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TWO ENGLISH CHEMISTS/AUTHORS/TEACHERS: JOHN READ AND JAMES RIDDICK PARTINGTON

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Abstract: John Read and James Partington were both prominent and highly respected academics, chemists, authors and teachers during the middle decades of the 20th century. Their books were widely read throughout this period and played a major role in educating and raising the awareness of chemistry among young people and adults. Today their names are forgotten. The aim of the present article is to re-establish these two remarkable men and to bring them to the forefront of educational programs. An outline is given of their careers as chemists, set against the background of the times they lived in, giving an emphasis to their formidable literary output. Although they had widely contrasting personalities, and were specialists in three different fields of chemistry, Read: organic, Partington: physical and inorganic, they both recognized the great importance of setting chemistry in an historical context. Accordingly, they both wrote many works on the origins and development of chemistry and included much historical material in their textbooks. This added not only a great interest to the subject, but also set it in a broader cultural context, which is so clearly lacking in today's chemistry teaching programs. A chronological list of their books is given and short contrasting fragments from four of them are analysed. Not only are these books of great interest, but they serve as an outstanding foundation for teaching the principles of chemistry today. A recommendation is made to incorporate one work of each author as compulsory reading material for students today, and in future years.

Keywords: Read, Partington, chemistry, organic chemistry, inorganic chemistry, physical chemistry, education

Introduction

There are several reasons for writing about these two remarkable men, who have inspired me for 50 years: initially as a student and subsequently as a chemistry teacher. They were contemporaries, highly respected academics and educators, and served as university professors for over 30 years - Read at St. Andrews in Scotland (1923-1965), and Partington at Queen Mary College, London (1919-1951). Between them they covered three major fields of chemistry - Read: organic, Partington: physical and inorganic. They were both prolific authors, writing dozens of academic papers and many textbooks and chemistry books for non-specialists, which were reprinted many times. They were outstanding historians of chemistry, publishing many important works in this field, and they understood and were aware of the role of chemistry in everyday life.

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Yet they had completely different writing styles, which stemmed from their very contrasting personalities - Read, who was an extrovert, had the "light touch", with much humour, whereas Partington, who was quiet and reserved, gave meticulous attention to clarity of exposition and detail. Coincidentally, they were both at Manchester University during the academic year 1907-1908, and each wrote a book on explosives.

Above all, I found their books compulsively interesting.

Their childhood times

Towards the end of the nineteenth century, Victorian England was at the height of its power and international influence. The British Empire extended to over 1/5 of the globe - developments in science and technology had played a significant role in its growth. These included coal mining, steel manufacture and steam power, which was now giving way to electric power and to the internal combustion engine. Rapidly expanding means of communication - railway transport, steamship ocean liners, wireless telegraphy, postage stamps and photography were hallmarks of those times.

During the first half of the century, quantitative and analytical chemistry had made an impact on our understanding of the ratios in which elements combine, following the elucidation of the Laws of Chemical Combination. These two growing fields of chemistry, coupled with much improved techniques for the separation of substances (e.g. fractional distillation) facilitated the classification of organic compounds, which led to the inventions of synthetic dyestuffs and high explosives. Great advances were made in our understanding of matter: its particulate nature and the types of particles which exist - atoms, ions and molecules. The structure of matter (i.e. arrangement of particles) in gases, liquids and solids (crystals) was providing experimental evidence for fundamental questions concerning the nature of living organisms. The science of thermodynamics was a rapidly expanding field which had great beneficial effects on the chemical industry and on transport: it improved the efficiency of combustion processes in the chemical industry and in steam engines. The discovery of radioactivity in the late 1890's threw a new light on our understanding of the nature of matter, of chemical bonding and of energy.

Accompanying these advances came a rapid increase in urban population. Associated with this were the problems of overcrowding, feeding people, and a wide variety of environmental issues, including the pollution of air, land and waterways.

Science and all things scientific were the buzzwords of those times and accordingly, its study occupied a foremost position in education programs.

John Read (17.02.1884-21.01.1963)

John's parents, John Read (1814-1889) and Bessie Gatcombe (1854-1904), came from families in the West of England, which had deep roots in the agricultural tradition. In short, they were "West Country folk", with ancient origins. John grew up as part of a large family in rural Somerset, in the village of Sparkford. He had 5 half-brothers, 6 half-sisters and 1 sister.

From an early age, he displayed an unusually high level of natural curiosity and intelligence. He did chemical experiments at home and had a passionate interest in astronomy. He also had an extraordinary ability to mix with people and to communicate with them. So great were his interpersonal skills, that through his conversations with locals - farmers, craftsmen and labourers - he became fully bi-lingual as a young lad, gaining complete mastery of the south-east Somerset dialect. Throughout his life, Read remained deeply attached to his cultural heritage, and actively promoted it.

Photo 1. John Read [courtesy of Oesper collections: University of Cincinnati]

He attended an infants' school at Queen Camel from the age of 6, and the local village school in Sparkford from the age of 9. When he was 12, John achieved his first significant academic success when he came first in the County Junior Scholarship Examination and joined the newly founded Sexey's School in Bruton. This had been founded in 1891, and its first headmaster was the brilliant young and inspiring William Albert Knight. Sexey's was one of the earliest schools in which a special emphasis was laid on the high quality teaching of the sciences and technology. Under Knight's guidance, Read did very well at school in academic subjects and was outstanding at sport, for which he won the *Dux Ludorum* award. Cricket was his favourite game, and he was to maintain his contact with it by supporting Somerset County Cricket Club until the end of his life. Even though history, literature and languages were his favourite subjects at school, Read was persuaded to study chemistry. In 1901 he won a Senior Somerset county scholarship to study at Finsbury Technical College in North London (this evolved into Imperial College, London University, during the early decades of the 20th century). Read was inspired by the teaching of Professor

S.P. Thompson FRS (1851-1916), who was an outstanding physicist and Principal of the College, and the organic chemists: Professor R. Meldola FRS (1849-1915) and in Read's words, the particularly good teacher, F.W. Streatfeild.

After gaining the College Diploma in 1904, Read remained at the college for a further year as a demonstrator/assistant, before being granted a London County Council (LCC) scholarship to further his studies. Through his personal college friend Watson Smith jr., whose mother was Swiss and lived in Zurich, Read was accepted as a PhD student (Doktorand) in organic chemistry in Zurich. His supervisor was the genial Professor Alfred Werner (1866-1919) (Nobel Prize in Chemistry in 1913, for proposing the octahedral configuration for transition metal complexes). Whilst in Zurich, Read quickly learnt German and made many friends. He also worked hard, and submitted his thesis: *Untersuchungen in der Cumar - und cumarinsäurereiche* (research into coumarin and its acid derivatives) after three years. Coumarin is a fragrant organic compound (1-benzopyran-2-one $C_9H_8O_2$) with colourless crystals, which occurs naturally in plants. It was first synthesized by the organic chemist William Perkin (1838-1907) in 1868 from coal tar derivatives, and entered into use in the perfume industry during the late 19th century. Perkin had established himself as a leading organic chemist through his serendipitous discovery of the aniline based dye mauveine in 1856. This revolutionized the dyestuffs industry, for it enabled a wide range of synthetic new colours to be manufactured. It is of interest to note that Perkins' son, William Perkins jr. (1860-1929) was also a prominent organic chemist, and was one of James Partington's teachers at Manchester University in 1908-1909.

Read was awarded his PhD in summer 1907 and in autumn of the same year he was awarded a B.Sc. degree from London University - not a sequence of events which we would envisage today! He returned to England in late 1907 and subsequently decided to join W.J. Pope FRS (1870-1939) at the Municipal School of Technology at Manchester, to continue research in the rapidly expanding field of the stereochemistry of organic compounds. Pope was already a highly regarded organic chemist, specializing in stereochemistry and molecular symmetry. In the summer of 1909 Pope was elected to the Chair of Chemistry at Cambridge University, and Read followed him as Assistant to the Professor. During the ensuing 8 years, Read established himself not only as a first class organic chemist but also as an outstanding teacher and mentor to students. His principal achievements in the field of organic chemistry during this period were: the discovery that a molecule could exist in both left handed and right handed forms, though it did not contain an asymmetric carbon atom, and the synthesis of optically active chloroiodomethanesulphonic acid, the simplest asymmetric compound known. In recognition of his work in the field of organic stereochemistry, he was awarded an MA degree *honoris causa* in 1912 by Cambridge University. At the outbreak of the Great War in 1914 Read worked for the Ministry of Munitions in the development of high explosives which were derived from Borneo petroleum, and this led to an increased production of TNT. The demand for Read's talent as an organic chemist thus began to grow.

