of disturbance, when by volcanic action or the shrinkage of the earth's crust the deposits became contorted, sometimes tilted or broken like a "chop sea," or gently undulating like the "ground swell" of the ocean.

Farming Implements in Morocco.

An undeveloped yet promising market for farming implements is reported in Morocco by U. S. Vice-Consul John Cobb at Casablanca. In a recent communication that officer, who takes a lively interest in the promotion of American trade, writes that farming implements are much needed in that country, no improvements having been made there in that line since the days of Mohammed the Great, nearly 1,300 years ago. Mr. Cobb believes that our manufacturers will find a large field for operations there, as many of the Moors have money and are particularly fond of useful inventions. They are very conservative, however, and must see an article in use or under conditions in which it can undergo a thorough investigation before they can be made to believe in it. American goods are favorably received by them, and can be made to take the lead. Possibly our manufacturers interested in the export trade may find it worth while to correspond with Mr. Cobb.

PECULIAR STEAM WHISTLING.

Some of our river pilots have become so proficient in the use of the steam whistles of the boats under their charge as to be able to make sounds that are almost articulate in their signification of the wishes or the feelings of the pilots.

Recently a large steamboat, well laden with passengers, was unable to reach its dock on account of a row-boatman who, while leisurely rowing about, had been surprised by the sudden appearance of the steamboat, and in his efforts to get out of its way became confused, and by rowing first one way and then another, annoyed the steamer's pilot; and he, apparently becoming impatient at the delay, expressed his feelings by causing the steamer's whistle to emit a series of short peculiar whistle sounds, which expressed something to the effect of, "Come! come! take one way or another, and get out of my road some time to-day," so plainly that some of the passengers of a neighboring boat noticed it, and one, laughingly referring to the whistling, said: "That is almost equivalent to swearing by steam." The row-boatman seemed to understand it, for he immediately took one way and got out of the steamer's course.

And again the other day we heard the steam siren whistle of one boat caused to salute another, in a most laughably sarcastic manner, as if to say: "Why! how do you do?" The pilot of the other boat endeavored to respond in the same tone, but probably because his boat's whistle was of a different style, he was only able to make it sound something like the first crowing efforts of a chicken.

We have some of the best pilots in the world to manage our river steamboats; and perhaps very few persons think of the great responsibility resting on these men. At times a moment's delay, resulting, perhaps, from sudden sickness or slight mistake of the pilot or engineer, would end in a fearful loss of life and property, and yet accidents rarely occur. We hope, however, that the steam whistling proficiency above mentioned will not lead to any mistakes in regard to the correct interpretation of the established code of whistle signals. L. L. D.

MOLECULAR CHEMISTRY.—No. 4.

H. Schroeder began the study of molecular volumes of solid bodies in 1840, and he has continued it up to the present time. His views, which have been repeatedly modified by his researches extending over so long a period, may be stated as follows in their matured form.

In any mechanical fraction of a uniform mixture, or of a compound, the constituents are contained in exactly the same proportions by weight as they are in the whole mass. The same must hold true for the proportions by volume, provided the given substance is homogeneous. Thus, in detonating gas, made by mixing two volumes of hydrogen with 1 volume of oxygen, we may say that H has the volume 2 and O the volume 1, although in reality both are diffused throughout the space represented by their combined volumes, 3. When the mixture is exploded we get only 2 volumes of H_2O instead of 3. The condensation so produced may be viewed in two ways. We may suppose that the compound is condensed as such, or else that its constituents suffer a change of volume before entering into combination, and that the volume of the compound is the sum of the volumes of its condensed constituents. The law of multiple proportions by weight may thus be made applicable to volumes. Experience has shown that every element varies so much in volume throughout the series of combinations into which it enters, that the volume of its molecule may be 2, 3, 4, 5, 6, etc., times as great in one compound as in another.

Among these numbers the factor 2 predominates just as it does in gases, where, for example, H_2 is first condensed to 1 volume and then combines with O to form 2 volumes instead of 3. In the case of solids these condensations of volume seem to depend on the forces that cause bodies to crystallize, since an element belonging to two bodies that have the same crystalline form (isomorphous bodies) is usually condensed equally in both. In other words, the volumes of elements common to a number of isomorphous bodies are generally the same. The volume of potassium (K) found, as has been explained, by dividing its molecular weight by its density, is 45·3; that of sodium (Na) is 23·9; difference, K − Na = 21·4. The difference in the volumes of their chlorides, KCl = 37·4 and NaCl = 27·1, is 10·3, or practically one half the difference of the metallic volumes of K and Na. The same result is obtained from the bromides: KBr = 44·3, NaBr = 33·4; difference, 10·9. And from the iodides: KI = 54, NaI = 43·5; difference, 10·5. Now considering the Cl volume the same in both chlorides, the Br volume the same in both bromides, and the I volume the same in both iodides, it is evident that the metals in these compounds have been condensed to one half their original volumes.

