Wrocław University of Science and Technology

Physics

JZL1001913C

summer semester

2020/2021

Wednesday, 18:20 - 19:50

Friday, 18:20 - 19:50

virtual room (ZOOM)

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https://majsylw.netlify.app/

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Outline

- Introduction - Physics rules the world
- Motion phenomena - Kinematics
- Motion phenomena - Dynamics
- Rotational motion
- Harmonic motion
- Gravitational field
- Relativistic phenomena
- Basics of Thermodynamics
- **Principles of Thermodynamics**
- Kinetic theory of matter
- Electrostatics
- Electric current
- Magnetic field
- Vibrations and electromagnetic waves
- Optics
- Quantum nature of radiation
- Nuclear Physics

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Thermodynamics

- short rewiev

Pressure $P = F/S$	Unit 1 Pascal $=1N/m^2$
Heat capacity **<value depends on materia>**	Unit J/kg/K
Heat $Q = mc\Delta T$	Unit 1 kg * J/kg/K * K = = J
Heat of change $Q = m\Delta T$	Unit 1 kg * J/kg = J

Quantities:
- Temperature
- Pressure
- Heat
- Specific heat capacity
- Heat of fusion/vaporation

The ideal gas law

$$PV = nRT$$

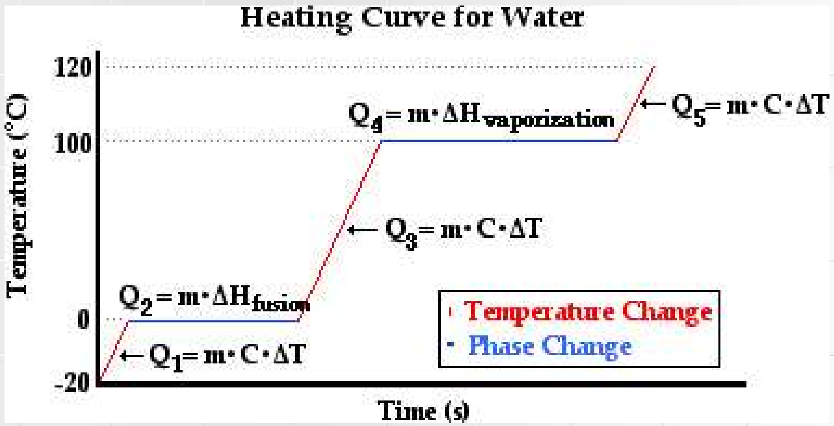
Process	Important point to remember
isothermal	Constant T, $\Delta U = 0$, $Q=W$
isovolumetric(isochoric)	Constant V, $W = 0$, $\Delta U=Q$
Isobaric	Constant P,$\Delta U = Q- (-P\Delta V)$
adiabatic	Nothing is Constant, $Q = 0$, $\Delta U= -W$

Example Problem 2 - review

So now we will make an effort to calculate the quantity of heat required to change 50.0 grams of water from the solid state at -20.0°C to the gaseous state at 120.0°C. The calculation will require five steps - one step for each section of the graph. While the specific heat capacity of a substance varies with temperature, we will use the following values of specific heat in our calculations:

Solid Water: C=2.00 J/g/°C
Liquid Water: C = 4.18 J/g/°C
Gaseous Water: C = 2.01 J/g/°C

Finally, we will use the previously reported values of ΔH_{fusion} (333 J/g) and $\Delta H_{vaporization}$ (2.23 kJ/g).



