Thermodynamique

Expériences : Deuxième principe

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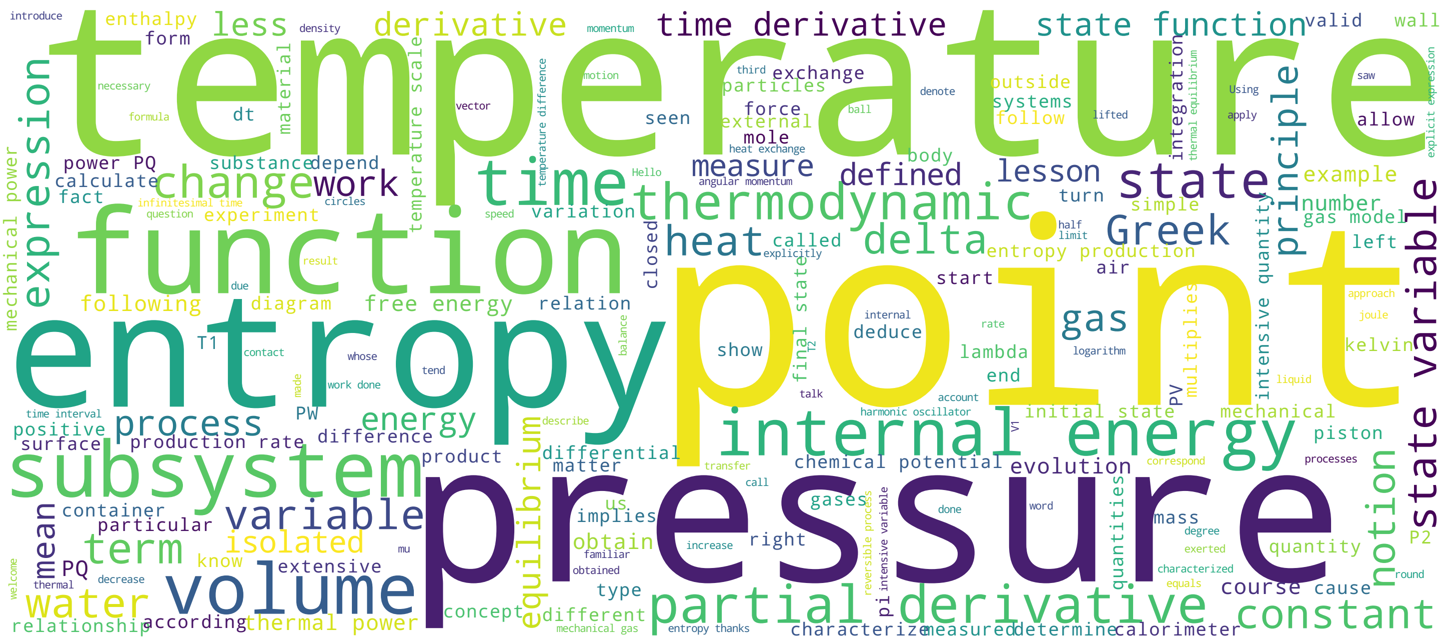
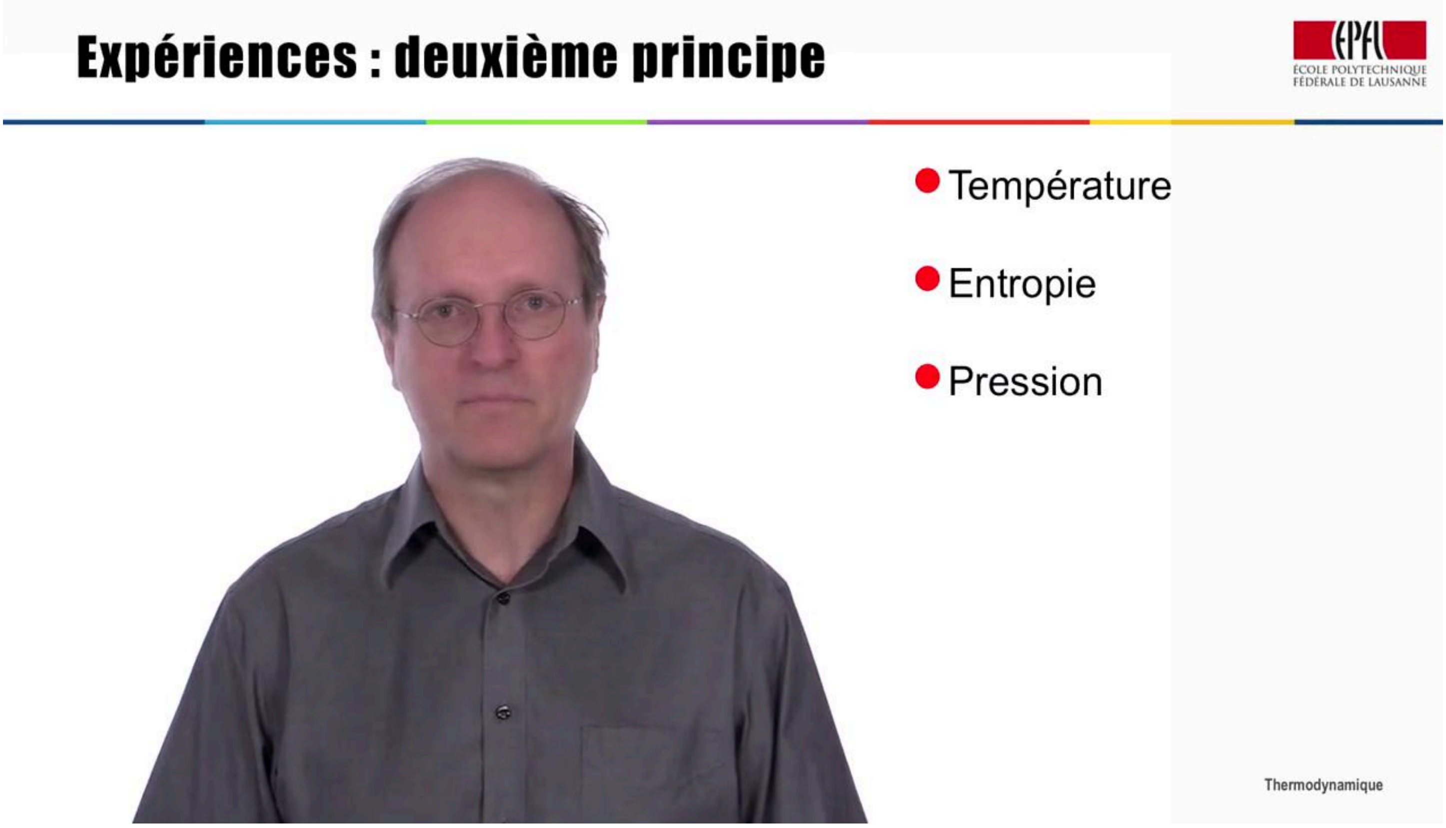
Clausius



