



الجمهورية الجزائرية الديمقراطية الشعبية
People's Democratic Republic of Algeria
وزارة التعليم العالي والبحث العلمي
Ministry of Higher Education and Scientific Research



Abdelhafid Boussouf Mila University Center
Institute of Natural and Life Sciences
Department of Natural and Life Sciences (SNV)

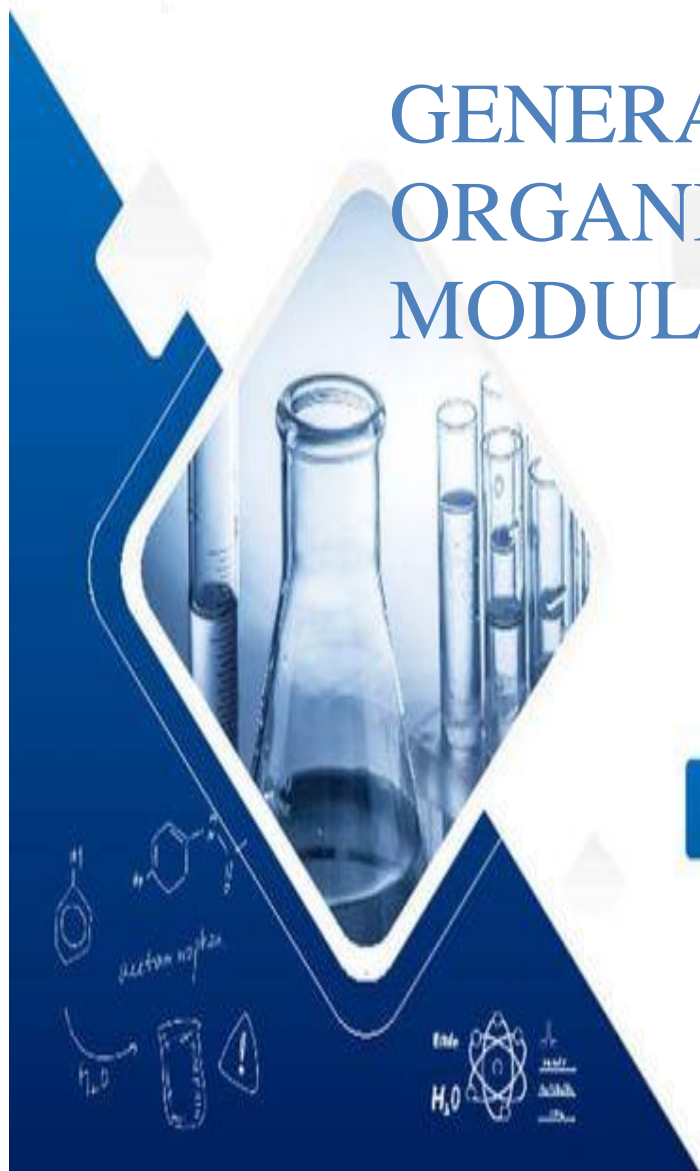
المركز الجامعي عبد الحفيظ بوالصوف ميلة
معهد علوم الطبيعة والحياة
قسم جذع مشترك علوم الطبيعة والحياة

GENERAL AND ORGANIC CHEMISTRY MODULE

Laboratory practical work


Dr. Hassiba Bougueria

Academic year 2024–2025



Preamble:

This practical work booklet is designed to be a hands-on guide that brings theoretical concepts to life, providing a platform for students to immerse themselves in the experimental side of chemistry. It is mainly intended for first-year university students in the fields of natural and life sciences. It adheres to the curriculum of the first. The use of hands-on activities aligns with educational theories that emphasize experiential learning, ensuring that students not only understand the concepts but also retain the knowledge through practical application. These experiments enable students to deepen their understanding of theoretical concepts by observing and practicing them in a real-world context. By engaging in hands-on learning, students acquire vital technical skills, such as accurate handling of laboratory equipment and adherence to safety protocols, fostering a secure and efficient working environment. Through the application of the scientific method, students enhance their critical thinking and problem-solving abilities, as they hypothesize, experiment, and analyze results. Additionally, these practical exercises illustrate the relevance of chemistry in everyday life and various industries, promoting an appreciation for the field's real-world applications. They also encourage innovation and research, inspiring students to explore creative solutions and conduct independent investigations. Collaboration and communication skills are developed as students work in teams, discussing and sharing their findings. Finally, practical assessments and constructive feedback help students improve their techniques and understanding, ensuring a comprehensive and fulfilling learning experience. This practical guide is an indispensable companion for 1st year students, guiding them through different experiments that illustrate the basic principles, the safety guidelines to be respected in the chemistry laboratory, and the different methods of preparing a solution and determining its concentration.

We aspire for this manual to achieve the intended objectives successfully.

Contents

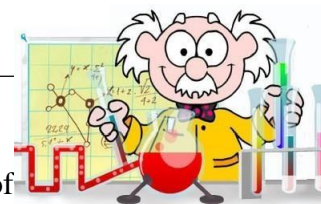
Preamble:	1
Lab Work N°1: Laboratory Safety Rules and equipment	5
I. Introduction:.....	5
II. Objectif.....	5
III. Laboratory Safety.....	5
IV. Laboratory rules for students	5
1- Knowledge of the products used and hazard symbols:	6
2- Understanding chemical pictograms	7
3- Some tools and equipment in the chemistry lab:	8
Lab Work N°2: Determine the amount of substance (in moles)	10
I. Introduction.....	10
II. Aim.....	11
III. Determine the quantity of material.....	11
Lab Work N°3: Preparation of aqueous solutions	14
I. Introduction.....	14
II. Ways of Expressing Concentration	14
III. Aims	16
□ Preparation of solution from a solid solute.....	16
□ Preparation of solution by dilution of a concentrated stock solution.....	16
IV. Materials Required.....	17
a) Preparing a standard solution from a solid.....	17
b) Diluting a Solution of Known Concentration	17
Lab Work N°4: Measurement of Volumic Mass (Density) of a substance	20
I. Definition	20
A. Measurement of Volumic Mass (Density) of a Solid	21
II. Objective	21
III. Materials Needed	21
IV. Theory	21
V. Procedure	21
VI. Results.....	22
B. Measurement of Volumic Mass (Density) of a Liquid	22
I. Objective	22
II. Materials.....	22
III. Procedure	22
IV. Measure the Combined Mass	23
V. Calculate the Density	23
VI. Results:.....	23

