This is a Class 1 exam

Lebanon Evangelical School
for Boys and Girls
Loueizeh - Baabda

Class 12 : Mock 1

20 - 23MAY2024

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 30 minutes

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 (8 points) **Identification of organic compounds**

Alcohols have a long history of several uses worldwide. They have many medical and industrial uses.

The aim of this exercise is to identify a saturated non-cyclic monoalcohol (A).

1. Identification of the alcohol (A)

A liquid monoalcohol (A) is saturated and non - cyclic.

The number of moles corresponding to 225 mg of liquid (A) is equal to 2.56×10^{-3} mol.

Given: Molar masses in g/mol: C = 12; H = 1; O = 16.

1.1. Calculate the molar mass of alcohol (A), then show that its molecular formula is $C_5H_{12}O$.

1.2. When (A) is treated with a strong oxidant, such as yellow-orange solution of potassium dichromate, the solution remains yellow-orange.

1.2.1. Specify the class of alcohol (A).

1.2.2. Identify (A).

2. Isomers of (A)

(A') is one of the isomers of (A).

2.1. Referring to document-1:

$$(Y) + H_2O \xleftarrow{Al_2O_3} (A') \xrightarrow{Cu} (X) + H_2$$

Document-1

2.1.1. Deduce the possible classes of alcohol (A').

2.1.2. Pick up a characteristic of a catalyst. Justify your answer.

2.2. The obtained product (X) is an organic compound that cannot undergo mild oxidation.

2.2.1. Justify the following proposition: "(A') is a secondary alcohol".

2.2.2. Write the three possible condensed structural formulas of (A').

2.2.3. Identify (A') knowing that its carbon chain is branched.

3. Reaction of an isomer (A'') of (A)

Catalytic oxidation of (A''), another isomer of (A), gives a compound (C). When (C) is dissolved in distilled water, a solution of pH clearly less than 7 is obtained. The carbon chain of (A'') contains two methyl groups. **Document - 2**

3.1. Verify whether the amount of oxygen is in excess.

3.2. Identify (A'').

Exercise 2 (9 points) **Esterification reaction**

Esters give to many fruits, flowers, and some conserved foods their characteristic odor and taste.

The aim of this exercise is to study the synthesis of an ester (E) according to the following equation:

$$\text{Acid (A)} + \text{Alcohol (B)} \leftrightarrow \text{Ester (E)} + \text{Water}$$

Given: density of (B)= 0.95 g/mL; M(B)= 88 g/mol ; M (E) = 144 g/mol.

At temperature 70 °C, 0.3 mol of acid (A) and 27.8 mL of alcohol (B) are heated to reflux for 60 minutes in the presence of a few drops of concentrated sulfuric acid solution as a catalyst.

The experimental mass of ester (E) formed at 60 minutes is equal to 26 g.

The equilibrium constant of the reaction K_C is 2.25 Document-1

1. Equilibrium state

1.1. Indicate a characteristic of the esterification reaction from kinetic point.
Pick up the sentence showing this characteristic.

1.2. Show that the initial mixture is equimolar.

1.3. Determine the number of moles of each component of the reaction system at time t = 60 minutes, then calculate the quotient of the esterification reaction Qr at time t = 60 minutes.

1.4. Verify that the reaction system is in a state of dynamic equilibrium at time t = 60 minutes.

2. Degree of conversion

To study the effect of temperature and the use of non-equimolar mixture on the esterification reaction, three reaction mixtures are realized.

Document – 2 shows these reaction mixtures, their experimental conditions, and their percentage yield at equilibrium.

Reaction mixture	Number of moles of acid	Number of moles of alcohol	Temperature	% yield
M	1	1	70 °C	Y
M_1	1	1	100 °C	Y_1
M_2	1.5	1	100 °C	$Y_2 = 71\%$

Document -2

2.1. Referring to document-2, compare Y and Y_1. Justify.

2.2. Referring to the mixture (M_2) in document-2, calculate the theoretical number of moles of ester obtained, then verify that the experimental number of moles of ester formed at equilibrium is equal to 0.71 mol.

