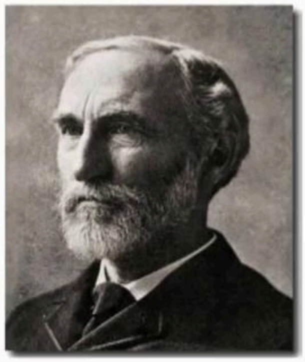
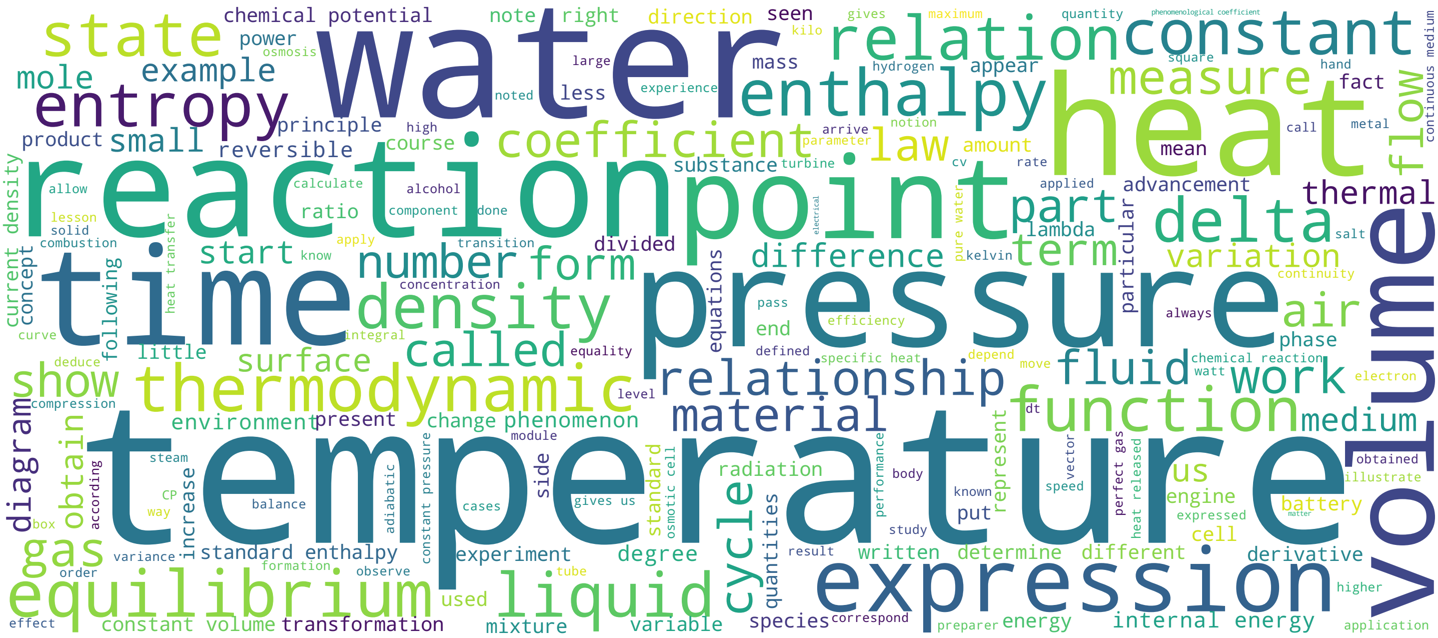
Thermodynamique

