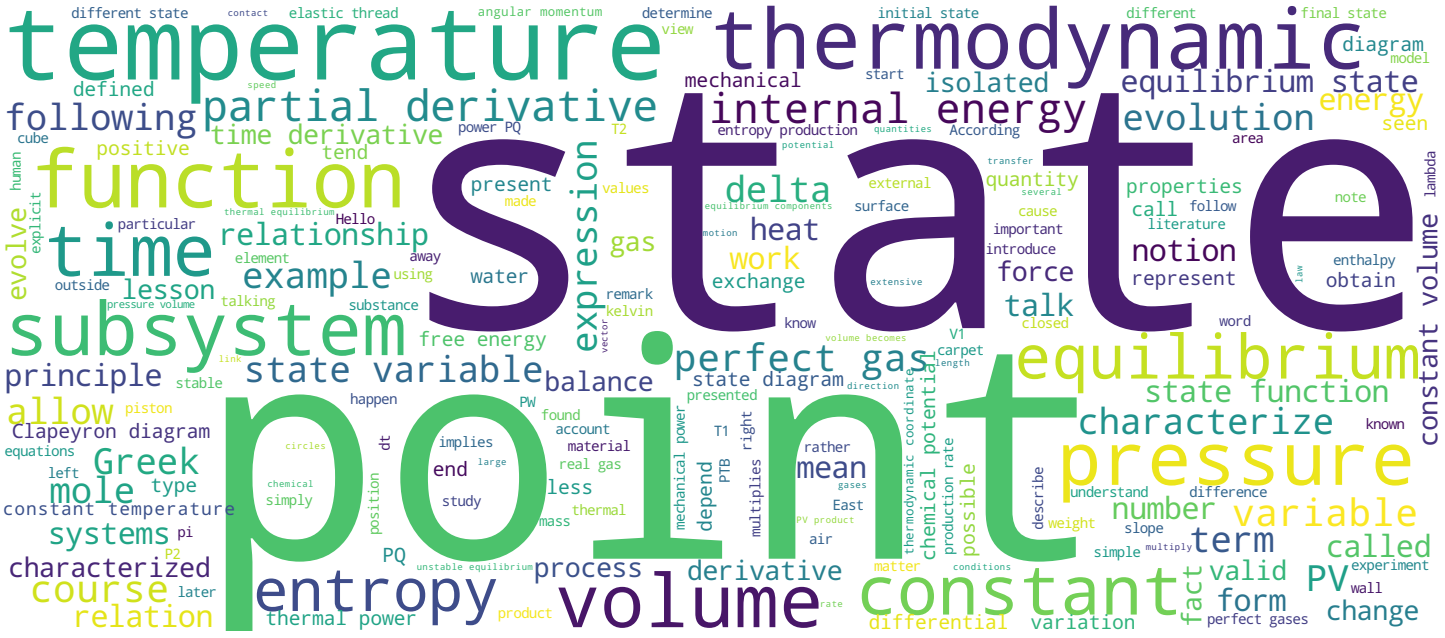
Thermodynamique

Equations d'état - Diagrammes d'état

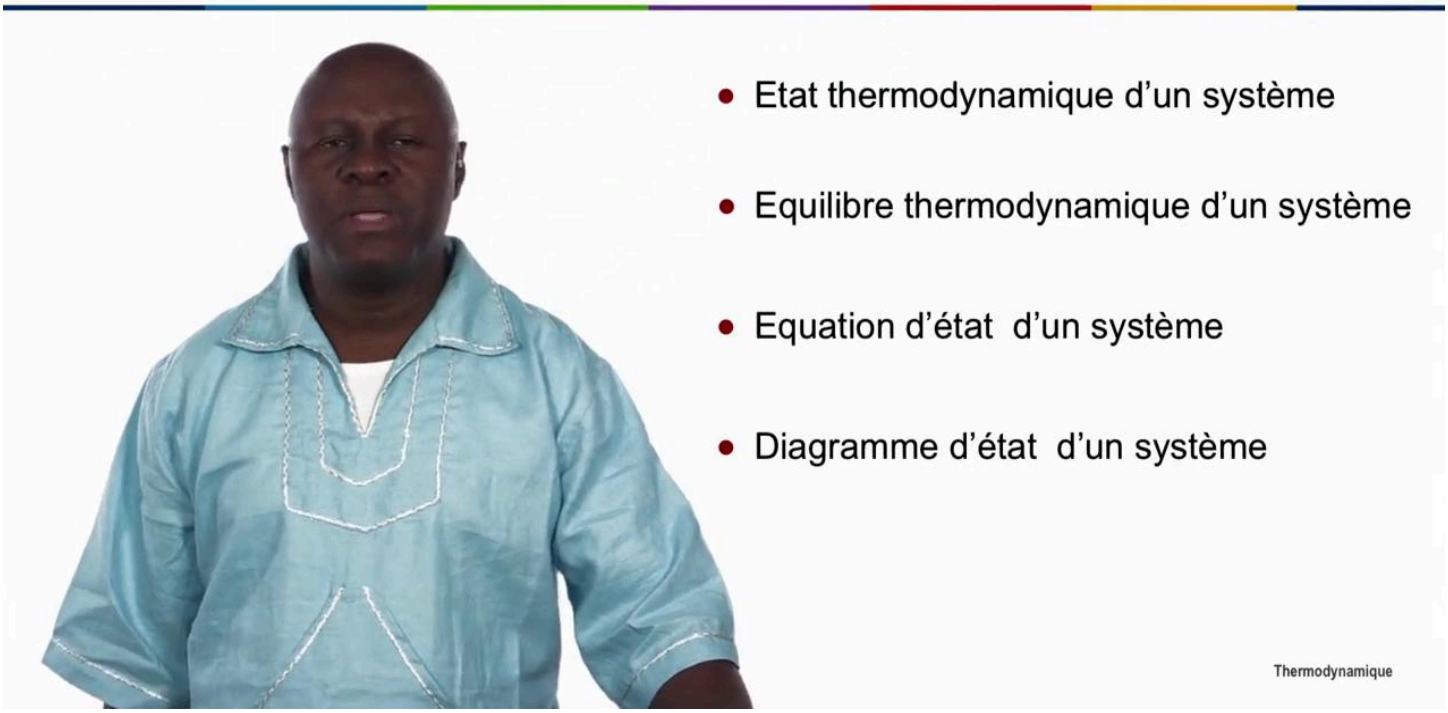
Ing. Dr. Paul-Salomon NGOHE-EKAM

Rudolf Clausius, 1822-1888



Video

Equations et diagrammes d'état



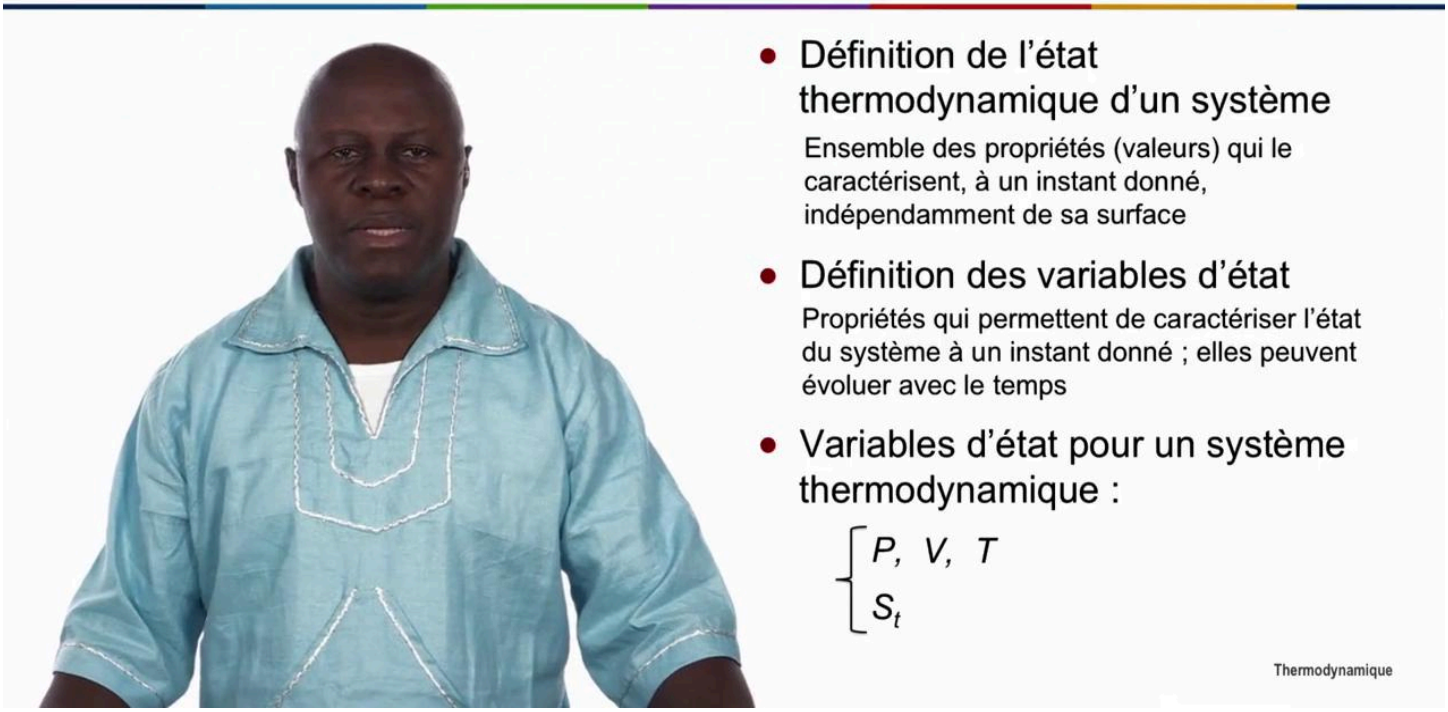
Hello. It was a real pleasure for me to contribute to the good story of thermodynamics coordinated by the Swiss Federal Institute of Technology in Lausanne, Switzerland. I am a lege and Dr. Paul Salomon is a teacher at the National School polytechnic of Yaoundé in Cameroon, that you maintain this time on the theme State Equations and state diagrams of a thermodynamic system. At the end of this lesson. You will be able to fully define. the state of a thermodynamic system. This definition will allow you to to understand or be able to determine the conditions in which a thermodynamic system can be an equilibrium. In third place. You will of course be able to understand and even describe the equation of state of any thermodynamic system that we can meet. And this state equation will allow you, on this condition of course, to be able to draw, to be able to draw diagrams of the state of a thermodynamic system. How can we define the state of a thermodynamic system?

