

λ 1300 platinum is not superior to speculum metal, in fact one or two of my negatives indicate that it is slightly inferior. But beyond λ 1300 the spectrum reflected from the platinum is distinctly the stronger. It would be very interesting to investigate the reflecting power of platinum throughout the region discovered by Lyman (λ 1250– λ 600). As noted above, silicon is a much better reflector than speculum metal in the portion of the spectrum with which this article deals, but, as compared with speculum metal, its reflecting power is growing less as we pass to the shorter wavelengths, whereas in the case of platinum the reflecting power is increasing.

Copper.—Copper spattered readily on glass from a cathode. The mirrors tested were quite opaque. The copper mirrors which I made were markedly inferior to those of speculum metal through the entire region. Hulburt finds that at λ 1850 the copper was slightly better as a reflector than the best speculum metal mirror which he tested.

Nickel.—About three hours were required to produce a brilliant opaque film on glass by cathode deposition. Between λ 1600 and λ 1300 the reflection from nickel and from speculum metal is the same. Beyond λ 1300 the nickel is very slightly superior to the speculum metal.

Aluminium.—Two pieces of aluminium cut from commercial sheet stock were polished by Alvan Clark & Sons Corporation. It was very difficult to polish, but a surface was finally obtained which was quite good. Aluminium reflects very poorly in the Schumann region. Only a few of the stronger groups of lines show in the four-minute exposure.

Silver.—The silver mirror was cut from a coin and polished. Speculum metal is much superior to silver over the whole range upon the plate. At the end of longer wave-length the speculum metal reflects twice as well as does the silver.

Steel.—The steel mirror was hardened and polished by Alvan Clark & Sons Corporation. Steel reflects markedly better than speculum metal from γ 1600 to approximately λ 1300. At λ 1200 the speculum metal reflects slightly better than the steel.

Conclusion.—The reflecting power of nine metals, silicon, stellite, copper, nickel, gold, platinum, aluminium, silver and steel, has been investigated in the portion of the spectrum lying between λ 1600 and λ 1030. The purpose has not been to determine the reflection coefficients on an absolute scale, but rather to determine directly what metals are superior to speculum metal for the construction of reflecting surfaces to be used for light in this region. The results indicate that:

1. Silicon is much the best reflector of all the metals tried, and over a portion of the region it reflects the light approximately twice as well as speculum metal.

2. The reflecting power of platinum as compared with that of speculum metal is increasing as we pass to shorter wave-lengths. It may possess advantages over other metals for work beyond λ 1030.

3. Stellite, copper, nickel, gold and steel show only minor variations of reflection when compared with speculum metal.

4. Silver and aluminium are very much poorer than speculum metal, with silver ranking above aluminium.

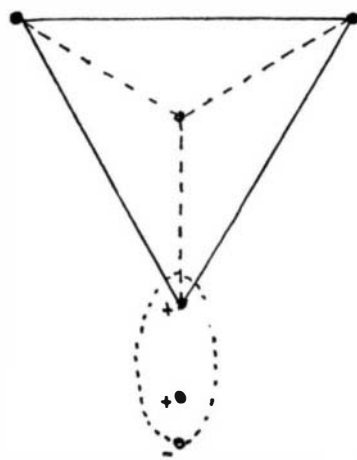
Peat as Locomotive Fuel

REPORTS from Sweden appear to be very favorable as regards the use of peat as a fuel for use upon locomotives, the peat being dried and powdered, and employed in the latter state, which is affirmed to be the best for firing locomotive furnaces. The government railroad administration appointed a commission within a recent date in order to make a thorough examination of powdered peat as a fuel, and after a series of tests upon the preparation and combustion of this substance, the commission reported in its favor, stating that the results were conclusive. The report established the fact that powdered peat can be utilized as a good source of fuel and concluded that it should be employed on a large scale. Accordingly the Swedish government is taking measures to erect a plant of considerable size near the peat fields of Lake Vetter for the purpose of making peat dust. As to the use of this fuel on locomotives, it is stated that all the locomotives on the 60-mile Falköping-Nassjö railroad line are now running on peat fuel with great success. The official tests showed that peat fuel as regards calorific power (by weight) is about two-thirds the value for coal. The results which are already obtained are claimed to justify the erection of large plants to utilize this national resource. In order to keep this production clear of all complicated questions regarding competition from coal, the government decided to have the new plants operated by the state, at least for the present, and is now engaged upon the plans for utilizing several large peat beds. For instance the Hästhagen fields would afford some 20,000 tons of powdered peat per annum, this to be used for the railroads, and on this basis the beds would last 20 years.

