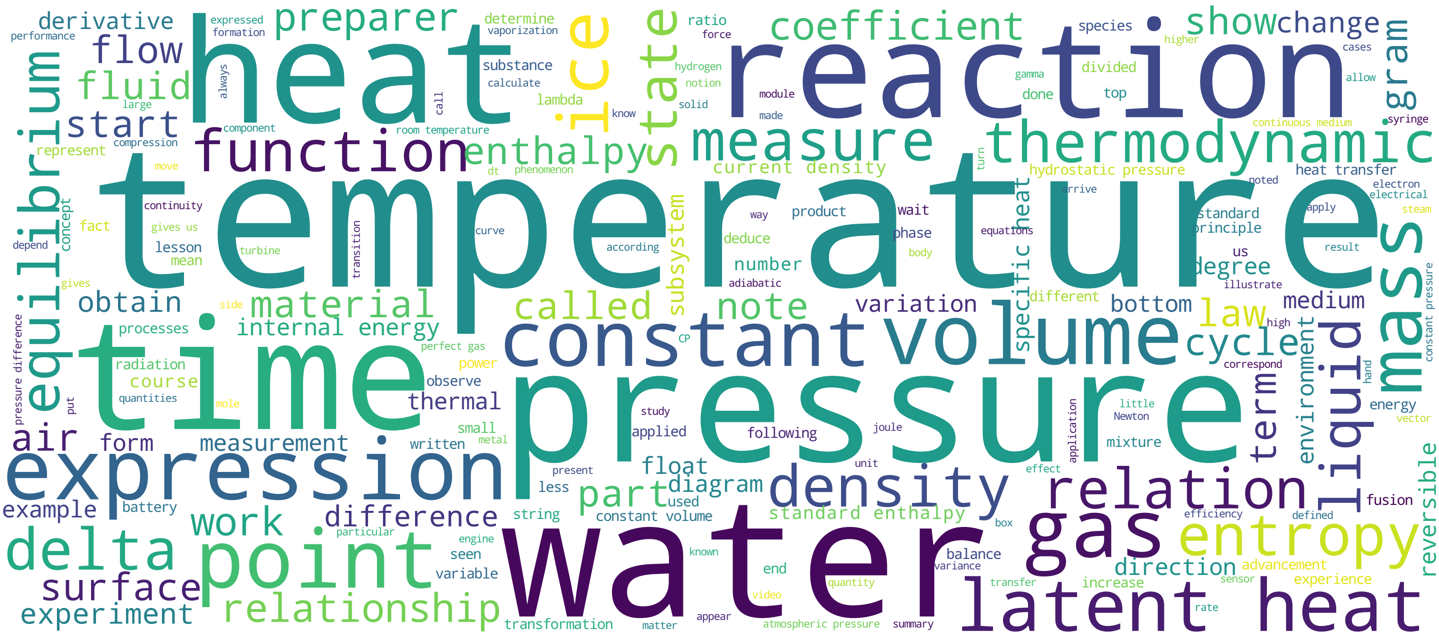
Thermodynamique

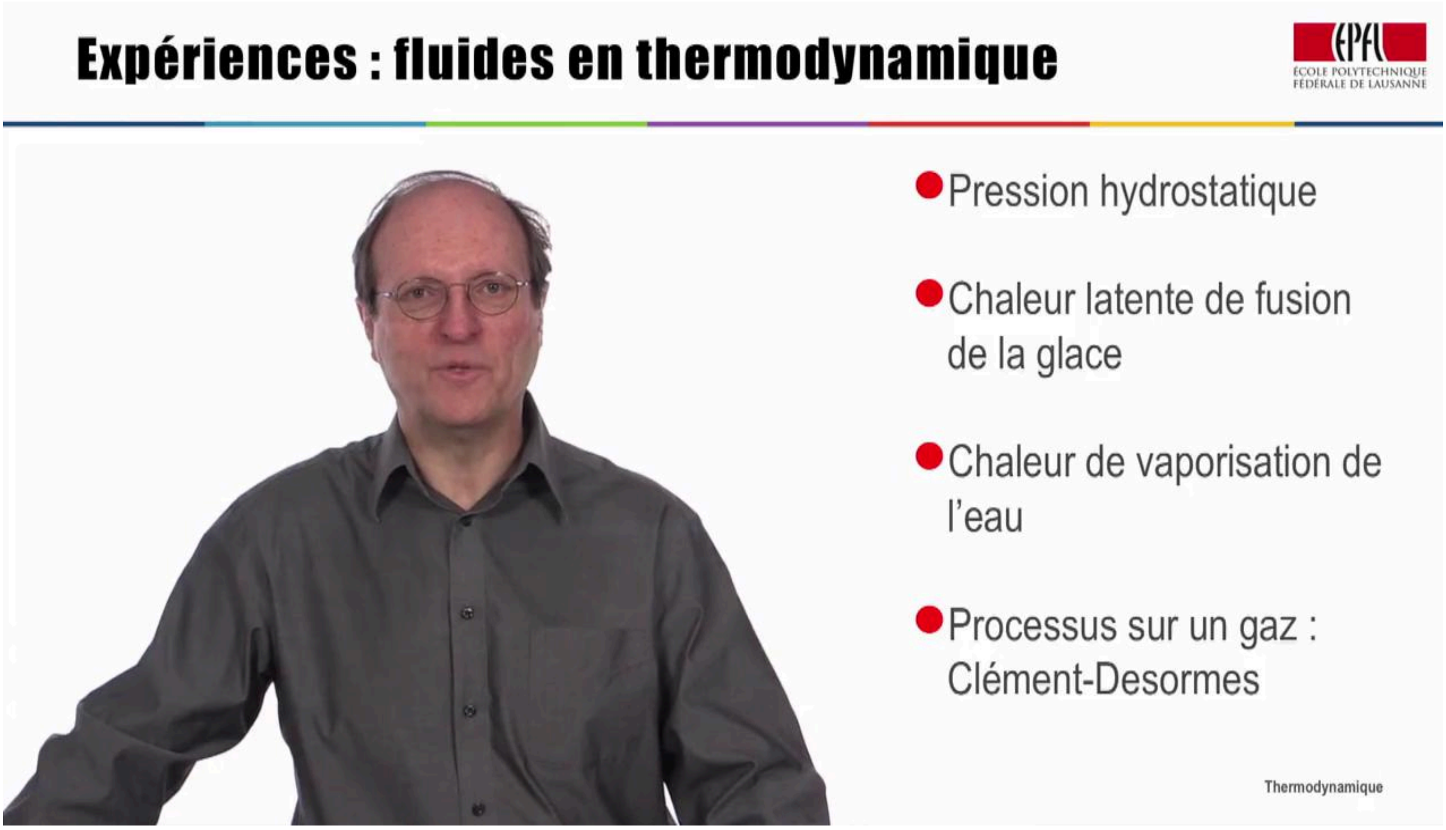
Expériences : Fluides en thermodynamique

