

# Practical Work Chemistry II

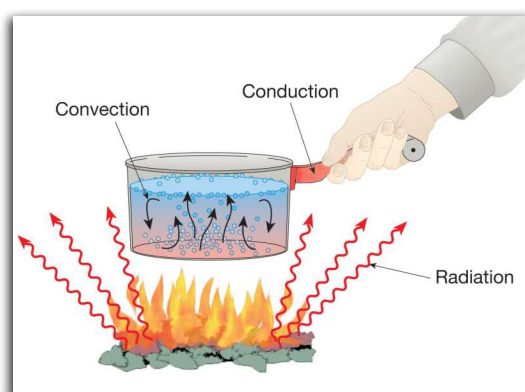
Dr. ZAKARYA ZEBIRI

Department of Chemistry

Faculty of Exact Sciences

University of Constantine 1-Mentouri Brothers

2.0 08/2026



# Table of contents

|                                                                  |           |
|------------------------------------------------------------------|-----------|
| <b>Objectives</b>                                                | <b>3</b>  |
| <b>Introduction</b>                                              | <b>4</b>  |
| <b>I - Practical N°3: Specific Heat Capacity of Liquids (Cp)</b> | <b>5</b>  |
| 1. Objectives .....                                              | 5         |
| 2. Theoretical Section .....                                     | 5         |
| 3. Experimental Part.....                                        | 6         |
| 3.1. Materials and Reagents Used .....                           | 6         |
| 3.2. Procedure .....                                             | 6         |
| 4. Results and Data Analysis.....                                | 8         |
| 5. Exercise .....                                                | 8         |
| 6. Quiz.....                                                     | 8         |
| <b>Bibliography</b>                                              | <b>9</b>  |
| <b>Web bibliography</b>                                          | <b>10</b> |

# Objectives

---



This lab is intended for first-year undergraduate students in science and technology. At the end of this course, the learner will be able to:

## **In terms of knowledge:**

- Become familiar with laboratory equipment.
- Know how to carry out a series of measurements in an organized and rigorous manner.
- Know how to use the information provided in various materials to write literal and numerical expressions, as well as equations modeling the situations proposed in the problems.

## **In terms of practical skills:**

- Know how to use the calorimeter and the different laboratory equipment to measure the various parameters required in the problem.
- Know how to perform calculations to determine different parameters (heat capacities, specific heat capacity, concentration, pH, etc.).
- Write reports with rigor and clarity.

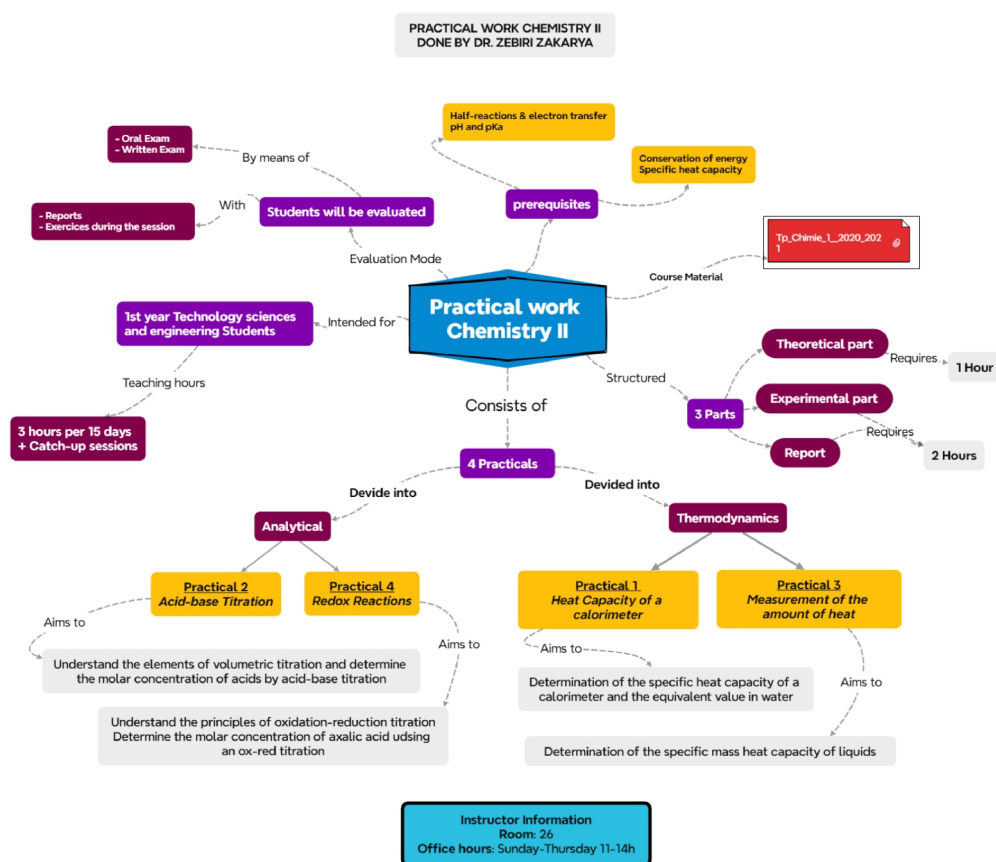
## **In terms of attitudes (professional behavior):**

