

eyes than his: so perhaps it may be permitted to be said that it was seen in the parish of Llanefydd, Denbighshire, by a correspondent of mine, who writes:—"On Tuesday night, November 15, while returning homewards on foot, happening to look eastwards I saw a long train of brilliant light suddenly flash out of the sky. At first I thought it was lightning. But instead of vanishing it descended with great rapidity, the light increasing in brilliancy as it neared the earth. The night was rather dark, although the sky was thickly studded with stars, but in a few seconds so intensely brilliant had the light become that a pin might have been picked up from the road with the greatest ease. While I was looking, the object that accompanied the flash burst, and displayed a magnificent mauve and red fringe of light. I say fringe, as it would be impossible for me to describe otherwise the shape, for it appeared to me to project shafts of light, some long and some short, like what would be the rays of a great star. There was in the direction in which I was looking a thick wood, and the effect on the trees of the silvery light I first noticed was richly beautiful. But the effect of the mauve and red light was magnificently grand, and to me in no little degree awful. The whole wood was enveloped in a red lurid glare, which lasted as near as I can calculate some six or eight seconds. The effect altogether was like a brilliant transformation scene, and the meteor having passed away, the darkness of the night seemed to be in the last degree intense."

J. LLOYD BOZWARD.

A Correction.

IN the footnote, p. 152, second column, there is an unfortunate transposition for which myself more than the printers are to blame, which it is important to correct.

After the words "by Aristotle, Probl. I E 3 and Metaph. A 5" occur the words "which he attributes to Pythagoras . . . on the nature of the Beast."

These words should have come at the end of the subsequent paragraph where I say that "Muhama-d-al-Sharastani assigns reasons for regarding all the numbers up to 10 inclusive as perfect numbers."

It is these reasons which I speak of as being by him attributed to Pythagoras, &c.

I may take this opportunity of giving, as another example of the use of the New Nomenclature, the well-known *extended* Theorem of Fermat, which may be expressed by saying:

"Every number must divide the Fermation of which the index is its *totient*, and the base any one of its *totitives*."

Athenæum Club, December 15. J. J. SYLVESTER.

ISOLATION OF FLUORINE.

ONE of the most difficult problems of modern chemistry has at last been satisfactorily solved. After three years of incessant labour, occasionally interrupted by temporary feelings akin to despair, M. Henri Moissan has at length isolated in considerable quantities that most baffling of elements—fluorine, and has been enabled to determine its principal properties. The experiments themselves are among the most interesting ever performed, and their details, as described by M. Moissan in the December number of the *Annales de Chimie et de Physique*, form the most fascinating reading. They must of necessity have been extremely costly, for by far the greater portion of the apparatus employed was constructed of platinum, and it is not often that one hears of a platinum tube 80 centimetres long and of $1\frac{1}{2}$ centimetre diameter being destroyed in each experiment, as happened in the earlier stages of these researches.

The isolation of fluorine has formed a worthy object of the attention of chemists ever since the first remarkable experiments of Sir Humphry Davy, who was rendered dangerously ill by being exposed to the corrosive fumes of hydrofluoric acid. Although Davy was not successful in obtaining free fluorine, yet he brought clearly to light the nature of hydrofluoric acid, and proved it to consist of hydrogen combined with an unknown but extremely active element—fluorine. The history of all the attempts which have since been made to effect the preparation of

free fluorine might occupy a volume, and it will therefore only be necessary to refer to the later work of our countryman, Gore, who, in 1869, published his researches upon the electrolysis of hydrofluoric acid, and of certain fluorides, and left our knowledge of the acid itself in a most complete state. M. Moissan, working in the laboratory of M. Debray, now steps in and achieves the result so ardently sought after during the last eighty years—another example of the irresistible power of human perseverance.