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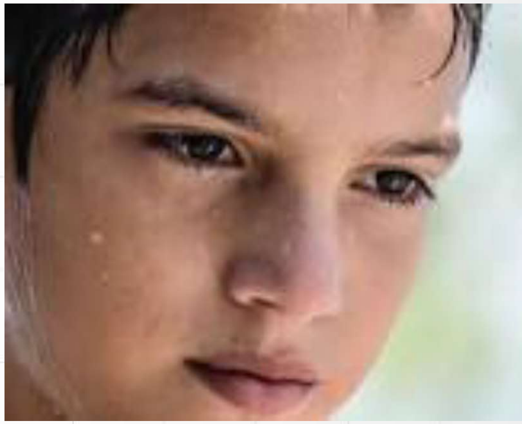
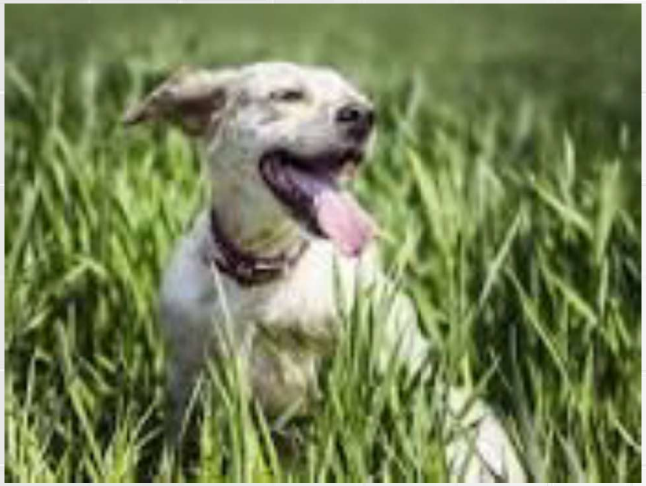
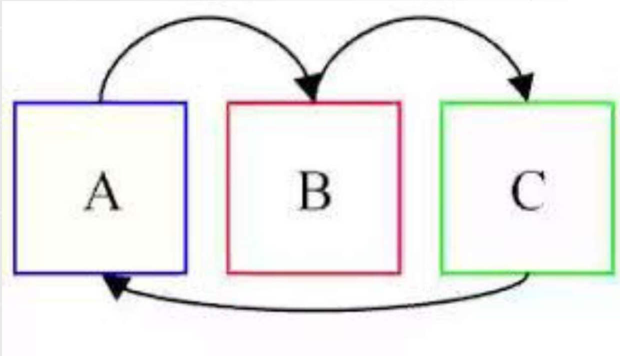
Principles of Thermodynamics

The laws of thermodynamics are simple to state. Do you know that the human body obeys the laws of thermodynamics? We start to sweat and feel warm when we're in a room full of people and the sweating becomes excessive if the room size is small. This happens because your body is trying to cool off hence heat transfers from your body in the form of 'sweat'. This entails the first law of thermodynamics. Interesting? Let us study more.



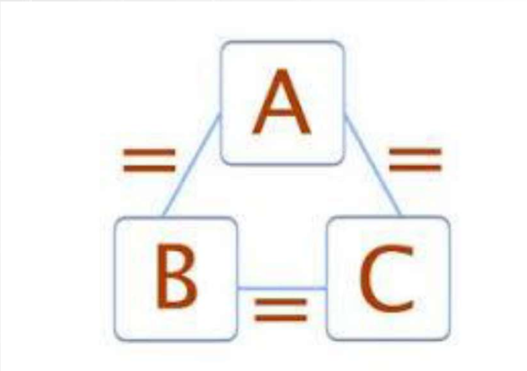


Zeroth Law of Thermodynamics



If two thermodynamic systems are in thermal equilibrium with a third, they are also in thermal equilibrium with each other.

This is named zeroth law because it is basic law that is formulated after the three laws are formulated. The above is the actual statement for Zeroth law of Thermodynamics. This can be understood as follows:



When two bodies, of which one is at a higher temperature than the other, are kept in contact, heat energy flows from the one at the higher temperature to the one at lower temperature.

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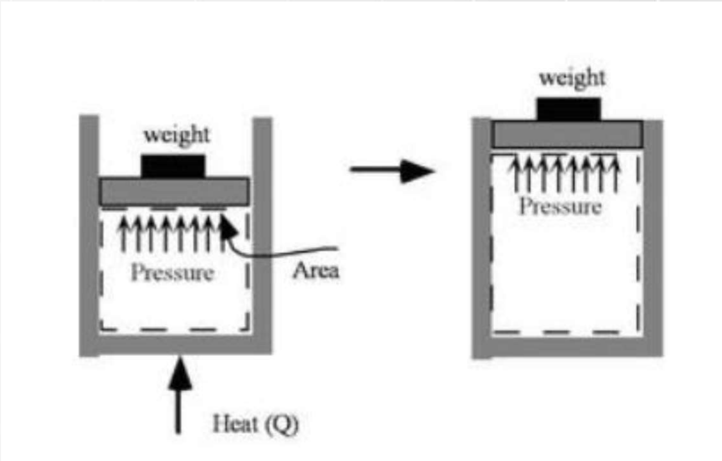
First Law of Thermodynamics

The first law of thermodynamics states that the total energy of an isolated system is constant. Energy can be transformed from one form to another, but can neither be created nor destroyed.