VII. Safety Precautions:.....	23
Lab Work N° 5: Identification of Functional Groups in Organic Compounds.....	25
I. Introduction.....	25
1- Common Functional Groups	25
2- Importance of Functional Groups	26
II. Objective	26
III. Materials.....	27
IV. Safety Precautions.....	27
V. Procedure	27
Reference	30

Lab Work N°1: Laboratory Safety Rules and equipment



Lab Work N°1: Laboratory Safety Rules and equipment



I. Introduction:

Working in a chemical laboratory requires the application of a number of safety rules; these are essential for the organization of work in a laboratory. When you come back to the laboratory for the first time, the student will need to know what to do, how to dress for a session, know the essential rules for handling materials and chemicals and the commonly used glassware and know how to write a report.

II. Objectif

Assess the student's knowledge of the equipment used in the chemistry experiments and the safety rules to be respected in the laboratory.

III. Laboratory Safety

Every university must have a set of laboratory safety rules. These rules should be sufficiently comprehensive to cover all eventualities yet be simple and concise. The rules must be displayed clearly in a prominent place in the laboratory. Safety training must play a major part in ensuring freedom from accidents and should aim to explain the basis for the rules. Everyone in a laboratory should be made aware that he/she is responsible for both his/her own safety and the safety of those working alongside them. It must be stressed that at all times the most important consideration is human safety.

IV. Laboratory rules for students

Simply entering a chemical laboratory requires strict compliance with certain rules

DO NOT enter the laboratory without permission.

DO NOT use any equipment unless permitted to do so by the professor. Make sure you know exactly what you are supposed to do. If in doubt, ask the professor.

Long hair **MUST** always be tied back securely.

ALWAYS wear eye protection when instructed to do so.

ALWAYS check that the label on the bottle is **EXACTLY** the same as the material you require. If in doubt, ask the teacher.

DO NOT eat, drink or taste anything in the laboratory or any food brought into the laboratory.



No Food or Drink

Any substance accidentally taken into the mouth must be spat out **IMMEDIATELY** and the mouth washed out with plenty of water before reporting to the professor.

Any cut, burn or other accident **MUST** be reported at once to the professor.

Any chemicals spilled on the skin or clothing **MUST** be washed at once with plenty of water and reported to the professor.

Always **WASH** your hands after practical work.

This list of rules is repeated and should be copied and displayed prominently in each laboratory. The professor must decide if the student needs first-aid and if it is necessary to go to hospital or to see a doctor.

It is essential to emphasize that human safety is the primary consideration at all times.

1- Knowledge of the products used and hazard symbols:

There are three major categories of intrinsic dangers to chemicals:

- Physical hazards (risk of explosion, ignition, etc.).
- Health hazards (acute toxicity, eye damage, reproductive toxicities, etc.).
- Hazards to the environment (danger to aquatic environments).

The handling of chemicals is not safe. Packaging labels contain pictograms (Figure 1) and codes showing the risks and safety instructions. The following image shows an example of Labeling elements of a primary chemical container.

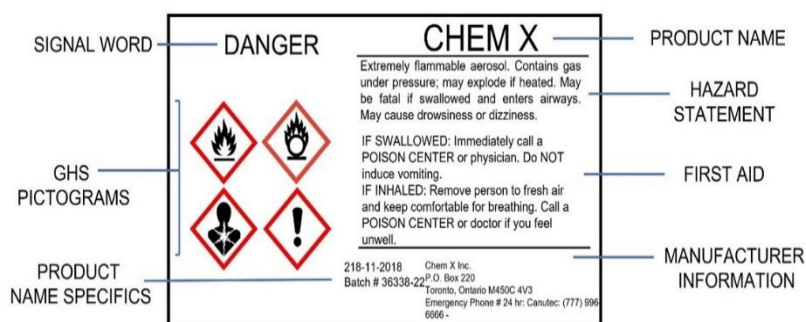











Figure 1 Labeling elements of a primary chemical container

2- Understanding chemical pictograms

The Hazard Communication Standard (HCS) requires pictogram labels to warn users of the chemical hazards associated with a substance. Reference the chart below to learn more about the nine HCS pictograms.

		
Health Hazard	Flammable	Exclamation Mark
These substances may cause serious health effects, such as cancer, mutated genes or a damaged respiratory system.	These substances may cause a fire hazard due to spontaneous combustion or flammable gas.	These substances may cause less serious health effects, such as irritation to the skin, eyes or respiratory system.
		
Compressed Gas	Corrosives	Explosives
These substances have gases under pressure (it could be liquefied gases such as Cl ₂ , NH ₃ , NO, CO ₂ and the liquefied such as N ₂ , H ₂). Examples include propane, methane and butane.	These substances may corrode or burn metals, skin and eyes. Examples include acids or bases, such as hydrochloric acid.	These substances, such as TNT, may explode or react with themselves.
		
Oxidizing	Environmental Hazards	Toxic
These substances are oxidizing gases, liquids or solids.	These substances, such as zinc oxide, may cause damage to an aquatic environment and the environment and the environment.	These substances may cause death or poisonous effects from short exposure.