Notes

Summary

0m 05s

Etat thermodynamique d'un système

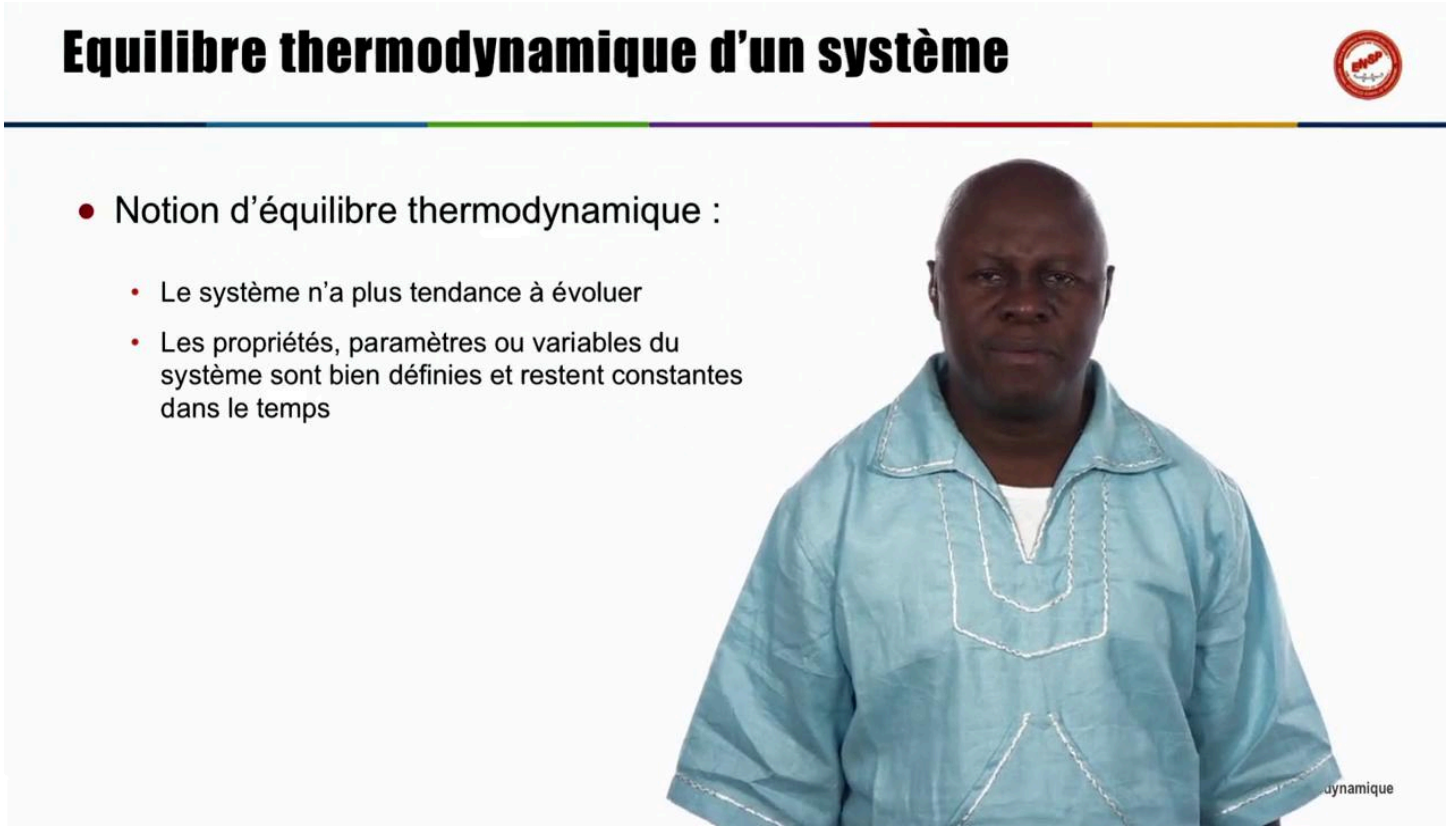


We will say that the state of a system thermodynamics is the set of properties or values which characterize the thermodynamic system at a given time. And regardless of what happens on its surface. Well, let's see now. How we can define. To validate many thermodynamic systems. We say it is valid. Lots of symptoms in Denmark are properties that allow to characterize this state or the state of these systems at a given time. And they are called valid because they are likely to change over time. Among the valid ones therefore. That allows us to define the thermodynamic state. We can note. The pressure, P the volume, v the system, the temperature T. But also the structure is. Are you from this system? And that calls for some remarks well after my remarks.

Notes

Summary

1m 29s



It is to report. That valid. Thermodynamics. Is also often called thermodynamic coordinate. Exactly like x. Has often been called the x-coordinate of some material point. The thermodynamic values are also. Thermodynamic coordinates. The second remark we will talk about. Take into account the specificity of classical thermodynamics. Fashion, classical music. We are going to launch statistical thermodynamics. Therefore, it is interested