Exercise 1 **Esterification Reaction**

Esterification is a reversible reaction, between a carboxylic acid and an alcohol, represented by the following equation: $R - COOH + R' - OH \rightleftharpoons R - COOR' + H_2O$

Given:

	Formula	M ($g.mol^{-1}$)	d ($g.mL^{-1}$)
Ethanoic acid	$CH_3 - COOH$	60	1.05
Methanol	$CH_3 - OH$	32	0.79

1. Preliminary Study

A mixture of ethanoic acid and methanol, heated in the presence of few drops of concentrated sulfuric acid, leads to the formation of an ester and water.

1.1- Write the equation of this reaction.

1.2- Why is the mixture heated?

1.3- If a mixture of ethanoic acid and methanol is heated in the absence of sulfuric acid, will the reaction take place? Justify.

2. Experimental Study

* Balloon A contains a mixture of 20.25 mL of methanol and 30 g of acid.

The balloon is closed and heated, at the same temperature, till equilibrium is established.

2.1- Show that the reacting mixture in balloon A is equimolar.

2.2- If the reaction is made complete, calculate the number of moles of ester formed in the balloon.

2.3- An acid-base titration permits to determine the number of moles of ethanoic acid remaining in the balloon which is 0.17 mol

2.3.1. Determine the composition in moles of the mixture at equilibrium.

2.3.2. Specify if the percentage yield of esterification changes upon adding few drops of sulfuric acid at the beginning of the experiment.

Exercise 2 **Properties of an Alcohol**

Alcohols are products with a great industrial and commercial importance. They undergo many and diverse chemical reactions and are used in the synthesis of many compounds such as esters. The aim of this exercise is to study the chemical properties of the alcohol (A) and its reaction with methanoic acid.

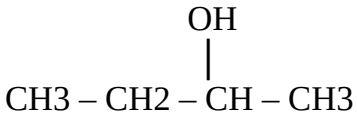
Given: Molar mass in $g.mol^{-1}$: M (H) = 1; M(C) = 12; M (O) = 16.

1. Chemical properties of the Alcohol (A)

Available is a saturated and non-cyclic mono-alcohol denoted (A). The quantitative analysis of alcohol (A) shows that the percentage by mass of oxygen is %O = 21.62%

1.1. Show that the molecular formula of the alcohol (A) is $C_4H_{10}O$.

1.2. The condensed structural formula of the alcohol (A) is:



1.2.1. Indicate the class of alcohol (A).
1.2.2. Give its systematic name.
1.2.3. Write the condensed structural formulas of the other three alcohol isomers of alcohol (A).

1.3. The mild oxidation of the alcohol (A) by a solution of acidified potassium permanganate leads to the formation of an organic compound (B).
Choose the correct proposition. Justify

1.3.1. The family of (B) is aldehyde.
1.3.2. the compound (B) is carboxylic acid.
1.3.3. The compound (B) is ketone.

2. Reaction of the Alcohol (A) With Methanoic Acid

A mixture of 0.2 mol of alcohol (A) and 0.2 mol of methanoic acid is heated to reflux, in the presence of few drops of concentrated sulfuric acid as a catalyst.
The esterification reaction is represented by the following equation:

methanoic acid + alcohol (A) ester (E) + water

At an instant of time t, the equilibrium is reached. The number of moles of methanoic acid remained at
equilibrium is n (acid) = 0.08 mol.

2.1. Write, using the condensed structural formulas, the equation of this esterification reaction.
2.2. Determine the number of moles of each constituent of the reacting mixture, at equilibrium.
2.4. The same experiment is carried out again with only one change: “without the addition of concentrated sulfuric acid". The equilibrium state is reached at an instant of time t’.
Choose the correct answer. Justify.

a. $t > t'$ **b.** $t = t'$ **c.** $t < t'$