3- Some tools and equipment in the chemistry lab:

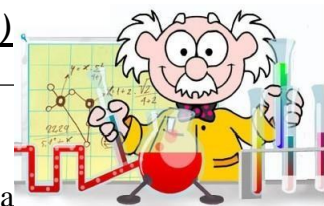
For every student, one of the common excitements of the school days remains associated with the discovery and introduction with the laboratory equipment in school labs. Between standard 5 to 8, students get the knowledge of the basic lab apparatus and get to know about their uses. All of these apparatuses are the pillars of every lab, be it in schools, colleges, research labs, or medical laboratories.

					
Beaker	Flash	2 Neck Round Bottom Flask	Test tube	Separating Funnel	Condenser
					
Measuring Cylinder	Burette	Lab glass Pipettes	pipette bulb	Volumetric flask	Dropper
					
Standard Jack	Watch glasses	Wooden or test tube clamp	Spatula	Funnel	Retort Clamp
					
Reagent Bottle	Petri Dish	Hotplate	Magnetic stirrer	Bunsen burner	Laboratory Weighing Scales
					
Wash bottles	Tongs	Thermometer	Buchner Funnel	Retort Stand	Crystallising Dish

Lab Work N°2:
Determine the amount of substance
(in moles)



Lab Work N°2: Determine the amount of substance (in moles)



I. Introduction

The mole (abbreviated mol) is an SI unit which measure the quantity of a “chemical entity,” such as atoms, electrons, or protons. It is defined as the amount of a substance that contains as many particles as there are atoms in 12 grams of pure carbon-12. So, 1 mol contains 6.023×10^{23} elementary entities of the substance.

The Avogadro number (N_A) is the proportionality factor that relates the number of constituent particles (usually molecules, atoms or ions) in a sample with the amount of substance in that sample.

With: The formula for the number of moles is expressed as follows:

$$n = \frac{m(g)}{M(g/mole)}$$

In which:

n: represents the number of moles, given in mol

m: signifies the mass of the substance, given in gramme (g)

M: represents the mass of one mole of that substance, given in g/mol

Special case of liquid:

The (volumetric mass density or specific mass) of a material substance is defined as the amount of mass contained per unit volume of this material.

$$\rho = \frac{mass}{Volume}$$

In which:

ρ : represents the volumetric mass

m: signifies the mass of the substance, given in gramme (g)

V: represents the volume.

The density of water is about 1000 kg/m^3 or 1 g/cm^3 , because the size of the gram was originally based on the mass of a cubic centimeter of water.

Density (without unit) of a solid or liquid material substance A, denoted $d(A)$, is the density of this material substance (A) divided by the density of water.

$$d = \frac{\rho(A)}{\rho(\text{water})}$$

Special case of Gaz:

Gases are compressible, meaning that when put under high pressure, the particles are forced closer to one another. This decreases the amount of empty space and reduces the volume of the gas. Gas volume is also affected by temperature. When a gas is heated, its molecules move faster and the gas expands. Because of the variation in gas volume due to pressure and temperature changes, the comparison of gas volumes must be done at normal condition of temperature and pressure.

STP stands for Standard Temperature and Pressure is set by the IUPAC as 0°C and 100 kPa or 1 bar.)

NTP stands for Normal Temperature and Pressure is set at 101.325 kPa but uses 20°C as the temperature. **The molar volume** of a gas is the volume of one mole of a gas at NCTP. At NCTP, one mole (6.023×10^{23} representative particles) of any gas occupies a volume of 22.4 L.

$$n = \frac{V(\text{Gaz})}{Vm}$$

In which:

V: represents the volume

Vm: signifies the volumetric mass density given in SI units of Kg/m^3 or in g/cm^3 for solids/liquids and Kg/m^3 or g/L for gases



II. Aim

- Explain the relation between mass, moles, volume and numbers of atoms or molecules, and perform calculations deriving these quantities from one another
- Determine the quantity of material contained in a given sample of pure substance.

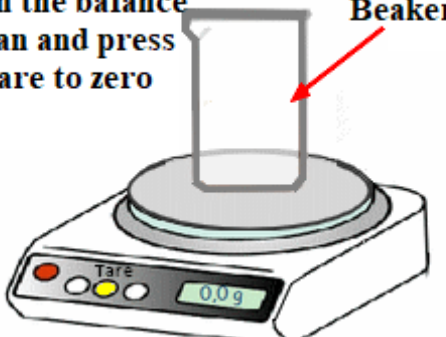
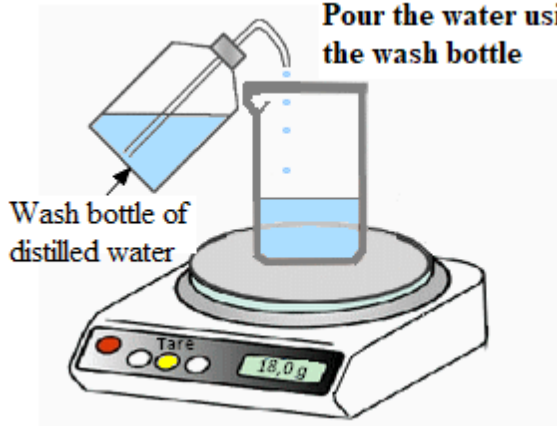
III. Determine the quantity of material

1. Procedure

a. Using weighing, weigh each sample (copper plate, piece of chalk and piece of sugar).

