

ments referred to in Rankine's "Civil Engineering," it may be said that the average strength of Fujisan lies between that of rubble work and sandstone; Iwakisan, Nantaisan, and Alaid are like good rubble masonry, while the strength of the ill-fated Krakatão is not much above that of ordinary brickwork.

8. *Theoretical Mountains*.—As it might be interesting to compare actual mountains with theoretical mountains constructed from the equation—

$$v = \frac{c}{2} \left(\frac{z}{c} - e^{-\frac{z}{c}} \right)$$

such mountains have been drawn, and are shown in Fig. 2. The values of c are given in the following table.

In drawing up the table the instantaneous breaking strength of granite and its crumbling strength, which is the largest possible value for k , are taken as being equal. For sandstone the crumbling strength is assumed to be three-fourths of the breaking strength, while for rubble work and brickwork it has been taken as one-half.

Material	Instantaneous breaking strength in lbs. square feet	Crumbling strength or k in lbs.	Weight cubic foot lbs.	$c = \frac{2k}{\rho}$
Granite	1,584,000	1,580,000	170	18,500
Sandstone.....	790,000	590,000	144	8,200
Rubble masonry ...	316,000	150,000	120	2,500
Brickwork	144,000	72,000	112	1,300

The diameter of the base of each of these mountains is 48,000 feet, and the height to which mountains of the following different materials could be built upon such a base without crushing would approximately be :—

Brickwork	4,600 feet	Sandstone.....	14,500 feet
Rubble masonry ..	7,300 ,,	Granite	20,000 ,,

9. *Causes Modifying Volcanic Forms*.—Causes modifying the natural curvature of a mountain are :—

(1) The tendency during the building up of the mountain of the larger particles to roll farther down the mountain than the smaller particles.

(2) The effects of atmospheric denudation, which carries materials from the top of the mountain down towards the base.

(3) The position of the crater, and the direction in which the materials are ejected.

(4) The existence of parasitic craters on the flanks of a mountain.

(5) The direction of the wind during an eruption.

(6) The sinking of a mountain in consequence of evisceration beneath its base.

(7) The expansions and contractions at the base of a mountain due to the acquisition or loss of heat before and after eruptions.

10. *Effect of Volcanic Eruptions on the People*.—The eruptions in Japan from time to time have exerted a very marked influence upon the minds of the Japanese people. Divine interference has been sought to prevent eruptions, priests have been ordered to pray, taxes have been repealed, charities have been instituted, special prayers against volcanic disturbances have been formulated, and have remained in use for the period of 100 years, while special days for the annual offering up of these prayers have been appointed. At the present day a form of worship to mountain deities is not uncommon.

SOLUTION¹

Opening of the Discussion by Prof. Tilden

FOR want of time, the consideration of various phenomena connected with the subject was necessarily omitted. Thus no reference could be made to the various formulæ relating to expansion or density of solutions, nor to their optical properties, magnetic rotation, nor to the subject of electrolysis. In what follows, a review is presented of the principal phenomena observed in the act of solution of solids (especially metallic salts and other comparatively simple compounds) in liquids, and the chief properties of the resulting solutions, with the object of arriving (if possible) at some conclusion as to the physical explanation of the facts. The question must at once arise whether these phenomena are to be considered as chemical or mechanical, and all the theories which have been put forward to explain the nature of solution are roughly divisible into two classes, according as, on the one hand, they represent the process as a kind of chemical combination, or, on the other, explain the

phenomena by reference to the mechanical intermixture of molecules, or by the influence of the rival attractions of cohesion in the solid and liquid, and of adhesion of the solid to the liquid. The former hypothesis seems to have been universally adopted by the older writers, such as Henry and Turner, and it seems pretty clear that Berthollet also regarded solution as an act of chemical combination. Among modern chemists, Prof. Josiah P. Cooke takes a similar view, but M. Berthelot is the most consistent and powerful supporter of the same hypothesis. In his "Mécanique Chimique," tome ii. p. 160, will be found a very clear and formal statement of the views upon this subject which, it is interesting to know, are retained by M. Berthelot without modification in any essential particular.