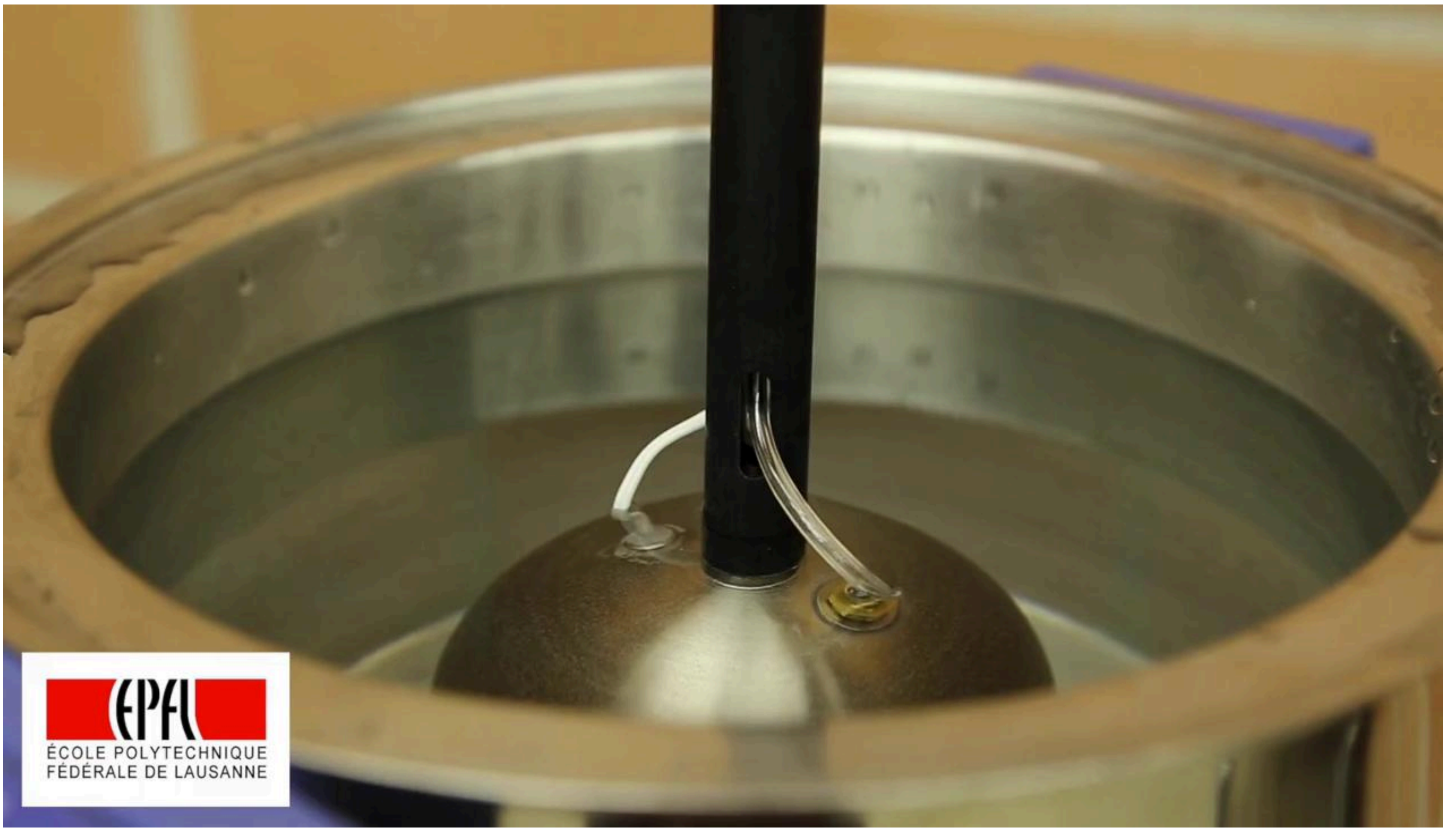


I join you again for show some experiments in this lesson. The notion of temperature has been introduced as an intensive quantity conjugated to the entropy. Of course, you are familiar with the concept of temperature. Here, we will measure the temperature of a gas as a function of its pressure. We will also get familiar with the notion of entropy thanks to a very interesting experiment simple with which we will try to measure a change of entropy. Pressure has been defined in this lesson also as an intensive variable combined with volume. To have a better intuition of the notion of pressure, we will look at a mechanical model of gases.

