USE OF THE SECOND LAW OF THERMODYNAMICS IN MACROSCOPIC FORM IN CREATION STUDIES

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Often creationists appeal to the second law of thermodynamics to show that evolution could never have happened in the way commonly alleged. Usually the second law is thought of in such arguments in terms of statistical mechanics, or of information theory. The author uses the law in its original macroscopic form, which entails nothing at all about any microscopic structure of things, to reach the same conclusion: that the alleged evolution is impossible. There may be certain advantages to the macroscopic formulation: for instance, it may leave less opportunity for quibbles about open and closed systems.

I. Introduction

As is well known, thermodynamics, especially the second law, is often appealed to in support of Creation. Sometimes the law is stated in some form to emphasize that the amount of order in a system decreases.[1, 2] Sometimes an author does not make very explicit just how the amount of order is to be judged; although anyone would agree that the evolution of "molecule to man," had it actually happened, would have involved an increase in order by almost any definition.

In fact, in the context intended, the statement is true enough. The order may be referred to the molecular or atomic level. There is nothing wrong with so doing. But one feels that it should not be necessary, for thermodynamics can be independent of any atomic or molecular theory. Indeed, it was established before those theories were worked out. So it may be of some interest to see how far it is possible to go, along the lines of interest in creationism, with the original macroscopic thermodynamics.

II. Historical Outline

Originally thermodynamics, as developed by Carnot and others, had to do with the connection between heat and work. The measurement of heat, which is the practice of calorimetry, was already an established technique; and the notion of mechanical work had been developed in mechanics. The industrial revolution, and the invention of the steam engine, had made this connection a matter of practical interest. The result of these studies was the formulation of thermodynamics in the macroscopic form, and in particular formulation of the first and second laws.

Subsequently much work was done on the kinetic theory. Heat was considered to be the motion of the atoms or molecules making up a hot object. But this motion was random or disorderly. Mechanical work, on the other hand, would involve the motion of the whole object, which could be considered to be orderly motion of the atoms. Hence the relation of heat to work was considered in terms of order and disorder.

Yet later, information theory and related studies arose. The aim was to consider information as if it were being sent by means such as the telegraph. The message would be represented by a series of dots and dashes; and in their distribution and mixing the succession might be more or less random. So it was natural to think of these studies as analogous to the newer, statistical, thermodynamics, and to use several thermodynamic terms.

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It will be enough at this point to give a short outline of these developments which were subsequent to the original classical thermodynamics. There will be occasion later to say more about them.

III. Classical Thermodynamics

The logical sequence of development, which is not always quite the historical one, is about as follows. Joule and others did experiments in which mechanical work was "wasted" in overcoming friction; and they measured the amount of heat resulting. For instance, by a system of pulleys a falling weight turned paddles which stirred a tank of water, heating the water somewhat. (Figure 1) It was found that there was a constant ratio of the amount of heating to the amount of mechanical work done by the weight.

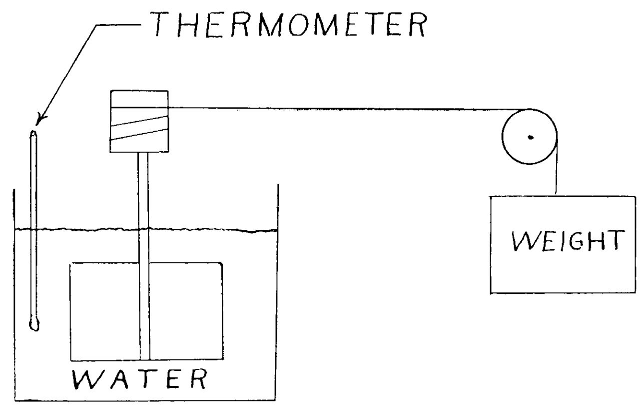

Figure 1. This illustrates how, in an experiment such as Joule's, mechanical work may be turned into heat, and the amounts measured.

Suppose, for instance, that a weight of 100 pounds fell 7.78 feet while turning the paddles. The result was the heating of 1 pound of water by 1°F, which represents 1 B. T. U. of heat. So 778 footpounds of mechanical work wasted against friction (which is what the stirring amounts to) results in 1 B.T.U. of heat. It was natural to say that the two are equivalent, in the way in which so many francs are equivalent to one dollar. The figure 778 is a sort of rate of exchange; but, of course, it does not fluctuate.