- Develop awareness of the two fundamental principles of calorimetry: the principle of equality of heat exchange (what is lost by one system is gained by another) and the principle of reverse transformations.
- Develop awareness of the principles of acid–base colorimetric titration and redox titration.

# Introduction



This module introduces key experimental techniques in thermochemistry and analytical chemistry through calorimetry and acid–base titration. It covers the determination of a calorimeter’s specific heat capacity, highlighting heat transfer and energy conservation principles. It also develops skills in quantitative analysis via titration, focusing on neutralization, equivalence points, and accurate measurement.



Presented with xmind

*Mind map.*

# Practical N°3: Specific Heat Capacity of Liquids ( $C_p$ )



## 1. Introduction

The power dissipated by an electrical resistor with resistance  $R$ , through which a current  $I$  flows under a potential difference  $U$ , is expressed by Equation (1).  $P = I^2 \times R = I \times U$  (1)

This phenomenon, commonly referred to as the **Joule effect**, involves the conversion of electrical energy into thermal energy. In this experiment, the heat produced is used to determine the **specific heat capacity** of a liquid, specifically water.

## 2. Objectives

By the end of this practical session, students will be able to:

- Determine the **water equivalent** of the calorimeter ( $\mu$ ).
- Experimentally determine the **specific heat capacity of water** ( $C_p$ )

## 3. Theoretical Section



### Definition

Water Equivalent of the Calorimeter (or Water Equivalent Mass),  $\mu$

The **water equivalent** (or **water equivalent mass**) of a calorimeter, denoted by  $\mu$ , is the mass of water that absorbs the same amount of heat as the calorimeter and its accessories (thermometer, stirrer, etc.) when subjected to the same temperature change.

- $C_{cal}$ : Heat capacity of the calorimeter.
- $C_p$ : Specific heat capacity of water,

$$C_p = 4.180 \text{ J g}^{-1} \text{ K}^{-1} \text{ (equivalent to } 1 \text{ cal g}^{-1} \text{ K}^{-1}\text{)}.$$

The definition of **specific heat capacity** ( $C_p$ ) was introduced in the previous practical session.



### Fundamental

#### • Determination of the Water Equivalent ( $\mu$ ) by the Mixing Method

The water equivalent ( $\mu$ ) of the calorimeter is determined by mixing two known masses of water,  $m_1$  and  $m_2$ , initially at two different known temperatures,  $T_1$  and  $T_2$ , inside the calorimeter. After thermal equilibrium is reached, the final equilibrium temperature,  $T_f$  is measured and used to calculate the water equivalent of the calorimeter.