Example for powdered sugar	For an object, simply place it on a watch glass
<p>Put the watch glass on the scale pan and press Tare to zero.</p> 	<p>Add the powdered sugar using a spatula</p> 

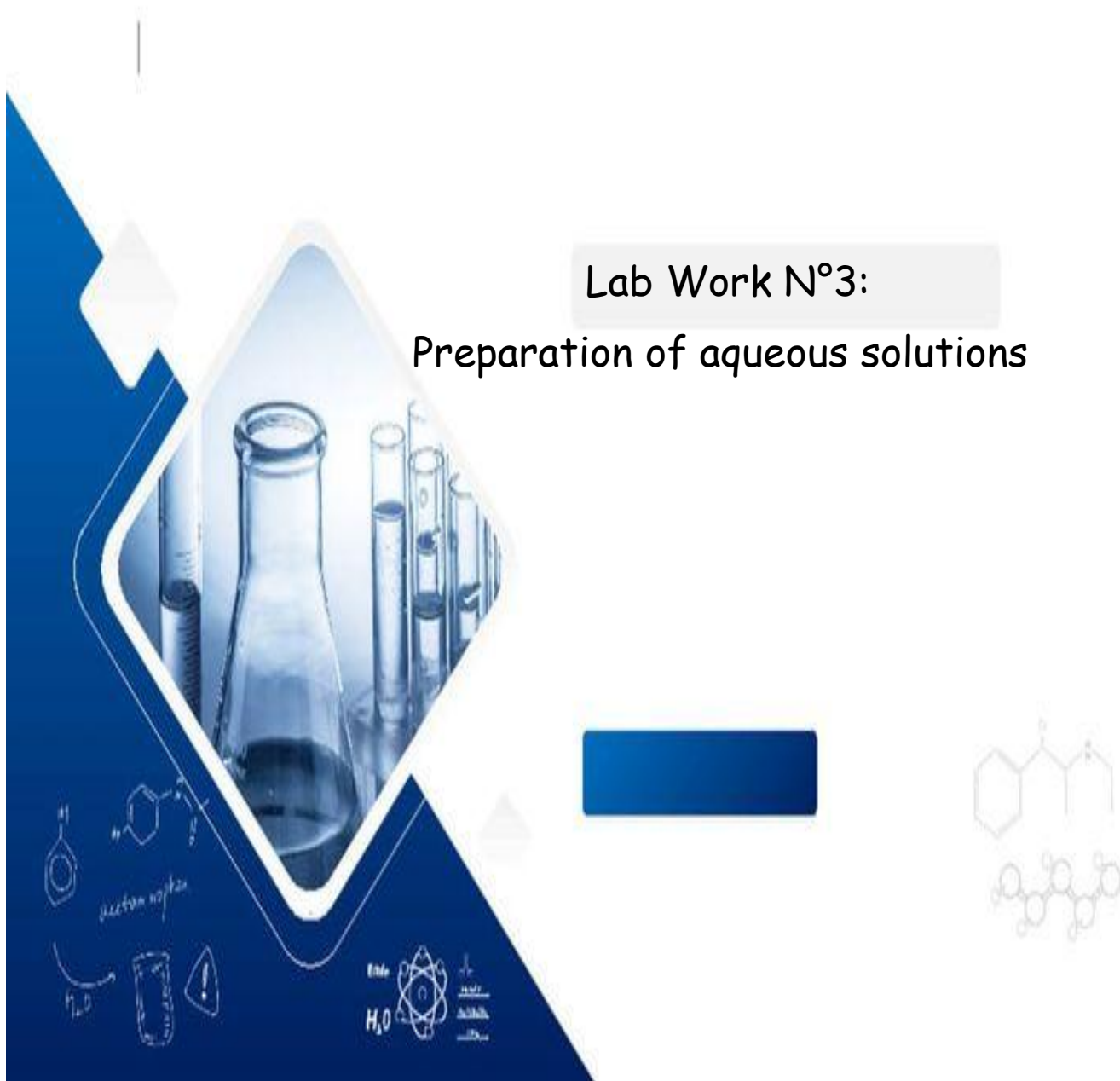
b. The operating protocol allowing **one mole of water** to be poured into a beaker.

A method for water	Pour until the scale shows 18.0 g
<p>Place the beaker on the balance pan and press Tare to zero</p> 	<p>Pour the water using the wash bottle</p> 

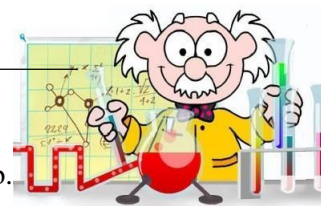
Pour the liquid into a beaker and note the corresponding volume V of water.

Lab Work N°3:

Preparation of aqueous solutions



Lab Work N°3: Preparation of aqueous solutions



I. Introduction

Making solutions is a very common activity for lab workers in a chemistry lab. Proper solution making requires basic math skills, accurate measurement, and the ability to follow instructions.

A **solution** is a homogeneous mixture of two or more substances. In a solution, the **solute** is the substance that is dissolved in the **solvent**. Most of the time, the solvent will be H_2O , so if it is not otherwise specified, assume that you should dissolve the necessary amount of solute calculated in H_2O .

For example, when a smaller amount of sugar (solute) is mixed with water (solvent), a homogeneous solution in water is obtained.

Solution = Solute + Solvent

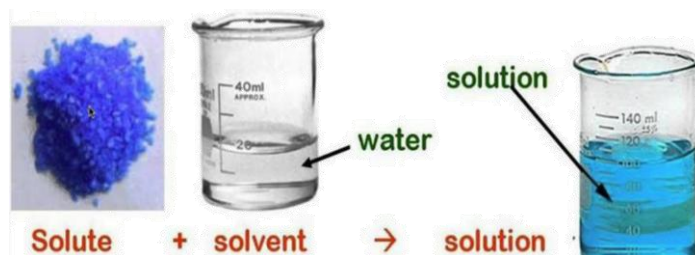


Figure2: Example of preparation

A **dilute solution** is one in which there is a relatively small amount of solute dissolved in the solution.

