Articles written by Robert John Strutt (4th Baron Rayleigh) and published by the Royal Society

The following 25 items relate to work carried out on electrical discharges in various gases, the properties of the resulting “activated gas”, and its effects on various substances. They cover the years 1911 to 1947, and are only a small portion of the articles written by Robert Strutt, and published in the society’s Proceedings.

Note: A full collection can be found at: https://royalsocietypublishing.org/action/doSearch?field1=Contrib&text1=Strutt&startPage=0&sortBy=relevancy

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Bakerian Lecture.—A chemically active modification of nitrogen, produced by the electric discharge

Robert John Strutt
Published: **10 May 1911** **https://doi.org/10.1098/rspa.1911.0033**

Abstract

It is known that vacuum tubes frequently show a luminosity of the contained gas after discharge is over. In a previous paper I was able to show that this effect, as it occurs in air, is of the nature of a phosphorescent combustion, and is due to the mutual reaction of nitric oxide and ozone, each formed in the discharge. In a second paper it was shown that other phosphorescent combustions can be observed in ozone, notably of sulphur, sulphuretted hydrogen, acetylene, and iodine. Some of these give continuous spectra, but the majority band spectra. In the first paper it was stated that pure nitrogen gives no afterglow whatever, and, with the simple induction coil discharge with which I was then working, this has been frequently verified since. Mr. Percival Lewis has however, described an afterglow obtained in nitrogen when a jar discharge with spark-gap is used. I had no difficulty in obtaining this glow as soon as the jar discharge was used, and have applied to its examination the method used in the former papers. This is due to Sir James Dewar, and consists in drawing a current of gas through the vacuum tube into an observing vessel, where the glow is developed, and thence into an air pump, which must be a mechanical one of good construction, driven by power. It is thus possible to examine the properties of the glowing nitrogen much more satisfactorily than can be done by intermittent examination after successive discharges.

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A chemically active modification of nitrogen produces by the electric discharge.—II

Robert John Strutt
Published: **22 November 1911** **https://doi.org/10.1098/rspa.1911.0080**

Abstract

It was noticed previously that oxygen destroyed the nitrogen afterglow. There is no doubt whatever that is a positively destructive effect, as opposed to a mere dilution. For if a stream of oxygen is admitted through a stoppock into the stream of glowing nitrogen, the glow is extinguished: replacing the oxygen with an equal (inert) nitrogen feed, the nitrogen glow reappears, only slightly weakened by dilution. No oxidation of nitrogen accompanies the destruction of the glow. The mixed gases were passed through a U-tube cooled in liquid air for half-an-hour. No deposit could be seen in the tube. The condensed gases from the U-tube (if any) were collected through a Töpler pump on warming up. Nothing was collected beyond about 1/2 c. c. of nitrogen peroxide, which was presumably derived from leakage, since liquid air could not have condensed it.

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A chemically active modification of nitrogen, produced by the electric discharge.—III

Robert John Strutt
Published: **26 March 1912** **https://doi.org/10.1098/rspa.1912.0020**

Abstract

In the first paper (2) it was mentioned that a stream of glowing nitrogen led through a tube cooled in liquid air glowed out with increased brilliancy, and then became extinguished. There is some ambiguity in the interpretation of this experiment, since the density of the gas is locally increased by cooling; and increased density may (and does) make the nitrogen expend its glowing power more quickly. A hermetically sealed bulb containing rarefied nitrogen was excited by the electrodeless discharge. Allowed to expend itself at room temperature, the glow in this bulb was conspicuous for more than a minute. But if the bulb was immersed completely in liquid air immediately after excitation, and after 15 seconds withdrawn and examined, it was found to be quite dark. The glow was very brilliant as seen under the surface of the liquid air. This experiment proves that the glow-transformation really occurs more quickly the lower the temperature, apart from changes of density.

