cases when the stop-valve is purposely used for reducing the pressure. In such cases the temperature of the steam at the reduced pressure shall be substituted. In the case of saturated steam the temperature corresponding to the pressure can be taken.

Lower limit: the temperature in the exhaust-pipe close to, but outside, the engine. The temperature corresponding to the pressure of the exhaust steam can be taken.

(5) That a standard steam-engine of comparison be adopted, and that it be the ideal steam-engine working on the Rankine cycle between the same temperature and pressure limits as the actual engine to be compared.

(6) That the ratio between the thermal efficiency of an actual engine and the thermal efficiency of the corresponding standard steam-engine of comparison be called the efficiency ratio.

(7) That it is desirable to state the thermal economy of a steam-engine in terms of the thermal units required per minute per Indicated HP., and that, when possible, the thermal units required per minute per Brake HP. be also stated.

(8) That, for scientific purposes, there be also stated the thermal units required per minute per HP. by the standard engine of comparison, which can readily be obtained from a diagram similar to that given, and from which the efficiency ratio can be deduced.

R. H. Thurston.

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*THE KINETIC THEORY OF GASES AND SOME OF ITS CONSEQUENCES.**

Though Science—Science with a capital S—is often contrasted with Art—Art with a capital A; though the former is held to be dry and unattractive, while the latter stirs the imagination and arouses 'thoughts that breathe and words that burn;' yet the follower of science now and then is rewarded for his toil by an ordered sequence which appeals to the imaginative side of his nature, no less than the rhythmic harmony of poetry, or the measured cadences of music. Indeed, it is not impossible for the poet to express better than, and as truly as in the pages of the *Philosophical Transactions*, the highest generalizations of science. In this Tennyson stands unrivalled. Take, for example, the stanzas:

"There rolls the deep where grew the tree,
O earth, what changes hast thou seen!
There where the long street roars, hath been
The stillness of the central sea.

"The hills are shadows, and they flow
From form to form, and nothing stands;
They melt like mist, the solid lands,
Like clouds they shape themselves and go."

It contains an epitome of the whole of geology. The science is mere elaboration of the ideas contained in Tennyson's beautiful verses.

The difficulty in gaining the appreciation of the 'general public' is in presenting the ideas in intelligible language. That the scientific and the romantic are sometimes closely intermingled is indisputable; but the romance is one which appeals to few. In the following pages an attempt will be made to show how the thoughts of many men, each striving to 'increase natural knowledge,' as the formula of admission to the Royal Society runs, have led to a discovery of some interest—that of a hitherto unsuspected constituent of atmospheric air.

The Roman poet Lucretius, a friend and contemporary of Cicero, was the author of a poem entitled 'De Rerum Naturâ' ('On the Nature of Things'). In this poem, which treats of almost all things in heaven and earth, he argues that the atoms, the existence of which is obvious because one sees them in a cone of light passing through a dark room, fall rapidly together in their dancing course throughout the spheres,

* Reprinted from the *Contemporary Review* for November, 1898.

and by their collision engender all known things. Their paths are, however, not directed, but fortuitous; and, therefore, the world is the product of chance.

Passing over many centuries, we find Boyle, in the reign of Charles II., suggesting that the difference between different kinds of matter is to be explained by the nature and the motion of the particles or atoms of which they are composed. The region of speculation was narrowed when Daniel Bernoulli, in 1738, attempted to account for the law, due to Boyle, that the volume of gases varies inversely with the pressure to which they are exposed; and similar attempts were made by Herapath in 1821, and by Joule in 1851. Their ideas were systematized by Clausius in 1857 under the name of the 'Kinetic Theory of Gases.'

