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A more complex, alternate statement of the second law of thermodynamics is that no heat engine (such as an automotive engine) can completely convert 100% of a certain amount of heat energy into work; there will always be a lower temperature substance with some heat left. The consequences of this law are responsible for the large cooling towers at nuclear reactors and conventional power plants, where low temperature heat is given off to the environment. The temperature at which this heat is delivered to the atmosphere is much lower than the high temperature steam that turns the turbines in an electrical generating plant. The heat of the expanding gases in an automobile engine is much more useful than the warm gases coming out of the tailpipe. There will always be wasted heat, no matter how carefully you design a heat engine. Therefore, by scientific law, no traditional power plant can ever be 100% efficient, that is, convert 100% of the chemical energy into electrical energy. It's a law that cannot be violated, according to the second law of thermodynamics.

Entropy

The above examples imply that high temperature heat is more valuable as a source of energy than low temperature heat. There is a thermodynamic quantity known as **entropy** that has the units of heat divided by temperature. For a fixed quantity of heat transferred under a certain set of conditions, the higher the temperature at which it is transferred, the smaller is the entropy change for that process. The lower the temperature at which the same amount of heat is transferred, the larger is the entropy change. Another way of stating the second law of thermodynamics is *the entropy of the universe strives towards a maximum value in any spontaneous (real life) process.* If we examine the types of chemical processes in which there is a maximum increase in the amount of entropy, we see that there is an increase in what we would tend to call the *disorder* in the chemical system. For example, there is a large increase in entropy when liquid water is turned into gaseous water vapor. Similarly there is an increase in entropy when ice, a highly ordered solid, melts into the more random liquid water structure. Thus entropy has generally been associated with the concept of disorder. The larger the disorder, the larger is the entropy.

In any chemical reaction, there are two potential driving forces, changes in energy and changes in entropy. Most spontaneous chemical reactions are exothermic, but not all. Those spontaneous reactions that are endothermic must be accompanied by an entropy increase. A useful example of the latter type of reaction is the spontaneous evaporation of water, which is an endothermic reaction. That is, energy must be taken from the surroundings for it to occur. This energy is used to break the many strong hydrogen bonds in liquid water to allow its molecules to escape into the gaseous state - yet water does evaporate spontaneously. Why? Because the driving force behind this evaporation of water is the large amount of entropy gain that arises from the much larger amount of disorder in gaseous water than in the much more organized liquid state. Thus spontaneous processes can cause the absorption of energy from the evaporating water's surroundings. For example, dissolving Epsom salts in water is a spontaneous process will cool the water and draw heat from the surroundings.