As a result of a recommendation by Pope, Read applied for the post of Chair of Organic Chemistry at Sydney University in Australia. On 8th December 1915, he was informed that his application had been successful. At Sydney University, which was much to Read's liking in every respect, he became involved in research into the chemistry of Australian flora. The increased focus on the study of natural substances was due to the better understanding of organic compounds and their structural relationships with one another, and to improved techniques in analytical chemistry, such as combustion analysis. The discovery, by Louis Pasteur (1822-1895), of the phenomenon of optical activity in 1848 had sparked off a new field of research into the substances which make up living organisms. This field of research had, as one of its many aims, the establishment of the origin of living forms.

Another important aim was investigating the chemical composition of natural substances which had, since time immemorial, found useful application as cosmetics, balms, solvents, fuels, medicaments or perfumes. Eucalyptus oil, derived from the eucalyptus tree which was indigenous to Australia, was one such substance with which Read became associated. He studied in detail the morphology of Eucalyptus plants (of which there are over 250 species in Australia) and investigated the chemical composition of Eucalyptus oils, which had been used for curative purposes. In this respect he was continuing the work of two eminent Australian chemists: R.T. Baker (1854-1941) and H.G. Smith (1852-1924) in ascertaining the composition of these oils, and relating it to the evolution of the Eucalyptus.

In addition to research, Read also became actively involved in teaching and with his colleague H.G. Smith, he gave talks to uneducated people in the Australian bush, and also to schoolchildren. This activity proved to be most rewarding for Read, and was subsequently the inspiration for his many school lectures.

On 20th November 1916, John married Ida Suddards (originally from Bradford in Yorkshire) at St Andrew's Cathedral in Sydney. Their marriage was a happy one, and their two sons John Hinton (1917-2012) and Arthur Hinton (1920-1961) were born in Sydney. Despite his many successes in Australia, John had an instinctive desire to return to England, closer to his beloved Somerset.

In 1923 he was appointed to the Purdie (Thomas Purdie (1843-1916) had been an outstanding Scottish chemist) Chair of Organic Chemistry at the University of St Andrew's in Scotland - a post which he held for a record breaking length of time - 40 years. When he joined the staff at St Andrew's, Read established contact with several internationally renowned scholars among the professoriate there. These academics spanned the arts, humanities and sciences, and it was they who formed the core of inspirational characters who were to influence Read's interdisciplinary output over the next 40 years. In 1926, at the suggestion of E.J. Holmyard (1892-1959) (a scholar, schoolteacher, author and historian of science, specializing in Islamic alchemy), Read started writing books on organic chemistry.

Throughout his career at St Andrew's, Read excelled as a teacher. So great was his popularity, that after lectures on certain occasions, students would leave birthday cards and Valentine cards on his lecture bench. He organized student exchanges with Canada, travelled widely, and lectured in German as well as Italian, on a wide variety of topics. Simultaneously, he continued his research into the stereochemistry of organic compounds. In 1935 he was elected an FRS and in the same year he was awarded the highest academic degree from Cambridge University - a Doctor of Science.

During his lifetime, John Read became a true celebrity in the world of chemistry, art and education. He died suddenly, while cycling home after lecturing, on a particularly cold afternoon during the Great Winter Freeze of 1963, on 21st January.

Read's literary output

John Read wrote 9 books. Their subject matter can roughly be divided into three categories: (a) organic chemistry - 4 books, (b) history of chemistry, with a special emphasis on alchemy - 4 books. These are all beautifully illustrated. (c) fiction - 1 book. It was his one work of fiction, *Farmer's Tales* (1949), which gave him most satisfaction in writing.

Below are listed the titles of his books, in order of first publication date, with their length given in pages.

1. *A textbook of organic chemistry*. London: G. Bell and sons Ltd; 1926, 702 pp.
2. *Introduction to organic chemistry*. London: G. Bell and sons Ltd; 1931, 364 pp.
3. *Prelude to chemistry. An outline of alchemy, its literature and relationships*. London: G. Bell and sons Ltd; 1936, 328 pp.
4. *Explosives. Tells of explosives, their magical creation, their fierce energy, their sudden disruption, their history and romance, and their uses in peace and war*. Harmondsworth, New York: Pelican; 1942, 160 pp.
5. *Humour and humanism in chemistry*. London: G. Bell and sons Ltd; 1947, 388 pp.
6. *The alchemist in life, literature and art*. London: G. Bell and sons Ltd; 1947, 100 pp.
7. *A direct entry to organic chemistry*. London: Methuen; 1948, 268 pp.
8. *Farmer's joy*. Edinburgh, London, Melbourne: Thomas Nelson and sons Ltd; 1949, 272 pp.
9. *Through alchemy to chemistry, a procession of ideas and personalities*. London: G. Bell and sons Ltd; 1957, 206 pp.

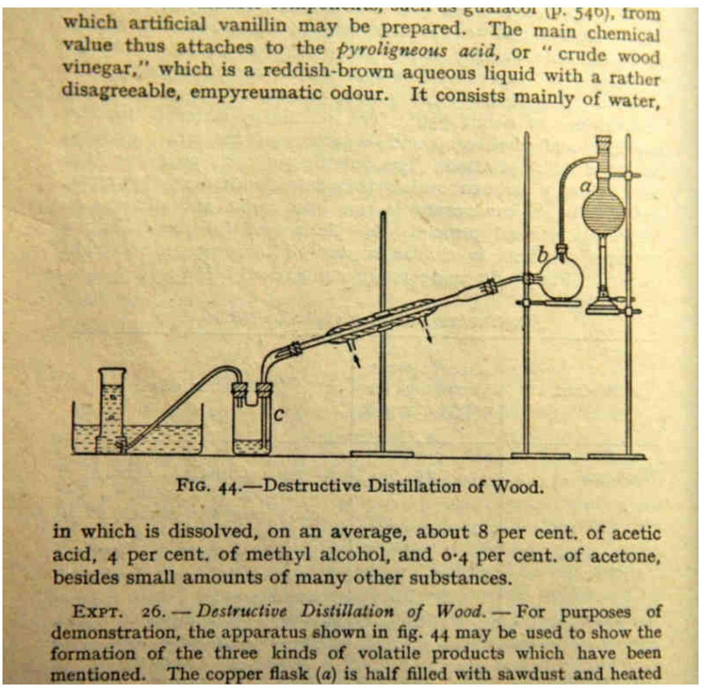

which artificial vanillin may be prepared. The main chemical value thus attaches to the *pyroligneous acid*, or "crude wood vinegar," which is a reddish-brown aqueous liquid with a rather disagreeable, empyreumatic odour. It consists mainly of water,

FIG. 44.—Destructive Distillation of Wood.

in which is dissolved, on an average, about 8 per cent. of acetic acid, 4 per cent. of methyl alcohol, and 0·4 per cent. of acetone, besides small amounts of many other substances.

EXPT. 26.—*Destructive Distillation of Wood.*—For purposes of demonstration, the apparatus shown in fig. 44 may be used to show the formation of the three kinds of volatile products which have been mentioned. The copper flask (*a*) is half filled with sawdust and heated

Photo 2. The destructive distillation of wood [1]

In addition to these books, Read published approximately 25 articles/chapters on a wide variety of topics and over 100 academic papers.

Short fragments from two books have been selected, to illustrate Read's remarkable versatility. The descriptive passage, shown in photo 2, with its small fonts and clear uncluttered diagram, represents the typical style of chemistry textbooks from the middle decades of the 20th century.

Photographs 3 and 4 illustrate a simplified and modified version of this experiment, which was recently conducted in a school laboratory. They also give an excellent visual representation of the material covered in pages 160-162 of Read's book.

