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Nobel Prize in Chemistry 1920

Walther Hermann Nernst

The Nobel Prize in Chemistry 1920 was awarded to Walther Nernst *"in recognition of his work in thermochemistry"*.

RESEARCH INFORMATION:

As long ago as the Ice Age, when our species was in its childhood, man found in fire a powerful ally in his fight against cold and darkness, and it helped him make a considerable step towards his domination of the world around him. The real nature of fire which, according to antique lore, Prometheus stole from Heaven, the home of lightning, remained unexplained far into later ages. In fact fire is in all probability the first chemical reaction which mankind took into his service.

Later, since the inception of chemistry, the connection between chemical reactions and heat has been the subject of innumerable experiments and a great deal of thought.

When coal or wood is burnt the carbon and hydrogen which they contain combine with the oxygen in the air. The mutual chemical affinity of these three elements plays its part in this, and the carbon tries with a certain amount of force to combine with oxygen to form carbon dioxide. This force of affinity can, up to a certain point, overcome obstacles or, in other words, perform a certain amount of work. As with other forces, the measure of the chemical affinity is the magnitude of the counte: force which this affinity can manage to overcome.

During the combustion of carbon in air no actual work is performed, since the affinity results only in heat or, as we understand it today, in an increase of the motions of the molecules. This is indeed, what we are trying to achieve when we want to use the affinity between carbon and oxygen to obtain heat.

If however, we want to use this mighty source of power in order to perform work, then we must proceed in some other way. For many years the combustion heat has been used indirectly to produce steam for driving steam engines. In doing this, however, we find that at the most no more than one-fifth of the heat produced can be transformed into work, while at the same time the remaining four-fifths are necessarily used up in the process of heating. This fact provides an empirical basis for the second fundamental law in the theory of heat, which deals inter alia with the requirements for the transformation of heat into work.

In carrying out experiments aimed at a more complete exploitation of the affinity between carbon and oxygen for the production of work, we are faced with two questions: which methods are we to consider? and: is there any connection between the degrees of affinity and of evolution of heat on burning carbon, from which we could predetermine how much energy could be achieved with suitable arrangement?

Numerous measurements of the change of temperature during chemical reactions - so-called thermochemical measurements - have been carried out for almost a hundred years, and chemists for their part have all been convinced that one day a connection would be shown between these temperature changes and the chemical affinity. Not surprisingly they also sincerely hoped that this connection would be soon found, since its demonstration would obviously be of the greatest importance.

Before Nernst began his actual thermochemical work in 1906, the position was as follows. Through the law of the conservation of energy, the first fundamental law of the theory of heat, it was possible on the one hand to calculate the change in the evolution of heat with the temperature. This is due to the fact that this change is equal to the difference between the specific heats of the original and the newly-formed substances, that is to say, the amount of heat required to raise their temperature from 0° to 1° C. According to van't Hoff, one could on the other hand calculate the change in chemical equilibrium, and consequently the relationship with temperature, if one knew the point of equilibrium at one given temperature as well as the heat of reaction.

The big problem, however, that of calculating the chemical affinity or the chemical equilibrium from thermochemical data, was still unsolved.

With the aid of his co-workers Nernst was able through extremely valuable experimental research to obtain a most remarkable result concerning the change in specific heats at low temperatures.

That is to say, it was shown that at relatively low temperatures specific heats begin to drop rapidly, and if extreme experimental measures such as freezing with liquid hydrogen are used to achieve temperatures approaching absolute zero, i.e. in the region of -273° C, they fall almost to zero.

This means that at these low temperatures the *difference* between the specific heats of various substances comes even closer to zero, and thus that the heat of reaction for solid and liquid substances practically becomes independent of temperature at very low temperatures.

This fact was an extremely important starting-point for Nernst but was still not enough to solve the problem. The new supposition or, as we are now justified in calling it, the new theorem laid down by Nernst which made it possible to solve the problem at hand, stated that what applies to the evolution of heat at very low temperatures also applies to the chemical aff'nity, or altogether to the magnitude of the driving force in a physical or chemical change, so that at very low temperatures, this too is also almost independent of temperature.

With the help of this assumption, which means amongst other things that the evolution of heat in the region of absolute zero is a measure of chemical affinity, it is therefore also possible to calculate this at all other temperatures. This calculation is based on the above assumption and on the known evolution of heat at one given temperature and the known change in this evolution of heat with temperature: this change again, can be calculated, as we have indicated, if the specific heats are known.

The great aim of being able to calculate the chemical affinity from thermochemical conditions was thus achieved.This principle has now been widely investigated and has successfully passed all tests. Galvanic cells are particularly suited for such tests, where use is made of the chemical affmity in some reaction for the production of electrical energy, and where an exact and easily determined measure of the chemical affinity is available in the voltage produced by the cell. In connection with the tests on the new heat theorem Professor Nernst has carried out comprehensive and valuable experimental work with his whole staff of collaborators.

This includes the research on the specific heats of various substances at very low temperatures which we have already mentioned and which is epoch-making in its field.

We should also especially mention his magnificent research work on chemical equilibrium at changing temperatures, which even from the practical point of view touches on significant questions such as the dissociation of steam into hydrogen and oxygen, and the formation of nitric oxide from atmospheric nitrogen and oxygen. This provides a theoretical explanation for the process of binding atmospheric nitrogen by means of an electric arc in the manufacture of nitric acid and fertilizers, and at the same time establishes the heat required.

Above all, perhaps, we should recall the investigations on the affinity between carbon and oxygen, since these together with the results of work done by other researchers, have shown that by making use of this affinity - as for instance, in the galvanic cell - about five times as much energy can be obtained from a kilogram of coal as could be obtained from the most efficient steam engines.

The most significant advance which chemistry owes to Nernst's thermochemical work might in short be stated by saying that it is now possible to calculate beforehand the conditions under which a given chemical reaction will take place to the extent where a required product will be obtained in sufficient quantities to make the method of production a practical proposition. Technical difficulties can naturally appear during the course of the experiments, but it is a most significant step forward to know that the aim can be achieved and that there is every chance that the experiments will finally succeed.

In view of the great significance which Nernst's thermochemical work has for chemistry, a significance which may become more and more apparent with the course of time, the Academy of Sciences has decided to bestow on Professor Nernst the Nobel Prize for Chemistry.

Herr Geheimrat Nernst. The discovery of fire, which during the classic age was still attributed to a titan, Prometheus, is both the oldest and certainly the most important of all discoveries.

For long years chemists eagerly sought the suspected connection between the evolution of heat and the chemical affinity during the combustion of coal and in other chemical reactions.

Your work has now brought this connection to light.

You have used brilliant acuteness during your masterly experimental researches on specific heat and chemical equilibria.

Using the heat theorem discovered by you it has now become possible on the one hand to calculate from the heat evolution during chemical reactions and the specific heats, the chemical affinity and the maximum possible output of energy during chemical reactions, and on the other hand to calculate the equilibrium in reactions not yet studied.

The Academy of Sciences has decided to hand you the Nobel Prize for Chemistry as recognition of the exceptional merit of your work on Thermochemistry.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/chemistry/laureates/1920/press.html