of atomic weights. These require to be known with all the precision of which quantitative chemistry is capable.

It is only by such knowledge that we may hope to find solutions to some of the most interesting and important problems with which contemporary chemistry is confronted. There is, to begin with, the fundamental question of the validity of the law of the conservation of mass. Is there a dissipation of matter, as of energy, in a cycle of chemical changes? Is an atomic weight a fixed and unalterable quantity? Or is it, as first suggested by Marignac, a statistical quantity varying within limits, doubtless very small, but still possibly appreciable?

There is further the perennial question of Prout's law, which, like the poor, seems to be always with us. Modern views of the genetic relations of the elements and of the dependence of their properties upon their relative masses are intimately connected with the exact values and numerical relations of atomic weights. It is these and similar questions lying at the very basis of chemical philosophy that render it imperatively necessary that these constants should be known with the greatest possible precision. The greatest possible precision is, of course, relative; it depends upon the degree of perfection of contemporary quantitative chemistry, and as this is progressive, each decade seeing improvements, both in the application of old methods and in the discovery of new, it necessarily follows that there is no such thing as finality in measurements of this kind. A large number of atomic weights are now known with accuracy to the first decimal place; even in the case of those of high values a considerable proportion indeed are known even to the second decimal, and a few, especially those elements which are habitually employed as a basis of comparison in atomic-weight work, as, for examples, silver and the halogens, are being ascertained with a still greater exactitude. It is only when atomic weights in general are known to a like degree of precision that we can hope for definite answers to such questions as have been indicated above.

It is largely due to the attention which this subject has received in America that our present position has been reached, and it is especially to the Harvard School of Chemistry that we are indebted for the high standard of accuracy which is now incumbent on every worker in this field of determinative chemistry. No laboratory in the world can point to such a remarkable sequence of memoirs as those which are embodied in the short synoptical statement in which Prof. Richards has dealt with the Harvard determinations of atomic weights between 1870 and the present year. Initiated by the late Prof. Josiah Parsons Cooke, whose determination of the atomic weight of antimony is still regarded as the best ascertained value for that element, the work has been continued by his assistant and successor, Prof. Theodore Richards, partly alone, but mainly in collaboration with pupils whom he has trained and imbued with his own high sense of exactitude. What the outcome of this work, extending over many years, has been is abundantly illustrated by the significant table on p. 90 of Prof. Richards's memoir. Of the eighty-three elements at present known, and of which the atomic weights are given in the annual tables prepared by the International Committee on Atomic Weights, no fewer than twenty-eight of those estimations which are regarded by the committee as among the best ascertained values are to be credited to the Harvard laboratory.

It is remarkable that this work should have been done in America. It is commonly held that no nation is more keenly appreciative of the utilitarian value of science than America; but there is no money to be made out of the results of an atomic-weight determination. It is quite impossible to evolve a new colouring matter out of it, or to turn it into a synthetic drug. Not even the "smartest" and most enterprising of German chemists could bring it within the protective influence of the mystic letters D.R.P. On the contrary, atomic-weight work requires money, and that frequently in no small amount; platinum vessels, and apparatus of transparent quartz, electric ovens, high-class balances, and pure materials, render such work extremely costly. No doubt Harvard is well endowed, and Prof. Richards presumably has been liberally supported by his university. But the beneficence of the university has been largely supplemented by the action of the Carnegie Institution of Washington; without the pecuniary help afforded by the Trust, the work could not, says Prof. Richards, have been carried out on so large a scale, nor could it have reached the degree of precision which it has attained. T. E. T.

TESTS FOR COLOUR VISION.

THE agitation concerning the official colour-vision tests for seamen has entered upon a new stage. The Board of Trade has announced its decision to hold an inquiry into the matter, and the *personnel* of the committee has been published (NATURE, June 30, p. 529).

After the reiteration of the confidence of the Board in the certitude of the official tests, this change of front comes somewhat as a surprise, but that can be forgiven in the welcome possibilities of a revision of tests that have forfeited the confidence of those most concerned.

It is not to be expected that the constitution of an official committee will please everyone, and already protest has been made by letter to the Board of Trade from the secretary of the Imperial Merchant Service Guild. The Guild protests that it was given to understand that the projected new committee would be of small size and of strictly impartial character, but that it proves to be large, and in the view of the Guild heavily weighted. The Guild states that of the members of the committee, at least two were prominent supporters of the official tests in recently disputed cases where the official position was admittedly wrong.

The choice of tests for colour vision is not so simple as it may seem at first sight. The difficulties presented in appreciating the mental picture of a colour-blind person are very great; and complexity is introduced by the several conflicting theories of colour vision which, consciously or unconsciously, bias the opinion of those who essay to determine these tests.

It is perhaps unfortunate that theories of colour vision should enter into the question of colour tests, at any rate, in the present state of our knowledge. It is, of course, conceivable, nay, even probable, that the true theory of colour vision when that is formulated and proven, supposing it for the moment to be none of those extant, will show an infallible means of testing the sense of colour in any and every person. Until then it would appear better that the test should be frankly empirical, and, so far as possible, unbiased by any theory. And for the reason that, unless rival theories be eliminated from the field, we can scarcely expect a reasonable uniformity in our tests.

