This is a Class 1 exam

Lebanon Evangelical School
for Boys and Girls
Loueizeh - Baabda

Stage Exam 04

12FEB2024

Do NOT write in this box. Your MARK will be placed here.

Subject :	Chemistry
Class :	12M and 12E
Teacher :	Mrs. Mirella Freige
Duration :	1 hour

Your name :		*Time taken to complete exam*
Your Class :		
Exam Room :		
How many sheets, including cover sheet :		

- Do not open this paper until the teacher in charge instructs you to do so.
- The most important thing to remember in taking an exam is NEVER PANIC.
- If you are caught cheating in this exam, you will be awarded zero for ALL exams that are taken on this day.

Exercise 1 (7 points) Study of an Esterification Reaction

Four flasks are available, each containing one of the following organic compounds:

Propanoic acid, 1-propanol, 3-pentanol and 2-butanol.

The available flasks are numbered and their contents are noted as follows:

Number of flask	1	2	3	4
Organic compound	A	B	C	D

Document-1

The aim of this exercise is to identify the content of each flask in order to carry out an esterification reaction.

1. Identification of the content of each flask

The following tests are carried out:

Chemical test	Experimental result
Mild oxidation of compound (A) by an acidified potassium permanganate solution.	An organic compound (F) is obtained which reacts with DNPH and Fehling solution.
The pH of an aqueous solution of compound (B) is measured.	The pH is clearly less than 7.0

Document-2

1.1. Referring to document-2, identify the organic compounds (A) and (B).

1.2. Knowing that the molecule of compound (C) is chiral:

1.2.1. Write its condensed structural formula. Justify its chirality.

1.2.2. Represent according to Cram its two enantiomers.

1.3. Give the condensed structural formula of the compound (D).

2. Esterification Reaction

- For an initial equimolar mixture of a carboxylic acid and a secondary alcohol, the yield of the reaction at equilibrium is 60%.
- Density of the propanoic acid is d = 0.99 $g.mL^{-1}$.
- Molar masses in $g.mol^{-1}$: M (propanoic acid) = 74 ; M (E) = 130.

Document-3

A mixture of 0.25 mol of 2-butanol and a volume V = 30 mL of propanoic acid is heated to reflux. At instant t, heating is stopped. The mass of the ester (E) obtained at instant t is 19.5 g.

2.1. Write, using condensed structural formulas, the equation of the esterification reaction taking place. Name the obtained ester (E).

2.2. Calculate the initial number of moles of propanoic acid.

2.3. Determine the yield of this reaction at instant t.

2.4. Referring to document-3, verify whether the equilibrium is reached at this instant t.

2.5. It is suggested to realize the following modifications:

- Modification 1: Extend the duration of heating.

- Modification 2: Add a catalyst to the initial mixture of the reactants.

Specify the effect of each modification on the yield of this reaction.

Exercise 2 (7 points) Identification of an organic compound

An organic compound (A) with the molecular formula C_4H_8O, consisting of a saturated, non cyclic carbon chain is available.
The aim of this exercise is to identify compound (A) in order to prepare an ester (E).

1. Identification of the compound (A)

The compound (A) is subjected to the two tests in document-1:

Chemical Test	Experimental Result
Test 1: (A) + DNPH	Formation of yellow-orange precipitate
Test 2: (A) + Fehling reagent	Formation of brick-red precipitate

Document-1

1.1. Interpret the result of each of these two tests.

1.2. Write the possible condensed structural formulas of the compound (A).

1.3. Name compound (A) knowing that the carbon chain is non-branched.

2. Preliminary Study

(B) and (C) are two organic compounds used in preparation of the ester (E).

(B) is obtained by catalytic hydrogenation of a sample of the compound (A).

(C) is obtained by mild oxidation of another sample of the compound (A).

2.1. Write, using condensed structural formulas, the equation of the reaction of formation of product (B), then name it.

2.2. Identify the organic compound (C).

3. Esterification Reaction

An equimolar mixture of the compounds (B) and (C) is heated to reflux in the presence of few drops of concentrated sulfuric acid.

3.1. Indicate the role of sulfuric acid.

3.2. Give the condensed structural formula and the name of the ester (E) obtained during this reaction.

3.3. Indicate the advantage of reflux heating.

Exercise 1 Study of an esterification reaction

1.1. The mild oxidation of (A) produces a compound (F), since (F) reacts with DNPH and with Fehling's reagent, then (F) is an aldehyde and the compound (A) is a primary alcohol.

