

Laboratory Calorimetry

OBJECTIVE

To calculate the enthalpy of solution of sodium thiosulfate pentahydrate



You will be measuring the change of temperature of a solution in which the reaction above occurs.

This change of temperature is generated by the heat of the salt dissolving in water.

The energy absorbed (or released) by the solution (measured) is the one from the reaction (to determine).

Energy is never lost. According to the first law of thermodynamic: ENERGY IS CONSERVED.

$$Q_{\text{solution}} + Q_{\text{reaction}} = 0 \quad (0 = \text{no heat lost!})$$

Both "Q" are equal but opposite ($Q < 0$ = exothermic or heat lost, $Q > 0$ endothermic or heat absorbed). If you record the temperature change, then you can calculate the heat of reaction Q_{reaction} .

General equation of calorimetry:

$$Q = m \cdot c_p \cdot \Delta T$$

where:

Q: heat in joule (released or absorbed) at constant pressure

m: mass of the component that absorbs the energy (here the solution)

c_p : specific heat capacity of the component at constant pressure, c_p , water = 4.184 J/(g °C)

ΔT : temperature change ($\Delta T = T_{\text{final}} - T_{\text{initial}}$)

You will measure the heat change of the solution. This change is generated by the heat of solution of the salt (heat of the reaction).