in the study of a system at a macroscopic scale. Therefore the internal structure of the system. Doesn't matter anymore. We just describe. The evolution of a system or the state of a system using the three parameters. The first three parameters, namely pressure, volume. And the temperature. Now let's talk about thermodynamic equilibrium. We will say that a single thermodynamic is an equilibrium when the system no longer tends to evolve. And as we have seen. It is valid theaters that are properties of the system and which allows to characterize it. Cessation of the evolution. Also allow to characterize a system as an equilibrium. The pleasant thing is that. The system is a balance. When it is valid heaps. Can be clearly defined. And when we see that it remains constant over time, there it is at equilibrium. Good. But the state of equilibrium has of course to be characterized from the qualitative point of view.

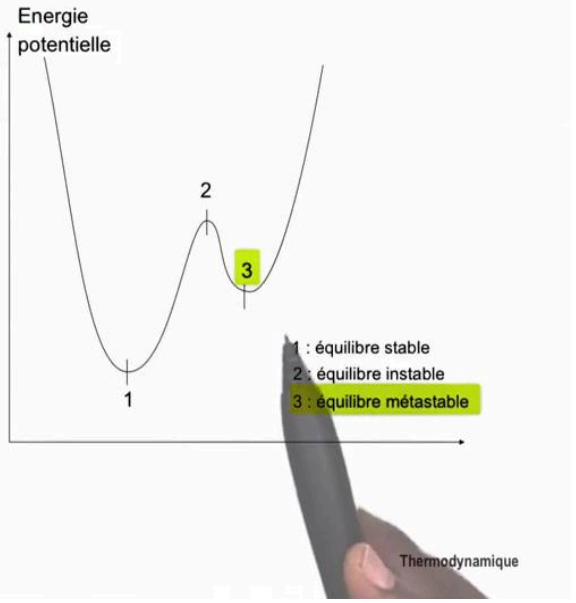
Notes

Summary

2m 47s

Equilibre thermodynamique d'un système

- Notion d'équilibre thermodynamique :
  - Le système n'a plus tendance à évoluer
  - Les propriétés, paramètres ou variables du système sont bien définies et restent constantes dans le temps
- Caractérisation qualitative de l'équilibre :
  - Stabilité
  - Instabilité
  - Métastabilité