In the light of the experience gained by former experimenters, it appeared that the action of a powerful electric current upon the compounds of fluorine with the non-metallic elements, such as hydrogen, phosphorus, and arsenic, would be most likely to yield the desired result; knowing also that fluorine must be an extremely energetic substance, it was absolutely essential to work at very low temperatures. Hence M. Moissan's first attack was made upon the fluorides of phosphorus and arsenic, but finding these to be practically impregnable, he diverted his attack, guided by certain indications afforded during his first attempt, upon hydrofluoric acid itself. Finding, however, that pure hydrofluoric acid is an exceptionally bad conductor of electricity, as has been stated by other workers—that even a current from fifty Bunsen cells would not pass through the liquid—he eventually, after several essays, succeeded in converting it into a conductor by dissolving in it a quantity of the double fluoride of potassium and hydrogen. On passing the current from twenty Bunsen cells through the now conducting medium, hydrogen immediately commenced to be evolved at the negative terminal, while fluorine was with similar rapidity evolved at the positive pole, and exhibited its tremendous activity upon everything that came near it: burning up hard crystalline silicon like tinder, setting fire to organic matter, and forming fluorides with incandescence with many other elements.

Having thus indicated the general course of these researches, it will no doubt be interesting to follow M. Moissan during the carrying out of his principal experiments.

The first series consisted in examining the action of electric induction sparks upon the gaseous fluorides of silicon, phosphorus, and arsenic. The gases were introduced into glass eudiometer tubes standing over mercury, and the spark was passed between two platinum wires connected with an induction-coil actuated by a few Grenet or Bunsen cells. On introducing dry silicon tetrafluoride, SiF_4 , and passing sparks for an hour, no decomposition was effected, the result being discouragingly *nil*. Dry phosphorus trifluoride, PF_3 , however, behaved quite differently, phosphorus being deposited upon the inner wall of the tube; but the fluorine liberated at once combined with the residual trifluoride to form the more stable pentafluoride, PF_5 . Some time ago this pentafluoride of phosphorus was prepared by Prof. Thorpe, who also submitted it to the action of the induction-spark, unfortunately without effecting any decomposition. Precisely the same result has been arrived at by M. Moissan, using a 0.04m. spark; but on obtaining sparks 0.2m. long, a rapid etching of the walls of the glass tube occurred, and the meniscus of mercury entirely lost its brilliancy. After an hour's duration the experiment was concluded, and the apparatus allowed to cool, when it was noticed that the volume had diminished; moreover, the gas was found to have changed its properties, yielding a precipitate of silica in contact with water, while the residual gas consisted of the trifluoride of phosphorus. Hence $\text{PF}_5 = \text{PF}_3 + \text{F}_2$, which latter forms, with the glass, silicon tetrafluoride, and, with the mercury, fluoride of mercury. So here again the experiment was disappointing, and although fluorine was for the moment liberated, this method was certainly not suitable for the preparation of free fluorine.

Fluoride of arsenic, AsF_3 , the next fluoride experimented upon, was first prepared by M. Dumas, who was severely injured in the experiment. It is a liquid which boils at 63°C ., and may be easily maintained in a gaseous condition, by use of a steam jacket, and submitted to the action of the spark. It is, however, a most disagreeable substance to work with, as it produces most terrible sores when by any mischance it comes in contact with the operator's skin. On passing sparks through it for an hour, as in case of the pentafluoride of phosphorus, the platinum wires became covered with a black incrustation of arsenic, while the walls of the tube were strongly corroded. On testing the gas, it was found to contain a large quantity of silicon tetrafluoride mixed with a smaller quantity of free fluorine, which displaced sufficient iodine from a solution of potassium iodide to give a good coloration to several cubic centimetres of chloroform. Clearly, progress was being slowly made, though still far from the isolation of fluorine.

And now a remarkable experiment of a new type was performed. It had been noticed that, on passing an electric current through a platinum wire in an atmosphere of phosphorus trifluoride, the platinum fused owing to the formation of a fusible phosphide of platinum; at the same time the glass of the containing vessel was etched and the mercury attacked. So the experiment was repeated on a grander scale. A quantity of spongy platinum, previously washed with hydrofluoric acid and calcined, was placed in a platinum tube 80 cm. long, and of 1.5 cm. diameter; that portion of the platinum tube which required to be heated was incased in a second outer tube of glazed porcelain, so that between the two a current of nitrogen could be kept circulating, and so prevent access of furnace gases. The tube was then heated in a furnace, and pure hydrogen passed through it for some time to remove all other gases; afterwards pure nitrogen was substituted, and finally phosphorus trifluoride. After passing a short time, the current of fluoride was suddenly stopped with a most singular result: a partial vacuum was caused, owing to absorption by the platinum.

