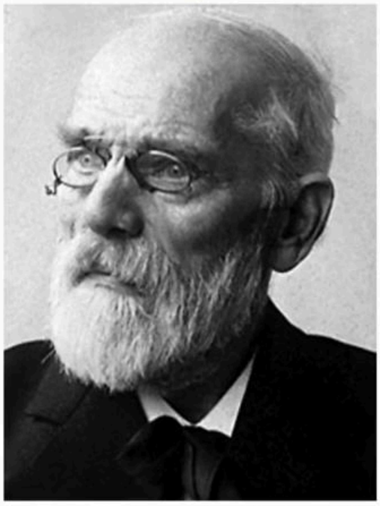
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

RESCIF
Réseau d'excellence des sciences de l'ingénieur de la Francophonie

Thermodynamique

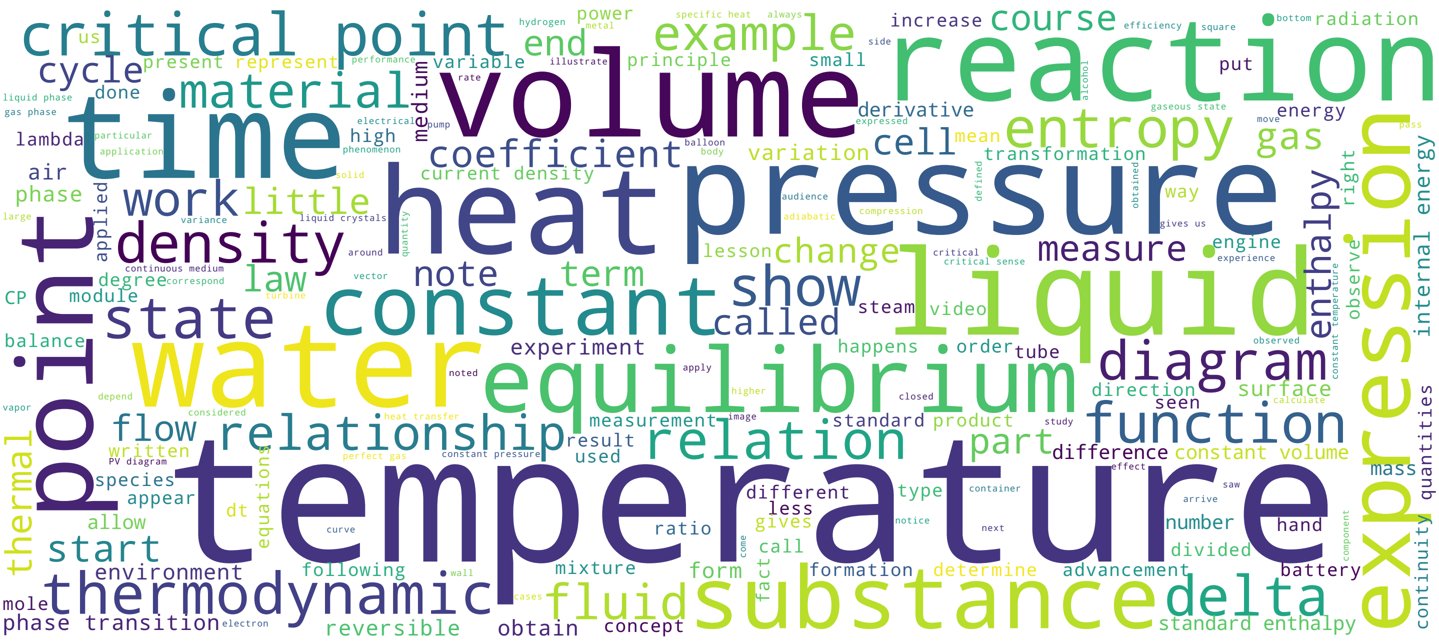
Expériences : Transitions de phases



Johannes Diderik van der Waals, 1837-1923

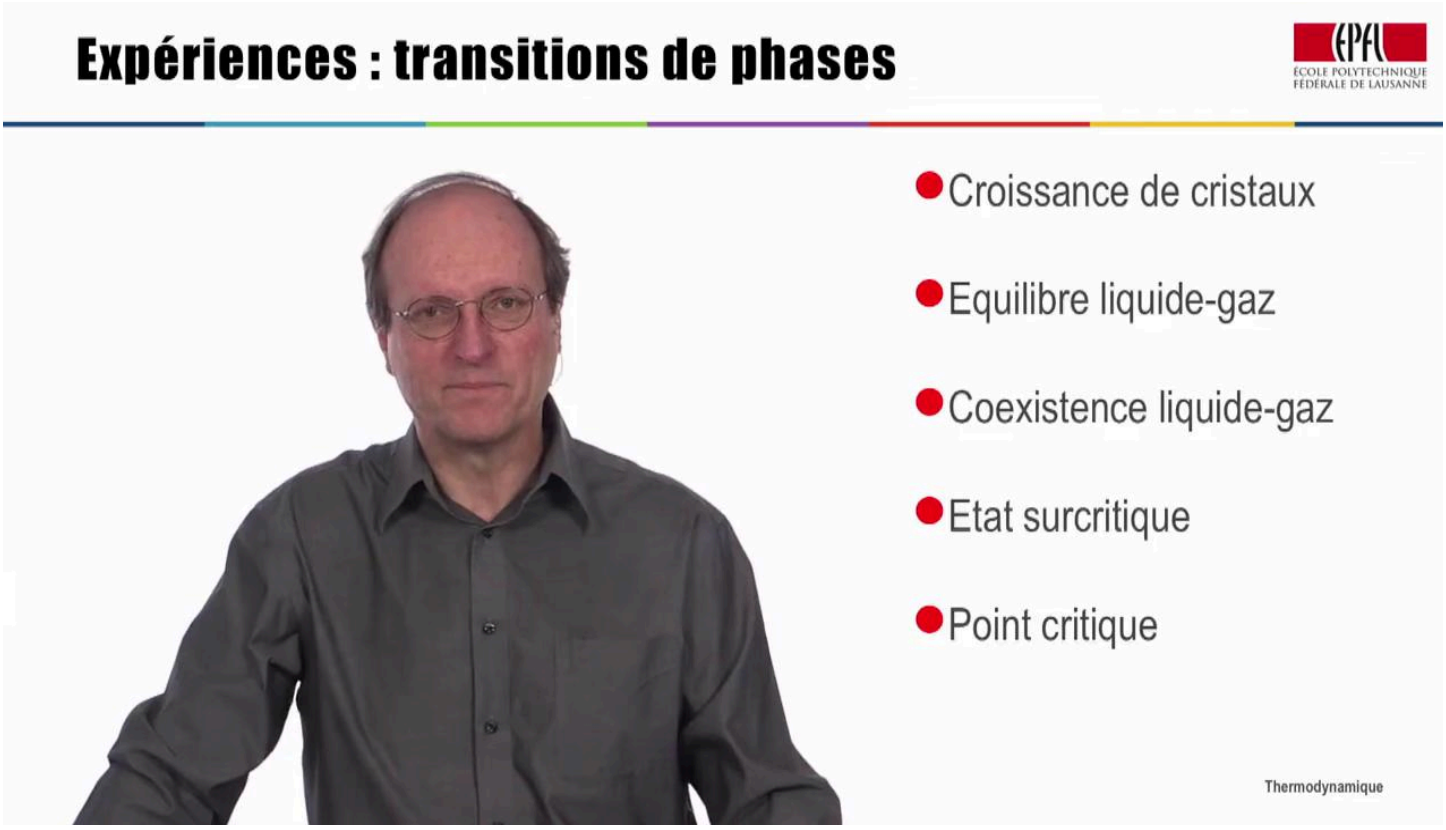
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Prof. Jean-Philippe Ansermet