Notes

Summary

0m 05s

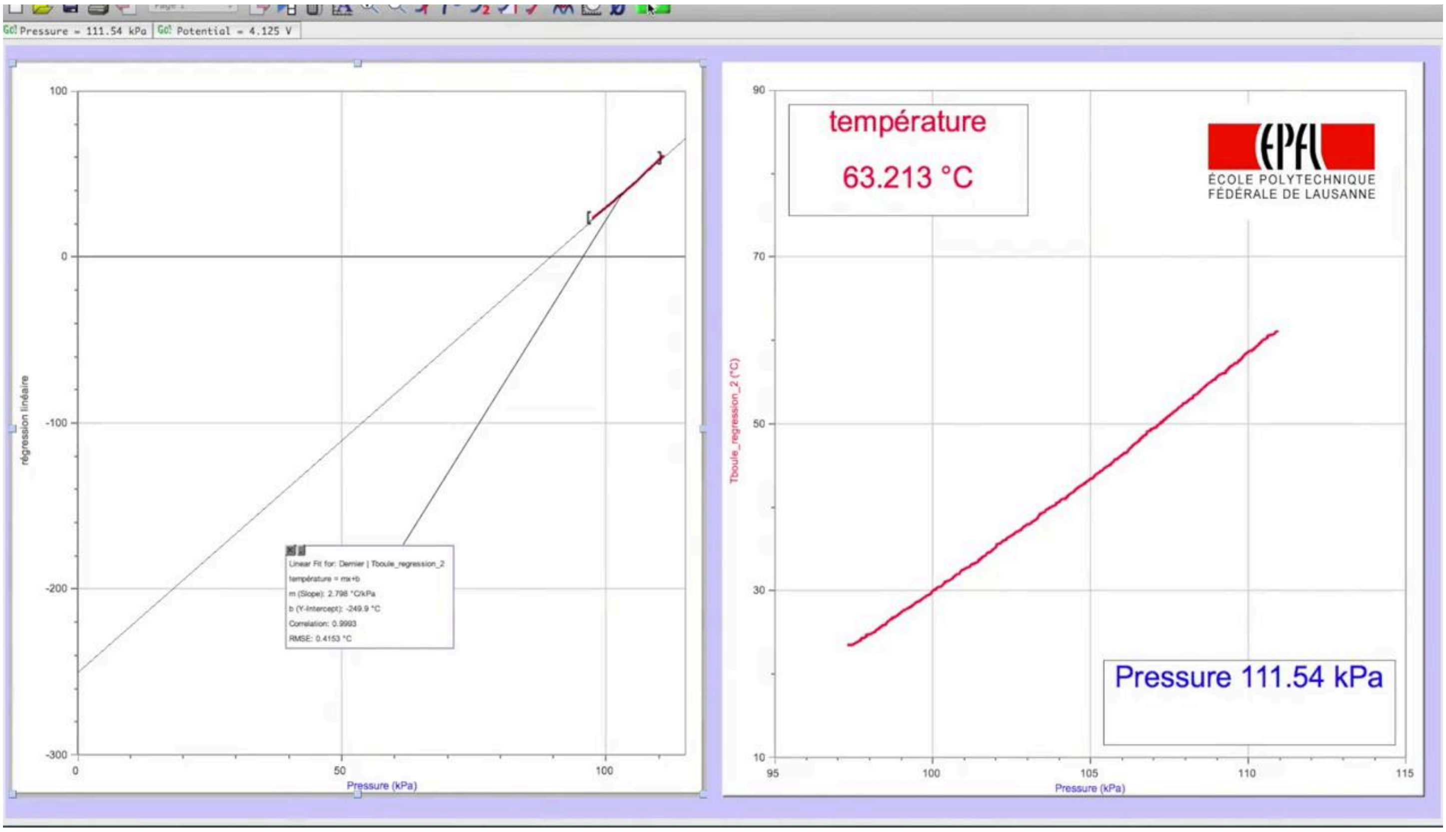


Let's start with an experiment that measures the temperature of a gas as a function of its pressure. In fact, we use a thermostatic bath to change the temperature and the gas pressure is measured.