A Kinetic Hypothesis to Explain the Function of Electrons in the Chemical Combination of Atoms*

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BEGINNING with Davy¹ and Berzelius, during the first part of the nineteenth century, chemists generally accepted the theory that chemical combination is due to electrical forces, but when Dumas discovered the chloroacetic acids in which chlorine atoms, supposedly negative, replace positive hydrogen atoms it was believed that the theory had been shown to be false and it was practically abandoned. Following this, for fifty years or more, a theory of valence which took no account of electrical forces was developed and while occasional reference was made to positive and negative atoms and groups, no definite meaning in an electrical sense was attached to these expressions. Helmholtz in his Faraday lecture in 1881² drew the attention of chemists once more to the very close connection between chemical forces and electrical phenomena and spoke for the first time of "atoms of electricity." He also pointed out that the "sulfur of sulfuric acid must be charged with positive equivalents of electricity." In 1887 Arrhenius proposed his theory of electrolytic dissociation and with the help of Ostwald and van't Hoff the belief in a separation of molecules into electrically charged parts in solutions was rapidly accepted. J. J. Thomson³ gave precision to the atomic character of electricity in 1897 when he demonstrated the material character of cathode rays and the very minute mass of the corpuscles carrying negative charges. Van't Hoff⁴ seems to have suggested for the first time that electrically charged atoms may play a part in reactions not usually considered as ionic. The same idea was proposed by the author⁵ and by Steiglitz,⁶ a little later. J. J. Thomson⁷ seems to have been the first to suggest that two atoms may be held together by the electrical forces resulting from the transfer of an electron from one to the other. He assumed a shell of electrically positive matter within which there was a



static arrangement of electrons. Abegg⁸ in an entirely independent paper published the same year, discussed the relation between electrons and ionization and the connection with older theories of Helmholtz and others. He also raises, I think for the first time, the question of polar and non-polar valences but seems to have decided that the former are more probable.⁹ Rutherford¹⁰ has advanced strong reasons for considering that atoms contain a positive nucleus around which electrons are rotating and this hypotheses has been further developed by Bohr,¹¹ Nicholson,¹² Moseley¹³ and others.

Physicists in general have directed their attention to rotating or rapidly moving electrons and to the relation between these and spectral lines, the disintegration of atoms and other phenomena involving individual atoms. Chemists, on the other hand, following the suggestion of J. J. Thomson, have considered chiefly the rôle which the valence electrons probably play in the combination of atoms. Sir William Ramsay¹⁴ in his address on "The Electron as an Element" considered that the electron takes a position between the two atoms which are held in combination. In a very recent paper, probably the

last which he wrote,¹⁵ he elaborates this thought further and describes models to illustrate the magnetic attractions which would result from electrons rotating in contiguous parts of two molecules. The magneton theory of the structure of the atom has also been developed elaborately by Parson.¹⁶ It cannot account for ionization where, if we accept the electron theory at all, electrons must be transferred completely from the positive atom or group to the negative. Falk and Nelson,¹⁷ Fry,¹⁸ L. W. Jones,¹⁹ Stieglitz²⁰ Bray and Branch,²¹ G. N. Lewis,²² and others have discussed the phenomena connected with the transfer of valence electrons from one atom to another but, with the exception of the magneton theories referred to above, no one, so far as I can discover, has suggested a possible connection between the motion of the valence electrons and chemical combination between atoms.

In the hypotheses here proposed the following assumptions, now more or less current among physicists and chemists, are made:

1. The atoms are of a complex structure made up of positive nuclei and electrons, of which the latter, at least, are in very rapid motion. If we assume that the electrons are 1/1800 the mass of hydrogen atoms and that they obey the same laws of motion as other atoms, their average velocity would be about sixty times the velocity of molecules of hydrogen (H_2). I will not attempt to discuss here the question whether the law of equipartition of energy actually holds for electrons.

2. That the electrons are of two kinds in their relation to the structure of the atom. Some of them are so involved in their orbits or motions among the positive nuclei that they can never escape from the atom. Others, called valence electrons, may be transferred to other atoms.