A **concentrated solution** contains a relatively large amount of solute.

A **standard solution** is a solution that has a known weight of the solute in the solution of unknown size.

An **Equivalent weight** (Eq.Wt.) (also known as gram equivalent) is the mass of one equivalent, that is the mass of a given substance which will combine with or displace a fixed quantity of another substance.

II. Ways of Expressing Concentration

We always discuss a solution being diluted or concentrated; this is a qualitative way of expressing the concentration of the solution.

There are several different ways to quantitatively describe the concentration of various solutions around us, we commonly express levels in the following way:

1- Concentration

It is the amount of solute present in one liter of solution. It is denoted by C.

$$C = \frac{\text{Weight of solute in grams}}{\text{Volume in liters}}$$

2- Mass Percentage (w/w)

When the concentration is expressed as the percent of one component in the solution by mass it is called mass percentage (w/w).

Suppose we have a solution containing component A as the solute and B as the solvent, then its mass percentage is expressed as:

$$\text{Mass \% of A} = \frac{\text{Mass of solute A in the solution}}{\text{Total mass of the solution}} \times 100$$

3- Volume Percentage (V/V)

Sometimes we express the concentration as a percent of one component in the solution by volume, it is then called as volume percentage and is given as:

$$\text{volume \% of A} = \frac{\text{Volume of Solute A in the solution}}{\text{Total volume of the solution}} \times 100$$

For example, if an aqueous solution of NaCl is marked 10 % by volume that means a 100 ml solution will contain 10 ml NaCl.

4- Mass by Volume Percentage (w/V)

This unit is majorly used in the pharmaceutical industry. It is defined as the mass of a solute dissolved per 100 mL of the solution.

$$\% \text{ w/V} = \frac{\text{Mass of solute A in the solution}}{\text{Total volume of the solution}} \times 100$$

5- Molarity (M)

One of the most commonly used methods for expressing the concentrations is molarity. It is the number of moles of solute dissolved in one liter of a solution. Suppose a solution of ethanol is marked 0.25 M, this means that in one liter of the given solution 0.25 moles of ethanol is dissolved.

$$M = \frac{\text{Moles of solute}}{\text{Volume of the solution in liters}}$$

6- Molality (\mathcal{M})

Molality represents the concentration regarding moles of solute and the mass of solvent. It is given by moles of solute dissolved per kg of the solvent. The molality formula is as given-

$$\mathcal{M} = \frac{\text{Moles of solute}}{\text{Mass of solvent in Kg}}$$

7- Normality

It is the number of gram equivalents of solute present in one liter of the solution and it is denoted by N.

$$N = \frac{\text{Weight of solute in grams}}{\text{Equivalent weight} \times \text{volume in liters}}$$

The relation between normality and molarity.

- $N \times \text{Eq. Wt} = \text{Molarity} \times \text{Molar mass}$
- $N = \text{Molarity} \times \text{Valency}$
- $N = \text{Molarity} \times \text{Number of } \text{H}^+ \text{ or } \text{OH}^- \text{ ion in a base or acid formula, e}^- \dots$

$N = \text{Molarity} \times \text{Basicity} = \text{Molarity} \times \text{Acidity}$

8- Mole Fraction

If the solution has a solvent and the solute, a mole fraction gives a concentration as the ratio of moles of one component to the total moles present in the solution. It is denoted by x. Suppose we have a solution containing A as a solute and B as the solvent. Let n_A and n_B be the number of moles of A and B present in the solution respectively. So, mole fractions of A and B are given as:

$$X_A = \frac{n_A}{n_A + n_B} \text{ and } X_B = \frac{n_B}{n_A + n_B}$$

III. Aims

- Preparation of solution from a solid solute.
- Preparation of solution by dilution of a concentrated stock solution.

IV. Materials Required

Weighing balance, watch glass, spatula, funnel, wash bottle that contain distilled water, volumetric flask, Rubber bulbs, pipette, beaker. Caustic soda NaOH.

a) Preparing a standard solution from a solid

Procedure: The teacher instructed four groups of student 'A', 'B', 'C' and 'D' respectively to prepare 50 mL, 100mL of (0,001 M, 0,002 M, 0,003 M, 0,004 M) sodium hydroxide solution NaOH (M=40g/mol).

1. Determine the mass in grams of NaOH needed to prepare the solution with the concentrations mentioned above. These equations may be helpful $m=C.M.V$
2. Weigh solute with scale out in a watch glass and then transferred directly to a volumetric flask calibrated to prepare desired volume. A funnel might be helpful when transferring the solid into the slim neck of the volumetric flask.
3. A small quantity of water is then added to the volumetric flask and the contents are swirled gently until the substance is completely dissolved.
4. More water is added until the meniscus of the liquid reaches the calibration mark on the neck of the volumetric flask (a process called "diluting to volume").
5. The volumetric flask is then capped and inverted several times until the contents are mixed and completely dissolved.

