This is a Class 1 exam

Lebanon Evangelical School for Boys and Girls

Loueizeh - Baabda

Stage Exam 03

26JAN2024

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

Graph paper is needed.

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 Titration of a diluted hydrochloric acid solution (10 points)

On the label of a bottle containing a commercial hydrochloric acid solution (S_0) ($H_3O^+ + Cl^-$) the following information is written:
Molar mass M = 36.5 g/mol
Density d = 1.2 Kg/L
Percentage by mass 18%

Available materials

Volumetric Flasks: 100, 250 and 500 mL.
Beakers: 100, 250 and 500 mL.
Graduated pipets: 5, 10 and 20 mL.
Volumetric pipets: 5 and 10 mL.
pH – meter
25 mL Graduated buret
Magnetic stirrer and magnetic bar
Distilled water bottle.

1- Dilution of the solution (S_0)

To prepare 500 mL of a diluted hydrochloric acid solution (S), a volume V_0 = 8.3 mL of (S_0) should be taken.

1.1. Choose, from the available materials, what is necessary for this preparation.

1.2. Calculate the molar concentration C_0 of the commercial solution.

1.3. Deduce that the molar concentration C_S of solution (S) is nearly 0.1 mol/L.

2- Titration of solution (S)

In order to determine the concentration C_S, solution S is titrated by 20 mL of sodium hydroxide solution ($Na^+ + OH^-$) of molar concentration $C_b = 4 \times 10^{-2}$ mol/L.

The pH readings during the titration are given in the table below:

V_S (mL)	0	1	2	3	4	5	6	7	8	8.5	9	10	11	12	13
pH	12.6	12.5	12.4	12.3	12.2	12.1	11.9	11.7	11.1	3.6	2.7	2.3	2.1	2	1.9

2.1- Plot the graph pH=f(V_S) . Scale: abscissa: 1 cm = 1mL; ordinate: 1 cm = 1 pH unit.

2.2- Determine graphically the equivalence point and give its coordinates.

2.3- Write the equation of the titration reaction.

2.4- Determine the concentration C_S of the solution (S).

2.5- Deduce the concentration C_0 of the solution (S_0).

2.6- Calculate the percent mass of HCl in the solution (S_0).

2.7- Calculate the percent error.

Exercise 2 Study of organic compounds (10 points)

The molar masses are given in g/mol: H = 1; C = 12 ; O = 16

1. **Identification of compound A:**

1.1. The analysis of saturated, non cyclic, and monofunctional alcohol (A) gives the following % by mass: % C = 68.1 % and % H = 13.63 %.

1.1.1. Express the molar mass of alcohols in terms of n where n is the number of carbon atoms.

1.1.2. Calculate the % by mass of oxygen, then verify that the molecular formula of compound (A) is $C_5H_{12}O$.

1.2. Document 1 represents some isomers of compound (A)

Isomers	**I**	**II**	**III**
Condensed formulas	CH_3-CH(CH_3)-CH_2-CH_2OH	CH_3-C(OH)(CH_3)-CH_2-CH_3	3-methyl-2-butanol

Indicate whether each of the following statements is true or false, then correct the false statements:

1.2.1. Isomer II can undergo mild oxidation.

1.2.2. The functional group of these isomers is the carbonyl group.

1.2.3. Isomers I and III are positional isomers.

1.3. Document 1 shows three out of eight isomers of compound (A).

Write the condensed structural formulas of the five other isomers of compound (A). **Name** them.

1.4. The continuous mild oxidation of compound (A) in the presence of oxygen O_2 gives the compound (B) of condensed structural formula

$$CH_3 - CH_2 - CH_2 - CH_2 - COOH$$

1.4.1. Give the meaning of mild oxidation.

1.4.2. Deduce the class of alcohol of compound (A).

1.4.3. Identify the compound (A).

1.4.4. Write, using condensed structural formulas, the balanced equation of the mild oxidation of compound (A) giving the compound (B), then name (B).