Briefly stated, the theory is this: Granted that in gases the particles—or, as they are now termed, the molecules—of which they consist are widely separated from each other, and that the pressure which the gas exerts on the sides of any vessel in which it may be confined—a pressure which may be realized by pumping away the air outside the vessel, when, if the vessel is constructed of yielding material, such as bladder, it will distend, and ultimately burst—is caused solely by the bombardment of the molecules of gas on the walls. It is at the first blush not very easy to conceive of a steady pressure being due to an enormous number of impacts irregularly delivered. But there are many analogies which help to form the conception. For instance, a musical note, which may strike us as of the utmost smoothness and uniformity, is in reality the result of a succession of blows on the tympanum of the ear, each following the preceding one too rapidly for our ears to distinguish the break in continuity. In a similar manner the pressure of a gas is accounted for. And the temperature, a rise in which also increases the pressure of a gas on the walls of a vessel containing it' is attributed to the increased velocity of the molecules of the gas. Now, for simplicity's sake, considering a blow given by only one molecule, the force of the blow—to use a rough expression which will serve the purpose—will depend not merely on the rate at which that molecule is moving, but also on the weight of that molecule. So that a light molecule with a high rate of motion may deliver as forcible a blow as a heavy molecule with a slower rate of motion. By Clausius's hypothesis the temperatures of two gases are believed to be equal when the products of their masses into the square of their rates of motion are equal. This is not quite the same thing as saying 'when the force of the blows they give is equal,' but it may be taken as connected with it.

Supposing, then, that two gases are at the same temperature—that when placed in contact neither gives up heat to the other—then the product above mentioned must be equal for both. For it is obvious that the specifically lighter gas must have the higher velocity; that is, the molecules must be endowed with a higher rate of motion.

What is that rate of motion? Clausius was able to answer that question: A molecule of hydrogen, the lightest gas known, if it moved in a straight line, unimpeded in its motion by collison with any other molecules or with any solid body, would pass through no less than a mile and a quarter in a second. And a molecule of oxygen equally free to move would travel through space with a velocity of rather less than one-third of a mile per second. The relative rates of motion are, therefore, in inverse proportion to the square roots of the densities of the gases. Thus, as oxygen is sixteen times as heavy as hydrogen, a molecule of hydrogen would move through space in a straight line, were it free to do so, at a rate four times as great as that at which a molecule of oxygen moves.

These rates of motion are calculated for the temperature of melting ice. But as the effect of rise of temperature is to quicken the rate of motion of molecules of gases, so fall of temperature will cause a decreased velocity. The question arises: Is there any possibility of so lowering temperature that the motion of such moving molecules will cease? Judging by the rate at which the pressure of a gas decreases with fall of temperature, there is: That temperature has been called the 'absolute zero of temperature;' it lies 273° below the melting point of ice on the Centigrade scale, or at —460° on the Fahrenheit scale, the one commonly in use in this country. This temperature has not been reached; it is unlikely that it will ever be reached; but an approach has recently been made to it by liquefying hydrogen gas and allowing it to boil at the atmospheric pressure. The temperature reached in this manner is about —243° Cent.; and Professor Dewar, who has recently succeeded in liquefying hydrogen in quantity, will no doubt be able to produce a still lower temperature, by causing the liquid hydrogen to boil in a vessel connected with an air pump, so that the pressure is reduced. For just as raising the pressure raises the boiling point of a liquid, as exemplified in the boiler of a steam engine, so lowering the pressure lowers the boiling point.

It is now many years since Dr. Johnstone Stoney applied the Kinetic Theory of Gases, in a series of papers read before the Royal Dublin Societies, to the question of the existence of atmospheres on planets and satellites. If a molecule happens to be moving on the surface of a planet at a rate which would carry it away from the planet more rapidly than the planet can draw it back, that molecule will escape into space. It is not theoretically impossible, although practically unrealizable, to construct a gun which would fire a bullet vertically into the air at such a rate that the bullet might never return to the earth. What, then, would occur to it? Well, it would wander on through space as a little planet, performing an ellipse round the sun, as indeed many aërolites, or 'shooting stars,' are known to do. It might, indeed, chance to come within the range of attraction of some planet—*e.g.*, Jupiter—massive enough to hold it; or it might actually fall on the surface of a planet; in the former case it would act like a little satellite and revolve round that planet, as the numerous stones of which Saturn's rings are composed revolve round Saturn; in the latter case it would simply become part of that planet, as the falling stars which reach the earth form, after their fall, a portion of the earth.

