Entropy and the second law of thermodynamics

The paper examines, explain clearly, rigorously the term entropy, then discuss and evaluate its meaning in the context of the second law of thermodynamics. Also It will give a historical overview of the term entropy and it will give some examples which are taken from the daily life and with these, I will try to explain clearly the term entropy and its intention not only in the context of the second law and also its results in our daily life.

2. Introduction (Appendices A.)

The term entropy has some related definitions. The first definition used by the German physicist Rodolf Julius Clausius in the 1850s and 1860s, he did that to state the second law of thermodynamics. The word entropy has been taken from the Greek word ‘ τροπη’ which means transformation. Also just as the first law of thermodynamics leads to the definition of energy as a property of a system, so the second law, in the form of Clausius inequality, leads to the definition of a new property of fundamental importance. This property is entropy. In the 1870s the term entropy is given by J. Willard Gibbs. The meaning of what he says is that the entropy shows the uncertainly about the state of a system. The latter can be defining from the probability distribution of its micro-states which demostrates, all molecular details about the system such as the position and the velocity of every molecule. If Pi is the possibility of a micro-state i, then the entropy of the system can be expressed by

$$S = -k \Sigma P_i \ln P_i$$

Where k is the Boltzmann constant equal to 1. 38062 x10^(−23) joule/kelvin.

Another definition, is the statistical definition developed by Ludwig Boltzmann in 1870s. This definition, describes the entropy as a measure of the number of possible microscopic configurations of the individual atoms, and molecules of the system; which would give rise to the observed macroscopic state of the system.

In statistical thermodynamics, Boltzmann's equation, is a possibility equation relating the Entropy S of an ideal gas to quantity W, which is the number of micro-states corresponding to a given macro-state:

$$S = k \log W$$

Where k is Boltzmann's equal to 1. 38062 x10^ (−23) joule/kelvin.

Boltzmann has proved that the entropy of a given state of thermodynamic al system is connected by a simple relationship to the probability of the state.

According to M. Kostic(2004): " Entropy is an integral measure of (random) thermal energy redistribution (due to heat transfer or irreversible heat generation) within a system mass and/or space (during system expansion), per absolute temperature level. Entropy is increasing from perfectly-ordered (singular and unique) crystalline structure at zero absolute temperature (zero reference) during reversible heating (entropy transfer) and entropy generation during irreversible energy conversion (lost of work-potential to thermal energy), i. e. energy degradation or random equip-partition within system material structure and space per absolute temperature level".

3. Entropy measures the disorder in a system (Appendices B.)

Therefore, metaphorically if a small bookshelf getting disorganized, it will be increasing the entropy of the bookshelf. Because, when the bookshelf is properly organized, finding a book is predictable and easy because all books are in a nice order. As the bookshelf is getting disorganized, the chance of not finding a book increasing, as a result is much higher. So that, when a bookshelf, a room a house are organized and they are moved from being organized to being disorganized, they generate Entropy. Also, liquids have higher entropy than crystals intuitively because their atomic positions are less orderly. Calculating the entropy of mixing illustrates this interpretation. An example is with scrambling eggs because when we mix the yolk and the white we cannot re-separate after. An example from this situation are given in figures 1. 1 and 1, 2.

V V 2V

Fig. 1. 1 Unmixed atoms. The premixed Fig. 1. 2 Mixed atoms. The mixed state: N/2

state: N/2 white atoms on one side, N/2 mixed atoms and N/2 black atoms scattered

black atoms on the other. Through the volume, 2V.

Fig. 1. 1

There are N/2 undistinguished ideal gas white atoms on one side and N/2 undistinguished gas black atoms on the other side. As a result, the entropy of this system:

$S_{unmixed} = 2k_B \log[V^{N/2}/(N/2)]$

Twice the configurational entropy of N/2 undistinguished atoms in a volume V. We assume that the black and white atoms have the same masses and the same total energy. Now the entropy change when the partition is removed, as a result from the scrambling and the two sets of atoms allowed mixing. Because, the temperatures and pressures from the both sides are equal and when the partition removing does not involve any heat transfer, and the entropy change to the mixing of the white and black atoms. In desegregated state, the entropy has increased to

Smixed = 2kB log[(2V)N/2/(N/2)]

and it is:

ΔSmixing = Smixed − Sunmixed =

= 2kB log[[V^N/2/(N/2)] / [(2V)^N/2/(N/2)] =

= kB log 2N = NkB log 2

So that, it gain kB log 2 in entropy every time we place an atom into one of the boxes. James P. Sethna (2006)

Furthermore, we can give another example which shows us that entropy measures the disorder in a system:

Which is more disorder?

The glass of ice chips or the glass of water?

For a glass of water, the number of molecules is astronomical. The ice chips probable look more disorder when we compare to the glass of water which looks uniform. However, according to thermodynamics the ice chips place limits on the

number of ways the molecules can be arranged. The water molecules in the glass can be arranged in many more ways; as a result, they have grater multiplicity and therefore greater entropy.

4. Entropy measures our ignorance in a system

The most general is to measure our ignorance about a system. The equilibrium state of a system, maximizes the entropy because, we have lost all information about the initial conditions, as a result, the entropy maximizing immediately maximises and our ignorance about the details of the system.

