have a good knowledge of the principles of chemistry. Sanitary inspectors should be familiar with certain chemical tests which would enable them to make preliminary examinations, and to determine how far the aid of the chemist is necessary. There is room in the community for a class of persons knowing a little engineering, a little chemistry, a little biology, and a little of other things, an occupation legitimate and honorable, but one which does not justify our calling a person so posted a sanitary engineer, or a chemist.

PROCEEDINGS OF THE SECTION OF CHEMISTRY.

THE meeting of the chemical section had an unusually large attendance; and Ann Arbor, not having very many attractions to withdraw the attention of members, allowed all chemists in attendance to be present. The total number of papers presented was small, — in all only seventeen. Of these one was not chemical, one was every thing, one organic, one applied, two mathematical, two pharmaceutical, three theoretical, and six analytical. The meeting, while not brilliant, was respectable, and was remarkable chiefly for the absence of the older and more renowned chemists of the country. It would certainly be an advantage if these would more generally endeavor to attend the meetings of the association, and encourage the younger members by their counsel. Following is a brief synopsis of the more important papers presented: —

Prof. A. B. Prescott gave results of experiments made under his direction, fixing the limits of recovery of certain poisons when mixed with organic matter, such as meat and bread.

Prof. W. A. Noyes read a paper on para-nitrobenzoic sulphunide. This body belongs to the class of sulphunides, the first representative of which was discovered by Fahlberg. The new substance is remarkable, in that it retains the imide grouping peculiar to the sulphunides in its salts. This nitro-sulphunide is intensely bitter, while benzoic sulphunide is probably the sweetest substance known.

Dr. H. W. Wiley presented a method of estimating lactic and acetic acids in sour milk or koumiss. The caseine is precipitated by adding an equal volume of strong alcohol to the milk. After filtering, the acid is determined in the filtrate, using phenyl-phthalein as indicator. The same author spoke of the composition of koumiss made from cow's milk. The analyses show a lower percentage of alcohol and lactic acid, and a higher one of milk-sugar and fat, than are found in European samples, whether made from cow or mare's milk. The adulteration of honey was also discussed by Dr. Wiley. The honeys of commerce are found to be largely adulterated. The substances most used for this purpose are, starch-sugar sirup (glucose), cane-sugar, and inverted cane-sugar. Results of numerous analyses made at the department of agriculture were given, and a comparison of American honeys made with those of Europe.

Messrs. H. W. Wiley and F. V. Broadbent described a new method of estimating water in glucose, honeys, etc. Samples are dissolved in alcohol mixed with a weighed portion of sand, and dried. After cooling to 70° C, they are saturated with absolute alcohol, and dried again to constant weight.

Messrs. E. H. Cowles, A. H. Cowles, and C. F. Mabery, presented an important and interesting paper on a new electric furnace, and aluminum alloys made in it. The furnace is of fire-clay. The mass to be acted on is mixed intimately with finely-powdered gas-carbon, and is placed in the break between the two electrodes, which are inserted in the two ends of the furnace, and connected with a powerful dynamo-electric machine. The mass to be reduced is surrounded with coarsely pulverized charcoal, to prevent the heat produced from attacking the fire-clay furnace. The temperature of the furnace is high enough to produce an alloy of copper and aluminum, when the aluminum is present in the state of oxide, or even of silicate. The aluminum alloys produced by this method cost much less than when made in the old way. The five per cent aluminum alloy is a close approximation in color to 18 carat gold, and does not readily tarnish. Its tensile strength, in the form of castings, is equivalent to a strain of 68,000 lbs. to the square inch. An alloy containing two or three per cent aluminum is stronger than brass, possesses great permanency of color, and would make an excellent substitute for that metal. The effect of silicon in the small portions, upon copper, is to greatly increase its tensile strength; and copper and silicon alloys are made easily in the furnace. When more than five per cent of silicon is present, the product is extremely brittle. Alloys of copper and boron have also been made. Boron seems to act upon copper as carbon does on iron. A small percentage of boron in copper increases its tensile strength to 50,000 or 60,000 lbs. per square inch, without diminishing to any great extent its conductivity. Aluminum seems to increase very considerably the strength of metals with which it is alloyed. An alloy of copper, nickel, and zinc, containing a small percentage of aluminum, has been named 'Hercules metal,' and withstood a strain of 105,000 lbs. to the square inch. The strength of common brass is doubled by the addition of two to three per cent of aluminum. Alloys of aluminum and iron are obtained, without difficulty, in the furnace. One product was analyzed containing forty per cent of aluminum.

