cal activity of ozone tends to its dissipation. If, therefore, in the long course of ages the quantity of this triatomic form of nitrogen remains inappreciable, we are scarcely entitled to assume its existence as a normal constituent of the atmosphere, unless we also assume that it is being utilized in some unknown way. It is not the first time that chemists and physicists have been tempted to believe in the production of an allotropic form of nitrogen, and to accept it as explaining certain curious phenomena, but hitherto the assumption has always broken down on more careful investigation. This time we may be permitted to hope that the elusive allotropic form has been fairly captured.

ON THE CHEMISTRY OF COAL FORMATION.*

By J. W. THOMAS, F.C.S., F.I.C.

WITH a view to lead up to the consideration of the "proximate chemical constituents of the various kinds of coal," a short sketch of the chemistry of coal formation will open the question respecting further experiments to increase our knowledge of the subject.

It is to be expected that the age of the coal, and the physical conditions such as the effect of water, heat, and pressure, should throw considerable light upon the chemistry of coal formation. If the tertiary lignites of Bovey Tracey are placed in position above the upper bituminous coals of the South Wales field, a striking gradation and regularity of change is seen between the lignite and the anthracite, as shown in the accompanying table. The lignites are soft, anthracite is very hard; lignites are wet, anthracite dry; lignites show high hygroscopicity, anthracite low. In the table the physical characters run fairly parallel with the chemical. In East Yorkshire the oolitic coals—jet, for instance—are as hard, and dry, and as little hygroscopic, as anthracite; and so is the highly bituminous Wigan cannel. The Scotch coals also furnish exceptions to the rule, and the physical conditions of the coals of Great Britain are of little value in determining their chemical character; and as there are instances of bituminous coals lying below more anthracite varieties, even the depth of the coal below the surface is no safe criterion of its chemical composition.

The decomposition of peat and wood to-day teaches us more respecting the chemistry of coal formation. The late Dr. Angus Smith showed that the woody fiber of recent decaying moss decomposed much quicker than the resinous and gummy portions, the result being a considerable increase of resinous matter in the older peat, and a corresponding loss of combined oxygen.

Observing the decomposition of wood to-day in the case of larch and pine railway sleepers, we see that the portions where the resinoids are in least quantity are first attacked, the knots and other parts saturated with resin and terpenes being preserved after all the woody fiber has disappeared. We know, too, that decomposition is greatly accelerated by myriads of insect and lower life, all of which appear to dislike resinous matters. Thus in forest decomposition, as well as in peat, there is an increase of resinous matter due to the rapid dissociation of the woody fiber. I am giving attention to the decomposition of wood, as further experiments are wanted in this direction.

Turning to the tertiary formation of Bovey Tracey, it is found that, just as in the case of peat and wood decomposition, the lignites have an excess of resinous matter in them; and there is, moreover, a considerable quantity of resin in lumps unmixed with the lignite coal. This resin melts at a low temperature, and the strata do not show the effect of much heat. Hatchett named this resin "retinasphaltum," and it was further examined by the writer (Chem. Soc. Journal, 1877). The late Dr. Percy ("Metallurgy," vol. Fuel) mentions coals, apparently of tertiary origin, from New Zealand, etc., containing particles of resin. Dr. Hofmann, in his investigations upon the coals of Canada (Trans. Roy. Soc. Canada, 1889), showed that certain coals, chiefly of tertiary origin, contained grains of mineral resin disseminated through them. And Mr. Watson Smith (Journ. Soc. Chem. Ind., 1892, 1893) found in the Miike coal of Japan as much as 9.5 per cent. of bituminous matter. It must be inferred, therefore, that there is an accumulation of resinoid and bituminous matters in lignite coals, and it is a curious fact that the woody varieties, and even the "leafy" coal of Bovey Tracey, composed of branches and leaves in perfect preservation, contained resinous matters in large excess over that which could have been present in the vegetable material in its normal condition. The same is true of those beds of lignite which have all the appearance of compressed wood. And from a careful study of the Bovey Tracey lignites it is not only evident that conifers and other dicotyledonous trees flourished, yielding much resinous and terpene compounds, but that the condition of vegetation was such that liquid gummy and resinous matters were showered from some of the trees during the tertiary coal period. The yellow resin found in quantity in the Bovey Tracey formation shows that the resinoids in the "leafy" and "woody" coals are not the result of the melting and soaking of the accumulated resinoid matters. As it is admitted, unreservedly, that the Bovey coal is made up of conifers and dicotyledons, the above conclusions may not be much questioned; but what of the coals of the carboniferous age? Where would the showers of liquid gummy and resinous matters come from when the vegetation was monocotyledonous?