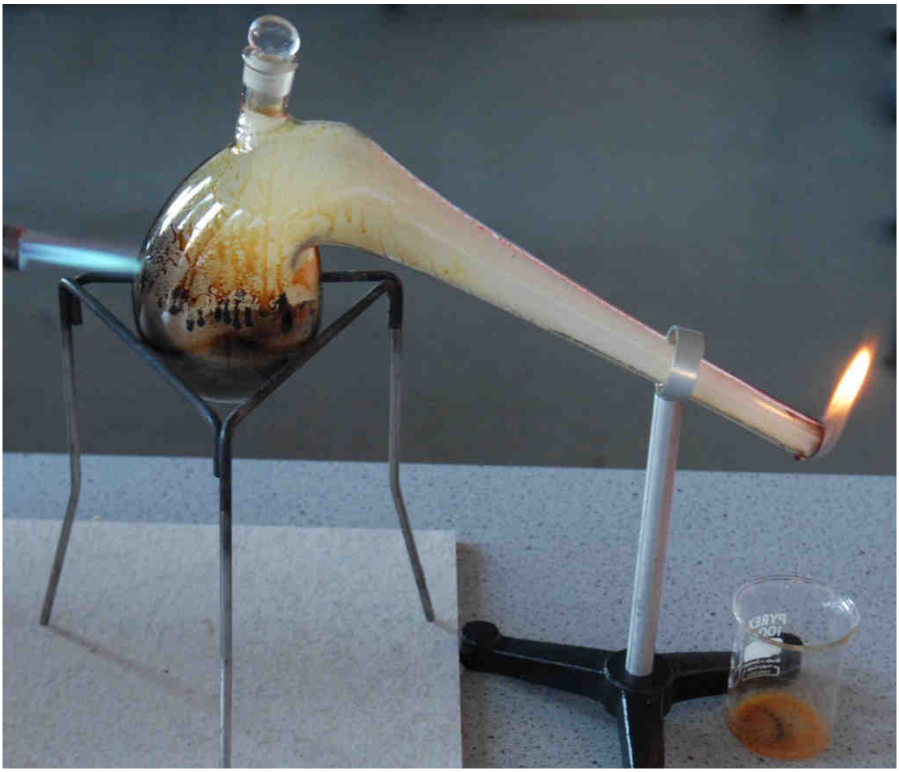


Photo 3. An experiment, showing the destructive distillation (pyrolysis) of wood, in a retort flask

Using a retort flask, which was an early form of distillation apparatus, it is possible to see vapours from the strongly heated sawdust condensing in the tube of the flask, and the ensuing "wood gas" burning at its end. By using more sophisticated apparatus, such as the one shown in the diagram in Photo 2, it is possible to analyse some of the products of this reaction. To see a live practical demonstration of this process, using an apparatus which is similar to the one in Read's textbook, together with a detailed explanation, see: YouTube *Bonfires with a bang,* Andrew Szydlo at the Royal Institution, London, 28th January 2018, 14 min onwards).

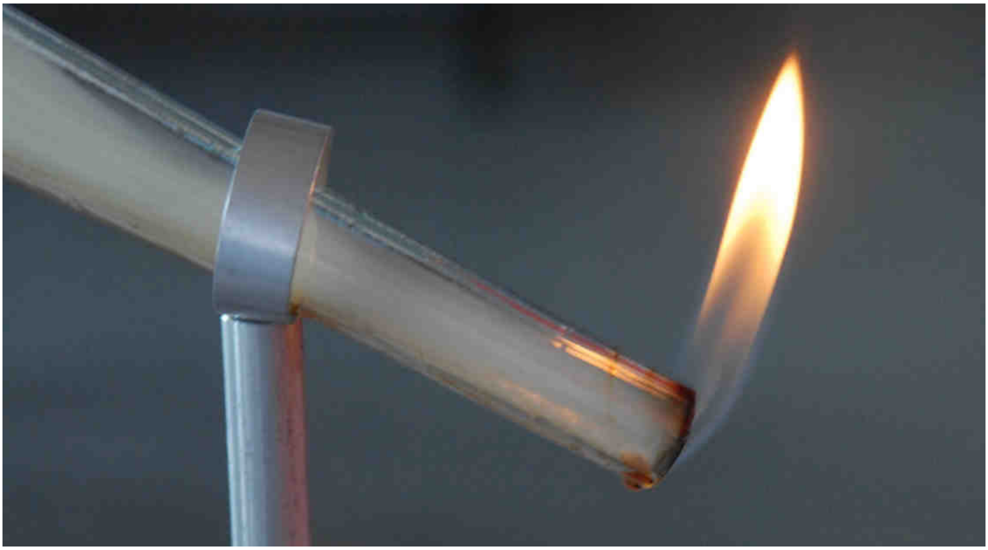
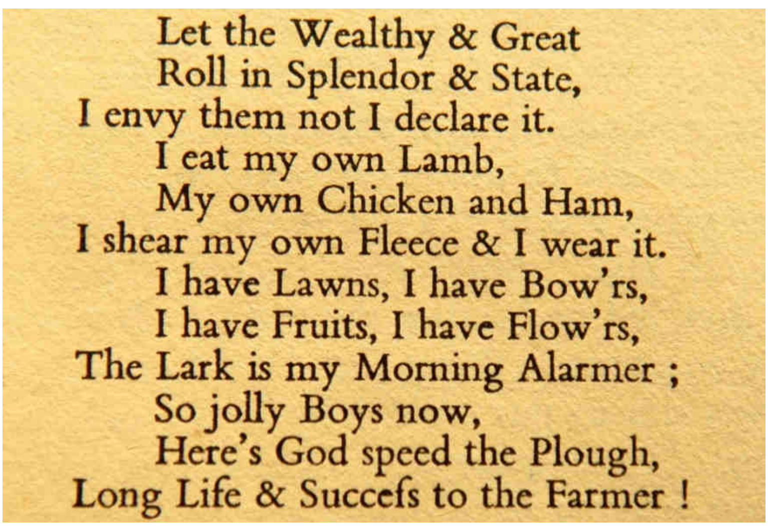


Photo 4. Burning "wood gas"

This shows a closeup of the flame of burning "wood gas", which is an approximate mixture of carbon dioxide (59 %), carbon monoxide (33 %), methane (3.5 %) and hydrogen (3 %), among others [2]. It is remarkable to note, that with such a high proportion of CO_2, the gas burns so well! Also visible is a drop of light brown distillate, containing methanol (methyl alcohol), propanone (acetone) and ethanoic (acetic) acid, at the mouth of the tube.

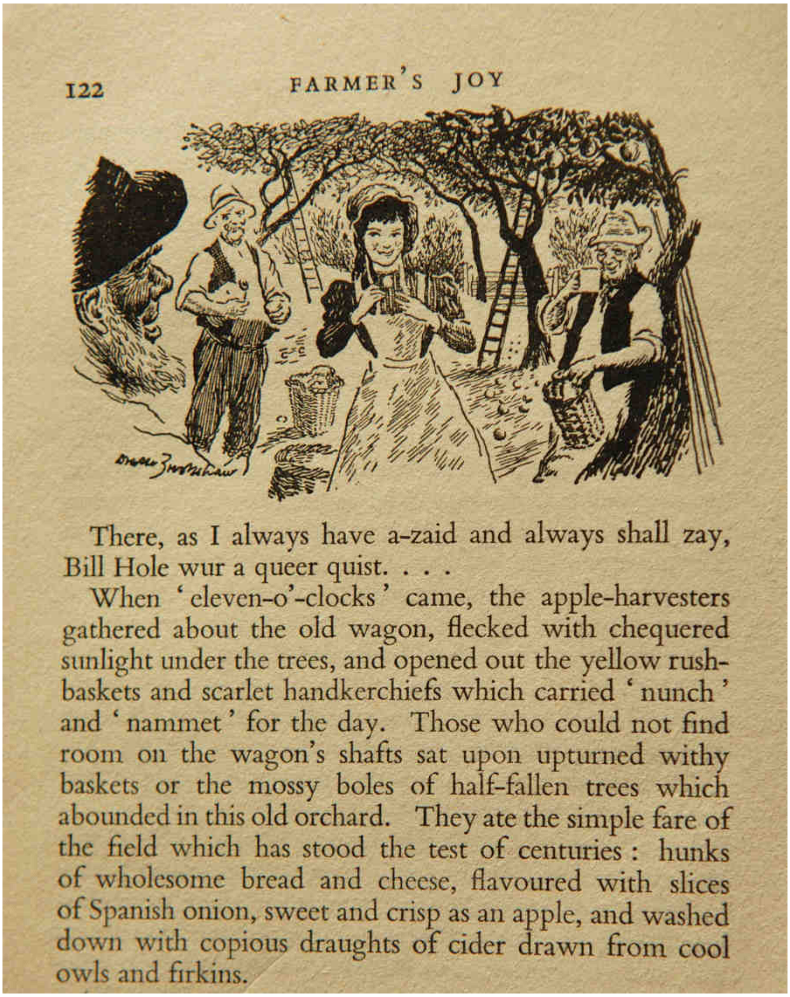
Photographs 5 and 6 illustrate the writing skills of a "completely different" John Read. They are taken from *Farmer's Joy* [3].