2. Reaction between alcohol (A) and acid (B)

We mix 66 mL of alcohol (A) and 0.6 mol of acid (B). Then, few drops of concentrated sulfuric acid are added and the mixture is heated to reflux at constant temperature **T**. Ester (E) and water are formed according to the following equation:

$$(A) + (B) \leftrightarrow (E) + H_2O$$

Given: Molar mass of alcohol (A) is 88 g/mol
Density of of alcohol A is 0.8 g/mL.
Molar mass of (E) = 172 g/mol.

2.1. List the characteristics of the esterification reaction.

2.2. Write, using condensed structural formulas, the equation of the preparation reaction of the compound (E) starting from the compounds (A) and (B). Name the compound (E).

2.3. Choose, from the following list, the appropriate materials needed to construct the reflux heating set-up:

Heating mantle
Round bottom flask
Graduated buret
100 mL beaker
Condenser.

2.4. Indicate the importance of the reflux heating for this synthesis.

2.5. Indicate the role of sulfuric acid added to the initial mixture.

2.6. Prove that the initial mixture of reactants is equimolar, then calculate the theoretical mass of (E) obtained.

SE03/2023 2024/12ME

Exercise 1

$S_0 (H_3O^+ + Cl^-)$ $d = 1.2 Kg/L$

18 %

$M(HCl) = 36.5 g/mol$.

1_1.1.(s): $V_0 = 8.3 mL \xrightarrow{dilution} V = 500 mL$

Materials needed for this preparation: (0.25 each)

- 10mL Graduated pipet.
- 500mL volumetric flask
- 250 mL beaker
- Distilled water bottle.

1.2. $C_0 = \frac{n_{solute}}{V_{solution}} = \frac{m_{solute}/M(solute)}{m_{solution}/d_{solution}} = \frac{18 \times 1.2 \times 1000}{100 \times 36.5}$

$C_0 = 5.91 mol/L$. (0.75)

1.3. During dilution, number of moles of solute is conserved:

$C_0 \times V_0 = C_{(s)} \times V$ (0.25)

$C_{(s)} = \frac{C_0 \times V_0}{V} = \frac{5.91 \times 8.3}{500} = 0.098 \simeq 0.1 mol/L.$ (0.25)

2_2.1. Curve $pH = f(V_{(s)})$; Graph paper. (1)

2.2. Parallel tangent method ; $E(V_s = 8.1 ; pH = 7)$ (0.75)

2.3. $H_3O^+_{(aq)} + OH^-_{(aq)} \longrightarrow 2 H_2O_{(l)}$ (0.5)

2.4. At equivalence point, reactants react according to stoichiometry: $n_{H_3O^+ added at E} = n_{OH^-}$ in the beaker (0.25)

$C_{(s)} \times V_{(s)E} = C_b \times V_b$.

$$C_{(S)} = \frac{C_b \times V_b}{V_{S(E)}} = \frac{4\times10^{-2}\times 20}{8.1} = 0.098 \text{ mol/L.} \quad (0.25)$$

2.5 $C_{S_0} = \frac{C_S \times 500}{8.3} = 5.903 \text{ mol/L.}$ (0.5)

2.6 % mass of HCl in S_0 $= \frac{m_{HCl}}{m_{solution}} \times 100$

$$\% = \frac{n_{HCl} \times M(HCl)}{d_{solution} \times V_{solution}} \times 100$$

$$= \frac{C_0 \times V_{solution} \times M(HCl)}{d_{solution} \times V_{solution}} \times 100 = \frac{5.903 \times 36.5}{1.12 \times 10^3} \times 100$$

$$\% = 19.23\% \quad (1)$$

2.7. Percent Error $= \left|\frac{18 - 19.23}{18}\right| \times 100 = 6.83\%.$ (0.5)

Exercise 2

1) 1.1.1. $M(C_nH_{2n+1}-OH) = 12n + 2n + 1 + 16 + 1$

$M(\text{alcohols}) = (14n + 18)$ g/mol. (0.25)