Notes

Summary

1m 02s

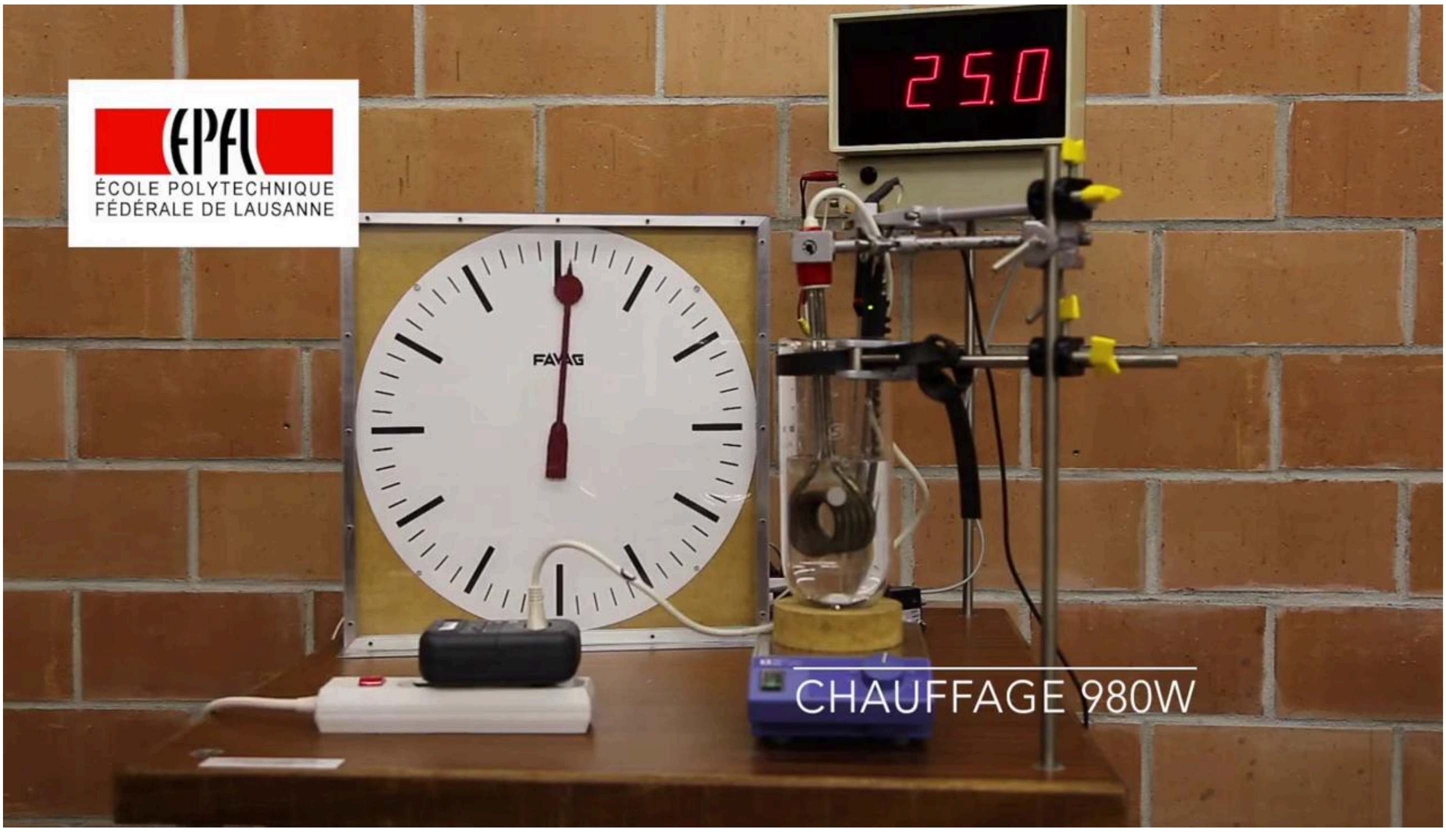


A sensor measures the temperature of the gas itself. Here we see a recording of the temperature as a function of pressure. At the same time, the program performs a linear regression. On the right, we see the measurement points on a temperature scale corresponding to the range of the measured values. While on the left, we have a temperature scale that extends to 300 degrees Celsius. This measurement provides a zero pressure at less than 150 degrees. It should have been obtained at less than 163 degrees. We can be satisfied with the accuracy of the measurement, because the extrapolation is pushed very far outside the measured domain.

