

Principle of Entropy Increase

Encyclopedia Article

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Principle of Entropy Increase

Entropy is a physical quantity that can be interpreted as a measure of the thermodynamic disorder of a physical system. Entropy has the unique property that its global value must always increase or stay the same; this property is reflected in the second law of **thermodynamics**. The fact that entropy must always increase in natural processes introduces the concept of irreversibility, and defines a unique direction for the flow of time.

On a fundamental level, entropy is related to the number of possible physical states of a system, $S = k \log (\Gamma)$, where S represents the entropy, k is Boltzmann's constant, and (Γ) is the number of states of the system. A useful example to illustrate the principle of entropy increase is a closed box containing an ideal gas with a fixed number of molecules. If the energy of the box is increased, the number of states increases because there are many ways that the gas molecules reflect the increased **energy** state. One molecule could represent the entire increase or two or more molecules could represent the increase.

Although the entropy of a system can be reduced by a reduction in energy (accomplished by doing **work** on the surroundings) there is an increase in the entropy of the system's surroundings. Any process that includes **heat** transfer from one system to another, therefore, increases the total entropy. When two systems are in thermal **equilibrium**, however, the energy is divided equally between them, no **heat transfer** takes place, and the entropy does not change. The entropy of a system, therefore, is greatest when it is in thermal equilibrium with its surroundings.

A process in which the net entropy change is positive is called irreversible, because a process with a negative net entropy change cannot be performed to counteract it. A process which has a zero net entropy change, however, is reversible, because the change can be counteracted by another process with a zero net entropy change. Entropy, therefore, increases in all real processes.

One interpretation of the principle of entropy increase is that it defines a unique direction for the flow of time. If all processes were reversible, then movement forward or backward in time would be impossible to tell; broken glass might spontaneously reassemble itself, for example. Increasing entropy sets the direction of the **arrow of time**.