1.1.2. $\%O = 100 - (68.1 + 13.63)$

$\%O = 100 - 81.73 = 18.27\%.$ (0.25)

$$\%O = 18.27 = \frac{16}{14n+18} \times 100$$

$$18.27(14n + 18) = 1600$$
$$255.78n + 328.86 = 1600$$
$$255.78n = 1271.14$$
$$n = 4.96 \quad \boxed{n \simeq 5} \quad (0.25)$$

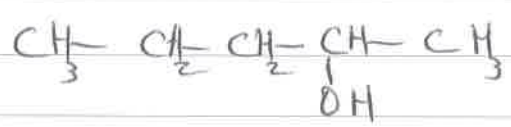
Molecular formula of (A) is: $C_5H_{12}O$. ($C_nH_{2n+2}O$)

1.2.1. false. Isomer II: tertiary alcohol can't undergo mild oxidation. (0.5)

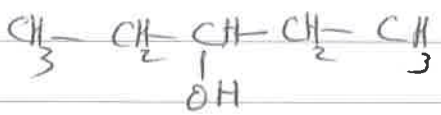
1.2.2. false the functional group of these isomers is the hydroxyl group (-OH). (0.5)

1.2.3. True. (0.5)

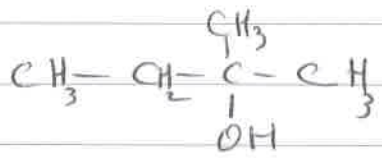
1.3. $CH_3-CH_2-CH_2-CH_2-CH_2-OH$: 1-pentanol (0.5 each)



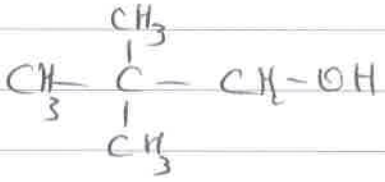
2-pentanol.



3-pentanol.



2-metyl-2-butanol.



2,2-dimethyl-1-propanol.

1.4.1. Mild oxidation: Takes place without breaking down carbon chain. (0.25)

1.4.2. Since the oxidation of alcohol (A) gives a carboxylic acid then, (A) is a primary alcohol. (0.25)

1.4.3. (A): 1-pentanol. (0.25)

1.4.4. $CH_3-CH_2-CH_2-CH_2-CH_2OH + O_2 \longrightarrow CH_3-CH_2-CH_2-CH_2-COOH + H_2O$

(B) (0.25) +½

(B): pentanoic acid. (0.25)

2 2.1. Esterification reaction: • slow
• limited
• athermic. (0.75)

2.2.

$CH_3-CH_2-CH_2-CH_2-COOH + CH_3-CH_2-CH_2-CH_2-CH_2OH \rightleftharpoons CH_3CH_2CH_2C(=O)O-CH_2CH_2CH_2CH_2CH_3 + H_2O$

(E) (0.75)

Ester (E): pentylpentanoate. (0.25)

2.3. Materials needed: • Heating Mantle
• Round Bottom flask
• Condenser (0.75)

2.4. Reflux heating: accelerates the reaction without any loss in the constituents of the mixture. (0.25)

2.5. Sulfuric Acid: Catalyst: accelerates the reaction. (0.25)

2.6. $V_{(A)} = 66\,mL$.
$d_{(A)} = 0.8\,g/mL$.

mass (A) $= d \times V = 0.8 \times 66 = 52.8\,g$.

initial number of moles of (A): $n_{0(A)} = \frac{m}{M(\text{Alcohol})} = \frac{52.8}{88} = 0.6\,mol$. (0.25)