Witham long ago pointed out the mistake which is frequently made to-day, and he showed, sixty years ago, that dicotyledonous trees formed a large portion of carboniferous coal, remarking, "I must contend that there existed coniferous trees, or such as contained a complicated woody structure in great abundance." More recent search has revealed, chiefly in the strata intermediate with the coal beds, many dicotyledons other than conifers; hence there is no evidence wanting to show that true wood formed a large share of the coal of carboniferous age. Mr. Hutton (Lond. and Edin. Phil. Mag., 1833) mentioned that he observed under the microscope that some of the coals of the North of England coal field contained minute grains of a yellow bituminous resinoid, so volatile as to be easily expelled by heat without altering the structure

THE LIGNITES OF BOVEY TRACEY, AND COALS OF THE SOUTH WALES FIELD.

Description.	Soft or hard.	Wet or dry.	Hygroscopicity.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.	Ash.
			Per cent.	Per cent. on dry sample.					
Soft lignite.....	Soft	Wet	15.0	59.9	6.0	25.0	0.6	1.5	7.0
Compact lignite.....	Medium	"	10.0	66.7	5.5	20.0	0.8	2.0	5.0
Upper carboniferous coal (Mynyddysllwyn).....	"	Medium	6.0	79.5	5.5	4.5	1.5	3.5	5.5
Pennant coals.....	Hard	"	4.0	81.5	5.0	4.5	1.5	3.0	4.5
Semi-bituminous coal....	"	"	2.5	84.2	4.5	4.0	1.3	2.0	4.0
Steam coal.....	"	Dry	1.5	87.8	4.2	3.0	1.0	1.0	3.0
Anthracite coal.....	Very hard	"	0.5	91.7	3.5	2.5	0.8	0.5	1.0

of the coal; and, since then, similar observations have been made.

These facts show that what was true of the Bovey Tracey lignite formation is true also of coals of the carboniferous age, and there seems every probability that not only did conifers and other dicotyledonous trees flourish during the carboniferous period, but that much liquid gummy and resinous matters were showered from the trees upon the dried and decomposing material on the surface. It is well known that various trees, like the lime, for instance, during the flowering period, often shed enough saccharine matter to render its leaves and the grass underneath covered with the saccharine material; and not unfrequently coniferous trees, like the Scotch fir, shower terpenes and resinoid matters upon the ground beneath. It is to this behavior of tree life I attach much importance, as having a weighty bearing upon the chemistry of coal formation, not only during the tertiary, but also during the carboniferous age.

It has long been an enigma to botanists and geologists why the forms of the delicate ferns of the carboniferous coal period should be so perfectly preserved, while so little of the structure of the woody material is discernible. My opinion is that these ferns and delicate undergrowth, when dying and drying, became saturated with liquid resinous matters falling from the trees, and, in this way, were preserved from putrefaction, to imprint their beautiful forms upon the shale and rock above the coal, and in other positions.

From a careful consideration of the condition of vegetation during the carboniferous age, and the decomposition which ensued, I think that the chemical nature of coal, as we find it, is the result, not so much of heat and pressure and decomposition in its deeply buried condition, as upon the character of the primary decomposition which took place at or near the surface, together with the nature of the material from which the coal was formed.

Starting with the bituminous shales, like those used by the Young Candle Company, and at the Pumperton Works in Scotland, I believe that there, as shown in the mineral strata, huge forests flourished from which the woody fiber was eliminated by surface decomposition, only resinoid matters remaining. The high percentage of mineral matter favors this view.

Resinous vegetation, without much dicotyledons, or if with dicotyledonous trees, much surface decomposition, by long continued exposure would produce Scotch cannel, rich bituminous coals, Wigan cannel, etc.

A luxurious resinous and dicotyledonous vegetation, without much surface decomposition, probably gave rise to semi-bituminous, steam, and anthracite coal, assisted, of course, by heat and pressure.

Now as to our present knowledge of coal itself.