Video

EPFL



Here I am again to present you some experiences in this lesson. Marc, briefly, talked to you about phase transition. In this sequence, I would like to illustrate the concept of phase transition by some experiments. I'd like to show you first. Under the microscope. A growth of crystals. Then I would like to discuss with you and see some numerical values, of the equilibrium pressure of a substance that is in equilibrium between its vapor phase and its liquid phase. Next, I would like to talk to you about the phase coexistence curve and see how we can have, in a system controlling its volume, a variable amount of liquid and gas. Next, I was showing a funny experiment related to the state on review that we define when we speak about the Van der Waals gas for example. And then I would like to show you a phase transition of the second order, the one obtained at the critical point.

Notes

Summary

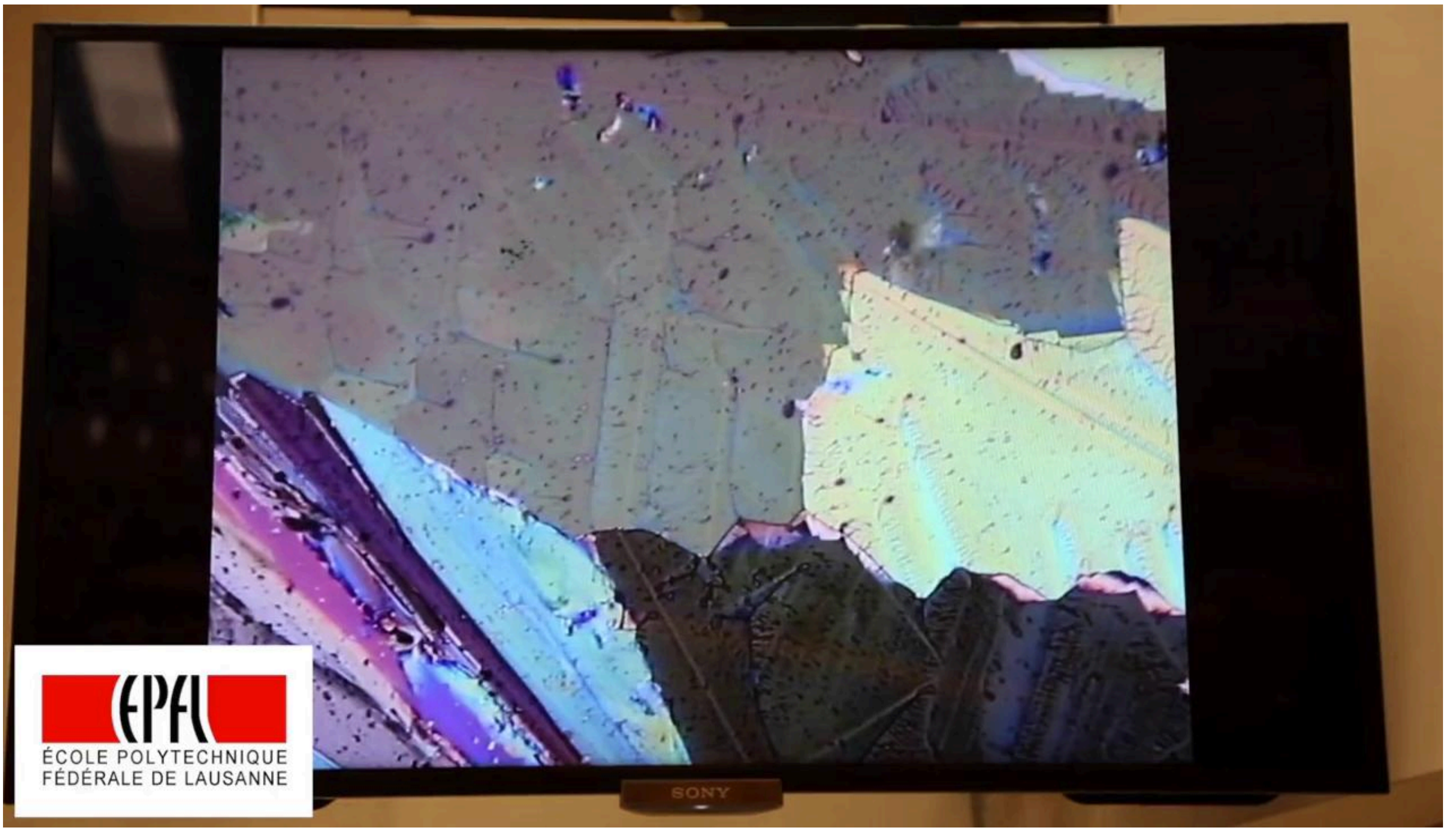
0m 04s

Let's start with crystal growth. We will look under the microscope. Liquid crystals. We have these liquid crystals on a glass slide, on a microscope mounted with crossed polarizers. When the substance is liquid, the polarizers being crossed, the image is black. When the crystals are formed due to their birefringence, we begin to see the light that passes through the sample and we get very nice colors.