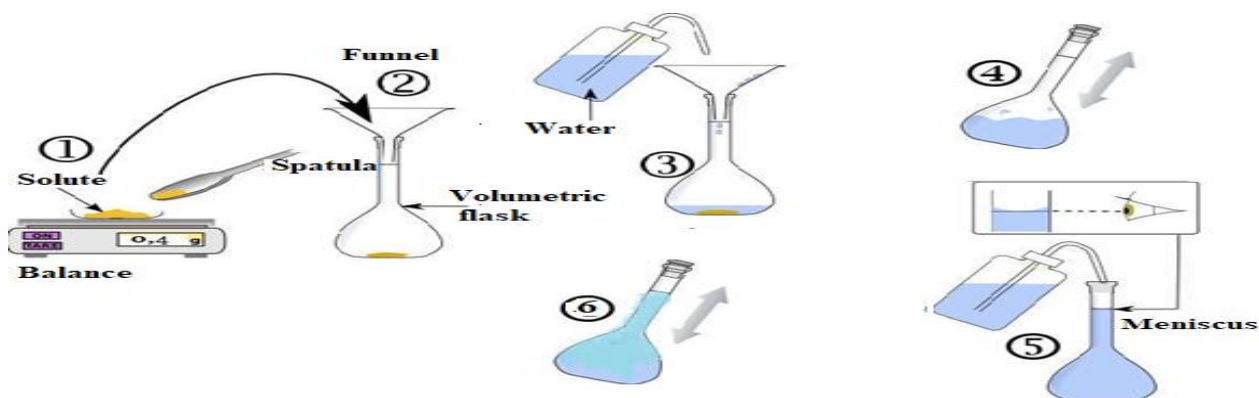


Figure 3: Procedure of Preparing a standard solution

b) Diluting a Solution of Known Concentration

Dilution is the addition of more solvent to produce a solution of reduced concentration. Most often a diluted solution is created from a small volume of a more concentrated stock solution.

Procedure: We need to prepare $V_1=100$ mL (Or $V_1=50$ mL) of $C_1=0,001$ M sodium hydroxide solution from $C_0 = 0,005$ M solution.

To make such a solution,

1. Calculate volume of stock solution needed using Dilution Equation: $C_0V_0=C_1V_1$
2. A volumetric pipet is used to deliver an exact amount of the stock solution into a clean volumetric flask to prepare desired volume. (To prevent extra dilution or contamination, prerinse the vol pipet with the stock solution to remove any water droplets or impurities).
3. Adds enough water until the meniscus of the liquid reaches the calibration mark on the neck of the volumetric flask

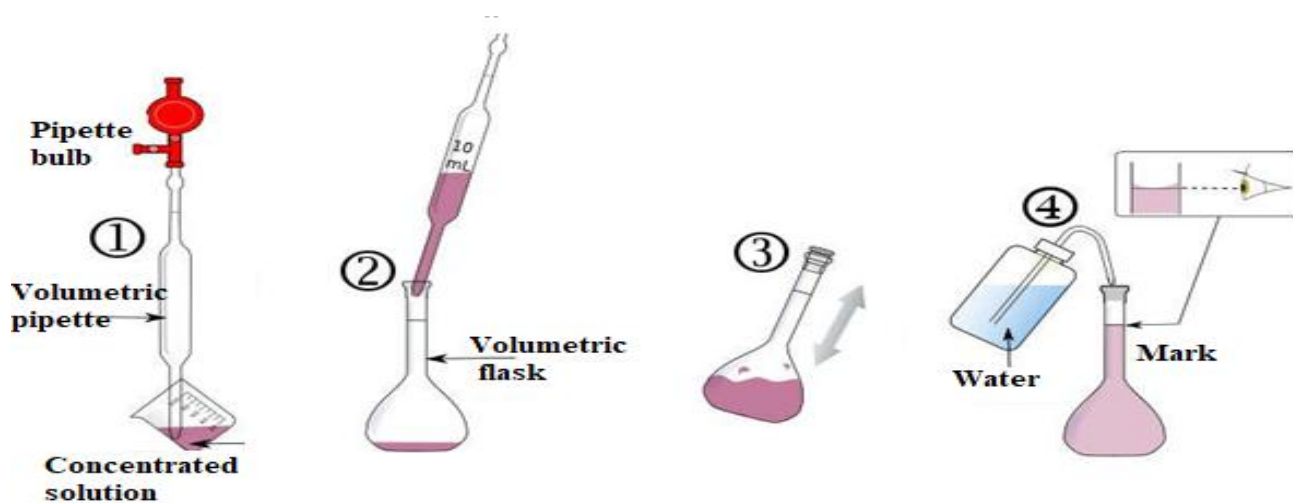


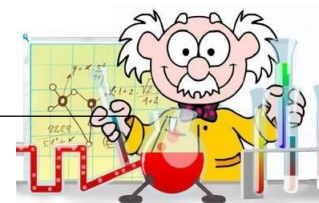
Figure 4: Procedure of preparation of a diluted solution

Lab Work N°4:

Measurement of Volumic Mass (Density) of a substance



Lab Work N°4: Measurement of Volumic Mass (Density) of a substance



I. Definition

Density, also known as volumetric mass density, is a measure of how much mass is contained in a given volume. It tells us how tightly matter is packed together in a substance, if you take a piece of lead and a piece of wood of the same size, the lead feels much heavier because it has a higher density it has more mass packed into the same volume.

The formula for calculating density is:

$$\text{Density } (\rho) = \frac{\text{Mass}(m)}{\text{Volume}(V)}$$

Where:

- **Mass (m)** is the amount of matter in the chemical substance, usually measured in grams (g) or kilograms (kg).
- **Volume (V)** is the amount of space the chemical substance occupies, usually measured in cubic centimeters (cm³) or cubic meters (m³).

So, is expressed in units like grams per cubic centimeter (g/cm³) or kilograms per cubic meter (kg/m³). For example, water has a density of about 1 g/cm³, meaning that 1 cubic centimeter of water has a mass of 1 gram.

The reference substance for liquids and solids is water, for gases it is air.

- When you say the value of d (density) equals that of ρ solution, it means you're comparing the density of a solution to the density of water (since $\rho_{\text{water}}=1\text{g/cm}^3$).
- In the case of heterogeneous mixture the density of the solution is greater than 1 g/cm³, it's denser than water and will sink. If it's less than 1 g/cm³, it's less dense and will float.

For example, oil floats on water because its density is less than 1. Similarly, a rock will sink because its density is greater.

