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The Ministry of Higher Education and Scientific Research

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CHEMISTRY II FINAL EXAM + CORRECTION

Exercise 1

1- QCM (5 points)

	Question	A	B	C	D
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	×4	Ne change pas
4	Half-life (1st order) /	Dépend de $[A]_0$	Constant	Dépend de T seulement	Nul
5	Integrated law (1st order)	$[A]=[A]_0-kt$	$\ln[A]=\ln[A]_0-kt$	$1/[A]=1/[A]_0+kt$	$[A]^2=[A]_0^2-kt$

Exercise 2

2- A solution of **ammonium chloride (NH_4Cl)** is prepared with a concentration:
C=0.10 mol*L^{-1}.
Given: **$K_b(NH_4^+/NH3)=1.8\times10^{-5}$.**
Calculate the acid dissociation constant **K_a**, then determine the **pH** of the solution. **(8 pts)**

1- **Understanding the Chemical System ……………….1pts**

Dissociation of NH_4Cl

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

$$NH_4Cl(s) \rightarrow NH_4^+(aq) + Cl^-(aq)$$

- **NH_4^+** is the conjugate acid of the weak base NH_3
- **Cl^-** is the conjugate base of the strong acid HCl (neutral, no effect on pH)

Acid Behavior of NH_4^+

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

$$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$$ **……………1pts**

This equilibrium is governed by the acid dissociation constant **Ka**.

2- **Calculate Ka from Kb …………….1 pts**

Relationship Between Ka and Kb

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

$Ka \times Kb = Kw$

Where:

- **Ka** = acid dissociation constant of NH_4^+
- **Kb** = base dissociation constant of $NH_3 = 1.8 \times 10^{-5}$
- **Kw** = ionic product of water = 1.0×10^{-14} at 25°C

Calculation

$Ka = Kw / Kb$

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

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

Result: $Ka(NH_4^+)$ = **5.56×10^{-10} …………………….. 0.25 pts**

3- Determine the pH of the Solution

Equilibrium Expression …………………2 pts

For the dissociation of NH_4^+:

$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$

The acid dissociation constant is:

$Ka = [NH_3][H_3O^+] / [NH_4^+]$

ICE Table (Initial, Change, Equilibrium)

	NH_4^+	NH_3	H_3O^+
Initial ($mol \cdot L^{-1}$)	0.10	0	0
Change ($mol \cdot L^{-1}$)	−x	+x	+x
Equilibrium ($mol \cdot L^{-1}$)	0.10 − x	x	x

4- Substitution into Ka Expression

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

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

Simplification

Since Ka 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:

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

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

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

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

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

5- Calculate pH……………………..1.75 pts

Since $\mathbf{x = [H_3O^+]}$:

$\mathbf{pH = -\log[H_3O^+]}$

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

$\mathbf{pH = 5.13}$

Final Result: The pH of the 0.10 $mol \cdot L^{-1}$ NH_4Cl solution is **pH = 5.13………………..0.25 pts**

Exercise 3

Given Equation:

$$C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$$

Questions:

1. Determine the oxidation numbers of carbon in the reactant (ethanol) and in the product (CO_2).
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_2H_5OH)

Ethanol has the structure: **CH_3-CH_2-OH**

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

Method:

Let the average oxidation number of carbon = x

In C_2H_5OH:

- 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………………………**1pts**

Carbon in Carbon Dioxide (CO_2)

Let oxidation number of C = x

Equation:

x + 2(-2) = 0
x - 4 = 0
x = +4

2- **Oxidation number of carbon in CO_2 = +4……………..1pts**

Summary Table

Species	Element	Oxidation Number
C_2H_5OH	C	**-2**
CO_2	C	**+4**
O_2	O	**0**
H_2O	O	**-2**

3- **Identify Oxidized and Reduced Elements**

Oxidation (Loss of Electrons)

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

Change: Δ = +4 - (-2) = **+6………………..1pts**

Carbon is oxidized (loses electrons)

Reduction (Gain of Electrons)

Oxygen in O_2 goes from **0** to **-2**

Change: Δ = -2 - 0 = **-2……………………1 pts**

Oxygen is reduced (gains electrons)

$6\alpha = 2\beta$ $\alpha = 1$ et $\beta = 3$……………………1pts

4. Balanced Equation:

$C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$………………..2pts