Notes

Summary

1m 20s

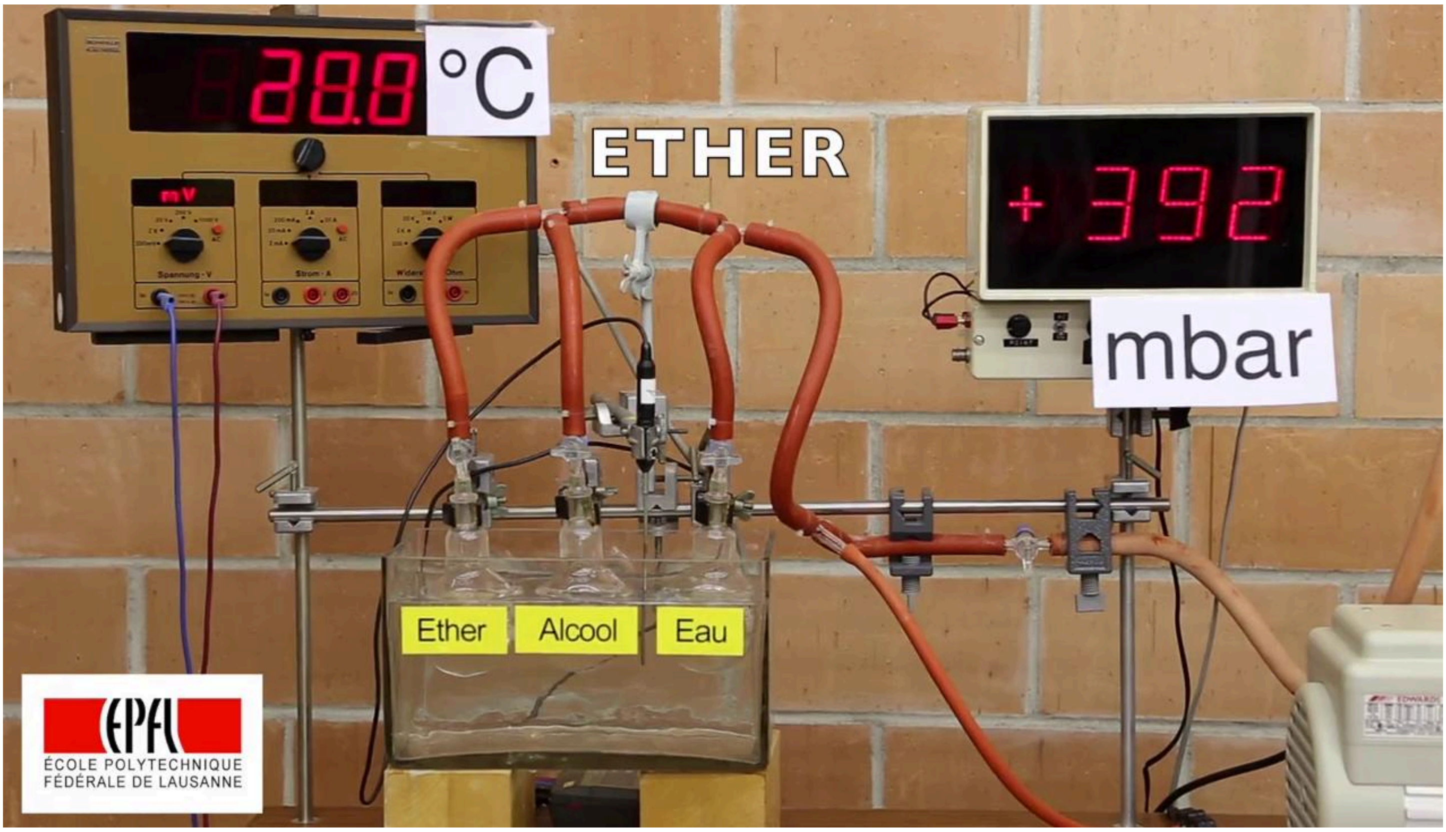


I invite you to watch the video. Here is Love, the image that we see in the solid state. Now the preparator heats the sample slightly. Christ, the substance passes to the liquid state. And we have a diffuse background with little light coming through. But little by little, the sample cools down. The critical temperature is passed again and we see from the right to form crystals by nucleation.

Notes

Summary

2m 03s



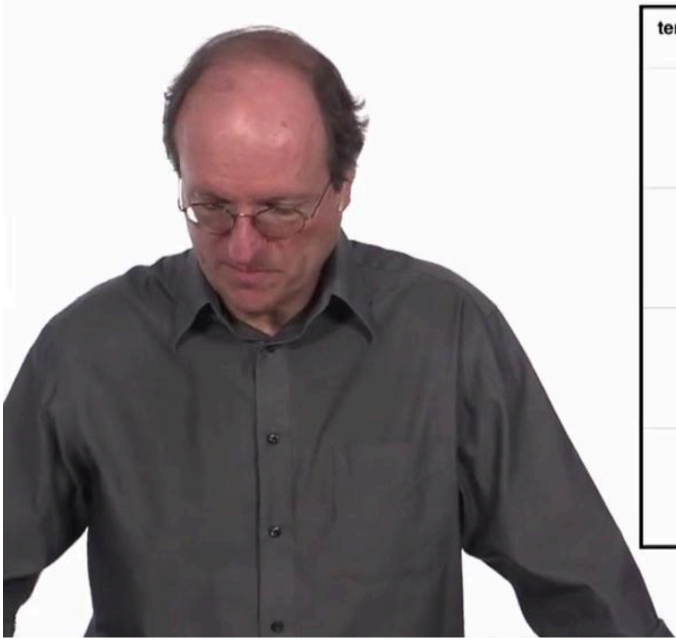
Let us now turn to the question of the balance of a substance. Who is present in a system at a given temperature, in its liquid and gaseous state. To do this experiment, we have the following setup. We have considered three substances, so we have three balloons that contain one of water, the other of alcohol, the third of earth. A pump ensures that each container contains only the substance under consideration and no air. The balloons are immersed in water which allows to ensure or define the temperature at which the pressure of the gas above the liquid will be observed. And of course we have a pressure gauge measurement. Observing the measure. These are the three containers. The three balloons. A valve that allows the pump to be shut off and the pressure to be measured. The thermostatic bath is. The preparer. Exposes the pressure gauge to one of the substances and notes the pressure. You will notice that here the measurement is done with a bottom at 20 degrees centigrade. Let's start again with alcohol. Of course, we closed the container for water, open the container for alcohol and measure the pressure of alcohol vapor above the liquid at a temperature of 20 degrees. Third experience with the Earth. We open in note the pressure of the lands. In equilibrium with the liquid at 20 degrees.