1. It contains water, and retains some after long exposure in dry air. As shown in the table, the quantity of water retained by a coal after drying at ordinary temperatures is, as a rule, proportionate to the age of the coal—being highest in lignite and lowest in anthracite. Jet, and numerous coals of the carboniferous age in various coal fields, are exceptions to the rule. Some lignites contain 30 per cent. of water in the natural condition, but the better qualities do not hold more than 20 per cent., and this is reduced by air drying to 10 per cent. Such coals as are used for fuel in this country rarely hold more than 5 per cent. after being air dried. Coals which we ship abroad in their air-dried condition generally contain less than 3 per cent. of moisture; while steam and anthracite coal from dry seams do not hold more than 1 per cent. of moisture. Coals won from seams to which water gains access contain much larger quantities of water; but I am referring now to the hygroscopicity of coal.

The point I wish to emphasize is, not the quantity of moisture air-dried coal contains, but to call attention to how this moisture is held. If the water still retained in an air-dried sample of coal be driven off by heat, and the dried coal afterward exposed in a moist atmosphere, the moisture is reabsorbed at a very quick rate; and so great is the hygroscopicity of some coals that it is not possible to estimate the water in an open vessel, as the weighing cannot be done quickly enough to prevent reabsorption. Dr. Hofmann, of the Canadian Geological Survey, has shown that a portion of the water in coal is most obstinately held, and there is no doubt, I think, that it exists in chemical combination. In the deep dry steam and anthracite coals, as they occur in their seams, there is, probably, no moisture, but these are very hygroscopic to a certain point, and in the analyses of coal the hygroscopicity has not received due attention. Furthermore, it seems to me that the hygroscopicity of coal is the key to the property of spontaneous combustion, and should be made the subject of further experiment.

2. Coal contains the gases, oily matters, and solids of the paraffin series. In my experiments on the gases inclosed in various coals I obtained gases and liquids of the paraffin series, and, in one instance, white solid paraffin from a coal of carboniferous age. Mr. Watson Smith's experiments (Journ. Soc. Chem. Ind., 1893) show conclusively that liquid and solid paraffins exist ready formed in coal, but they rarely exceed 1 per cent. in coals of the carboniferous period.

3. Coals contain 0.5 to 10 per cent. of ash or mineral matter in good samples, and from 0.5 to 4 per cent. of sulphur, generally present as disulphide FeS₂, in coals

of carboniferous age. In lignites it frequently occurs in organic combination.

4. The bulk of coal consists of carbon, hydrogen, and oxygen, with from 0.5 to 2 per cent. of nitrogen. How the nitrogen is combined is not known. The same remark applies to the carbon, some of which doubtless is in combination with hydrogen. How much of the carbon is free and how much is in combination with hydrogen will, most probably, never be known. The oxygen is generally regarded as being combined with hydrogen, but I do not think that this is the case with the dry deep coals containing occluded marsh gas; some oxycarbon compound containing hydrogen is probably the condition.

In conclusion, I suggest that further experiments be made in the following directions:

1. Upon the decomposition of dicotyledons with a view to throw light upon the formation of coal.
2. Upon the hygroscopicity of coal; and to study its bearing upon the spontaneous combustion of coal on board ship.
3. Upon the coals from all the British coal fields to determine the quantity, and, if possible, the constituents soluble in gasoline (petroleum ether), or benzene, as employed by Mr. Wilson Smith.
4. To act upon the various coals with a weak solution of potassic hydrate.

THE PTOMAINES FORMED DURING PUTREFACTION.

By C. A. MITCHELL, B.A. Oxon.

SELDOM does a year pass without the medical journals recording several cases of poisoning whose cause can only be traced to the eating of unwholesome meat or fish. It is no uncommon thing to hear of whole families suffering from the effects of eating mussels, while tinned meats and sausages are also sometimes found to be most dangerously poisonous. Sometimes the attack ends in death, as in the case mentioned by Czaut in his "History of Greenland," where thirty-two persons died from eating the brains of a walrus which had begun to decompose. In other instances only temporary indisposition is the result, even when a large quantity of the substance has been eaten. These symptoms, whose origin was formerly quite obscure, are now believed to be due to the presence of one or more of the ptomaines or animal alkaloids.

The name "alkaloids" was formerly confined to the complex nitrogenous bodies formed under normal circumstances by the vegetable protoplasm of certain plants, and containing, in addition to nitrogen, varying quantities of carbon and hydrogen, and in some cases oxygen. They may be solid and crystalline like strychnine, or a volatile liquid like nicotine, the alkaloid contained in the tobacco plant. They are more or less soluble in water, combine readily with acids to form salts, and have characteristic test reactions by which they can be distinguished from other bodies containing the same elements arranged in a different manner. Many of them act as deadly poisons on the animal system.

