belonging to sodium, with wave-lengths 8187 and 8199 (*Proc. Roy. Soc.,* xxxii. p. 443, 1881). Becquerel finds lines in the infra-red at 11,420. The vapour of sodium and potassium heated up in a tube is coloured and shows a spectrum of fluted band ; but in the ease of sodium the yellow line is always present at the same time. It is probable that the band spectrum belongs to the vapour, con­taining two atoms in each molecule, and that at higher tempera­tures the molecules are split up, the single atoms showing the line spectra. Both potassium and sodium show an additional absorption line (5510 for Na and 5730 for Ka) at the temperature at which the fluted bands appear. According to a suggestion of Liveing and Dewar, these lines may depend on the presence of hydrogen, which it is very difficult to exclude. These experimenters have also de­scribed interesting but complicated absorption phenomena depend­ing on the simultaneous presence of two or more metals. Thus sodium and magnesium show a band in the green (λ=5300), which does not appear when sodium alone or magnesium alone is volati­lized. Potassium and magnesium show similarly two lines in the red (*Proc. Roy. Soc.,* xxvii. p. 350, 1878). If a spark is taken from potassium in an atmosphere of carbonic oxide a band appears (5700) depending probably on a combination between the potassium and the carbonic oxide. Lockyer has observed certain curious phenomena (*Proc. Roy. Soc.,* vol. xxii. p. 378) taking place at the temperature at which the band spectrum of sodium changes into the line spectrum ; these phenomena deserve a fuller investigation. Lithium furnishes a good example of a change in the relative in­tensity of lines at different temperatures. At the temperature of the flame the red line is the most powerful, an orange line being also seen. When a spark is taken from a liquid solution the orange line is far the strongest, and a blue line is seen, which in its turn rapidly gains in intensity as the temperature is raised. When the spark is taken from solutions of different strengths the more con­centrated solution shows a change in relative intensity of lines in the direction in which an increase of temperature would act. Com­bination of the metals with transparent acids does not when in solution show any appreciable absorption in the visible part of the spectrum ; but Soret has mapped their ultra-violet absorption.

*Metals of Alkaline Earths.—*Calcium, strontium, and barium are distinguished by the fact that their volatile compounds give fine spectra in the Bunsen flame. The more stable salts, as the phos­phates and silicates, give the reaction only feebly or not at all. When a salt like the chloride of barium is introduced into the flame the spectrum is seen to change gradually ; the spectrum seen at first is different according as the chloride, bromide, or iodide is used, while the spectrum which finally establishes itself is the same for the different salts of the same metal. Mitscherlich, who was the first to investigate carefully these phenomena (*Pogg. Ann.,* cxxi. p. 459, 1864), ascribes the spectra seen at first to the compound placed in the flame, while gradually the oxide spectrum gets the upper hand. This explanation has always been accepted, and receives support from the fact that the bromide spectrum is strengthened by introducing bromine vapour into the flame, and the other compound spectra can be similarly strengthened by introducing suitable vapours. There is an observation, however, made by Pro­fessors Liveing and Dewar which in one case is not compatible with Mitscherlich's explanation. “A mixture of barium carbonate, aluminium filings, and lamp-black heated in a porcelain tube gave two absorption lines in the green, corresponding in position to bright lines seen when sparks are taken from a solution of barium chloride, at wave-lengths 5242 and 5136, marked *a* and *β* by Lecoq de Boisbaudran.” These two lines, or rather bands, are the brightest in the spectrum commonly ascribed to barium chloride. In addi­tion to the compound spectra the brightest of the metallic lines seep at a low temperature appear in the flame. The metallic line is in the violet with calcium, in the blue with strontium, and in the green with barium. Sparks taken from a solution of the metallic salts show the compound spectra well, and in addition more of the true metallic lines than the flame. The best drawings of the compound spectra are those given in Lecoq de Boisbaudran’s *Atlas* ; but measurements with higher resolving powers are much wanted. When the salts are introduced into the voltaic arc numer­ous metallic lines appear which have been mapped by Thalén. Liveing and Dewar have investigated those lines which can be reversed and have also mapped the ultra-violet spectra. Captain Abney has mapped a pair of infra-red lines belonging to calcium between 8500 and 8600, and, according to Becquerel, with the help of a phosphorescent screen bands or lines appear of still lower refrangibility (8830 to 8880). Lockyer (*Phil. Trans.,* clxiii. p. 253, 1873, and clxiv. p. 805, 1874) has measured and mapped as regards their length the lines of these as well as of many of the other metals.