Notes

Summary

2m 50s

Equilibre liquide-gaz



température	pression saturante eau	pression saturante alcool	pression saturante éther
3°C	8 mbar	18 mbar	198 mbar
13°C	14 mbar	37 mbar	309 mbar
20°C	22 mbar	58 mbar	401 mbar
30°C	39 mbar	93 mbar	552 mbar

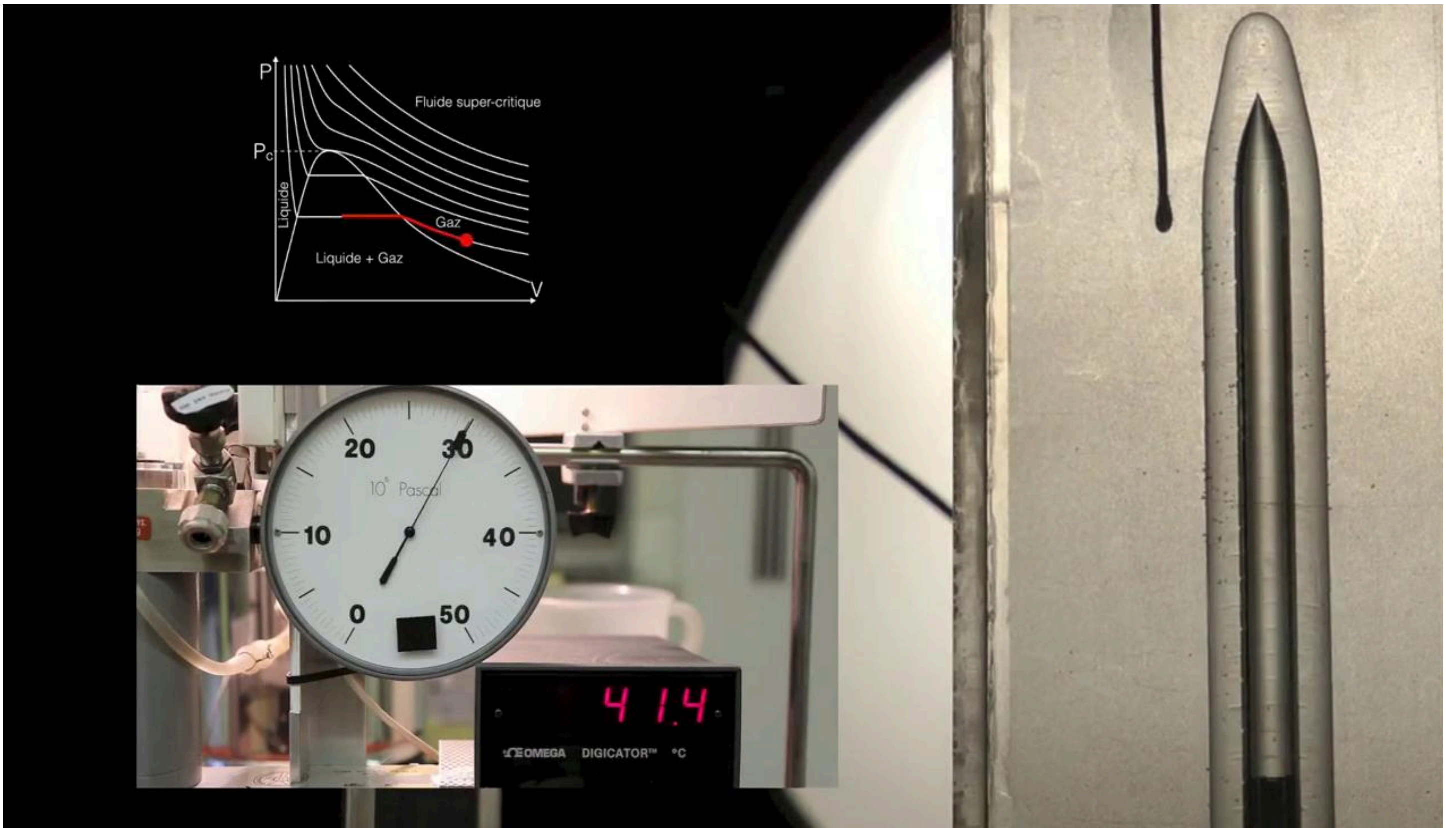
Thermodynamique

That's it. The preparer made his measurements with a thermal bath at several temperatures and here are the measurements he observed. You can use these measures for each substance. For example to make a graph of the line coexistence of phases between the gas phase and the liquid phase. For each of these substances. So you have the pressure? Depending on the temperature. And you can analyze the prediction of the Claudius Clapeyron equation, for example.