Expériences : Thermochimie

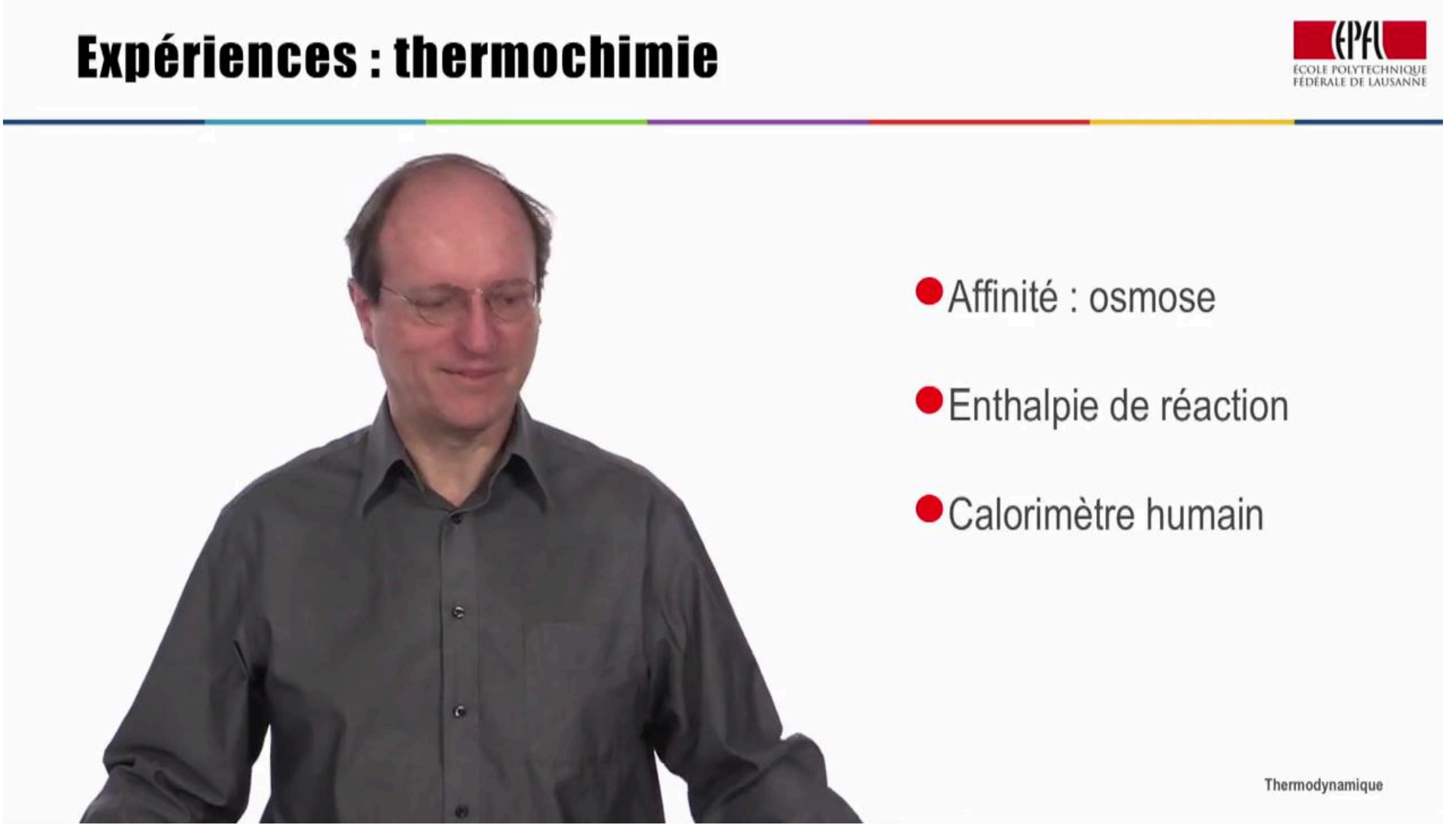


Josiah Willard Gibbs, 1839-1903

Prof. Jean-Philippe Ansermet



Video

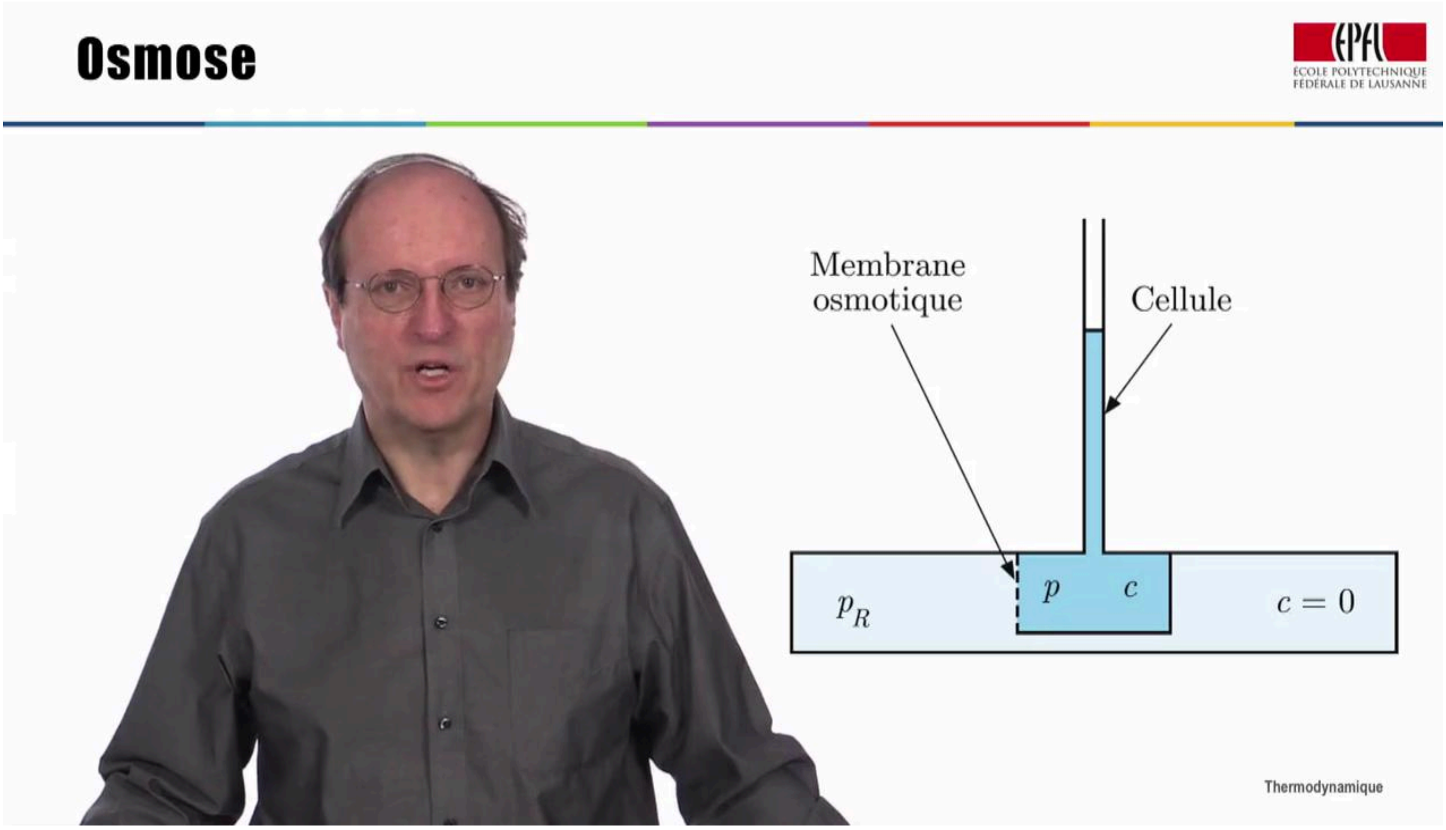


Here I am again to present you some experiences in this lesson. Théophile M'Bengue gave you some applications, from thermodynamics to chemistry. Here. I would like to show you the phenomenon of osmosis. Which I consider as a very beautiful illustration of the notion of affinity. Next, I would like to show you a measure which will make concrete the notion of enthalpy of reaction. Finally, I show you a small but modest experiment that seeks to analyze the thermal behavior of a human being in a box. Need a calorimeter?