5. Entropy measures the multiplicity of a system

The probability of finding a system in a given state depends upon the multiplicity of that state. As a result it is proportional to the number of ways someone can produce that state. Here, it is a pair of dices, and in throwing this pair, that measurable property is the sum of the number of dots which are facing on the top. The multiplicity for two dots showing is just one because there is only one case of the pair that will give that state. For example, the multiplicity for seven dots is six, because there is six cases of the pair that will show a total of seven dots.

Probable one way to define the quantity entropy is to do it in terms of the multiplicity.

Multiplicity = W

Entropy = k lnW

Where K is Boltzmann’s constant.

For a system, of a large number of particles. We can expect that the system at equilibrium will be found in the state of highest multiplicity since the fluctuations from that the state will usually be extremely small to measure. As a result, as a large system approaches equilibrium, its multiplicity therefore, entropy tends obviously to increase. This is one way of stating the Second Law of Thermodynamic.

6. The Second Law of Thermodynamics (Appendices C.)

The second law of thermodynamics states that heat flows always from the warmer to colder bodies and never opposite. This is a common experience which everyone has seen and probably every day we have a case of those. For example, whenever we leave a cup of warm coffee it will become cool in 10 minutes. The special point of this process is that by the end of years can never become backward. It has just one direction as time passes. Indeed, through our everyday experience know that when contacting a hot and a cold body will be transferred heat from the hot to the cold body, so the hot body will be a little cooler and the cold body the opposite will be a little bit hotter. However, it is never possible as the time passes and the two bodies are in contact the cold body to be colder and the hot body to be hotter, for example, if we put an ice-cube into our drink, the drink does not boil. Therefore, it is only one direction in the flow heat which if we displaced it with a line, then this line will show everything from the past to now and to future.

” The second law of thermodynamics states that heat cannot be transferred from a colder to a hotter body within a system net changes occurring in other bodies within that system, in any irreversible process, entropy always increases”.

In nowadays, it is customary to use the term entropy in conjunction with the second law of thermodynamic. Consequently the entropy indicates the unavailable energy of a system, according to the law ” the entropy of a closed system can never reduce”. Another form of the second law thermodynamic says that the minimum amount of heat which exchange a system during a change, which takes place at constant temperature T, associated with a change which is called entropy, with the equation:

dQ=

~~The equality applies, so call reversible changes. Therefore, those, which if we do exactly the opposite, which we did during the change our system and its environment are driven back to their original statements.~~

~~For the changes which are not reversible, is the symbol < in the above equation.~~

~~According to the second law of thermodynamics entropy namely the disorder in a system, if it is left alone, it will grow. In addition, it is not able to go into a higher-order situation, but tends to greater state of disorder. Moreover, the second law of thermodynamics prohibits two bodies of~~

~~equal temperature in contact with each other and isolated from the environment, but to evolve into a situation where one of them to have a particular higher temperature than the other one. Also, the second law of thermodynamics says: In any closed system, entropy does not decrease ever. For example if it is a black bucket with water, which was originally located in the same temperature as the air that surrounds it. If we put it in the sun, it will absorb heat from the sun, as all the black items do, if you live them for several minutes. Now the water has become warmer, and the available energy has increased. However, it does not mean that entropy has decreased because the system, which is under consideration, is not closed system. The energy of the sun enter the water coming from the external environment of our system. If in our system include the sun energy, the energy of the system, which was available before, has reduced after that. Obviously the entropy has increased, as required by the second law of thermodynamics, the processes in which the entropy of a closed system would decreased is not possible, because, in every process, which is taking place in a close system, the entropy of the system will increased or it will remain constant. In addition, the second law of thermodynamics says a closed system is not able to work for ever and also a closed energy system, tends to the maximum (infinite) entropy. So that " The American Heritage Dictionary" gives as the first definition of entropy, " For a closed system, the quantitative measure of thermal energy not available to do work". So it is a negative quantity, the opposite of available energy. Therefore, the entropy does not symbolize the energy of the system in general, but the amount of energy that cannot be used for production work.~~

7. Conclusion

In conclusion, the second law of thermodynamic is an expression of universal law of increasing entropy stating that: the entropy of an isolated system, not in equilibrium, will tent to increase as the time continue, approaching maximum price equilibrium. In a general sense, the second law says that temperature differences system in contact with each other tend to be normalized, and action can also be obtained from these disequilibrium differences, however, that heat loss occurs in the form of entropy, when work is produced. The pressure differences, particularly differences temperature tent to equalize if given the chance. This means that an isolated system will eventually acquire a uniform temperature. Therefore, the second law of thermodynamic says " it is impossible to construct a machine that converts thermal energy into work at 100%". Also, according to Clausius, " it is impossible to construct machine to transfer heat from a cold to a warm body without offering energy in the form of mechanical work on the machine from the external environment". " The amount of free energy, which is the useful energy, in the universe is always decreasing, or in the universe, as a whole, the total amount of free energy is declining". In brief, the term of entropy defined as follows: " entropy: the amount of disorder in a system". In general the entropy meaning, and its association with the second law of thermodynamic as follows: free energy is always decreasing, entropy is always increasing. As a result, the concept of entropy is one of the most important concept in science because of the second law of thermodynamic.