VII

PRIESTLEY AND THE DISCOVERY OF OXYGEN

FROM the earliest times until Joseph Priestley discovered oxygen in the latter part of the eighteenth century, fire was considered one of the great enigmas. Aristotle believed it to be one of the so-called elements, and that fire, together with earth, air and water, made up the entire universe. It was not held that these four elements were distinct kinds of matter which could be separated and identified; but rather that they were abstract qualities exhibited by one original, primordial substance. Each of the elements was characterized by the possession of two of the four qualities expressed by the adjectives: warm, cold, dry and moist. Thus, water was moist and cold; earth, cold and dry; and fire, dry and warm. Differences in the material world were therefore attributed to properties inherent in matter. Assuming that these properties can alter, it seemed to follow as a natural consequence that one form of matter could be transformed into another.

The immediate influence of the Aristotelian theory of the universe on the chemistry of the ancients was small; but it prepared the way for the reception of belief in the transmutation of the elements, an idea that dominated the minds of chemists or alchemists, as they were called, for many centuries. The labors of the alchemists were directed toward finding the mysterious philosopher's stone by the aid of which gold and silver could be obtained in abundance from the baser metals and the life of man prolonged.

While their search was in vain, the varied nature of their experiments had the effect of increasing, in no small degree, knowledge of chemical facts. But chemistry as a science can scarcely be said to have had its beginning until the latter part of the seventeenth century, when Robert Boyle taught that the real goal of experimentation was the acquisition of knowledge of the composition of bodies and the reasons underlying phenomena in nature, rather than the transmutation of iron or copper into gold. As soon as this lofty conception gained currency, chemists turned their attention once more to the baffling problem of the nature of fire and the phenomena associated with fire.

Conspicuous among the contemporaries of Boyle was the German chemist, George Ernst Stahl, who put forth the first comprehensive theory of combustion. According to Stahl's conception, all combustible substances such as carbon, sulphur, and metals capable of calcination contained a common volatile principle—phlogiston, or fire stuff—which escaped when they burned or were reduced to ashes. To illustrate, the burning of iron or coal may be represented as follows:

(Iron, phlogiston) − phlogiston = iron calx (ashes)
(Coal, phlogiston) − phlogiston = ashes;

the reduction of what we now know as iron oxide may be formulated thus:

Iron calx + (coal, phlogiston) = iron.

From this point of view a substance burned in air in proportion to its richness in phlogiston; thus, coal burned readily leaving but little ash because it was mostly phlogiston; iron burned less readily because it contained less phlogiston. The reverse process, the conversion of a calx (oxide) into a metal, was accomplished by heating the calx with a substance rich in phlogiston. The theory recognized dependence on the nature of the surrounding gas. When a substance burned or an animal breathed in air, it was supposed that the air gradually became saturated with phlogiston thus destroying its power to support life and combustion. The enclosed air in which a lighted candle had gone out or an animal had expired, was said to be full of phlogiston or completely phlogisticated.

The outstanding weakness of Stahl's naïve theory of combustion was phlogiston itself. Sometimes it was called a principle, at other times it was regarded as a substance; but the real nature of this so-called fire stuff was never clearly defined. On this account, the upholders of the theory were confronted with many difficulties in explaining the phenomena concerned with combustion. For example, it was found that when iron, say, lost phlogiston, that is, burned, the weight of the ashes was more than that of the element. A logical conclusion from this observation was that phlogiston weighed less than nothing. We may wonder how a conception that was so replete with errors and misconceptions could have taken such a hold on the minds of the scientists of the eighteenth century. But to appreciate their position we must remember that people still believed air, water and fire to be elemental bodies and that the modern view of combustion was possible only after the discovery of the element oxygen. It is to this epoch-making discovery and to the man who made it that attention is directed in the present lecture.