Richard Mollier, 1863 - 1935

Prof. Jean-Philippe Ansermet



Video

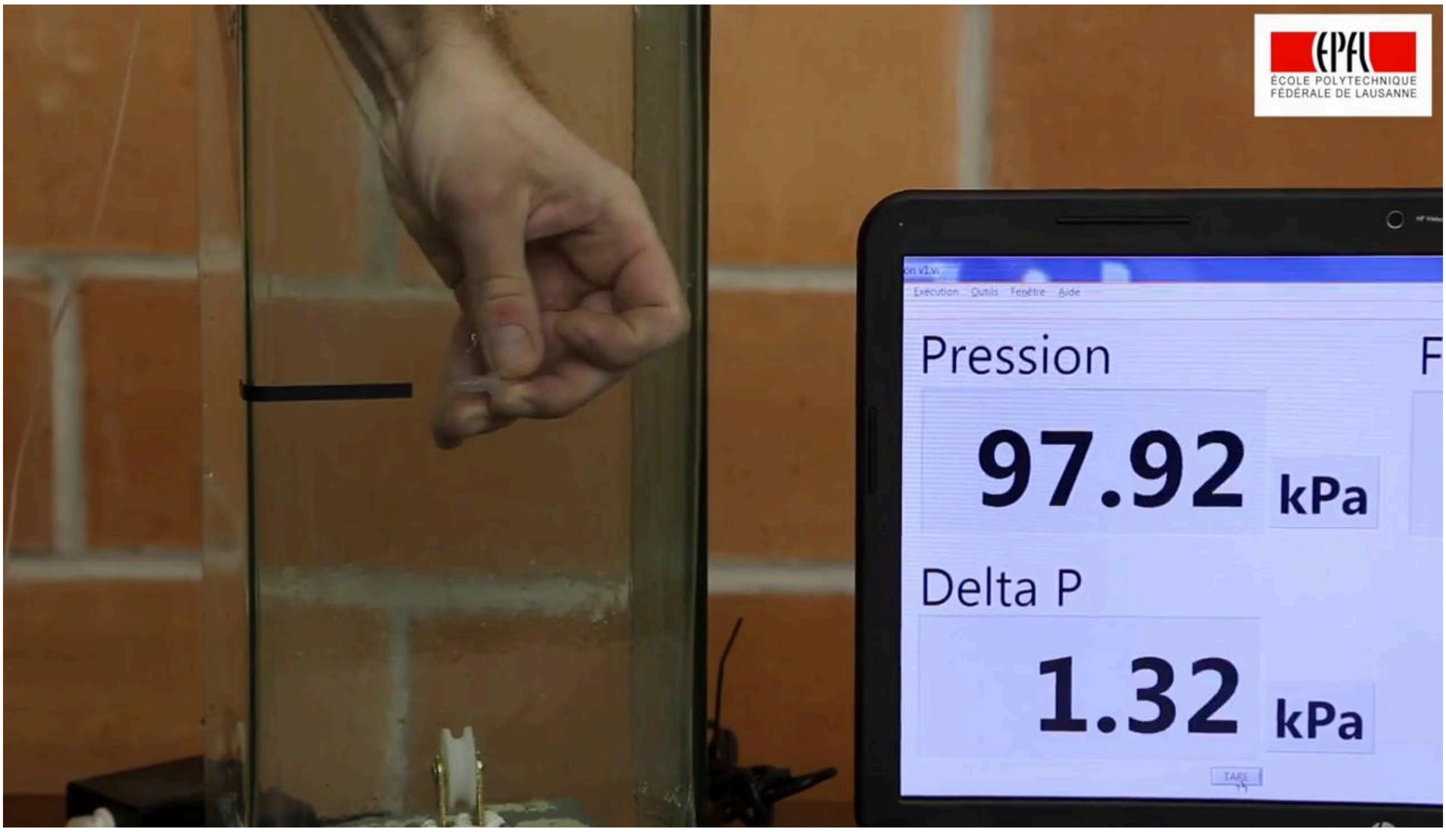


In this lesson, André Tala introduced you to the concept of hydrostatic pressure. So I'd like to give you a little experiment to illustrate this concept. I would like to use this lesson to show you some experiences relative to colorimetric coefficients. The latent heat of fusion and we'll see. A measure of the latent heat of fusion of ice is the latent heat. Vaporization. A measurement will be made for the heat of vaporization of water. And in preparation for the In the next lesson, I would like to show you an experiment by which we make a process on a gas, a series of processes on a gas.

Notes

Summary

0m 04s



It is an experience that is known like the experiment of Clément Desormeaux starting with the hydrostatic pressure. It seems that some students are surprised to the idea that the hydrostatic pressure is the same in all directions. So, here is a little experiment to check with a pressure sensor that the pressure is the same at a point in a fluid, regardless of the direction of the sensor. Let us observe. This is the sensor. Who is measuring right now. Atmospheric pressure. We host it. We observe a higher pressure and the processor changes the direction of the sensor. And we see that the pressure is the same.

Notes

Summary

0m 57s

Now we will immerse a float. By pulling a string on the float to keep it at the bottom of the water. We will measure the strength to be applied to the string and we will also measure the pressure on the top and bottom of this float. By watching the video. Here is the device. We pull on the string. You see on the computer screen the strength. 