On the other hand, there are a number of writers who, whilst referring the phenomena of solution to a molecular attraction of some kind, do not attribute solubility to the formation of chemical compounds of definite composition. Graham distinctly ranges himself on this side. Brande also appears to have taken a similar view; Daniell, Miller, Nicol, and Dossios may be more or less ranked with them. A theory differing in some important respects from those of the above writers was briefly enunciated in a paper communicated to the Royal Society by Tilden and Shenstone in 1883. In discussing the connection between fusibility and solubility of salts, the authors point out that the facts tend to "support a kinetic theory of solution, based on the mechanical theory of heat. The solution of a solid in a liquid would accordingly be analogous to the sublimation of a solid into a gas, and proceeds from the intermixture of molecules detached from the solid with those of the surrounding liquid. Such a process is promoted by rise of temperature, partly because the molecules of the still solid substance make longer excursions from their normal centre when heated, partly because they are subjected to more violent encounter with the moving molecules of liquid." This theory, however, only relates to the initial stage of the process of solution, and does not sufficiently explain saturation nor the influence of dissolved substances upon vapour-pressure, specific heat, specific volume, &c. How far is it true that evolution of heat indicates chemical combination: does the evolution of heat which often takes place on dissolving a solid in water, or on adding more water to its solution, indicate the formation of hydrates, *i.e.* compounds of the dissolved body with water in definite proportions? Thomsen answers this question in the negative ("Thermochemische Untersuch.," Band iii. p. 20).

Take the case of sulphuric anhydride (SO₂). It is evident from the diagram exhibited that more than half the total evolution of heat occurs on addition of the first molecule of water to the solid substance; yet the succeeding molecules give quite an appreciable thermal change. At what point in such a curve should we be justified in setting up a distinction between the effect due to chemical combination and that due to other causes, such as the change of volume consequent on dilution or the possible loss of energy from the adjustment of the motion of the molecules of the constituents to the conditions requisite for the formation of a homogeneous liquid, or (though not in the present case) the decomposition of the compound by the water? In the act of solution of the solids, and especially of anhydrous salts in water, the volume of the solution is always less than the sum of the volumes of the solid and its solvent, with the exception of some ammonium salts in which expansion occurs. Similarly the addition of water to a solution is followed by contraction. This contraction may be due to mere mechanical fitting of the molecules of the one liquid into the interspaces between the molecules of the other (see Mendelejeff's abstract in *Journ. Chem. Soc.*, Feb. 1885, p. 114). This would probably not be attended by loss of energy. Or the contraction may arise from the readjustment of molecular motion already referred to.

If we know the coefficient of expansion of the liquid and its specific heat, we can calculate the amount of heat evolved for a given contraction. If this is done for sulphuric acid, and many other cases, it is found that, after accounting for the thermal change due to alteration of volume alone, there is a surplus of heat evolved which may really indicate some kind or some amount of chemical combination.

Thomsen has found that as a rule the heat of solution and of dilution are both either positive or negative. Of thirty-five salts examined, only four supply well-marked exceptions. However we may ultimately explain the anomaly exhibited by these salts, the fact remains that the heat evolved or absorbed during the admixture of any substance with water is in every case a continuous function of the quantity of water added. Similarly

¹ Report of a discussion at the Birmingham meeting of the British Association.

the contraction which ensues on diluting an aqueous solution proceeds continuously, and the molecular volume of a salt in solutions of different strengths is continuously greater the larger the amount of salt present. So that in none of these thermal or volumetric phenomena is any discontinuity observed, or any indication of the formation of compounds of definite composition, distinguishable by characteristic properties.

The question we are now considering, as to whether in a solution the solvent and the substance dissolved in it—or any portion thereof—exist independently of each other, is in some degree answered by the facts known as to the specific heats and vapour-pressures. For instance, when water is added to a solution of sodium nitrate, the molecular heat of the resulting liquid seems to show that all the water added is influenced at least until a very large quantity is present. In this case one molecule of sodium nitrate can affect the movements of a hundred molecules of water, and probably more. It is also well known that the vapour-pressures of water holding in solution almost any dissolved solid is less than the vapour-pressure of pure water, and that the boiling-point of a liquid is raised by the addition to it of any soluble non-volatile substance. This fact of reduction of pressure can only be explained upon the hypothesis that there is no free water present at all; that is, that there is no water present which is not more or less under the influence of the dissolved substance.

What becomes of water of crystallisation forms a part of the same question as to the relation of solvent to solute. Observed facts lead us to conclude that white copper sulphate, blue anhydrous cobalt chloride—and, by analogy, other salts which are colourless—retain their hold upon water of crystallisation when they are dissolved in water. A very important observation has been made by Dr. Nicol which bears directly upon this question. In his study of the molecular volumes of salt solutions he finds that, when a salt containing water of crystallisation is dissolved, this water is indistinguishable by its volume from the rest of the water of the solution. In the report presented to the British Association last year, the following passage occurs: "These results point to the presence in solution of what may be termed the anhydrous salt in contradistinction to the view that a hydrate, definite or indefinite results from solution; or in other words, no part of the water in a solution is in a position relatively to the salt different from the remainder."