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The after-luminosity of electric discharge in hydrogen, observed by Hertz

Robert John Strutt
Published: **27 June 1912** **https://doi.org/10.1098/rspa.1912.0044**

Abstract

In previous papers I have examined certain striking cases of after-luminosity in gases through which the electric discharge has been passed. The cases dealt with fall under two heads, those due to ozone, and those due to active nitrogen. I wish now to pass to case in which neither of these substances is concerned. Hertz described a phenomenon of after-luminosity which he had observed in hydrogen. The method of investigation was somewhat special. A series of jar discharges was passed through a small discharge tube, with an open end, arranged inside a bell jar. It was then observed that at each discharge a stream of luminous gas was squirted from the end of the small discharge tube into the bell jar. This is apparently due to kind of explosive action of the spark—the same, probably, as that described by De La Rue and Muller. The method is well adapted to show the afterglow in other gases, nitrogen or air, for instance, but the immediate concern is with hydrogen. With this gas, Hertz sometimes observed a jet of blue luminosity, which was best developed at a pressure of 100 mm. He considered that he had good evidence that this luminosity showed the hydrogen spectrum, but be found an unaccountable capriciousness of the effect, which sometimes refused to appear at all. He did not succeed in tracing the cause of this uncertainty. Goldstein made similar experiments; he states that the spectrum consists of at least 10 bands, from the green to the ultra-violet, totally unrelated to the recognised hydrogen spectrum. But he believed that the glow was due to pure hydrogen.

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A chemically active modification of nitrogen, produced by the electric discharge.— IV

Robert John Strutt
Published: **21 August 1912** **https://doi.org/10.1098/rspa.1912.0070**

Abstract

1. *General*. The properties of active nitrogen have been described throughout on the assumption that it is to be classed with other chemical substances, and that its reversion to ordinary nitrogen is to be regarded simply as a chemical reaction, as one would regard the change of ozone to oxygen, or of red to ordinary phosphorus. I see no reason to abandon this position. There are, however, some

circumstances not at first sight falling in very naturally with it. One of these is the acceleration of the change by cooling, a phenomenon without parallel in any recognised reaction. Another is the development of many of the bands of the nitrogen spectrum. This spectrum has never been produced by any other purely chemical process, but (apart from active nitrogen) is only observed when an electric current is actually passing through the gas at the moment of observation. Lastly, the ionisation associated with a stream of glowing nitrogen has suggested serious doubts whether its chemical peculiarities are really due to the presence of a definite chemical substance in the ordinary sense, or to some unexplained survival of the conditions of the disruptive discharge. Evidence will he brought forward in this paper which is considered to be entirely in favour of the former alternative. 2. *Energy of Active Nitrogen*. These considerations have made it important to determine whether the energy emitted by active nitrogen in reverting to ordinary nitrogen is comparable with that liberated in other chemical changes. The experiments to be described answer this question in the affirmative.

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Absorption of helium and other gases under the electric discharge

Robert John Strutt
Published: **02 October 1912** **https://doi.org/10.1098/rspa.1912.0092**

Abstract

Berthelot announced in 1896 that he had succeeded in observing an absorption of argon, and later of helium, when these gases were submitted to the silent electric discharge, in the presence of either benzene or bisulphide of carbon: further, that the gases could be extracted by heat from the solid substances deposited on the walls of the vessel. The experiments were regarded as proving that argon and helium were after all capable of entering into chemical combination. I shall confine discussion to the supposed interaction of helium and carbon bisulphide. Berthelot obtained more definite results with this reagent than with benzene. At the time they were published, these accepted, and, so far as I have been able to learn, they have not been more favourably regarded since. Berthelot, however, adhered to them in his ‘Traité Pratique de l’Analyse des Gaz,’ published in 1906, about the time of his death, and other experimenters have not produced definite evidence against them. The subject cannot be considered unimportant, and I have long felt that the experiments ought to be repeated. This has now been done, with results altogether negative.

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Duration of luminosity of electric discharge in gases and vapours

Robert John Strutt
Published: **24 February 1913** **https://doi.org/10.1098/rspa.1913.0013**

Abstract

The electric discharge produces luminosity in any gas or vapour through which it passes. The question presents itself, Does the luminosity persist after the current has ceased, or does its top immediately ? A full answer is likely to be of great importance in unravelling the cause and mechanism of the luminosity. There are exiting observations bearing on the subject, but these are somewhat scattered in the literature, and, so far as I am aware, their mutual relations have not been pointed out. It is hoped in this paper to do something towards systematising and extending them. The most conspicuous phenomena in this connection are the various forms of afterglow which have been discussed in previous papers. But these are not really relevant to tire present subject, for they are due to secondary causes of a chemical nature. Some of them, produced in gaseous mixtures containing oxygen, are due to the interaction of ozone with other substances present. Others, again, are connected with the formation of an active modification of nitrogen. In none of these cases can the after-luminosity be considered continuous with the luminosity of tire discharge which produced it. For it is always much less brilliant, even at first, and always has a quite different spectrum.