There are two main lines of cleavage between rival schools of testing. One insists upon the matching of colours, the other on the necessity for naming colours. The first is official and based upon Holmgren's tests. A candidate is given a skein of coloured wool, and required to pick out from a heap of skeins other wools that, in his opinion, match the wool given him. The second method of testing is performed by exhibiting a colour in wool, card, or preferably by means of light from a distant lantern, and the candidate is required to name the colour shown in whatever language he knows. The colour is exhibited detached from any other colour that could give external help, the man must judge of the exposed colour alone and unaided, and name it in common terms. Now each of these modes of colour perception are common habits with us in our daily life. We constantly match colour, consciously or unconsciously, and we as often, perhaps more often, name colours we see, matching them mentally and naming them according to a standard we have learned by experience. On the respective merits of these methods, the rival schools clash, and, so far as can be judged, the disagreement rests upon theoretic conclusions rather than practical experience.

If we consider these two tests in relation to actual life, or, at any rate, the life of a seaman, it can scarcely be denied that the second non-official test, naming the colour, is the one that most nearly tallies with his experience. The seaman is required to pick up a light, most likely a solitary light, and judge of its colour without possible comparison; he must rely on his judgment of that light in relation to the mental impressions that are part and parcel of his cerebration, and the impression he receives is instantly and unconsciously correlated with a name, the name of a colour in the language in which his mind works. To name is second nature. What the name may be matters not, so long as it be current coin; the "B" line in the spectrum may be "red" to us or "blood-colour" to the savage, and "F" "blue" to us and "sea-colour" to the savage: the intention is the same.

But it is argued by the adherents of the Holmgren test that the matching of colour is more likely to be true, for it eliminates possible errors due to ignorance in precise nomenclature, *e.g.*, three people may see the same colour and variously describe it as purple or mauve or heliotrope, with a result that a fourth might not be sure what colour was meant, yet each of the three would find no difficulty in matching the colour correctly, particularly if they were women who took an interest in their dress.

The good and bad of these tests can only be put to proof when they are tried on known colour-blind persons. Then it has been found that persons can successfully match colours who grossly misname them when the colours are shown singly. On the other hand, there are some who can name colours who fail to match well. The evidence of the cases, particularly those of the first and more important group, has been sifted and is established. Which, then, of these two persons is the colour blind, he who can match but not name or he who can name but not match? The solution of this perplexity is as follows: Matching depends rather on a keen sense of light and shade than on colour sense; colour-blind persons can be educated up to the matching test, but never to acquire a colour sense they do not possess. Those who name colour accurately yet fail to match are bunglers, folk just ignorant of what matching means; the maid-of-all-work will know, but a youth or a seaman may not.

On the mode of applications of tests, if a little pleasantry be permitted, it can scarcely be denied that in some aspects the official methods are as fine a joke as could well be devised. What would a stranger visitant think of these heaps of coloured wools? Surely he would commend a State whose paternal care extended to the examination of young ladies desiring employment in haberdashery shops, to the end that they may be good at matching their customers' patterns! That these wools were to test the seaman's ability to pick up lights in rain and shine, storm and fog, our visitant would surely find unthinkable. And yet it is so. So far has theory divorced from experiment carried us. If it be well to let the punishment fit the crime, how much more should the test of a quality fit the usage of that quality. It seems obvious that the ability to see lights and signal flags should be tested with lights and flags. That this is now recognised is shown by the number of testing lanterns that have been fathered since Edridge Green directed attention to the matter; but some of the lanterns are bad by reason of the poor range of their tints.

The next line of cleavage between rival schools is due to differences in opinion as to what are to be the crucial colours of the tests. Here theories of colour vision come in most emphatically, and until this problem is solved, we cannot expect agreement unless there be a truce to theory and a trial by ordeal.

There is one satisfactory mode of surmounting the difficulty in the choice of crucial colours, that is, by the use of the spectrum itself. Much of the experimental work on colour vision has been done with the spectroscope, and the appreciation of the value of it as an everyday appliance is shown in that, within the last two years, there has been devised three pieces of apparatus for colour testing by direct appeal to the spectrum. A very clever projection spectroscope has been devised by Dr. J. H. Tomlinson, and valuable instruments for direct view of the spectrum by Dr. Maitland Ramsey and by Dr. Edridge Green. Of these instruments, the first has the advantage that both examiner and candidate can view the spectrum together. But Edridge Green's instrument has the germ of the right principle in colour testing, for it is provided with scales which give the measurement of the aperture of the shutters in wave-lengths, so that by this means the range of distinction of colour throughout the spectrum can be measured and registered.

In conclusion, what we want is not only a trustworthy mode of qualitative test, but also a quantitative test—some mode whereby we can express a man's colour-sense in terms as stable as we can express his form-sense by Snellen's test types. At present, opinion and fact are hopelessly muddled by our inability to convey what our tests show. Say a man fails to distinguish a certain red: he must be written down "red blind," notwithstanding he can see another red. To say he is red blind is both true and false, but it is the only statement that can be made in the absence of finer modes of expression. We want to take the measure of his perception of the colours of the spectrum and register them in simple terms. Given such an absolute register of his colour sense, there will remain only the expression of opinion as to his capability for doing certain work. Requirements will vary with the work to be done. For seamen and railway men we should require the highest standard, even as is required of them for form vision.

We wish the new committee a happy issue out of all its troubles! N. B. H.