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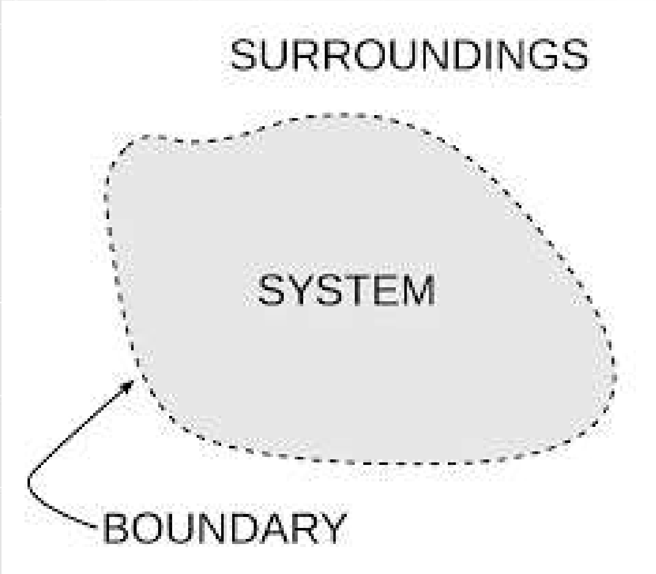
System

In thermodynamics, the system is defined as a definite space or area on which the study of energy transfer and energy conversions is made.

- **Open system:** System in which both mass and energy cross the boundaries of the system.
- **Closed system:** System in which mass does not cross boundaries of the system, though energy may do so.
- **Isolated system:** System in which neither mass nor energy crosses the boundaries of the system.



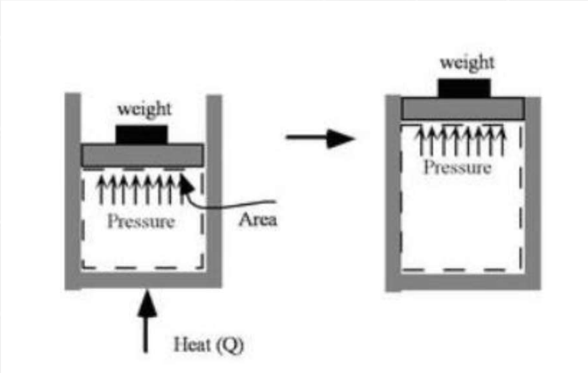
Boundary

The system and surroundings are separated by a boundary. It may be fixed or movable or imaginary. It will not occupy any volume or mass in space.

Surroundings

Anything outside the system which affects the behavior of the system is known as surroundings.

First Law of Thermodynamics



According to this law, some of the heat given to system is used to change the internal energy while the rest in doing work by the system. Mathematically,

$\Delta Q=\Delta U+\Delta W$

where,

ΔQ = Heat supplied to the system

ΔW= Work done by the system.

ΔU = Change in the internal energy of the system.

If Q is positive, then there is a net heat transfer into the system, if *W* is positive, then there is work done by the system. So positive *Q* adds energy to the system and positive *W* takes energy from the system.

It can also be represented as **$\Delta U=\Delta Q-W$**

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Limitations of First Law of Thermodynamics

- The limitation of the first law of thermodynamics is that it does not say anything about the direction of flow of heat.
- It does not say anything whether the process is a spontaneous process or not.
- The reverse process is not possible. In actual practice, the heat doesn’t convert completely into work. If it would have been possible to convert the whole heat into work, then we could drive ships across the ocean by extracting heat from the water of the ocean.

