J. R. PARTINGTON (1886-1965): PHYSICAL CHEMISTRY IN DEED AND WORD

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Introduction

Today James Riddick Partington (1886-1965) is remembered as an historian of chemistry rather than as the significant British research chemist and textbook writer he was perceived to be in the 1920s and 1930s. Because his textbooks were specifically geared to the British secondary school and university systems, he is probably not well known in the United States as a textbook writer. Nor, in America or in Europe, is he remembered as a practicing physical chemist who made contributions to thermodynamics, the determination of specific heats, and to electrochemical theory. So, for example, he is not mentioned in Keith Laidler's *World of Physical Chemistry* (1993). Nevertheless, as an outstanding example and model of the chemist-historian, it is of interest to examine his career as a chemist. This profile falls into four sections: Partington's early career and his establishment as a London chemist; examples of his research in physical chemistry; the reasons for his failure to gain a Fellowship of the Royal Society; and, a summing up.

1. Early Career and Establishment as a London chemist

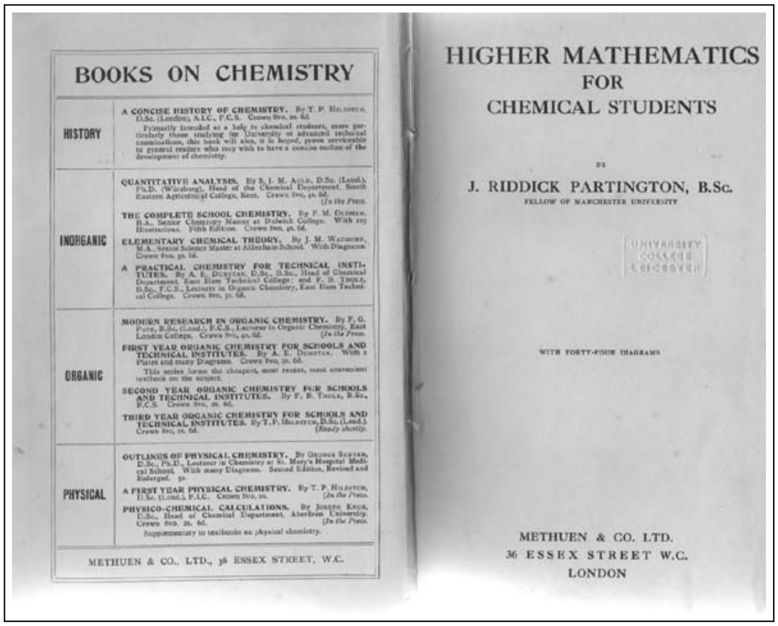
Partington was born on June 30, 1886, at the tiny coal-mining village of Middle Hulton to the south of Bolton. His father was a book keeper [i.e. in American parlance, an accounting clerk] in Bolton and his mother, from whom he took the middle name of Riddick, was the daughter of a Scottish tailor. While he was still quite young his parents moved to the seaside town of Southport, to the north of Liverpool, allowing Partington the benefit of education at the Victoria Science and Art School that had opened in 1887 (1). Here his prowess as a mathematician and practical chemist must have been forged. He left school in 1901 when he was 15 because his parents moved back to Bolton. There he began to assist the town's Public Analyst, a post that must have involved the acquirement of the skills in volumetric and gravimetric analysis that were a hallmark of his later work. After a couple of years, and still in local government employment, he became a laboratory assistant in the town's Pupil Teachers Training College before finally becoming a clerk in Bolton's Education offices (2). During these five years between 1901 and 1906, he embarked upon an intensive course of part-time private study, developing his knowledge of foreign languages, and mathematics. In 1906, at the age of 20, he qualified for entry to the University of Manchester to read chemistry and physics. There he would have used the laboratories that Henry Roscoe had erected in Oxford Road in 1872. Among his teachers was Harold Baily Dixon (1852-1930), whose lectures, Partington recalled (3):

> …were illustrated by striking experiments, were brilliant, stimulating, and in close contact with original sources and research. They were sometimes enlivened by touches of his characteristic humour." He was, however, "somewhat hampered by insufficient knowledge of mathematics.

In other words, although it must have been Dixon who taught Partington thermodynamics, the pupil felt he knew more than his teacher. Other instructors included W. H. Perkin Jr., but Partington was never taken with organic chemistry. His interest in the history of chemistry was engendered both by Dixon and Andrew Norman Meldrum (1876-1934), whose Carnegie Research Fellowship overlapped with Partington's undergraduate and postgraduate studies. Meldrum had already published an outstanding study of the atomic theory in 1906 and was planning to write a history of chemistry in his spare time. Although he emigrated to India in 1913, Meldrum and Partington remained in close contact (4).