Let the Wealthy & Great
Roll in Splendor & State,
I envy them not I declare it.
I eat my own Lamb,
My own Chicken and Ham,
I shear my own Fleece & I wear it.
I have Lawns, I have Bow'rs,
I have Fruits, I have Flow'rs,
The Lark is my Morning Alarmer ;
So jolly Boys now,
Here's God speed the Plough,
Long Life & Succeſs to the Farmer !

Photo. 5. From pg. 51 of the short story entitled: "Wood fire and Cider cup" [3]

This amusing poem which was recited by the Farmer “slowly, from memory” was inscribed on the side of a “fine old” cider cup.



122 FARMER'S JOY

There, as I always have a-zaid and always shall zay,
Bill Hole wur a queer quist. . . .

When 'eleven-o'-clocks' came, the apple-harvesters gathered about the old wagon, flecked with chequered sunlight under the trees, and opened out the yellow rush-baskets and scarlet handkerchiefs which carried 'nunch' and 'nammet' for the day. Those who could not find room on the wagon's shafts sat upon upturned withy baskets or the mossy boles of half-fallen trees which abounded in this old orchard. They ate the simple fare of the field which has stood the test of centuries: hunks of wholesome bread and cheese, flavoured with slices of Spanish onion, sweet and crisp as an apple, and washed down with copious draughts of cider drawn from cool owls and firkins.

Photo. 6. From pg. 122 of the short story entitled: “In the cider orchard” [3]

Both the above texts speak for themselves - Read included a glossary of the Somerset dialect at the back of the book. What is remarkable about them is that they were written by an internationally renowned professor of organic chemistry. The book itself is a series of sketches of old-time life and ways among the village and farming communities of Somerset and Dorset. But this was more than just a story book - in the world of rapidly expanding technology, Read was acutely aware of the dangers to society, and to civilization in general, through the misuse of technology. He warned against the destruction of ancient rural traditions, which had formed the backbone of society for millennia. In the preface we read: “The replacement of multiformity by uniformity and of individuality by centralization is bound to lead to a loss of much of that zest and sparkle of life, and of that pride in the work of one's hands, which stood out so strongly in old English country life. Herein is to be seen one of the most regrettable tendencies of the present age." 70 years after this text was written, Read's comments continue to be relevant.

James Riddick Partington (30.06.1886-9.10.1965)

Photo 7. James Riddick Partington [courtesy of Oesper collections, University of Cincinnati]

James was born in Middle Hutton, south of Bolton, in Lancashire. His mother was a Scottish tailoress and his father was a bookkeeper. He attended Southport Science and Art School. In 1901 his family returned to Bolton, where James, as a young teenager, undertook a variety of jobs. In 1906 he began his studies in chemistry at Manchester University. In 1908 he was awarded a B.Sc. (1^{st} class) degree in chemistry, in 1909 a Teacher's Certificate, and in 1911 a Master of Science in chemistry. By this time he had already published 6 research papers in the field of physical chemistry, which was a most unusual achievement. It was also at this stage that Partington began his extraordinary book writing career. In 1911, at the age of 25, his first book, *Higher Mathematics for Chemical Students* was published, and his second book, a 544 page volume, *Thermodynamics,* was published in 1913. Remarkably, there is no evidence that he ever completed a PhD - he probably felt that this was not necessary, since he was too busy writing books and publishing academic papers!

His exceptional abilities were recognized by his teachers and he was awarded a University Scholarship, which in 1911 enabled him to undertake research under the direction of Arthur Lapworth FRS (1872-1941), who was Professor of Inorganic Chemistry from 1913. Lapworth himself was an eminent Scottish physical chemist. Partington's specialist field of interest began to emerge at this stage: chemical thermodynamics, dealing in particular with the specific heats of gases. This was an important field of research at that time, since industrial processes involving gases were beginning to play a significant role in the chemical industry. Of particular importance was the recently (in 1909) developed process by Fritz Haber (1868-1934) for the synthesis of ammonia. This process, which is still in worldwide use today, revolutionized the manufacture of ammonia (vital for the manufacture of nitric acid, fertilizers and high explosives), which had, until that time, been obtained from coal tar distillates. A knowledge of the specific heats of gases at various conditions of temperature and pressure was critical for the efficient use of energy in industrial processes involving gases.

After the outbreak of the First World War he joined the Army, and finished with the rank of Captain for his active service as an infantry officer and engineer. During the War he also worked on nitric acid production, necessary for explosives manufacture, for which he was awarded the MBE in 1918. In 1919, he was awarded a D.Sc. degree from Manchester University. Later that year on 6th September, he married Marian Jones who was his former student, and with whom they had two daughters and one son. Marian herself was a schoolteacher and assisted James with several of his books.

During the ensuing years Partington became established as an outstanding scholar and author in the fields of physical and inorganic chemistry. This was due, in part, to his special gift for mathematics, to his encyclopedic memory, and to his extraordinary capacity for writing. Simultaneously, as a result of being inspired by one of his teachers, Professor H.B. Dixon (1852-1930), who was a specialist in gaseous explosions, and his co-worker Dr A.N. Meldrum (1876-1934) he developed an interest in the history of chemistry. He started collecting books and used them to chronicle, from the earliest times through alchemy, the development of chemistry as a branch of modern science. He became actively involved in promoting the history of chemistry as an integral component of chemistry courses. In 1937 he was elected first president of the Society for the study of Alchemy and early Chemistry - today this is known as the Society for the History of Alchemy and Chemistry (SHAC). Later he became an active member of the British Society for the History of Science, which was founded in 1947. In 1949-1951 he was president of this society, and in his presidential address, delivered on 6th May 1951, he discussed the importance of the use of historical examples in the teaching of science. He made special reference to the writings of the great French chemist Lavoisier (1743-1794), who did not feel that historical examples in science were necessary in its teaching [4].

In 1939 at the outbreak of World War Two, his department was evacuated to Cambridge University, where he undertook research in the University Copyright Library. His wife, who stayed behind in their family home in Wembley, tragically committed suicide in 1940. Partington retired from his post as Professor of Chemistry at Queen Mary College in 1951, and for 13 years he continued writing at home, in a house which was full of books. In 1961 he received the prestigious Dexter award for his numerous books and articles on the history of chemistry. When his health started to fail, he moved to live with his sister in Northwick in 1964. He was awarded the George Sarton Medal (the most prestigious award, given by the History of Science Society, for a lifetime of scholarly achievement in this field for his contribution to the History of Science) in 1965, and died in hospital on 9th October of that year. From personal recollections, we can gather that Partington was "intensely reserved, but with a dry sense of humour…", yet "Many will mourn the death of this great scholar of chemistry" [5].

Today, a tangible legacy remains - his collection of 1249 books which was bequeathed upon his death to Manchester University Library, and 9 books of handwritten notes. These records show what a remarkable capacity Partington had for noting details of chemical reactions, their historical origins, their experimental details and their authors. A detailed study of these notebooks alone would serve as a basis for a most interesting research project.