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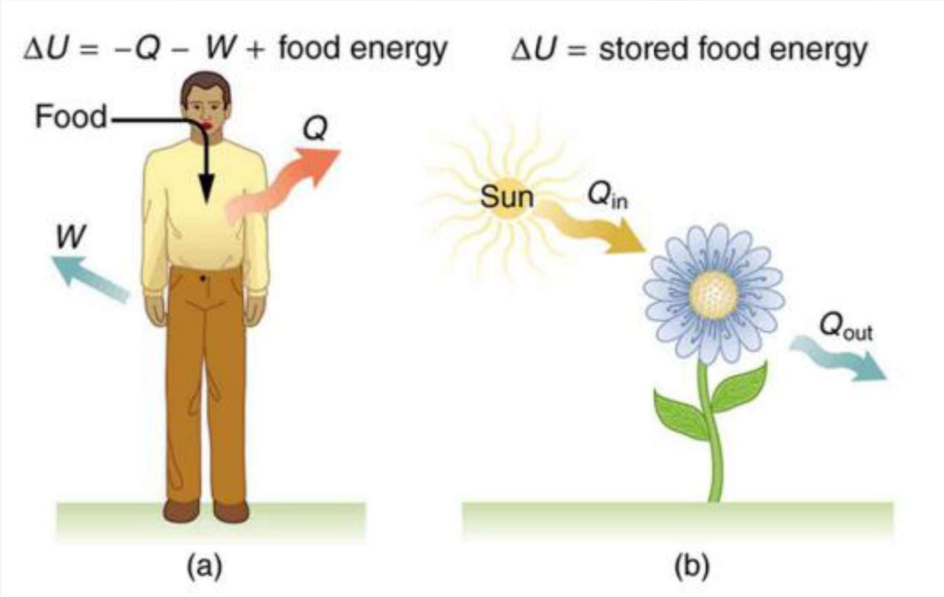
Explanation of First Law of Thermodynamics



The first law of thermodynamics applied to metabolism. Heat transferred out of the body (Q) and work done by the body (W) remove internal energy, while food intake replaces it. (Food intake may be considered as work done on the body.)

Plants convert part of the radiant heat transfer in sunlight to stored chemical energy, a process called photosynthesis.

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Example 1

Find out the internal energy of a system which has constant volume and the heat around the system is increased by 50 J?

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Example 1

Find out the internal energy of a system which has constant volume and the heat around the system is increased by 50J?

Sol: Given, $Q = -50$ J

Since the gas is in constant volume, $\Delta V=0$

$W= p\Delta V=0$

The equation for internal energy is: $\Delta U = Q + W$

$\Delta U= q+0$

$\Delta U = q = -50$ J

Second Law of Thermodynamics

If you ever drop a glass and watch it shatter, you know there is no way of going back in time and getting back the unbroken glass. This is irreversibility. **The second law of thermodynamics states that the heat energy cannot transfer from a body at a lower temperature to a body at a higher temperature without the addition of energy.** This is why running an air conditioner for a long period of time, costs you money.

Total conversion of heat into work is not possible i.e 100% efficiency is not possible as it will lead to a negative change in entropy of universe which is not valid according to the Second Law of Thermodynamics. **No heat engine can be 100% efficient**

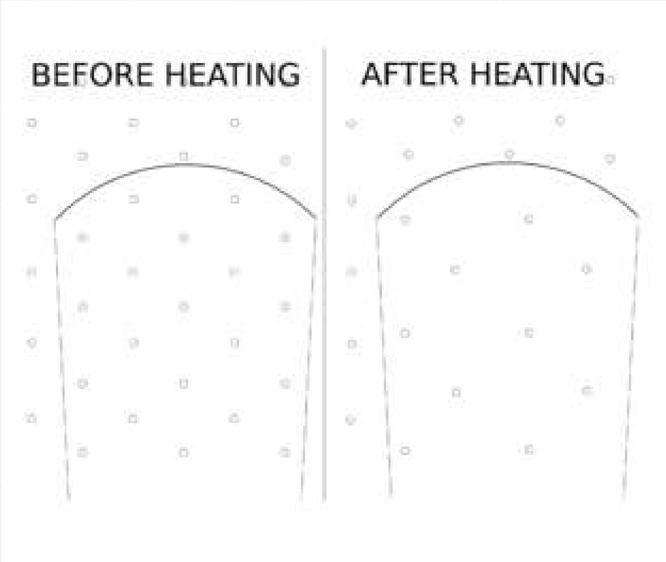
Some obvious truth

Kelvin-Planck statement
It is impossible to convert all the heat extracted from a hot body into work. In the heat engine, the working substance takes heat from the hot body, converts a part of it into work and gives the rest to the cold body. There is no engine that can convert all the heat taken from the source into work, without giving any heat into the sink. This means that for obtaining continuous work, a sink is necessary.

Clausius statement
It is not at all possible to transfer heat from a cold body to a hot body without the expenditure of work by an external energy source.