Joseph Priestley was born in Fieldhead, near Leeds, in 1733, only a few months before the passing of that other torch-bearer, Stahl. He was brought up among Calvinists of the strictest orthodoxy, and early in life became devoted to the profession of a minister of religion. Owing to ill health during his early years he was prevented from going to school and so was largely self-educated. At the age of twenty years, he was sent to the Dissenting Academy of Daventry where the outstanding policy was to encourage full discussion of every proposition with complete freedom. Priestley tells us in his autobiography that he usually found himself on the unorthodox side of a religious discussion. This native tendency increased with the years so that he passed from Calvinism to Arianism, and finally, in middle life, found for himself a credible and consistent theory of things in a broad form of Unitarianism. On leaving Daventry, Priestley became a minister, first at Needham and later at Nantwich. His early efforts were attended with little success either on account of his heterodox views or the difficulty he had in expressing them because of a tendency to stutter, a "thorn in the flesh" which troubled him more or less throughout his life. After this disappointing experience he decided to give up his ministerial work to become tutor in languages at the Dissenting Academy of Warrington. His versatility was evidenced by the fact that at different times during his ten years at Warrington he taught mathematics, natural philosophy, Latin, Greek, French, Italian, Hebrew, and anatomy, besides writing books and giving occasional lectures on logic, history and law. It is interesting to note that the book which superseded his on the "Laws and Constitution of England" was Blackstone's celebrated "Commentaries." In 1767 Priestley returned to his chosen profession, this time at Mill Hill Chapel in Leeds. It was here that he began his career as a theological controversialist and a defender of political freedom. While he carried out some scientific experiments during his six years at Leeds, his main efforts then and thereafter were devoted to theological work. He left Leeds to become librarian to Lord

Shelburne, who later as Prime Minister concluded peace with the United States. During this period he made his most important contribution to experimental science. After seven years with Lord Shelburne he once more accepted a call to become minister to a large congregation in Birmingham. This call was a particularly fortunate one, for he was well compensated and suitable arrangements were made so that it was possible for him to confine his ministerial duties to Sundays only, leaving the week days for work in science and for carrying on his numerous political and theological controversies.

By his forceful writings and his fearless public utterances through many years, Priestley came to be regarded as the protagonist of English Non-conformity as well as of political Liberalism. At one time or another he had had controversies with most of the leading divines of all schools of thought. And when the French Revolution broke out, he was one of its most ardent sympathizers, defending it with all the vigor characteristic of his nature. His invectives against Burke brought down the condemnation of Parliament, and the part he took in a local controversy in Birmingham roused public opinion against him to such an extent that a mob riot ensued on the evening of July 14, 1791, when a group of men had gathered together to celebrate the second anniversary of the taking of the Bastille. Priestley's church and home were sacked and burned and he was lucky to escape with his life. He fled to London where he hoped to be protected, but public opinion against him was so strong that he had great difficulty in finding a place to stay. George III expressed openly his personal satisfaction at the sufferings Priestley was compelled to endure. Finally he could stand it no longer and so emigrated to America in 1793, never to return to his native land.

From this brief survey of the activities of Priestley we see that he was first and foremost a theologian and a defender of political liberty. While he had a live interest in science throughout his life, he seldom allowed his scientific investigations to interfere with his life work. This should be kept in mind as we proceed to a consideration of the work which he put aside as of secondary importance but which gives him his chief title to distinction.

