Exercise 1: reaction between strong acid and strong base

I- Dilution of a commercial hydrochloric acid solution:

A bottle of commercial hydrochloric acid solution (S_0) labeled with the following information:

Density d= 1.14 $g.ml^{-1}$, percentage by mass, P=13% M(HCl)= 36.5 $g.mol^{-1}$

1.1-show that the concentration C_0 of S_0 is 4 $mol.l^{-1}$

1.2- 1000ml of solution S_1 is prepared by diluting 1000times the solution (S_0) .

1.2.1-list the material used to prepare the solution S_1

1.2.2-describe the procedure followed to prepare S_1 .

1.2.3-show that the concentration C_1 of S_1 is 4.10^{-3} $mol.l^{-1}$

1.3-the PH of the solution S_1 is 2.4

1.3.1-calculate $[H_3O^+]$ and $[HO^-]$ in the solution S_1

1.3.2-show that HCl is a strong acid

1.3.3-write the equation of the reaction between HCl and water

II- Preparation of a House hold product NaOH:

It is required to prepare 1000ml of a House hold product of sodium hydroxide of concentration $2x10^{-2}$ $mol.l^{-1}$ (S_1)

2.1-Determine the mass of NaOH that should be taken to prepare (S_1) M(NaOH)=40 $g.mol^{-1}$

2.2Indicate the glassware used in this preparation

2.3-Determine the PH of the solution S_1 knowing that NaOH is a strong base

2.4-write the dissociation reaction of NaOH in water

2.5-the basic solution is diluted 40 times .Determine the PH of the solution obtained

III- reaction between the hydrochloric acid solution and the sodium hydroxide solution:

A volume V= 25 ml of hydrochloric acid solution (S)of C= 4.10^{-3} $mol.l^{-1}$ are mixed with 50ml of solution (S_1) of strong base NaOH of Cb= $2x10^{-2}$ $mol.l^{-1}$

3.1-wite the equation of the reaction that takes place
3.2-give two characteristics of this reaction
3.3-justify why this reaction is an acid base reaction
3.4-determine the limiting reagent
3.5-calculate PH of the solution obtained at the end of the reaction

exercise 2

Study of a household product: "Kimo"

Sodium hydroxide powder is often used in cleaning.

The aim of this exercise is to titrate the sodium hydroxide in the "Kimo" and to determine the percentage of purity of the descaling agent in sodium hydroxide by pH-metric titration.

This study was carried out at 25 ºC.

Molar mass of NaOH is 40g.mol^{-1}

Experimental protocol :

-First step: dissolve 1.2 g of this product in distilled water in such a way as to have a solution (S') of volume V = 500 mL.

-Second step: a volume V_B = 20 mL of the solution (S') is introduced into a beaker. We add a volume V of distilled water to ensure good immersion of the pH meter electrode.

- Third step: the titration is carried out using the hydrochloric acid solution of concentration C_S = 0.07 mol.L^{-1}.

The volume of the acid solution added to reach the equivalence is **15.6 ml**

I- Dilution of a commercial solution of hydrochloric acid

We have a bottle of commercial hydrochloric acid. On the label of this bottle, we read, among other things, the following indications:

Density: = 1.12 g.ml^{-1}; % by mass = 32.13%; M $_{HCl}$ = 36.5 g.mol$^{-1.}$

1.1- Show that the molar concentration of this solution, noted (S_0) isC_0 = 9.86 mol.L-^{1}.

1.2-From (S_0), a solution (S) is prepared by dilution and titrated with a sodium hydroxide solution. The concentration of (S) is found to be C_S = 0.07 mol.L^{-1}.

The following two sets of glassware are available:

Set (a): 1000 mL volumetric flask, 10 mL graduated pipette (1/10), 50 mL beaker.

Set (b): 100 mL volumetric flask, 2 mL volumetric pipette, 50 mL beaker.

Explain, **for each set**, if it is suitable for carrying out this dilution.

II- titration of the "Kimo" S' solution:

2.1-Write the equation of the titration reaction.

2.2-Based on the chemical species present in the beaker, justify the value of the

pH = 7 at equivalence.