Entropy

Let us see what is entropy, and its relation to the second law of thermodynamics. The entropy of the system is measured in terms of the changes the system has undergone from the previous state to the final state. Thus the entropy is always measured as the change in entropy of the system denoted by ΔS. If at all it is necessary to measure the value of the entropy at a particular state of the system, then zero value of entropy is assigned to the previously chosen state of the system.



Increase in Entropy

Causes of increase in entropy of the closed system are:

- In a closed system, the mass of the system remains constant but it can exchange the heat with surroundings. Any change in the heat content of the system leads to disturbance in the system, which tends to increase the entropy of the system.

- Due to internal changes in the movements of the molecules of the system, there is disturbance inside the system. This causes irreversibilities inside the system and an increase in its entropy.

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Thermodynamic Processes

A system undergoes a thermodynamic process when there is some sort of energetic change within the system, generally associated with changes in pressure, volume, internal energy (i.e. temperature), or any sort of heat transfer.

There are several specific types of thermodynamic processes that have special properties:

- **Adiabatic process** - a process with no heat transfer into or out of the system.
- **Isochoric process** - a process with no change in volume, in which case the system does no work.
- **Isobaric process** - a process with no change in pressure.
- **Isothermal process** - a process with no change in temperature

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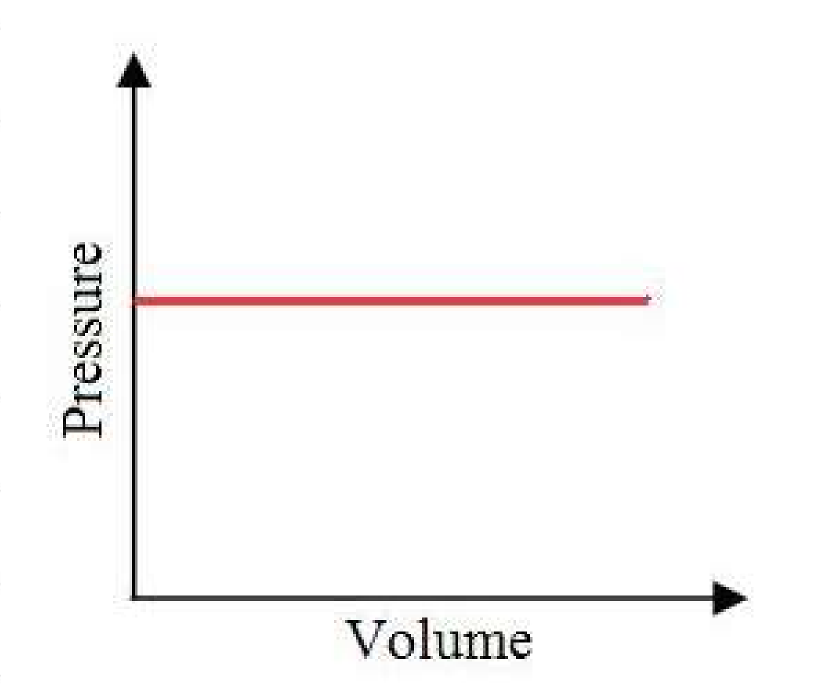
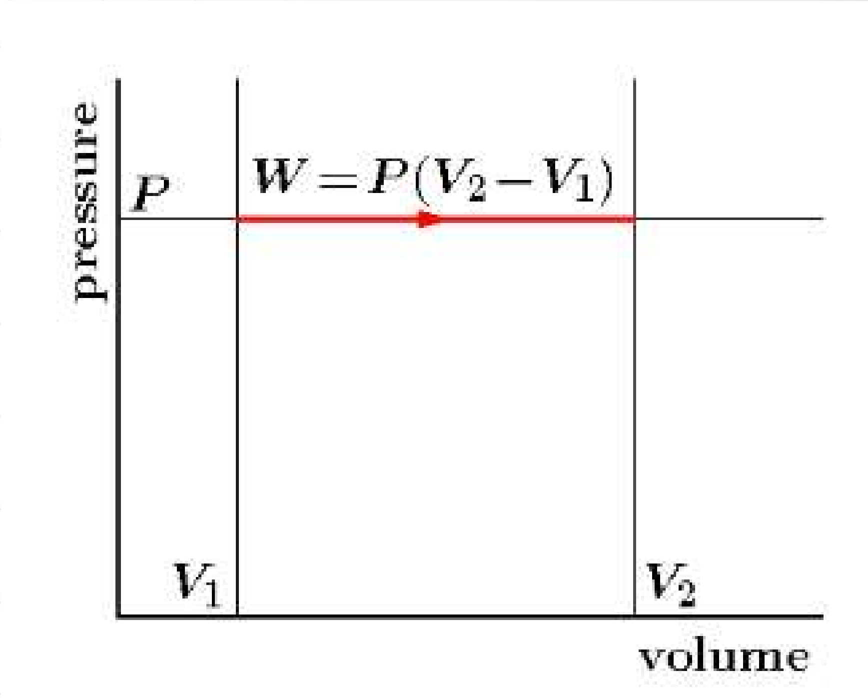
Isobaric Process