Priestley appears to have had a strong bent toward the study of nature from his earliest days. His brother Timothy tells us that as a boy he used to bottle up spiders to see how long they would live in the same atmosphere. As we shall see, this experiment anticipated in almost uncanny fashion the investigations which he undertook in later years. But he seems not to have devoted himself seriously to natural science until 1766 when he had the good fortune to meet the illustrious Benjamin Franklin, who was occupied, at the time, in defending the cause of the American colonists against the English Government. This acquaintanceship ripened into a warm friendship that had a far-reaching effect on Priestley's life. Encouraged by Franklin, he wrote a book on the "History and Present State of Electricity" that ran through five editions in the author's lifetime. In the preface to the first edition be manifested his scientific intuition in a striking fashion: "Electricity," he says, "together with chemistry and the doctrine of light and color, seem to be giving us an inlet into the internal structure on which their sensible properties depend." This prophecy has proved to be surprisingly true in the light of recent research on radioactivity and the electron theory. While preparing his book on electricity, Priestley discovered, among other things, the conducting power of charcoal and the phenomenon of the "alternative path," that is, the tendency of a high voltage discharge to take a short path of high resistance rather than a lengthy path of considerably lower resistance. His most important discovery in this connection was the law of force for electrostatic attraction, the generalization usually known as Coulomb's Law, although Coulomb's rediscovery was not made until eighteen years after Priestley gave the account of his work. The same year that these discoveries were made, Priestley received his call to Leeds and, fortunately for the science of chemistry, he happened to take up his abode in a house next door to a public brewery. Here he became very much interested in the carbon dioxide or fixed air, as he called it, which was evolved during the process of fermentation and contributed to the formation of the foam. Thus was started the long series of experiments on gases which gained for Priestley the title of "Father of Pneumatic Chemistry." When he removed from the immediate vicinity of the brewery, he was confronted with the necessity of making fixed air for himself. He heated powdered limestone in a gun-barrel and thus obtained fixed air, carbon dioxide, as well as inflammable air which was in reality carbon monoxide, a gas that he prepared on various occasions but which he never took the trouble to investigate until after he came to America. Numerous other methods were tried for making carbon dioxide and finally he hit upon the method of treating chalk with an acid, a stock experiment at the present day to which every student of chemistry is introduced early in his career. In this connection Priestley says: "When I began these experiments I knew very little of chemistry and had in a manner no idea on the subject before I attended a course of chemical lectures delivered in the academy at Warrington, by Dr. Turner of Liverpool. But I have often thought that, upon the whole, this circumstance was no disadvantage to me; as in this situation, I was led to devise an apparatus and processes of my own, adapted to my peculiar views; whereas if I had been previously accustomed to the usual chemical processes, I should not have so easily thought of any other, and without new modes of operation, I should hardly have discovered anything materially new." The apparatus to which he referred was the now well-known and well-nigh indispensable pneumatic trough. The first form used by Priestley was improvised from an earthenware tub used for washing linen. This contained water, below the surface of which was a shelf containing funnel-shaped openings. Over the openings were placed bottles filled with water. The delivery tube from the apparatus generating any particular gas was placed below one of these openings and the gas was collected by displacement of the water in the bottle.

The first paper on chemistry published by Priestley was in 1772 when he was thirty-nine years of age. This gave an account of his experiments on impregnating water with carbon dioxide by means of pressure. Even in Priestley's day this work had some importance besides mere novelty, for it was hoped that the solution now known as "soda water" might be of use in preventing scurvy. While such is not the case, there is no doubt that carbonated beverages have proven of real value in quenching natural thirst particularly in the depressing days of midsummer, and, by virtue of their sparkling evanescence, they are probably not without some psychic influence in allaying the artificial thirsts of these latter days. Priestley presented the results of his work on carbon dioxide to the Royal Society of London, which regarded it so highly that the Society at once conferred upon him its highest distinction namely, the Copley medal.

The same year that Priestley published his observations on carbon dioxide, he discovered hydrochloric acid gas, nitric oxide, and nitrous oxide. Hydrochloric acid gas being very soluble in water, its discovery was made possible by substituting mercury for water in his pneumatic trough. He first prepared the gas by heating hydrochloric acid with copper; but later found that the acid alone yielded the gas. He was then led to prepare it by the method that is most commonly employed to this day—the action of sulphuric acid on salt.

The preparation of nitric oxide or nitrous air, as Priestley called it, by the action of nitric acid on copper was a particularly important discovery, as it had a determining influence on his future work. As was his custom, he carried out numerous types of experiments with this new gas. To give you some idea of the diversity of these experiments, I will point out a few of them. He tested the antiseptic properties of the gas by preserving pigeons in it. He states that one preserved in the gas from the 28th of April till the 4th of June, had, on being cooked, a peculiar but not offensive taste. He heated the gas, nitric oxide, in the presence of iron and obtained the compound, nitrous oxide, familiarly known to most of us as the anæsthetic "laughing gas." He was made aware of his discovery by the fact that it supports combustion whereas nitric oxide does not. He therefore called his new preparation dephlogisticated nitrous air. Probably his most important experiment with nitric oxide was the use he made of it in the quantitative analysis of air. On account of the reactivity with oxygen, he was able to show that air was diminished by about one-fifth of its volume when mixed with nitrous air and exposed to the action of water. As we now know, this is due to the fact that the air is approximately one-fifth oxygen. But

Priestley's interpretation was that common air consists to the extent of about four-fifths of its volume of air which is already phlogisticated, while the other one-fifth is dephlogisticated and becomes phlogisticated by combustion, respiration, or by adding nitric oxide.