A chemical study of Yucca angustifolia was presented by Miss Helen C. D. Abbott. Besides many of the usual constituents found in plants, the following were detected: manganese in the ash, four fixed oils, a new resin which it is proposed to name yuccal, another new resin which it is proposed to name pyrophaeal, a red crystalline coloring matter, a new gum, four crystalline compounds, and saponin. In the subterranean part of the yucca the oil extracted from the bark is solid at ordinary temperatures; from the wood it is of a less solid consistency, while the yellow base of the leaf contains an oil quite soft; and in the green leaf the oil is still more fluid. Yuccal was obtained from the bark and wood of the root. It is a transparent ruby-colored substance, melts at 70° C, and its specific gravity is 1.091. A blood-red color reaction was obtained by warming the resin with ammonium molybdate, and a few drops of strong nitric acid. Pyrophaeal was extracted from the yellow base of the leaf, and melts at 79° C. The amount of saponin obtained in the wood varied from 8.95 per cent to 10.4 per cent. Saponin was also found in the bark and leaves of the plant.

Prof. F. P. Dunnington described a method of fixing crayon drawings. The drawings made on unsized manila paper are saturated with a preparation consisting of one part Damar varnish, and twenty-five parts turpentine. After drying, they are ready for use. A paper by the same author describes a peculiar porous mineral containing titanic acid, found on a steep mountain side, and evidently of igneous origin. The surrounding soil was found also to contain titanic acid. The origin of the mass is somewhat uncertain.

Mr. O. C. Johnson presented a paper on negative bonds, and a rule for balancing equations. After giving rules for determining bonds, the author presented his views of simple oxidation, oxidation with combination, double oxidation and complex oxidation in their relations to chemical equations.

Mr. A. V. E. Young presented a study of the thermo-chemical reaction between potassic hydrate and common alum. After describing the experiments which had been made, the following conclusions were reached: 1°. That if potassic hydrate in excess be added to alum, there results a characteristic distribution of constituents between the soluble and insoluble portions of the mixture. 2°. This distribution is a function of temperature, as well as of dilution and mass. 3°. This phenomenon is probably due to dissociation by water of compounds Al_2O_3, and SO_3, and of potassic aluminate.

Prof. J. W. Langley read a paper on the results of an investigation of the concentration produced by the differential action of chemism on certain acid radicles. The paper showed, that, by this action (as for instance when a copper plate is suspended in solution of argentic nitrate), the NO_3 divided into two parts, having an approximate ratio of 1:3. Copper and zinc in aqueous bromine behave in the same way. Copper in solution of ferric chloride, and zinc in solution of copper sulphate, produce a concentration of the radicle in opposition to gravitation.

By communication with the various members of the section, the secretary had arranged the following question for discussion: What is the best initiatory work for students entering upon laboratory practice?

Dr. H. W. Wiley was requested to open the discussion. He said it was with laboratory work largely as Pope said about governments, 'What's best administered is best.' Students beginning laboratory work should understand at once that chemical science is no guess-work, but a science of definite proportions. They should learn the use of the balance, and their experimental work in general chemistry should be conducted quantitatively from the start. Students should be taught to rely upon themselves: their faculties of observation and powers of reason should be developed. At first they should be kept as much as possible from books, and from too garrulous professors. They should be told nothing of the physical and chemical properties of a body, which, by proper diligence, and under wise direction, they might find out for themselves. For instance, in studying hydrogen, the student should be directed to take definite quantities of zinc and sulphuric acid, to measure the volume of gas given off, to dry and weigh the residual zinc sulphate, and study its properties, etc. Whether beginning students should be kept at work in the study of general chemistry, or be taught also analytical work, will depend largely upon the judgment and taste of the instructor. Laboratory work, in order to give its full benefit, must be combined with lectures and recitations: and through it all, the work illustrating stoichiometry must be fully done and comprehended. The progress of the work should be gauged neither for the dullest nor brightest pupil, but the middle course will be found best. In all cases, much will depend on the judicious oversight and guidance of the instructor.

Prof. R. B. Warder asked whether it were better to begin with gases or with metals? He was inclined to prefer metals, since their properties were more easily discovered. Prof. F. P. Dunnington suggested a course of metallurgy and assaying as being well adapted to a student's initial laboratory work; afterwards the use of the blow-pipe could be introduced. Mr. Thos. Antisell said that the object of instruction ought to be considered in determining its character. If the study of chemistry was begun only as a part of a liberal education, the course of instruction should be largely qualitative analytical work. On the other hand, if the pupil was looking forward to chemistry as a profession, it would be better to put him to quantitative work.

Prof. A. B. Prescott was impressed with the idea that the study of chemistry might be approached in two ways; viz., as descriptive chemistry, and, experimentally, in general chemistry. Students should, in analytical work, practice first on known bodies before beginning on unknowns. Care must be taken not to place too much reliance on laboratory work alone. It is of the utmost importance that rigid class-work in the lecture and recitation rooms go along with the experimental work in the laboratory. As great a mistake may be made by relying on laboratory work alone as there was formerly by neglecting it altogether.

Prof. C. F. Mabery regretted that chemistry was not taught practically in high schools and academies. School trustees generally thought that seventy-five dollars a year was a liberal allowance for laboratory purposes. He would have young people begin with common phenomena, such as the rusting of iron, etc.