When other metals are compared in this manner with their isomorphous compounds it was found that in pairs containing strontium and lead, sodium and silver, magnesium and nickel, aluminum and iron, the heavy metals often entered into combination with their volume unchanged, while the light metals were condensed one half. Schroeder believes that this occurs too frequently to be accidental. In the rhombic sulphates and carbonates of strontium and of lead, in their oxides, in the bromides, chlorides, and iodides of sodium, and of silver, etc., the differences of volume are equal to the unchanged volume of the heavy metal minus one half the volume of the light one.

While comparing the volumes of numerous compounds in this manner Schroeder was struck by the fact that the oxygen in quartz would have exactly the same volume as the silicon associated with it, on the supposition that the silicon retains the volume that belongs to it in the free state. Finding similar relations in other compounds, he conceived the idea that the molecular volumes of the constituents might have a common measure of which they are all multiples. To this common measure he gives the name of stere. A few examples will illustrate his meaning:

Volume KI = 54·0	KCl = 37·8
NaI = 43·2	NaCl = 27·0
K − Na = 10·8	K − Na = 10·8 = 2 × 5·4
Volume NaI = 43·2	NaCl = 27·0
LiI = 37·8	LiCl = 21·6
Na − Li = 5·4	Na − Li = 5·4 = 1× 5·4
Volume RbI = 70·2	RbCl = 54·0
KI = 54·0	KCl = 37·8
Rb − K = $\overline{16·2}$	Rb − K = $\overline{16·2}$ = 3 × 5·4.

Again, twice the volume of LiCl (2 × 21·6) is equal to the volume of NaI (43·2); twice NaCl (2 × 27·0) = KI (54·0), etc. Hence 1 volume I = 2 volumes Cl, 1 volume Na = 2 volumes Li, and 1 volume K = 2 volumes Na. We have found, then, that these substances, as well as their differences, have a common measure; and this is what Schroeder means by the expression that they have the stere 5·4.

But this is not all. Comparing still further, we get the following differences of volume:

RbI = 70·2	KI = 54·0	NaI = 43·2	LiI = 37·8
RbCl = 54·0	KCl = 37·8	NaCl = 27·0	LiCl = 21·6
I − Cl = $\overline{16·2}$	I − Cl = $\overline{16·2}$	I − Cl = $\overline{16·2}$	I − Cl = $\overline{16·2}$ = 3 × 5·4

In other words, iodine and chlorine have the same stere as the metals with which they are in each case associated. From these and many analogous examples Schroeder has quite recently generalized the proposition: "In every compound a definite volumic measure or stere predominates and causes all the components to subordinate themselves to it."

As many isomorphous bodies, such as KCl and NaCl, magnesite and calcite, potassium sulphate, selenate and chromate, have the same stere, it was natural to connect the latter with the crystalline form. Further extensive research has shown, however, that the stere does not depend directly upon the form; that there are isomorphous bodies with unlike, and heteromorphous bodies with like steres. It was found that the stere of a compound is determined entirely by that of one of its elements, which impresses its own stere on all the rest. The fact that isomorphous bodies so often have equal steres is explained by the reason that their controlling elements are also isosteric. Thus the rhombohedric carbonates of magnesia, manganese, and lime, are isosteric because Mg, Mn, and Ca have the same stere. From these observations Schroeder deduces the following law, which he calls the steric law: "In every compound the stere of one of the components predominates, in consequence of the forces active during crystallization, and impresses itself upon all the others." For example, the stere of silver (Ag) is 5·14, one half the volume 10·28, calculated from its density and equivalent. AgCl has a volume of 25·70 or 5 × 5·14; AgI = 41·1, or 8 × 5·14; AgBr = 30·84, or 6 × 5·14; Ag_2O = 30·8, or 6 × 5·14; $C_2H_3O_2Ag$ = 51·4, or 10 × 5·14. All these volumes are exact multiples of the silver stere, and consequently the other elements associated with silver must also have assumed volumes divisible by 5·14, as the law requires.

The steres of all the elements hitherto determined lie between the narrow limits of 5·0 and 6·1. Thus carbon has a stere of 5·11, which it impresses on a series of organic bodies; phosphorus and arsenic cause most of their compounds to assume the stere 5·3, etc.

In Liebig's *Annalen* for 1874, and more recently in the report of the session of the Munich Academy of Sciences, December 1, 1877, Schroeder shows the applicability of his law to five important groups:

1. Silicon, quartz, sillimanite, disthene. Stere, 5·65.
2. Aluminum, corundum, chrysoberyl, diospore, andalusite. Stere, 5·14.
3. Magnesium, periclase, spinelle, olivine, diopside, humite, and garnets. Stere, 5·52.
4. Oxides and silicates of manganese. Stere, 5·52.
5. Sulphides and arsenides of iron, cobalt, nickel, copper, zinc, and lead.

Those who desire more detailed information on these points are referred to the above memoirs, and also to Liebig's *Annalen* for 1878, and to the Berlin *Chem. Gesell.* for May, 1878.