Notes

Summary

1m 19s



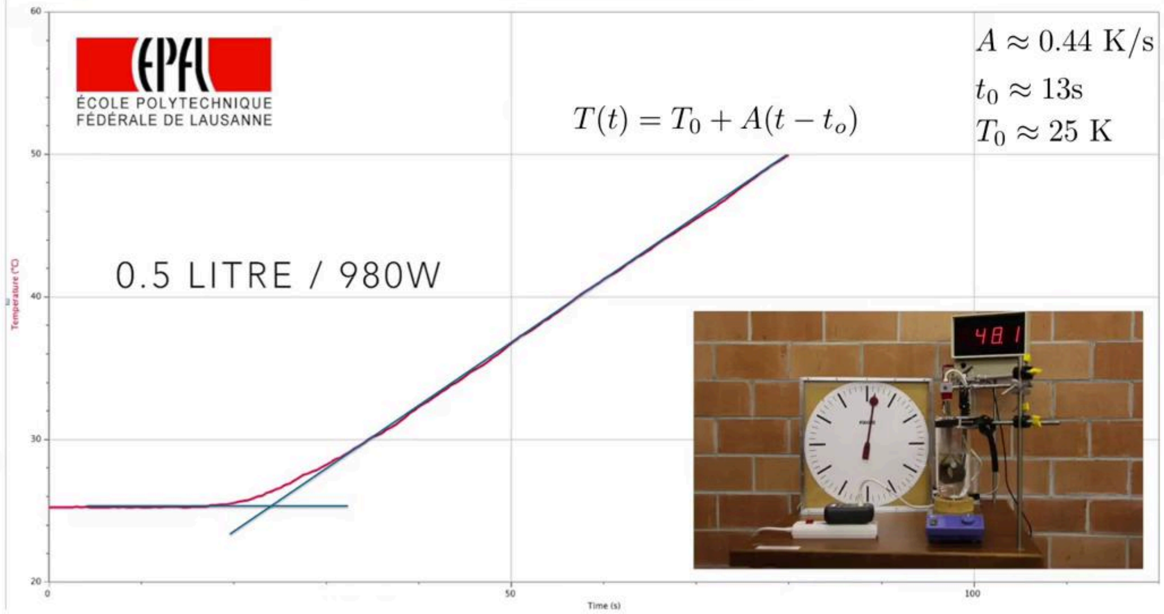
Let us now turn to the notion of entropy. We will try to measure a change of entropy thanks to very simple instruments. We have here a calorimeter in which we introduced 500 grams of water. The calorimeter is equipped with a body of 900 eighty watts and a brewer.

Notes

Summary

2m 04s

Changement d'entropie de l'eau



Thermodynamique

The temperature of the water is measured as a function of time. Here is the result. We will make the following approximation we consider that the temperature evolves according to a straight line. Thus we have. Temperature as a function of time. With the estimated coefficients very approximately from the graph data. Here they are.

Notes

Summary

2m 30s

Changement d'entropie de l'eau

$$T(t) = A(t - t_o) + T_0$$

$$A \approx 0.44 \text{ K/s} \qquad t_0 \approx 13\text{s} \qquad T_0 \approx 25 \text{ K}$$

$$P_Q \approx 980 \text{ W}$$

$$\dot{S} \approx \frac{P_Q}{T}$$

$$\Delta S_{t_0 \to t_1 \approx 80 \text{ s}}$$

$$\Delta S = \int_{t_0}^{t_1} \frac{P_Q \, dt}{A(t - t_0) + T_0}$$

$$\approx \frac{980}{0.44} \ln\left(\frac{50}{25}\right) \text{ J/K} \approx 1.5 \; 10^3 \text{ J/K}$$