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An active modification of nitrogen, produced by the electric discharge.—V

Robert John Strutt
Published: **01 July 1913** **https://doi.org/10.1098/rspa.1913.0049**

Abstract

Experience has led to certain modifications of detail in preparing nitrogen for the experiments. Commercial nitrogen from cylinders is still used, but instead of passing it over phosphorus it is allowed to stand in contact with it for some hours. The former method does well enough when the phosphorus is freshly cut, but in time the surface deteriorates, owing, in part at least, to the accumulation of oxides of phosphorus, which tend to obstruct access of the gas. Two 15-litre aspirator bottles are arranged as a gasholder in the usual way, the gas being displaced by water. In the gas space is hung up a muslin bag containing chopped phosphorus. On filling the gasholder with commercial nitrogen the phosphorus fumes freely, and all traces of oxygen are removed in the course of two or three

hours. The fumes subside, and the gas is ready for use. It merely requires drying on its way to the discharge tube. This 15-litre supply is more than enough for most experiments. When it is used up the water rises and drowns the bag of phosphorus, dissolving out the oxides which have been formed, and leaving it in good condition for use next time.

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A peculiar form of low potential discharge in the highest vacua

Robert John Strutt
Published: **01 August 1913** **https://doi.org/10.1098/rspa.1913.0064**

Abstract

Mr. C. E. S. Phillips has described a curious electrical effect. Iron electordes E_1, E_2, fig. 1, were fixed in a glass bulb as shown. The bulb was exhausted very highly; a discharge was passed for a moment, and turned off. The iron electrodes were then magnetised by exciting the electromagnets M_1, M_2. On magnetisation, a luminous ring was observed in the equatorial plane of the magnet, which lasted for a few seconds, and then died out. The effect excited considerable interest at the time, and careful experiments were made by the discoverer to elucidate its causes. The following may be quoted from the concluding section of the paper as representing his views. “The preceding experiments show that the principal effect of the magnets is to produce a concentration of negative ions at the strongest portion of the magnetic field, and centrally within the bulb • • • • I consider that this concentration of negative ions is due to two main causes. In the first place it is partly produced by the action of the magnetic field on ions already in motion within the bulb • • • • • And secondly owing to the reaction resulting from the sudden excitation of the magnets, the comparatively dense cloud of ions situated at the ends of the bulb would, in rapidly turning about the magnetic axis, tend to move towards the pointed end of the electrodes, and so concentrate as observed.”

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Note on electric discharge phenomena in rotating silica bulbs

Robert John Strutt
Published: **01 November 1913** **https://doi.org/10.1098/rspa.1913.0088**

Abstract

The late Rev. F. J. Jervis Smith described some curious experiments on this subject before the Royal Society, without, however, offering any interpretation of his

results. I have recently repeated most of his experiments, and have made others which have thrown light on the matter. As the result, it does not seem that anything fundamentally new as to the mechanism of discharge is to be learnt from this line of research. Still, the work is worthy of brief record, if only to save others the trouble of traversing the same ground. Jervis Smith's fundamental experiment is as follows: The exhausted bulb is placed near a body charged to 1,000 volts or more. When the bulb is rotated, a luminous glow is maintained within it. It is not difficult to foresee this result. The rarefied gas may be regarded as a conductor. Suppose the body negatively electrified. Then, since the potential on the inside of the bulb is lower near the outside electrified body than elsewhere, positive electricity will flow to this neighbourhood and negative electricity to other parts of the bulb, until the electric field inside the bulb is nearly neutralised. When the bulb is rotated, these induced charges will be carried round with it, and will have to flow through the gas to recover their equilibrium position. In doing this they set up the ordinary luminosity of discharge. To predict the precise direction of the stream lines would be very difficult, and it does not appear that much would be gained by success. As regards the detailed effects of magnetic fields in various directions in deflecting the luminosity the same may be said. I find that, just as in ordinary discharge tubes, the luminosity at low vacua is mainly that characterising the residual gas, while at high vacua the fluorescence of the silica under cathode rays predominates.