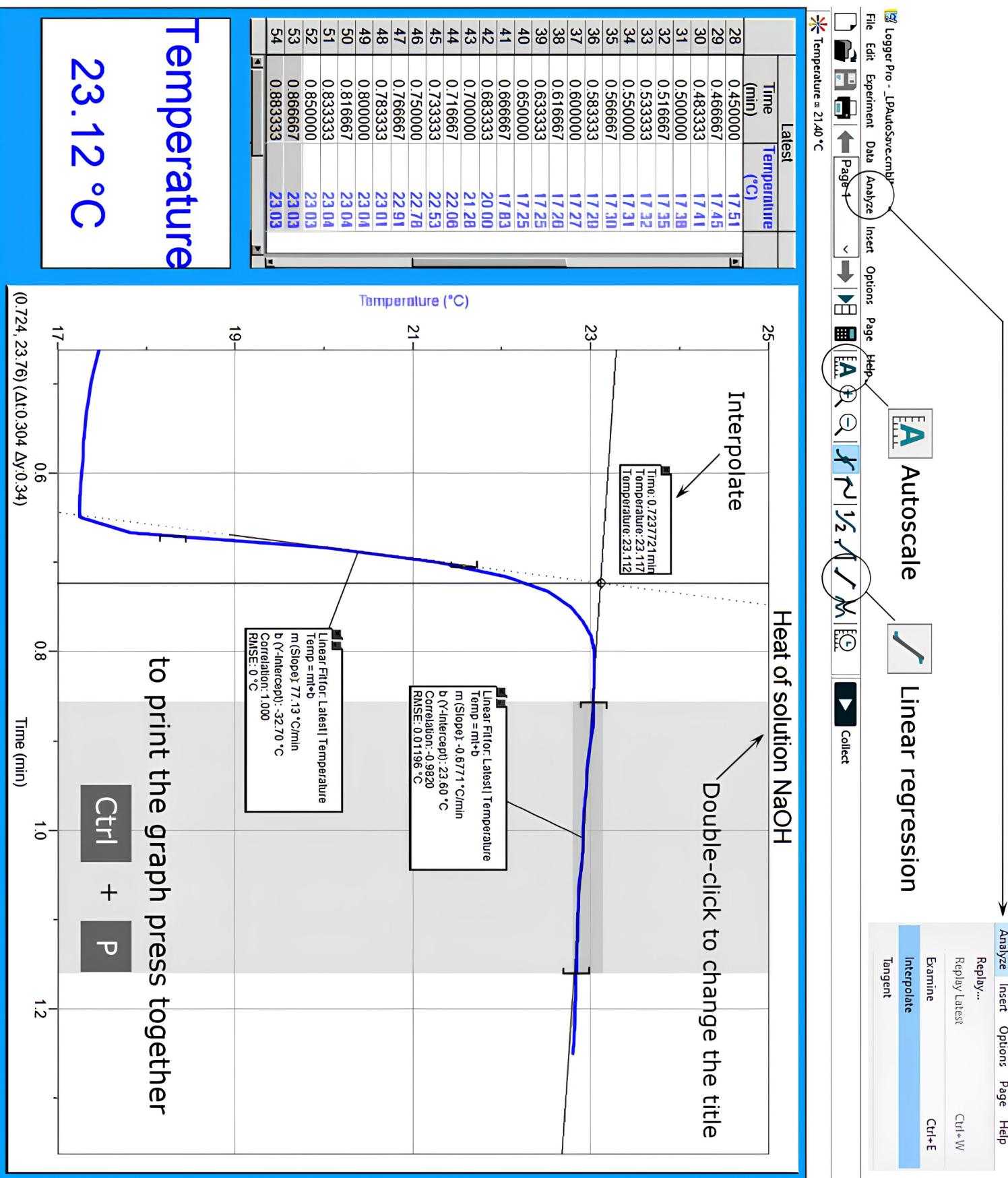
PROCEDURE

Start the computer and run the Logger-pro software. Open the file: "**Bond & matters: 8-Calorimetry**"

- 1- Use a graduated cylinder to pour 50.0 mL of distilled water in the calorimeter. Place in the calorimeter the temperature probe, the stirrer and the cover. Do not collect the temperature yet.
- 2- Use a weighing dish to weigh 5 g of sodium thiosulfate pentahydrate ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$). Weigh the chemical just before its addition to the cup since $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ absorbs humidity from the atmosphere, causing the reaction to start without being in the solution (therefore, %error).
- 3- When you are ready to perform the experiment, **start the temperature acquisition**. This is your initial temperature. Then rapidly add the salt to the calorimeter. Close the lid and stir the solution continuously with the stirrer while recording the temperature.

The recording is completed when a constant temperature is obtained (less than 5 min). The recording will automatically stop after 10 min.

- 4- From the table of data (computer left column), record the initial temperature or room temperature.
- 5- By doing the graph analysis, (linear fit + interpolate) find the maximum (or minimum) temperature of the reaction.
- 6- Print the graph with a proper title and name using the same procedure as performed last week.



Name:

first (print)

family (print)

date

Enthalpy of solution : Table of data and results

DATA (must be filled in ink)

Mass of $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ (recorded ± 0.0001 g) $m =$ _____ g

Volume of water (recorded ± 0.1 mL) $V =$ _____ mL

Initial temperature of the solution (before reaction) $T_{\text{initial}} =$ _____ $^{\circ}\text{C}$

Final temperature of the reaction (after reaction) $T_{\text{final}} =$ _____ $^{\circ}\text{C}$

Results (calculations can be completed in pencil)

Mass of water used ($\rho_{\text{water}} = 0.998$ g/mL) $m =$ _____ g

Total mass of the solution ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ + water) $m_{\text{sol}} =$ _____ g

Temperature change of the solution ($\Delta T_{\text{sol}} = T_{\text{final}} - T_{\text{initial}}$) $\Delta T_{\text{sol}} =$ _____ $^{\circ}\text{C}$

Heat absorbed / lost by the solution ($Q_{\text{sol}} = m_{\text{sol}} c_p \Delta T_{\text{sol}}$) $Q_{\text{sol}} =$ _____ J

Heat of solution of the reaction ($Q_{\text{reaction}} = -Q_{\text{sol}}$) $Q_{\text{reaction}} =$ _____ J

Mole of $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ used (mol.mass: 248.19 g/mol) $n =$ _____ mol

Molar enthalpy of solution of $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ $\Delta\bar{H} = Q/\text{mol} =$ _____ **kJ/mol**

%error = _____ %

Note: Never round off your numbers throughout a calculation, always keep the maximum number available. Round-off only the final answer.

Sample calculations

Total heat absorbed / released by the solution ($Q_{\text{sol}} = m c_p \Delta T$):

(1 mark)

Enthalpy of solution of $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ ($\bar{\Delta H}_{\text{sol}} = Q_{\text{sol}} / n$):

(1 mark)

$$\% \text{error} = \frac{|\text{value obtained} - \text{value literature}|}{\text{value literature}} \times 100\%$$

(1 mark)

(note: for $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$: $\bar{\Delta H}_{\text{sol}} = 48.8 \text{ kJ/mol.}$).

Post-lab questions

a. If your thermometer was uncalibrated and constantly giving a value 3 °C higher than the real one, what will be the impact on the ΔH obtained in the lab vs. ΔH literature? (Circle one) 1 mark

i) ΔH_{Lab} will be more positive ii) ΔH_{Lab} will be more negative iii) no change

b. If you weigh your chemical and wait 1 hour before starting the reaction, what will be the impact on the ΔH obtained in the laboratory compared to the ΔH in the literature?? (Circle one) 1 mark

i) ΔH_{Lab} will be more positive ii) ΔH_{Lab} will be more negative iii) no change