hand ; otherwise the method is too wasteful. The current is brought into the solution by a platinum wire, sealed into a small glass tube ; the platinum wire

reaches about to the level of the open end

of the tube. A capillary of thick-walled

glass tubing is placed over the platinum

wire ; the liquid rises in the capillary and

sparks can be taken as from a solid. The

lines due to the glass are easily eliminated.

If a small quantity of material only is avail­

able, the plan adopted by Bunsen and ex­

tensively used by Hartley@@1 seems the most

successful. Pointed pieces of charcoal (Bun­

sen) or pieces of graphite pointed to a knife

edge (Hartley) are impregnated with the

liquid, and the spark is taken from them. Some sub­stances, when introduced into a vacuum tube, especially near the negative pole, and under great exhaustion, show a characteristic phosphorescence. Becquerel was the first to examine the spectra shown under these circumstances, and Crookes has lately used the same method with great success.

*Spectra of Metalloids.*

A good deal of discussion has taken place on the spectra of the metalloids, owing to the fact that they seem to he able to give different spectra under different circumstances. Spectra have occa­sionally been assigned to the elements which on further investiga­tion were found to belong to some compound present. According to the general opinion of spectroscopists at present, different spectra of the same elements are always due to different allotropic condi­tions. If a complex molecule breaks up into simpler molecules the breaking up is always accompanied by a change of spectrum.

*Nitrogen.* —(*a*) The line spectrum appears whenever a strong spark (jar discharge) is taken in nitrogen gas. It is always present when metallic spectra are examined by the ordinary method of allowing the jar discharge to pass between metallic poles.@@2 Hartley (*Phil. Brans.,* 1884, part i.) has measured the ultra-violet lines of the air spectrum, but has not separated the oxygen from the nitrogen lines, (*b*) The band spectrum of the positive discharge, which is generally called the band spectrum of nitrogen, always appears when the discharge is sufficiently reduced in intensity. The spectrum con­sists of two sets of bands of different appearance, one in the less re­frangible part and one in the more refrangible part of the spectrum, —the two sets of bands overlapping in the green. Hence some observers believe the spectrum to be made up of two distinct spectra. Plücker and Hittorf (*Phil. Trans.,* 1865) give a coloured drawing of this spectrum, which is one of the most beautiful that can be observed. The most complete drawing of it is given by Piazzi Smyth (*Trans. Roy. Soc. Edin.,* vol. xxxii. part iii.), and there is also a good drawing by Hasselberg (*Mém. Acad. Imp. de St.Pétersb.,* vol. xxxii.). (c) The glow which surrounds the negative electrode in an exhausted tube shows in many cases a spectrum which, as a rule, is not seen in any other part of the tube. The memoir of Hasselberg contains a drawing of it. The spectrum seen when a weak spark is taken in a current of ammonia is neither that of nitrogen nor that of hydrogen, but must be due to a compound of these gases. When the pressure of the gas is reduced, a single band is seen having a wave-length from 5686 to 5627 *X*th metres (*Nature*, vi. p. 359). When a spark is taken from a liquid solution of ammonia a more complicated spectrum appears (Lecoq de Bois- baudran), and, if ammonia and hydrogen are burnt together either in air or oxygen, a complicated spectrum is obtained the chemical origin of which has not been satisfactorily explained. Drawings of it are given by Dibbits (*Pogg. Ann.,* cxxii. p. 518) aud by Hofmann (*Pogg. Anm.,* cxlvii. p. 95). The absorption spectrum of the red fumes of nitrogen tetroxide has often been mapped ; the most per­fect drawing is given by Dr B. Hasselberg (*Mém. Acad. Imp. de St. Pét.,* xxvi.). According to Moser (*Pogg. Ann.,* clx. p. 177), three bands close to the solar line C disappear when the vapour is heated. Recently Deslandes has obtained in vacuum tubes some ultra­violet bands which seem to be due to a compound of nitrogen and oxygen (*C. R.,* chap. i. p. 1256, 1885).

*Oxygen.—(a)* The elementary line spectrum of oxygen is that which appears at the highest temperature to which we can subject oxygen, that is, whenever the jar and air break are introduced into the electric circuit. It consists of a great number of lines, especially in the more refrangible part of the spectrum, (*b*) The compound

@@@1 *Phil. Trans.,* clxxv. p. 49 (1884).