2.3. Copy and complete the following table in terms of α , the degree of conversion of alcohol (B) into ester in the mixture (M_2).

	Acid	Alcohol	Ester	Water
Initial state (in mol)	1.5	1		
Equilibrium state (in mol)				

2.4. Deduce the value of α.

3. Synthesis of ester (E)

3.1. Knowing that acid (A) is propanoic acid and alcohol (B) is 1-pentanol, write the corresponding equation of esterification reaction using condensed structural formulas.

3.2. Name ester (E).

3.3. Indicate the advantages of reflux heating.

Exercise 1 Identification of organic compounds

1. Identification of the alcohol (A):

1.1 The general formula of a saturated non cyclic monoalcohol is $C_nH_{2n+2}O$

$M(A) = 12n + 2n + 2 + 16$

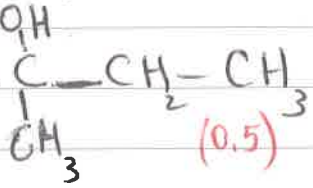
$= (14n + 18)$ g/mol.

$n(A) = \frac{m(A)}{M(A)}$ so, $M(A) = \frac{m(A)}{n(A)}$ Molar mass: $= \frac{225 \times 10^{-3}}{2.56 \times 10^{-3}} = 87.89$ g/mol.

$(14n + 18) = 87.89 \Rightarrow \boxed{n = 5}$

Then, the molecular formula of (A) is $C_5H_{12}O$. (0.75)

1.2.1 Since the color of the solution doesn't change (it remains yellow-orange), then no reaction takes place. Therefore, (A) doesn't undergo an oxidation. So, (A) is a tertiary alcohol. (0.5)

1.2.2  (0.5) 2-methyl-2-butanol. (0.5)

2.1.1 (A') undergoes oxidation ($A' \xrightarrow{Cu} X + H_2$) then, (A') is a primary or secondary alcohol. (1)

2.1.2 Selectivity. (0.5)
Starting from the same reactant (A') and using different catalysts, different products are obtained.

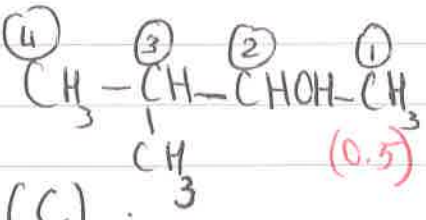
2.2.1. Since (X) doesn't undergo oxidation, then it's a Ketone. Therefore, (A') is a secondary alcohol. (0.5)

2.2.2. $CH_3-CHOH-CH_2-CH-CH_3$. (0.5)

$CH_3-CH_2-CHOH-CH_2-CH_3$. (0.5)

$CH_3-CH(CH_3)-CHOH-CH_3$ (0.5)

2.2.3. (A'): 3-methyl-2-butanol. (0.5)

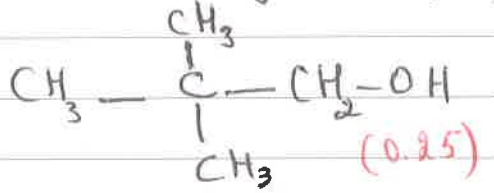


(0.5)

3.3.1. Catalytic oxidation of (A") gives (C).
pH(solution of C) < 7 ⟹ (C) is a carboxylic acid.

Since the catalytic oxidation of (A") gives a carboxylic acid, then the mild oxidation is continuous. Therefore, the amount of O_2 is in excess. (0.5)

3.2. Since (C) is a carboxylic acid, then (A") is a primary alcohol. Therefore, (A") is: (0.25)



(0.25)

2,2-dimethyl-1-propanol. (0.25)

Exercise 2 Esterification Reaction

Acid (A) + Alcohol (B) $\rightleftharpoons$ Ester (E) + Water.

1.1. Esterification reaction is slow. (0.5)

The sentence is: At temperature 70°C, 0.3 mol of (A) and 27.8 mL of (B) are heated to reflux for 60 minutes.