On graduating in 1909 with first-class honors and being granted a teaching diploma, Partington was awarded a fellowship funded by the Manchester engineering firm of Beyer to begin postgraduate research with the physical organic chemist Arthur Lapworth, whose first research student he was (5). Astonishingly, within a year he had published two papers in the *Transactions* of the Chemical Society and a further four in 1911 before gaining his M.Sc.. The first paper, written with Lapworth, confirmed that the presence of water in the hydrolysis of an ester diminished the catalytic influence of hydrogen chloride. In the second paper he investigated ionic equilibria in electrolytes from a thermodynamic viewpoint. Effectively, this was a study of the literature on Ostwald's dilution law and the reasons strong electrolytes diverged from the law of mass action (6). Both these early papers show Partington's adeptness at thermodynamic reasoning and his commitment to research in the area of electrolysis, as the other four papers confirm. This was, by any measure, an astonishing output from a postgraduate student of 24.

Then, even more astonishingly, in 1911, and while still a graduate student, he published his first textbook, *Higher Mathematics for Chemical Students*. Nernst and Schönflies had published the first "math for chemists" text in 1898, which had appeared in English in 1900. Partington gave no reason for publishing his textbook and this is odd, given that John William Mellor, a previous student of Dixon's (and with his ardent support) had published *Higher Mathematics for Students of Chemistry and Physics* nine years earlier in 1902. Longmans had kept this in continuous print, so why the need for Partington's book? His dense introduction on scientific method, which shows him already very familiar with the history of chemistry, provides no clue (7). All one can say is that Partington's text was shorter (272 pp) compared with Mellor's (600 pp) and that it was less detailed. Both texts remained rivals and in print until World War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II, following which Partington re-used much of the material as the introductory chapter of the first volume of his multi-volume treatise on physical chemistry (8). It is little wonder, then, that a reference from Dixon describes Partington as "one of the most brilliant students we have had during the last thirty years" (9).

Armed with his M.Sc. in 1911, Partington went to Berlin to study with Walther Nernst though, for reasons unknown, he did not complete a doctorate (10). When he arrived, he spoke German imperfectly, but was soon asked to give a seminar. He carefully wrote this out to read so as not to stumble, but Nernst kept interrupting, forcing Partington to speak without a script. This was Nernst's way of giving him confidence! Following the deduction of his heat theorem in 1906, Nernst had urged chemists to undertake a program of experimentation on the heats of reaction, specific heats, and temperature coefficients to test whether the theorem was an approximation to truth or a true third law of thermodynamics. In a sense this gave Partington his program of research in physical chemistry for the next thirty years: the testing of theory against very precise physical measurements.

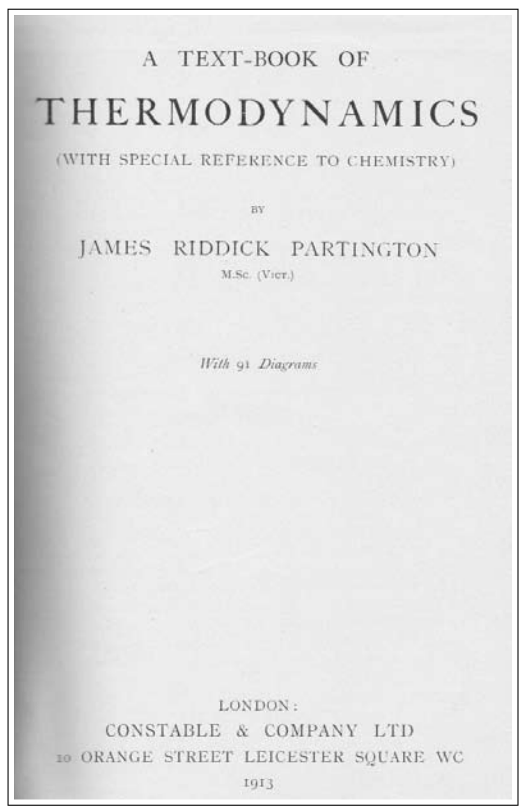
Partington stayed in Berlin until 1913, working on the variations of specific heats of gases with temperature using an adaptation of the adiabatic expansion apparatus first developed at the University of Berlin by Otto Lummer and Ernst Pringsheim (11). He had to persuade Nernst that an improvement of the Berliners' complicated apparatus was needed, since Nernst "had a profound distrust of large, complicated, and expensive apparatus" (Ref. 10, p 2854). Nernst refused to speak to Partington for a couple of days before relenting, and providing him with his own resistance box and string galvanometer for the experiments. Partington used the change in resistance of a Wollaston platinum wire as a thermometer. The wire was placed in a copper balloon of 130-liter capacity, and the gas expanded through a stopcock.

Although there was to be no Berlin D. Phil., Partington did publish five papers in German on his research in the Leipzig journal, *Physikalische Zeitschrift*. These were on the specific heats of air, carbon dioxide and chlorine, and on heats of vaporization and evaporation. While in Berlin he must also have drafted his next book on thermodynamics since it appeared immediately after he returned to England in 1913. The text was indebted to the insights of Nernst's *Theoretische Chemie* (1893), which had been translated into English in 1907. In this detailed account of classical thermodynamics the last two chapters dealt with Nernst's heat theorem and with energy quanta. A reviewer in *Nature* thought it tough reading for chemists unequipped with mathematics (12). Partington later described his thermodynamics as "a pioneer work, [as] nothing of its scope and character was then available in English" (13). This was true since Lewis and Randall's textbook did not appear until 1923, and the only major competitor was Nernst's.