The molecule of gas, which we have been considering, differs in no particular from a bullet, in its wanderings or in its fate. If it chance to come within the sphere of attraction of a planet of sufficient mass to retain it, it will, according to Dr. Stoney, form part of that planet's atmosphere. If not, it will wander on until it may, by chance, come near enough to the sun to fall a victim to its enormous attractive force, and it will then become part of the sun's atmosphere.

Dr. Stoney has summed up the results of various inquiries of this kind in a memoir, entitled 'Of Atmospheres upon Planets and Satellites.'*

One important point has been omitted in the sketch given of the Kinetic Theory. It is this: When it was said that a molecule of oxygen moves at the rate of about one-third of a mile per second it was not implied that all molecules are moving at that rate. Some, urged on by collisions from behind, acquire a much more rapid rate; others, hindered in their motion by collisions with other molecules moving more

* 'Royal Dublin Society,' Vol. VI., Nov., 1897, pp. 305–328.

slowly than themselves, or in opposite directions, have their rate of motion decreased. A gas must be conceived as composed of an almost infinite number of such molecules, jostling each other in every conceivable way. The rate of one-third of a mile per second, deduced by Clausius as the average rate of motion of a molecule of oxygen, must be understood to mean that, if all the rates of motion were to be balanced out, so that the swiftly-moving molecules gave up some of their motion to the slowly-moving molecules, and *vice versa*, the molecules would all be moving at the above-mentioned rate. But it must be distinctly borne in mind that this imaginary state of things never occurs. There are always many molecules moving faster, many slower, than the average.

I find, in my own case, that it helps greatly to a clear understanding of such a conception as that of which a short account has been given, if a mental picture can be called up which will illustrate the conception, although even imperfectly. Some such picture may be formed by thinking of the motions of the players in a game of football. At a critical point in the game the players are running, some this way, some that; one has picked up the ball and is running with it, followed by two or three others; while players from the opposite side are slanting towards him, intent upon a collision. The backs are at rest, perhaps; but on the approach of the ball to the goal they quicken into activity, and the throng of human molecules is turned and pursues an opposite course. The failure of this analogy to represent what is believed to occur in a gas is that the players' motion is directed and has a purpose; that they do not move in straight lines, but in any curves which may suit their purpose; and that they do not, as two billiard balls do, communicate their rates of motion one to the other by collision. But, making such reservations, some idea may be gained of the encounters of molecules by encounters in a football field.

In considering averages it is clear that there must be a practical limit on both sides of the mean. If a man throws dice he may turn up sixes thrice in succession, or some greater number of times, by chance; but it is clear he will not go on throwing sixes for ever, though there is no absolute reason why he should not. Similarly, in thinking of the rates of motion of molecules there will be a practical limit of rate at which any one molecule will move. It is unlikely that any one molecule will cease to move for any appreciable time; and it is unlikely, too, that any one molecule will develop any exceptionally rapid velocity, say twenty times the mean. Still, such events may conceivably occur; they will, however, be very infrequent.

Those gases which are light, and whose molecules have a high intrinsic average rate of motion, will, in the nature of things, contain some molecules which happen to be moving at a high speed, and necessarily will contain more such than a gas of higher density, the average rate of motion of whose molecules is slower. It may happen that molecules of each kind, of gas with low as well as of gas of high density, may possess such exceptionally high velocity at the confines of our atmosphere, where there are comparatively few gaseous molecules altogether; and it may also happen that these molecules are moving in a direction more or less nearly perpendicular to the surface of the planet, and it may also happen that such molecules suffer no collisions in their vertical path; if these events all happen the molecules will escape. But as, on the doctrine of chances, there are more molecules of light gas endowed with such exceptionally high velocity than there are of heavy gas, more molecules of the former will escape away from the neighborhood of the planet, and enter free space as independent entities, than of the latter.

