

## Second Law And Entropy

***9.3.1 State that heat can be completely converted to work in a single process, but that continuous conversion of heat into work requires a cyclical process and the rejection of some heat.***

It is possible to completely convert heat to work once, such as a gas being heated, expanding and pushing on a cylinder, thus doing work. If this expansion is done isothermally, all the heat energy is converted into work. However unless the heat is removed so the gas can contract, no more work can be done. The excess heat energy must be dumped into a cold reservoir and then the cycle can begin again. The energy that is dumped into the cold reservoir is lost and is the cause of less than 100% efficiency.

***9.3.2 State the Kelvin–Planck formulation of the second law of thermodynamics***

*It is sufficient for students to acknowledge the impossibility of constructing a heat engine operating in a cycle that does not transfer energy to a cold reservoir. Teachers might like to show that if this were possible then it would imply that energy can be transferred spontaneously from a cold to a hot reservoir. This leads to the Clausius statement of the second law.*

It is impossible to make a cyclic engine whose only effect is to transfer thermal energy from a colder body to a hotter body. Energy flows from hot to cold.

For 100% of the energy to be converted to work in a cyclic engine the engine must return to its initial state with no increase in internal energy. An isothermal expansion does work with no loss to heat energy, thus to return to its initial state the engine must contract isothermally... the result no net work is done. Unless heat energy is lost!

***9.3.3 Analyze situations in terms of whether they are consistent with the first and/or second law.***

***9.3.4 State that entropy is a system property that expresses the degree of disorder in the system***

***9.3.5 State the second law in terms of entropy changes***

Rudolf Clausius proposed a general statement of the 2nd law of Thermodynamics in terms of a quantity he called entropy. Entropy is essentially a measurement of the disorder of a system. If a system gets less organized then the entropy increases, if it gets more ordered then the entropy decreases.

2nd Law in terms of Entropy:

- The entropy of the Universe is increasing
- Natural processes tend to move toward a state of greater disorder

What does that mean? When you organize your room your socks go one place, your shoes another, homework on your desk, etc. Things that are similar are put together, a heterogeneous mixture. Disorder is when everything is mixed together, a homogeneous mixture if you will. Things in nature tend to want to be homogeneous, they want to be disordered. This is the reason your room gets messier not neater.

So how can anything be organized? How do you organize your room? You have to do work to organize. Same way with thermodynamic systems, if you want to organize a system you must do work on it. Which results in more disorder somewhere else.

### ***9.3.6 Discuss examples of natural processes in terms of entropy changes***

Increasing Entropy:

- The rotting of food or biological material.
- Ice melting
- Gas dissipating
- Dissolved material spreading out in a material
- The birth and death of stars... They burn their fuel heating the surroundings, they run out of fuel and cool off, the universe temperature becomes more uniform... no more heat engines, we die. This is known as the heat death of the universe.

Decreasing Entropy

- Evolution
- Building a house
- A tree growing

### ***9.3.7 Discuss the idea of energy degradation in terms of the second law***

Energy is more useful in some forms than others. Energy in chemical form is very useful, all biological systems rely on stored chemical energy (food), as that energy is used most of the energy is converted to heat energy, which is then lost to the environment. Some of this heat energy may be used again by something else, but in general than heat energy is not as useful. We say the energy has been degraded. We could also say that the entropy of the system has increased. As energy gets converted to heat, it is less useful, at some point the universe becomes homogenous and no work can be done, entropy has reached a maximum.

Source: <http://ibphysicsstuff.wikidot.com/second-law-and-entropy>