”Iso” means the same, and ”baric” means pressure.

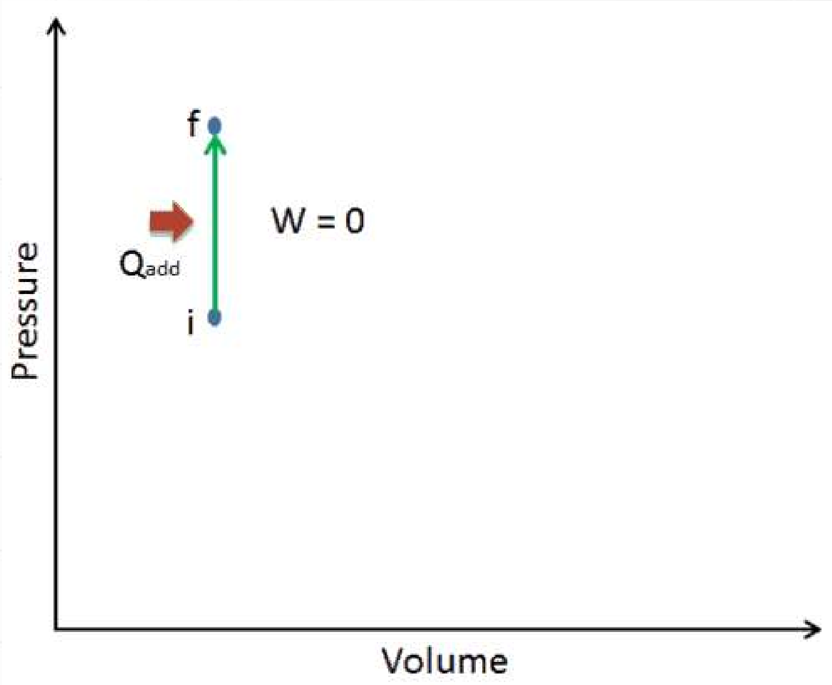
The process, during which the volume of the system remains constant, is an **isochoric process**. Heating of a gas in a closed cylinder is an example of the isochoric process. The change in temperature for a given amount of heat is determined by the specific heat of the gas at a constant volume.

PV Curve



Practically, it is not possible to attain an ideal constant and constant pressure. An isobaric process is one in which the pressure is constant.The quantity of the gas in an isobaric process remains constant and the work done by the system is directly promotional to the change in volume or temperature of the system.

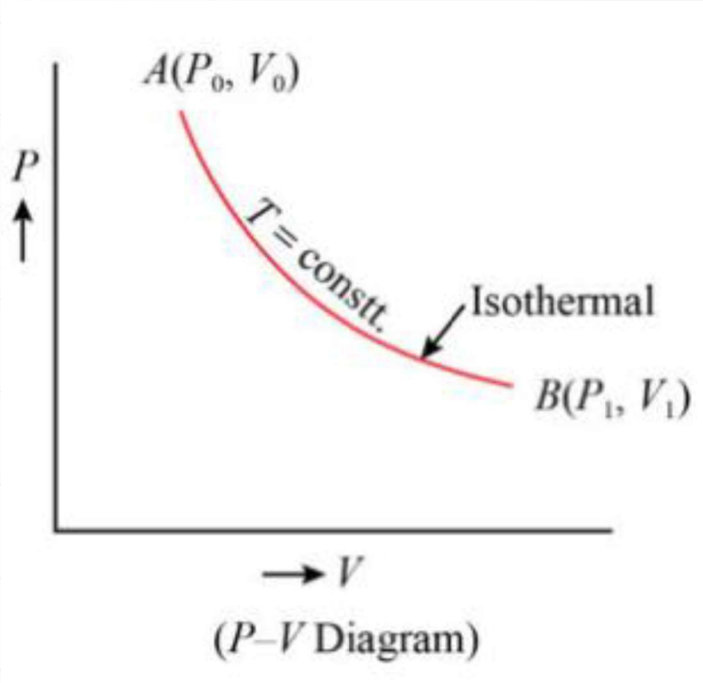
Isochoric Process



”Iso” means the same, and ”choric” means volume.