@@@2 We may refer once for all to Watts, *Index of Spectra,* for a list of wave-lengths of the different spectra.

line spectrum of oxygen appears at lower temperatures than the first. It consists, according to Piazzi Smyth, of six triplets and a number of single lines. This spectrum corresponds to the band spectrum of nitrogen, (*c*) The continuous spectrum of oxygen appears at the lowest temperature at which oxygen is luminous. The wide part of a Plücker tube, for instance, filled with pure oxygen generally shines with a faint yellow light, which gives a continuous spectrum. Even at atmospheric pressure this spectrum can be ob­tained by putting the contact breaker of the induction coil out of adjustment, so that the spark is weakened, (*d)* The spectrum of the negative glow was first accurately described by Wüllner, and is always seen in the glow surrounding the negative electrode in oxygen. It consists of five bands, three in the red and two in the green. For further information respecting these spectra, see Schuster (*Phil. Trans.,* clxx. p. 37, 1879) and Piazzi Smyth (*Trans. Roy. Soc. Edin.,* vol. xxxii. part iii.). According to Egoroff, the A and B lines of the solar spectrum are due to absorption by oxygen in our atmosphere, and some recent observations of Janssen seem to support this view.

*Carbon.—*(*a*) The line spectrum appears when a very strong spark is sent through carbonic oxide or carbonic acid. The ultra-violet lines observed by Hartley when sparks are taken from graphite electrodes also belong probably to this spectrum, (*b*) Considerable discussion has taken place as to the origin of the spectrum seen at the base of a candle or a gas flame. At first observations seemed to point to the fact that it was due to a hydrocarbon. It has been ascertained, however, that sparks taken in cyanogen gas, even when dried with all care, show the spectrum, and a flame of cyanogen and oxygen gives the same bands brilliantly. These facts have convinced the majority of observers that the spectrum is a true carbon spectrum. The best drawing is given by Piazzi Smyth, who ascribes the spectrum, however, to a hydrocarbon. The flame of cyanogen, which had already been examined by Faraday and Draper before the days of spectrum analysis, shows a series of bands in the red, reaching into the green. There is no doubt that they are due to a compound of nitrogen and oxygen. Another series of bands in the blue, violet, and ultra-violet have been also proved by Liveing and Dewar to be due to a compound of nitrogen and carbon. If the discharge is passed at low pressure through carbonic acid or carbonic oxide a spectrum is seen which seems to belong to carbonic oxide. A very beautiful and remarkable drawing of this spectrum, especially of its most brilliant band, has been published by Piazzi Smyth.

Very little need be said of the remaining metalloids, as we do not possess a sufficiently careful examination of their spectra. Chlorine, bromine, and iodine show bands by absorption. If a spark is passed through the gases line spectra appear. Sulphur volatilized in a vacuum tube may show either a line or a band spectrum under the influence of the electric discharge. The absorption through the vapouι, of sulphur is continuous at first on volatilization, but as the vapour is heated to 1000° the continuous spectrum gives way to a band spectrum. A spark through the vapour of phosphorus gives a line spectrum. We may obtain the spectra of fluorine, silicon, and boron by comparing the spectra given by sparks taken in atmospheres of fluoride of boron and fluoride of silicon.

*Spectra of Metals and their Compounds.*

*Hydrogen.—*If sparks are taken through hydrogen, four well- known lines appear in the visible region of the spectrum. The remarkable series of ultra-violet lines photographed by Dr Huggins in the spectra of some stars which in their visible part show hydro­gen chiefly has suggested the question whether the whole series is not due to that gas. This has now been proved to be the case by Cornu, who has recently examined the hydrogen spectrum with great care. In vacuum tubes filled with hydrogen a complicated spectrum often appears which is so persistent that nearly all ob­servers have ascribed it to hydrogen (though Salet had given reasons against that conclusion). According to Cornu, the purer the gas the feebler does this spectrum become, so that the above-mentioned line spectrum seems to be the only true hydrogen spectrum. A flame of hydrogen in air or oxygen shows a number of lines in the ultra-violet belonging apparently to an oxide of hydrogen (Live- ing and Dewar, Huggins). Aqueous vapour gives an absorption spectrum principally in the yellow.

*Alkali Metals.—*The metals of the alkali group are distinguished by the fact that their salts give the true metal spectra when ren­dered luminous in the Bunsen burner ; that is to say, their salts are decomposed and the radiation of their metallic base is sufficiently powerful to be visible at the temperature of the flame. Their spectra are not so easily seen if sparks are taken from the liquid solution, but Lecoq de Boisbaudran has obtained fine spectra of sodium and potassium by taking the spark from a semi-fluid bead of the sulphates. The most complete description of the spectra of sodium and potassium seen when the metals are heated up in the voltaic arc is given by Liveing and Dewar (*Proc. Roy. Soc.,* xxix. p. 378, 1879), who have also mapped their ultra-violet lines (*Phil. Trans.,* 1883, pt. i.). Abney has found a pair of infra-red lines