When, however, the current of trifluoride was passed more rapidly, a small quantity of pentafluoride was formed; the fluorine liberated, when the absorption of phosphorus by the platinum occurred, having combined with the trifluoride just as in the spark experiment. But, on examining the gas which passed out of the tube under these conditions, it was found to liberate iodine from potassium iodide, attack mercury, and etch glass. In fact, it was proved that free fluorine was liberated, and mostly absorbed by the platinum, causing the diminution of pressure on stopping the current, but being more or less carried away when the current was more rapid. The fluo-phosphide of platinum formed was found to contain only 70 to 80 per cent. of platinum, and the formation of this substance was so rapidly effected that every experiment required a new tube. The action of pentafluoride of phosphorus upon platinum was next tried, and with still more encouraging results. On sweeping the tube, heated in a coke blast-furnace, with a rapid stream of the pentafluoride for some minutes, then moderating the rapidity, and five minutes later again increasing the speed, the issuing gas was found to blacken solid potassium iodide by liberating free iodine, inflame phosphorus, and attack crystalline silicon, glass, and mercury. It was, in fact, free fluorine drowned in excess of trifluoride of phosphorus. This was a decided advance, and the outlook was becoming considerably more hopeful.

The next experiments were made with liquid fluoride of arsenic, AsF_3 , a quantity of which was placed in a platinum crucible, which served as the negative electrode. A platinum wire, dipping into the liquid in the crucible, and reaching to within 5 millimetres of the base, served as the positive electrode. The current from three Grenet cells was then passed through the liquid, causing a de-

position of arsenic upon the interior surface of the crucible, but no gas could be perceived at the positive pole. However, on dipping the platinum wire into a solution of starch paste and potassium iodide, blue striæ were at once formed in the solution, showing the presence of a condensed gas sheath of fluorine around the platinum wire. Following up this indication, the current from twenty-five Bunsen cells arranged in series was next employed, and immediately the deposition of arsenic commenced upon the walls of the crucible, while bubbles of gas were evolved around the platinum wire. Unfortunately the action soon ceased, owing to the bad conductivity of the liquid and of the thick deposit of arsenic. The wire, however, was strongly attacked. So attempts were next made to increase the conductivity of the fluoride by the addition of metallic fluorides, and it was soon discovered that the best results were obtained by use of the double fluoride of hydrogen and potassium, $\text{HF} \cdot \text{KF}$. It was probably this discovery which led to the grand success with which these efforts have been finally crowned, for, as has been previously mentioned, it was by the electrolysis of this double fluoride that M. Moissan eventually succeeded in preparing free fluorine.

Before leaving the experiments upon arsenic fluoride, it may be mentioned that it was eventually electrolyzed in a continuous manner by use of seventy to ninety Bunsen cells, the arsenic liberated remaining in suspension in the liquid, instead of adhering to the tube, but the bubbles were rapidly seen to diminish in size in passing through the liquid, and scarcely a trace of gas escaped; instead of permitting its isolation, the fluorine preferred to form a new fluoride, the pentafluoride of arsenic, thus once more baffling the ingenious experimenter.

But success was not now far away. The wonderful manner in which the double fluoride of potassium and hydrogen increased the conductivity of arsenic fluoride determined M. Moissan in employing it for the same purpose in an attempt to electrolyze pure anhydrous hydrofluoric acid. Faraday long ago showed that the electric current will not pass through the anhydrous acid, and Gore more recently came to the same conclusion. The current from fifty Bunsen cells was found by M. Moissan to be absolutely powerless to penetrate the acid used in these later experiments. But, on dissolving a few fragments of the double fluoride $\text{HF} \cdot \text{KF}$ in the acid, the current at once passed freely, and the experiment thus became possible. The apparatus used in the first attempts with this mixture consisted of a platinum U-tube, of which each branch was closed by a paraffined cork, through which the rods of platinum forming the poles were passed. Upon each branch, just above the level of the liquid and beneath the cork, was soldered a little platinum delivery-tube to lead off the gases evolved. As hydrofluoric acid boils at $19^\circ 4 \text{C}$., the apparatus was immersed in a bath of methyl chloride, which boils at -23° , but which could be reduced in temperature to -50° by driving through it a current of dry air. Hence the electrolysis could be conducted without fear of the gaseous products being drowned in excess of vapour of hydrofluoric acid, and the activity of the liberated fluorine was at the same time moderated. On passing the current, a gas was at once produced at each electrode, a regular evolution of hydrogen at the negative pole, and a continuous disengagement of gas at the positive pole. But still affairs were not satisfactory: crystalline silicon did not take fire when held in the gas coming off from the positive pole; so the apparatus was taken to pieces an hour later, in order, if possible, to find a clue to the source of failure. The paraffined cork at the negative branch was intact, but, behold the mischief, the other was carbonized to the depth of a centimetre; so the liberated fluorine had extracted hydrogen out of the cork, and passed on as hydrofluoric acid. The positive platinum rod was also much corroded. Closely-fitting stoppers of fluor-spar were next tried, coated with melted