Such a process, prolonged over ages, will ultimately remove from the atmosphere of a planet all gases possessing less than a certain minimum density.

The next question to which Dr. Stoney addresses himself is: What rate of motion must a molecule have in order that it may escape from the attraction of the earth? The least velocity which will enable such a molecule to escape is about seven miles per second. And it is assumed, from observations taken at high altitudes, that the temperature of the upper regions of the atmosphere is about —66° Cent., or about —87° Fahr.

This velocity of seven miles a second is, however, considerably greater than the average velocity of a molecule of hydrogen, which, at 32° Fahr., it will be remembered, is only about a mile and a quarter. But it is not greater than the velocity of some of the molecules; and these will, therefore, escape. In fact, Dr. Stoney concludes that in every gas a considerable proportion of the molecules have a velocity at least ten times as great as the mean.

Now, on this earth the important constituents of the atmosphere are nitrogen, oxygen. argon, carbon dioxide, water-vapor and ammonia; and their densities are as follows, that of hydrogen being taken as unity:

Nitrogen	14
Oxygen	16
Argon	20
Carbon dioxide	22
Water-gas	9
Ammonia	8.5

We are here chiefly concerned with the gases of the earth's atmosphere, but it may be of interest to cast a glance at other conclusions which follow from Dr. Stoney's speculations.

The moon, the mass of which is much less than that of the earth, would retain a gas of density 40, or thereabouts; but all less dense gases would escape rapidly. From the planet Mercury water-vapor would at once escape, and it is probable that both nitrogen and oxygen would escape more slowly. Argon and carbon dioxide might, however, be permanent constituents of the atmosphere of Mercury. Venus, on the other hand, retains water-vapor; but lighter gases would escape. It must be remembered that if the water were to escape from a planet in the state of vapor its place would be at once supplied by evaporation of planetary seas, if there were any, and that, in the long run, all the water would, in the state of gas or water, leave the planet.

Indeed, Dr. Stoney thinks it not unlikely that we are slowly losing our stock of water. This, however, need excite no alarm, and our water will probably outlast our coal many millions of years. For so few of the molecules of water comply with the required standard of velocity that the rate of loss is almost infinitesimally small.

Similarly, Dr. Stoney conjectures that water cannot remain on Mars; that all known gases would be imprisoned by Jupiter, and that Saturn, Uranus and Neptune may probably be able to retain all gases heavier than hydrogen. As for the sun, its mass is so enormous relatively to that of the planets that, even at the exceedingly high temperature which its atmosphere possesses, it is impossible for any known gas to remove itself from the neighborhood of the luminary.

We must now take leave of Dr. Stoney's fascinating hypotheses for a time, and consider the recent discoveries of gaseous constituents of our atmosphere.

After the discovery of argon as a constituent of air, in 1894, one of the discoverers, acting on advice given him by Professor Miers, was so fortunate as to isolate helium, a gas contained in certain rare minerals, the best known of which bears the name of clèveite. Helium had previously been detected in the chromosphere, the colored atmosphere of the sun, by M. Janssen, the well-known French astronomer; and its name was suggested by Messrs. Frankland and Lockyer, in 1868, to characterize the brilliant yellow line by which its presence in the sun is revealed. Neither of these elements has been combined with others, although it is possible that each exists in combination with one or more of the elements contained in the minerals from which helium can be obtained by heating, for it has been found that small quantities of argon, along with considerable quantities of helium, are evolved from such minerals. Again, both of these elements possess one curious property, which they share with gaseous mercury alone, so far as is known, among all elements. That is technically called the ratio between their specific heats at constant pressure and at constant volume. It would be difficult here to set forth the reasoning by which it is deduced that, inasmuch as the ratio for these gases is $1\frac{2}{3}$ to 1 between specific heat at constant pressure and at constant volume, the molecules of these elements, unlike those of oxygen and hydrogen and the other commoner gases, but like those of mercury gas, consist not of agglomerations of two or more atoms, but of single atoms. These characteristics at once establish a connection between the two elements helium and argon, and differentiate them in kind from all other gaseous elements.