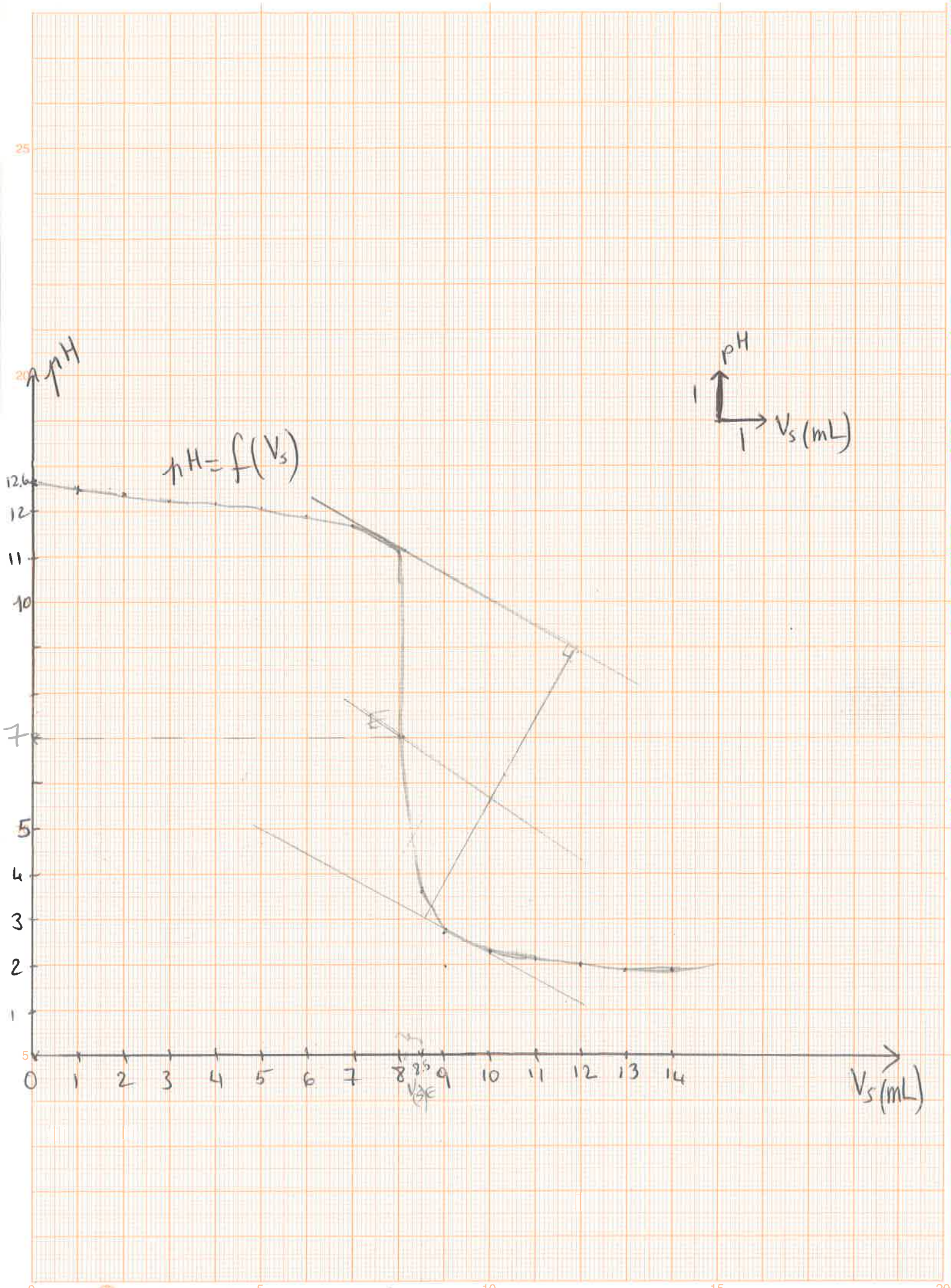
$n_0(B) = 0.6\,mol$

So, the initial mixture is equimolar.

According to stoichiometry: $\frac{n\,\text{Alcohol}}{1} = \frac{n\,\text{ester obtained}}{1}$ (0.25)

$n_{ester} = 0.6\,mol$.

mass (E) $= n \times M(E) = 0.6 \times 172 = 103.2\,g$. (0.5)


pH
$pH = f(V_s)$
12,6
12
11
10
7
5
4
3
2
1
0 1 2 3 4 5 6 7 8 8,5 9 10 11 12 13 14
V_s (mL)
pH
1
1
V_s (mL)