That's why we can talk about stability of equilibrium in the different states of equilibrium that a system can have. And we call in particular on a system in which we can say the other is a human being in the gravitational system. So we will decline. We can then qualify the balance using the potential energy and the position of an individual. But the definition that we will give of the quality or qualification of the cubes is easily generalized. So we will speak of a stable equilibrium when the system is first an equilibrium whose parameters have stopped evolving. More. Second thing when, if we are far from the elements, the system of equilibrium components and system tends to return to it. There by talking about a stable balance. We then talk about an unstable equilibrium. If the system, even slightly from this state of equilibrium, it is observed that it tends to move away from it. further away that the system is there more of this equilibrium state as soon as a parameter validates elements. To the notion of stable and unstable equilibrium. We finally add the notion of balance and a metastable equilibrium state characterized by the fact that when the elements are discarded, the system of equilibrium components and moves further away from it, but towards a position more stable than the first or summer.

Notes

Summary

4m 58s

Equilibre thermodynamique d'un système

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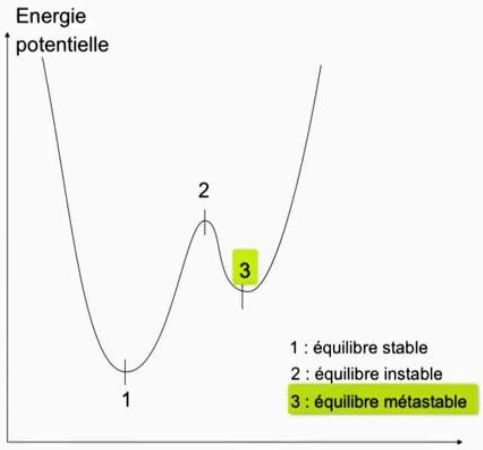

Thermodynamique

So that's the metastable balance. Very good. After talking about the balance thermodynamics of a system, we will now present a notion that characterizes this state of equilibrium. This is called the equation of state of a system.

Notes

Summary

6m 47s

Equation d'état d'un système

- Définition:

  Relation entre les variables d'état du système à tout état d'équilibre

  $$f(P,V,T)=0 \rightarrow \begin{cases} P=P(V,T) \\ V=V(P,T) \\ T=T(P,V) \end{cases}$$

- Exemples :
  - Gaz parfait : $PV=nRT$ R = 8,32 J/K/mol

Thermodynamique

We define the equation of state of a system as a relation between the thermodynamic variables of this system. But we also specify that this relationship, which takes place when the system, is a state of equilibrium outside of the equilibrium state, we do not know how the system evolves, but the equation of state of the system is a steady state equation systems of relationships that link the different parameters or variables of a system in the equation of the form f. From P. VD equals zero the area that will link pv summer. Of course, if we have a formal DCF relationship and it is possible to make explicit one valid, one will thus have relations in the form the variable P. Who will go with VT. The valid v that goes with a valid pt and the valid t temperature is a function of the valid pv. So we can see why this is already valid. the state could be composed of functions state long after the demerger, thus state rentals. Let's look at some examples of equation of state. The first example concerns a thermodynamic system that several of you have already borrowed, namely a perfect gas. Note that we present here the different equations of state without any effort from the East and Talbot from the East to go up in the perfect gas will thus be characterized by the equation pv equal to nt.

Notes

Summary

7m 05s

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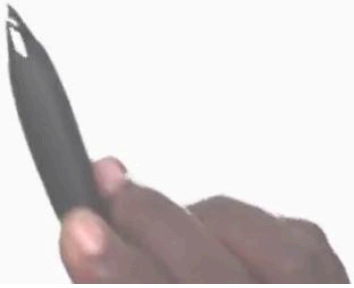
  - Gaz parfait : $PV=nRT$ R = 8,32 J/K/mol
  - Van Der Waals : $(P+\frac{n^2A}{V^2})(V-nb)=nRT$



