Entrance exam (2025-2026) **Chemistry Exam (A)** **Time: 1 hour**
17 July 2025

Answer the Following Two Exercises:

Exercise 1 – Isopropyl Alcohol (10 points)

Isopropyl alcohol is an organic compound characterized by a strong and pungent odor. However, it is often used to synthesize molecules with fruity aromas.
In this exercise, we focus on the synthesis of isopropanol, then use it to manufacture a molecule with a fruity odor.

Given:

- Molar masses in $g.mol^{-1}$: M(H) = 1; M(C) = 12 ; M(O) = 16 ;
- The equilibrium constant Kc of an esterification reaction depends on the class of alcohol. It is equal to 4.12 if the alcohol is primary and 2.25 if it is secondary.
- At room temperature, compound (B) is a liquid with density: $\rho = 0.8\ g.mL^{-1}$.

1. Synthesis of Isopropyl Alcohol

One of the synthesis methods of isopropyl alcohol is the hydration of an alkene (A), at high pressure and in the presence of concentrated sulfuric acid (H_2SO_4).
The equation of this reaction is represented as follows:

$$\underset{(A)}{C_nH_{2n\,(g)}} + H_2O_{(l)} \xrightarrow{H_2SO_4,\ 300\ ^oC} \underset{(B)}{\text{Isopropyl alcohol}_{(l)}} \qquad \text{(Reaction 1)}$$

1.1. Assign the formula that corresponds to isopropyl alcohol (B):
a) $C_nH_{2n}O$ b) $C_nH_{2n}O_2$ c) $C_nH_{2n+2}O$
1.2. Indicate the role of sulfuric acid in this synthesis.

A quantity of n_1 = 0.3 mol of compound (A) is reacted with excess water. At the end of the reaction, the compound (B) formed is cooled, purified, and its volume measured. V_2 = 18 mL is obtained.

1.3. Given that the yield of this synthesis is 80%, show that the molecular formula of compound (B) is C_3H_8O.
1.4. Write the two possible condensed structural formulas of (B).
1.5. Identify compound (B) knowing that under mild oxidation, it forms a compound (C) which reacts with 2,4-DNPH but not with Schiff's reagent.

2. Synthesis of a Fruity-Smelling Compound

A mixture of 0.8 mol of compound (B) and 0.5 mol of ethanoic acid is heated under reflux at constant temperature T for 100 minutes. A compound (E) is formed according to the following reaction 2:

$$B_{(\ell)} + \text{Ethanoic acid}_{(\ell)} \rightleftarrows (E)_{(\ell)} + H_2O_{(\ell)} \qquad \text{(Reaction 2)}$$

2.1. Write the condensed structural formula of compound (E). Name it.
2.2. Verify if equilibrium is reached after 100 minutes of heating, knowing that the degree of conversion of compound (B) at that time is 0.4.

The same synthesis is repeated, with only one change, replacing ethanoic acid by its oxygenated derivative: ethanoic anhydride.

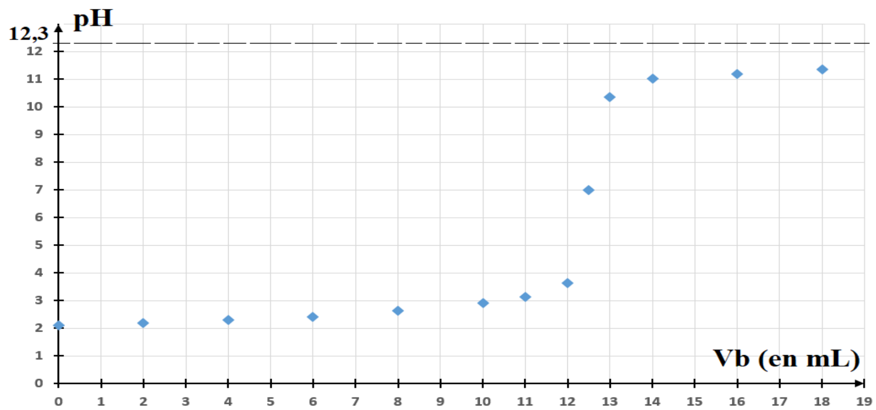
2.3. Indicate whether each of the two statements about this new synthesis are true or false:
a) The conversion degree of compound (B) becomes less than 0.4.
b) The amount of ester formed after 100 minutes of heating is 0.2 mol.

Exercise 2 – An Acid HA (10 points)
Given for all parts of the exercise:

- The study is carried out at 25 °C
- The ionization constant of water is $K_w = 1.0 \times 10^{-14}$
- pKa (NH_4^+ / NH_3) = 9.2

A bottle in the laboratory is labelled as follows: « concentrated solution S_0 of acid HA with a density $d = 1.25 g.ml^{-1}$ and a molar mass $M = 63$ g. mol^{-1}».