The process, during which the volume of the system remains constant, is an **isochoric process**. Heating of a gas in a closed cylinder is an example of the isochoric process. The change in temperature for a given amount of heat is determined by the specific heat of the gas at a constant volume.

Isothermal Process



”Iso” means the same, and ”thermal” means temperature.

In an isothermal process, there is no change in temperature, that means the temperature remains constant.Like when hot water is kept in a thermos flask, if we remove a certain quantity of water from the flask, but keep its temperature constant then the process is said to be an **isothermal process**.

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Adiabatic Process

The process, during which the heat content of the system remains constant, is an adiabatic process. During this process heat neither enters the system nor leaves the system.

For an adiabatic process,

$\Delta Q=0$

Then according to the first law of thermodynamics,

$\Delta U+\Delta W=\Delta Q=0$

where, Q is the heat supplied to the system and W is the work done by the system and U is the internal energy of the system.

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Thermodynamic Processes

Isobaric	Constant pressure $$W = P\Delta V$$
Isochoric	Constant volume $$W = 0$$
Isothermal	Constant temperature $$Q = W$$
Adiabatic	No heat transfer $$Q = 0$$

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Third Law of Thermodynamics

The Third law of thermodynamics is sometimes stated as follows, regarding the properties of closed systems in thermodynamic equilibrium: *The entropy of a system approaches a constant value as its temperature approaches absolute zero.*

This constant value cannot depend on any other parameters characterizing the closed system, such as pressure or applied magnetic field. At absolute zero (zero kelvin) the system must be in a state with the minimum possible energy. Entropy is related to the number of accessible microstates, and there is typically one unique state (called the ground state) with minimum Energy. In such a case, the entropy at absolute zero will be exactly zero. If the system does not have a well-defined order (if its order is glassy, for example), then there may remain some finite entropy as the system is brought to very low temperatures, either because the system becomes locked into a configuration with non-minimal energy or because the minimum energy state is non-unique. The constant value is called the residual entropy of the system.

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Carnot Engine

Do you know what a Carnot engine is? It’s an engine that is found in your refrigerators and air conditioners. It involves two reversible isothermal transitions and two reversible adiabatic transitions.

The Carnot cycle is reversible representing the upper limit on the efficiency of an engine cycle. Practical engine cycles are irreversible and thus have inherently lower efficiency than the Carnot efficiency when operating at the same temperatures. One of the factors determining efficiency is the addition of to the working fluid in the cycle and its removal. The Carnot cycle achieves maximum efficiency because all the heat is added to the working fluid at the maximum temperature.

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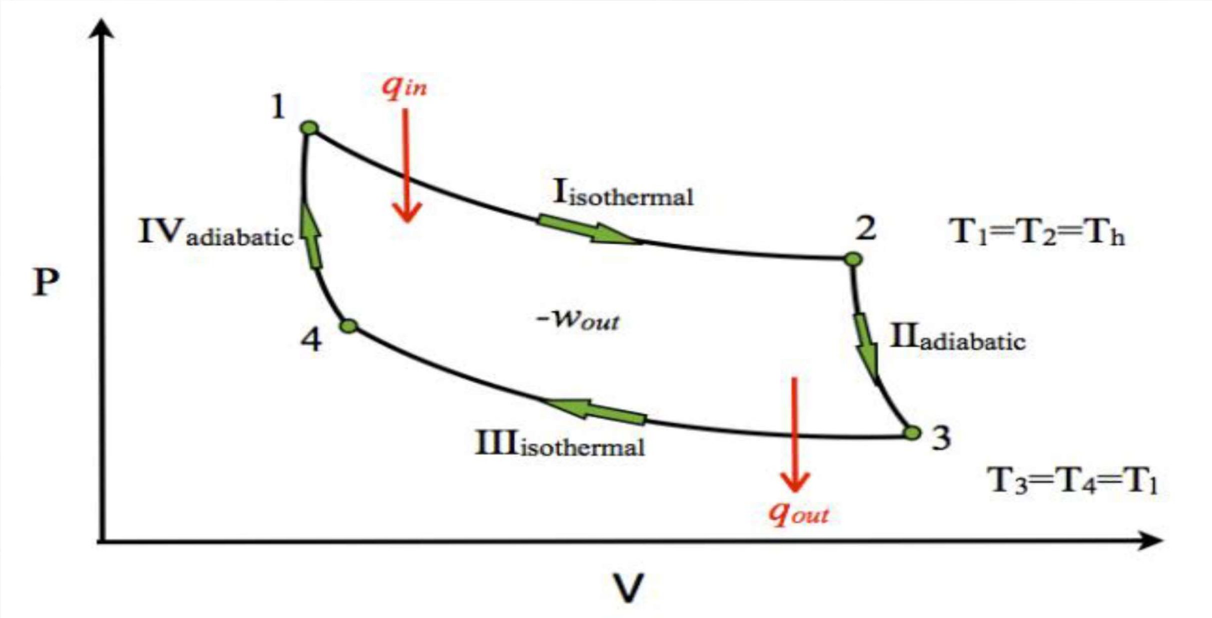
Carnot Engine