Thermodynamique

When a state of equilibrium. And the circulation is worth 1.32 joule per kelvin and per mole is called the perfect gas constant. Of course, P is the volume of the gas and it is the pressure of the gas via its volume, its temperature and l is the number of moles of these gases. Of course, the idea of the perfect gas is only a utopian idea and the human being having been created imperfect, nothing else will be possible. There, the creature is perfect. So the perfect gases, that is only a view of mind. However, therefore, we have equations of state which is the real plane of the real gases and several musicians have tried to study. It is a gas and waves established for most of these gases. This equation of state. But let's say they are models which are sometimes derived from experimental studies. Thus, for example, Van der Valse proposes the following equation of real gas an equation in which we see well vane, pressure, volume and temperature. Is the number of Molène? But two other big questions, to Eglin and PTB. We will come back to this later. In the basic equation, therefore. We can notice that. When Gantois and PTB. One of my heroes, you can practically find him. Gas rental by fire.

Notes

Summary

8m 49s

Equation d'état d'un système

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  - Van Der Waals : $(P+\frac{n^2A}{V^2})(V-nb)=nRT$ *n=1 mole* $\Longrightarrow$ $(P+\frac{A}{V^2})(V-b)=RT$
  - Clausius : $(P+\frac{a}{TV^2})(V-b)=RT$
  - Dieterici : $P(V-b)=RTe^{-\frac{a}{RTV}}$
  - Fil élastique : $F=KT\left(\frac{L}{L_o}-\frac{L_o^2}{L^2}\right)$ $L_0 = L_0(T)$

Thermodynamique

Or when the volume becomes very large, which will cancel the erosion followed, spread out and will bring back the theme. N. B. Did you find the perfect gas fish? Well, we still point out than in the literature, you will find much more. The real gas equations with one mole. Thus, for the waltz wine gas equation. With a mussel. We have this equality in which it is clear that when V becomes infinite. We have the gas of Vendée. Go to the gas. Next equation the city gas given by Clausius. That in this regard the equation of faith pays me more to insult. Shift the car, multiply by 20. Moimbé equal to LT or pleasant stuck in the mold. He also pointed out that when V tends to infinity. The gas equation grows equations. This is the dedicated equation here. These words the fourteenth the form of P. Fighter by B. Mb. Equal was exponential from less to a TV. Here also we can see that when the volume becomes the eagle, the dedicated guy interested. Heirs, it can happen. An example of the state of a thermodynamic system. This time, the concept is not about gas anymore. INSOLITE This is the case, for example, of an elastic thread, so it can be dismantled.

Notes

Summary

10m 34s

Equation d'état d'un système

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Thermodynamique

It is mentally that an elastic thread subjected to a force and f having a constant of stiffness or elasticity K when it has an empty length l0. When the elastic thread and separates it from the force is f, et cetera The equilibrium is given by this equation. It is the length of the wire. When this is not the force is f, making the length multiply to eight by the temperature, the strongest reason for the length. When the thread has solicited knowledge equations of state, we can, but in the following, to define and even draw the state diagram of a system.

Notes

Summary

12m 18s

Diagramme d'état d'un système

- **Définition du diagramme d'état**

  Graphe 2D où sont représentés (par des points géométriques), les différents états d'équilibre du système lors d'une transformation

- **Les diagrammes d'état les plus utilisés**
  - Diagramme de Clapeyron : *(P,V)*
  - Diagramme de Amagat : *(PV,P)*
  - Diagramme entropique: (T,S)
  - Diagramme de Mollier*: (P,H)*
  - Diagramme *(H,S)*

Thermodynamique

Let's first define the. We assume that the state diagrams of a system is a representation of to dimensions of the different equilibrium states of these systems, a good evolution in the literature or among researchers, if you like. We are more used to presenting it. These different states in a 2D diagram and the most used ones that you encounter are the following. First, the Clapeyron diagram proposes to represent the gas pressure or the system as a function of its volume in a P versus V diagram. Thus, you have the diagram. Damana Hamada proposes to represent the PV product as a function of p. Then you have a diagram called a topic. During which the system temperature is represented as a function of a quantity. Do you later encounter what is known as a small of the system? We also find the diagram of Mollier, in which the pressure of the system in function. Two are a carpet, purchase of a carpet, but also an energetic size. All this will be clarified later. Come on, do you have the HS diagram? It's a carpet and it's to the company of greatness that you go later. We will now dwell on on the Clapeyron diagram and consider a most accurate equation of state simple, namely the equation of perfect gases.

