Classics of Science: Spectrum Analysis

Physics—Chemistry

Make a spectroscope after the directions of Kirchhoff and Bunsen, given below, and see the spectra given off by the metals of the two alkali groups as they color the flame of the familiar burner, invented by the same Bunsen.

CHEMICAL ANALYSIS BY SPECTRAL OBSERVATIONS, by G. Kirchhoff and R. Bunsen. Poggendorf's Annalen, Band 110, 1860. Translated by D. B. Brace, published in The Laws of Radiation and Absorption. New York, 1901.

Bright Line Spectra

It is well known that many substances have the property when they are brought into a flame of producing in the spectrum certain bright lines. We can found on these lines a method of qualitative analysis which greatly enlarges the field of chemical reactions and leads to the solution of problems, unsolved heretofore. We shall confine ourselves here only to the extension of the method to the detection of the metals of the alkalis and the alkili earths and to the illustration of their value in a series of examples.

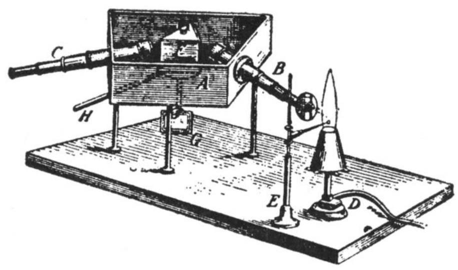
The lines referred to show themselves the more plainly, the higher the temperature and the weaker the natural illuminating power of the flame. The gas lamp described by one of us gives a flame of very high temperature and very small luminosity; this is consequently especially adapted to investigations on those substances characterized by bright lines. . . . .

The potassium compound used for the investigation was obtained by heating chlorate of potassium which had been six to eight times recrystallized beforehand.

The chloride of sodium was obtained by combining pure carbonate of sodium and hydrochloric acid and purifying the same by repeated crystallization.

The lithium salt was purified by precipitating fourteen times with carbonate of ammonium.

For the production of the calcium salt a specimen of marble as pure as possible, and dissolved in hydrochloric acid, was used. From this solution the carbonate of calcium was thrown down by a fractional precipitation with carbonate of ammonium in two portions, of which only the latter, precipitated in calcium nitrate, was used. The calcium salt thus obtained we dissolved several times in absolute alcohol and converted it finally into the chloride by evaporating the alcohol and by precipitation with carbonate of ammonium by hydrochloric acid.



APPARATUS FOR SPECTRUM ANALYSIS

In order to obtain the pure chloride of barium we extracted it from the commercial salt by pulverizing and boiling repeatedly in nearly absolute alcohol. The residue thus extracted and freed from alcohol was dissolved in water and thrown down by fractional precipitation in two portions, only the second being dissolved in hydrochloric acid, and the barium chloride thus obtained being further purified by repeated crystallizations.

In order to obtain chloride of strontium, as pure as possible, the commercial salt was crystallized out from alcohol, and fractionally precipitated in two portions with carbonate of ammonium, the second part being dissolved in nitric acid and the nitrate freed from the last traces of calcium by pulverizing and boiling with alcohol. From the product thus purified the chloride of strontium was obtained finally by precipitating with carbonate of ammonium and dissolving the precipitate in hydrochloric acid. All these purifications were made in platinum vessels as far as it was possible.

The Spectroscope

The figure represents the apparatus which we have used mainly in the observation of the spectra. *A* is a box blackened on the inside the bottom of which has the form of a trapezium and rests on three feet; the two inclined sides of the same form an angle with one another of about 58° and carry the two small telescopes *B* and *C*. The ocular of the first is removed and replaced by a plate in which is a slit formed of two brass cheeks which are placed at the focus of the objective. The lamp *D* is so placed before the slit that the mantle of the flame is intersected by the axis of the tube *B*. Somewhat beneath the point where *(Turn to next page)*

News of the Hittites

Archæology

On a high plateau in Asia Minor lie the desolate ruins of the largest city of the ancient Hittite Empire, is the report by H. H. von der Osten, of the Hittite Expedition of the Oriental Institute, University of Chicago.

The existence of a city at this remote place has long been known, but the site has hitherto been ignored by scientists. Mr. von der Osten, while excavating at a Hittite site nearby, journeyed to the plateau and surveyed the huge city area which is still outlined by broken down stone walls.

The walls of the city were originally more than 13 feet thick, he reported. The walls were strongly fortified by rounded towers set at strategic points, and on a mountain top rising on the plateau are the remains of a fortress. Fragments of pottery lying on the surface of the stone heaps are pronounced characteristic Hittite pottery and also Roman and Byzantine.

The city buried beneath the stones and drifting soil dates back more than 3,000 years. It must have been a great city at the time when Tutankhamon's young widow offered her hand to a Hittite prince in a vain, desperate attempt to save her Egyptian throne.