2.3- Determine the concentration C_B of the solution (S') in sodium hydroxide

2.4-Deduce the mass percentage of sodium hydroxide this descaling agent

2.5-Specify the effect of adding distilled water in the beaker to properly immerse the pH meter electrode on the volume of acid added at equivalence

2.6-justify if the following statements are correct or not
2.6.1-the acidic solution is added using 25ml graduated pipet
2.6.2-the characteristics of the titration reaction are: slow and complete
2.6.3-the PH of the solution obtained after a large addition of the acidic solution tends to zero
2.7-

2.7.1-show that at any instant t after equivalence point the PH of the obtained solution is calculated according to the following relation :

$$pH = 1.155 - \log \frac{va - 15.6}{50 + va}$$

2.7.2-deduce the PH of the solution obtained after adding 25 ml of the acidic solution

Exercise 3 : A scale product

In markets, scale products are concentrated sodium hydroxide solutions. These solutions are used to remove scales and sediments from pots. The label of this scale product gives the following indications:

- Density μ=1,2 g/mL.
- %m (NaOH)= 20%

The aim of this exercise is to verify the mass percentage

of sodium hydroxide in this scale product.

Given: M(NaOH) = 40g.mol^{-1}

I- Experimental Procedure:

first step: Starting from the commercial solution (S0), 1L of a solution (S1) of concentration $C1 = \frac{C0}{50}$

second step: A volume V_b = 10 mL of solution (S) is put into a beaker. A volume V´ of distilled water is then added into this beaker.

Third step:Titration is carried out by using hydrochloric acid solution of concentration C_a= $0.12 mol.L^{-1}$.

I- <u>Experimental Study:</u>

1.1- Among the following sets of glasswares choose by justifying, the most available set of glasswares for this dilution.

Sets	**Set 1**	**Set 2**	**Set 3**
Glasswares	5 ml graduted pipet 500mL Volumetric flask Beaker 50 ml	5 ml volumetric pipet 1LVolumetric flask Beaker 50 ml	20 ml volumetric pipet 1L Volumetric flask Beaker 50 ml

1.2- Indicate the reason of the addition of the volume V' of distilled water in the beaker before titration. **Specify its effect on Va (equivalence), PH initial.**

II- <u>Make Use of the Titration Results :</u>Part of the titration results is given in the following table:

V_a (mL)	0	9,8	15
pH	12,5	7.0	1,2

2.1-Draw the shape of the curve pH = f(V_a) for $0 \leq V_a \leq 15$ mL.

Take the following scale: abscissa : 1cm for 1mL, ordinate: 1 cm for 1 unit of pH.

2.2-Write the equation of the titration.

2.3-Justify by referring to the chemical species the value of PH at equivalence

2.4-Determine the concentration C_b of sodium hydroxide in solution (S) deduce C_0.

2.5-Determine the mass percentage of sodium hydroxide in this scale product.

2.6-Justify if the error is accepted such that the acceptable error does not exceed 3%.

2.7-During titration, equivalence point can be detected using indicator, between the following given indicators, choose the best one to be used in this experiment. **justify**

Indicator	**Methyl orange**	**Bromothymol blue**	**Phenolphthalein**
Average change	**3.1 - 4.4**	**6.2 - 7.6**	**8.2 - 10**

Exercise 4: **"Neel"** cleaning product

"Neel" is a commercial household product. Its main component is hydrochloric acid HCl
The objective of this exercise is to determine the mass percentage of HCl in this product.

Given:

-Molar mass of HCl in $g.mol^{-1}$: 36.5 - Reaction takes place at 25°C. -Density of the commercial solution is $1180g.l^{-1}$

I-dilution of the commercial solution (S0):

A solution (S) is prepared by diluting the solution(S_0) 250 times

1.1- Choose from the following list the glassware needed to prepare the dilute solution (S).justify

List of material -volumetric pipets :2mL, 10 mL, 20 mL; -graduated cylinder : 10 mL, 100 mL, 200 mL ; -beakers : 100 mL, 200 mL ; - volumetric flasks :250 mL, 500 mL, 1000 ml

1.2- Knowing that hydrochloric acid is a strong acid
Write the equation of the reaction between HCl and water

II-titration of solution S:

In order to titrate the solution S, we proceed as follows:
- 20 ml of solution S are taken and introduced into a 100 ml beaker
- add 40 ml of distilled water
- a solution of sodium hydroxide (NaOH) of concentration Cb=$0.05\ mol.l^{-1}$ is gradually poured in, the volume of the base added to reach the equivalence is 19.2 ml.