Notes

Summary

4m 54s

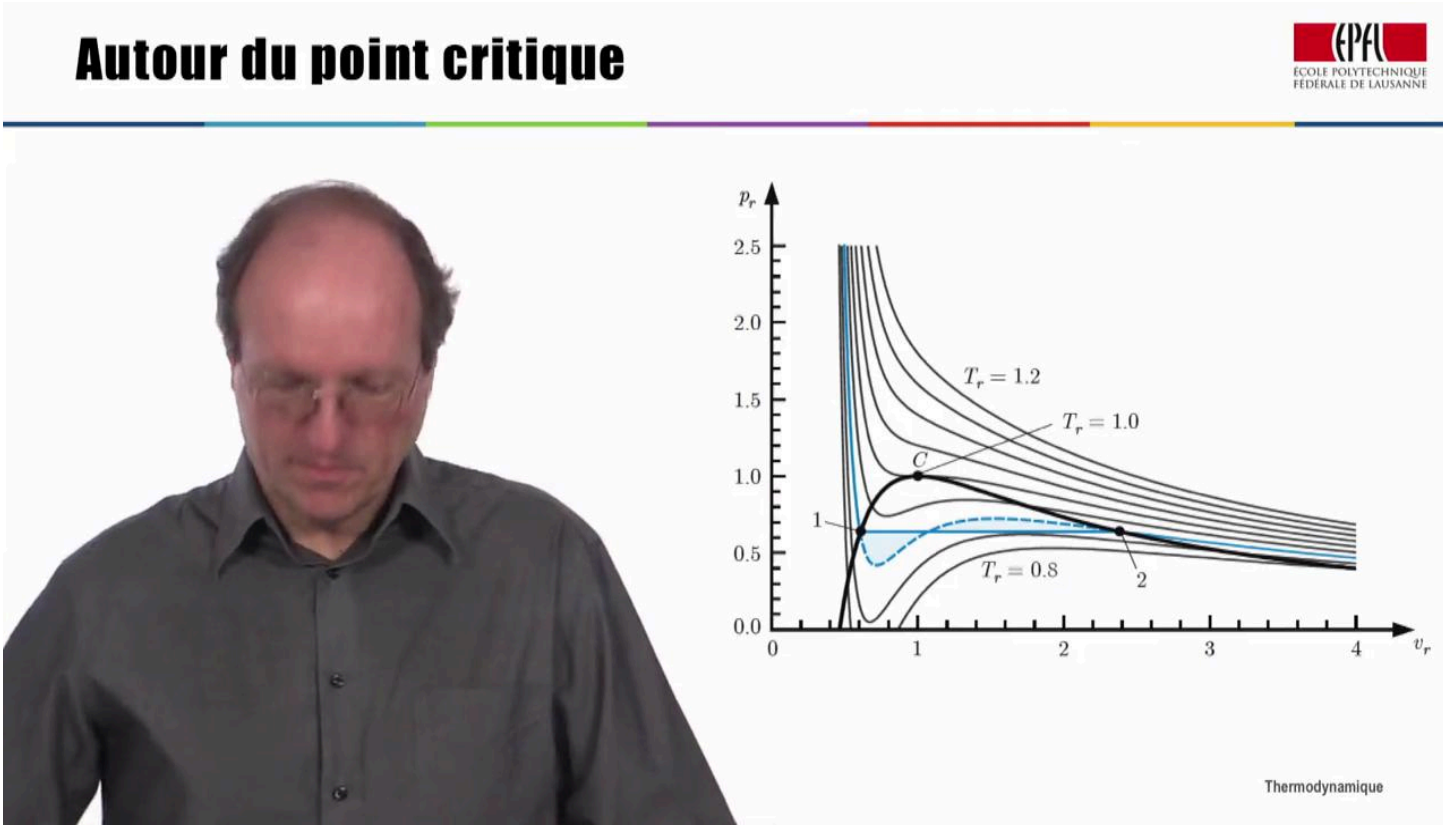


Now I'd like to show you another experiment. We see the coexistence of phases. Here we have a liquid, a type of Freon which is taken in a tube that you see on the right of the picture. The tube is closed with a drop of mercury that allows us to control the volume. From the system. Here we have a temperature measurement. This glass tube is immersed in water whose temperature is controlled. We measure the temperature here and we have a pressure measurement. The system enclosed in the tube. And here you have a typical Van der Waals diagram. Or we have iso terms on a pressure versus volume diagram. Watching the video, we start here. In the gas diagram, we pass the saturation pressure curve. We start to see liquid appearing. The more you decrease the volume, the more liquid you have. And we can observe that we can go back. And at the same point. The liquid disappears. We only have gas, therefore steam.