He would insist on his pupils mastering the principles of stoichiometry, and in working, as far as possible, quantitatively, even in general chemistry. Mr. C. L. Mees heartily indorsed the ideas advanced by Professor Mabery. For three hundred dollars, a good practical chemical laboratory could be established in high schools, which, if properly conducted, would result in great good. He would insist on a student repeating his work until it was exact. No careless work should be allowed. Mr. C. W. Kolbe gave an illustration of high-school instruction in chemistry, which was evidently purely bookish. The young man who had passed a brilliant examination in stoichiometry failed to do the simplest kind of a problem afterwards, because, he said, 'it was not in the book.' Miss L. J. Martin thought chemistry should be taught in high schools so as to make the pupils think, and not become mere machines. Prof. O. C. Johnson gave an amusing account of the failure to develop the sense perceptions, which he thought should be an important part of laboratory instruction. Messrs. Bennett, Sheppard, Smith, and the acting vice-president, Lupton, also took part in the discussion.

The second subject discussed was, 'To what extent is the knowledge of molecular physics necessary for one who would teach theoretical chemistry ?

Prof. J. W. Langley was invited to open the discussion on this topic. He gave a very clear and satisfactory exposition of the dependence of chemistry upon physics, and of their close relation to one another. He drew attention to the fact, that only under fixed or limited ranges of physical conditions do the ordinarily accepted reactions and chemical affinities manifest themselves. Professors Prescott and Lupton took part in the discussion, showing the advisability of delaying any attempts to teach the higher branches of physics until the student had advanced well in practical laboratory work.

THE SECOND LAW OF THERMODYNAMICS.[1]

THE second law of thermodynamics has been chosen for the subject of this address: what that law is will be the main question, and the ground will be taken that Rankine's view of the subject is the correct one. After calling attention to the statements of Tait and others as to this law, and as to Rankine's way of stating it, no apology will be necessary for the choice of a question which ought already to have been fully and satisfactorily settled.

There are three different statements, each claiming to be the second law of thermodynamics. I. Rankine's law : "If the total actual heat of a homogeneous and uniformly hot substance be conceived to be divided into any number of equal parts, the effects of those parts in causing work to be performed are equal." Rankine gives also a second form of the law, in which the expression 'absolute temperate' takes the place of 'total actual heat.' II. Clausius gives as the 'Second fundamental principle,' "Heat cannot of itself flow from a colder to a warmer body." This may be a law in the general theory of heat, but not in thermodynamics, which treats of the relations between heat and mechanical energy; and it has nothing to do with Rankine's law, except as all natural phenomena may be connected. III. The formula for the maximum efficiency of a heat-engine is given as the second law, but this is only a consequence of that law, and the form of the engine.

It would seem from this variety of statement, that a law of nature might be any thing to suit our purpose. I think, however, that a careful examination of Rankine's second law will show that it is genuine, and that it is not universally quoted only because it is not understood. Rankine's law is either copied *verbatim*, or modified in a way to make this evident; and I must confess, that, before working upon the subject myself, I had difficulty with Rankine's statements: they seem now, however, so reasonable, that I shall endeavor to lead you to the same opinion.

Let us see now what is most natural and appropriate for a second law: the first law states that heat and work are mutually convertible, and convertible in a fixed ratio; and it is appropriate that the second law should state the agency by which such conversion may be accomplished, and the rate at which it may be effected.

A quantity of heat, W', may be employed as an instrument for the conversion of another quantity of heat, W, into work, or for the conversion of a quantity of work, A, into heat; and the converted quantity will be proportional to the converter quantity for a given change of volume or of entropy.

To realize the truth of this statement, let us imagine the simplest physical air-engine: we need no fly-wheel, valves, etc., but simply a vertical cylinder of infinite height, and unit section, with non-conducting walls, the bottom permeable to heat, and the non-conducting piston loaded with a pressure varying so as to be always equal to the gaseous pressure beneath it.

But this is no more than the shell of the engine: we will suppose the piston at such a point that the cylinder shall have a volume of one cubic unit; and we must now put in it, say, one unit of mass of the molecules of a perfect gas, resting on the bottom as dust, or distributed through the space as in any gas, but devoid of motion: we have now added the muscles, but they are dead flesh; the engine is not capable of transforming heat into work, or *vice versa.* The agent by which such a transformation may be accomplished is not present; the space through which the piston may move exists, but the molecules exert no pressure against the piston, and there can be no question of work until we have both space and pressure. To obtain this necessary pressure we must heat the gas to the absolute temperature, τ; i.e., we must store in the molecules an amount of kinetic energy propor-

[1] Abstract of an address delivered before the section of mechanical science of the American association for the advancement of science, at Ann Arbor, Aug. 26, by Prof. J. BURKITT WEBB of Ithaca, N.Y., vice-president of the section. For the complete address, see *Van Nostrand's eng. mag.*, October, 1885.