2.1-complete the following table indicating the missing material and the purpose of use:

Material used	purpose of use
Buret 25 ml	
	Measure the PH during titration
20ml volumetric pipet	

2.2-Write the equation of the titration reaction. .
2.3- justify qualitatively the PH value of the solution obtained at equivalence.

2.4- determine the concentration of the solution S deduce that of S_0
2.5- determine the mass percentage of HCl in the solution S_0
2.6- show that the pH of the solution after the equivalence, is given by the following relation: **pH =12.7 + log** $\frac{vb-19.2}{60+Vb}$
where Vb is the volume of the base added after the equivalence

2.7- the following table represents the variation of PH as a function of Vb(ml)

Vb(ml)	0	19,2	40
PH	2	7	Y

2.7.1 show using the relation in part 2.6 that Y=12
2.7.2- Plot the shape of the curve PH=f (vb)
Scale x axis: 1cm for 4mL, y axis: 1cm for 1 pH unit.
2.8-if the same experiment is repeated using a potassium hydroxide solution of the same concentration Cb=0.05 $mol.l^{-1}$. Choose by justifying the correct answer
a-V'(B)equivalence =19.2 ml
b- V'(B)equivalence <19.2 ml
c-V'(B)equivalence >19.2 ml

exercise 5: HOUSEHOLD PRODUCT

On the label of a bottle containing a household product used as drain opener, we read:

19% NaOH; causes severe burning; dissolves all organic materials; keep out of reach of children; **d**ensity = 1.2 Kg/L

Given: Molar mass of NaOH in g/mol is 40, Titration is carried out at a temperature of 25º C.

Materials

Beakers (100; 200; and 500ml); Erlenmeyer flasks (100; 250; and 500ml); volumetric pipets (5; 10 and 20 ml), Pipet filler, graduated cylinders (10; 25; and 50 ml), volumetric flasks (100; 250; 500; and 1000 ml); buret (25 and 50 ml), magnetic stirrer, magnetic bar, pH meter; gloves and goggles for safety.

Indicators and pH range with the corresponding colors:

Methyl red	4.2-6.2	Red - yellow
Bromothymol blue	6.0-7.6	Yellow - blue
Phenolphthalein	8.2-10.0	Colorless – pink

I) Dilution

The concentration of NaOH being very high, we prepare V= 0.5L of solution (S) of concentration C= $C_o/50$; C_0 is the concentration of NaOH in the commercial solution.

1.1- Write the equation of ionization of NaOH in water.

1.2- Describe in detail, the procedure followed for preparing the diluted solution

II) Titration

We take V_b= 20 mL of the diluted solution of concentration C_1 and we place it in a beaker. We add progressively a solution of HCl of concentration C_a= 0.1mol/L. Using a pH-meter we follow the change of pH of the mixture as function of V_a; the volume of HCl solution added.

2.1- choose from the list of the material given the glassware used in the titration process.

2.2- Write the equation of the reaction that takes place.

2.3- Calculate the concentration of sodium hydroxide in solution (S) and deduce the concentration C_0 of the commercial solution, knowing that V_a at equivalence point is 24mL.

2.4- Calculate the percentage by mass of NaOH in the household product

2.5- If the titration is done using an indicator. Choose the convenient indicator that can be used.Justify

2.6-justify if the following statements are correct or not

2.6.1-the equation of the reaction that takes place at equivalence point is:

$$2H_2O \rightarrow H_3O^+ + HO^-$$

2.6.2-the characteristics of the titration reaction are: slow and complete

2.6.3-the PH of the solution obtained after a large addition of the acidic solution tends to one.