1.8 Newton approximately. And now the preparer will immerse the pressure sensor. First, on the upper side. It will make a zero of the measure so that the pressure difference can be easily read between the top and bottom of this float. That's it. And we note the pressure difference between the top and bottom of the float. Then the preparer goes. Place the float lower in the container. Like this. We have to wait for the system to balance. We obtain the same force on the string. We will measure the pressure difference again. So obviously, the absolute pressure is larger, but we make a zero of the pressure. You will see that the difference pressure between the top and bottom of the float remains the same.

Notes

Summary

1m 50s

Pression hydrostatique

EPFL
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

	h1	h2
Force	**1.78N**	**1.87N**
Delta P	**0.75kPa**	**0.75kPa**

Volume de la boîte : 230cm^3

Poussée d'Archimède : 2.3N

Poids de la boîte : 0.5N

Force résultante : 1.8N

surface S : 28cm^2

$F_z = S(p_2 - p_1)$

$F_z \approx 2.1\text{N}$

Thermodynamique

Here is a summary of the measurements made by the preparer. The volume of the float is 230 cubic centimeters. From this, we can deduce the thrust which is equal to the weight of the displaced volume. That's about 2.3 Newtons. Since we have a box that is about one that has a weight of about 0. 5 Newton we have a resulting force on which is therefore the force that must be applied on the string which is 1.8 Newton, it corresponds well to what we measured. Given the uncertainties of the measurement, the surface of the box is 28 square centimeters. The surface of the upper side or the underside of the box, it is about 28 square centimeters. The associated strength. At hydrostatic pressure, it is the area times the pressure and you have a resulting force due to the difference in hydrostatic pressure between the top and bottom of the float which is given by the formula that I have indicated and this gives us a value of 2.1. Newton given the errors in measurement, it's close enough, close enough of the estimated value for the buoyancy.