Below I have selected two pages of his notes, from which we are able to gain more insight into Partington's mind. Photograph 8 shows a diagrammatic representation of an experimental setup of "work in progress" for Professor Dixon's research into the determination of the atomic weight of chlorine. The results of this work were published in 1905 [6] and 1908 [7].

The notebook is entitled: *Chemistry* III. *Lectures*. Manchester University: Session 1906-1907. Lecturer: Prof. H.B. Dixon, M.A., M.Sc., F.R.S. Book 2. 1906.

These hand drawn diagrams, which are probably a "fair copy" of undergraduate lecture notes, are supremely neat. A remarkable degree of skill shown in drawing thin parallel lines in ink, and a complex arrangement of glass tubing and apparatus. The handwriting is beautifully formed and clearly legible. The labels are simple and clear, and red ink is sparingly used to enhance the diagrams. The experiment itself involves complex procedures - the diagram shows the electrolysis of a fused salt (AgCl melts at 455 ^{o}C), and the use of highly toxic gaseous and liquid chlorine, and the intensely cold liquid air. These substances are exceedingly difficult to manipulate safely, yet their graphical exposition is so simple. This page clearly shows the result of Partington's extraordinarily ordered mind at work.

Photograph 9 shows a page of notes on chlorine chemistry. The title page of this notebook is: *Lectures* III. *Inorganic Chemistry.*

It is most likely that the page shown here contains notes which were made in preparation for publication in a textbook of inorganic chemistry. In contrast to the previous page, we see here a sample of his intensely active mind - a huge level of attention to detail is given - with many facts crammed tightly into one page, in a variety of coloured inks/pencil, with deletions, cross-references and updates all included. This is the handwork of a truly extraordinary "chemical" mind. The topic is also of interest, since chlorous anhydride Cl_2O_3, is nowhere described today. Indeed, in 1889 it was already known that "The existence of this body is very doubtful" [8]. Yet Partington was still determined to summarize the work of earlier chemists, who had thought that they had prepared it. The research on this topic, which Partington describes in such detail, proves that Cl_2O_3 is not a compound, but is a mixture of ClO_2 and Cl_2. The essence of this page of notes is summarized in one of his many textbooks [9]. The question is raised - what, in that case, was its purpose? Partington had a compulsive desire to honestly present all known research on any topic. He was thus giving a truthful representation of how progress is made, including ideas which were subsequently experimentally disproved.

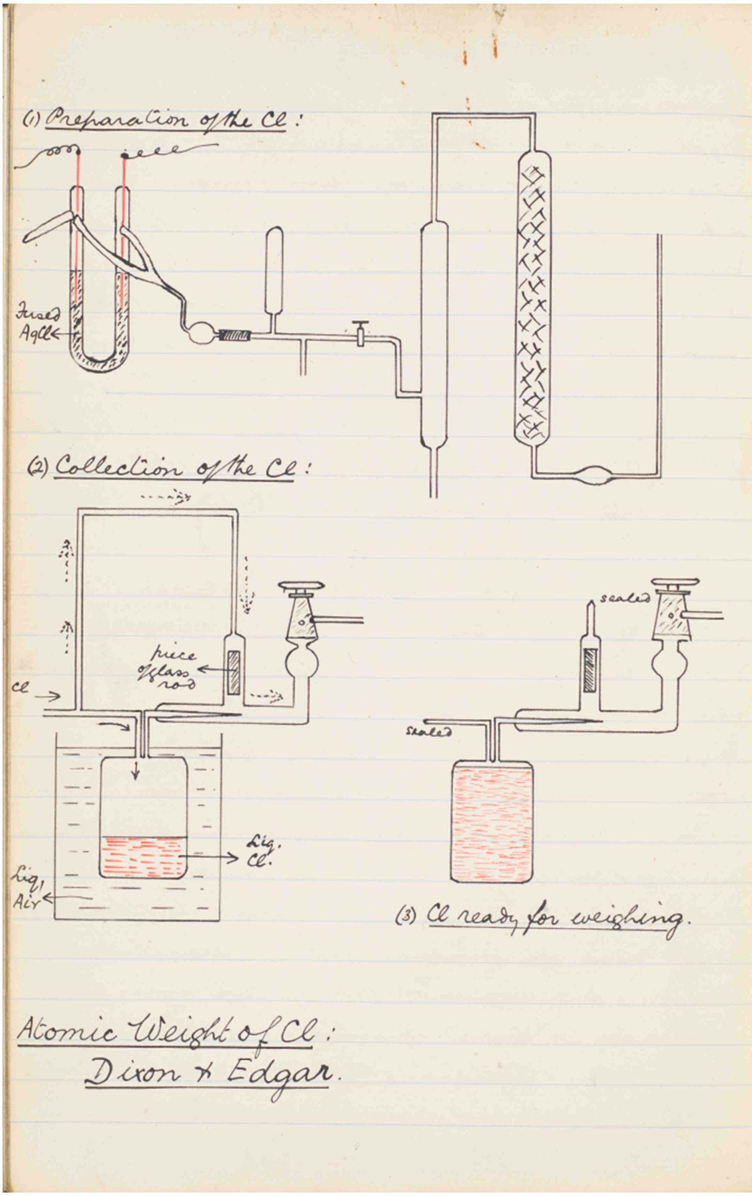
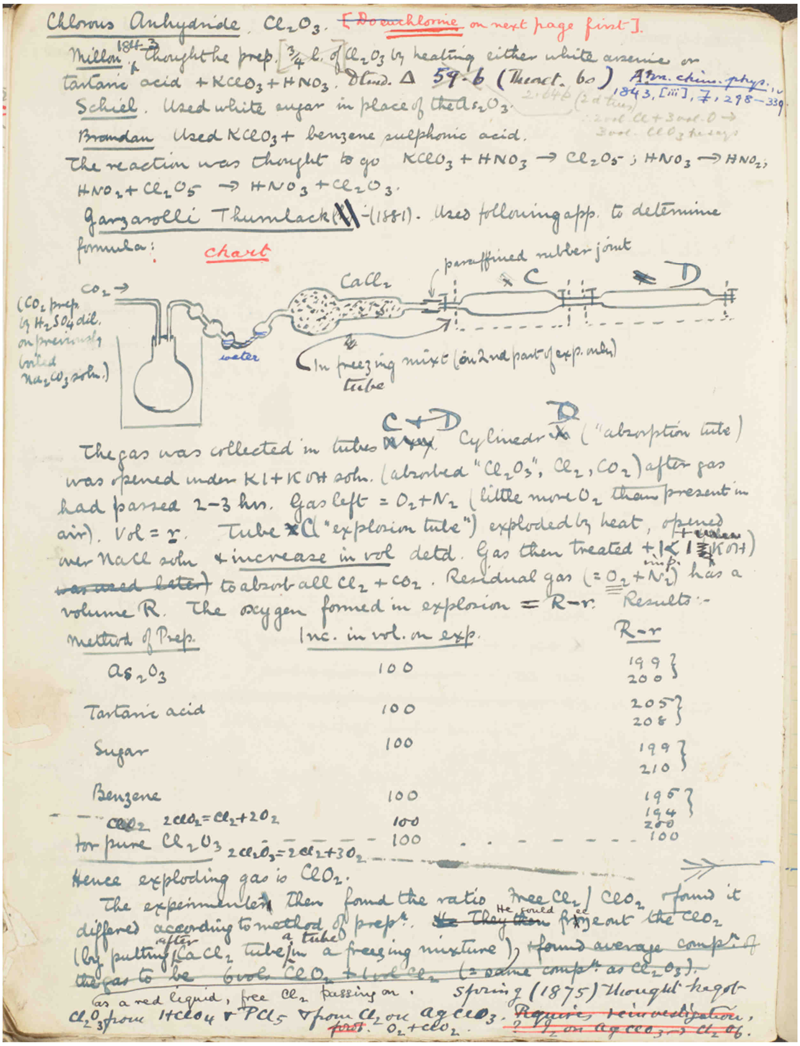


Photo 8. A page from Partington's notebook (1906) - Atomic Weight of Cl: Dixon & Edgar (Copyright of the University of Manchester)



Chlorous Anhydride. Cl_2O_3.