Notes

Summary

13m 02s

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  - Diagramme *(H,S)*

- Cas d'un gaz parfait (1 mole)

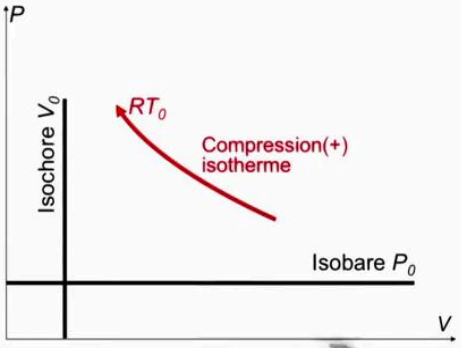

Diagramme de Clapeyron d'un gaz parfait

Thermodynamique

So, in a Clapeyron diagram which is a P diagram. We will note first that when the system evolves at constant volume. Points. Such a state of equilibrium is found on a vertical, for example. For their volume preserved water. Thus the water bodies. A constant volume evolution of a perfect gas. According to the Clapeyron diagram, represented by a vertical segment when the system evolves this time, not at constant volume, at constant pressure obviously, it is the pressure of the water evolution or the set of points of evolution corresponding to zero is found on an area on a zone such as we will call an isobar. Now, the pressure and volume of perfect gases may not be constant. For example, when we have rather the constant temperature, we will consider the case or in addition to gas at constant temperature. The conclusion is the main fact that the volume. Decreases and the power increases, so does this one. And when for a ball we have the sum pv equal to it t0. This is the constant temperature. It is included in the PV which is equal to to was water which is equal to constant in pressure. This from the constant raised form of a branch. The hyperbole and in this sense is the white is not known in this sense.

Notes

Summary

14m 40s

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- **Cas d'un gaz parfait (1 mole)**

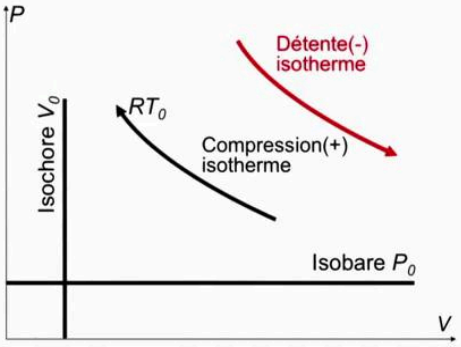

Diagramme de Clapeyron d'un gaz parfait

Thermodynamique

Moreover, of volume dimension, we have an isotropic composition. And if the evolution is rather in the other direction, so the pressure decreases, the volume increases. We will have a relaxation. ISO t1. So here is a Clapeyron diagram for the perfect gas. Are you kidding? A Damana diagram for a perfect gas?

Notes

Summary

16m 22s

Diagramme d'état d'un système

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- **Cas d'un gaz parfait (1 mole)**