Notes

Summary

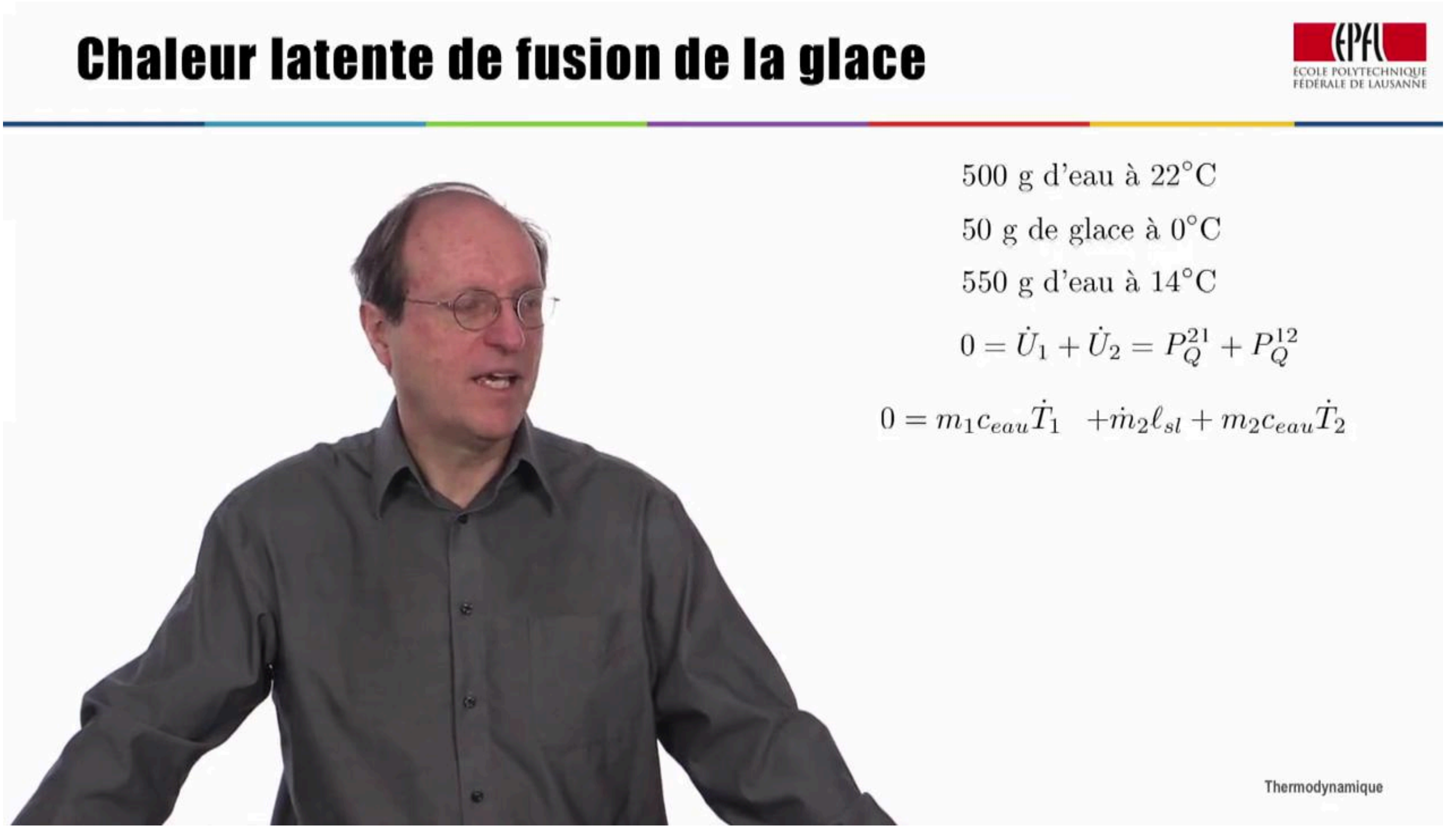
3m 56s

I now turn to latent heat measurements. We will start with the latent heat of the ice. Finally from the fusion of the ice. In this experiment, we do the following we mix 500 milliliters of water at room temperature with 50 grams of ice at zero degrees. In May. Water and ice in a fathom calorimeter and we wait. And the equilibrium temperature of the mixture system is determined. We find about fourteen degrees Celsius.