These two statements, however, are not strictly consequent upon each other. The view seems preferable that (save, perhaps, in excessively dilute solutions) the dissolved substance is attached in some mysterious way—it matters not whether it be supposed to be chemical or physical—to the whole of the water. We cannot otherwise get over the difficulty presented by the hydrated salts, which give coloured solutions, by the control of the vapour-pressure of the dissolved salt, and by the altered specific heat. With regard to water of crystallisation, E. Wiedemann has shown that hydrated salts in general expand enormously at the melting-point; and the observations of Thorpe and Watts on the specific volume of water of crystallisation in the sulphates of the so-called magnesium group show that, whilst the constitutional water occupies less space than the remaining molecules, each successive additional molecule occupies a gradually increasing volume. So that when a salt, with its water of crystallisation, passes into the liquid state (either by melting or by solution in water), it requires a very slight relaxation of the bonds which hold the water to the salt for it to acquire the full volume of liquid water, whilst the water of constitution is not so easily released. And this conclusion accords with Nicol's observations on the molecular volumes of the salts when in solution.

Now comes the question as to what determines the solubility of a substance. Why, for example, is magnesium sulphate very soluble in water, whilst barium sulphate is almost totally insoluble? With regard to salts the following propositions seem to be true:—(1) Nearly all salts which contain water of crystallisation are soluble in water, and for the most part are easily soluble; (2) insoluble salts are almost always destitute of water of crystallisation and rarely contain the elements of water; (3) in a series of salts containing nearly allied metals the solubility, and capacity for uniting with water of crystallisation generally, diminish as the atomic weight increases.

The fusibility of a substance has also much to do with its solubility. Neither fusibility alone nor chemical constitution alone seems to be sufficient to determine whether a solid shall be soluble or not. But it may be taken as a rule to which there

are no exceptions that when there is a close connection in chemical constitution between a liquid and a solid, and the solid is at the same time easily fusible, it will also be easily soluble in that liquid.

Salts containing water of crystallisation may be considered as closely resembling water itself, and these are for the most part both easily fusible and easily soluble in water. But space is wanting for the discussion of the details of these matters, as well as of the relation of molecular volume to fusibility of solids.

The fascinating character of the phenomena of supersaturation has attracted a host of experimenters, but no definite explanation has been generally accepted. In the opinion of the speaker supersaturation is identical with superfusion. Supersaturated solution of, say, alum, thiosulphate of sodium melted in its water of crystallisation, and fused sulphur at 100°, exhibit phenomena of exactly the same kind.

Finally, we are led to the consideration of what is meant by chemical combination. From the phenomena under discussion, and others, the conclusion seems inevitable that chemical combination is not to be distinguished by any absolute criterion from mere physical or mechanical aggregation; and it will probably turn out ultimately that chemical combination differs from mechanical combination, called cohesion or adhesion, chiefly in the fact that the atoms or molecules of the bodies concerned come relatively closer together, and the consequent loss of energy is greater.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—Of the students in Natural Science entered at Cambridge this term no fewer than 116 have already announced their intention of studying medicine.

DUBLIN.—The Senate of the Royal University has conferred the degree of Doctor of Science *honoris causa* upon James Bell, Ph.D., F.R.S., Principal of the Somerset House Laboratory.

SCIENTIFIC SERIALS

Revue d'Anthropologie, troisième série, tome 1, Paris, 1886.—On the Simian characters of the Naulette jaw, by M. Topinard. This celebrated find, which was discovered at the bottom of an obscure cavern 25 m. below the present level of the Lesse, near Dinant, in Belgium, is chiefly remarkable for its excessive prognathism, which is due alike to the great thickness of the horizontal branch of the jaw when compared with its height, and to the special obliquity of the axis of the alveolus of the second molar. In its relative proportions the Naulette jaw must be characterised not only as non-human, but as plus-Simian. A careful comparison of the Naulette jaw with the maxillary processes of the anthropoids, and of several of the lowest extant human races, has led M. Topinard to the conclusion that in the age of the mammoth, tichorine rhinoceros, and cave-bear, there had already appeared numerous mixed human types, to one of the lowest of which it may be presumed that the Naulette jaw belonged.—On the population of Bambouk, on the Niger, by Dr. Colin. An interesting paper on an extensive, but very imperfectly-known, region of Western Soudan, exclusively inhabited by a branch of the great Manding race, known as the Mali-nkès. The Bambouk territories, more than 600 kilometres in length, and from 80 to 150 in width, are divided into numerous little States, most of which enjoy a complete autonomy. Their want of consolidation, and the indifference of the people to all forms of religion, have made the Mali-nkès objects of contempt to their Mussulman black neighbours, but according to the narrations of the Griotes, or itinerant bards, who are to be met with in every part of Western Africa, they had at one time extended their dominion over all the tribes on the right banks of the Niger, and were preparing to invade Saigon when the advance of the French forced them to fall back within their original limits. For a time they submitted to the restrictions of Mohammedanism, but now they appear to have absolutely no religion. They prepare an intoxicating drink from honey, called "dolo," in which women as well as men indulge to excess. The men are indolent, hunting only to avert starvation, and working their exten-