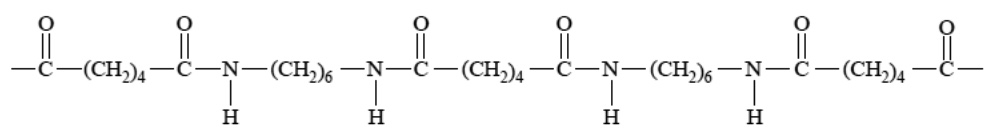
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**Question 32 (8 marks)**

According to Wikipedia, Nylon is a class of polymers that have found significant commercial applications in fabrics and fibre (apparel, flooring and rubber reinforcement), in shapes (moulded parts for cars, electrical equipment, etc.), and in films (mostly for food packaging). The following diagram shows a segment of Nylon.



(a) Draw the structural formulas of the two (2) monomers from which this polymer is formed and state the IUPAC name for each of the monomers. (4 marks)

|  |  |
| --- | --- |
| Structural diagram of monomer 1 | Structural diagram of monomer 2 |
| Name of monomer 1 | Name of monomer 2 |

(b) i. Is this polymer a ‘polyester’ or a ‘polyamide’? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

ii. Circle **ALL** the ester or amide bonds (links) in the polymer above. (1 mark)

Nylon is a thermoplastic that has a higher melting temperature than polyethene (PE). Its strength is also higher than that of polyethene.

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

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**Question 33 (13 marks)**

A few pale yellow crystals of ammonium nitrite (NH4NO2) were placed in an empty, sealed flask at Time 0. The ammonium nitrite crystals began to decompose according to the chemical equation shown below.

**NH4NO2(s) + heat ⇌ N2(g) + 2 H2O(g)**

Equilibrium was first established at Time T1. At this time, the concentration of nitrogen gas in the flask was 0.2 mol L-1.

(a) On the axes above, sketch (and label) the concentration of all **relevant** species involved in the equilibrium from Time 0 until Time T1.

Continue your graph from Time T1 to Time T2, where the system maintained equilibrium. (3 marks)

At Time T2, the temperature of the system was decreased, and equilibrium was then allowed to re-establish. The new equilibrium was established at Time T3.

(b) On the same axes above, continue your sketch from Time T2 until Time T3. (2 marks)

(c) Would the value of the equilibrium constant (K) at Time T3 be larger, smaller or the same as the value of K at Time T1? Explain your answer. (3 marks)

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(d) Explain, in terms of collision theory, the effect of the decrease in temperature on the rates of **both** the forward and reverse reactions, from T2 to T3. (3 marks)

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(e) State the effect of the following imposed changes on the equilibrium reaction below.

**NH4NO2(s) + heat ⇌ N2(g) + 2 H2O(g)**

Note: Explanation is not required. (2 marks)

|  |  |
| --- | --- |
| Imposed change | Effect on equilibrium position  (Write: forward favoured, reverse favoured or no change) |
| More NH4NO2(s) crystals were added into the flask |  |
| The flask was opened |  |

**End of Section Two**

**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.

**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 acidic 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.

(a) State:

1. The oxidant: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The reductant: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1 mark)

1. Two (2) advantages associated with this cell , compared to other primary and secondary cells (2 marks)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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1. One (1) disadvantage associated with this cell, compared to other primary and secondary cells (1 mark)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Alkaline fuel cells were used by NASA in Apollo space shuttles.

An engineer working on an Apollo mission found that one of the fuel cells in a space shuttle was leaking potassium hydroxide solution (KOH). The potassium hydroxide solution was slowly dripping from the cell and forming a puddle on the warehouse floor.

The engineer estimated the concentration (or density) of the potassium

hydroxide solution to be 400 g L-1 and the volume of the puddle to be 1.5 L.

To neutralise the spill, he took a bottle of 2.75 mol L-1 sulfuric acid solution

and poured 1.9 L of this acid onto the potassium hydroxide puddle.

The neutralisation reaction that took place is as follows;

**2 KOH(aq) + H2SO4(aq) → K2SO4(aq) + 2 H2O(l)**

(b) Based on the engineer’s estimations, determine the limiting reagent. Show all working. (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 (H5IO6) and metaperiodic acid (HIO4). Orthoperiodic acid is a weak acid, that has a melting point of 128.5 °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 values |
| 1. |  | KA1 = |
| 2. |  | KA2 = |
| 3. |  | KA3 = |

A student researched on the internet and found the KA values for the three ionisation reactions above. The KA values, in no particular order, were:

2.45 x 10-12 5.13 x 10-4 4.90 x 10-9

However, the student forgot to match each of the K values with its ionisation equation.

(b) Write EACH of the KA values above in their correct boxes (i.e. the shaded area) above. Briefly explain your choice. (3 marks)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Orthoperiodic acid is an oxidising agent (oxidant) of moderate strength. It can be produced from the oxidation of iodic acid (HIO3) using a suitable anode.