Let us suppose that two atoms, which have an affinity for each other are brought close together. A valence electron which is rotating around a positive nucleus in the first atom may find a positive nucleus in the second atom sufficiently close so that it will include the latter in its orbit and it may then continue to describe an orbit about the positive nuclei of the two atoms. During that portion of the orbit within the second atom that atom would become, on the whole, negative while the first atom would be positive. During the other part of the orbit each atom would be electrically neutral, and the atoms might fall apart. When we remember, however, the tremendous velocity of the electrons and the relatively sluggish motions of the atoms it seems evident that the motion of an electron in such an orbit might hold two atoms together. In ionization the electron would, of course, revolve about the nucleus of the negative atom leaving the other atom positive. It seems impossible to explain ionization otherwise than on the supposition of the complete transfer of the electron. This complete transfer in ionization is one of the strongest arguments against the magneton theory as the only explanation of chemical combination.

An interesting feature of the hypothesis proposed is that it may be used to account for that localization of the affinities in particular parts of atoms which is indicated by many of the properties of organic compounds. Thus if we suppose that there are four (or eight) positive nuclei in a carbon atom around which valence electrons may rotate, an atom of hydrogen may be held to the neighborhood of one of these nuclei as indicated in the figure.

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Photographic Color Prints on Silk

THE Manufacture Nationale des Gobelins has recently adopted the process of Messrs. Vallette and Férat for photographic color printing, the process being applied to articles de luxe that cannot well be printed by machine. Three successive impressions are made, in blue, yellow and red. The precision which is required in the superposition of the three impressions is secured by means of a special frame on which the article is stretched with the aid of metallic eyelets. The sensitizers used are alkaline phenols and diazo sulphites, and the colors are developed by exposure to the electric light.—*Engineering*.

¹⁵Ramsay, Sir W., *London, Proc. R. Soc.*, (A), 92, 1916, (451).

¹⁶Parson, A magneton theory of the structure of the atom. *Washington, Smithsonian Inst., Misc. Collect.*, 65, 1915, No. 11.

¹⁷Falk and Nelson, *New York, Sch. Mines Q., Columbia Univ.*, 30, 1909, (179), *J. Amer. Soc., Easton, Pa.*, 32, 1910, (1637).

¹⁸Fry, *J. Amer. Chem. Soc., Easton, Pa.*, 34, 1912, (1268), *Zs. physik. Chem., Leipzig*, 76, 1911, (385, 398, 591).

¹⁹Jones, L. W., *J. Amer. Chem., Easton, Pa.*, 36, 1914, (1268).

²⁰Stieglitz, *Ibid.*, 36, 1914, (272); 38, 1916, (2046).

²¹Bray and Branch, *Ibid.*, 35, 1915, 1913, (1440).

²²Lewis, G. N., *Ibid.*, 35, 1915, (1448).

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¹Davy, *London, Phil. Trans. R. Soc.*, 1807, p. 1.

²Helmholtz, *London, J. Chem. Soc.*, 24, 1881, (291).

³Thomson, J. J., *Phil. Mag., London*, (Ser. 5), 44, 1897, (291).

⁴Van't Hoff, *Ibid.*, 23, 1901, (797).

⁵Noyes, W. A., *J. Amer. Chem. Soc., Easton, Pa.*, 23, 1901, (463).

⁶Stieglitz, *Ibid.*, 23, 1901, (797).

⁷Thomson, J. J., *Phil. Mag., London*, (Ser. 6), 7, 1904, (237).

⁸Abegg, *Zs. Anorg. Chem., Hamburg*, 39, 1904, (330).

⁹*Loc. cit.*, Note 8, p. 347.

¹⁰Rutherford, E., *Phil. Mag., London*, (Ser. 6), 21, 1911, (669).

¹¹Bohr, N., *Ibid.*, 26, 1913, (1,476,857). On p. 862 Bohr discusses the hypothesis that atoms may be held in combination by electrons rotating about the line joining the positive nuclei of two atoms. This is similar to Ramsay's view mentioned below.

¹²Nicholson, *Phil. Mag., London*, (Ser. 6), 27, 1914, (54).

¹³Moseley, *Ibid.*, 26, 1913, (1024).

¹⁴Ramsay, Sir W., *London, J. Chem. Soc.*, 93, 1908, (775).