Now, taking the density of hydrogen as unity, that of helium is very nearly 2 and that of argon 20. And one of the conclusions which follows from the Kinetic Theory of Gases is that equal volumes of gases contain equal numbers of molecules. Thus the fact that helium is twice as heavy as hydrogen carries with it the conclusion that a molecule of helium is twice as heavy as a molecule of hydrogen, whatever the absolute weight of the latter may be.

Now, it can be demonstrated that there is a strong probability in favor of the assumption that a molecule of hydrogen consists of two atoms, inseparable from each other unless by combination with some other element. And if a molecule of helium consisting of one atom is twice as heavy as a molecule of hydrogen consisting of two, then it follows that an atom of helium is four times as heavy as an atom of hydrogen; in other words, the atomic weight of helium is 4, that of hydrogen being taken as 1. Similar reasoning proves the atomic weight of argon to be 40, from the known fact that it is twenty times as heavy as hydrogen. Moreover, it is noteworthy that the difference between these numbers 40 and 4 is 36.

Mr. John Newlands, whose recent death is deplored by the scientific world, as long ago as 1863 brought forward what he termed a 'law of octaves.' It consisted in arranging the numbers which represent the atomic weights of the elements in seven rows, beginning again with the eighth element, so that its atomic weight occupies a position in the table below that of the first, the ninth below the second, the fifteenth again below the first, and so on. The reproduction of three of such rows will make the meaning clear.

Li	7	Be	9.2	B	11	C	12	N	14	O	16	F	19
Na	23	Mg	24.3	Al	27	Si	28	P	31	S	32	Cl	35.5
K	39	Ca	40	Sc	44	Ti	46	V	52	Cr	52.5	Mn	55

Etc. Etc.

The elements appear in this table in groups, of which the individual members closely resemble each other, often in appearance, and always in the nature of the compounds they form with other elements. Thus, to take the first column, the three elements lithium, sodium and potassium, together with others not here produced, but which occur later on in the table, rubidium and cæsium, are all white waxy metallic solids, easily cut with a knife, tarnishing rapidly in contact with ordinary moist air, and forming compounds which themselves present the greatest resemblance to one another. Now, in Mr. Newlands' view, the fact that the eighth element resembles the first suggested an analogy with the musical scale, where the tones can be similarly classified, each eighth note of the major scale reproducing, as it were, the fundamental note. In the ordinary notation the name C refers to many notes, separated from each other by octaves. The analogy may be regarded as fanciful, and in the light of more modern work the word 'octave' is here inapplicable; and this perhaps overstrained analogy did much to discredit Mr. Newlands' views in the eyes of the leading chemists of the day. It was not until 1868, when the late Professor Lothar Meyer and Professor Mendeléef independently arrived at a similar arrangement, that the attention of chemists was recalled to the subject and the justice of Mr. Newlands' ideas was acknowledged. The somewhat tardy award of a medal by the Royal Society placed in its true position the work of Mr. Newlands, and was regarded as an act of justice by his friends. It is deeply to be regretted that his recent death has removed from our midst a man so kindly and so alive to every advance in science.