Millon 1843 thought he prep. ¾ l. of Cl_2O_3 by heating either white arsenic or tartaric acid + $KClO_3$ + HNO_3. Δ 59.6 (Theoret. 60) Ann. chim. phys. 1843, [iii], 7, 298–339

Schiel. Used white sugar in place of the As_2O_3.

Brandau Used $KClO_3$ + benzene sulphonic acid.

The reaction was thought to go $KClO_3 + HNO_3 \rightarrow Cl_2O_5$; $HNO_3 \rightarrow HNO_2$, $HNO_2 + Cl_2O_5 \rightarrow HNO_3 + Cl_2O_3$.

Garzarolli Thurnlackh (1881). Used following app. to determine formula:

The gas was collected in tubes C + D. Cylinder D ("absorption tube") was opened under KI + KOH soln. (absorbed "Cl_2O_3", Cl_2, CO_2) after gas had passed 2–3 hrs. Gas left = $O_2 + N_2$ (little more O_2 than present in air). Vol = r. Tube C ("explosion tube") exploded by heat, opened over NaCl soln + increase in vol detd. Gas then treated + KI to absorb all $Cl_2 + CO_2$. Residual gas (= $O_2 + N_2$) has a volume R. The oxygen formed in explosion = R − r. Results:–

Method of Prep.	Inc. in vol. on exp.	R−r
As_2O_3	100	199, 200
Tartaric acid	100	205, 208
Sugar	100	199, 210
Benzene	100	195, 194
ClO_2 $2ClO_2 = Cl_2 + 2O_2$	100	200
for pure Cl_2O_3 $2Cl_2O_3 = 2Cl_2 + 3O_2$	100	100

Hence exploding gas is ClO_2.

Photo 9. A page from Partington's notebook (no date) (Copyright of the University of Manchester)

Partington's collection of printed books is today housed in the archives department of another building, the John Rylands Library, Manchester University, and consists of the following numbers of printed works, arranged by century: 16th - 46, 17th - 191, 18th - 268, 19th - 342, 20th - 402. The oldest (1527) printed work, by PHILIPPO VLSTADIO PATRICI (Philip Ulstadt) [10] consists of 62 double page spreads, printed on handmade paper with a characteristic delicate aroma, and bound in white calfskin. The book is illustrated with many woodcuts, some of which are repeated twice in different parts of the book. Photograph 10 shows an illustration of one of the oldest known chemical processes - distillation.

Photo 10. Frontispiece to: Philip Ulstadt, *Coelum Philosophorum - seu de Secretis Naturae Liber* [10] (Copyright of the University of Manchester)

Distillation has been used for countless millennia to separate liquid mixtures by condensing their boiled vapours. The magnificent woodcut shown here, reproduced from Partington's oldest book, is almost identical to the one which appeared in Hieronymus Brunschwig's *Liber de Arte Distillandi de simplicibus*, first published in Strasburg in 1500. Brunschwig (1430-1512/13) was a surgeon, alchemist and botanist, and this work from 1500 was the first printed book on distillation. Little is known about Ulstadt: he came from Nurnberg and taught medicine in Fribourg in Switzerland. The *Coelum Philosophorum* "gives recipes for spiced wines, claret, hypocras etc., and also describes the preparation of the spirit of wine (aqua vitae - "the water of life") by distillation" [11]. On this picture, the central column is kept full of water, and it condenses the vapours rising in curled tubes from the heated flasks. "The operator on the left is estimating the temperature gradient in the apparatus, by touching the heated flask with his right hand, and the outgoing tube with his left hand" [12].

With his insatiable thirst for chemical and historical knowledge, it is possible to see how having direct access to early books could have had an addictive effect on Partington, for both the history of alchemy and of chemistry.

Partington's literary output

Partington wrote 27 books. Their subject matter can broadly be classified as follows: (a) inorganic chemistry - 7, (b) physical chemistry - 8, (c) mathematics - 3, (d) history of chemistry - 9. This is a colossal output. His monumental 4 volume *History of Chemistry* alone contains 1.5 million words. Below are listed the titles of his books, in order of first publication date, with their length given in pages.

1. *Higher mathematics for chemical students*. London: Methuen; 1911, 272 pp.
2. *A textbook of thermodynamics (with special reference to chemistry)*. London: Constable; 1913, 544 pp.
3. *Chemical thermodynamics*. London: Constable; 1913, 276 pp.
4. *The alkali industry*. London: Balliere; 1918, 304 pp.
5. *A textbook of inorganic chemistry for university students*. London: Macmillan; 1921, 1062 pp.
6. *The nitrogen industry* (co-authored with L.H. Parker). London: Constable; 1922, 336 pp.
7. *The specific heats of gases* (co-authored with W.G. Shilling). London: Ernest Benn; 1924, 252 pp.
8. *Calculations in physical chemistry* (co-authored with S.K. Tweedy B.Sc.). London: Blackie; 1928, 152 pp.
9. *The composition of water*. London: G. Bell and sons Ltd.; 1928, 106 pp.
10. *Everyday chemistry*. London: Macmillan; 1929, 668 pp.
11. *A school course of chemistry*. London: Macmillan; 1930, 392 pp.
12. *The origins of applied chemistry*. London: Longmans; 1935, 598 pp.
13. *A short history of chemistry*. London: Macmillan; 1937, 416 pp.
14. *Intermediate chemical calculations* (co-authored with Kathleen Stratton M.Sc.). London: Macmillan; 1939, 236 pp.
15. *A college course of inorganic chemistry*. London: Macmillan; 1939, 658 pp.
16. *General and inorganic chemistry for university students*. London: Macmillan; 1946, 916 pp.
17. *An advanced treatise on physical chemistry*. London: Longmans; Vol/1, *Fundamental properties. The properties of gases*, 1950, 986 pp., Vol/ 2, *The properties of liquids*, 1951, 448 pp., Vol. 3, *The properties of solids*, 1952, 640 pp., Vol. 4, *Physico-chemical optics*, 1953, 688 pp., Vol. 5, *Molecular spectra and structure: dielectrics and dipole moments*, 1954, 576 pp.
18. *A history of Greek fire and gunpowder*. Cambridge: Heffer; 1960, 382 pp.
19. *The life and work of William Higgins, chemist (1763-1825)* (co-authored with T.S. Wheeler). London: Pergamon Press;1960, 174 pp.
20. *A history of chemistry*. London: Macmillan; Volume 2, 1961, 796 pp, Vol. 3, 1962, 854 pp., Vol. 4, 1964, 1008 pp.
21. *A history of chemistry*. London: Macmillan; Vol. 1 part 1, 1970, 370 pp.

In addition to these books, Partington published over 60 academic papers.

Three short extracts have been selected from his books, which illustrate his style of writing in two different contexts: chemistry and mathematics.

Photographs 11 and 12 are taken from his *General and inorganic chemistry for university students* [13].

Properties of chlorine.—Chlorine is a greenish-yellow gas, about $2\frac{1}{2}$ times as heavy as air, with a suffocating and corrosive action on the mucous membranes, and is poisonous. The density is slightly higher than corresponds with Cl_2 (perhaps a little Cl_4 is present), but becomes normal at 240° and remains normal up to 1200° at least. At higher temperatures some dissociation occurs : $Cl_2 \rightleftharpoons 2Cl$.

Photo 11. A paragraph from page 774, describing chlorine [13]

In this paragraph on the properties of chlorine, using concise language which was so characteristic of his style, Partington has given 8 interesting facts, most of which are not commonly known.

Photograph 12 summarizes some simple experiments.

EXPT. 4.—Sprinkle powdered arsenic and antimony into jars of chlorine ; they burn, producing poisonous fumes of $AsCl_3$ and $SbCl_5$. Leaves of Dutch metal inflame.

A piece of phosphorus in a deflagrating spoon inflames in a jar of chlorine, burning with a pale flame to fumes of PCl_5.

EXPT. 5.—Pass chlorine over a piece of sodium strongly heated in a hard glass bulb tube. The metal burns with a very brilliant yellow flame forming NaCl.

EXPT. 6.—A burning jet of hydrogen burns in a jar of chlorine with an enlarged greenish flame, forming fumes of hydrogen chloride. A jet of chlorine burns with a green needle-shaped flame when passed into an inverted jar of hydrogen burning at the mouth.