Not surprisingly, he had been welcomed back to the University of Manchester in 1913 as a lecturer. One of his first students was Marian Jones, the daughter of a brickworks manager from Chester, whom he supervised for an M.Sc. degree on supersaturated solutions (14). Partington fell in love with his student and married her after the war on September 6, 1919. She became a chemistry schoolteacher before having two daughters and a son, Roger, who also became a physical chemist (15).

As soon as war broke out in 1914, Partington joined the army, only to be seconded to the Ministry of Munitions to work on water purification with the young physical chemist Eric K. Rideal. Later the two chemists turned to the question of the oxidation of nitrogen to form nitric acid and investigated the Haber-Bosch process that the Germans were pursuing. This led to a book on the alkali industry in Rideal's series on the chemical industry in 1918 and, later, collaboration with Leslie Henry Parker on a history and analysis of the contemporary post-war nitrogen industry (16). For his war work Captain Partington was awarded the MBE (Military Division) (17). Outside his war work for the government, Partington managed to continue with thermodynamics, joining the Faraday Society in 1915. In 1919 he presented a major review of the literature on the dilution law to the Faraday Society, to whose Council he was elected that same year (18).

In 1919 he was appointed sole Professor of Chemistry at the East London College (renamed Queen Mary College in 1934). This Victorian enterprise had begun life as the People's Palace in 1887 as a place of entertainment and education for the poor living in the insalubrious conditions of London's east end. Its educational functions rapidly became more important than its leisure ones, and it was recognized by the University of London for degree purposes in 1915. Partington's immediate predecessor as professor of chemistry was John Hewitt (1868-1954), an organic chemist whose pupils had included Samuel Glasstone. Hewitt had designed a three-story laboratory in 1914, and Partington subsequently added a fourth story in 1934. The conditions for teaching and research were



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(WITH SPECIAL REFERENCE TO CHEMISTRY)

BY

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M.Sc. (Vict.)

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1913

Title page, Text-Book of Thermodynamics hardly ideal. Accommodation and discipline were serious problems because of the influx of men from war service, and laboratory stocks of chemicals and equipment were dire (19). However, with the support of the college's administrators, and with small grants from the Chemical Society and the Department of Scientific and Industrial Research, Partington succeeded in establishing a modest research school with colleagues such as W. H. Patterson and D. C. Jones, and on the organic side, F. G. Pope, E. E. Turner, and H. D. K. Drew. College Calendars show that Partington's rate of publication not only outshone that of his chemistry colleagues, but those of colleagues throughout the college. Even so, when Michael Dewar inherited the Department in 1951 he complained at its shabbiness and unsuitability for research. The chemistry building was not demolished and rebuilt, however, until 1967 after Dewar had left (20). Partington chose to lecture exclusively on inorganic and physical chemistry. A compulsory one-term course on the history of chemistry that he introduced in 1919 was soon abandoned, though he revived it as an elective from 1945 onwards.

With the outbreak of World War II in 1939 Partington's department was evacuated to Cambridge, and Partington spent the war years in that city enjoying the facilities of the university's copyright library. Although arrangements had been made for the families of staff to be accommodated at Cambridge, Mrs Partington stayed behind at the family home in Wembley. Tragically, she committed suicide in March 1940, leaving Partington a widower for the remainder of his life (21).

On returning to the badly damaged East End of London in 1945, he more or less abandoned laboratory research and devoted himself instead to historical work and to the completion of his *Advanced Physical Chemistry*. He retired in 1951 to a house in Mill Road, Cambridge, and was looked after by an aged housekeeper. The house was filled with books from cellar to roof. According to Joseph Needham, he became something of a recluse, rarely stirring from his writing desk (22). At the end of 1964, following his housekeeper's retirement, unable to look after himself, he joined relatives in the salt-mining town of Northwich in Cheshire, where he died on October 9, 1965 (23).

2. Partington's Research in Physical Chemistry

Throughout the 1920s and 1930s, Partington made many other contributions to Faraday Society discussions. Although never elected President (probably because his modesty and intense reserve deterred him from seeking such office), he served on Council almost continuously from 1919-38, and particularly on its Publications Committee on which he also served as representative for the American *Journal of Physical Chemistry* (24).