gutta-percha, but the latter again soon melted on passing the current, and was put *hors de service*. Gum-lac and many other substances were tried, but all to no purpose, and much precious time was lost. Finally, however, the difficulty was overcome by using stoppers of fluor-spar, carefully inserted in hollow cylinders of platinum carrying fine screw threads upon their outer surfaces, which engaged with corresponding threads upon the interior surfaces of the two branches of the U-tube. The platinum rods passed through the axis of each cylinder of fluor-spar: the rods themselves were of square section, of 2 millimetres side and 12 centimetres long, and passed to 3 millimetres from the base of the U-tube; they were made of irido-platinum, containing 10 per cent. iridium, which is less attackable than pure platinum. The U-tube simply consisted of a platinum tube, bent twice at right angles, 1.5 centimetre diameter and 9.5 centimetres high, and was fitted with side tubes and immersed in methyl chloride as before.

The pure anhydrous hydrofluoric acid, which was the next necessity, was prepared in the following manner. A known volume of commercial acid was treated with sufficient potassium carbonate to neutralize about a quarter of it, and then distilled in a leaden retort over an oil bath at 120°. At this temperature the fluosilicate of potassium, formed from the hydrofluosilicic acid, contained as impurity in the commercial acid, was not decomposed, and the distillate was therefore free from silica. This distillate was then divided into two parts, and one half, saturated with pure potassium carbonate, forming neutral potassium fluoride, was then added to the other half, and transformed into HF.KF. The double fluoride was then dried at 100°, and afterwards kept for some days in the vacuous receiver of an air-pump, containing also strong sulphuric acid and a few sticks of fused potash. When absolutely dry it fell to powder, and was then ready for the preparation of hydrofluoric acid, which was always freshly prepared immediately before each experiment. The dry fluoride was in each case introduced into a recently ignited platinum retort, and maintained at a moderate heat for some time so as to commence the decomposition slowly; the first portions of distillate were rejected, as they would contain the last traces of water. The platinum receiver was then adapted and surrounded by ice and salt; on heating the retort more strongly, pure hydrofluoric acid condensed in the receiver as a limpid liquid boiling at 19°4, very hygroscopic and fuming in the air.

While the preparation of the acid was in progress, the U-tube and electrodes were drying at 120°. From 6 to 7 grammes of the dry double fluoride were now introduced into the apparatus, the stoppers were screwed in and covered with gum lac. The whole was then fixed in the methyl chloride bath, and, until the introduction of the acid, the delivery-tubes were connected with desiccators containing fused potash. A constant supply of methyl chloride at -23° was maintained in the outer cylinder, as a slight rise of temperature allowed of the volatilization of some of the acid. About 15 to 16 grammes of the anhydrous hydrofluoric acid were then gently aspirated into the apparatus, and the current from twenty Bunsen cells allowed to pass, when immediately a regular evolution of gas occurred at each pole. At the negative pole pure hydrogen was evolved, which burnt with its characteristic flame, forming water. At the positive pole was liberated a colourless gas of penetrating and very disagreeable odour, somewhat resembling that of hypochlorous acid, and rapidly irritating the mucous membranes of the throat and eyes. It was no other than pure fluorine itself. All the trouble, all the expense, and all the disappointments were repaid. It must indeed have been a supreme moment for M. Moissan.

In order to study its action upon solids, they were placed in small glass tubes, and brought near to the orifice

of the platinum delivery-tube at the positive side. The test was generally repeated, holding the solids in small platinum capsules.

Sulphur, brought thus near the orifice, at once melted and inflamed; selenium behaved in like manner; as did also tellurium, with incandescence, forming fumes and becoming coated with a solid fluoride.