The elements helium and argon, if they be really elements and not compounds (and there is no reason to doubt their elementary nature), should find places in this table, now known as the 'Periodic Arrangement of the Elements.' And confining our attention to only a few of the vertical columns, their position should be for helium before lithium, and for argon before potassium, thus :

Hydrogen	1	Helium	4	Lithium	7
Fluorine	19	?		Sodium	23
Chlorine	35.5	Argon	40	Potassium	39
Manganese	55	Iron / Cobalt / Nickel	56 / 58 / 59	Copper	63.5
Bromine	80	?		Rubidium	85

Now, we find the difference between the atomic weights of hydrogen and chlorine to be 34.5 ; and between lithium and potassium to be 32; also between argon and helium to be 36. These numbers are roughly of the same order of magnitude. It is, therefore, not unreasonable to suspect the existence of an undiscovered element with atomic weight between 19 and 23, as well as of others occupying the other unfilled positions in the argon group.

It is no easy matter to hunt the earth through for an unknown element. The question is, where to look. And some clue is necessary to guide the inquiry. At first it was thought that minerals similar to those from which helium had been obtained might possibly yield the new element; and experiments were made, for months at a time, to test the gases obtainable from almost every known mineral, but in vain, so far as a new element was concerned. They resulted in the discovery of many new sources of helium ; but the spectrum of the gas in each case exhibited no unknown lines A new method of attack was then organized. It might be that the so-called helium was really a mixture of elements, and not a pure element. Now, an effective method of separating from each other two gases of different molecular weights, and hence of different densities, is the process of diffusion. From observations of the late Professor Graham, of University College, London, subsequently Master of the Mint, it appears that lighter gases, with rapidly moving molecules, will pass through a porous diaphragm, such as the material of a clay pipe, more rapidly than a heavier gas, with its more slowly moving molecules. An attempt was, therefore, made to ascertain whether any heavier gas could be thus separated from the helium obtained from minerals; the experiments involved an enormous amount of labor, but, in the end, no gas other than a trace of argon could be detected. It appeared, therefore, vain to attempt to discover a new gas in minerals; and the justice of Dr. Stoney's hypothesis was next tested. It was, of course, not out of the question that the sought-for gas might exhibit some powers of combination, and that it might have been absorbed, along with the nitrogen of the air, by the magnesium over which the gas had been sent at a red heat in order to absorb and remove the nitrogen. The compound of magnesium with nitrogen is very readily decomposed by water; the products are ammonia and hydroxide of magnesium. A large quantity of this magnesium nitride was accordingly treated with water, and the resulting ammonia absorbed by means of weak sulphuric acid. There was merely a trace of gas which refused to be absorbed, and, on examination, it turned out to be the familiar hydrogen, which was formed by the action of the water on some metallic magnesium which had escaped combination with nitrogen. This experiment was interesting, inasmuch as it proved that magnesium refuses to combine with even the smallest trace of argon. The ammonia resulting from this treatment, it is true, might have conceivably contained a compound of the new gas; but a similar sample had previously been decomposed, so as to obtain from it its nitrogen, and that sample of nitrogen had been found by Lord Rayleigh to possess the same density as a sample of nitrogen of which the source could not be traced to the atmosphere. Lastly, it was conceivable that the hydroxide of magnesium might have contained some compound of the new element. It was, therefore, treated with water, and the soluble portion separated from the insoluble. The soluble portion, on examination, proved to contain nothing but the carbonate of magnesium. The insoluble portion was not further dealt with, but was kept in reserve.