A. Measurement of Volumic Mass (Density) of a Solid

II. Objective

To determine the volumic mass (density) of a solid object using the displacement method.

III. Materials Needed

- Solid object (a metal block, a stone)
- Weighing balance or scale (for measuring mass)
- Measuring cylinder (graduated cylinder)
- Water

IV. Theory

The density (ρ) of a solid is defined as its mass (m) per unit volume (V):

$$\rho = \frac{\text{Mass}(m)}{\text{Volume}(V)}$$

Where:

- ρ = density of the solid (kg/m^3 or g/cm^3)
- m = mass of the solid (kg or g)
- V = volume of the solid (m^3 or cm^3)

V. Procedure

1. Measurement of Mass

- Weigh the solid object using the balance and record the mass m .

2. Measurement of Volume by Displacement

- Fill the measuring cylinder with a known volume of water and record this volume V_{initial} .
- Carefully immerse the solid object into the water contained in the measuring cylinder.
- Ensure that the solid is completely submerged without touching the sides of the cylinder.
- Record the new volume of water with the solid submerged, V_{final} .
- Determine the volume of the solid object by subtracting the initial volume from the final volume:

$$V_{\text{solid}} = V_{\text{final}} - V_{\text{initial}}$$

- ✚ For a solid of defined shape (sphere), wrap a string around the solid to determine its circumference (perimeter), then determine its radius and apply the formulas to calculate its volume. The calculation of the volume is necessary to determine the volumic mass of a sample.

3. Calculation of Density

- Calculate the density of the solid using the formula:

$$\rho_{Solid} = \frac{m}{V_{Solid}}$$

VI. Results

Record your measurements and calculations in a table:

Solid Object	Mass (g)	Initial Volume of Water (cm ³)	Final Volume of Water (cm ³)	Volume of Solid (cm ³)	Density (g/cm ³)
Solid A					
Solid B					

B. Measurement of Volumic Mass (Density) of a Liquid

I. Objective

To determine the volumic mass (density) of a given liquid using a graduated cylinder and a weighing balance or scale.

II. Materials

- A graduated cylinder (50 mL or 100 mL)
- weighing balance or scale.
- Liquid sample (e.g., water, alcohol, oil)
- Dropper or pipette
- Distilled water.

III. Procedure

- Turn on the weighing balance and calibrate it.
- Ensure that the weighing balance reads zero before starting the experiment.
- Measure the Mass of the Graduated Cylinder
- Place the empty graduated cylinder on the weighing balance and record its mass (M₁).
- Add the Liquid to the Graduated Cylinder:

- Using the dropper or pipette, carefully add the liquid to the graduated cylinder until it reaches a specific volume (V) marked on the cylinder. Record the volume.
- Typical volumes to use are 10 mL, 20 mL, or 50 mL, depending on the size of your graduated cylinder.

IV. Measure the Combined Mass

- Place the graduated cylinder with the liquid on the weighing balance and record the new mass (M₂).
- Calculate the Mass of the Liquid:
- Subtract the mass of the empty graduated cylinder (M₁) from the combined mass (M₂) to find the mass of the liquid (M). Mass of liquid (M) = M₂ - M₁

V. Calculate the Density

Use the formula for density:

$$\text{Density } (\rho) = \frac{\text{Mass of liquid } (M)}{\text{Volume of liquid } (V)}$$

Ensure the units are consistent (e.g., grams for mass and milliliters for volume).

VI. Results:

Record your measurements and calculations in a table:

Sample	Mass of Liquid (g)	Volume of Liquid (cm ³)	Density (g/cm ³)
Liquid A			
Liquid B			

VII. Safety Precautions:

Handle all laboratory equipment with care to avoid breakage.

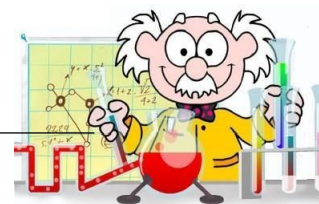
Clean up any spills immediately to prevent slips.

Follow all safety guidelines for handling the liquid sample.

Lab Work N° 5:
Identification of Functional Groups in
Organic Compounds



Lab Work N° 5: Identification of Functional Groups in Organic Compounds



I. Introduction

Functional groups are specific groups of atoms within molecules that have characteristic properties and predictable chemical behavior. They are the key structural components that determine the chemical reactivity and physical properties of organic compounds. Here are some common functional groups:

1- Common Functional Groups

a) Hydroxyl Group (-OH):

Found in alcohols (e.g., ethanol $\text{-CH}_3\text{CH}_2\text{OH}$). Responsible for their solubility in water and their reactivity with acids and bases.

b) Carbonyl Group ($>\text{C}=\text{O}$):

Found in aldehydes (e.g., formaldehyde CH_2O) and ketones (e.g., acetone $\text{-(CH}_3)_2\text{CO}$). Highly reactive, involved in many chemical reactions such as nucleophilic addition.

c) Carboxyl Group (-COOH):

Found in carboxylic acids (e.g., acetic acid $\text{-CH}_3\text{COOH}$). Exhibits acidic properties and can donate a proton (H^+).

d) Amino Group (-NH- or -N<):

Found in amines (e.g., ethylamine $\text{-CH}_3\text{CH}_2\text{NH}_2$). Acts as a base and can accept a proton (H^+).

e) Ester Group (-COOR):

Found in esters (e.g., ethyl acetate $\text{-CH}_3\text{COOC}_2\text{H}_5$). Known for their pleasant fruity smells and are used in fragrances and flavorings.

f) Amide Group (-CONH₂):

Found in amides (e.g., acetamide $\text{-CH}_3\text{CONH}_2$). Present in proteins and peptides.

g) Nitrile Group ($\text{-C}\equiv\text{N}$):

Found in nitriles (e.g., acetonitrile $\text{-CH}_3\text{CN}$). Involved in organic synthesis and pharmaceuticals.

h) Thiols or Sulfhydryl Group (-SH):

Found in thiols (e.g., ethanethiol -CH₃CH₂SH). Known for their strong odors and are present in some amino acids like cysteine.

i) Ether Group (-O-):

Found in ethers (e.g., diethyl ether -C₂H₅OC₂H₅). Used as solvents in organic reactions.

j) Phenyl Group (-C₆H₅):

Found in aromatic compounds (e.g., benzene -C₆H₆). Known for their stability and presence in many organic molecules.

k) Halogen Group (-X, where X = F, Cl, Br, I):

Found in halogenated compounds (e.g., chloroform -CH₃Cl). Commonly used in organic synthesis and pharmaceuticals.