#### • Determination of the Specific Heat Capacity of a Liquid by the Electrical Method

When an electrical resistor of resistance  $R$  is subjected to a potential difference  $U$  and carries an electric current  $I$ , the electrical power dissipated by the resistor is given by Equation (1).

Since power is the rate at which energy is transferred, if the electrical power remains constant, the electrical energy, **E<sub>elec</sub>**, supplied during a time interval **t** is given by Equation (2).  $E_{elect} = P \times t$  (2)

This electrical energy is converted into heat through the **Joule effect** and is used to determine the specific heat capacity of the liquid.

By substituting Equation (1) into Equation (2), we obtain Equation (3).  $E_{elect} = U \times R \times t$

When an electrical resistor absorbs electrical energy, it converts this energy into heat. If the resistor is immersed in a calorimeter containing a mass **m<sub>liq</sub>** of a liquid, the heat generated increases the temperature of the calorimeter–liquid system by an amount  $\Delta T$ . Assuming that heat losses to the surroundings are negligible, the energy balance is expressed by Equation (4).  $U \times I \times t = (m_{liq} + \mu) \times C_{liq} \times \Delta T$  (4)

Therefore, by knowing the water equivalent of the calorimeter, **μ**, and the mass of the liquid **m<sub>liq</sub>**, the specific heat capacity of the liquid, **C<sub>liq</sub>** can be determined from the temperature–time curve, **T=f(t)**.

$$\frac{U \times I}{(m_{liq} + \mu) \times C_{liq}} (5)$$

## 4. Experimental Part

### 4.1. Materials and Reagents Used

#### Equipment

- Calorimeter
- Thermometer
- 50 mL and 200 mL graduated cylinders
- Water bath maintained at **65 °C**
- Stopwatch
- Beaker
- Ohmmeter
- Voltmeter
- Electrical resistor (heating element)
- DC power supply (generator)

#### Reagent

- Distilled water

### 4.2. Procedure

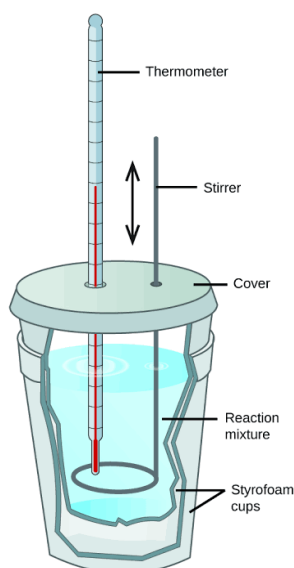
#### Part 1: Determination of the Water Equivalent (**μ**)

- Pour approximately 50 mL of water at room temperature into the calorimeter.
- Record the initial temperature **T<sub>1</sub>** once it has stabilized.
- Quickly add approximately 50 mL of hot water from the thermostatically controlled water bath maintained at 50 °C. Measure its temperature **T<sub>2</sub>** immediately before mixing.
- Close the calorimeter, stir the mixture thoroughly, and record the final equilibrium temperature **T<sub>f</sub>**.

#### Part 2: Determination of the Specific Heat Capacity of Water (**C<sub>p</sub>**)

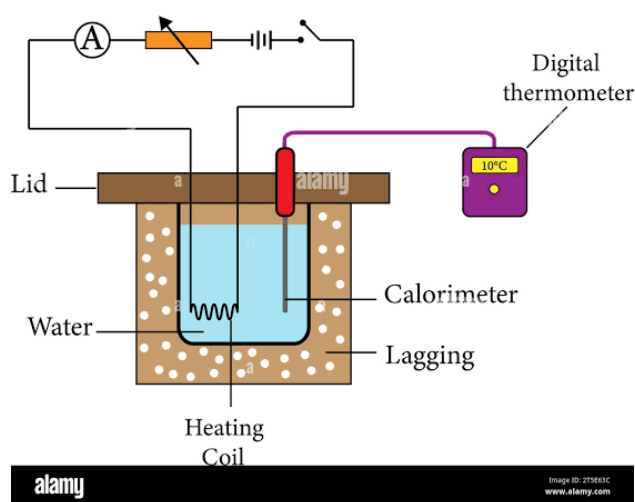
- Connect the electrical resistor to the power supply. Connect the ammeter in series with the resistor and the voltmeter in parallel across it.
- Pour approximately 150 mL of water at room temperature into the calorimeter.