A similar class of substances is formed in living animals by the chemical processes of the body; these have been called leucomaines, while the alkaloids formed after death in the course of putrefaction have received the name of ptomaines. The leucomaines, of which the first known were extracted from normal tissue by Gautier in 1886, are in many cases non-poisonous, though some which have been prepared from the saliva and urine have proved fatal when injected in small quantities into animals. In composition they are, as a general rule, less complex than the ptomaines, though this distinction cannot be rigidly maintained. Brieger and others* do not allow their separate existence, and assert that they are not formed in the living body, but are ptomaines absorbed from the intestinal canal. The general consensus of opinion, however, seems to be against this view.†

That poisonous principles could be extracted from decaying meat was known long ago, but our knowledge of them is quite recent. In 1856, Prof. Panum, of Copenhagen, extracted from the flesh of dogs a poisonous substance which he called "putrid venom," and afterward sepsin. The name ptomaines (πρωμα—a corpse) was first used in 1875 by Selmi, of Bologna, who applied it to a mixture of alkaloidal products which he had separated from the putrefying remains of dead bodies. It has since become the general term for these products. It used to be thought that these animal alkaloids were different in kind to those formed in the vegetable kingdom,‡ but recent research has proved that they closely resemble each other in their properties, and are in some cases of apparently identical chemical composition.§

Brieger, to whom we owe much of our knowledge of the subject, defines the ptomaines as "all nitrogenous bases formed by the action of bacteria," but it is more usual to confine the term to those products formed during putrefaction. This process, as was shown by Pasteur in 1863, is a species of fermentation carried on

* E. g., Bouchard and Schar.

† Cf. Sir William Aitken's Animal Alkaloids; Gould's Medical Dictionary, 1890; Pouchet in Dict. Encycl. des Sciences Medicales.

‡ P. Spicca, Gazzetta, ii., 486-487.

§ Aitken, Animal Alkaloids.

* A paper read before the British Association (Section B), Oxford meeting, 1894.

by micro-organisms derived from the air. It is a property of vegetable and animal nitrogenous substances, and is the natural chemical sequel to life. After death, unless artificial means of preventing it occur, the work of splitting up complex substances into simpler and more stable forms commences. As Huxley says: "Tendency to equilibrium of force and permanency of form are the characters of that portion of the universe which does not live." Liebig's theory, that blood would not undergo putrefaction if protected from air germs, has since been again and again verified by only allowing access to air which had been sterilized by heating or filtration. Heating on successive days in steam or by dry heat at a higher temperature will destroy bacteria, or they may be removed by drawing air through cotton wool, which will retain them; and Tyndall's experiments also proved that organic matter protected from micro-organisms would not putrefy. In this work of disintegration two classes of organisms bear part—the aerobic, which require the presence of oxygen, and the anaerobic, to which that gas is fatal. After death the body becomes a suitable culture medium for the reception of the anaerobic bacteria (vibrios) with which the air swarms. Some of these falling on the body draw their nourishment from the albuminous substance, splitting it up into simpler forms, and thus produce putrefaction. To complete the work of destruction the assistance of aerobic organisms is essential, for the vibrios, living without oxygen, sooner or later perish, and are themselves oxidized. Oxidation is the name given to the chemical process in which substances combine with oxygen. Since about one-fifth of the atmosphere is composed of this gas, the process is continually going on in nature. Familiar examples of it are the rusting of iron and the burning of wood, where the heat enables the carbon and hydrogen in the wood to enter into combination with the atmospheric oxygen. The aerobic organisms which complete the work belong to the class of moulds, and on their advent the oxidizing process continues until the whole substance is transformed into the final simple and stable forms.

The mechanical process of putrefaction was studied by Gautier and Etard in 1882.* Muscles of beef and horseflesh, which were odorless and having a slight acid reaction, were exposed to the action of putrefactive organisms. After a time, there was an acid odor, and a clear, serum-like fluid exuded. This apparently coincided with the commencement of fermentation. Large bacilli were present, and the gases given off were ammonia and carbonic acid, with a little sulphureted hydrogen and phosphureted hydrogen. Toward the fourteenth or fifteenth day free nitrogen began to be given off, and at this point putrefaction proper commenced. The large bacteria disappeared, being replaced by very small ones, which attacked the albuminoid substance, liberating carbonic acid gas and ammonia, and quickly causing the mass to become alkaline.