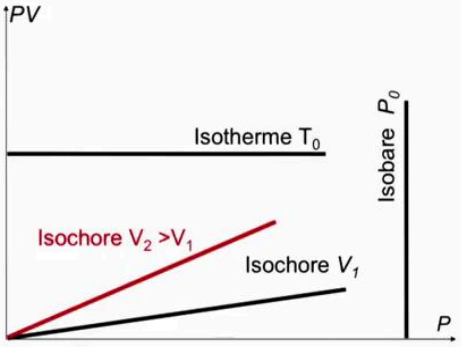


Diagramme de Amagat d'un gaz parfait

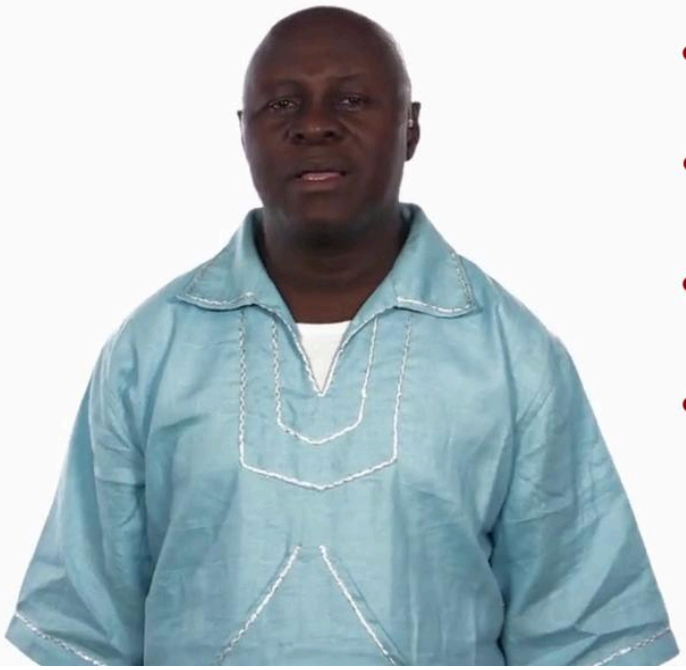
Good. Morgan's diagram is the PV product as a function of p. And the perfect gas is characterized by the crescent of state PV equal to FT. When we consider a mole, well then in this diagram, we won't have any more takes me away from the zero. When T is equal to zero, a constant we have the product PV that was there the RD zero it is by noting PV that constant. So the point of evolution along a straight line with PV equal to constant. Here we have a hypothesis. Of course, if the system evolves at constant volume and pressure, then we will talk about of an isobaric isobaric and represent no points whose pressure is constant. This weight has shifted in a. A vertical line segment in the Amara diagram. Now, what will a. Evolution or an iso core transformation. ISO. This means a constant volume. If the volume is constant, the weight of the PV would be equal to five times the pressure constant to the slope of the curve coming from the origin of abandonment to the body V1. Or V1 and in fact the slope of this law. Of course, if we have a glue with a volume more important, the slope of the line will be even more important in our schools. We want to keep it. Here is presented as simply a magma diagram for the perfect gas.

Notes

Summary

16m 47s

Equations et diagrammes d'état



- Etat thermodynamique d'un système
- Equilibre thermodynamique d'un système
- Equation d'état d'un système
- Diagramme d'état d'un système

Thermodynamique

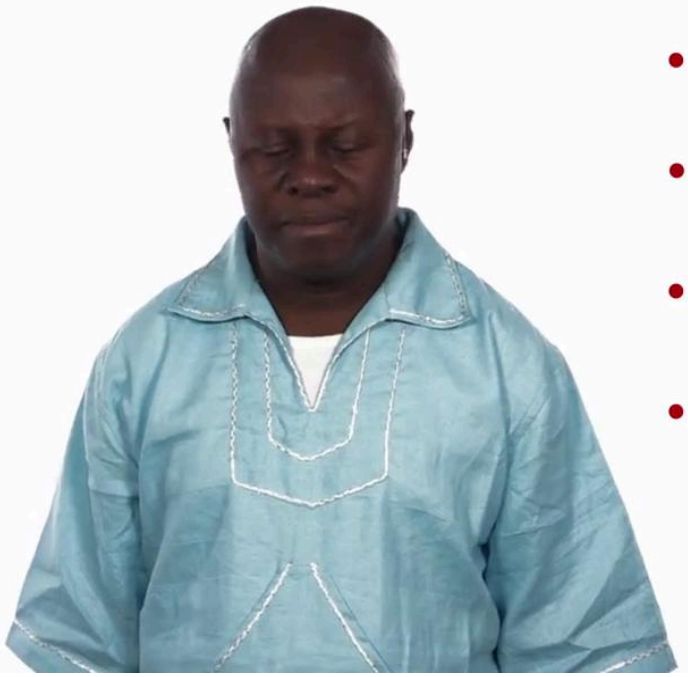
To conclude this lesson. We see that we have presented. Or defines the thermodynamic state of a system. We don't have a valid one. the state of the system. Data that allow to characterize the state of these systems. We have thus introduces the notion of equilibrium in a word of thermodynamics, characterized by the fact that the valid state. Are fully defined and have constant values over time. The state equation, which is a relationship between the different state values of a system at an equilibrium state. The sum of the f-form of PVT and are zero at. We ended by saying that when we have an evolution. And this is a reversible evolution, that of a reversible system, because in this case, states of equilibrium, as you will see later. If you haven't already seen the. The transmission is a succession of equilibrium states very close to each other. So if we have a target transmission. We can define a state diagram in which we represent the relation between the different valid PVT and the equilibrium states. We have therefore seen that several studies have made it possible to retain. This is a particular diagram, namely the Clapeyron word diagram which made him raise the diagrams of Amarna.

Notes

Summary

18m 37s

Equations et diagrammes d'état



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- Diagramme d'état d'un système

Thermodynamique

What is the most PV as a function of p etc.? Seems like 20 times to me to see the pool during this study and it is your full attention. We hope to have you present again next year. The Holy Thank You.

Notes

Summary

20m 25s