In this connection Priestley had observed, as early as 1771, that growing plants did not vitiate the surrounding air but that a candle would burn very well in air in which plants had grown for a long time. He conceived the idea that there was something attending vegetation that restored air injured by respiration or combustion. He demonstrated this conclusively by putting plants in air in which a candle had burned out and found after a time that the candle would burn in the restored air. He also showed that air which he had breathed himself until it would no longer support combustion, would do so after being exposed to the action of plants; and demonstrated that light was necessary for this effect as well as for the development of the green color in certain algæ. It was Priestley, therefore, who recognized for the first time that the action of plants and animals on air was not the same, but opposed, or, rather, complementary.

As a result of the observations on the comparative ease with which common air becomes phlogisticated by combustion, the natural question to arise was whether it is possible to get air that will support combustion better, or is less phlogisticated,—to use Priestley's terminology,—than common air. But Priestley apparently did not ask himself this question, and so regards his discovery of dephlogisticated air or oxygen as more or less accidental. In the initial paragraph of his classic paper[1] Priestley says: "The

[1] Experiments and observations on Different Kinds of Air, Sec. III, p. 29 (1775).

contents of this section will furnish a very striking illustration of the truth of a remark which I have more than once made in my philosophical investigations; viz. that more is owing to what we call chance, that is, philosophically speaking to the observation of events arising from unknown causes, than to any proper design or preconceived theory in this business. For my own part I will frankly acknowledge that at the commencement of the experiments recited in this section, I was so far from having formed any hypothesis that led to the discoveries I made in pursuing them, that they would have appeared very improbable to me had I been told of them." This introduction to one of the most momentous of papers in the history of chemistry is characteristic of the absolute honesty and sincerity of its author. Many a discovery has doubtless been made under circumstances no less accidental than the discovery of oxygen; but the discoverer is seldom so frank in admitting it.

Priestley employed a method of investigation, so persistently employed in recent years by Edison as to be called the Edisonian method, in contradistinction to the scientific or professional method; that is to say, he tried every kind of experiment he could think of on all kinds of substances. At the time he discovered oxygen, he was engaged in heating substances in a glass tube over mercury to find out what would happen, the heat being applied to the tube by a large burning-glass. The story of the discovery of oxygen is a brief one and I shall let Priestley tell it in his own words: "On the first of August, 1774, I endeavored to extract air from mercurous calcinatus, per se; and I presently found that by means of this lens, air was expelled from it very readily. Having got about three or four times as much as the bulk of my materials, I admitted water to it and found that it was not imbibed by it. But what surprised me more than

I can well express, was, that a candle burned in this air with a remarkably vigorous flame, very much like that enlarged flame with which a candle burns in nitrous air, exposed to iron or liver of sulphur; but as I had gotten nothing like this remarkable appearance from any kind of air besides this particular modification of nitrous air, and I knew no nitrous acid was used in the preparation of mercurous calcinatus, I was utterly at a loss how to account for it.

"In this case also, though I did not give sufficient attention to the circumstance at that time, the flame of the candle besides being larger, burned with more splendor and heat than in that species of nitrous air; and a piece of red-hot wood sparkled in it, exactly like paper dipped in a solution of nitre, and it consumed very fast; an experiment which I had never thought of trying with nitrous air."

On the same day that he carried out the experiments with mercuric oxide, he heated red lead and obtained the same gas. Thinking there might be some impurity in the mercuric oxide originally employed, he repeated his experiments with a number of other samples with the same results. He had no idea at this time, so he tells us, of the real nature of the gas, but he could not get away from the notion that it must be nitrous oxide. And then, at the most important stage of the work for which he is famed, Priestley decided to take a continental trip. While in Paris he visited Lavoisier and performed the mercuric oxide experiment for him. Later Lavoisier claimed priority in the discovery of oxygen because Priestley did not know himself exactly what he had discovered; but the claim of the great French chemist was altogether unjust as well as unkind.