The argon of the atmosphere was next examined. A large quantity having been prepared, it was purified, and by passing it into a vessel immersed in liquid air, made to boil at an even lower temperature than usual by pumping away the air-gases as they boiled off; the argon, too, was completely changed into liquid. Liquid argon is clear and colorless, whereas liquid air has a faint blue tint, owing to the blue color of the oxygen it contains. The argon was next made to boil, by allowing the temperature of the liquid air to rise a few degrees, and the first portions of argon-gas were collected separately, the remainder going back into the gas-holder in which it had originally been stored. The gas thus obtained was lighter than argon, and more difficult to liquefy; this was shown by the necessity of compressing it into the bulb in which liquefaction took place. The most volatile portions of this liquid were next collected separately, and the gas proved to be still less dense than the former sample. It was not possible to liquefy more than a small fraction of this last specimen of gas, to however low a point the temperature of the boiling air was reduced; and after another repetition of the same process the gas appeared to be as light as the process could make it. Its density was 9.75 times that of hydrogen, and, making allowance for a small quantity of argon which it must necessarily have contained, this number becomes reduced to 9.6.* The weight of a molecule, compared with the weight of an atom of hydrogen, as previously explained, must therefore be 19.2; and 19.2 lies between the atomic weights of fluorine, 19, and of sodium, 23, falling therefore into the predicted place in the Periodic Table. The specific heat ratio of this new gas, to which

* This gas has since been found to contain a trace of helium, the presence of which would lower the above density. The actual density will, therefore, be somewhat higher than 9.6, but it will probably not exceed 10. It has not yet been determined.

the name 'neon,' or 'the new one,' has been given, is, as in the cases of helium and argon, $1\frac{2}{3}$; like them, too, it resists combination with other elements, and possesses a brilliant and characteristic spectrum.

This account of the fulfilment of a prediction has, I am afraid, been somewhat elaborate for the general reader; but it is interesting as a case of discovery, where many lines of evidence, founded on the work of many different observers, have led to the foreseen conclusion. It possesses, to my mind at least, some of the qualities of a scientific poem—an orderly arrangement of ideas, drawn from many different sources, each throwing light on the other, and all tending towards a final event. It is true that the subject is not one to which poetical diction can be applied with advantage; the details are too complicated, too unfamiliar, and to be expressed only in language which has not received the impress of poetical tradition; but to enlarge on this would open a wide field of discussion, in which æsthetics, a subject not as yet reduced to accurate formulation, and perhaps hardly susceptible of treatment by scientific methods, would form the chief theme.

In epic poems the 'argument' usually precedes the matter. Here it may be convenient to reverse the order and to sum up the preceding pages by the argument. We have seen, then, that the discovery, by Lord Rayleigh, of a discrepancy in the density of atmospheric nitrogen has resulted in the discovery of a new constituent of air—argon; its discovery has led to that of a constituent of the solar atmosphere, helium; speculations on the ultimate nature and motion of the particles of which it is believed that gases consist has provoked the consideration of the conditions necessary in order that planets and satellites may retain an atmosphere, and of the nature of that atmosphere; the necessary existence of an undiscovered element was foreseen, owing to the usual regularity in the distribution of the atomic weights of elements not being attained in the case of helium and argon; and the source of neon was, therefore, indicated. This source, atmospheric air, was investigated, and the missing element was discovered. A new fact has been added to science, and one not disconnected from others, but one resulting from the convergance of many speculations, observations and theories, brought to bear on one another.

WILLIAM RAMSAY.

ON SOME ANALOGIES BETWEEN THE PHYSIOLOGICAL EFFECTS OF LACK OF OXYGEN, HIGH TEMPERATURE AND CERTAIN POISONS.

ONE of the striking characteristics of vital phenomena, from a chemical standpoint, is the comparatively low temperature at which oxidations take place. Among the more commonly accepted theories which try to account for this fact is that of Hoppe-Seyler. Hoppe-Seyler found that in case of putrefaction reducing substances, such as nascent hydrogen, are formed. These reducing substances, if atmospheric oxygen is present, attack the molecule of oxygen, taking one atom to themselves and setting free one atom. This free atom of oxygen, being in an active state, is able to bring about the oxidations characteristic of living organisms.

According to Hoppe-Seyler's theory similar fermentations take place in all living matter whereby reducing substances are formed. In case of lack of oxygen it is clear that, while fermentation may go on, the oxidation of the reducing substances comes to a standstill. In this case the reducing substances may attack other substances in the animal body, instead of oxygen, and form compounds which may act as poisons.

It is a well-known fact that an increase