Partington's 1919 Faraday Society paper (Ref. 18) was a critical examination of theories of strong electrolytes. In particular, he examined Jnanendra Chandra Ghosh's theory of strong electrolytes published the previous year and showed that it was not in agreement with experiment (25). Ghosh assumed complete dissociation of strong electrolytes, with the majority of the dissociated ions arranging themselves into a crystal-like space lattice. Partington found the theory "startling" but deduced that it was incompatible with observed data. Ghosh, who was due in England to take up a research post at University College, London, was not present but sent in a reply. Unfortunately, Partington made an arithmetical blunder that enabled Ghosh to rebut the valid criticism Partington had made. Partington's response showed again that Ghosh's theory was based upon "guess-work." According to an appraisal of Ghosh by R. Parthasarathy in *The Hindu* for December 12, 2002, the criticism caused Ghosh to withdraw from being elected FRS! This is obviously based upon a misconception, but may, perhaps, have been an anti-imperialist story told by Ghosh in later years (26).

Partington's other principal research was on the temperature dependence of specific heats. As we have seen, this interest was initiated by Nernst while Partington studied in Berlin. Once settled at Queen Mary College, Partington took up this research again. Whereas Nernst had been interested in the determination of specific heats at low temperatures because of quantum effects, Partington was interested in their behaviour at high temperatures. There were obvious industrial applications in the automobile and refrigeration industries, as well as the need for specific heat data in designing industrial plants involving gases. Instead of measuring specific heats by adiabatic expansion, as he had in Berlin, he determined c_p/c_v from the velocity of sound by using a modified Kundt tube, as Dixon had recently done at Manchester (27). He initially determined values for air and some simple gases, using a modified electrically-heated Kundt tube to determine the velocity of sound at different temperatures. Later, with W. G. Shilling, the son of the owner of an engineering firm, he developed a modified and improved form of the apparatus to enable measurements up to 1000° C. The joint work was summarized in 1924 as a "coherent and critical account of the state of our knowledge" (28).

Work on specific heats led Partington into an interesting controversy with the young Mrs Ingold. In 1921 Hilda Usherwood, the future wife of Christopher Ingold, working with Martha Whitely at Imperial College, began an investigation of tautomerism by using the variation of specific heats with temperature as a guide to changes of equilibria. Her two papers on "the detection of tautomeric equilibria in hydrocyanic acid" and "specific heats of gases with special reference to hydrogen" (the latter with Ingold) appeared in 1922 (29). In 1925, a year after he and Shilling had published their book, *The Specific Heats of Gases*, Partington challenged Mrs Ingold's results (30). He claimed her values for hydrogen had been only approximate, that her HCN was impure, and that her values for the hydrogen cyanide-hydrogen *iso*-cyanide equilibrium were due not to thermal effects accompanying isomeric change, but polymerization, which Hilda had ignored. She replied, standing her ground; and Partington stood his. But Mrs. Ingold won the day by showing that Partington's evidence for association was valid only for a very small part of the temperature range studied (31). In his biography of Christopher Ingold, Kenneth Leffek suggests that Partington's criticisms were weak and that (32):

> …in 1925 Partington felt that it was fashionable to attack someone with the name Ingold, in view of all the activity in the Chemical Society and in the pages of *Chemistry and Industry* concerning the theory of chemical reactions.

Partington demonstrating before the Duke and Duchess of York (later King George VI and Queen Elizabeth) May 15, 1928 (courtesy Queen Mary College)

This is unfair. Partington's 1925 paper, based upon an M.Sc. thesis by his pupil M. F. Carroll, merely noted that measuring the specific heats of HCN by a different procedure from Mrs. Ingold's gave different results and suggested why this might be so. It is clear, in any case, that the Ingolds did not hold the controversy against Partington, since Christopher Ingold signed Partington's Royal Society application in 1926.

3. Partington and the Royal Society

Partington had read three papers on specific heats to the Royal Society in the years 1921-1925, and these had been communicated by Dixon and the physicist, J. A. Harker. He was first put up as a candidate for its Fellowship in 1927 during the Presidency of Ernest Rutherford (33). By 1924, when the book on specific heats appeared, Partington had published some eleven papers on specific heats and could be considered the British expert on the subject. Given Partington's publication record and his prominence in the Faraday Society, why was his candidature a failure?

In the 1920s election to the Fellowship was by recommendation in writing by six or more Fellows, of whom three had to be recommending from personal knowledge. A printed list of candidates was circulated to all the Fellows each January. The Society's Council then selected twenty of the names by ballot and recirculated its proposals, which were then voted on by those Fellows present at the next ordinary meeting. Proposals were allowed to stand for four further years after initial failure, following which the candidate could be proposed again by new sponsors (34). Election of Partington having failed the first time in the years 1927-31, he was proposed a second time from 1935 to 1939. The first two signatories were conventionally understood to be the proposer and seconder, and in Partington's case they were the physical chemists Herbert Brereton Baker and Frederick George Donnan in 1927, and Eric K. Rideal and Donnan in 1935. All three sponsors had connections with Partington through his wartime activities and were prominent in the affairs of the Faraday Society.

Baker and Donnan, however, did a poor job of the nomination, merely stating that Partington was "distinguished for his research work in inorganic and physical chemistry," citing a few papers (but omitting his many contributions to the Faraday Society), and stating that there were 52 other papers as well as books on thermodynamics, inorganic chemistry, mathematics for chemists, and five other books. Despite this lack of specificity, the nomination attracted many additional distinguished chemists, who added the support of their signatures.