A very important corollary follows from Schroeder's law. If bodies combine only in whole volumes or steres, we can determine the molecular constitution of solids, because their molecules must contain a sufficient number of atoms to bring out the volume of each constituent as an entire multiple of the controlling stere. Thus the volume of silicon determined from its density was found to be 11·3, and its stere is consequently 5·65. To express the fact that the silicon molecule occupies two steres, Schroeder writes Si_1^2, the upper right hand exponent representing the number of steres, and the lower the number of atoms. Now the volume of quartz, to which allusion has been made before, is just double that of silicon; consequently it contains four steres, two of which belong to oxygen, and its molecular formula is written $\overline{Si}_1^2\ O_2^2$, with a line over Si to show that the compound is controlled or dominated by the silicon stere. In his calculations Schroeder marks the steres with a line drawn above, and the volumes with a line drawn below the figures; thus, $\overline{Si}_1^2\ O_2^2 = 4 \times \overline{5·65} = \underline{22·6}$. Take another example:

Corundum $\overline{Al}_2^2\ O_3^3 = 5 \times \overline{5·14} = 25·7$. This means that in corundum, as in most oxides, each oxygen atom occupies one stere; that aluminum is present with one half its metallic volume, $\frac{10·28}{2} = 5·14$; that the aluminum stere 5·14 impresses itself upon all the atoms present; and that the observed volume of corundum, 25·7, is made up of the equal volumes of five such atoms, two of aluminum and three of oxygen.

But this is not all. If the atomic weights are taken in grammes, the volumes will be expressed in cubic centimeters; thus $\overline{Ag}_1^2 = 2 \times \overline{5·14} = \underline{10·28}$ means that one atom of silver or 108 grammes occupies a space of 10·28 cubic centimeters, or of two silver steres, each equal to 5·14 c.c.

A few examples will suffice to show the manner of arriving at the molecular formulas of compounds.

The observed volume of chloride of silver is 25·7, as has been stated before. This is equal to five silver steres (5 × 5·14 = 25·7). As two of these belong to the silver present, we have left three for the chlorine, and we write $\overline{Ag}_1^2\ Cl_1^3 = 5 \times \overline{5·14} = 25·7$.

The observed volume of iodide of silver is 41·12, or eight times the silver stere. Subtracting two steres for Ag, there remain six for the iodine, and we have $Ag_1^2\ I_1^6 = 8 \times \overline{5·14} = 41·12$.

The observed volume of bromide of silver is 30·84, or 6 × 5·14. Our formula is, therefore, $Ag_1^2\ Br_1^4 = 6 \times 5·14 = 30·84$.

The volumic constitution of the iodides and chlorides of the alkaline metals is determined from the data already given:

$K_1^4\ I_1^6 = 10 \times \overline{5·4} = 54·0$	$K_1^4\ Cl_1^3 = 7 \times 5·4 = \underline{37·8}$
$Na_1^2\ I_1^6 = 8 \times \overline{5·4} = 43·2$	$Na_1^2\ Cl_1^3 = 5 \times 5·4 = 27·0$
$Li_1^1\ I_1^6 = 7 \times \overline{5·4} = \underline{37·8}$	$Li_1^1\ Cl_1^3 = 4 \times \overline{5·4} = \underline{21·6}$

Rubidium was found to contain three steres more than potassium; we have, therefore:

$Rb_1^7\ I_1^6 = 13 \times \overline{5·4} = \underline{70·2}$	$Rb_1^7\ Cl_1^3 = 10 \times 5·4 = \underline{54·6}$

Again, rubidium was found to have double the volume of ammonium, and we must, therefore, write $Am_2^7\ Cl_2^6 = 13 \times \overline{5·4} = 70·2$, or twice the observed volume 35·1. The bromides have been calculated in the same way.

The difference in the densities and volumes of the two varieties of cinnabar is explained as follows: Amorphous black cinnabar is $\overline{Hg}_2^5\ S_2^6 = 11 \times \overline{5·52} = 60·72$, or twice the observed volume 30·36; while red rhombohedric cinnabar is $Hg_2^5\ \overline{S}_2^6 = 11 \times \overline{5·30} = 58·30$, or twice the observed volume 29·10. In the black variety the mercury stere predominates, while the red is ruled by the sulphur stere.

Schroeder has the modesty to call his steric law simply a hypothesis, but he believes that it will force its way into general acceptance; and he concludes his memoir with the following general statements. Bodies combine only in whole volumes having whole steres, just as they have only whole atoms. Simple volumic relations are perceived in gases at equal temperatures and pressures, in liquids at temperatures producing an equal tension of their vapors, and in solids when the steres of their controlling elements are ascertained.

C. F. K.

Formation of Coal.

E. Fremy holds that there are several kinds of isomeric cellulose, constituting the skeleton of plants. Coal is not an organized substance. The vegetal impressions presented by coal are produced as in shales or other mineral matters. The chief substances contained in the cells of plants under the double influence of heat and pressure produce bodies having a great analogy to coal. The pigments, the resins, and the fats of leaves, if submitted to heat and pressure, yield compounds which approximate to bitumens. The vegetable matter which gave rise to coal has undergone, first, the peaty fermentation, the coal being then formed by a secondary transformation.

H. W. WILEY finds that one part of uranine in one million parts of water is readily detected by means of the spectroscope.