1.2. $n(B) = \frac{m(B)}{M(B)} = \frac{\text{density}(B) \times V}{M(B)} = \frac{0.95 \times 27.8}{88}$

$n(B) = 0.3$ mol. (0.5)

$n(A) = n(B)$, then the initial mixture is equimolar.

1.3. Let x be the number of moles of ester formed at 60 min.

$n(\text{ester})_{60\,\text{min}} = \frac{m}{M} = \frac{26}{144} = 0.18$ mol.

	Acid (A)	Alcohol (B)	Ester (E)	Water
Initial state	0.3 mol	0.3	0	0
At $t = 60$ min	$0.3 - x$	$0.3 - x$	x	x
	0.12	0.12	0.18	0.18
	(initial − reacted)			

(1)

Quotient of the reaction:

$$Q_r = \frac{[\text{Ester}]_{60\,\text{mins}} \times [\text{water}]_{t=60\,\text{mins}}}{[\text{Acid}]_{\text{remained}} \times [\text{Alcohol}]_{\text{remained}}} = \frac{\frac{n(\text{ester})}{V} \times \frac{n(\text{water})}{V}}{\frac{n(\text{acid})}{V} \times \frac{n(\text{alcohol})}{V}}$$

$$Q_r = \frac{(0.18) \times (0.18)}{(0.12) \times (0.12)} = 2.25 = K_c. \quad (1)$$

1.4. the reaction system is in a state of dynamic equilibrium at 60 min. (0.5)

Since $Q_r = K_c$.

2.1. (M): 1 mol (Acid) and 1 mol (Alcohol)
(M_1): 1 mol (Acid) and 1 mol (Alcohol)
(M) and (M_1) are composed of the same initial number of moles of reactants, $y = y$ since temperature doesn't affect the yield of esterification reaction which is athermic. Temperature affects the rate of the reaction and not its yield. (0.5)

2.2. (M_2): 1.5 mol (Acid) + 1 mol (Alcohol)

Assume that the reaction is complete:

$R_{acid} = \frac{n_{acid}}{coefficient} = \frac{1.5}{1} = 1.5$

$R_{alcohol} = \frac{n_{alcohol}}{coefficient} = \frac{1}{1} = 1$

$R_{alcohol} < R_{acid} \Rightarrow$ Alcohol Limiting reactant. (0.5)

According to stoichiometry:

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

* Theoretical $n_{ester\ formed} = 1\,mol.$ (0.5)

Yield $y_2 = \frac{n(ester)\ experimental}{n(ester)\ theoretical} \times 100 = 71\%$. (0.25)

$\Rightarrow$ Experimental $n_{ester} = \frac{71 \times 1}{100} = 0.71\,mol.$ (0.25)

2.3.

	Acid	Alcohol	Ester	water
Initial state (mol)	1.5	1	0	0
Equilibrium state (mol)	1.5−α	1−α	α	α

(1)

$$\alpha = \frac{\text{reacted } n(\text{Alcohol})}{\text{initial } n(\text{Alcohol})} = \frac{\text{reacted } n(\text{alcohol})}{1}$$

$\Rightarrow$ reacted $n_{alcohol} = 1 \times (\alpha) = \alpha$.

According to stoichiometry: $n_{ester\ formed} = n_{H_2O\ obtained} = n_{alcohol\ reacted}$

$= \alpha$

2.4. $\alpha = n_{ester\ formed\ at\ equilibrium} = 0.71$ (0,5)

3. Synthesis of ester (E)

3.1. $CH_3-CH_2-COOH + HO-CH_2-CH_2-CH_2-CH_2-CH_3 \rightleftharpoons CH_3-CH_2-COO-CH_2-CH_2-CH_2-CH_2-CH_3$ (E) $+ H_2O$.

(1)

3.2. (E): Pentylpropanoate (0.5)

3.3. Reflux heating: accelerates the esterification reaction without any loss of components of the reaction system. (0.5)