The germs producing putrefaction are in themselves harmless, and the poisons produced during their work are formed either by alterations in the substances on which they feed or by their secreting some chemical product. Prof. Burdon Sanderson has shown that when dead matter, such as blood serum, is deprived of every trace of living organism, it still possesses the power of producing disease when introduced into the blood of animals.

Brieger used the following method for extracting the ptomaines from human bodies; parts of the internal organs were placed in a cold cellar for from twenty-four to forty-eight hours. The mass was then made slightly acid with hydrochloric acid, heated nearly to boiling, and concentrated by evaporation. Alcohol was added to extract the alkaloid, which was then precipitated by platinic chloride. Alkaloidal bodies are readily dissolved by alcohol, and by filtration after treatment. With this the ptomaine would to a great extent be separated from other animal products. On now adding to the clear filtered liquid a solution of platinum chloride, which combines with alkaloids, a compound containing the ptomaine, insoluble in the alcohol, would be formed. This, filtered off, would leave most of the impurities still dissolved in the alcohol. From this combination the ptomaine choline was easily separated. If the putrefaction was allowed to proceed further, other ptomaines besides choline were formed.

Like the vegetable alkaloids, some of the ptomaines contain no oxygen, while others have four or six atoms in the molecule. The term "atom" is a theoretical term to denote the smallest particle of a substance—that which cannot be divided any more. A "molecule" may be defined as the smallest particle of a substance capable of separate existence. There are usually two or more atoms in a molecule.

Mytilotoxine, the alkaloid separated by Brieger from putrefying mussels, may be taken as a typical ptomaine. Its percentage composition is:

Carbon.....	58.5
Hydrogen.....	4.0
Nitrogen.....	11.5
Oxygen.....	26.0
	100.0

Other well-defined animal alkaloids are neurine, which, like choline, is found in putrid flesh, and tyrotoxin, which occurs in milk, and was the alkaloid separated in a case of poisoning by ice cream.†

Most of them are extremely poisonous, and very minute injections have proved fatal to birds and small animals. The general symptoms are increased activity of the secretive organs and slowness of the heart's action, often followed by convulsions, paralysis, and death. In some of the cases of poisoning by putrid fish, there has been dilatation of the pupil of the eye and double vision. The action of neurine is stated to be very similar to that of curare.§

Closely allied to the ptomaines in composition are the products formed by the pathogenic bacteria; they are termed albumoses, and may be obtained from pure cultivations of disease organisms after removal of these organisms by filtration through porous porcelain.

Disease organisms are cultivated outside the body by introducing a fragment of diseased tissue or blood containing the organisms into a tube in which is some medium, such as gelatine, on which the bacteria can grow. When such a "colony" is obtained, containing only one species of micro-organism, it is called a "pure cultivation." It is highly probable that these albumoses are the poisons by means of which the bacteria produce certain diseases, for inoculation with them has produced results in some instances analogous to those obtained by inoculating with the bacteria themselves. Many of them are named after the disease with which they appear to be connected. Thus we have diphtheridine, obtained by Löffler from the pure cultivation of the diphtheria bacillus, and scarlatine and puerperaline connected with scarlet and puerperal fevers. Quite recently* Dr. Griffiths stated that he had isolated an albumose which he believed to be connected with influenza. It was a white substance, crystallizing in needles, soluble in water, and having a slightly alkaline reaction. Injected, it was extremely poisonous, producing much fever, followed by death in eight hours. Whether it really is a cause of influenza requires corroboration, and indeed the whole subject is one in which further investigation is needed.—Knowledge.

CHEMISTRY AT THE BRITISH ASSOCIATION.

THE meeting of section Bat Oxford, Nature says, will be remembered as one of quite exceptional interest. That portion of the president's address urging upon the University fuller recognition of the claims of science in their curriculum will doubtless have valuable results. Certain of the communications brought forward in the course of the meeting may be described as epoch making. The presence of a large number of eminent foreign chemists served further to render the proceedings memorable and attractive.