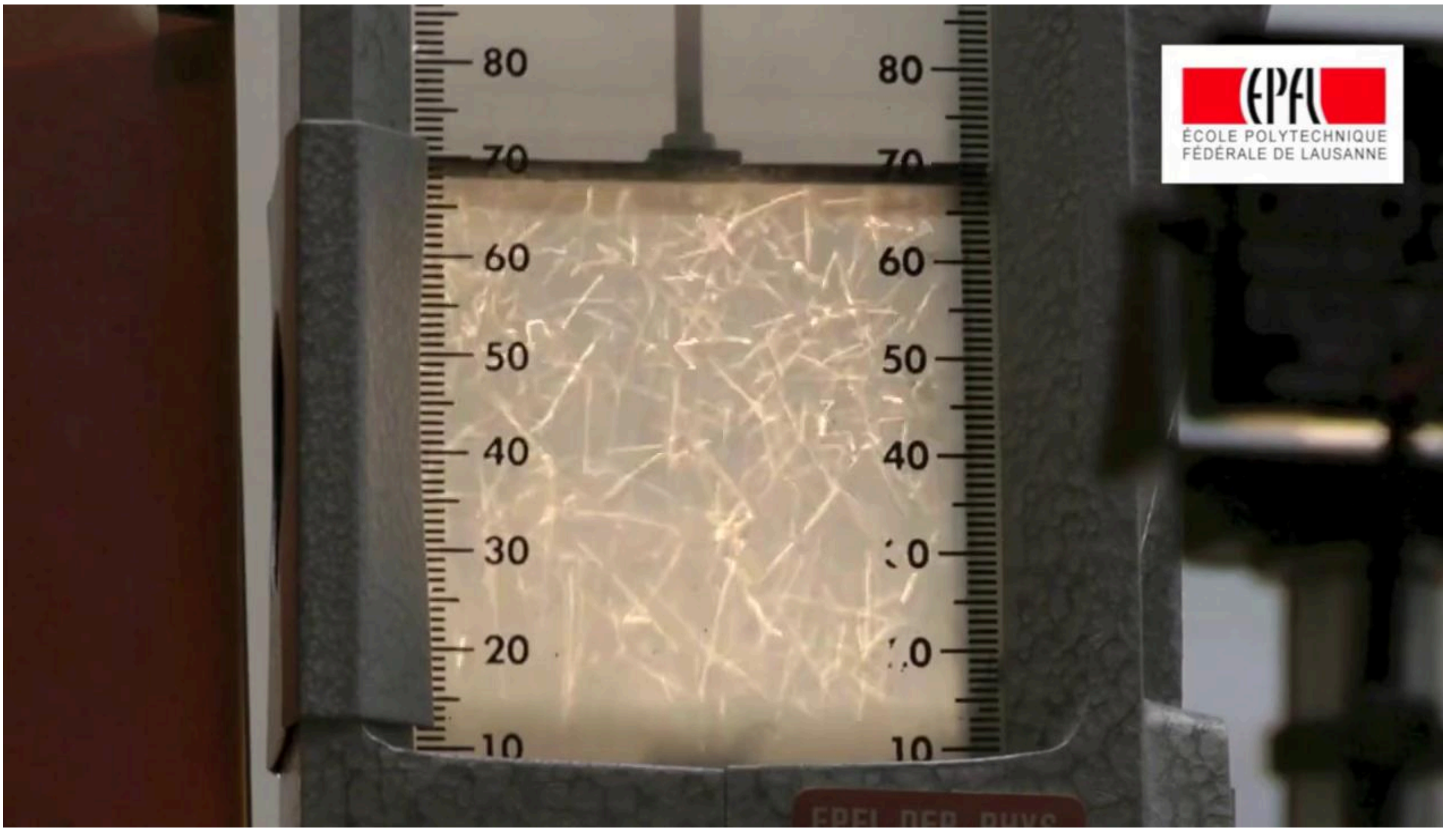
Thermodynamique

Here are the experimental data again. The question I'm asking now, is to know how we can deduce a change of entropy. I invite you to take a break and try to find out for yourself. Here is how we will proceed. We will use the following relationship of the course which gives the evolution of the entropy for a process. For a thermal power p a discus. This formula is valid in the case of a reversible process. If we really wanted to to approach a reversible situation, it would have been necessary to heat the body to minimize the difference between the two. temperature difference between the heating element and the water. But finally, we are going to use this approximation from there by integration. Between the time t0 when lo starts to heat up and the time t1. When the water has reached 50 degrees centigrade, we can. Calculate the change in entropy. This is done by integration over time. This integral gives rise to a logarithm. It is quickly seen that it is the logarithm of the temperature ratios which intervenes. And we find a numerical value in joule per kelvin as it should be.