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Attempts to observe the production of neon or helium by electric discharge

Robert John Strutt
Published: **02 February 1914** **https://doi.org/10.1098/rspa.1914.0017**

Abstract

Very general interest has been aroused by the observations of Collie and Patterson on the above subject. It is understood that their results have been endorsed by Sir W. Ramsay from independent evidence. The present experiments were begun in the hope of confirming the work of Collie and Patterson and of sharing in the interesting field of research thus opened up. The results, however, have been negative, whether from a failure to appreciate the proper conditions for the production of neon or from some other cause.

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Luminous vapours distilled from the arc, with applications to the study of spectum series and their origin.-I

Robert John Strutt
Published: **01 July 1914** **https://doi.org/10.1098/rspa.1914.0060**

Abstract

In a paper entitled "Duration of Luminosity of Electric Discharge in Gases and Vapours," reference was made to a known phenomenon shown by the mercury arc *in vacuo*: when mercury is allowed to distil away from a mercury lamp into a lateral tube sealed on to it, the rapidly moving vapour carries its luminosity for a long distance out of the electric field. It was shown how effects not essentially different might be obtained with mercury, and other metals also, using not the arc, but the leyden jar spark between poles of the metal; but this method, owing to the intermittence of the sparks and the small scale of the effects, is far less satisfactory than the use of the arc. At the time of writing the paper cited, I thought that it would be very difficult to extend the use of the arc to metals less volatile than mercury, but the problem has proved more tractable than was expected 2. *Method of Experimenting-Apparatus used*. The vessel in which the arc is confined will be called, for convenience, a lamp, though it is not used directly as a source of light.

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Luminous vapours distilled from the arc, with applications to the study of spectrum series and their origin.—II

Robert John Strutt
Published: **01 December 1914** **https://doi.org/10.1098/rspa.1914.0105**

Abstract

This paper is in continuation of a former one. It has been observed by Stark, and subsequently by Matthies and Child, that a luminous jet of mercury vapour, distilling away from the arc *in vacuo*, into a region quite remote from the electric field of the arc itself, may be deprived of its luminosity by an independent electric field. The present paper describes experiments made to elucidate this effect in the case of mercury, and similar observations made upon other metallic vapours.

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A chemically active modification of nitrogen, produced by the electric discharge.—VI

Robert John Strutt

Published: **01 April 1915** **https://doi.org/10.1098/rspa.1915.0021**

Abstract

1. *Effect of Catalysts in Promoting the Formation of Active Nitrogen*. There has been considerable controversy on the question of whether or not pure nitrogen would give the afterglow, which, as I have shown in the previous papers of this series, is associated with the presence of chemically active nitrogen. E. P Lewis was disposed to think that the presence of oxygen or nitric oxide was essential, but in a much later paper, though still inclined to the same opinion, he states that the afterglow continually increased in intensity as the proportion of oxygen was reduced.

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An active modification of nitrogen. -VII

Robert John Strutt
Published: **01 July 1916** **https://doi.org/10.1098/rspa.1916.0029**

Abstract

In previous papers attention has chiefly been paid to the properties of active nitrogen when produced. The present one deals almost entirely with the circumstances of its production by the electric discharge. The jar discharge is much the most efficient, but does not lend itself easily to quantitative investigation. It is not easily maintained steady for any length of time, but there is a more fundamental difficulty than this, for measurements of current and potential with the jar discharge do not admit of any simple interpretation. Each discharge lasts for a time which is very short compared with the intervals between discharges, and, when it does occur, it is oscillatory. For these reasons attention has been given to the steady discharge obtained from a direct current dynamo machine. This yields much less active nitrogen than the jar discharge, but still enough to admit of satisfactory observations on many points.

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Spectroscopic observations on the active modification of nitrogen. —V

Robert John Strutt
Published: **03 May 1917** **https://doi.org/10.1098/rspa.1917.0017**

Abstract

The spectrum of the nitrogen afterglow, as ordinarily obtained, consists of three groups of bands, which we designated as the α, β, and γ groups. The α-group is in

the visual region, and consists of a selection of the first positive bands of nitrogen. The β-group is chiefly in the ultra-violet, but extends into the violet. It can be observed in the discharge, but is much better developed in the afterglow. The γ-group is wholly in the ultra-violet, and identical with Deslandres' third positive nitrogen group. I have not much to add to the results of the former paper as regards the measurement and classification of these various groups of bands. The circumstances under which they appear have, however, been reinvestigated, and the conclusions of the earlier paper modified in some important respects.