- Monitor the temperature of the system for 3 minutes, recording the temperature every 1 minute. The temperature measured at the end of the third minute is taken as the initial temperature  $T_0$ .
- After the third minute, switch on the power supply to allow a constant current ( $I$ ) to flow through the resistor. The resistor will heat the water by the Joule effect.
- Record the water temperature every 30 seconds for 20 minutes.
- During the heating period, record the voltage ( $U$ ) across the resistor and the current ( $I$ ) displayed by the measuring instruments.
- After 20 minutes, switch off the power supply.
- Record all experimental measurements in an appropriate data table.



Calorimeter diagram

## Joule's Law



Device used to determine the specific heat capacity of liquids.

## 5. Results and Data Analysis

### Part 1: Determination of the Water Equivalent ( $\mu$ )

1. Write the expressions for the amounts of heat exchanged in the calorimeter.
2. Show that the expression for the water equivalent  $\mu$  is given by Equation  $\mu = m_2 \left( \frac{T_2 - T_e}{T_e - T_1} \right) - m_1$ .
3. Calculate the water equivalent of the calorimeter  $\mu$ .

### Part 2: Determination of the Specific Heat Capacity of Water (cpc\_pcp)

1. Plot the graph showing the variation of temperature with time,  $T=f(t)$ .
2. Using the energy balance, derive the theoretical expression for the specific heat capacity  $C_p$  as a function of the slope  $a$ , the mass of water  $m$ , the water equivalent of the calorimeter  $\mu$ , the voltage  $U$ , and the current  $I$ .
3. Determine the experimental value of the specific heat capacity of water  $C_p$  using the experimental data.
4. Compare the experimental value with the theoretical value. What conclusions can you draw regarding the accuracy of the experiment and the possible sources of error?

## 6. Exercise

A calorimeter contains a mass of water  $m_1 = 250 \text{ g}$ . The initial temperature of the system is  $T_1 = 18^\circ\text{C}$ . A mass of water  $m_2 = 300 \text{ g}$  at a temperature of  $80^\circ\text{C}$  is added. What would be the thermal equilibrium temperature,  $\theta_{eq}$ , of the system if the heat capacity of the calorimeter and its accessories were negligible?

## 7. Quiz

To experimentally determine the specific heat capacity of water, an electrical method is used. An electrical                      (also called a resistor) is placed inside a calorimeter containing a known                      of water. An electric current is passed through this resistor for a measured                     . the electrical energy is then converted into                      by the Joule effect. By measuring the                      change of the water, its specific heat capacity can be calculated using the relation                     .

# Bibliography

---



[4] 10.5772/intechopen.94666

## Web bibliography

---



[1] [https://uel.unisciel.fr/chimie/chimther/chimther\\_ch02/co/apprendre\\_ch2\\_02.html](https://uel.unisciel.fr/chimie/chimther/chimther_ch02/co/apprendre_ch2_02.html)

[2] <https://www.vedantu.com/chemistry/titration-of-oxalic-acid-with-kmno4>

[3]  
[https://chem.libretexts.org/Bookshelves/General\\_Chemistry/Chemistry\\_2e\\_\(OpenStax\)/05%3A\\_Thermochemistry/5.02%](https://chem.libretexts.org/Bookshelves/General_Chemistry/Chemistry_2e_(OpenStax)/05%3A_Thermochemistry/5.02%3A_Enthalpy)