> *Sir Thomas Henry Holland*, geologist, member of the Munitions Board 1917, Rector Imperial College

> *Thomas Martin Lowry*, physical chemist at Cambridge
>
> *Nevil V. Sidgwick*, physical chemist at Oxford
>
> *T. Slater Price*, Director British Photographic Research Association, former physical chemist at Birmingham Municipal Technical School
>
> *Christopher K. Ingold*, physical organic chemist at Leeds
>
> *James C. Philip*, physical chemist at Imperial College
>
> *William Jackson Pope*, organic chemist at Cambridge
>
> *Frank Lee Pyman*, Director Boots Pure Drugs Co, and former physical chemist at Manchester College of Science and Technology
>
> *Alexander Scott*, inorganic chemist, Director of Laboratories at British Museum
>
> *Kennedy Orton*, physical organic chemist at University of Wales (Bangor)

It is curious that Dixon (who died in 1930) was not one of the signatories.

That proposal having failed, Partington was sponsored again in 1936 during the Presidency of William H. Bragg. This time the sponsors, led by Rideal and Donnan, were more elaborate in extolling Partington's virtues as a scientist (35):

> The candidate has published numerous scientific papers and several valuable text books since 1910. Of the latter, one on higher mathematics for Chemical Students, the other on Inorganic Chemistry are in their fourth edition, and one on Thermodynamics is in its second edition. His work on the specific heat of gases by classical methods is well known, and several of his determinations are accepted internationally. He has also published two series of papers, one on dielectric polarization and the other on concentration cells which are records of careful and accurate work in physical chemistry. He has investigated analytically a number of unusual inorganic reactions and elucidated their mechanisms. There have been published in the *Journal of the Chemical Society* and the *Transactions of the Faraday Society*. His interests in the history of Chemistry are exemplified by a series of papers and a research monograph of unusual character.

This was signed by:

> *Eric K. Rideal*, physical chemist at Cambridge
>
> *F. G. Donnan*
>
> *James C. Philip*
>
> *Alfred C. Egerton*, physical chemist (thermodynamics) at Imperial College
>
> *John Theodore Hewitt*, chemist and inventor; Partington's predecessor at Queen Mary College
>
> *Henry T. Tizard*, physical chemist, Rector of Imperial College
>
> *Arthur John Allmand*, physical chemist at King's College, London. Further support was gained when four physicists added their names in 1938:
>
> *Harold Roper Robinson*, professor of physics and historian of science at Queen Mary College
>
> *William Wilson*, mathematical physicist at Bedford College, London
>
> *Neil Kensington Adam*, physical chemist at University of Southampton
>
> *Edward N. da C. Andrade*, physicist at University College, London

As both proposals show, my initial assumption that being a writer of textbooks and history of science counted against Partington does not seem to have been the case. On the other hand, Partington's research was hardly innovative; rather it relied upon perfecting others' work, or what T. S. Kuhn aptly described as "normal science." Partington was not blazing any new trails in his research such as those being undertaken in the 1920s in quantum chemistry, kinetics, and spectroscopy. A comparison with Mellor, another encyclopedic chemist, is especially apt since he was one of the two chemists elected in 1927 in preference to Partington. Mellor was also largely self-taught before gaining his first degree at the University of Otago in New Zealand by part-time study (36). Like Partington, he had then joined the University of Manchester, where he wrote his previously mentioned mathematics for chemists and his *Chemical Statics and Dynamics* (1904). Unlike Partington, however, he did not become a university teacher; instead he used his deep knowledge of physical chemistry to transform the ceramics industry of Staffordshire. Although, like Partington, he continued to publish excellent textbooks on inorganic chemistry, including the multi-volume *Comprehensive Treatise on Theoretical and Inorganic Chemistry* (1922-1937), it was the originality of his research in ceramics chemistry, where he opened up an economically important industry to scientific scrutiny, that brought him the FRS in 1927. Similar points can be made about originality for all the other chemists who were successfully elected FRS between 1917 and 1939 (See Table).

4. Conclusion

Throughout the 1920s and 1930s Partington regularly published five or six papers a year, either independently or with students, on a variety of topics in inorganic and