Phosphorus at once took fire, forming tri-, penta-, and oxyfluorides. Powdered arsenic and antimony combined with incandescence, the former yielding drops of AsF₃.

A fragment of iodine placed in the gas combined with production of a pale blue flame; in an atmosphere of iodine vapour fluorine itself burnt with a similar flame. Vapour of bromine lost its colour and the combination was sometimes accompanied by detonation.

Cold crystalline silicon at once became incandescent, and burnt with great brilliancy, sometimes with scintillations. On closing the little tubes containing it with the thumb and opening under water, the silicon tetrafluoride formed was absorbed and decomposed with precipitation of silica. Any undecomposed silicon was found to have been fused.

Debray's adamantine boron also burnt in the gas, becoming incandescent and giving off fumes.

Fluorine has a most extreme affinity for hydrogen; they combine in the dark with explosion. In one of the experiments the electrolysis was allowed to continue several hours, so that eventually the small quantity of undecomposed acid remaining in the U-tube was insufficient to keep the two gases apart; the experimenters were consequently suddenly startled by a violent detonation. The hydrogen and fluorine had combined in the dark at the low temperature of -23°. The same detonation was afterwards brought about on a smaller scale by reversing the current. On bringing the wide-mouthed delivery-tube of a hydrogen generator near the orifice, the detonation at once occurred, and the hydrogen inflamed.

Metals are all attacked with more or less energy by fluorine, forming fluorides. Cold sodium and potassium were at once rendered incandescent. Calcium, magnesium, and aluminium acted similarly, in a more modified manner, becoming incandescent when slightly warmed. Powdered iron and manganese, on gently warming, burnt with bright scintillations; lead was attacked in the cold, and tin at a slightly elevated temperature. Mercury, as suspected, entirely absorbed the gas, forming yellow proto-fluoride. Silver at a gentle heat became coated with a beautiful satin-like fluoride, soluble, unlike the chloride, in water. Gold and platinum at 300°-400° became coated with their respective fluorides, which were decomposed again at a red heat, with evolution of free fluorine.

Perhaps the strongest evidence of the intense chemical activity of fluorine is exhibited in its action upon cold potassium chloride: the chlorine was at once expelled, filling the air with its disagreeable odour, and was identified by the usual chemical tests. Chlorine was also expelled from its combination with carbon in carbon tetrachloride.

All organic compounds are violently attacked by fluorine: a piece of cork at once carbonized and inflamed; alcohol, ether, benzene, and turpentine took fire immediately in contact with it.

Glass, as might have been expected, is at once corroded by fluorine; some very delicate experiments were carried out with perfectly dried glass, with the same result.

Many other reactions, all interesting and all showing the immense energy with which the atoms of fluorine are endowed, were performed, but one especially ought to be noticed, viz. the action of fluorine upon water. It is a singular fact that, whenever oxygen is liberated in the cold, there is a great tendency to form ozone: hence when fluorine is attempted to be collected over water, the gas collected is not fluorine, but ozonized oxygen; water is decomposed by the fluorine forming hydrofluoric acid,

while the oxygen is set free, and a considerable quantity of it is converted into the more condensed form of ozone.

On taking the apparatus to pieces after each experiment, the hydrofluoric acid remaining was found to contain a small quantity of platinum fluoride in solution, and a black mud consisting of a mixture of iridium and platinum in suspension. The negative electrode was not attacked, but the platinum rod forming the positive pole was eaten away to a point, so that one rod only served for two experiments. The average delivery of gas was about 1.5 to 2 litres per hour.

With regard to the chemical processes involved in the electrolysis, it appears probable that potassium fluoride is first decomposed into fluorine, which is evolved at the positive pole, and potassium, which decomposes hydrofluoric acid, liberating its equivalent of hydrogen at the negative pole, and re-forming potassium fluoride, which may again be electrolyzed. Hence a small quantity of the double fluoride can serve for the decomposition of a comparatively large amount of hydrofluoric acid.

The double fluoride HF.KF is very soluble in hydrofluoric acid, forming a crystallizable compound, richer in hydrofluoric acid than HF.KF, and which gives off no acid vapour at the boiling-point of the anhydrous acid, 19°4. It is this compound which one ought to seek to obtain for electrolysis, as it is very soluble in excess of acid, forming a liquid of good conductivity.