The Carnot engine cycle when acting as a heat engine consists of the following steps:

- Reversible isothermal expansion of the gas at the “hot” temperature.
- Isentropic (reversible adiabatic) expansion of the gas.
- Reversible isothermal compression of the gas at the “cold” temperature.
- Isentropic compression of the gas.

Laws of thermodynamics – short review

The laws of thermodynamics govern the way energy is transferred from one state to another. They are:

- ***<u>First law of thermodynamics</u>***: When energy moves into or out of a system, the systems internal energy changes in accordance with the law of conservation of mass.
- ***<u>Second law of thermodynamics</u>***: The state of the entropy of the entire universe, as an isolated system, will always increase over time.
- ***<u>Third law of thermodynamics</u>***: Entropy of a perfect crystal at absolute zero is zero.

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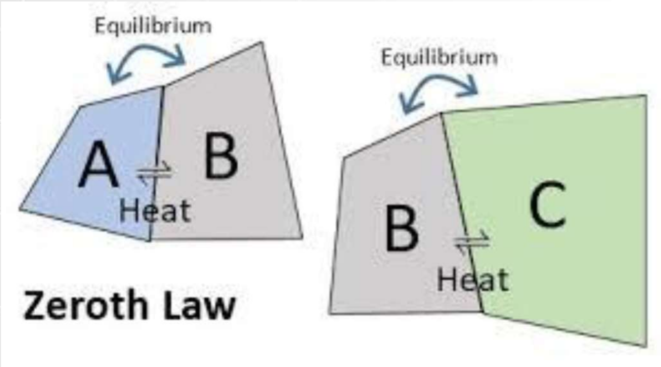
Additional materials

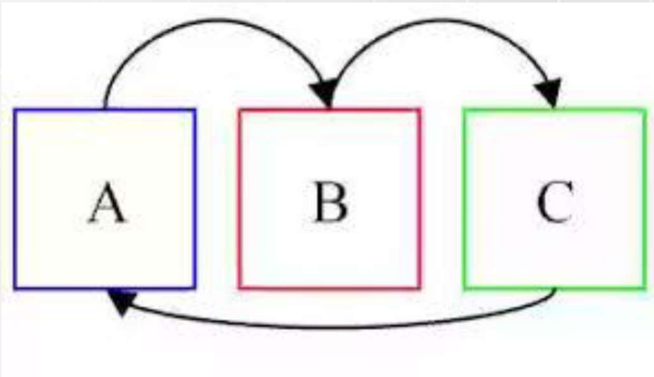
Lectures:
https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Thermodynamics/Energies_and_Potentials/THERMAL_ENERGY

Videos:
https://www.youtube.com/watch?time_continue=4&v=hxnIJ4IVB5w&feature=emb_title

Principles of Thermodynamics

All right. So if you go to our website today, you will find I've assigned some problems and you should try to do them. They apply to this chapter. Then on Friday we'll do problems connected with this topic.





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Quizz

Kahoot link: https://kahoot.it/challenge/05714078?challenge-id=459c69ba-0699-474d-ae7d-12916780bd23_1618057282875

Deadline: 21st April 2021, 18:00