*Metals of Magnesium Group.—*Beryllium presents comparatively simple spectroscopic phenomena, as far as it has hitherto been in­vestigated. Two green lines were mapped by Thalén and five in the ultra-violet by Hartley (*Jour. Chem. Soc.,* June 1883). The spectrum of magnesium is well known from its green triplet ; but tħe vibrations of the metal seem very sensitive to a change of

conditions. Full details are given by Liveing and Dewar in *Proc. Roy. Soc.,* xxxii. p. 189. These authors have found that some of the bands seen occasionally, when magnesium wire is burned in air, are due to a compound of magnesium and hydrogen. The spec­trum appears when sparks are taken from magnesium poles in an atmosphere containing hydrogen. For a description of the pecu­liarities of the flame, arc, and spark spectrum, the reader is referred to the original paper. The ultra-violet spectrum, which contains several repetitions of the green triplet, has also been mapped and measured by Hartley and Adeney (*Phil. Trans.,* clxxv., 1874, pt. i.). The spectra of zinc and cadmium are obtained either by sparks from liquid solution or by the spark, with Leyden jar, from the metal poles. The ultra-violet spectra show for both elements a remarkable series of triplets, the lines of the cadmium triplet being about three times as far apart as those of the zinc triplets. The least refrangible of the series is in the blue with wave-lengths 5085·1, 4799·l, 4677·0 for cadmium, and 4809·7, 4721·4, 4679·5 for zinc.

*Lead Group.—*The spectrum of lead is best obtained by taking the spark from the metallic poles. Care must be taken, however, to renew the surface frequently, otherwise the oxide spectrum will gradually make its appearance. The oxide itself shows its spectrum, according to Lecoq de Boisbaudran, in the Bunsen burner. The salts of thallium show the principal metal line at the temperature of the flame. The spark spectrum is more complicated. The ultra­violet spectra of both lead and thallium have been mapped.

*Copper Group.—*The spectra of the metals belonging to this group are easily obtained in the ordinary way. When copper chloride is introduced into the Bunsen flame a fine spectrum of bands is seen. It is the same spectrum which is found when com­mon salt is thrown upon white hot coals. This reaction for copper chloride is very sensitive, but it has never been satisfactorily decided whether the presence of copper is really necessary for its production or whether the spectrum belongs to a peculiar condition of chlorine vapour. Silver when first volatilized gives a green vapour, which at a low temperature shows continuous absorption, but at a higher temperature a spectrum of fluted bands (Lockyer). Mercury shows its lines with great brilliancy if introduced and heated in a vacuum tube. Some of the lines widen easily, and at higher pressures a con­tinuous spectrum completely covers the background. The copper salts in aqueous solution absorb principally the red end of the spectrum, the green salts also the violet end. The glass, coloured green with oxide of copper, transmits through sufficient thickness exclusively the yellow and green rays between D and E (H. W. Vogel).

*Cerium Group.—Yttrium* gives a good spark spectrum from the solution of the chloride ; the salts show no absorption bands. Crookes has found, however, that a certain substance yields brilliant phosphorescent bands under the influence of the negative pole in a vacuum tube. These bands he has, after a lengthy investigation, put down to yttrium compounds, and explained the changes they undergo in different compounds and the sensitiveness of the reaction. Lecoq de Boisbaudran, who obtains the same spectrum by taking a spark (without Leyden jar) from solutions, making the solution the positive pole, has expressed an opinion that the bands are not due to yttrium but to two substances provisionally called by him Zα and *Zβ.* He has also under certain conditions seen a higher temperature spectrum, which he ascribes to Zγ, leaving it undecided whether Zγ is a new substance or identical with Zα (*Phil. Trans.,* 1883, p. 891, and *C.B,* ci. p. 552, cii. p. 153).—*Lanthanum* is easily recognized by a strong spark spectrum. —*Cerium,* like yttrium and lanthanum, has no peculiar absorption spectrum when in combin­ation and solution ; although the salts are strongly coloured yellow, its line spectrum has characteristic lines in the blue.—*Didymium* is characterized spectroscopically by the fine absorption spectra of its salts. Different salts show slightly different spectra, but they can be recognized at first sight as didymium spectra. The crystals of didymium salts show remarkable differences in the absorption spectra according to the direction in which the ray traverses the crystal. Light reflected from the powdered salts shows the character­istic spectrum. According to Auer von Welsbach (*Monatsschr. f. Chemie,* vi. p. 477), didymium has lived up to its name *δίδυμοι*, “twins,” for by fractional crystallization he has found it to be an intimate mixture of two substances, each of them giving half the ab­sorption spectrum and half the emission spectrum of didymium.*—Terbium* has a characteristic line spectrum when the spark is taken from a solution of the salts.—The salts of *erbium* give a characteristic absorption spectrum, but till recently the drawings of it contained also absorption bands due to thulium and holmium. The spectrum of erbium, as previously mapped by Thalén, belongs almost exclusively to ytterbium ; but he has recently mapped the lines belonging to what is now known as erbium (*C.R*.., xci. p. 326). Erbium salts heated in the Bunsen burner show a spectrum of bright bands without apparent volatilization. — *Ytterbium,* discovered by Marignac (atomic weight 17·3, Nilson), gives an ab­sorption band in the ultra-violet. Its luminous spectrum is rich in lines (Thalén, *C.R.,* xci. p. 326).—*Samarium,* also discovered by