J. N. BRØNSTED MEMORIAL ISSUE

Johannes Nicolaus Brønsted — An English View-point

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The general aspects of Brønsted's life and scientific work will be dealt with by those who have known him longer, and who are better qualified to judge his position in Danish academic life. I shall therefore confine myself to some of the particular points which have impressed an Englishman who had the good fortune to work with him for several years and to know him intimately: such an account is bound to embody a personal view-point, but I know that many of my impressions are shared by those of my countrymen who also enjoyed the hospitality of his laboratory.

I first met Brønsted when he attended the Faraday Society Conference on 'Strong Electrolytes' held in Oxford in 1927. This was an important occasion to me for other reasons (since my first published scientific work was presented at this meeting), but I still remember the clarity of Brønsted's paper on the activity of electrolytes, his keenness in debate, and his charm on informal occasions. It was partly this impression which led me to take the opportunity of visiting his laboratory in the following year, and the four years which I spent there were of the very greatest pleasure and profit. During the period 1922–37 a large proportion of Brønsted's collaborators were foreigners, largely from England and the United States. His fame outside Denmark rested chiefly at that time on his work on reaction velocities in solution, in particular in the fields of acid-base catalysis and kinetic salt effects. His definition of acids and bases also became well-known, but there was some tendency at first to dismiss it as 'just another definition' without appreciating its great stimulating and co-ordinating effect in the physical chemistry of solutions. The solubility measurements of Brønsted and LaMer rapidly became famous in relation to the Debye-Hückel theory, but it was not generally realised that these measurements represented the continuation of a long series of valuable experimental studies on solubilities. Similarly, few people knew the importance of Brønsted's early work on affinity in laying the foundations of chemical thermo-

dynamics, where his contributions rank with those of Nernst and G. N. Lewis. His series of papers on chemical affinity (now mostly 30—40 years old) constitute a veritable text-book of thermodynamics, and contain a wealth of fertile suggestion. It is interesting to record that a suggestion which he made in 1911 has just been realised by the help of modern experimental methods. He pointed out then that the affinity of formation of naphthalene picrate from its solid components could be obtained from the E. M. F. of a cell of the type

where solution I is saturated with picric acid and solution II with naphthalene + naphthalene picrate. Brønsted chose mercury-mercurous picrate as the picrate electrode, but was unable to make the necessary measurements because the picrate solutions were reduced by hydrogen. We have recently studied cells of the above type with the hydrogen electrodes replaced by glass ones, and have found exactly the same value for the affinity of formation of naphthalene picrate as Brønsted obtained by an indirect method.

Brønsted's absorption in thermodynamics was one of the aspects of that general integrity and intensity of scientific endeavour which impressed itself so forcibly on those who worked under him. One guest worker in his laboratory described it as a place of 'high chemical potential', and the phrase does give something of the tense and personal feeling which Brønsted inspired. His skill as an experimentalist was not immediately apparent because of the simple nature of many of his methods, and it took some time to realise how much skill and discrimination lay behind an apparently simple piece of experimental work. His great strength lay in the choice of the most suitable substance or reaction, and in the planning of a series of experiments to attain the desired end with the greatest economy of measurement. For this reason his researches always had a much wider application than the immediate purpose in hand, and one of the greatest benefits of working with him was the opportunity of sharing his insight into general methods and planning of research. Many of his pupils have modelled their later work on Brønsted's prototypes: for example, a large proportion of subsequent work on activity coefficients from solubility measurements and general acid-base catalysis follows closely on some lead originally given by Brønsted.

It is more difficult to place Brønsted as a theoretical physical chemist in relation to the main developments of his time. His approach was essentially an experimental one, and his treatment of experimental results always had a strongly thermodynamic flavour, in that he sought to derive empirical relations which should be as simple and as general as possible, without reference to

any particular features of the molecules concerned. In fact, Brønsted showed a great reluctance to speculate in terms of molecular models, and a striking indifference to many of the advances made during his lifetime towards a theoretical and experimental knowledge of molecular structure. There are many examples of this attitude in his work: for example, one felt sometimes that he almost regretted the mechanistic explanation provided by Debye and Hückel for the regularities which he had previously observed in the thermodynamic properties of electrolytes, while he would listen politely, but without marked interest, to my own attempts to provide a molecular basis for the 'Brønsted relation' between catalytic power and dissociation constant. Similarly, his famous expression for the primary kinetic salt effect was arrived at by a curious mixture of intuition and experiment, and the theoretical treatment which he gives in his 1922 and 1925 papers has almost a mystical flavour. Once again he was not much interested in later statistical derivations of the expression.

This attitude was naturally at its strongest when dealing with purely thermodynamic matters, and I remember well his indignation when I suggested (only a few months before his death) that a statistical approach was helpful in teaching students about the second law of thermodynamics. Such a suggestion obviously ranked as heresy, and although his recent work on the fundamentals of thermodynamics strongly criticises many traditional view-points, it never departs from a strictly phenomenological treatment. So far his new ideas on the bases of thermodynamics have aroused little interest in England, and those who have studied them regard them as sound but without much general scientific importance. It would indeed be interesting if these highly formal considerations proved ultimately to be fruitful in the same way as the acid-base definition. This might possibly be the case in the treatment of processes in which a steady state is accompanied by an irreversible transfer of matter or energy, and it is interesting to note that Brønsted had started experimental work on this kind of process shortly before he died.

A large proportion of Brønsted's collaborators were from overseas, and his relations with all these visitors were of the best. They were treated with unfailing kindness and consideration, and the subsequent work done by most of them shows the lasting effect of his influence. On first acquaintance he seemed rather reserved, but one soon realised that this represented only an unwillingness to talk carelessly or lightly about scientific matters, arising from his deep personal feelings about scientific truth. Certainly there was no suggestion of any exclusiveness or selfishness about his own ideas, as may be seen from the large number of major themes which were originated by him and later elaborated by his pupils. When he had once embarked on a dis-

cussion his acuteness and remorseless logic were remarkable, and there can be very few occasions on which he was worsted in a scientific argument.

Brønsted was not altogether easy to know as a person, but when once made the acquaintance was a highly rewarding one. In spite of his strong Danish patriotism he had a great deal of sympathy and understanding for other countries, and especially for England. For the people, the literature and the countryside of England he had a keen interest based on a considerable knowledge, and he could speak and write the English language not only with accuracy but with elegance. The war intensified his English affinities, and the passing of those five years served only to strengthen the ties which bound him to English things and English people. He had read even more about English affairs during the period of separation, and had acquired a remarkable knowledge of Anglo-European politics of the 19th and 20th centuries. Fortunately he was able to visit England again just before his death, and I believe that he enjoyed every minute of his stay: not only the centenary celebrations and the International Chemical Congress, but also the quieter times which he and Mrs. Brønsted spent in the homes of their English friends, and by themselves in a remote corner of the English countryside. It was a great shock to hear of his sudden death so soon afterwards, and many people in this country will mourn him, not only because of his contributions to science or for his inspiring personal genius, but also as a fine and lovable person.