On returning to his laboratory after a two months' visit, Priestley convinced himself that the gas from mercuric oxide was not the same as nitrous oxide since the power of the latter to support combustion was appreciably diminished by shaking with water. As we now know, this is due to its rather high solubility in water as compared with oxygen. About this time Priestley tried heating sulphuric acid to prepare a gas in the same way as he had prepared hydrochloric acid gas. He had the good fortune to have some of the mercury he used in the pneumatic trough suck back into the hot acid where it reacted with explosive violence, producing clouds of a very pungent smelling gas. This led to the discovery of sulphur dioxide, a gas in which he became so interested that he forgot about his oxygen until March 1, 1775, when it occurred to him to add nitric oxide to it to see what would happen. To two measures of oxygen he added one measure of nitric oxide and found that it behaved like ordinary air. This merely led to the conclusion that it would support respiration. When he came into the laboratory the next day he tried the residual gas to see whether a candle would burn in it. Much to his surprise it still proved to be a better supporter of combustion than ordinary air. "I cannot at this distance of time," says Priestley, "recollect what it was that I had in view in making this experiment but I know I had no expectation of the real issue of it. Having acquired a considerable deal of readiness in making experiments of this kind, a very slight and evanescent motive would be sufficient to induce me to do it. If, however, I had not happened for some other purpose to have had a lighted candle before me, I should probably never have made the trial and the whole course of my future experiments relating to this kind of air would have been prevented." The succession of experiments that were tried are classics. He put mice in the gas and found that they lived considerably longer than in the same volume of common air. He then made a quantitative test of its goodness, so-called, by means of nitric oxide and found that it was five times as good as common air, an observation that accords very closely with the facts. The new product was named dephlogisticated air. He exploded hydrogen and oxygen and suggested that gunpowder be mixed with oxygen for making explosives. He anticipated the oxyhydrogen blowpipe by blowing oxygen into a flame and noting the extent to which the combustion was hastened. He suggested its possible use in medicine when common air was inadequate to support life. The final experiment which he records is particularly interesting: "My reader will not wonder, that, after having ascertained the superior goodness of dephlogisticated air by mice living in it, and the other tests above mentioned, I should have the curiosity to test it myself. I have gratified that curiosity by breathing it, drawing it through a glass syphon, and, by this means, I reduced a large jar full of it to the standard of common air; but I fancied that my breast felt peculiarly light and easy for some time afterwards. Who can tell but that, in time, this pure air may become a fashionable article in luxury. Hitherto only two mice and myself have had the privilege of breathing it."

Some historians mention Scheele in the same breath with Priestley as co-discoverer of oxygen, since the notes of the great Swede showed that he had prepared oxygen a few months before Priestley, although he never published his work. But this does not detract from the recognition due Priestley for his independent discovery. As a matter of fact, Eck de Sultzbach, in 1489, knew that red oxide of mercury gave off a "spirit" when heated. There are also indications that oxygen was known to the Greeks and that the Chinese were acquainted with the gas long before the time of Scheele and Priestley. For that matter Priestley himself had heated potassium nitrate in a gun-barrel as early as 1771, and obtained a gas with an enhanced power of supporting combustion.