Part A: Determination of the Percentage by mass of the acid HA in Solution S_0
The aim of this exercise is to determine the percentage by mass of the acid HA in Solution S_0. For this, the following experimental procedure is carried out:
- The solution S_0 is diluted 250 times to obtain solution S_1.
- A volume Va = 10.0 mL of solution S_1 is taken and transferred into 100 mL beaker. 20 mL of distilled water is added.
- A pH metric titration is carried out by gradually adding a sodium hydroxide ($Na^+ + OH^-$) solution of concentration Cb.
The following curve pH = f(V_b) represents the progress of the pH metric titration performed as described :



Q.1. The most appropriate glassware to prepare solution S_1 is:

a. 100 mL volumetric flask and 2 mL volumetric pipet.
b. 250 mL volumetric flask and 2 mL volumetric pipet.
c. 500 mL volumetric flask and 2 mL volumetric pipet.
d. 1 L volumetric flask and 2 mL volumetric pipet.

Q.2. The glassware used to withdraw Va and add the sodium hydroxide solution is:

a. 25 mL graduated cylinder and 10 mL graduated pipette.
b. 25 mL graduated cylinder and 25 mL buret.
c. 10 mL graduated cylinder and 25 mL buret.
d. 10 mL volumetric pipet and 25 mL buret.

Q.3. From the curve pH = f(V_b), we deduce that:

a. Cb = $10^{pKw - 12.3}$ mol. L^{-1}
b. Cb = $10^{12.3 - pKw}$ mol. L^{-1}
c. Cb = $-10^{pKw - 12.3}$ mol. L^{-1}
d. Cb = $10^{-12.3}$ mol.L^{-1}

Q.4. The equation of titration is:

a. $HA_{(aq)} + HO^{-}_{(aq)} \rightarrow A^{-}_{(aq)} + H_2O_{(l)}$
b. $HA_{(aq)} + HO^{-}_{(aq)} \rightleftharpoons A^{-}_{(aq)} + H_2O_{(l)}$
c. $H_3O^{+}_{(aq)} + HO^{-}_{(aq)} \rightleftharpoons 2\,H_2O_{(l)}$
d. $H_3O^{+}_{(aq)} + HO^{-}_{(aq)} \rightarrow 2H_2O_{(l)}$

Q.5. The molar concentration of solution S_1 in acid HA is:

a. Ca = 1.0×10^{-2} mol. L^{-1}
b. Ca = 2.0×10^{-2} mol. L^{-1}
c. Ca = 2.3×10^{-2} mol. L^{-1}
d. Ca = 2.5×10^{-2} mol. L^{-1}

Q.6. The percentage by mass of solution S_0 in acid HA is:

a. 12.6 %
b. 25.2 %
c. 28.98 %
d. 31.5 %

Q.7. The same titration, performed without adding distilled water, gives respectively for V_b = 0 mL and V_b = 18 mL:

a. pHi = 1.6 and pH_f = 10.9
b. pHi = 1.6 and pH_f = 11.6
c. pHi = 2.4 and pH_f = 11.6
d. pHi = 2.4 and pH_f = 10.9

Part B - Reaction of Solution S_1 with a Weak Base

This part concerns the acid-base reaction that occurs when a solution of ammonia (NH_3 is a weak base) is mixed with solution S_1.

In a beaker initially containing a volume V_1= 20 mL of solution S_1 of acid HA with concentration C_a, a volume V_2= 20 mL of an ammonia solution with concentration $C_2 = 2\ C_a$ is added. A fast and complete reaction occurs. A mixture M is obtained.

Q.8. The pH of the ammonia solution is close to:

a. 1.3
b. 8.75
c. 11.6
d. 12.69

Q.9. The acid-base reaction equation leading to mixture M is:

a. $HA_{(aq)} + NH_{3\,(aq)} \rightarrow NH_4^+{}_{(aq)} + A^-{}_{(aq)}$
b. $HA_{(aq)} + NH_{3\,(aq)} \rightleftharpoons NH_4^+{}_{(aq)} + A^-{}_{(aq)}$
c. $H_3O^+{}_{(aq)} + NH_{3\,(aq)} \rightleftharpoons NH_4^+{}_{(aq)} + A^-{}_{(aq)}$
d. $H_3O^+{}_{(aq)} + NH_{3\,(aq)} \rightarrow NH_4^+{}_{(aq)} + A^-{}_{(aq)}$

Q.10. One of the following statements about mixture M is false:

a. The pH of the mixture is basic.
b. The concentration of OH^- ions is zero.
c. The concentration of remaining NH_3 is equal to that of NH_4^+ formed.
d. The concentration of H_3O^+ ions is equal to 6.3×10^{-10} mol. L^{-1}

Lebanese University
Faculty of Engineering

Date : 17-7-2025

Entrance Exam
CHEMISTRY
Answers sheet (Exercise 2)
Group A
(Lebanese Program)

Answer to each question, by circling only one of the letters a, b, c or d.