Notes

Summary

0m 04s

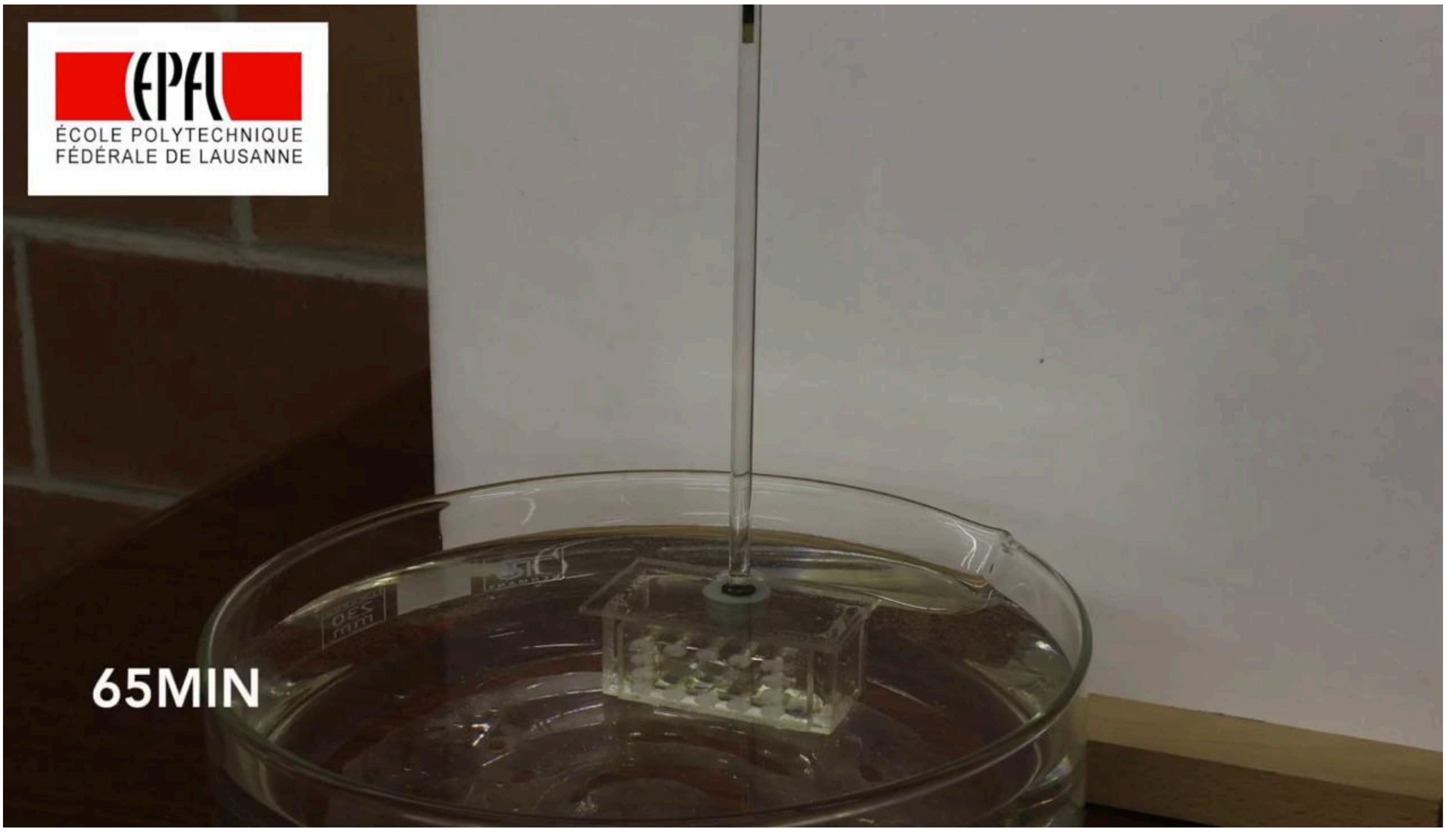


Let's start with osmosis. The phenomenon of osmosis takes place in the following situation you have a so-called osmotic cell which contains a salty solution. Noteworthy. This is the concentration of salt in water. This cell is immersed in pure water. So in the basin, we have, it's equal, zero. Between the pelvis and the osmotic cell, there is a membrane that has a particular property. It lets water through, but not salt ions. We're going to settle down, we're going to see what's going on and we will ask ourselves what the level is. Water in the tube above the osmotic cell.