Notes

Summary

5m 24s

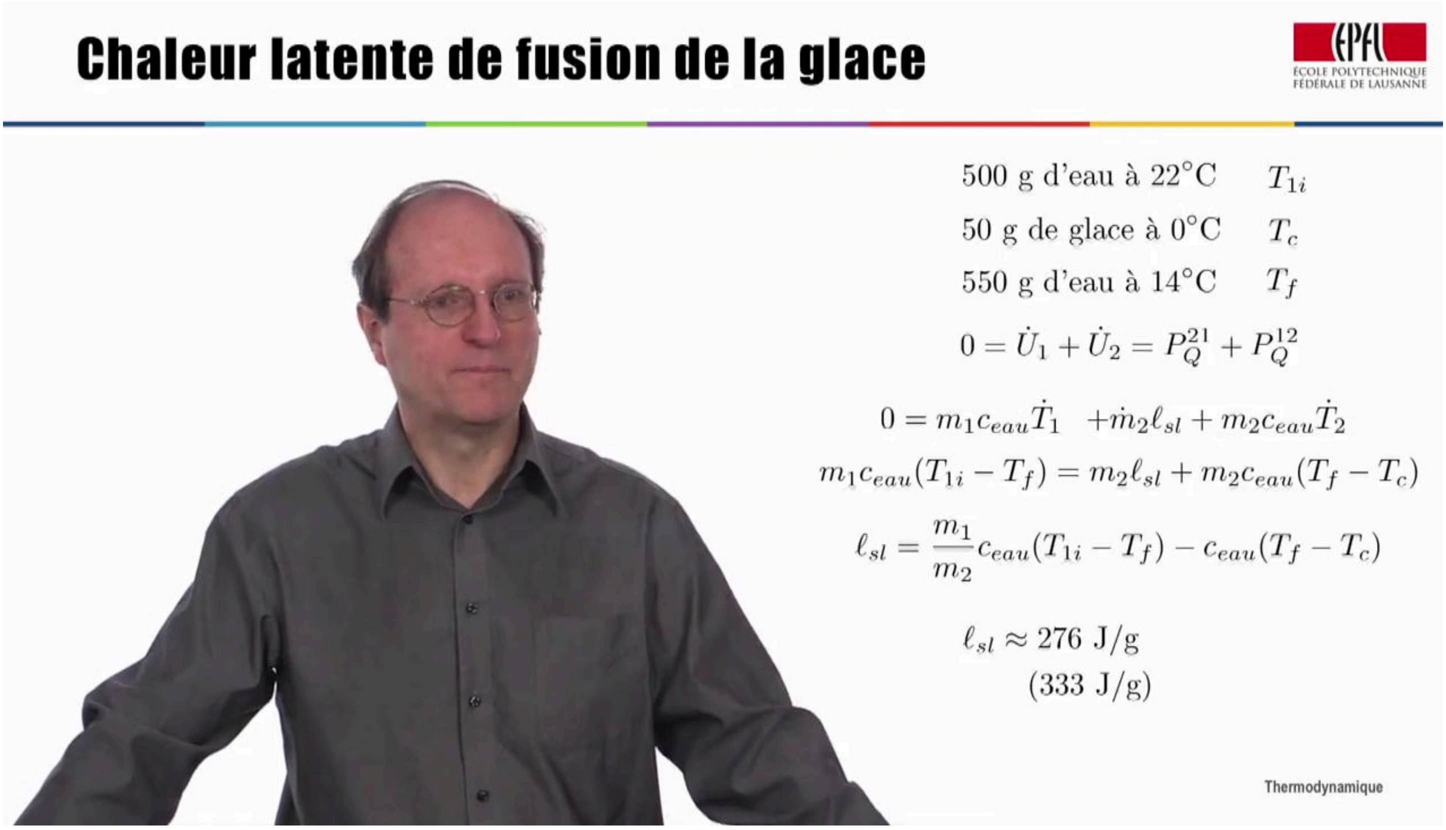


How to analyze this experience? I start by recalling the experimental data. We have 500 grams of water at 20 degrees, 50 grams of ice at zero degrees and it is observed that the mixture reaches a. Temperature of fourteen degrees. We will consider that the calorimeter is an isolated system. So I can write that its internal energy does not change in time. Now we have a heat transfer. I will consider that we have two subsystems. One is the 500 million liters of water, the other is the 50 grams of ice. This is my system and my system. Two. So we have a heat transfer of subsystem two subsystem one and subsystem one subsystem two. For the transfer of 2 to 1. We simply have an expression for the thermal power in terms of these waters, it is the specific heat of the water. And here I have specific heat per unit of mass and mass to mass of water. Pros. The action of. Two for two, one for two. So the action of water on ice. We have to be careful. Two things are happening. First, the ice at zero degrees melts. So my QP contains here the derivative of the mass of subsystem two with respect to time times the heat specific heat, the latent heat of fusion of the ice per unit of mass.

Notes

Summary

6m 06s



And then we have after the water at zero degrees that changes temperature. We therefore have the following expression. For the PQ, which contains again the specific heat of the water and the mass. Of ice transformed into water at a temperature of. We integrate. T he. The initial temperature of the 500 milliliters of water is called TC. The melting temperature of the ice. I call the final temperature of the mixture FST. And I have the complete set here. I rearrange the terms and so I have an expression for the latent heat of fusion of ice per unit of mass which is given by this expression. If I do a numerical application, I find 266 joules per gram. The tabular value of 333. Again, this was not intended to be a very but rather to illustrate the concepts of calories. Matrix.

Notes

Summary

7m 59s

I now turn to the latent heat of vaporization of water. Let's watch the video to make this measurement. We put water in a calorimeter placed on a scale, we apply 500 watts. Hello. We make a heat transfer of 500 watts, or exactly 455 watts when measured accurately. And. Over time, the water evaporates. What we detect with the scale. I give you the final result of this measure.