(A): 1-propanol $CH_3-CH_2-CH_2-OH$ (0.5)

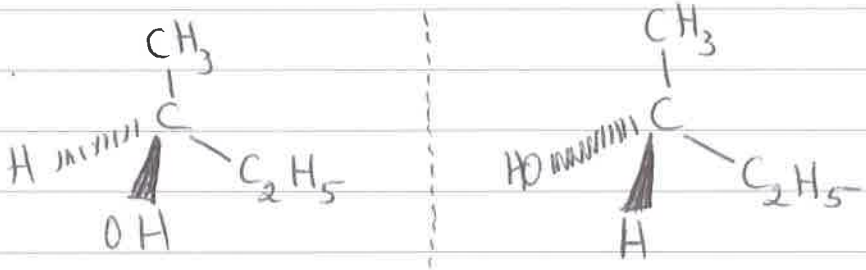
The solution of compound (B) gives a value of pH < 7, then (B): carboxylic acid.

(B): propanoic acid CH_3-CH_2-COOH (0.5)

1.2.1. (C) is chiral : *2-butanol $CH_3-\overset{*}{\underset{OH}{CH}}-CH_2-CH_3$ (0.5)

It's a chiral molecule since it contains an asymmetric Carbon (number 2) which is connected to 4 different groups of atoms. (0.5)

1.2.2.



(1)

1.3 (D) $CH_3-CH_2-\underset{OH}{CH}-CH_2-CH_3$ (0.5)

2.1. $CH_3-CH_2-COOH + CH_3-\underset{OH}{CH}-CH_2-CH_3 \rightleftharpoons CH_3-CH_2-COO-\underset{CH_3}{CH}-CH_2-CH_3 + H_2O$ (0.75)

(E): 1-methylpropylpropanoate (or 2-butylpropanoate) (0.25)

2.2. $V_{acid} = 30\ mL$

$d_{propanoic\ acid} = 0.99\ g/mL$.

$d = \frac{m}{V}$; $m = d \times V = 0.99 \times 30 = 29.7\ g$.

Initial number of moles of propanoic acid:

$$n = \frac{m}{M} = \frac{29.7}{74} = 0.401\ mol \qquad (0.25)$$

2.3. $n_{0\ alcohol} = 0.25\ mol$.

$n_{0\ acid} = 0.40\ mol$.

Assume that the reaction is complete:

$R_{(acid)} = \frac{n_0}{coeff} = \frac{0.40}{1} = 0.4$.

$R_{(alcohol)} = \frac{n_0}{coeff} = \frac{0.25}{1} = 0.25$

$\Rightarrow R_{alcohol} < R_{acid} \Rightarrow$ Alcohol is the limiting reactant.

According to stoichiometry:

$$\frac{n_{(alcohol)\ reacted}}{1} = \frac{n_{(ester)\ formed}}{1} = 0.25\ mol.$$

$\Rightarrow$ Theoretical mass of ester: $m = n \times M(E)$

$= 0.25 \times 130$

$m_{(E)} = 32.5\ g$.

$$Yield = \frac{m\ (ester)\ experimental}{m\ (ester)\ theoretical} \times 100 = \frac{19.5}{32.5} \times 100 = 60\% \qquad (0.75)$$

2.4. The initial mixture of reactants isn't equimolar, the yield of this reaction at equilibrium should be greater than 60% therefore the equilibrium isn't reached yet. (0.5)

2.5. Modification 1 : Extended duration of heating increases the number of moles of ester formed and as result the yield increases. (0.5)

Modification 2 : Adding a catalyst to the initial mixture of reactants increases the rate of the reaction without affecting the yield. (0.5)

Exercise 2 Identification of an organic compound:

(A) : C_4H_8O

1.1) Test 1: Compound (A) gives with DNPH a yellow orange precipitate : compound (A) is a carbonyl compound (0.5)
Test 2 : (A) gives a red precipitate with Fehling reagent : (A) is an aldehyde. (0.5)

1.2. $CH_3-CH_2-CH_2-CHO$ (0.5)

$CH_3-\underset{\underset{CH_3}{|}}{CH}-CHO$ (0.5)

1.3. (A) : butanal. (0.5)

2.2.1. $CH_3-CH_2-CH_2-CHO + H_2 \xrightarrow{Cu} CH_3-CH_2-CH_2-CH_2OH$ (0.75)
1-butanol. (0.25)

2.2. (C) is the product of mild oxidation of butanal, then (C) is Butanoic Acid (0.5)
$CH_3-CH_2-CH_2-COOH$ (0.5)

3.3.1. Sulfuric Acid : Catalyst : accelerates the reaction (0.5)

3.2. $CH_3-CH_2-CH_2-COO-CH_2-CH_2-CH_2-CH_3$: butyl butanoate (1)

3.3. Reflux heating : accelerates the esterification reaction without any loss of reactants or products. (1)