The account of Priestley's discovery of oxygen as well as a number of other gases impresses one with his versatility in devising and carrying out experiments. But in spite of his unusual success in discovering new gases, he had little scientific imagination and his speculations regarding the composition of the substances he discovered were uniformly erroneous and unsound. He recognized clearly for the first time that the gaseous substances he prepared were chemical individuals and not mere modifications of one primordial air; yet he regarded water as the basis of all gases and considered it an element. This seems rather strange since he himself anticipated Cavendish in the synthesis of water by passing hydrogen over heated mercuric oxide; but he did not recognize the profound significance of his experiment. So deep-seated were his convictions that he was never convinced that his impressions were erroneous. With the discovery of oxygen by Priestley and the discovery of the composition of water by Cavendish, Lavoisier overthrew completely the phlogiston theory and established on a quantitative basis, the modern theory of combustion. But Priestley failed to keep pace with the developments and remained loyal to the phlogiston theory after every one else had given it up. Indeed, his last paper on chemistry written in America in 1800, four years before his death, was entitled, "The Doctrine of Phlogiston Established and that of the Composition of Water Refuted." This lack of scientific vision has caused some chemical historians to discredit Priestley's work as a chemist and to attribute his discoveries to accidental rather than rational causes. Indeed, Priestley himself is somewhat responsible for furthering this view as I have pointed out from time to time. But when we review his work as a whole, we are impressed with the brilliance of many of his investigations. It is true that the single apparatus, the pneumatic trough, was responsible for a great many of his observations; but Priestley invented the pneumatic trough. It is equally true that he would not have discovered hydrogen chloride, ammonia, silicon fluoride, and sulphur dioxide if he had used water instead of mercury in his pneumatic trough. But the fact remains that Priestley did not use water, but mercury, if the gas happened to dissolve in water. Although Priestley himself modestly attributes his discovery of the true nature of oxygen to the presence of a candle near at hand on March 2, 1775, there is no doubt but that he always had a candle near at hand; and I cannot help but feel that if he had not made the test on the day he did, he would have done so later on. While we recognize the random nature of his experiments, we must not forget that he had the ability to devise apparatus out of such articles as gun-barrels and washtubs and that he discovered more new gases than all his predecessors put together. Moreover, his work with nitric oxide laid the foundation of gas analysis and by a series of brilliant experiments he showed the complementary action of plants and animals on the atmosphere; and a hundred and fifty years ago he crowned his achievements with the discovery of oxygen. Thus, in spite of the apparent purposeless nature of many of his experiments and his shortcomings as a theorist, he holds a conspicuous place "among the swift runners who hand over the lamp of life."

Let us now give some attention to Priestley the philosopher, politician and theologian. In his own day Priestley's views found little favor with the masses, and, although he makes no particular pretensions to originality either as a philosopher or politician, his clear and unflinching expositions brought condemnation from a large body of his countrymen. As a philosopher he denied the freedom of the will in the sense of self-determination. He also denied the existence of a soul distinct from the body, and, as a logical consequence, he denied the natural immortality of man. According to the materialistic view which he advocated, the bodily and mental faculties—matter and spirit—are in the same substance and so they grow, ripen, die and decay together. He had a profound conviction, however, that man would be raised from the dead by the power of God and would thereafter be immortal. In his book on "Disquisitions Relating to Matter and Spirit" he states his position repeatedly. Thus, on page 247 he says: "The doctrine of the Scripture is, that God made man of the dust of the ground, and by simply animating this organized matter made man that living percipient and intelligent being that he is. According to revelation, death is a state of rest and insensibility, and our only though sure hope of a future life is founded on the doctrine of the resurrection of the whole man at some distant period; this assurance being sufficiently confirmed to us by the evident tokens of a Divine commission attending the persons who delivered the doctrine and especially by the actual resurrection of Jesus Christ, which is more authentically attested than any other fact in history."

Priestley's political conceptions were likewise not original but were based largely on those of Locke. But here again, his utterances were so outspoken that they commanded immediate attention. In his "Essay on the First Principles of Government" to which I have already referred, his thesis is that kings, senators, and nobles are the servants of the public and that government exists for the good of the governed. This leads him on page 13 to say: "But in the largest states, if the abuses of the government should at any time be great and manifest; if the servants of the people, forgetting their masters and their masters' interests, should pursue a separate one of their own; if, instead of considering that they are made for the people, they should consider the people as made for them; if the oppressions and violation of right should be great, flagrant and universally resented; if the tyrannical governors should have no friends but a few sycophants, who had long preyed upon the vitals of their fellow citizens, and who might be expected to desert a government whenever their interests should be detached from it; if in consequence of these circumstances, it should become manifest that the risk which would be run in attempting a revolution would be trifling and the evils which might be apprehended from it were far less than those which were actually suffered, and which were daily increasing; in the name of God, I ask, what principles are those which ought to restrain an injured and insulted people from asserting their natural rights, and from changing or even punishing their governors—that is—their servants—who had abused their trust or from altering the whole form of their government, if it appeared to be of a structure liable to abuse."

We can readily understand why George III was a party to the punishment inflicted on Priestley which ultimately drove him into exile and why the new American Government welcomed him with open arms.