Since chlorine has a strong affinity for hydrogen but practically none for carbon, hydrocarbons burn in chlorine with formation of hydrogen chloride and liberation of free carbon.

Photo 12. A fragment from page 775, which describes some experiments with chlorine [13]

In experiment 4, descriptions are given of spontaneous combustion reactions of the elements antimony, arsenic and phosphorus. The mention of Dutch metal (an alloy of tin and copper) spontaneously combusting, is given just 5 words. This reaction can be conveniently demonstrated in the school laboratory today. The photographs 13-15 illustrate this reaction, and how it can be used to teach some important aspects of inorganic chemistry.

These three photographs illustrate chemical reactions which I use for classroom teaching today. During this experiment, I like to challenge pupils by announcing to them that chlorine gas is so reactive that it will even react with gold. As I lower the thin leaf of metal into the jar, it spontaneously inflames. On pouring in 0.880 (concentrated) ammonia solution, a deep blue colour is seen, accompanied by a flame. I then ask the pupils whether, bearing in mind how very unreactive gold is, do they really believe that this reaction is possible? And where does the blue colour come from? These reactions, and the questions which I ask, naturally cause much surprise and confusion. I then explain to them that of course, gold cannot possibly react with chlorine in this manner, and the “gold” foil is in fact

Dutch metal, an alloy of copper and tin. These effects, I explain, are caused by: (i) the spontaneous combustion, or reaction, of the alloy in chlorine, demonstrating its extreme affinity for metals (ii) the reaction of ammonia solution with copper(II) ions (released from copper(II) chloride formed during the spontaneous combustion) to form the intense deep blue copper tetramine complex ion, and (iii) the spontaneous combustion of ammonia reacting with excess chlorine, in accordance with the equation: $2NH_3 + 3Cl_2 \rightarrow N_2 + 6HCl$.

Photo 13. Dutch metal above a sealed gas jar of chlorine

Photo 14. Dutch metal spontaneously igniting in chlorine

Photo 15. The spontaneous combustion of ammonia reacting with excess chlorine, and the appearance of the deep blue copper tetramine complex ion at the bottom of the gas jar

Partington, I am sure, would NOT have approved of this method of teaching whereas Read, I suspect, could well have approved, and indeed, mentioned alchemical transmutation as an additional red herring!

The combustion of sodium in chlorine, described in experiment 5, is one of the great classics of the chemistry teacher's repertoire, and is still used in school lessons. It is an outstanding experiment in many respects, for it covers much important theoretical material:

a) fire - bright orange flame (sodium flame colour) - exothermic reaction
b) three types of chemical bond: metallic (Na), covalent (Cl_2), ionic (NaCl)
c) three types of particle: atoms (giant structure), molecules (simple structure), ions (giant structure)
d) three states of matter, and three colours: liquid (Na - silver), gas (Cl_2 - green), solid (NaCl - white crystalline solid).
e) writing a balanced chemical equation, with state symbols:

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$$

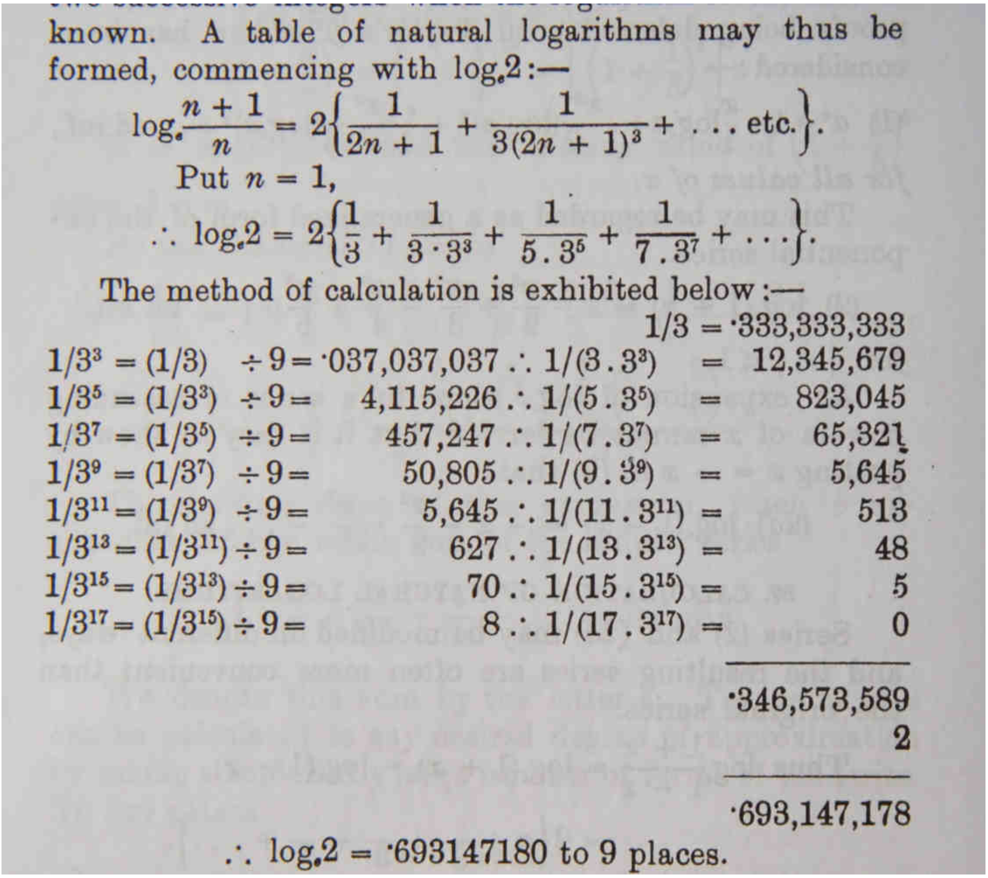
f) redox reaction - involves transfer of electrons

Finally, this reaction demonstrates the essence of what chemistry is - the science of substances changing into different substances. And just **how** different they are: chlorine is highly toxic by inhalation, sodium reacts in the body to cause severe burns, yet the chemical combination of these two deadly elements yields sodium chloride, which provides a vital source of sodium ions and chloride ions in our blood and is thus necessary for life. Even more paradoxically, the reason why it is safe to drink tap water today, is because it contains 7 ppm of chlorine, which is just enough to kill harmful organisms, but not enough to affect humans.

From two such short fragments of Partington, there is so much implied knowledge!

Experiment 6, also described on this page, is interesting not only from the viewpoint of the experiments, but also because some theory is included to explain experimental observations.

Photograph 16, taken from one of Partington's mathematical works, gives an example of his great competence and interest in the manipulation of numbers.



known. A table of natural logarithms may thus be formed, commencing with $\log_e 2$:—

$$\log_e \frac{n+1}{n} = 2\left\{\frac{1}{2n+1} + \frac{1}{3(2n+1)^3} + \ldots \text{etc.}\right\}.$$

Put $n = 1$,

$$\therefore \log_e 2 = 2\left\{\frac{1}{3} + \frac{1}{3 \cdot 3^3} + \frac{1}{5 . 3^5} + \frac{1}{7 . 3^7} + \ldots\right\}.$$

The method of calculation is exhibited below:—

		$1/3 =$	·333,333,333
$1/3^3 = (1/3) \div 9 =$	·037,037,037	$\therefore 1/(3 . 3^3) =$	12,345,679
$1/3^5 = (1/3^3) \div 9 =$	4,115,226	$\therefore 1/(5 . 3^5) =$	823,045
$1/3^7 = (1/3^5) \div 9 =$	457,247	$\therefore 1/(7 . 3^7) =$	65,321
$1/3^9 = (1/3^7) \div 9 =$	50,805	$\therefore 1/(9 . 3^9) =$	5,645
$1/3^{11} = (1/3^9) \div 9 =$	5,645	$\therefore 1/(11 . 3^{11}) =$	513
$1/3^{13} = (1/3^{11}) \div 9 =$	627	$\therefore 1/(13 . 3^{13}) =$	48
$1/3^{15} = (1/3^{13}) \div 9 =$	70	$\therefore 1/(15 . 3^{15}) =$	5
$1/3^{17} = (1/3^{15}) \div 9 =$	8	$\therefore 1/(17 . 3^{17}) =$	0
			·346,573,589
			2
			·693,147,178

$\therefore \log_e 2 =$ ·693147180 to 9 places.