Table 1: Chemists elected FRS 1927-31 and 1936-40

1927	James P. Kendall (1889-1978), physical chemist Joseph William Mellor (1869-1938), ceramics chemist
1928	Walter Norman Haworth (1883-1950), organic chemist Robert Whytlaw-Gray (1877-1958), inorganic chemist
1929	Cyril N. Hinshelwood (1897-1967), physical chemist
1930	Eric K. Rideal (1890-1974), physical chemist
1931	Ian Morris Heilbron (1886-1959), organic chemist
1936	Joseph Kenyon (1885-1961), organic chemist Ronald G. Norrish, physical chemist
1937	George R. Clemo (1889-1983), organic chemist William Hume-Rothery (1899-1968), metallugist William Edward Garner (1889-1960), physical chemist
1938	Sir Robert L. Mond (1867-1938), industrial chemist George Ingle Finch (1888-1970), physical chemist
1939	James Irvine Masson (1887-1962), physical chemist Eustace E. Turner (1893-1966), organic chemist
1940	William T. Astbury (1898-1961), crystallographer Charles F. Goodeve (1904-1980), physical chemist Patrick Linstead (1902-1966), organic chemist

physical chemistry. All his work was characterized by meticulous experimentation and the gathering of quantitative information whenever possible. It seems to me that the whole of Partington's research was devoted to the appraisal of deductions made from thermodynamic equations and comparison between theory and experiment with the aim of perfecting theory and the creation of sound and accurate physical constants and measures. For example, he worked prolifically on solubility effects, and devised and developed a new form of electric vacuum furnace in 1925 to investigate high temperature reactions (37).

Partington had well over 70 collaborators between 1914 and 1951, when he retired. Among his pupils were Frederick E. King, later a professor at the University of Nottingham before he entered the chemical industry; Arthur Israel Vogel, the analytical chemist and textbook writer; and Raymond J. W. Le Fèvre, who was not impressed (38). It was said of Harold Dixon that he was singularly reticent and was "difficult to penetrate within his outer ring of electrons" (39). The same was true of Partington, though one obituarist thought him reserved rather than reticent and that he was "extremely modest" (40). He was a small man with a military bearing, Teutonic, and seemingly testy in manner. Conservative in attire until quite late in life, he still dressed with a wing collar. He spoke very quietly, so that students and fellow academics often found his lectures inaudible, and therefore boring.

His working methods were those of the Victorian and Edwardian scholar. He wrote neatly (or typed) on the backs of proofs, which he then cut up and rearranged as necessary by gluing them together. Patient printers and publishers allowed him to tinker with several proofs until he was satisfied with their accuracy. His encyclopaedic four-volume *Physical Chemistry* (1949) was compiled at Cambridge during the war and kept in a suitcase, which he carried into underground shelters to work on during German air raids.

Partington was a highly competent practical and theoretical chemist and gifted (as Hartley remarked in the

Dictionary of Scientific Biography), with an encyclopedic mind; but although the problems he tackled were often intricate, they could be rather dull normal science. He seems to have lacked the ability, or the desire, to tackle frontier problems. Undoubtedly he gave excellent training to several generations of chemists (including several from India) who went into teaching or industry, while his texts offered great value to generations of school and university chemistry students. Nevertheless, just as his four-volume *History* is an indispensable aid to our discipline, his chemistry papers, his *Higher Mathematics for Chemical Students,* his *Thermodynamics*, his *Specific Heats of Gases*, and his huge *Advanced Physical Chemistry* remain monuments to the development of physical chemistry since the 1900s. What Partington wrote of Nernst in 1953 is equally a memorial to his own work as a physical chemist (41):

> A physical chemist is at some disadvantage, compared with the organic chemist, since new compounds remain, but new [physical] measurements soon give way to newer, and sometimes better, ones. The pioneering investigations are soon forgotten, and results which in their time were highly important and significant are amplified and revised by later workers, who not infrequently reap the benefit of newer techniques which make their task easier than that of the earlier pioneer experimenters, whose contributions to science tend to be overlooked.

ACKNOWLEDGMENTS

I am grateful to Lorraine Scheene, archivist at Queen Mary College; and, for information on Partington's relations with the Royal Society, to Nichola Court, archivist at the Royal Society, and Sir John Rowlinson.