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Duration of luminosity of electric discharge in gases and vapours: further studies

Robert John Strutt
Published: **01 December 1917** **https://doi.org/10.1098/rspa.1917.0051**

Abstract

In several previous papers, I have described experiments showing that the luminosity of the spark or arc discharge through gases and metallic vapours lasts for an appreciable length of time after the discharge has ceased to pass, and that the luminous vapour can be removed from the region where the electric current is passing, and still remain luminous, showing the same spectrum as before, though in certain cases some lines of this spectrum fade out sooner than others. The present paper is a continuation of these studies. 1. *The Luminous Jet at Very Low Pressures. Effect of a Transverse Electric Field*. The first experiments to be described were designed to observe the effects at very low gaseous pressures, and with small currents. The advantage of this is that the luminous particles in the jet are then comparatively free to move under the action of an external force, and their motion in an electrostatic field can be conveniently examined. Moreover, since the ions are few, they do not disturb the uniformity of the electric field applied for this purpose.

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Note on the oxygen afterglow

Robert John Strutt
Published: **01 May 1935** **https://doi.org/10.1098/rspa.1935.0086**

Abstract

A paper on the oxygen afterglow by Stoddart appears in 'Proc. Roy. Soc.,' A, December 1, 1931. Many years ago I made an investigation on this subject. The

title was perhaps not sufficiently explicit, and the paper escaped Stoddart's notice. The conclusions reached are not in agreement with his, and I wish to draw attention to the old experiments, which appeared to me at the time, and appear still, to be definite and conclusive, as far as they go. Stoddart's experiments seem to have been carefully carried out. But rather different experiments would, I believe, have led to a different conclusion. Before coming to the main point, it is necessary to deal with one preliminary matter. That is the meaning to be attached to the expression "Electrodeless discharge." The phrase has usually been applied to the bright discharges obtained by J. J. Thomson, by *electromagnetic* induction, using the currents induced by a coil of wire wrapped round the tube, through which is passed the oscillatory discharge of a condenser. Discharges of this kind approximate to the condensed discharge in an electrode tube.

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Active nitrogen of long duration, law of decay, and of increased brightness on compression

John William Strutt
Published: **01 October 1935** **https://doi.org/10.1098/rspa.1935.0166**

Abstract

1-Active Nitrogen-Influence of Vessel Walls on the Duration The length of time for which the afterglow associated with active nitrogen remains perceptible varies very greatly under different experimental conditions; and, what is more important, if we start from a given luminosity per cc of the gas, the integrated amount of light emitted before the luminosity sinks to zero varies also. This is connected with the fact that the walls of the certain gaseous impurities may have an unfavourable effect. In other words, the active nitrogen may go out of existence either by a luminous or a non-luminous reaction. If it is desired to study the homogeneous luminous reaction, then it becomes important to eliminate the other as far as possible. So far as I am aware, no systematic attempt has ever been made to do this, though many writers have referred to the subject. The electrodelss ring discharge at low pressures is suited for the production of active nitrogen, and it has the advantage that no metal electrodes need be introduced. An oxidized copper surface, even of very small area, immediately destroys the afterglow when introduced into it, and a clean (freshly formed) mercury surface is attacked with formation of nitride. In view of these facts it seemed best to avoid metal, though more information would be desirable.

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New studies on active nitrogen. I. Brightness of the after-glow under varied conditions of concentration and temperature