As a Dissenter and a Unitarian, Priestley was deprived of many rights accorded to members of the state Church. He therefore had very definite opinions concerning Ecclesiastical Establishments which he did not hesitate to voice.

But as always, we find him reasonable in his demands, advocating the reformation rather than the immediate destruction of an established institution. In his "Essay on the First Principles of Government" he recommended four important reforms. First of all, he suggested that the Articles of Faith to be subscribed by candidates for the ministry should be reduced from 39 to 1. He considered it a reproach to any Christian establishment if every man could not claim the benefit of it who could say that he believes in the religion of Jesus Christ as it is set forth in the New Testament. A second reform suggested was to pay the clergyman in proportion to the work done; a third, to exclude Bishops from Parliament; and a fourth, complete toleration, so that every man might enjoy the rights of a citizen whether he belonged to the established church or not.

Thus in religion as in politics we find Priestley a staunch defender of rational freedom in thought and in action. While the religious and political freedom he advocated would be considered conservative in our day, yet he all but became a martyr to the cause he championed. Throughout the realm he was branded as an unbeliever in Revelation, a heretic no better than an atheist, a gloomy fanatic whom children were taught to insult as he passed along the street. And yet we are told that Priestley was anything but a gloomy fanatic. On the contrary he is pictured as being a cheerful and kindly soul, who was literally idolized by children and who never lost a friend. It has been said: "By some strange irony of fate this man who was by nature one of the most peaceable and peace-loving of men, singularly calm and dispassionate, not prone to disputation or given to wrangling, acquired the reputation of being perhaps the most cantankerous man of his time."

On the one hundredth anniversary of the discovery of oxygen a statue of Priestley was unveiled in the City of Birmingham. In a commemorative address delivered on that occasion Professor Thomas H. Huxley commended in particular the character of the man who was exiled for his honest opinions respecting church and state, nor if speaking to-day would Huxley alter one syllable of these two sentences[1]: "The unspotted purity of Priestley's life, the strictness of his performance of every duty, his transparent sincerity, the unostentatious and deep-seated piety which breathes through all his correspondence are in themselves a sufficient refutation of the hypothesis invented by bigots to cover uncharitableness, that such opinions as his must arise from moral defects. And his statue will do as good service as the brazen image that was set upon a pole before the Israelites if those who have been bitten by the fiery serpent of sectarian hatred which still haunts their wilderness of a world are made whole by looking upon the image of a heretic who was yet a saint."

On coming to America, Priestley went to Northumberland, Pennsylvania, where it was proposed to found a settlement composed mainly of Englishmen who had left their native land. This scheme was abandoned, but Priestley was so attracted by the beauty of the surrounding country that he decided to settle there and so built himself a house on a hillside overlooking the Susquehanna Valley. He was invited to accept the chair of chemistry at the University of Pennsylvania, but this invitation he modestly declined, declaring frankly that he was unprepared for such an appointment. "Though I have made discoveries in some branches of chemistry, I never gave much attention to the common routine of it and know but little of the common processes." However, he set up a laboratory at Northumberland and

[1] "Science and Education," p. 23 (1895).

here he fought until the end a losing fight to establish the phlogiston theory. He also built a little church in which he preached weekly until his strength gave out. He had hoped to found a college but this ambition was never realized.

In the "American Chemist" for 1874 appeared a communication calling on the chemists of America to celebrate the centennial of the discovery of oxygen and the birth of modern chemistry. This proposal met with so immediate and general response that, on the last day of July, 1874, there gathered together at Northumberland, Pennsylvania, the most notable assemblage of chemists that had ever convened on this continent, and in the course of this meeting at the grave of Joseph Priestley was organized the present American Chemical Society,—a perpetual monument to his memory.

During the simple ceremonies held in connection with the commencement exercises of last June for the breaking of ground for the new Rice Laboratory of Chemistry, Dr. Edgar F. Smith of the University of Pennsylvania generously presented to the Rice Institute from his personal collection the original of a letter written by Joseph Priestley. It would seem to be particularly appropriate that a copy of this old letter should find a place in the corner stone of this new edifice which is dedicated to chemistry, and is to be ready for teaching and research in the year that marks the one hundred and fiftieth anniversary of the discovery of oxygen.

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