MANIPULATION N°05

The Heat capacity (Specific Heat)

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1 - ***Introduction*** :

The specific heat capacity at constant pressure is the quantity of energy that must be supplied to one kilogram of the body in consideration to raise its temperature by one degree K (or °C), while keeping its pressure constant.

The unit in the international system is the joule per kilogram kelvin, $J·kg^{-1}·K^{-1}$ The determination of the heat capacities of substances is known as calorimetry.

***Note**: molar heat capacities are also defined (values related to the unit of matter, i.e. 1 mole; a distinction should be made between capacities at constant volume and capacities at constant pressure (the difference being particularly important for gases).*

- *The specific heat capacity of different substances: (at constant pressure)*

Substance	Phase	Spicific ()heat $J·kg^{-1}·K^{-1}$
Air (dry)	Gas	1005
Aluminium	Solid	897
Copper	Solid	385
Iron	Solid	444
Gold	Solid	129
Water	Gas	1850
Water	liquid	4180
Water	Solid (0 °C)	2060
Ethanol	liquid	2460
Butanol	liquid	2650
Nitrogen	Gas	1042
Helium	Gas	5190
Hydrogen	Gas	14300
Oxygen	Gas	920

- *The calorific capacity of a calorimeter is generally very low, of the order of a few tens of Joules. It is an experimental quantity which can be determined from measurements and calculations of the type described in the paragraph " Examples of calorimetric calculations, Calculation of the final temperature of a system when 2 miscible liquids are mixed ".*
- *The quantity of heat exchanged **dQ** for a variation in temperature **dT** of a body is proportional to the mass **m** of the body and its mass heat **c**. (**δQ = m.c.dT**)*

2- ***Objective of the work*** :

***1 -** Determine the calorific capacity of the calorimeter.*
***2-** Determining the specific heat of some elements.*

3- *Partie Expérimentale* :

1- Determining the calorific capacity of the calorimeter (C_{Cal}) :

a) *Introduce a mass* m_1 **=50 g** *of distilled water at* **room temperature** *into the calorimeter. Note the equilibrium temperature* T_1 *(Water + Calorimeter).*

b) *Add* m_2**=50 g** *of warm water at temperature* T_2 *(25°C <* T_2*< 40°C). Note* T_2

c) *Record the new temperature (*$T_f = T_{eq}$*) (minimum temperature reached in the calorimeter) (Water at* **T***emperature* T_1 *+* **Cal***orimeter + Water at* **T***emperature* T_2*).*

d) *Determine (***C***) the Calorific Capacity of a Calorimeter knowing that :*

- *the quantity of heat* Q_2 ***ceded*** *by the hot water is* $Q_2 = m_2\, c_{eau}\, (T_f - T_2)$.
- *the quantity of heat* Q_{cal} ***received*** *by the calorimeter +* Q_1 ***received*** *by the cold water.*

$$Q_{cal} + Q_1 = \mu\, c_{al}\, (T_f - T_1) + m_1\, c_{eau}\, (T_f - T_1) = (\mu + m_1)\, c_{eau}\, (T_f - T_1).$$

- *And the isolated system can be written as:* **(ΣQi =0)** $\Rightarrow$ $Q_1 + Q_{cal} + Q_2 = 0$

C_{cal} the calorific capacity of the calorimeter in Joule per Kelvin ($J.K^{-1}$).
*c_e : the specific or mass heat of liquid water, equal to **4180** $J.\ K^{-1}.Kg^{-1}$.*
*μ : the water equivalent mass of the calorimeter in **kilograms** (kg).*

2- Determining the specific heat of some elements:

We have a group of substances (elements) that we want to ***identify*** *by calculating their* ***specific heat*** *(mass).*

a) *We take the previous calorimeter whose* ***calorific capacity*** *we have calculated and we place* ***50 ml*** *of* ***distilled water*** *at a temperature (*T_1*) in each experiment.*

b) *Each time we put a mass (*m_2*) of the substance to be identified into the calorimeter at the same initial temperature (*T_2*).*

The following table summarises the experiments carried out:

Sample	m_1 g	m_2 g	T_1 °C	T_2 °C	T_f °C	c_e $J\cdot kg^{-1}\cdot K^{-1}$	C_{Cal} $J\cdot K^{-1}$	$c_{element}$	Element (substance)
1	0.05	0.05	61	19		4180			
2	0.05	0.05	61	19		4180			
3	0.05	0.05	61	19		4180			
4	0.05	0.05	61	19		4180			
5	0.05	0.05	61	19		4180			
6	0.05	0.05	61	19		4180			

c) *Find the* ***relationship*** *that enables the specific heat to be calculated.*

d) *For each sample, calculate the* ***specific heat*** *and* ***identify the type*** *(nature) of substance.*