The double fluoride HF.KF itself was finally electrolyzed by M. Moissan. It fuses at 140° to a colourless liquid which is quite suitable for electrolysis. The experiment was performed, as before, in a platinum U-tube, and, on passing the current, fluorine was again liberated at the positive pole, and at once set fire to crystalline silicon; but the platinum was strongly attacked, so the experiment was stopped in order to save the tube. On plunging a couple of platinum wires connected with the battery into a quantity of the fused double fluoride contained in a platinum crucible, gas was evolved in abundance at each pole, and on bringing the wires in contact, even in the dark, detonation occurred, owing to the combination of the evolved hydrogen and fluorine. At the same time the platinum wire from which the fluorine was evolved was almost entirely eaten away.

In concluding these remarkable researches, which have happily terminated so successfully, M. Moissan discusses very fully the question of the identity of the gas liberated at the positive pole with the element fluorine; and there can be no doubt that he has completely proved this identity, at the same time showing that fluorine occupies the place of honour as the most intensely active chemical element with which we are at present acquainted, and that it assumes its rightful position, theoretically destined for it, at the head of the group of halogens.

A. E. TUTTON.

TIMBER, AND SOME OF ITS DISEASES.

I.

ON carefully examining the clean-cut end of a sawn log of timber, it is easy to convince ourselves of the existence of certain marks upon it, which have reference to its structure. These marks will vary in intensity and number according to the kind of tree, the age at which it is felled, and some other circumstances, which may be overlooked for the present; but in a given case it would be possible to observe some such marks as those indicated in Fig. 1. In the specimen chosen there is a nearly

central spot, the pith, around which numerous concentric lines—the “annual rings”—run. Radiating from the pith towards the periphery are cracks, the number, and length, and breadth of which may vary according to the time the log has been exposed to the weather, and other circumstances; these cracks are due to the contraction of the wood as it “shrinks,” and they coincide with medullary rays, as lines of weakness. Between these cracks are to be seen numerous very fine radiating lines indicating the course of the uninjured medullary rays, which again will vary in distinctness, &c., according to the species of timber.

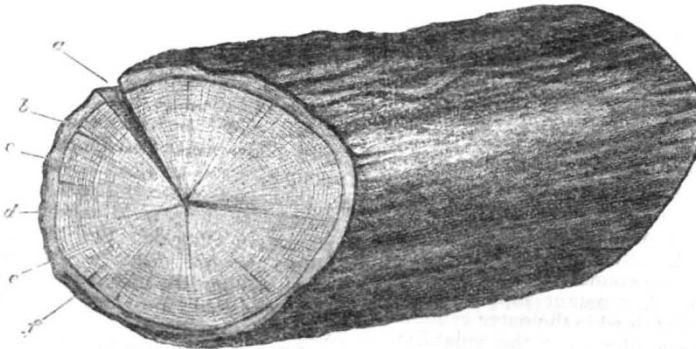


FIG. 1.—A log of timber, showing radial cracks after lying exposed for some time. *a*, a large crack extending from pith to circumference; *b*, the cortex; *c*, medullary ray; *d*, cambium; *e*, annual ring; *f*, outer bark, proper. Reduced.

This log of wood, with its annual rings and medullary rays, is clothed by a sort of jacket, consisting of cork and softer tissues, and termed the cortex, or, more popularly, the “bark” (an unfortunate word, which has caused much trouble in its time). The largest of the cracks is seen to traverse the whole radius of the face of the wood from centre to circumference, and also to pass through the cortex, which gapes widely.

The remaining cracks, however, stop short at a line which marks on the one hand the inner face of the cortex, and on the other the outer face of the wood: this line also represents the cambium, a thin sheet of generative tissue

which remains after giving rise to practically the whole of the wood (a very little in the centre excepted) and cortex visible in the woodcut. Since we are not concerned with the cortex and bark at present, it will be convenient to regard the log as “barked,” and only deal with the wood or timber itself, in the condition to which the woodman reduces it after removing the cortex with certain implements.

If now we split such a log as Fig. 1 along the line or the big crack, neatly and smoothly, the well-known “grain” so often observed on planks of wood will come into view, and it will be noticed that the lines which mark the “grain” are continuations of the lines which mark