A campaign of at least seven or eight years would be needed to investigate the huge ruin, in Mr. von der Osten's opinion, and even a detailed survey of the surface would require six months.

Children of the Hittite race who went to school in Asia Minor about 1000 B. C. had to learn dead languages just as the modern school boy learns Latin. Baked clay tablets found in the capital city of the ancient Hittite Empire have been deciphered by scholars who say that eight languages are represented on them, written in the neat, wedge-shaped characters known as cuneiform writing.

The Sumerian language was then long dead, but the Hittites learned it and taught it to their children because they believed that charms sung in the old language were peculiarly effective. In some of the tablets, the Sumerian text is followed by columns containing the same text translated into official Hittite language and into Babylonian, and also a column pronouncing the Sumerian words. Babylonian was apparently the language of diplomacy among the Hittites. *(Turn to next page)*

Hittites—*Continued*

Several thousand tablets were discovered in a palace and a temple used as a record office, by German archæologists some years ago, but early attempts at reading them were hampered because the different languages were not sorted out. Writers of long records on the baked tablets were careful to indicate the sequence from one tablet to the next, and usually at the end of the document the author wrote his name, his profession, and place of residence, in modern fashion.

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Bacteria average about one twenty-five thousandths of an inch in length.

The temperature in Alaska has been known to mount to 100 degrees in the shade.

The mocking bird is being urged for adoption as the state bird of Texas.

Opium provides over one-fourth of the revenue of Indo-China and British Malaya.

Spectroscope—*Continued*

the axis meets the mantle the end of a very fine platinum wire bent into a small hook and carried by the holder *E* passes into the same; on this hook is melted a globule of the chloride previously dried. Between the objective of the telescopes *B* and *C* is placed a hollow prism *F* with a reflecting angle of 60° and filled with carbon disulphide. The prism rests on a brass plate which can be rotated on a vertical axis. This axis carries on its lower end the mirror *G* and above it the arm *H* which serves as the handle to rotate the prism and the mirror. A small telescope is adjusted before the mirror which gives an image of a horizontal scale placed at a short distance. By rotating the prism we can cause to pass before the vertical thread of the telescope *C* the entire spectrum of the flame and bring every portion of the spectrum into coincidence with this thread. To every reading made on the scale there corresponds a particular portion of the spectrum. If the spectrum is very weak the cross hair of the telescope *C* is illuminated by means of a lens which throws some of the rays from a lamp through a small opening which is placed laterally in the ocular of the telescope *C*.

Lines Characteristic of Metals

The spectra obtained by means of the pure chlorides above mentioned we have compared with those which we obtained if we introduce the bromides, iodides, hydrated oxides, sulphates, and carbonates of the several metals into the following flames:

into the flame of sulphur,
into the flame of carbon disulphide,
into the flame of aqueous alcohol,
into the non-luminous flame of coal gas,
into the flame of carbonic oxide,
into the flame of hydrogen and
into the oxyhydrogen flame.

From these comprehensive and lengthy investigations whose details we may be permitted to omit, it appears that the difference in the combinations in which the metals were used, the multiplicity of the chemical processes in the several flames, and the enormous differences of temperatures of the latter *exert no influence on the position of the spectral lines corresponding to the individual metals.*

Robert Wilhelm von Bunsen was born March 31, 1811, at Göttingen and died August 16, 1899, at Heidelberg. At 17 he entered the university at his home, at 23 he became a Privat-docent, at 25, teacher of chemistry at the Polytechnic School of Cassel. The next year he began reasearches on cacodyl compounds which lasted six years, cost him the sight of one eye and a bad case of arsenic poisoning, and were the forerunner of later work on arsenicals and other metallo-organic compounds by other chemists. At 28 Bunsen became professor of chemistry at Marburg, where he took up the study of photometric measurements and invented the grease-spot photometer. In 1846, on a vacation trip, he visited Iceland and studied the geological formations there, particularly the geysers, at that time the only known geysers in the world. In 1851 Bunsen went to Breslau, where he met Kirchhoff. The following year Bunsen accepted the chair of chemistry at Heidelberg, and was joined in 1854 by Kirchhoff as professor of physics. Here the two collaborated on the photometric and spectroscopic researches which were the crowning achievement of both men.

Gustav Robert Kirchhoff was born March 12, 1824, at Königsberg, and died October 17, 1887 in Berlin. He attended the university near his home and received his Ph.D. at the age of 23. He was a Privat-docent in Berlin until 1850, when he went to Breslau as extraordinary professor of physics. There, the following year, he met Bunsen. In 1852 he followed Bunsen to Heidelberg, where their joint researches in spectroscopy were made, in 1859-60. Kirchhoff was at that time 35, Bunsen 48. Kirchhoff's other work was in electricity and mathematical physics. His principal book is "Vorlesungen über Mathematische Physik," published in 1876, the year following his removal from Heidelberg to Berlin. Kirchhoff died twelve years before the death of Bunsen, who was 13 years his senior.

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