

**CHEMISTRY II FINAL EXAM + CORRECTION**

**Exercise 1**

**1- QCM (5 points)**

	<b>Question</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
1	A first-order reaction follows	$v = k[A]^2$	$v = k$	$v = k[A]$	$v^2 = k [A]$
2	Unit of k (2nd order)	$s^{-1}$	$L \cdot mol^{-1} \cdot s^{-1}$	$mol \cdot L^{-1} \cdot s^{-1}$	s
3	If [A] doubles (2nd order) vitess rate	Double	Triple	$\times 4$	Ne change pas
4	Half-life (1st order) /	Dépend de [A] <sub>0</sub>	Constant	Dépend de T seulement	Nul
5	Integrated law (1st order)	$[A]=[A]_0-kt$	$\ln[A]=\ln[A]_0-\frac{kt}{[A]}$	$1/[A]=1/[A]_0+kt$	$[A]^2=[A]_0^2-kt$

## Exercise 2

- 2- A solution of **ammonium chloride** ( $\text{NH}_4\text{Cl}$ ) is prepared with a concentration:  
 $C=0.10 \text{ mol}\cdot\text{L}^{-1}$ .  
Given:  $K_b(\text{NH}_4^+/\text{NH}_3)=1.8\times 10^{-5}$ .  
Calculate the acid dissociation constant  $K_a$ , then determine the **pH** of the solution. (8 pts)

### 1- Understanding the Chemical System .....1pts

#### Dissociation of $\text{NH}_4\text{Cl}$

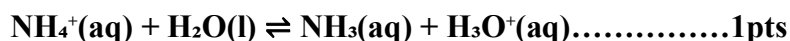
Ammonium chloride is a **strong electrolyte** that dissociates completely in water:



- $\text{NH}_4^+$  is the conjugate acid of the weak base  $\text{NH}_3$
- $\text{Cl}^-$  is the conjugate base of the strong acid  $\text{HCl}$  (neutral, no effect on pH)

#### Acid Behavior of $\text{NH}_4^+$

The ammonium ion acts as a **weak acid** in solution:



This equilibrium is governed by the acid dissociation constant  $K_a$ .

### 2- Calculate $K_a$ from $K_b$ .....1 pts

#### Relationship Between $K_a$ and $K_b$

For a conjugate acid-base pair, the following relationship holds:

$$K_a \times K_b = K_w$$

Where:

- $K_a$  = acid dissociation constant of  $\text{NH}_4^+$
- $K_b$  = base dissociation constant of  $\text{NH}_3 = 1.8 \times 10^{-5}$
- $K_w$  = ionic product of water =  $1.0 \times 10^{-14}$  at  $25^\circ\text{C}$

#### Calculation

$$K_a = K_w / K_b$$

$$K_a = (1.0 \times 10^{-14}) / (1.8 \times 10^{-5})$$

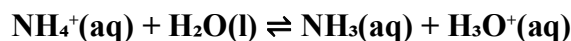
$$K_a = 5.56 \times 10^{-10}$$

**Result:**  $K_a(\text{NH}_4^+) = 5.56 \times 10^{-10}$  ..... 0.25 pts

### 3- Determine the pH of the Solution

**Equilibrium Expression** .....2 pts

For the dissociation of  $\text{NH}_4^+$ :



The acid dissociation constant is:

$$K_a = \frac{[\text{NH}_3][\text{H}_3\text{O}^+]}{[\text{NH}_4^+]}$$

#### ICE Table (Initial, Change, Equilibrium)

	$\text{NH}_4^+$	$\text{NH}_3$	$\text{H}_3\text{O}^+$
<b>Initial (mol·L<sup>-1</sup>)</b>	0.10	0	0
<b>Change (mol·L<sup>-1</sup>)</b>	-x	+x	+x
<b>Equilibrium (mol·L<sup>-1</sup>)</b>	0.10 - x	x	x