It was natural, moreover, to say that, since the 1 B.T.U. was equivalent to the 778 foot-pounds, nothing had been lost. Before the weight fell, there was the potential for mechanical work, often called mechanical potential energy. Afterwards, the heat could be called thermal energy. So the total amount of energy, mechanical plus thermal, was the same after as before;

the energy was conserved. This is an example of the conservation of energy, which, when heat is involved, is often called the first law of thermodynamics.

It was easy enough to let a weight fall, and thereby to heat someting, or in other ways to get heat from mechanical work. Is it possible to go the other way? It is usually more difficult; nobody would expect the water in Joule's experiment to become cooler, and at the same time the paddles and pulleys to act to lift the weight. Still, work is accomplished from the heat of every steam or internal-combustion engine.

But there is a difference. The efficiency of these engines, in terms of work done for a given amount of heat used, is limited. One finds that only a fraction of the heat involved in the engine, from the burning of fuel, for instance, goes into work. Some, in practice often more than half, of the heat must be rejected, and as far as the engine goes it is wasted.

In a steam electric plant, for instance, the heat rejected is from the cooling of the condenser; and it may be rejected into the local river. It is for that reason that some people are concerned about thermal pollution. Sometimes the wasted heat can be used, to heat buildings for instance; but that is a separate story. In general, the conversion of work into heat goes more efficiently than that of heat into work. That is one aspect of the second law of thermodynamics.

Again, suppose that there were two equal blocks of copper, the one at temperature 0°, the other at 100°. If they were put together, they would come to 50° (approximately). One could say that so many units of heat had gone from the hot block to the cold one. If, however, both blocks were at 50°, and they were put together, nobody would expect the one to become hot, the other cold. On the basis of research, the flow of heat is from hotter to colder. This is another aspect, or maybe even a statement, of the second law.

The notion of entropy, which is usually introduced, may be used conveniently in the last example. Suppose that something takes in a certain amount of heat. The amount of heat, divided by the absolute temperature, is called the increase in entropy. In symbols:

$$dS = \frac{dQ}{T} \qquad (1)$$

Where S representing the entropy, Q the amount of heat, and T the absolute temperature. (It will be recalled that the absolute temperature measured from absolute zero; in the Farenheit scale it is given by adding approximately 460° to the ordinary Farenheit temperature.)

It has been suggested that, if one distributes and takes in money, the number found by dividing the amount taken in by the denomination in which it was taken in (e.g., 0.25 for a quarter, 1.00 for a dollar bill, etc.) would be analogous to the entropy. It would also, of course, correspond to the number of pieces of money in the till.[3]

The cooler of the two pieces of copper would take in an amount of heat Q, say, and at some average temperature T_c, between 460 and 510 on the absolute scale. So the entropy of the cooler copper would increase. The hotter one would give up heat, the same amount Q; correspondingly its entropy would decrease. But the average temperature in the denominator, T_h, would be between 510 and 560. So the net increase in entropy for the process would be:

$$dS = \frac{Q}{T_c} - \frac{Q}{T_h} \qquad (2)$$

which would be greater than zero, since T_c is less than T_h.

This is one example. In all cases, it is found that the entropy increases during an irreversible process. It is granted that the flow of heat from the hotter to the colder is irreversible, because in fact it does not go the other way.

All spontaneous processes are irreversible. The temperatures in the two blocks of copper would equalize spontaneously, once the blocks were put together; but the reverse process, i.e., the heating of one and cooling of the other if they were put together at the same temperature, does not happen.

IV. Order

It may be convenient, in connection with the last point, to consider the matter of "order." At first thought, it is tempting to identify "order" with "uniformity," and to think that the situation when the two blocks were at the same temperature was more orderly. Of course, the word could be used thus. But that is not what it meant when it is said that the order in a system tends to decrease.

In this paper, order must be understood as referring to arrangement, or something of the sort. Some have defined "order" as "adaption to a purpose," or words to that effect.[4] Aristotle used to like to speak of the order of an army.[5] In this sense, an army has order, a mob very little; although the members of the mob might look more alike than those of the army.

V. Another Statement

In principle, when the two blocks of copper were at different temperatures it would have been possible to get some mechanical work from them. The hot one, e.g., might have boiled some liquid, say ether, and the vapor would have run a small steam engine, and then might have been condensed by the cooler one. Such a process, of course, would cause a transfer of heat from the hotter block to the cooler; but, it would bring about something that would have happened spontaneously anyway.