Notes

Summary

9m 21s

Chaleur latente de vaporisation

$P_Q = 455$ W $\qquad \delta t = 120$ s

$\delta m = 21$ g

$\ell_{lg} \approx 2.6$ kJ/g

(2.2 kJ/g)

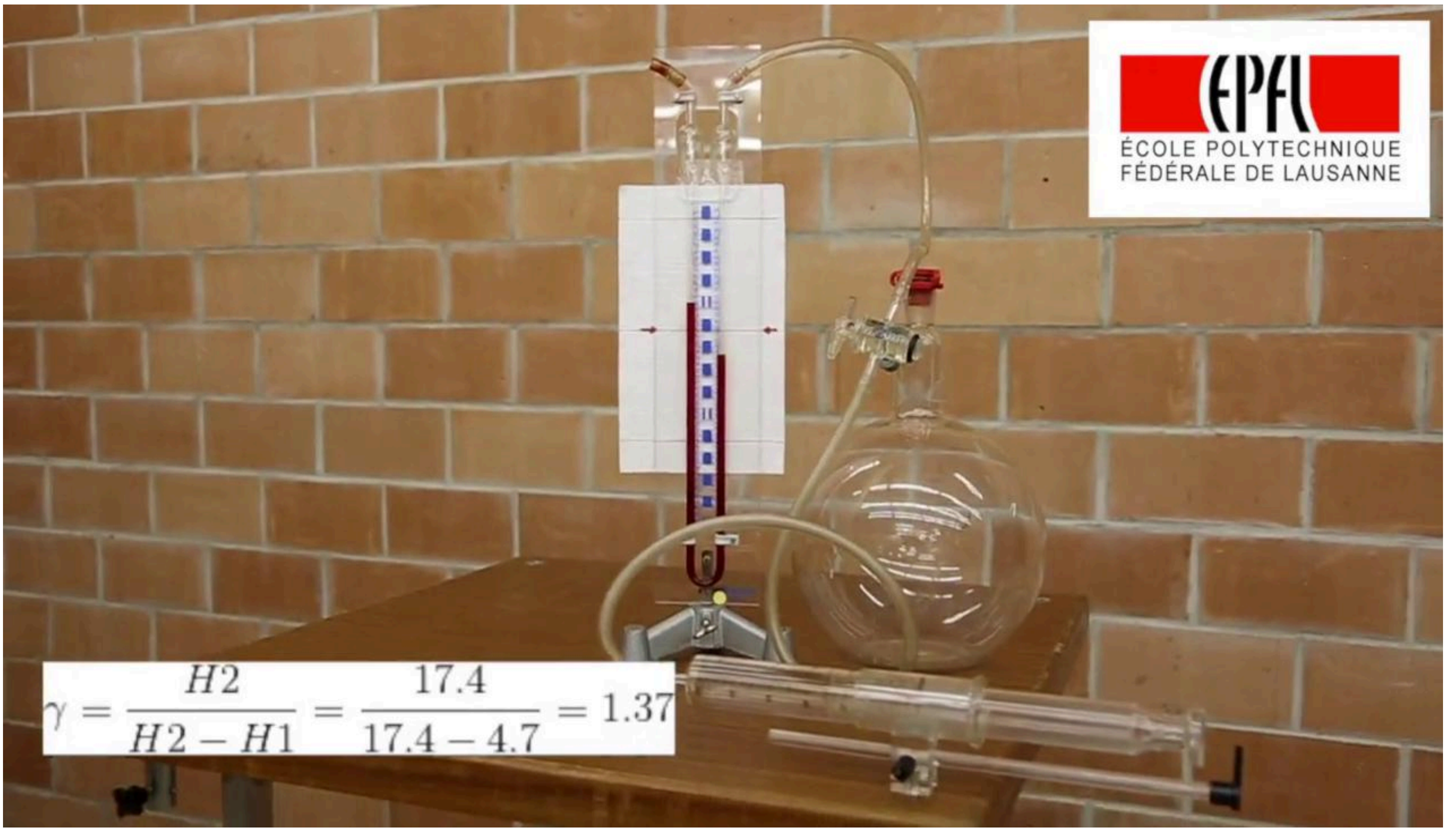
Thermodynamique

Here are the experimental data. We have 453455 watts. Applied for 120 seconds and 21 grams of water evaporated. We deduce a latent heat of evaporation of 2.6 kilo joules per gram. The value is tabular and 2.2 kilo joules per gram. Again, no attempt was made to make a very precise measurement here.