(c) Write the balanced half-equation for the oxidation of iodic acid to produce orthoperiodic acid (H5IO6). Assume acidic conditions. (2 marks)

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When heated, orthoperiodic acid is converted to metaperiodic acid, according to the following reaction;

H5IO6(aq) + heat ⇌ 2 H2O(l) + HIO4(aq)

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

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When metaperiodic acid is heated further, the compound diiodine pentoxide (I2O5) is formed. Diiodine pentoxide is a water soluble, white crystalline solid which has a melting point of 300 °C.

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

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**Question 36 (20 marks)**

Ethanol (C2H5OH) is commonly manufactured by the hydrolysis of ethene. The reaction for this exothermic process is shown below.

 (g) (g)

+ H2O (g) ⇌ + 45 kJ

This reaction is carried out at a temperature of 300 °C and a pressure of 6-7 MPa, in the presence of a phosphoric acid catalyst. The ethene is present **in excess**, with an ethene : steam (gaseous H2O) reacting ratio of 1 : 0.6 in the reaction chamber.

Using these conditions, a 5% yield of ethanol is achieved per pass. However, by collecting the unreacted ethene and steam, and recycling 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 300.0 °C and 6.00 MPa, that should be added to the reaction chamber to produce the desired ratio of reactants (1 : 0.6). Express the final answer in correct significant figures. (Note: 1MPa = 1.0 x 103kPa) (5 marks)

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

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

(c) Use relevant knowledge of Collision Theory and chemical equilibrium to 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 appropriate chemical equation to show how this process may occur. (2 marks)

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An alternative method for ethanol synthesis is via the fermentation of glucose. The ethanol formed is referred to as ‘bioethanol’.

(e) Use your knowledge of green chemistry to briefly describe why the fermentation method is a more sustainable process in terms of the temperature, pressure and starting materials used. (5 marks)

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**Question 37 (16 marks)**

A useful data regarding fats and oils is the ‘saponification value’. Saponification value is defined as ‘**the number of milligrams of potassium hydroxide (KOH) required to saponify 1 gram of fat or oil**’.

The saponification value provides information about the molecular weight of the fat (or oils). In general, a low saponification value indicates a high molecular weight fat (or oils) with a long hydrocarbon chain.

Knowledge of saponification value is important in soap making. Soap can be produced from many different fats and oils and each has a different saponification value. The saponification value thus affects the quantities of chemical used in the soap making. Some examples of oils and their saponification values are shown in the table below.

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

The saponification value of an oil can determined experimentally by a **back titration**, according to the following procedures.

1. Dissolve 1.00 g sample of oil in 10.00 mL of ethanol-ether-solvent.
2. Add 25.00 mL of 0.5 mol L-1 KOH solution to the mixture in step (1). This ensures the KOH is in excess. The general saponification reaction that takes place is shown in the following simplified equation.

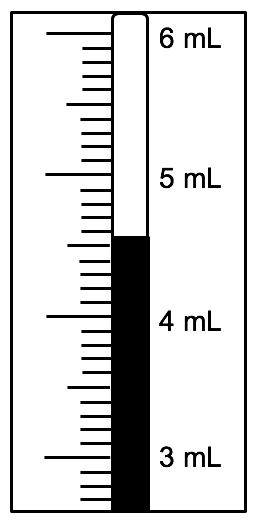
**Oil (or Fat)(s) + 3 KOH(aq) → 3 potassium fatty acid salt(aq) + glycerol(l)**

1. Heat the resultant sample in a water bath at 100 °C for 30 minutes to ensure all the oil has reacted. Cool the sample.
2. Add several drops of phenolphthalein to the sample in (3). A pink colour should be observed, confirming the presence of excess KOH(aq).
3. Titrate the sample with 0.5 mol L-1 HCl(aq) until the end point is reached. This allows the amount of KOH(aq) remaining to be determined. The equation for this reaction is:

**KOH(aq) + HCl(aq) → KCl(aq) + H2O(l)**

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

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

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

(a) i. Read the final burette value to the appropriate degree

of accuracy and record it in the table.

ii. Calculate the average titre that should be used. (2 marks)

Average titre: \_\_\_\_\_\_\_\_\_\_\_\_

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

(c) i. Calculate the mass of the **reacted** KOH(aq) in part (b). (1 mark)

ii. Use the method stated in the question to determine the saponification value for this oil

and hence identify the oil using the values given in the saponification table. (2 marks)

(d) Calculate the molecular weight of this oil. (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 social to raise money for a charity foundation.

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

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(f) Use knowledge of soap chemistry, briefly explain how soap is able to clean oily food particles off human hands. (3 marks)

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**Question 38 (19 marks)**

‘Copper peptide GHK’ (also written GHK-Cu) is a tripeptide composed of three (3) amino acid residues,

Glycine Histidine Lysine (or GLY-HIS-LYS).

(a) Draw a structural diagram of the GLY-HIS-LYS tripeptide. (3 marks)

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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.

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



(b) i. Circle and label **ALL** the acidic and basic groups on the diagram of lysine above

(2 marks)

ii. Define a ‘zwitterion’. (1 mark)

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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 a pH of 14 (i.e. strongly alkaline). (1 mark)

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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 (N2) was also captured, at 220 °C and 174 kPa.

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

(e) Use your answer to part (d) to identify the amino acid residue that was isolated from the GHK-Cu. Justify your answer. (2 marks)

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**End of questions**

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