



PW02: Preparation of aqueous solutions

Objective

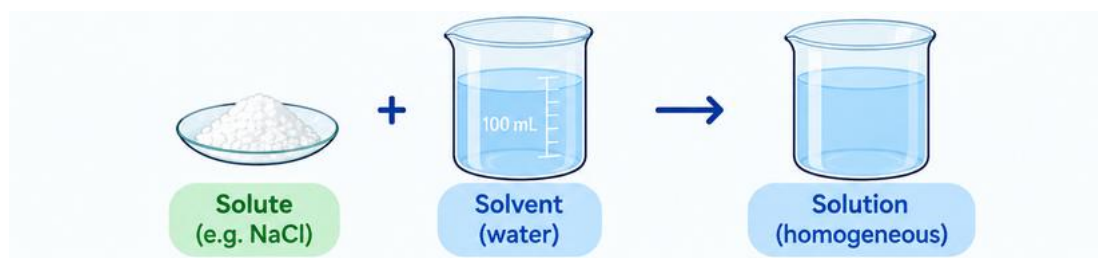
- ✓ Identify the laboratory equipment used to prepare aqueous solutions.
- ✓ Prepare an aqueous solution by dissolving a solid (NaOH).
- ✓ Prepare a diluted solution from a concentrated solution (HCl).

Introduction

Solution: An aqueous solution is a homogeneous mixture obtained by dissolving one or more substances (solutes) in water (the solvent).

Solute: It is the substance that is dissolved by the solvent. It is present in smaller quantity and can be a solid, liquid, or gas.

Solvent: It is the liquid substance capable of dissolving other substances. It is always present in the largest quantity in the solution.



The expression of the solute proportion

The amount of solute in a solution can be expressed in different ways.

✓ Mass concentration (C_m): $C_m = \frac{m_{solute}}{V_{solution}} \left(\frac{g}{l} \right)$

✓ Molar concentration (C): $C = \frac{n_{solute}}{V_{solution}} \left(\frac{mol}{l} \right)$

✓ Molality (M): $M = \frac{n_{solute}}{m_{solvent}} \left(\frac{mol}{kg} \right)$

✓ Normality (N): $N = \frac{n_{eq \cdot g}}{V_{solution}} \left(\frac{eq \cdot g}{l} \right)$ or (N)

Normality can be expressed in terms of molar concentration using the following formula:

$$N = z \cdot C$$

z: Number of equivalents per mole of a substance. Its value depends on the type of chemical reaction.

- ✓ In acid- base reaction, **z** depends on the number of H^+ ions donated by an acid or OH^- ions supplied by a base.
- ✓ In redox reactions, **z** is the number of electrons exchanged per mole of the species.

Substance	Chemical reaction	Reaction type	z
HCl	$HCl \rightarrow H^+ + Cl^-$	Acid-base reaction	1
H ₂ SO ₄	$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$	Acid-base reaction	2
NaOH	$NaOH \rightarrow Na^+ + OH^-$	Acid-base reaction	1
Ca(OH) ₂	$Ca(OH)_2 \rightarrow Ca^{2+} + 2OH^-$	Acid-base reaction	2
Fe ²⁺	$Fe^{2+} \rightarrow Fe^{3+} + e^-$	Redox reaction (oxidation)	1
MnO ₄ ⁻	$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$	Redox reaction (reduction, acidic medium)	5
Cr ₂ O ₇ ²⁻	$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	Redox reaction (reduction, acidic medium)	6

Experimental Part

Materials and chemicals



Preparation of a solution from a solid

This solution is prepared by **dissolving** a mass (m) of solid in water. First, we calculate its mass using the following equation: $m_{\text{solid}} = C_{\text{solution}} \cdot M_{\text{solid}} \cdot V_{\text{solution}}$

Example: Preparation of a 100 ml Sodium hydroxide (NaOH) solution with a concentration of 0.1 mol/l ($M_{\text{NaOH}} = 40 \text{ g/mol}$)