Notes

Summary

3m 12s

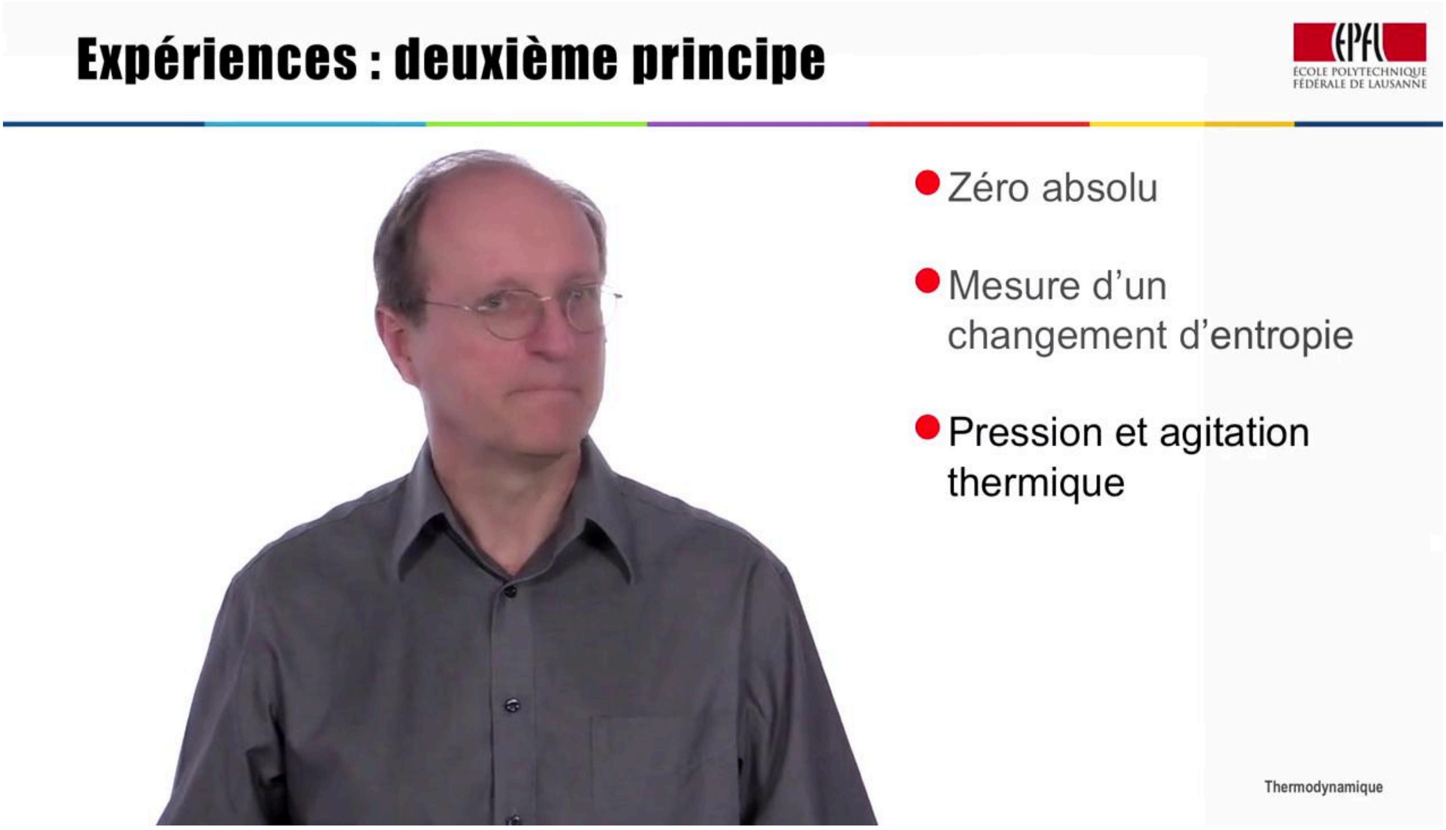


Let's now turn to the notion of pressure. I propose to look at a mechanical gas model. We have balls in a container to simulate thermal agitation. We will shake the container and we will. We have a piston that will be lifted by the random flow movement. This model offers a visualization of of internal energy as kinetic energy at the molecular level. We also see that the pressure is due to the collisions of the particles on the walls. In particular, the piston is lifted by the particles.

Notes

Summary

4m 48s



In summary. We have seen an experiment that suggests how to demonstrate the existence of of an absolute zero on the temperature scale. We have seen how, with a very simple apparatus, we can try to measure a change of entropy. And with a mechanical gas model, we saw. The concept of pressure and internal energy.

Notes

Summary

5m 31s