Notes

Summary

0m 51s

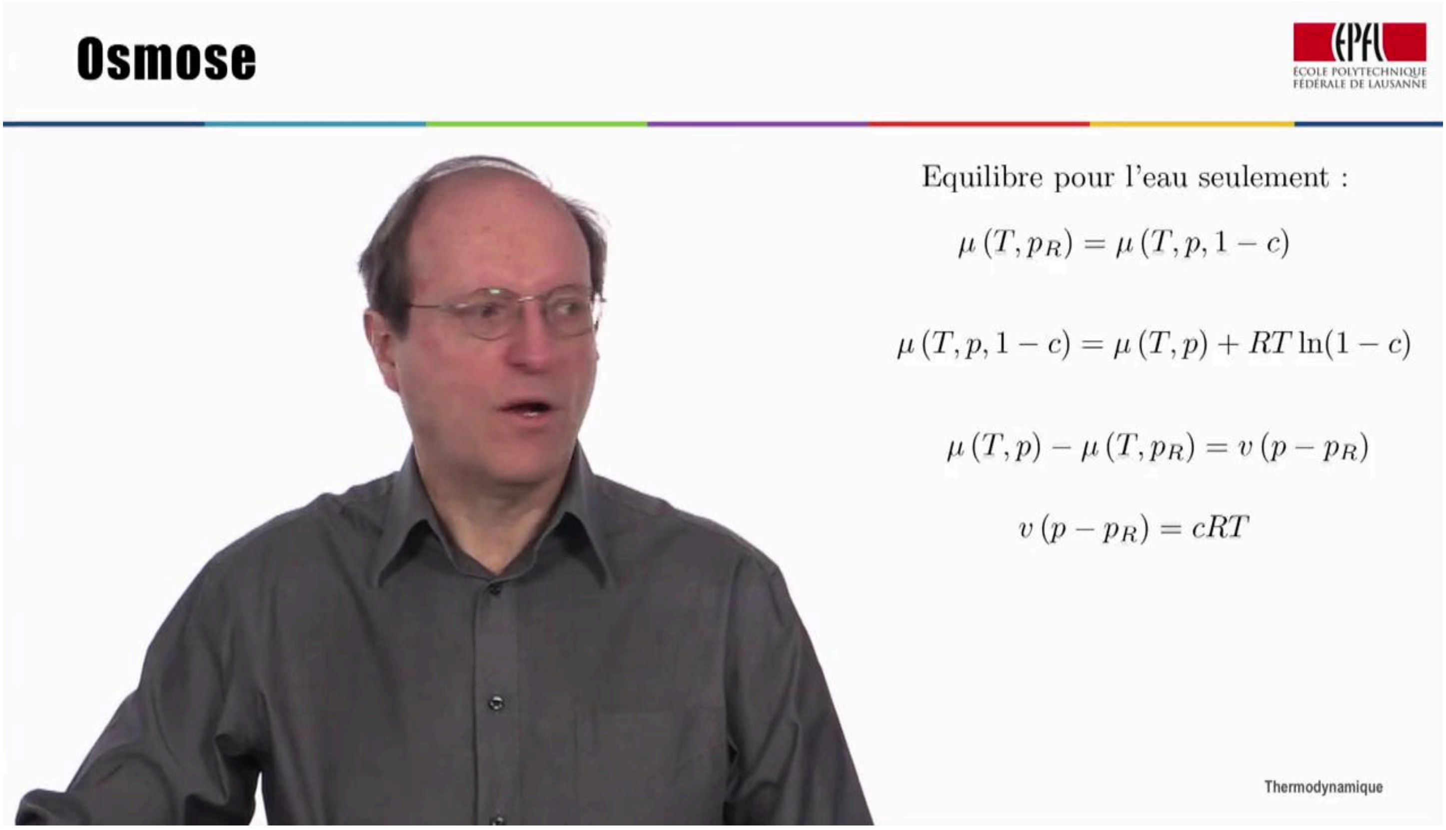


At equilibrium, this is the pure water basin and on the right, you have the osmotic membrane filled with salt water and which in this moment soak in a salt water bath as well. The preparer puts the cell in pure water. He put. In the tube. A black marker that will allow us to see better. That the water level in the cell rises. Like this.

Notes

Summary

1m 52s



What is the condition that describes the equilibrium of this system? Here we have. Only water is the substance chemical that can pass from one side of the membrane to the other. Therefore, the condition of chemical equilibrium. One is necessary, that is the condition of equality of chemical potentials. Be careful with the notation here mue is the chemical potential of water. If I indicate the variables T, the temperature is PR. Here it is the pressure of the tank, therefore of the water basin, therefore the atmospheric pressure. This means that I am talking about the potential of pure water to the right of this equality. I have a chemical potential that depends on temperature, pressure P in the cell and then the concentration of water in the solution which is a c. It can be shown that for an ideal mixture, the chemical potential. Of one of the substances, of a mixture. Follows the following law where we have the term rt log of the concentration that appears. Pros. A pure substance. The chemical potential may depend on the pressure. And for an incompressible liquid like water, we have the following law. And the equilibrium condition gives us the following result.

