MANIPULATION N°02

The Latent Heat of Fusion of the ice

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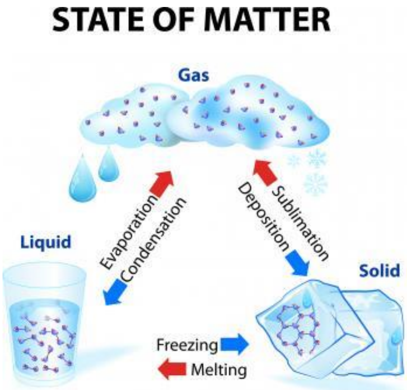
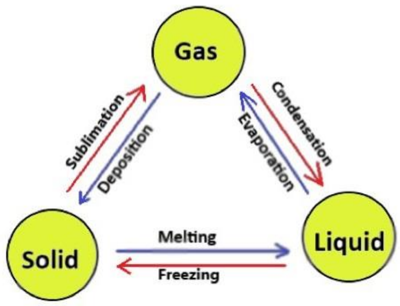
1 - *Introduction* :

*A given pure substance can exist in 4 states: **solid**, **liquid**, **gas** and **plasma**. The change of physical state requires an exchange of heat (energy) with the external environment.*





A physical change is produced when there is no transformation of matter, for example, liquid water that evaporates always remains water, H_2O.

But this physical change is accompanied by the release or absorption of heat, depending on the case. Melting ice, for example, is a physical phenomenon that absorbs heat.

$$H_2O\ (s) + 6{,}03\ kj \text{ ----------> } H_2O\ (l)$$

All chemical reactions release or absorb heat.
For example, burning paraffin is a chemical phenomenon that releases (give off) heat.

$$C_{25}H_{52}\ (s) + 38\ O_2\ (g) \text{ ----------> } 25\ CO_2\ (g) + 26\ H_2O\ (g) + 15200\ kJ$$

The energy involved in a chemical reaction is much greater than that found in physical transformations.

2- *Objective of the work* :

1 - Study of change of state phenomenon.
2- Determination of the calorific capacity of the calorimeter (C_{cal}).
3- Determination of the latent heat of fusion of the ice (L_f).

3- Theoretical part :

3-1 . Definition of latent heat : :

*At constant pressure, once a pure substance (such as water) has reached its change-of-state temperature, it needs an additional quantity of energy to change state: this is the **mass energy of change of state**, also called the « **latent heat of change of state** », noted **L**. It is measured by the variation in thermal energy **Q**, such as :*

$$Q = m \cdot L \qquad m\text{: the mass in Kg.}$$

3-2 . Principle of measuring L ::

A piece of ice at $T_2 = 0°C$ (taken from a melting water-ice mixture), of known mass m_2 is plunged into a calorimeter containing a mass of water m_1 of temperature T_1. The mixture is stirred until the ice cube has completely melted. The equilibrium temperature T_f is recorded.

We then have :

$$\Sigma Q = 0 \quad \text{(Isolated calorimeter)} \quad \Rightarrow \quad Q_{Eau} + Q_{cal} + Q_{Glace} + Q_{fus} = 0.$$

$$m_1 \cdot c_e \cdot (T_f - T_1) + C_{cal} \cdot (T_f - T_1) + m_2 \cdot c_e \cdot (T_f - T_2) + m_2 L_f = 0.$$

C_{cal} : the calorific capacity of the calorimeter in Joule per Kelvin ($J.K^{-1}$).
m_1 : mass of water in kilograms (kg).
m_2 : mass of ice in kilograms (kg).
c_e : the specific heat or heat mass of liquid water, equal to 4180 $J.\ K^{-1}.Kg^{-1}$.
L_f : latent heat of fusion in Joule per Kilogram ($J.Kg^{-1}$).

The purpose here is to determine the value of the latent heat of fusion of water L_f.

4- Experimental part :

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 Temperature T_1 + Calorimeter + Water at Temperature 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: **($\Sigma Qi = 0$)** $\Rightarrow$ $Q_1 + Q_{cal} + Q_2 = 0$*

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).

1 - Determining the latent heat of fusion of the ice (L_f).

a) *Place a mass m_1 = 50g of hot water ($T = 70°C$) in the calorimeter. Note T_1.*

b) *Prepare 3 or 4 ice cubes of precise mass* $\mathbf{m_2}$ *(*$\mathbf{T_2 = 0°C}$*), then immerse them quickly in the water in the calorimeter.*

c) *Read the temperature* $\mathbf{T_f}$ *at thermal equilibrium: the ice should be completely melted and the temperature should not vary much.*

d) *Determine the latent heat of fusion of the ice* $\mathbf{L_f}$ *given that :*

- *La quantité de chaleur* $\mathbf{Q_{Eau}}$ ***cédée*** *par l'eau chaude.*
- *La quantité de chaleur* $\mathbf{Q_{Cal}}$ ***cédée*** *par le calorimètre.*
- *La quantité de chaleur* $\mathbf{Q_{fus}}$ *nécessaire pour faire fondre la glace.*
- *La quantité de chaleur* $\mathbf{Q_{liq}}$ ***reçue*** *par l'eau a (*$\mathbf{T_2 = 0\ °C}$*), nécessaire pour l'élever à la température* $\mathbf{T_f}$*.*
- *The quantity of heat* $\mathbf{Q_{water}}$ ***ceded*** *by the hot water.*
- *The quantity of heat* $\mathbf{Q_{Cal}}$ ***ceded*** *by the calorimeter.*
- *The quantity of heat* $\mathbf{Q_{fus}}$ *required to* ***melt*** *the ice.*
- *The quantity of heat* $\mathbf{Q_{liq}}$ ***received*** *by water a (*$\mathbf{T_2 = 0°C}$*), needed to raise it to temperature* $\mathbf{T_f}$**.**

*c_e : la chaleur spécifique ou massique de l'eau liquide, soit **4180** J. $K^{-1}.Kg^{-1}$.*

TP 02 Report (Latent heat)