Robert John Strutt

Published: **28 August 1940** **https://doi.org/10.1098/rspa.1940.0074**

Abstract

This paper examines quantitatively the behaviour of nitrogen gas emitting the after-glow, under varied conditions. The integrated light emitted under the most favourable conditions has been measured as 3.18 candle-sec. per c.c. of nitrogen, the (rarefied) nitrogen being reckoned as at N.T.P. The number of quanta emitted is estimated as about 1.3 x 10^{-3} of the number of molecules present. It is concluded, in agreement with Kneser, that the addition of unexcited nitrogen to glowing nitrogen increases the (instantaneous) emission. It was found that a fivefold increase of total pressure produced about a fivefold increase of brightness. These tests were carried out at very low luminous intensities, when the spontaneous decay was negligible during an experiment. If the active gas contained in 1 litre of weakly glowing nitrogen is allowed to diffuse quickly into an additional 1 litre volume of nitrogen, so as to dilute it by half, the candle power per unit volume is reduced about 4.3-fold. This is a fair approximation to the value 4, which would be expected if the reaction were bimolecular as regards active nitrogen, and is in agreement with the conclusion which has generally been drawn from observation on the rate of decay of the luminosity in closed vessels. The effect of compressing the glowing gas has been re-examined, using a solid piston moving in a cylinder. It is now found that with the improved arrangements the brightness varies as the inverse cube of the volume. This is the logical conclusion from, and confirmation of, the previous experiments in which the concentration of (1) the inert nitrogen, and (2) the active nitrogen, are separately varied. A further test was to expand the glowing gas into a doubled volume which was carried out by letting it pass into a supplementary exhausted vessel. This was expected from the previous result to reduce the intensity 8 times, but in fact did not reduce it more than 7 times. The gas was therefore somewhat brighter after the expansion than had been expected. Most sources of error would have the opposite effect, and there is an outstanding discrepancy in this result. The effect of temperature on the nitrogen after-glow is examined quantitatively, maintaining the cooler and hotter portion in pressure equilibrium. Cooling to liquid air temperature, for instance, increases the brightness some 80 times. Most, but not all, of this is due to the additional concentration. Assuming (in accordance with the compression experiment) that the brightness is as the cube of the concentration, and correcting the results to uniform concentration, it is found that over the range

examined the brightness varies as $T^{-0.64}$, when T is the absolute temperature. The positive temperature effect on ordinary chemical reaction corresponds to something more like T^{+100}.

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New studies on active nitrogen. II. Incandescence of metals in active nitrogen, and quantitative estimates of the energy liberated

Robert John Strutt
Published: **28 August 1940** **https://doi.org/10.1098/rspa.1940.0075**

Abstract

It is shown that pieces of sheet gold, copper, silver, or platinum may be made red hot or even melted by exposing them to active nitrogen produced in a low-pressure discharge. The nitrogen gives up its energy to the metal, which remains unacted on. This phenomenon is applied to measuring the energy of active nitrogen, drawing a known quantity of gas through the activating discharge and then over the metal, and measuring the energy liberated on the latter. The amount of energy collected from the gas was surprisingly large, and is difficult to reconcile with existing theories of the nature of active nitrogen. In some cases the energy was as high as 10 eV for every molecule of nitrogen that passed through the discharge. This quantity of energy can with difficulty be accounted for by dissociation, even if it occurred to the extent of 100%. The energy radiated as after-glow under favourable conditions is only of the order of 10^{-3} of the energy collected by the metal.

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Further studies on active nitrogen. III. Experiments to show that traces of oxygen or other impurity affect primarily the walls of the vessel, and not the phenomena in the gas space

Robert John Strutt
Published: **05 June 1942** **https://doi.org/10.1098/rspa.1942.0029**

Abstract

This paper deals in the first place with the effect of minute gaseous impurities which have apparently an important effect in promoting the formation of active nitrogen by the electric discharge. Oxygen is one of them. It is shown that the action of oxygen must be on the walls of the tube: for when a minute oxygen tributary is added to the nitrogen stream, it takes much longer to assert its action than the time required to establish the changed composition of the gas stream:

and similarly when the oxygen tributary is checked its activity persists for a time. This is interpreted to mean that the action of the oxygen or other impurity is to modify the glass wall in a way favourable to the accumulation of active nitrogen. The restoration of the afterglow by addition of tributary stream of oxygen can be observed even better with the electrodeless discharge at low pressure (0.3 mm. say) than with high-pressure electrical discharges at say 3 mm. pressure. The intensity in some experiments has been raised 32-fold by the admission of oxygen. Under certain conditions of the glass the cutting off of the oxygen tributary causes a temporary fall of intensity to considerably less than the static value, followed by a rise to that static value. This shows that the phenomena are complicated and not likely to admit of any very simple analysis. The paper goes on to examine how various treatments of a glass vessel affect its action on the afterglow. As found by Herzberg strong preliminary heating in vacuo makes it destructive of the glow. It is now shown that heating in nitrogen at atmospheric pressure does the same. Heating in oxygen, even at 1 mm. pressure, restores it. It seems clear that these effects cannot easily be explained by the formation or removal of gas layers. The behaviour of glass is therefore very complex, and not likely to be easily unravelled. The behaviour of the gas itself away from any surface is more fundamental. By a special device it is shown that in this case the purest nitrogen is the best, and that the addition of a trace of oxygen has no favourable effect in promoting the active nitrogen phenomena.