✓ **Preliminary Calculation:** Calculate the required mass of NaOH (m_{NaOH})

$$C = \frac{n}{V} = \frac{m}{M \cdot V} \rightarrow m_{\text{NaOH}} = C_{\text{solution}} \cdot M_{\text{NaOH}} \cdot V_{\text{solution}}$$

$$m_{\text{NaOH}} = 0.1 \times 40 \times 0.1 = 0.4 \text{ g}$$

✓ **Experimental procedure:**

- 1- Weigh 0.4 g of NaOH.
- 2- Transfer the 0.4 g of NaOH into a clean 100 mL volumetric flask using a funnel.
- 3- Fill the flask two-thirds full with distilled water and stir until the NaOH is completely dissolved.
- 4- Add distilled water up to the calibration mark of the volumetric flask.
- 5- Stopper the flask and mix thoroughly to obtain a homogeneous NaOH solution.



Preparation of a solution from solid (Dissolution)

Preparation of a solution from a liquid

This solution is prepared by **diluting** a concentrated solution with water. First, we calculate the required volume of the concentrated solution using the following dilution equation

$$C_c \cdot V_c = C_d \cdot V_d \Rightarrow V_c = \frac{C_d \cdot V_d}{C_c}$$

Example: Preparation of a 100 ml hydrochloric acid (HCl) solution with a concentration of 0.1 mol/l from concentrated commercial HCl solution with the density **d** is 1.18, the purity rate **p** is 37%, and the molar mass **M** is 36.5 g/mol.

✓ Preliminary Calculation:

Calculate the concentration of the concentrated HCl (C_c)

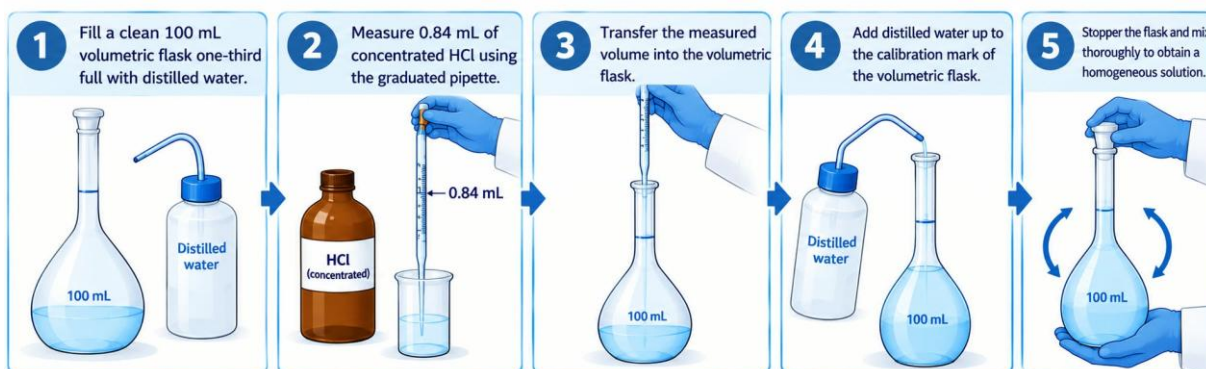
We have
$$C_c = \frac{10 \cdot p \cdot d}{M} = \frac{10 \cdot 37 \cdot 1.18}{36.5} \rightarrow C_c = 11.96 \text{ mol/l}$$

Calculate the required volume of the concentrated HCl (V_c)

We have
$$V_c = \frac{C_d \cdot V_d}{C_c} = \frac{0.1 \cdot 100}{11.96} \rightarrow V_c = 0.84 \text{ ml}$$

✓ Experimental procedure:

- 1- Fill a clean 100 mL volumetric flask one-third full with distilled water.
- 2- Measure 0.84 mL of concentrated HCl using the graduated pipette.
- 3- Transfer the measured volume into the volumetric flask.
- 4- Add distilled water up to the calibration mark of the volumetric flask.
- 5- Stopper the flask and mix thoroughly to obtain a homogeneous solution.



Preparation of a solution from a liquid (diluting)