Notes

Summary

2m 38s

Osmose

Equilibre pour l'eau seulement :

$$\mu(T, p_R) = \mu(T, p, 1-c)$$

$$\mu(T, p, 1-c) = \mu(T, p) + RT\ln(1-c)$$

$$\mu(T, p) - \mu(T, p_R) = v\,(p - p_R)$$

$$v\,(p - p_R) = cRT$$

$$\frac{V}{N_{eau}}(p - p_R) \simeq \frac{N_{sel}}{N_{eau}}RT$$

$$(p - p_R)V \simeq N_{sel}RT$$

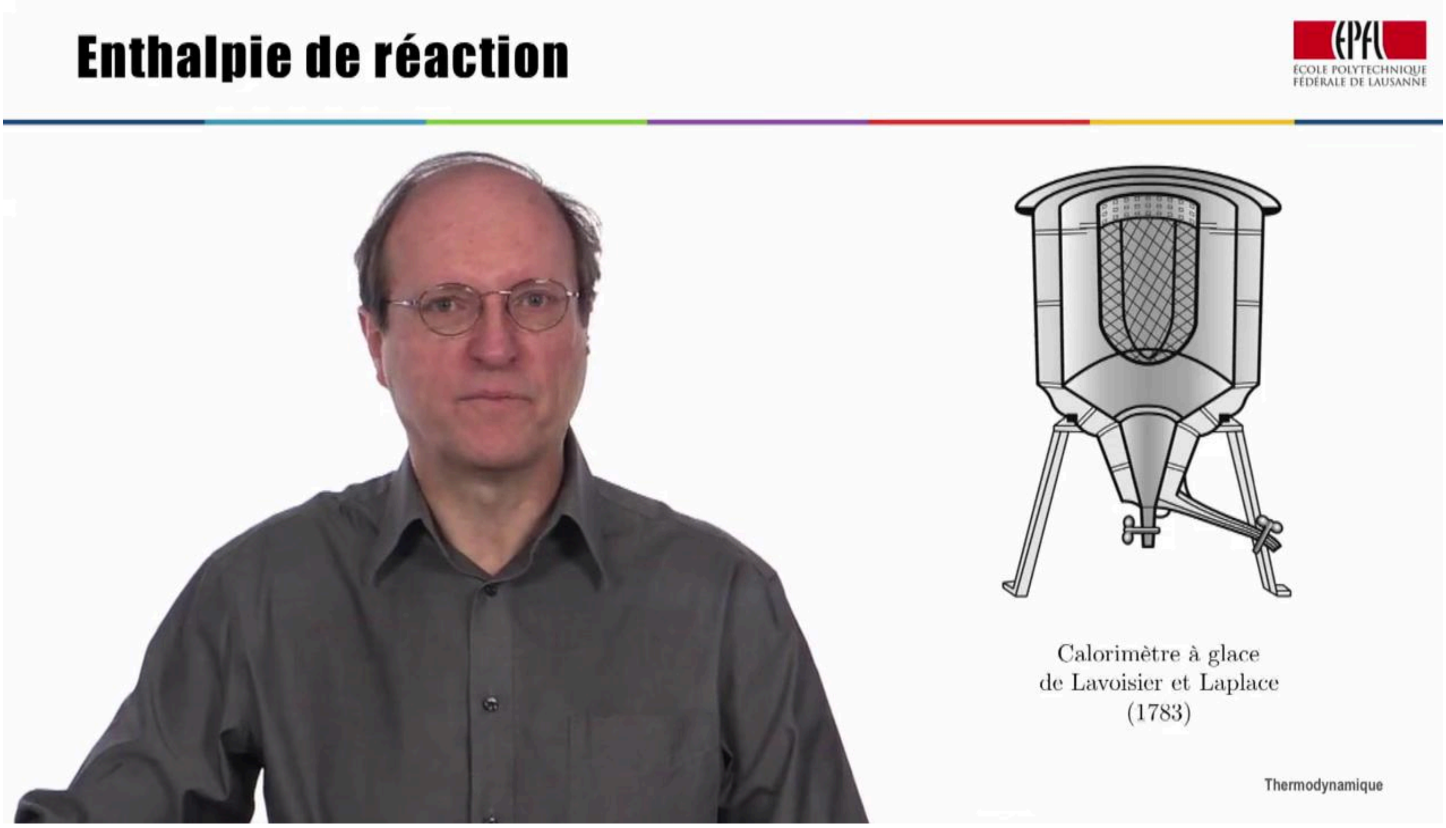
Thermodynamique

We can manipulate this equation a bit if we use the definition of the molar volume which appears here. The molar volume of water, is the volume of water divided by the number of moles in water. For the low concentration concentration is the number of moles of salt divided by the number of moles of water. And if I simplify this equation, I see a delta type equation sometimes V equals a RT. It means that this difference of pressure, called the osmotic pressure, is the pressure that a gas of salt would have, of mol of salt in the volume V of water.

Notes

Summary

4m 19s



Let us now turn to the enthalpy of reaction. I try to give a concrete vision of what is meant by enthalpy of reaction and we will look at an enthalpy of combustion. I'm fighting to do the experiment. I was inspired by the historical calorimeter of Lavoisier. Laplace, who had imagined the following experiment. He wanted to. Study the heat released by a chemical reaction. They proposed to make this reaction inside a sphere of ice and measure the amount of ice transformed into water to estimate the heat released by the reaction.