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Further studies on active nitrogen IV. The ionisation associated with active nitrogen

Robert John Strutt
Published: **05 June 1942** **https://doi.org/10.1098/rspa.1942.0030**

Abstract

In this paper the ionization associated with afterglowing nitrogen is examined more thoroughly than has yet been done. It is found that this ionization is completely cut off if the testing vessel is separated from the afterglow by a silica wall. The ionization cannot therefore be directly produced by light, at any rate within the range from A 1850 to the visible. No increased current is observed when the surface action of the active gas is so vigorous as to make the testing cathode (of gold) red hot. The ionization is in general nearly the same when the cathode of the testing vessel is one of the common metals or a surface coated with metaphosphoric acid. Copper, however, is an exception. While the copper is clean it gives an effect several times larger, though this soon goes off, as it becomes dull by the action of the gas. It appears therefore that though there is

some surface emission of electrons, it is in most cases small compared with the volume ionization in the gas space. Comparisons are made of the number of ion pairs generated, and the number of photons emitted, per cubic centimetre at various stages as the glow dies down. At first the number of photons is m any times greater, but as the glow gets down the numbers become equal, and at intensities too low for convenient observation it is likely that the number of ion pairs may become greater than the number of photons. It is certain that the light emission and the ionization do not go down at the same rate. The latter goes down much more slowly, and gains relatively. The interpretation of this is discussed. It is found that the admission of inert nitrogen which is known to increase the (instantaneous) emission of photons, also increases the (instantaneous) ionization. It is pointed out that the ionization of nitrogen requires 15*51 V, and the presence of this ionization seems to throw much doubt on the attempts to calculate the energy of active nitrogen from the band spectrum emitted, which suggests an energy of 9*6 V.

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Long duration of the Balmer spectrum in excited hydrogen

Robert John Strutt
Published: **10 August 1944** **https://doi.org/10.1098/rspa.1944.0018**

Abstract

The light of a condenser discharge through hydrogen, emitting the Balmer series of lines, persists for much longer than current theories and experimental determinations of the time of relaxation of the hydrogen atom would lead one to anticipate. These determinations indicate a time of the order of 10^{-8} sec. for the intensity to diminish in the ratio e: 1. It is shown in the present paper that in fact, if hydrogen made luminous by a powerful discharge is blown out of the electric field by its own expansion, the time in question is under some conditions a thousand times more. The discrepancy is not cleared up, but the aim has been to present the evidence as clearly as possible for criticism.

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The surprising amount of energy which can be collected from gases after the electric discharge has passed

Robert John Strutt
Published: **01 May 1947** **https://doi.org/10.1098/rspa.1947.0041**

Abstract

It was found in earlier work (Rayleigh 1940 *b*) that a piece of gold sheet, say 1 cm. square, hung up in a stream of glowing active nitrogen became red hot, and collected an amount of energy which was very surprising. It was necessary to assume that every molecule of nitrogen in the stream imparted 10 eV to the gold plate. In this form of experiment it was impossible to avoid large and undetermined losses of energy; thus the energy actually given up by each molecule was probably much larger still. A new form of experiment is now described in which this loss is avoided. A platinum strip is kept hot by periodic discharges, and by making the experiment (1) with the platinum exposed to the gas and (2) with the platinum protected by a thin glass sheath it is possible to determine what part of the total energy is to be attributed to catalytic action of the discharge products. This amount of energy is found to be very great. Reckoning in electron-volts per molecule of gas present it increased rapidly as the gas pressure was lowered and at the lowest pressure used it rose as high as 223 eV/mol. Results of the same order were obtained with other gases, so it is not clear that the glow of active nitrogen is the essential condition. This great liberation of energy much exceeds what can be explained by dissociation of the molecules and single ionization of every atom which results, which would only afford 36 V.

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