REFERENCES AND NOTES

1. The school was replaced by a technical college in 1935 and, since 1983, now forms Southport College.
2. These sparse details of his early career come from A. Sparke, *Bibliographia Boltoniensis*, Manchester University Press, Manchester, 1913.
3. J. R. Partington, *A History of Chemistry*, Macmillan, London, 1964, Vol. 4, 621.
4. For an obituary of Meldrum by M. O. Forster, see *Trans. Chem. Soc.,* 1934, pp. 1476-77. This mentions that his intentions to write a history of chemistry were thwarted by his entry into the Indian Educational Service in 1912. He became professor of chemistry at the Royal Institute of Science, University of Bombay in 1918. See A. N. Meldrum, *Avogadro and Dalton: the Standing in Chemistry of their Hypotheses*, William F. Clay, Edinburgh, 1904; *The Eighteenth-Century Revolution in Science – The First Phase*, Longmans, Green, Calcutta, 1930. His historical essays were edited by I. B. Cohen, *Andrew N. Meldrum, Essays in the History of Chemistry*, Arno, New York, 1981. Meldrum and Partington became close friends. Meldrum's position in Bombay led to Partington's being invited to examine Indian students and to receive several as research students at Queen Mary College. Note the many Indian examination questions in J. R. Partington and K. Stratton, *Intermediate Chemical Calculations,* Macmillan, London and New York, 1956.
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7. The second edition appeared in 1920 and carried exactly the same introduction. The third edition (1929) has not been examined. Both Mellor and Partington covered more than just the calculus treated by the German collaborators. See W. H. Brock, "Math for Chemists, " *Chem. Heritage*, **1998**, *16 (2)*, 2, 17-18.
8. J. R. Partington, *An Advanced Treatise on Physical Chemistry*, 5 vol., Longmans, Green, London, 1949-1954. See Vol. 1 (1949), 1-114. Mellor's text remains in print as a Cosimo Classic, 2007.
9. Archive of the University of Manchester Department of Chemistry DCH/2/9/81, The John Rylands Library, Manchester. The testimonial is undated, but since it refers to Partington's war work, it was probably written in support of Partington's application for the chair in London in 1919.
10. J. R. Partington, "Nernst Memorial Lecture," *J. Chem. Soc.*, **1953**, 2853-2872; D. K. Barkan, *Walther Nernst and the Transition to Modern Physical Science*, Cambridge University Press, Cambridge and New York, 1998. (Neither Partington nor his memorial lecture on Nernst is mentioned.)
11. O. R. Lummer and E. Pringsheim, "Bestimmung des Verhältnisses (ϰ) der specifischen Wärmen einiger Gase," *Ann. Phys.*, **1898**, *300*, 555-583.
12. J. R. Partington, *A Text-Book of Thermodynamics (with Special Reference to Chemistry)*, Constable, London,

1913; 2nd ed. 1924; 3rd ed. 1940; 4th ed. 1950. See *Nature*, **1913**, *92*, 265.

13. Ref. 12, preface to revised 4th ed., 1950.
14. M. Jones and J. R. Partington, "Experiments on Supersaturated Solutions," *Trans. Chem. Soc.*, **1915**, *107*, 1019-1025. He also collaborated on the surface energy of supersaturated solutions with a fellow lecturer, William Jacob Jones (1886-1952), no relation, who later became a professor at Cardiff.
15. I have not been able to trace a set of Mrs M. Partington, *Set of Cards for Teaching Chemical Formulae and Equations,* Baird and Tatlock, London, 1921 which she devised for schools. This was a set of cardboard pieces colored blue for positive radicals and pink for negative radicals. Formulas were constructed by placing appropriate cards side by side. See review in *Nature,* **1921**, *107*, 108.
16. J. R. Partington, *The Alkali Industry*, Ballière, Tindall, and Cox, London, 1918; 2nd ed., 1925; J. R. Partington and L. H. Parker, *The Nitrogen Industry*, Constable, London, 1922.
17. In his entry on Partington for the original edition of the *Dictionary of Scientific Biography,* Charles Scribner's, New York, 1974, Vol. 10, 329-330, Sir Harold Hartley stated that Partington was awarded a knighthood for his wartime work. This blunder has not been amended in the *New Dictionary of Scientific Biography*, Scribner's, New York, 2007. In 1921 Partington attacked the British government for its German Reparation Act, which made it difficult to order laboratory goods from Germany. He was then serving on the Committee of the British Science Guild concerned with the supply and pricing of laboratory glassware and chemicals. See *Nature*, **1921**, *107*, 394, 458.
18. L. Sutton and M. Davies, *The History of the Faraday Society*, Royal Society of Chemistry, London, 1996, 48-51, 106, 110, 189-190. Captain J. R. Partington, "Some Recent Investigations of the Dilution Law," *Trans. Faraday Soc.*, **1919**, *15*, 98-121.
19. W. J. Hickinbottom, "Schools of Chemistry: Queen Mary College, London," *J. R. Inst. Chem.*, **1956**, *80*, 457-465. For a general history, see G. P. Moss and M. V. Saville, *From Palace to College. An Illustrated Account of Queen Mary College,* The College, London, 1985.
20. M. J. S. Dewar, *A Semiempirical Life*, *Profiles, Pathways and Dreams*, American Chemical Society, Washington, DC, 1992.
21. Academic Board Minutes, Queen Mary College, May 16, 1939. Coroners' reports are embargoed for 75 years, but those for Middlesex have already been destroyed.
22. See Joseph Needham's description of Partington, *The Times,* **1965**, October 15, 23.
23. In a letter to this author, November 16, 1964, he remarked, "although cut off from some large libraries to which I now have access, I hope to be able to finish my book [Vol. 1 of the *History of Chemistry,* half of which had been set in type], since I have a library of my own and [will be] within reach of Manchester and Liverpool." In fact, he was unable to complete his *History* and the notes he had made on the development of alchemy proved unpublishable.
24. Ref. 18, p 106. Partington was Vice-President in 1935.
25. J. C. Ghosh, "The Abnormality of Strong Electrolytes," *Trans. Chem. Soc.*, **1918**, *113*, 449-458, 627-638, 707-715, 790-799; J. C. Ghosh, "The Abnormality of Strong Electrolytes," *Trans. Faraday* Society, **1919**, *15*, 154-162, with Partington's comment, 162-163. See J. H. Wolfenden, "The Anomaly of Strong Electrolytes," *Ambix*, **1972**, *19*, 175-196 (191).
26. See: www.hinduonnet.com/thehindu/seta/2002/12/12/stories/2002121200120300.htm, accessed September 1, 2008. Sir Jnan Chandra Ghosh (1894-1959), a graduate of Calcutta University, postgraduate studies at University College London (1919-1921), taught at Dacca University (1921-39); directed Indian Institute of Science, Bangalore (1939-47) and Indian Institute of Technology, Kharagpur (1950-54). His last years were spent on government planning. He was knighted in 1943 for his services to Indian science and industrialization. See "Eminent Bengalees" website, www.geocities.com/eminent-bengalees.html (accessed September 3, 2008).
27. H. B. Dixon, C. Campbell, and A. Parker, "On the Velocity of Sound in Gases at High Temperatures, and the Ratio of Specific Heats," *Proc. R. Soc.,* **1921**, *100*, 1-26.
28. J. R. Partington and W. G. Shilling, *The Specific Heats of Gases*, Ernest Benn, London, 1924. Shilling had graduated at Queen Mary College with third class Honours in 1921 and was presumably taken on by Partington as a graduate student because of his experimental abilities. He subsequently did a Ph.D. with Partington on the calculation of the molecular heats of gases from equilibrium constants. See *Trans. Faraday Soc.*, **1926,** *22*, 377-400.
29. E. H. Usherwood, "Tautomerism of Dyads," *Trans. Chem. Soc.*, **1922**, *121*, 1604-1609, 2286-9.
30. Her results for HCN at five different temperatures are tabulated in *Specific Heats* (Ref. 28, p 200), without any critical comment.
31. The controversy can be followed in *Philos. Mag.,* **1925**, *49*, 49 (1925), 665-680 (Partington and M. F. Carroll); *Trans. Chem. Soc.*, **1926**, *129*, 26-29 (E. H. Ingold); *Trans. Chem. Soc.,* **1926**, *129*, 1559-1562 (Partington); *Trans. Chem. Soc.,* **1926**, *129*, 2816-2817 (E. H. Ingold).
32. K. T. Leffek, *Sir Christopher Ingold. A Major Prophet of Organic Chemistry*, Nova Lion Press, Victoria, BC, 1996, 100.
33. In *The Specific Heats of Gases* (Ref. 28, p 75), Partington writes that the work on air and carbon dioxide described in his German paper of 1913 had only been in summary form, and was given later in detail in *Proc. R. Soc*, **1921**, *100A*, 27-49, **1924**, *105A*, 225-243, and **1925**, *109A*, 286-291. Partington's values for specific heats were widely used. See, for example, R. Fowler, *Statistical Mechanics. The Theory of the Properties of Matter at Equilibrium*, Cambridge University Press, Cambridge, 1929.