Notes

Summary

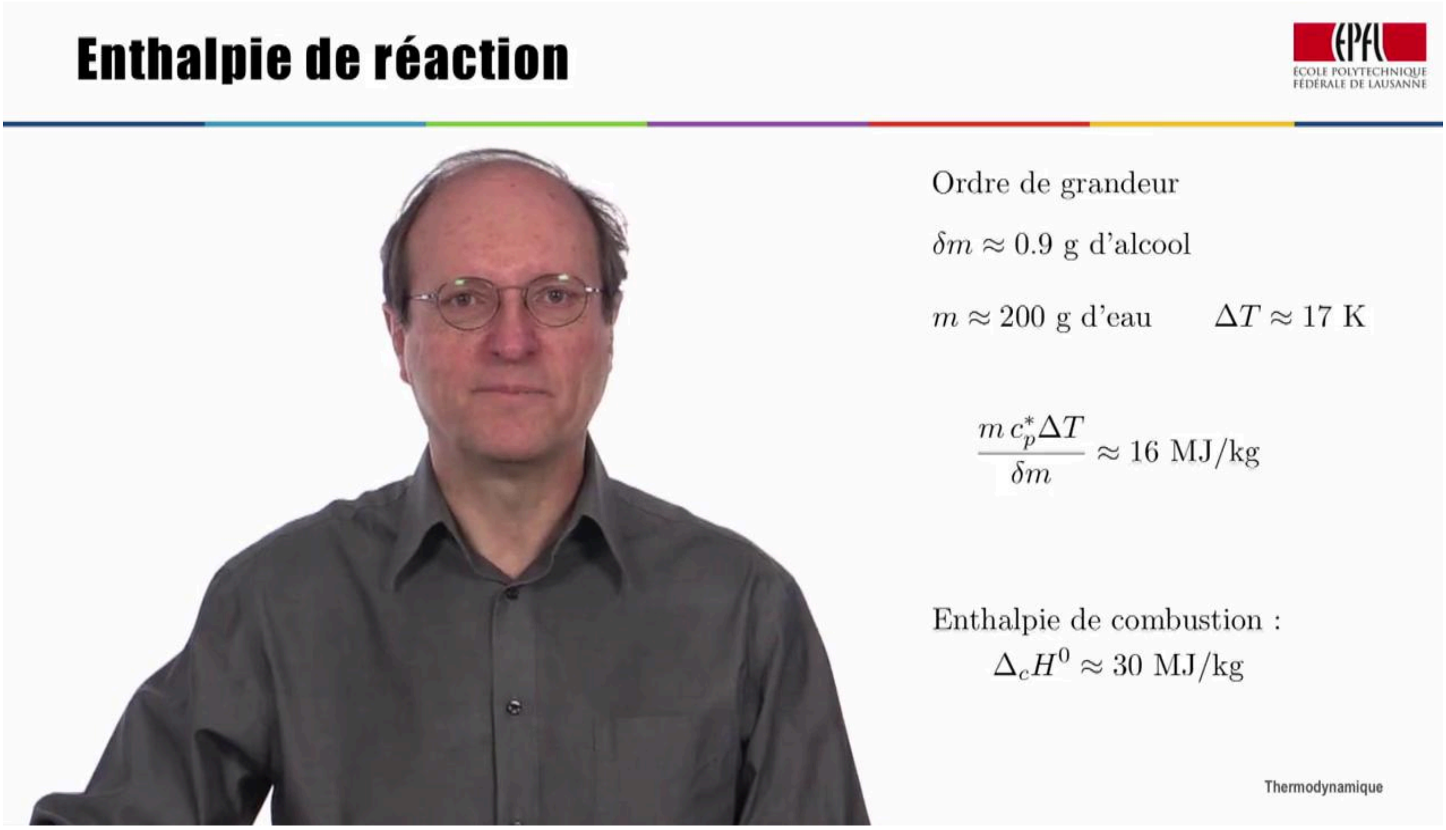
5m 02s

So I'm going to suggest something similar. But instead of using ice, we will heat water. I have here an alcohol stove on a scale. So we will measure the amount of alcohol that has burned. We have water below the flame. Whose temperature will be measured. The specific heat of water is known. We will be able to measure the amount of heat stored by the water. The preparer put 200 grams of water in the fisher. The timer is on and we measure the temperature of the water at the same time that we see the weight of the alcohol stove decreases because the alcohol has burned. I stop the experiment here.