### 4- Substitution into Ka Expression

$$K_a = x^2 / (0.10 - x)$$

$$5.56 \times 10^{-10} = x^2 / (0.10 - x) \dots\dots\dots 0.75 \text{ pts}$$

#### Simplification

Since  $K_a$  is very small ( $5.56 \times 10^{-10} \ll 0.10$ ), we can assume:

$$0.10 - x \approx 0.10$$

This simplifies the equation to:

$$5.56 \times 10^{-10} = x^2 / 0.10$$

$$x^2 = 5.56 \times 10^{-11}$$

$$x = \sqrt{(5.56 \times 10^{-11})}$$

$$x = 7.46 \times 10^{-6} \text{ mol}\cdot\text{L}^{-1}$$



---

**Note:** The value of  $x$  is indeed much smaller than 0.10, confirming our approximation was valid.

**5- Calculate pH.....1.75 pts**

Since  $x = [\text{H}_3\text{O}^+]$ :

$$\text{pH} = -\log[\text{H}_3\text{O}^+]$$

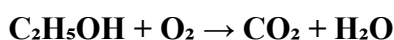
$$\text{pH} = -\log(7.46 \times 10^{-6})$$

$$\text{pH} = 5.13$$

**Final Result:** The pH of the  $0.10 \text{ mol}\cdot\text{L}^{-1} \text{NH}_4\text{Cl}$  solution is **pH = 5.13.....0.25 pts**

### Exercise 3

#### Given Equation:



#### Questions:

1. Determine the oxidation numbers of carbon in the reactant (ethanol) and in the product (CO<sub>2</sub>).
2. Identify the oxidized element and the reduced element.
3. Show the electron transfer (change in oxidation numbers).
4. Balance the overall chemical equation using the oxidation number method.

#### 1- Determine Oxidation Numbers

##### Rules for Oxidation Numbers

- **Pure elements:** 0
- **Oxygen:** -2 (except in peroxides)
- **Hydrogen:** +1 (when bonded to non-metals)
- **Sum of oxidation numbers** = charge of the species

##### Carbon in Ethanol (C<sub>2</sub>H<sub>5</sub>OH)

Ethanol has the structure: **CH<sub>3</sub>-CH<sub>2</sub>-OH**

For organic molecules, we calculate the **average oxidation state** of carbon.

##### Method:

Let the average oxidation number of carbon = x

In C<sub>2</sub>H<sub>5</sub>OH:

- 2 carbon atoms
- 6 hydrogen atoms (+1 each)
- 1 oxygen atom (-2)

**Equation for the neutral molecule:**

$$2x + 6(+1) + 1(-2) = 0$$

$$2x + 6 - 2 = 0$$

$$2x + 4 = 0$$

$$2x = -4$$

$$x = -2 \dots \dots \dots 1\text{pts}$$

**Carbon in Carbon Dioxide (CO<sub>2</sub>)**

Let oxidation number of C = x

**Equation:**

$$x + 2(-2) = 0$$

$$x - 4 = 0$$

$$x = +4$$

2- Oxidation number of carbon in CO<sub>2</sub> = +4.....1pts

**Summary Table**

Species	Element	Oxidation Number
C <sub>2</sub> H <sub>5</sub> OH	C	-2
CO <sub>2</sub>	C	+4
O <sub>2</sub>	O	0
H <sub>2</sub> O	O	-2

**3- Identify Oxidized and Reduced Elements**

**Oxidation (Loss of Electrons)**

**Carbon** in ethanol goes from **-2** to **+4**

**Change:**  $\Delta = +4 - (-2) = +6 \dots \dots \dots 1\text{pts}$

**Carbon is oxidized** (loses electrons)

**Reduction (Gain of Electrons)**

**Oxygen** in O<sub>2</sub> goes from **0** to **-2**

**Change:**  $\Delta = -2 - 0 = -2 \dots \dots \dots 1 \text{ pts}$



---

**Oxygen is reduced** (gains electrons)

$$6\alpha = 2\beta \quad \alpha = 1 \text{ et } \beta = 3 \dots\dots\dots 1\text{pts}$$

**4. Balanced Equation:**