Thus it has been proposed that the second law might be stated in some such terms as: mechanical work can be obtained only from a process which will proceed spontaneously—or perhaps better, from a process such that some spontaneous process will produce the same end result.[6] (Which, in this case, would be the transfer of heat from the one block to the other.)

VI. Yet Another Statement

The statement above is akin to what is wanted here. What is needed now is a statement to the effect that if a system should undergo an irreversible process without exchanging either heat or work with anything outside the system, it would afterwards be less able to do mechanical work than it was before.

For instance, the two blocks of copper could be considered a system. Suppose that they were put together for a short time, then separated. The temperatures would have equalized partly, but not wholly. And the process, of course, would be irreversible. Afterwards, the blocks would still effect some mechanical work, as suggested above, but less than before.

This may be shown by adapting a result given in some books on thermodynamics.[7] It has been shown that in an irreversible process the entropy increases, and it is shown in the reference that as a result an amount of energy given by

$$E = T_0 (S_f - S_i) \tag{3}$$

becomes unavailable for doing work as a result of this. In this equation, S_f is the entropy after the irreversible process, S_i that before, and T_0 the temperature of the "heat sink" which is available. (In the example of the power plant, the river, into which waste heat went, was the "heat sink.")

A definite number cannot be assigned to T_0, but at least the number would be positive. So a certain amount of energy becomes unavailable. If the system has no interaction with anything outside the system, then the total energy is constant. Hence there is less energy available for doing work than before. So any spontaneous process, during which a system is isolated, leaves the system less able to do work than before. Q.E.D.

VII. Application to (Alleged) Evolution

First, consider a cloud of gas, dust, or whatever it may be, in equilibrium in space. Since it is in equilibrium, there is no way of getting mechanical work from it. Then, if it be possible, let it condense spontaneously into two or more stars, planets, etc., as some evolutionists allege has happened.

The resulting system would produce mechanical work; the parts could attract each other by gravitation and pull on ropes, or something of the sort. But then the potential for mechanical work would have increased as a result of an irreversible process in an isolated system, which has been shown to be impossible. Hence the alleged condensation into stars would have been impossible.

Now consider a more ambitious case, which might be represented by Figure 2. Let there be a system in equilibrium, maybe a chamber containing oxygen, nitrogen, carbon (possibly in the form of carbon dioxide), and various other elements. The system, as it stood, would have no potential for any mechanical work, being in equilibrium.

Suppose (again, if it be possible), that the elements were to come together spontaneously to form a man. The man could, e.g. turn a crank, which could extend out of the system; thus the system (of which the man would have to be considered a part, or a stage), would have an increased potential for mechanical work through a spontaneous process. Since it would lead to an imposible result, the spontaneous process of "molecules-to-man" could not have happened.

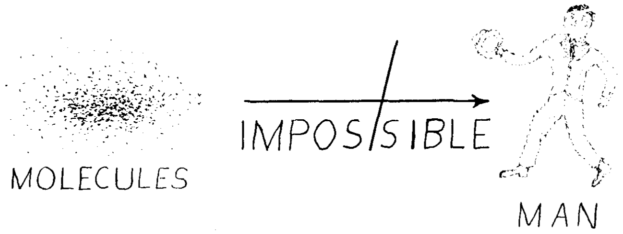

Figure 2. The "molecules-to-man" process, sometimes claimed to have happened, could not have gone spontaneously.

Notice that any "all-out" theory of evolution, in the final analysis, must entail just that: that the various elements united spontaneously to form a man. The untold ages which it is claimed to have taken do not matter. For classical thermodynamics involves nothing about the time taken for something to happen, but entails rather whether or not it will happen at all.

Neither does it matter that intermediate stages are alleged. For, again, thermodynamics does not involve any intermediate stages. Some chemical reactions may be considered to go through many intermediate stages before reaching the end result. Thermodynamics is related to whether or not the reaction will reach the end result, but does not need to be concerned about any intermediate stages.

Incidentally, the reception of radiation from the sun does not seem to matter for this argument. For one could consider the chamber of chemicals, and later (if it were possible), the man, both in the dark, but at some suitable temperature. Either the man is thermodynamically "more likely" than the chemicals, or he is not. Were he "more likely" the process from chemicals to man should, in principle, be able to go spontaneously.