Notes

Summary

5m 51s

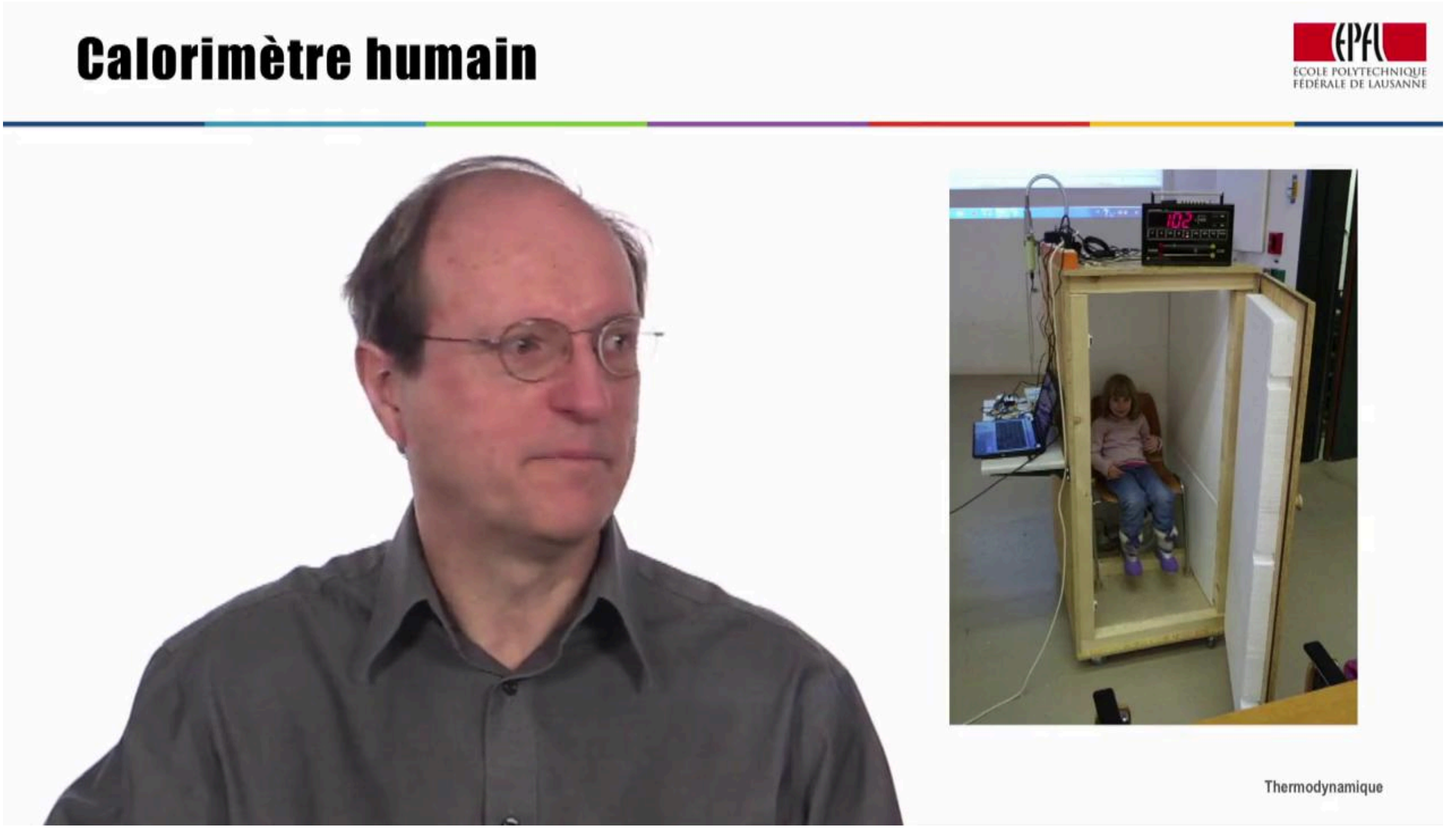


I propose you to try to estimate the order of magnitude of the enthalpy of combustion. We have the following data. We have 0.9 grams of alcohol which allowed to heat 200 grams of water of 17 degrees. So I simply calculate. The heat brought. I divide by the amount of alcohol used. I find sixteen megajoules per kilo. The tabular Typekit value is more like 30 megajoule per kilo. Our experience was by far not accurate. In particular, some of the heat released by the flame is convected into the air to heat the air. Instead of heating the water. So I'm not surprised that we don't find the right value. The purpose of this experiment was to illustrate a concept rather than to make a precise measurement.

Notes

Summary

6m 50s



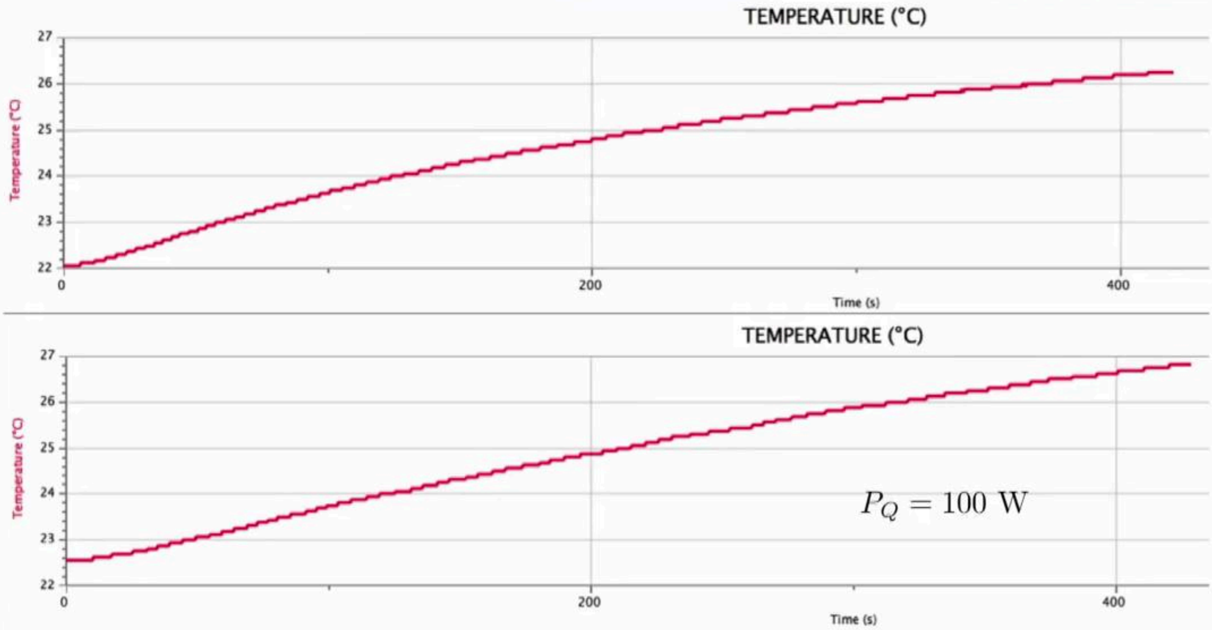
Let us now pass a human calorimeter. Here it is. It is a wooden box. Insulated with panels. Which do not conduct heat very well. And then we're going to put one person there, the assistant's dad here, and we will measure the temperature of the air in the box for a few minutes. Don't worry, the preparer will only be left for a few minutes in this box.