Q.1	**a**	**b**	**c**	**d**
Q.2	**a**	**b**	**c**	**d**
Q.3	**a**	**b**	**c**	**d**
Q.4	**a**	**b**	**c**	**d**
Q.5	**a**	**b**	**c**	**d**
Q.6	**a**	**b**	**c**	**d**
Q.7	**a**	**b**	**c**	**d**
Q.8	**a**	**b**	**c**	**d**
Q.9	**a**	**b**	**c**	**d**
Q.10	**a**	**b**	**c**	**d**

Ansswer key

Exercise 1 – Isopropyl Alcohol (10 points)

<table>
<tr><th>Questions</th><th>Expected Answers</th><th>mark</th></tr>
<tr><td>1.1.</td><td>According to the law of conservation of atoms, the formula corresponding to (B) is $C_nH_{2n+2}O$ (answer c).</td><td>1</td></tr>
<tr><td>1.2.</td><td>Sulfuric acid in this synthesis acts as a catalyst that speeds up the rate of reaction</td><td>1</td></tr>
<tr><td>1.3.</td><td>The yield of this synthesis is given by %Y= $\frac{n(B)exp}{n(B)theo}$ x100
$n(B)_{exp} = \frac{m(B)exp}{M(B)} = \frac{\rho(B) x VB}{M(B)} = \frac{18 x 0.8}{M(B)} = \frac{14.4}{M(B)}$ mol
according to stochiometric $n(B)_{theo} = n(A)_i$ = 0,3 mol (H_2O is in excess, so A is the limiting reactant)

$80 = \frac{\frac{14.4}{M(B)}}{0.3}$ x100 = $\frac{14.4}{0.3 x M(B)} x100$
M(B) = 14n + 18 = 60 g.mol^{-1}
n = $\frac{60-18}{14}$ = 3 Molecular formula of (B) is C_3H_8O.</td><td>2</td></tr>
<tr><td>1.4.</td><td>$CH_3 - CH_2 - CH_2OH$; $CH_3 - CHOH - CH_3$</td><td>1</td></tr>
<tr><td>1.5.</td><td>Compound (C) reacts with 2,4-DNPH (indicating a carbonyl group) but not with Schiff's reagent, so it is a ketone. Mild oxidation of a secondary alcohol gives a ketone. Therefore, (B) is a secondary alcohol: 2-propanol $CH_3–CHOH–CH_3$</td><td>1</td></tr>
<tr><td>2.1.</td><td>$CH_3 - COO - CH - CH_3$ 1-methylethylethanoate
CH_3</td><td>1</td></tr>
<tr><td>2.2.</td><td>α(B) = $\frac{n(B)}{n(B)i} = \frac{x}{08}$ = 0.40.1024
x = 0.32mol
<table>
<tr><th></th><th colspan="4">B (l) + Ethanoic acid (l) ⇄ (E) (l) + H_2O (l)</th></tr>
<tr><td>n initial</td><td>0.8 mol</td><td>0.5 mol</td><td>0</td><td>0</td></tr>
<tr><td>t = 100 min</td><td>0.8 – x
0,48 mol</td><td>0.5 – x
0.18 mol</td><td>x
0.32 mol</td><td>x
0.32 mol</td></tr>
</table>

$Q_r = \frac{[E]x [water]}{[B]x [etha ac]} = \frac{0.32 x 0.32}{0.48 x 0.18}$ = 1.18 < Kc = 2.25 because the alcohol is secondary, the equilibrium is not reached at this time.</td><td>2</td></tr>
<tr><td>2.3</td><td>a.false
b. false</td><td>1</td></tr>
</table>

Exercise 2 – An Acid HA (10 points) (A)

Questions	Expected Answers	mark
Q.1.	c	1
Q.2.	d	1
Q.3.	b	1
Q.4.	d	1
Q.5.	d	1
Q.6	d	1
Q.7.	b	1
Q.8.	c	1
Q.9.	d	1
Q.10.	b	1

(B)

Questions	Expected Answers	mark
Q.1.	d	1
Q.2.	c	1
Q.3.	d	1
Q.4.	b	1
Q.5.	d	1
Q.6	d	1
Q.7.	b	1
Q.8.	d	1
Q.9.	c	1
Q.10.	b	1