Notes

Summary

5m 40s

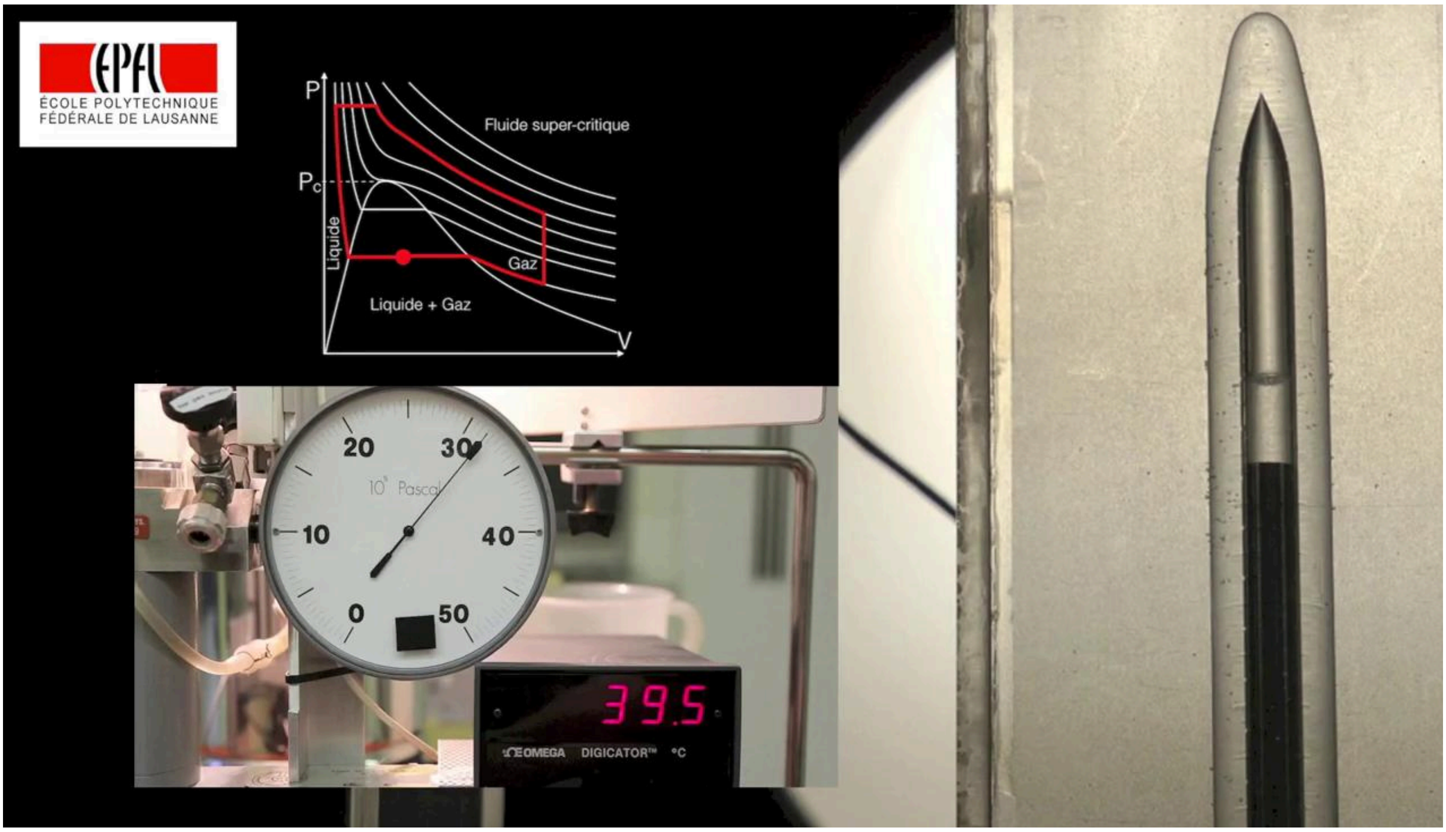


I would now like to show you a fun experiment that consists in turning around the critical point. So we will operate on the gas enclosed in the tube. A series of transformations that can be illustrated on a PV diagram. Here you have a PV diagram in relative units. The pressure is measured relative to the critical point pressure noted C on this diagram is the volume also related to the critical volume. Critical molar volume.

Notes

Summary

7m 09s

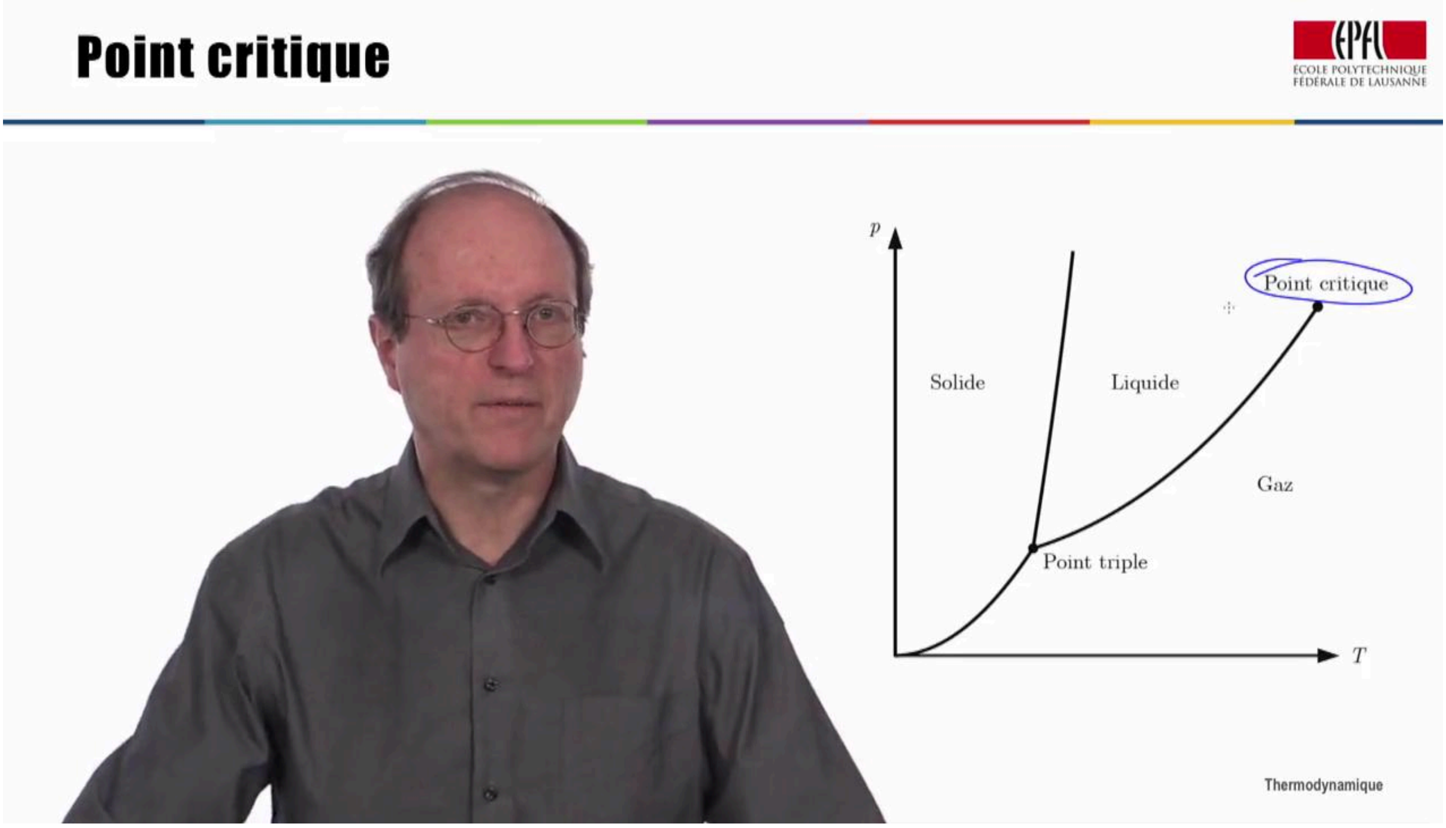


By watching the video, you can follow along on the diagram. The route we take around the critical point. Here we are in the gas phase on an ISO. Term. The temperature of the water around the tube ensures the temperature of the system. Now at constant volume, the meniscus is not moved from. Mercury and increase the temperature of the water. The temperature of the system is increased. And now we change the volume of the system at constant temperature. So we walk on an island at the end. In critical condition. This is experimentally the most difficult part to achieve. It is trying to change the temperature keeping the pressure constant or jerks that correspond to the adjustment of the preparator and the adjustment of the volume. What's next? In fact. Increase the volume. And what happens at this place? Gas appears. So we had in the tube on the picture on the right. We started by getting gas and we have turned around the critical point and we end up with a liquid. This is a good example of what happens in the critical phase.