The committee for preparing an international standard for the analysis of iron and steel reported that their work was now completed and that it is proposed to shortly deposit the standards with the Board of Trade, or with some other suitable authority where they will be at the public service. Prof. Clowes gave an account of his experiments on the proportions of carbonic acid in air which are extinctive to flame, and which are irrespirable. He finds that the flames of candles, oil, paraffin and alcohol are extinguished by air containing from 13 to 16 per cent. of carbonic acid. The flame of coal gas, however, required the presence of at least 33 per cent. of the extinctive gas, and the flame of hydrogen was not extinguished until the amount of carbonic acid in the air reached 58 per cent. Comparing his experiments with those of Mr J. R. Wilson on the percentage of carbonic acid required to suffocate a rabbit, Prof. Clowes concludes that air containing at least 10 per cent. of carbonic acid more than is required to extinguish a candle flame can be breathed with impunity. By taking advantage of the extraordinary vitality of the hydrogen flame in presence of high proportions of carbonic acid, it is possible to maintain the flame of the composite safety lamp (previously described by the author) after the oil flame has been extinguished.

Mr. Haldane concluded from some experiments he has made on the respirability of air containing carbonic acid that the percentage of this gas considered by Prof. Clowes to be respirable is too high.

Much interest was shown in the successful experiments of Dr. Lobry de Bruyn, demonstrating the properties of free hydroxylamine. On heating a small amount in a test tube, a sharp explosion took place. Left exposed to air, it was shown by its action on iodized starch paper to have become converted into nitrous acid. In a series of test tubes its behavior with various reagents was demonstrated. With potassium permanganate and with chromic acid oxidation took place, accompanied by flame; potassium bichromate produced an explosion. The anhydrous sulphates of copper and cobalt were reduced by the substance. Free hydroxylamine was dissolved in anhydrous ether and sodium added, hydrogen was evolved and the very explosive sodium compound of hydroxylamine produced. Chlorine and iodine were shown to act spontaneously on hydroxylamine, producing inflammation. It is of interest that hydroxylamine will dissolve many salts which are soluble in water, the order of solubility differing in the two solvents.

Dr. Bernthstein described a new bacterium which occurs in milk, whose chief property is that of peptonizing the caseine, thus forming a soluble compound, and rendering the milk transparent, and more readily digested.

A discussion took place on the behavior of gases with regard to their electrification, and the influence of moisture on their combination. It was opened by Prof. J. J. Thomson, who exhibited some brilliant experiments illustrating the connection between chemical change and electrical discharge through gases. The gases were confined, under a pressure of about 100 mm., in glass bulbs which were placed in the center of a coil of wire connecting the exterior of two Leyden jars, the interior coatings of which were connected with the two poles of a Wimshurst machine. As each spark passes between the poles of the machine, a rapidly alternating current is set up in the coil, and hence by induction in the gas. In the case of oxygen it was found that the moist gas gives a vivid incandescence, followed by an afterglow or phosphorescence, on removing the bulb from the coil. With the dry gas, on the other hand, incandescence does not take place. The incandescence can, however, be started in the dry gas by a brush discharge, and if once started, continues under the influence of the induced current. With air the phenomenon is reversed; damp air does not glow, dry air will. By making use of two coils in one of which was a beaker of fairly strong sulphuric acid, and in the other a bulb containing moist oxygen, the presence of the acid was shown to prevent the incandescence in the bulb, showing the conductivity of the gas to be much greater than that of the acid. As the glow is only given in gases forming polymeric modifications, it is suggested by Prof. Thomson that the drops of water present may act as conductors, causing the original molecules to dissociate. In the case of

dry gases this preliminary dissociation can only be brought about by expenditure of a large amount of energy. Alcohol vapor will behave similarly to water, and it becomes of interest to study other solvents.

Mr. Brereton Baker followed with some experiments on the influence of moisture on chemical substances. He showed that ammonia and hydrochloric acid when dry do not combine. He also exhibited tubes containing dry sulphur trioxide and cupric oxide, and dry sulphur trioxide and lime, side by side, without action upon one another, a kind of "chemical happy family," as he expressed it. He concludes that the function of moisture is physical rather than chemical, from the fact that on heating together a dry mixture of cupric oxide, carbon and oxygen, no action takes place. He has obtained analogous results to Prof. Thomson, by using semi-vacuous tubes, into one end of each of which a platinum wire is fused and which contain a small quantity of mercury. On shaking these tubes in a dark room incandescence takes place in those containing moist oxygen. This is less if nitrogen is present, and ceases if the gas is dry.—Dr. Ewan read a paper on the rate of oxidation of phosphorus, sulphur and aldehyde. The results obtained with aldehyde are free from the uncertainty produced by the correction for the changing rate of evaporation. When proper precautions are taken, this reaction goes perfectly regularly at 20°, and its velocity is proportional to the product of the pressure of the aldehyde and the square root of the pressure of the oxygen. These results are most simply explained by assuming (in accordance with Williamson's theory) that the oxygen first splits up to some small extent into atoms, and that these alone take part in the oxidation.