34. H. Lyons, Ed., *The Record of the Royal Society of London*, Royal Society, London, 4th ed., 1940.
35. Citation kindly supplied by Nichola Court.
36. F. Habashi, "J. W. Mellor (1869-1938)," *Bull. Hist. Chem.,* **1990,** *7*, 13-16. Mellor's proposers, led by H. E. Armstrong and William J. Pope, identified him as "the leading authority on the scientific principles underlying the Pottery Industry" and stressed that the ongoing *Comprehensive Treatise* was "so valuable to chemists that its importance can hardly be over-estimated." (Quoted by Habashi in his Mellor entry, *Oxford DNB*, Oxford University Press, Oxford, 2004).
37. F. E. King and J. R. Partington, "The Effect of One Salt upon the Solubility of Another," *Trans. Faraday Soc.*, **1927**, *23*, 522-535; J. R. Partington and N. L. Anfilogoff, "An Improved Form of Electric Vacuum Furnace," *Trans. Faraday Soc*, **1925**, *21*, 360-370.
38. On King, see *Biogr. Mem. Fellows R. Soc.*, **2003**, *49*, 299-314; on Vogel, *Chem. Br.*, **1996,** 548; on LeFèvre, *Hist. Rec. Aust. Sci.*, **1987***,* *7*, 273-297.
39. H. B. Baker and W. A. Bone, "Harold Baily Dixon" in A. Findlay and W. H. Mills, Ed., *British Chemists,* The Chemical Society, London, 1947, 126-145 (145).
40. F. H. C. Butler, "James Riddick Partington," *Br. J. Hist. Sci.*, **1966**, *3*, 70-72, 71.
41. Partington, Nernst Lecture (Ref. 10, p 286). The passage continues: "In physical chemistry, as in geology, time is a great leveler. Landscapes of theory dissolve and are replaced by newer formations overlaying and concealing more primitive ones. Yet there are some hard and resisting primitive masses which appear, unconformably sometimes, projecting from the level of material derived from the comminution of old formations."

ABOUT THE AUTHOR

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