Notes

Summary

10m 05s

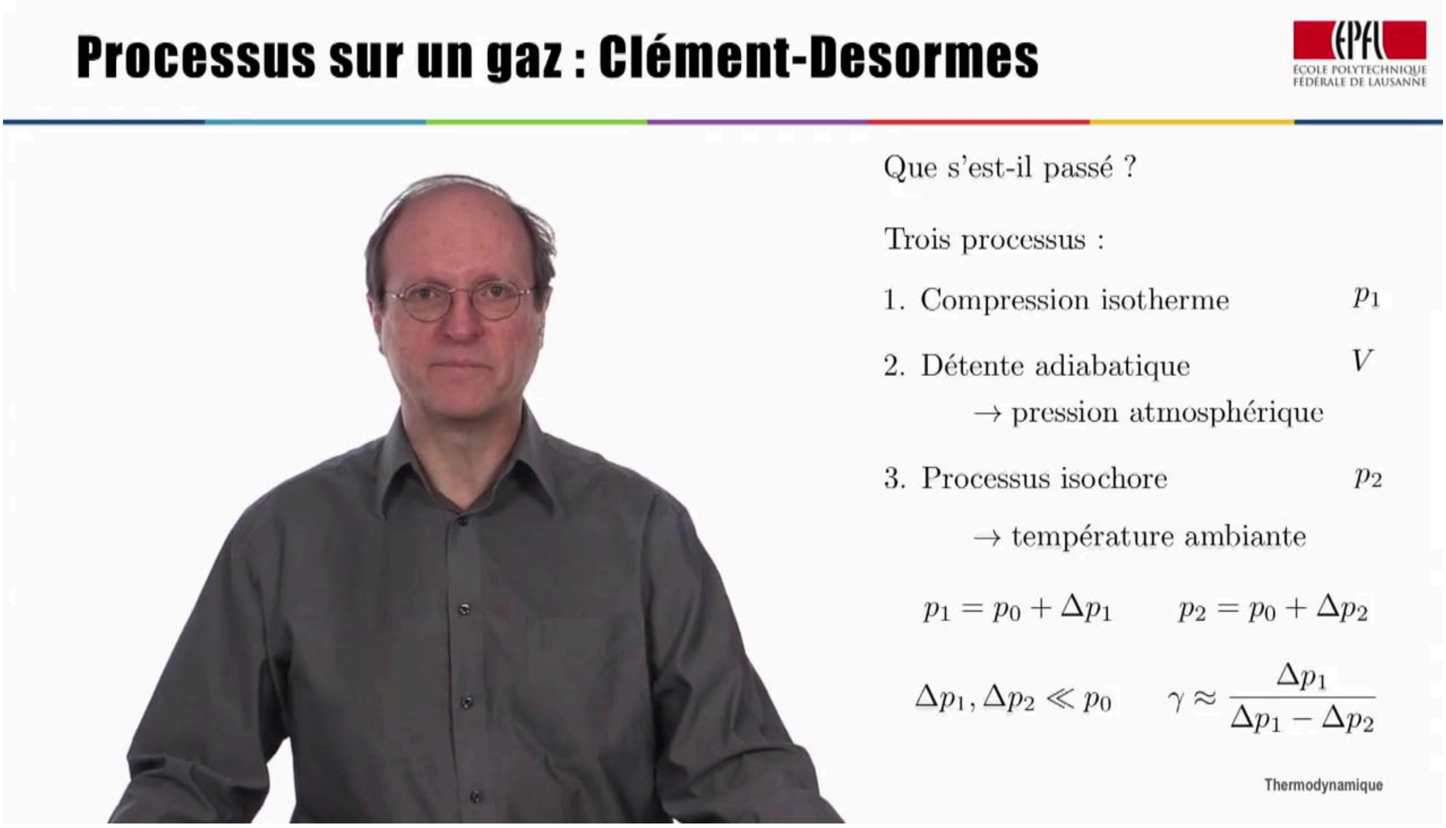


I am now thinking of an experiment where we do several processes on a gas. I do this here in anticipation of the next lesson on thermal machines. I suggest you look at what the preparer and then we will try to model the experiment. This experience is known as the method of Clément II Desormeaux to measure the gamma coefficient of a gas. Watching the video, you have a large balloon that contains of air at room temperature and atmospheric pressure. There is also a syringe that is connected to the system. Now we're closing the system. And slowly the preparer. We see the gas in the syringe, in the balloon. And. It observes the pressure. Air in the balloon at equilibrium. Like this. Now the preparer will search. A. Do a quick process. Which brings the pressure back to the initial pressure. He'll shoot the wave with a bang. Like this. Then he waits for a touch plus the syringe and waits. And that's going to give him a second push. When the system has reached equilibrium. Here is the second pressure. With these two pressure values. He makes the following calculation to estimate the gamma, it is the method known as of Clement II orders to measure the gamma of a gas.