Notes

Summary

7m 47s



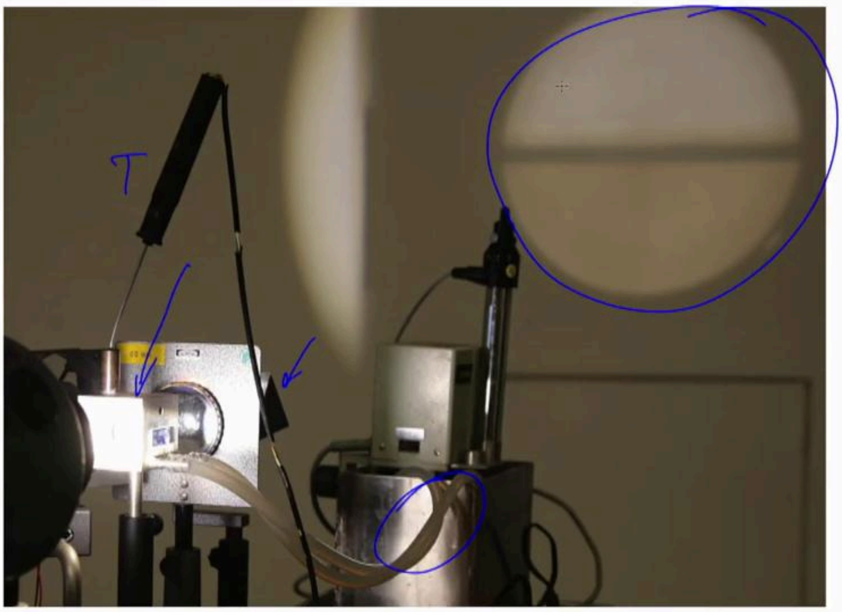
Now I would like to show you an experiment that we will drive to the nearest possible neighborhood of the critical point. I have represented here a typical pressure versus temperature diagram, we have the line of coexistence of phases between the liquid and the gas. And now I'd like to.