Photo 16. An example of the use of Taylor's series, to derive $\log_e 2$ [14]

The layout of this derivation is very clear and is executed to an unusually high number of significant figures, demonstrating yet again Partington's precision and attention to detail.

Concluding remarks on Read's and Partington's writing

Both Read and Partington were clearly extraordinary men - as scholars, chemists and human beings. Their characters were very different, as can be clearly inferred from their writings: Read had an "organic, or analogue" character, Partington had a much more "inorganic, or digital" character. And yet both men, like many other great scientists of their time, were fully aware of the enormous impact that scientific advances were having on ordinary people's lives. Their remarkable written output, which served to educate schoolchildren, students, and the public at large during the middle decades of the twentieth century undoubtedly raised the awareness of chemistry as a science, and instilled an element of awe, amazement and respect for its achievements.

Immortal texts

Through this short sketch of two giants of chemistry, we have been able to gain some idea of the extraordinary milieu of characters with which they mingled, and to see how, in their times, progress in science and technology was a key driving force and source of inspiration. But what is also quite clear, is how the history of chemistry and its broad cultural context constituted an integral part of their education and inspiration.

I will now give an example from today's world, from which we can see how an historical approach to teaching can continue to be a major driving force for outstanding chemists and innovators.

An efficient means of storing energy is one of the most important fields of scientific research today. In this field, rechargeable lithium-ion cells have become universally accepted as cheap, reliable and efficient sources of electrical energy, for use in cell phones, power tools and notebook computers, for example. Although these cells were invented and initially developed by the American solid state physicist Professor John Goodenough (b. 1922), they have more recently been significantly improved by the Japanese chemist Professor Akira Yoshino (b. 1948). For his work in this field, Professor Yoshino was awarded the prestigious Japan Prize in 2018, following many other awards in the preceding few years. When asked what inspired him to take an interest in chemistry, he said that when he was about 9 years old, his teacher gave him a book to read - it was Michael Faraday's *The Chemical History of the Candle*. He then added that he's "never looked at a candle the same, since reading Faraday's classic work" [15], which was based on his celebrated series of lectures, given at the Royal Institution of Great Britain in London, to a "juvenile auditory" on 19 occasions between 1827 and 1860. Today this book continues to be studied by all Japanese children as part of their science curriculum [16], and it has also been translated into 17 languages and has been continuously in print since 1861 [17]. The reason for the enormous popularity of this book is that Faraday brilliantly uses the chemistry of a burning candle to explain the fundamental principles of chemistry, physics and the nature of matter [18]. As such, this work constitutes an **immortal chemical text** for young people. I believe that such texts must be made available to all children, to stimulate and inspire an interest in chemistry. The idea of an "immortal text" in this context implies that such texts will be forever relevant. Chemistry, as a branch of human culture, will continue to serve mankind forever. Naturally it will evolve, but its roots will always form the foundation for new discoveries and for our better understanding of Nature.

Like Michael Faraday, whose immortal text: *The Chemical History of a Candle i*s studied by children in Japan today, I believe that Read and Partington had created further immortal texts some 80 years ago. In the English language we have the immortal classic texts of William Shakespeare, in philosophy we have the immortal classic texts of Aristotle. I would propose that the following books should constitute two **immortal texts of chemistry**:

Read J. *A Direct entry to organic chemistry*. London: Methuen & Co. Ltd.; 1948.

Partington JR. *Everyday chemistry*. Third edition. London: Macmillan; 1952.

For his *Direct entry to organic chemistry*, Read was awarded the newly-created Cortina-European prize if a million lire. This created an excuse for him to learn Italian and to visit Italy on several occasions. During these visits he played an important ambassadorial role in Anglo-Italian cultural relations (which had suffered significant damage as a result of WW2), and his lectures, delivered in Italian in many universities, were very well received. This prize-winning book ran into several editions.

Everyday chemistry was a best-selling popular science book, and ran into several editions over a period of three decades. It is of interest to note that *Everyday chemistry* which is today available for purchase on the internet, and has 5 star reviews - "I had this book 60 years ago when I was still a student. Now I am retired and the book still makes interesting reading (10.10.2017)", and "Despite how long ago this book was published it is still a great textbook on chemistry and it gives the reader a clear understanding of the "scientific method" which can be useful in the study of other science subjects. The language is clear and accessible (5.06.2009)."

A knowledge of these two works should be treated as compulsory for all students of chemistry. Their programmed study will enable a student to gain an in-depth understanding of:

a) What chemistry is
b) Important aspects of the history of chemistry
c) How chemistry is relevant to everyday life
d) The differences between organic and inorganic chemistry

Furthermore, the student would have access to facts concerning a huge number of substances. Any student who is not inspired by these two books should not be studying chemistry. Indeed, it is my suggestion that these books should be used as a criterion for self-assessment: if any prospective student of chemistry in not galvanized by them, that person should not study chemistry.

My suggestion for the use of these books as an introduction to A level chemistry would be as follows:

(i) Read the preface and publisher's blurb
(ii) Read chapters 1-3 in both books
(iii) Read one further chapter of the student's choice, from each book.

At the end of one week (per book), write a 500 word essay to summarize what has been learnt from the book. Students who will have fulfilled such an exercise will have not only gained a respect for the science of chemistry and a sound foundation for its application in the world, but they will also have had exposure to two outstanding and immortal authors.

Conclusion

Today, when more than ever before, we need scientifically trained citizens in society, a familiarity with Read and Partington, and their **immortal texts** will undoubtedly generate more respect for science, and more outstanding chemists like Professor Akira Yoshino.

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DWAJ ANGIELSCY CHEMICY/AUTORZY/NAUCZYCIELE: JOHN READ I JAMES RIDDICK PARTINGTON

Abstrakt: W połowie dwudziestego wieku John Read i James Partington byli wysoko cenionymi naukowcami w dziedzinie chemii, autorami i nauczycielami. Ich książki były czytane w szerokich kręgach i odgrywały ważną rolę w edukacji i w rozszerzaniu świadomości chemii wśród młodzieży i dorosłych. Niestety, dzisiaj ich nazwiska są zapomniane. Celem tego artykułu jest przywrócenie należytego miejsca w historii nauki tym dwóm niezwykłym postaciom i wprowadzenie ich na pierwszy plan we współczesnych programach edukacyjnych. Ich życiorysy zostały przedstawione w skrócie na tle epoki, w której żyli. Szczególny nacisk położono na ich olbrzymi wkład w literaturę. Read i Partington posiadali zupełnie odmienne osobowości i specjalizowali się w trzech dziedzinach chemii, a mianowicie Read: w organicznej, Partington: w fizycznej i nieorganicznej. Mimo tych różnic, obaj chemicy w pełni doceniali konieczność przedstawiania chemii w perspektywie historycznej. W związku z powyższym autorzy ci napisali wiele prac na temat początków chemii i rozwoju nauk chemicznych, a także uwzględniali materiały historyczne w podręcznikach. Materiały te w dużym stopniu wzbogacały i uprzyjemniały nauczanie chemii. Równocześnie uświadamiały czytelnikowi, jak doniosłą rolę odegrała chemia w dziejach ludzkości. Takiego uświadamiania w jaskrawy sposób brakuje w dzisiejszych programach nauczania chemii. Ponadto przedstawiono w układzie chronologicznym listę ich książek i dokonano szczegółowej analizy czterech różnych fragmentów z tych dzieł. Książki Johna Reada i Jamesa R. Partingtona są nie tylko bardzo interesujące, ale również stanowią doskonały fundament do nauczania chemii obecnie. Przedstawiono propozycję, żeby chociaż jedna książka tych autorów stała się obowiązującą lekturą dla studentów chemii, zarówno dzisiaj, jak i w przyszłości.

Słowa kluczowe: Read, Partington, chemia, chemia organiczna, chemia fizyczna, chemia nieorganiczna, edukacja