Prof. Hartley described some new methods of spectrum analysis and some Bessemer flame spectra. He has found that if a mixture containing alkalies and alkaline earths be fused with borax or silica, the alkalies are first volatilized and give their characteristic spectra very clearly. For obtaining spectra at high temperatures it has been found useful to heat the substance in the oxyhydrogen flame on a rod of kaimite, pipe clay, or dried alumina. The elements can be classified according to the type of spectrum given under these conditions. On vaporizing alloys, those constituents which, when free, give band spectra, are found to produce line spectra, e. g. silver, in an alloy of copper and silver. This is thought to be due to the difference between the vapor pressure of the element when alloyed and when in the free state.

A large audience assembled to hear the announcement by Lord Rayleigh and Prof. Ramsay of the existence of a new gas in the atmosphere. It appears that certain experiments of Cavendish pointed to the presence, in air, of some substance other than the gases with which we are familiar. Attention was recalled to this substance by the fact that the density of nitrogen obtained from atmospheric air differs by about 1/2 per cent. from the density of nitrogen obtained from other sources. It was found that if air (with excess of oxygen) be subjected to electric sparks, the resulting nitrous fumes absorbed by potash, and the excess of oxygen by alkaline pyrogallate, their remains a residue which is neither oxygen nor nitrogen, as can be seen from its spectrum. The same gas can be isolated by exposing nitrogen obtained from air to the action of magnesium. As the magnesium gradually absorbs the nitrogen, the density of the residual gas gradually rises to nearly 20. The newly discovered substance constitutes nearly 1 per cent. of the atmosphere, and gives a spectrum with a single blue line much more intense than a corresponding blue line in the nitrogen spectrum.

Sir H. E. Roscoe, in proposing a vote of congratulation on the discovery, spoke of the special interest which attached to it as being the outcome of a purely physical observation.

Prof. Emerson Reynolds noted the place which the new substance, if it proved to be an element, would occupy in Mendeleef's table among the platinum metals.

Prof. Roberts-Austen suggested that this gas might be the one which is frequently found as a residue among the gases extracted from steel.

The president, in putting the vote of congratulation to the meeting, drew attention to an observation made by Prof. Dewar, that while a mixture of pure liquefied oxygen and nitrogen forms a clear liquid, air in a similar state shows a turbidity. The president suggested that at this turbidity might be due to the new gas.

Some very interesting experiments on the electrolysis of glass were described by Prof. Roberts Austen. In conjunction with Mr. Stansfield he has found that if a bulb of soda glass be filled with sodium amalgam and immersed in a vessel of mercury heated in a sand bath to rather over 200°, on connecting the sodium amalgam and the mercury respectively with the terminals of a battery, sodium will pass from the amalgam through the glass into the mercury. At the end of the experiment the glass is unchanged. If lithium amalgam be substituted for the sodium amalgam, however, a certain percentage of lithium is found in the glass at the end of the experiment, sodium from the glass is driven into the mercury, and the glass is altered in appearance and frangibility. With potassium amalgam and soda-glass no change takes place. These phenomena are believed by Prof. Roberts-Austen to depend on the relative atomic weights and consequent atomic volumes of the elements concerned. Lithium, having a smaller atomic volume than sodium, is able to follow in the galleries left by the atoms of the latter metal; potassium, on the other hand, having an atomic volume greater than sodium, cannot force a passage. From the results he has obtained, using other amalgams, such as those of gold and copper and different kinds of glass, Prof. Roberts-Austen hopes to throw light on the formation of mineral veins in rocks which apparently have not undergone fusion.

REFINING OF CARBON BISULPHIDE.

By J. FAREBAY.

RAW carbon bisulphide is contaminated with from 6 to 10 per cent. of dissolved sulphur, and in consequence of this and other impurities has a brownish color and a penetrating odor. The redistillation in order to purify the chemical has since 1888 been performed successfully by a continuous process. For this purpose an iron vessel is used having a circular cross section and provided with a wooden jacket. It is 185

* Comptes Rendus, 1882.

† Ber. Deut. Chem. Ges., 17, 2741-2742.

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