Notes

Summary

10m 37s

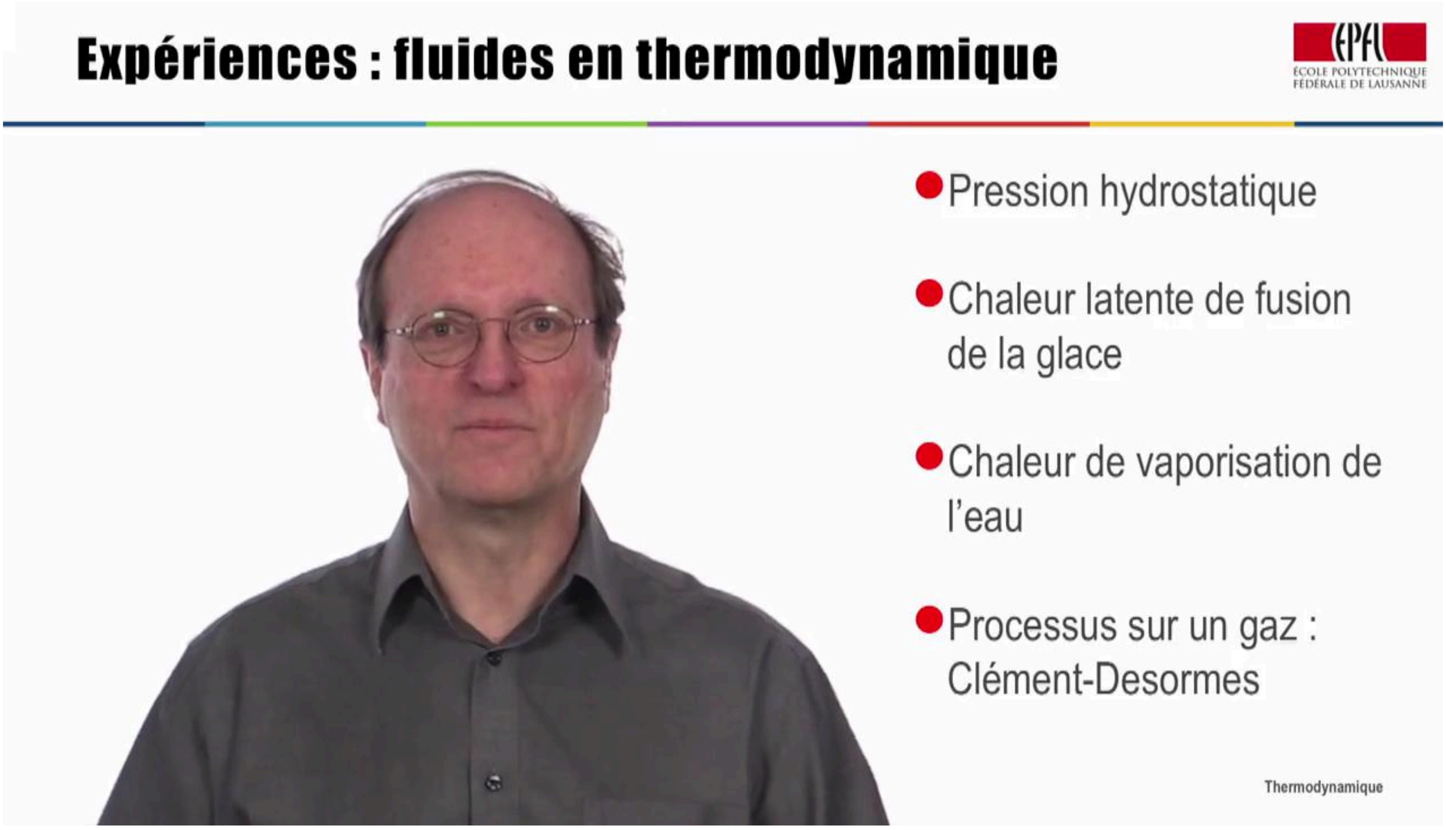


It is now a matter of modeling what the preparer has done. I invite you to take a break and try to accurately describe the processes. Which represents what the preparer has done. So, what happened? There were three processes. When the first. The gas was compressed very slowly. This gave the gas time to equilibrate with the thermal bath. So we had a, that is, the room temperature. So we had an ISO term compression. Then the preparer pulled the syringe quickly. And so he did something approaching an adiabatic expansion. And you will note that he did so until this that the pressure returns to atmospheric pressure. Then the preparer left the system to itself. The volume was constant and there was a heat exchange with the ambient air. So we had an ISO core process. If we analyze these three processes. The first one will define a pressure. Not. The second, a particular volume V. Is the third process. Gives a P2 pressure. We can write that these pressures are small variations with respect to the atmospheric pressure. And if we do the math, we find that the ratio, as calculated by the preparer, is the gamma of the gas. To do this, we use the fact that pressure times volume at the gamma power is a constant in an adiabatic expansion.

Notes

Summary

12m 58s



In summary, in this lesson, we have seen a small experiment on the notion of hydrostatic pressure. Then, latent heats were measured latent heat of fusion of ice, latent heat of vaporization of water. And finally, I have shown you the experience of Clément Delorme. Thank you for your attention.

Notes

Summary

15m 00s