Notes

Summary

7m 54s

Calorimètre humain



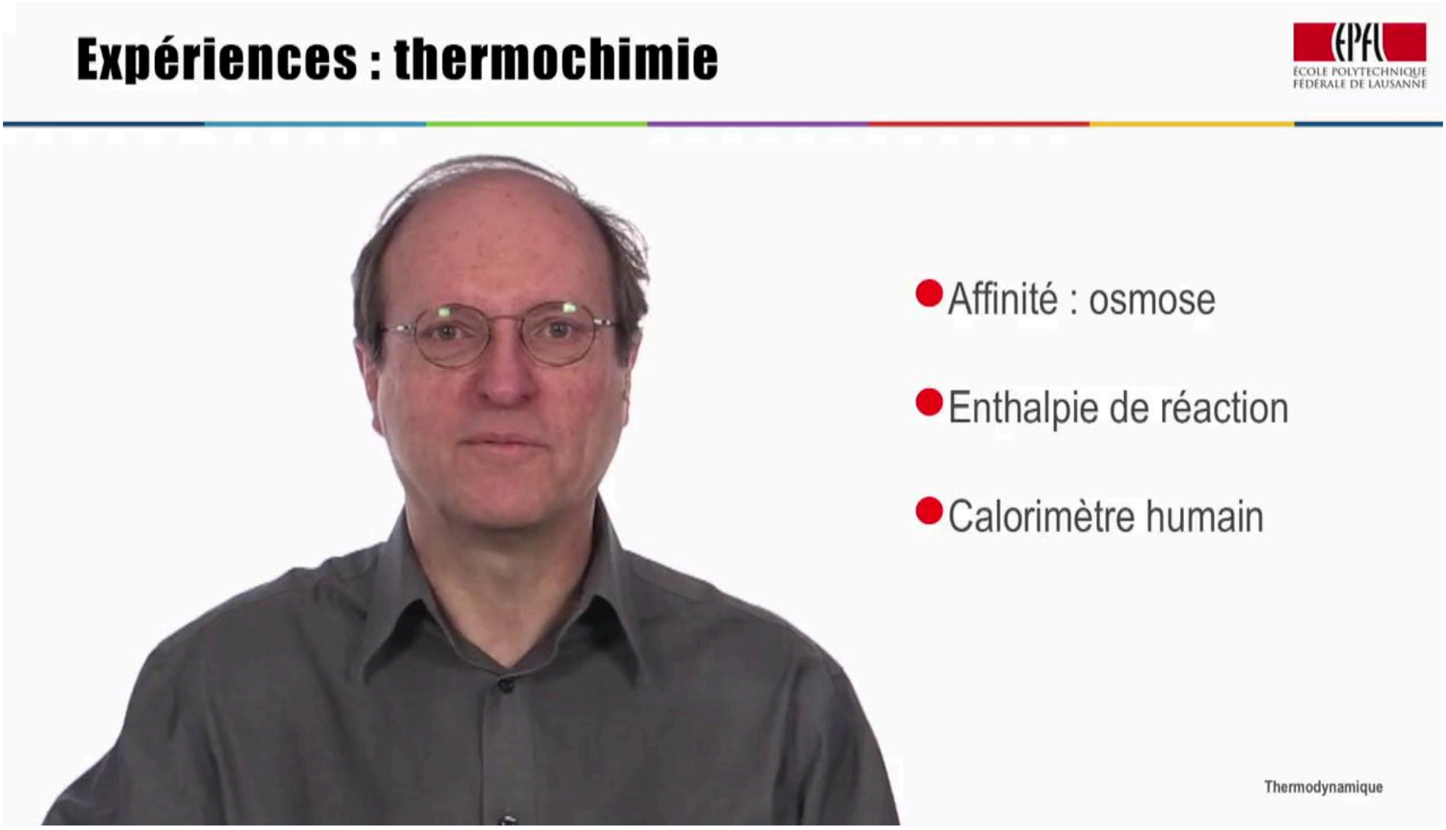
Thermodynamique

Here is what we observed. Do you have the air temperature? There was a fan in the case to ensure good air circulation. You see here, in the interval of 400 seconds, how much the air has changed in temperature. We then removed the preparator of this box and replaced it with a resistor The electrical wire is heated by forcing a current through the resistor. We had an electrical power of 100 watts and we observe about the same air heating for a 100 watt resistance. Therefore, we deduce that a person dissipates about 100 watts, which corresponds to 2000 kilocalories per day.

Notes

Summary

8m 28s



In summary. To illustrate the concepts of thermodynamics applied to chemistry. I have illustrated the concept of affinity by showing you the phenomenon of osmosis. I tried to make a naive measurement but very explicit of a combustion enthalpy. And then Joseph showed a small experiment with a human calorimeter. Thank you for your attention.

Notes

Summary

9m 19s