Notes

Summary

9m 27s

Point critique



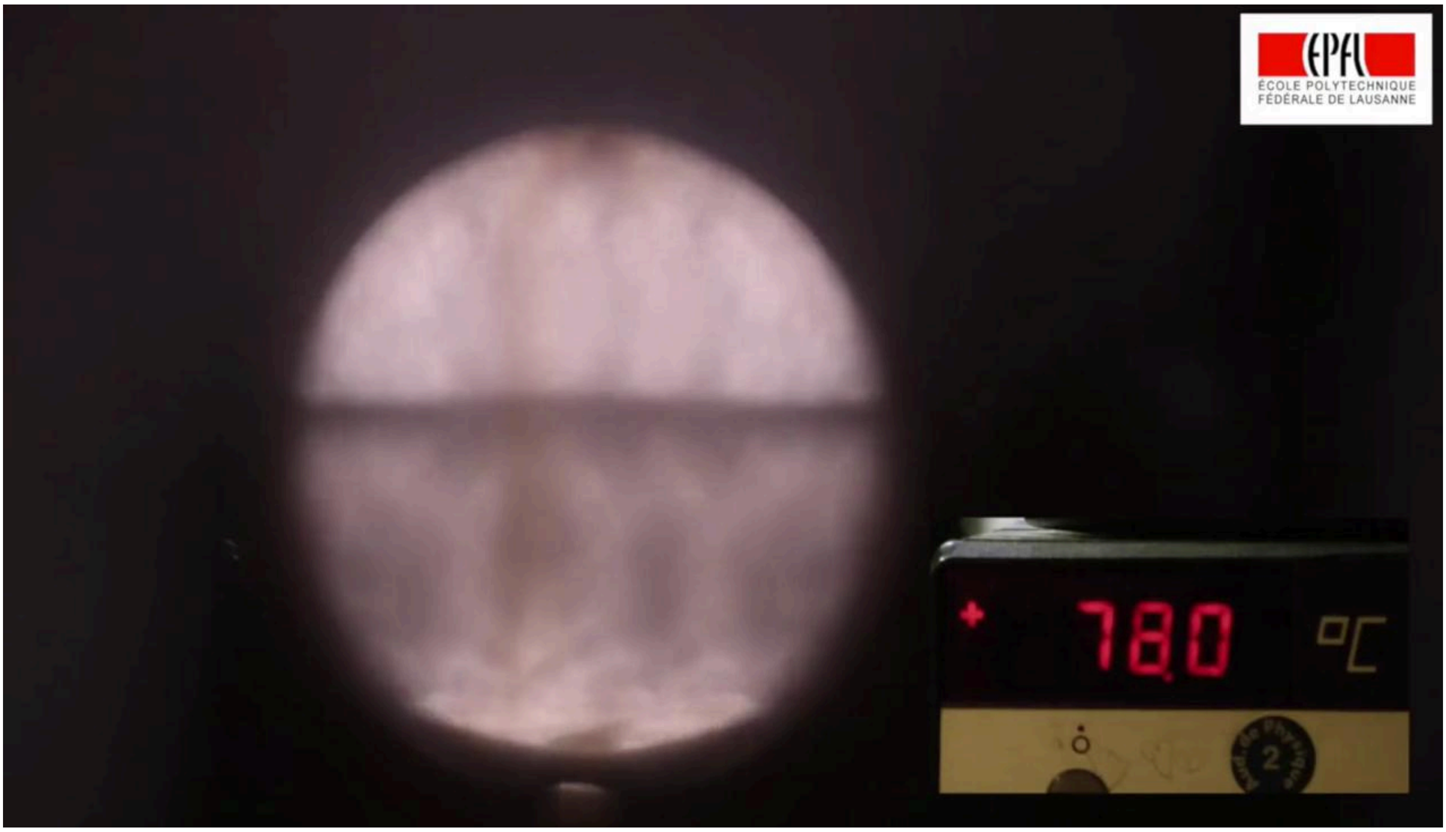
Thermodynamique

Look what's happening very close by of the critical point to observe what happens around the critical point? We have the following device here a cell that contains a fluid, a type of freon. There is just the right amount of material, has just the right pressure. To conduct the experiment, we measure the temperature of the cell which is controlled by a thermostatic bath. Do you recognize an intense light from an arc lamp? A lens. Behind the lens, there is a prism here that allows to give a safe image. The wall of the audience of what happens in the cell. I will now show you a film or we can see closely what happens in the cell when the temperature of the cell is near the critical point.

Notes

Summary

9m 57s

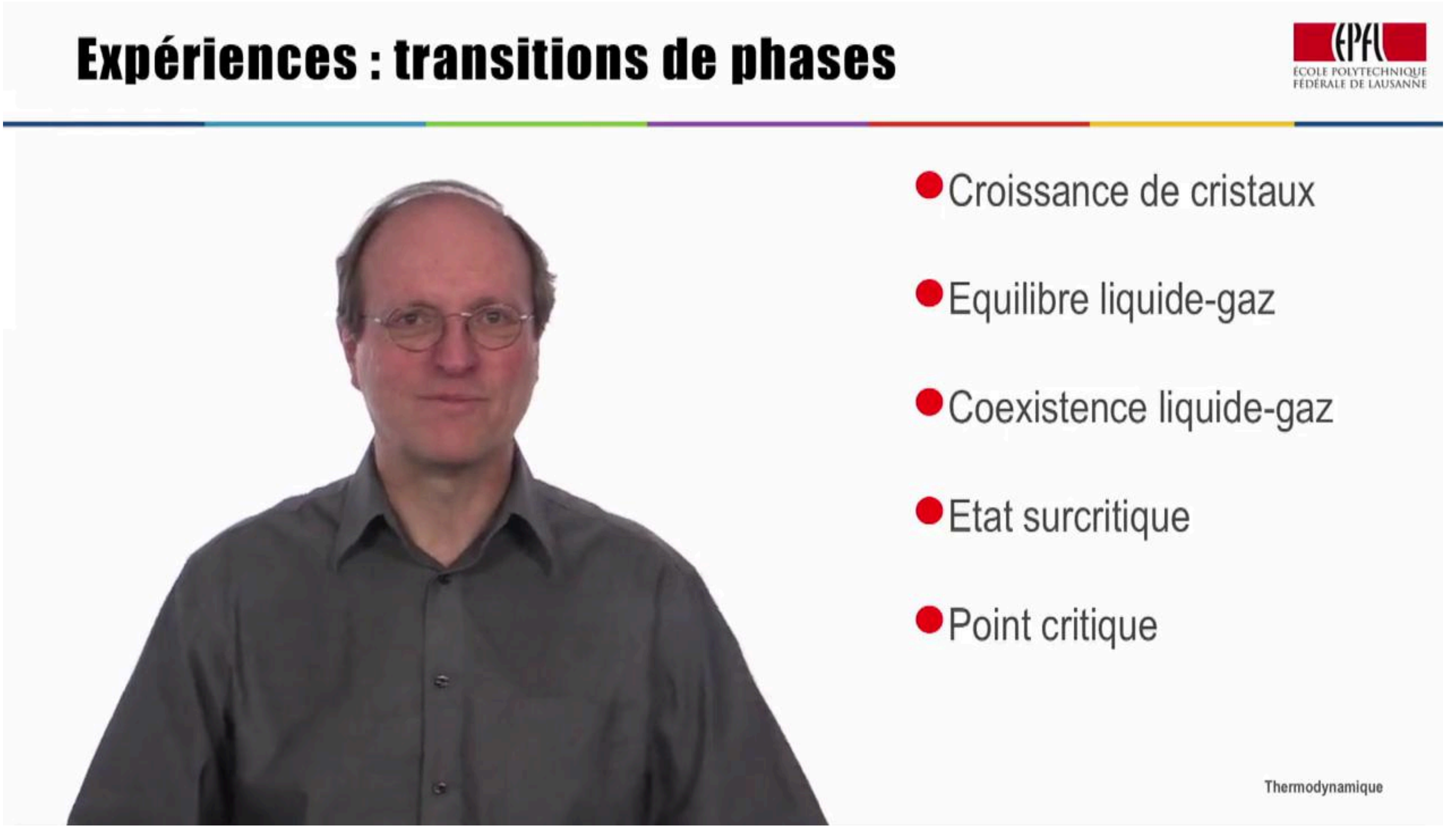


This is the bench in the audience. The cell. Thermostatic is. And the projected image of the cell projected on the screen of the audience. We are now one temperature below. From the critical point. And gradually, the temperature of the cell is lowered. The experience is delicate. You have to go slowly. You will suddenly see what is called OPA, critical thinking. There will be such fluctuations a production very small droplets, liquid of great fluctuation, the formation to the disappearance of these droplets that give rise to what we calls the OPA, the critical sense, here it comes. The color changes. And there you have it. We pass the phase transition. We can't see anything anymore. It's the water, not the critical senses. And now the temperature continues to drop and we Here is the presence of the liquid in the cell. The great fluctuation. But little by little. Here we go with it. The liquid at the bottom.

Notes

Summary

11m 01s



In this module, I have presented some experiments to illustrate the concept of phase transition. We first saw the phase transition crystal growth with liquid crystals. Then, we observed the pressure of vapor in equilibrium with the liquid of the same substance. And this at several temperatures. We saw how we could get around in a typical van der Waals gas PV diagram between the liquid state and the gaseous state with a coexistence of the two. We took a little walk in the space of the states, between the critical point and finally, we saw that at the critical point, there is a phase transition that takes place with large fluctuations that give to the so-called critical sense palate. Thank you for your attention.

Notes

Summary

12m 42s