2- Importance of Functional Groups

Functional groups are crucial in organic chemistry because:

- They determine the types of chemical reactions that a molecule can undergo.
- They influence the physical properties, such as boiling point, melting point, and solubility.
- They help in classifying and identifying organic compounds.
- They play a vital role in biochemical processes and the function of biomolecules.

Understanding functional groups allows chemists to predict the behavior of organic compounds and design new molecules for various applications, from pharmaceuticals to materials science.

II. Objective

The aim of this practical work is to identify various functional groups present in different organic compounds through qualitative analysis. Functional groups are specific groups of atoms within molecules that determine the characteristic chemical reactions of those molecules.

III. Materials

- Test tubes
- Test tube holder
- Droppers
- Distilled water
- Ethanol (as solvent)
- Organic compounds (e.g., alcohols, aldehydes, ketones, carboxylic acids, esters, amines...)
- Reagents for functional group tests (e.g., 2,4-Dinitrophenylhydrazine, Tollens' reagent, Fehling's solution, Bromine water, Ferric chloride solution)

IV. Safety Precautions

- Wear safety goggles, gloves and a lab coat at all times.
- Handle all chemicals with precautions and follow proper waste disposal protocols.
- Work in a well-ventilated area or under a fume hood.

V. Procedure

1. Alcohols (Hydroxyl Group)

Test: Add a few drops of the organic compound into a dry test tube. Add 1–2 mL of a carboxylic acid (e.g., acetic acid) and a few drops of concentrated sulfuric acid (H_2SO_4). Warm the mixture gently in a water bath.

Observation: The appearance of a pleasant fruity smell indicates the formation of an ester, confirming the presence of an alcohol ($-\text{OH}$) group.

2. Aldehydes (Formyl Group)

Test: Add a few drops of the organic compound to a test tube. Add Tollens' reagent and gently warm the mixture.

Observation: The formation of a silver mirror on the inner walls of the test tube indicates the presence of an aldehyde group.

3. Ketones (Carbonyl Group)

Test: Add a few drops of the organic compound to a test tube. Add 2,4-Dinitrophenylhydrazine (2,4-DNP).

Observation: The formation of a yellow or orange precipitate indicates the presence of a ketone group.

4. Carboxylic Acids (Carboxyl Group)

Test: Add a few drops of the organic compound to a test tube. Add a few drops of sodium bicarbonate solution.

Observation: If the reaction gives brisk effervescence of carbon dioxide gas (bubbles) it indicates the presence of a carboxyl group.

5. Esters (Ester Group)

Test: Add a few drops of the organic compound to a test tube. Add a few drops of Ferric chloride solution.

Observation: The formation of a red or violet coloration indicates the presence of an ester group.

6. Amines (Amino Group – Primary aromatic)

Test: Add a few drops of the organic compound to a test tube. Add Bromine water.

Observation: The disappearance of the yellow color of Bromine water indicates the presence of an amine group.

7. Ethers (Alkoxy Group)

Test: Add a few drops of the organic compound to a test tube. Add dilute hydrochloric acid and sodium iodide solution.

Observation: The formation of a precipitate of iodoalkane indicates the presence of ethers.

8. Amides (Carboxamide Group)

Test: Add a few drops of the organic compound to a test tube. Add sodium hydroxide solution and heat gently.

Observation: The evolution of ammonia gas (detected by its characteristic smell) indicates the presence of amides.

9. Nitriles (Cyano Group)

Test: Add a few drops of the organic compound to a test tube. Add dilute sulfuric acid and heat gently.

Observation: The evolution of a characteristic smell of hydrogen cyanide gas indicates the presence of nitriles.

10. Thiols (Sulphydryl Group)

Test: Add a few drops of the organic compound to a test tube. Add sodium nitroprusside solution and then add dilute sodium hydroxide.

Observation: The formation of a purple color indicates the presence of thiols.

11. Alcohol group

Test: In a dry test tube, take 1ml of the given compound. Add a few drops of ceric-ammonium nitrate and shake the solution well.

Observation: If red precipitate occurs, it conforms to the involvement of the alcoholic group.

Reference

Paula Yurkanis Bruice Organic Chemistry Seventh Edition; 2014

Jerry R. Mohrig , David Alberg , Gretchen Hofmeister , Paul F. Schatz , & Christina Noring Hammond Laboratory Techniques in Organic Chemistry Fourth Edition.

Bardez E. *Exercices et Problèmes de Chimie Générale.*; 2009.

Thermometer S. Experimental Organic Chemistry. *Nature*. 1921;107(2704):807-807.
doi:10.1038/107807d0

Ertl P. An algorithm to identify functional groups in organic molecules. *Journal of Cheminformatics*. 2017;9(1):36. doi:10.1186/s13321-017-0225-z

Chimie_analytique des solutions.pdf.

Stephane Caron - Practical Synthetic Organic Chemistry_ Reactions, Principles, and Techniques-John Wiley & Sons Inc (2020)