But it has been shown that this is not possible. So the man is not "more likely" (as anyone would have said upon glancing at the question); and the introduction of vast times, intermediate stages, etc., would not change the conclusion. As for the radiation, it would seem to be more like a catalyst. It might make a reaction go more quickly, cause a better yield, etc.; but it would not cause a reaction to go which would not go at all in the absence of radiation.

VIII. Conclusion

It has been shown that the second law of thermodynamics, in its macroscopic form, may be used to demonstrate the impossibility of any "molecules-to-man" evolution. Of course, that impossibility has been demonstrated before, in various ways, in papers in this *Quarterly* and elsewhere. But the present discussion involves a rather different argument.

Appendix I. Statistical Mechanics

As was mentioned, a specialist using statistical mechanics, working from an atomic or molecular theory, undertakes to deal, in a statistical way, with the motion of the molecules. Since it is the entropy that is of the greatest interest here, let us consider very briefly how it is handled.

Suppose that, in a sample of gas containing many molecules, a fraction, f_0, at a particular instant, is standing still; a fraction, f_1, moving to the right at say 100 miles per hour; a fraction, f_2, at 200 miles per hour, etc. If one plotted the f's versus the corresponding velocities, the graph might be like that shown in Figure 3. The entropy, then, is given by:

$$S = -k(f_0 \log f_0 + f_1 \log f_1 + f_2 \log f_2 + \quad) \quad (4)$$

The logarithms should be to base $e = 2.718\ldots\ldots$; but another base could be used by changing the constant k. As it is, k is called Boltzmann's constant.

By comparison with the known behavior of gases, it is shown that the entropy obtained in this way corresponds to that used in the macroscopic theory.[8]

A simple example may indicate how this could work. Suppose that the molecules were all moving to the right at 500 miles per hour; if, e.g., they had just been squirted out of a cylinder of compressed gas. The f_5 would be equal to 1, and all the other f's zero. Since $f \log f$ is equal to zero when f is either zero or one, the sum gives zero for the entropy.

Later, after some "bumping around" there will be a great variety of velocities; many of the f's will be different from zero; and, since they will be fractions, their logarithms will be negative. Thus the entropy will have some positive magnitude; it will have increased. Since the derangement of the molecules into a more random pattern of motion was a spontaneous process, this instance shows how the entropy would increase in a spontaneous process.

Appendix II. Information Theory

By information theory specialists consider what might be a message, e.g., a series of dots and dashes if the message were sent by telegraph; and try to apply some notions of probability to the situation. For instance, a message of say 50 dots followed by 50 dashes would be highly unlikely; it would be much more likely that the dots and dashes would be quite well mixed together.

One might consider a lot of possible messages—sequences of dots and dashes—and assign to them probabilities, which could be considered as the fractions of the time that the sequence would be found. These fractions could be called f's, as was done above for the molecular velocities, and a similar formulation set up for entropy.[9]

If, then, the operator were to make mistakes, or something became wrong with the equipment, the message would be changed here and there, in the direction of greater randomness, just as the molecular velocities were changed. Then the entropy, calculated in the way proposed, would increase.

The natural tendency is for the entropy to increase in this field too; in other words, messages become garbled. If one thinks of the "genetic code" as a message, mutations would be garbling. And just as no new information arises by garbling a message, but only nonsense, so mutations cannot lead to new kinds of creatures, but merely flaws in existing kinds.

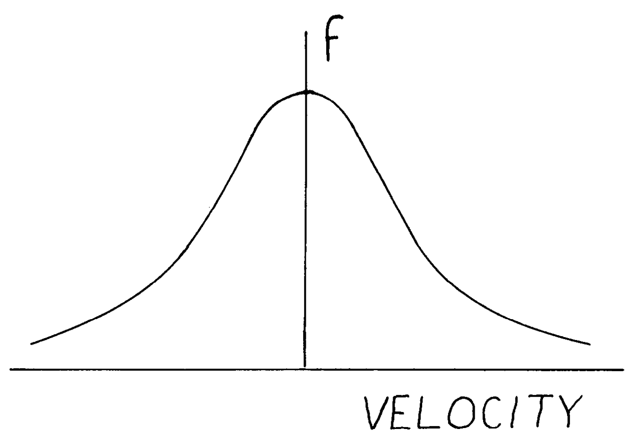

Figure 3. The fraction f of molecules in a gas moving to the right (or left), at various speeds might depend on the speed in a way something like this.

References

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