THE ORDER OF ACCURACY OF A DETERMINATION

THE idea of the "order of accuracy of a determination," for some peculiar reason, presents far greater difficulties to teachers than to pupils. We all know from our own teaching experience that examination tests show our candidates as being weakest in those sections of the work that interest us least, and that they are quite astray in any small portion of the work on which our own ideas are in any way hazy. So that when we find many of our senior students answering a particular question badly, we wonder if perhaps we have been unconvincing in. our presentation of the work to which it refers, or if, possibly, without admitting it to ourselves, we have glossed over details with which we were not perfectly familiar.

The basis of all quantitative science is measurement. With the figures obtained, we make simple or difficult mathematical calculations, and derive a result, which sometimes is expressed in words, sometimes in numbers. It is of fundamental importance to us to know how accurately we should work to produce a final answer of the required accuracy; and a child cannot begin too early in the study of Physics or Chemistry to estimate the order of accuracy required in the individual measurements made.

Bearing in mind the object of the experiment, we may decide that we wish to get our final answer as accurate as possible with the measuring equipment at our service. In elementary work, approximations are forced upon us by our instruments, and not by our mathematics; we may shorten our work by employing approximations in mathematics, if the error thus introduced is small when compared with our experimental error, and thus we save time by simplifying our calculations.

In other cases, we may decide that we do not wish to attempt to get as accurate a result as is possible with our equipment, because, in general, the more accurate the result at which we aim, the longer the time taken in obtaining it. Is it worth while spending half an hour in making very accurate measurements of one quantity if big errors are going to be introduced by the later addition of other measurements? Science has decided that it is wrong to spend time on the making of unnecessarily accurate determinations and calculations;

and strongly condemns the statement of results in figures which claim an unjustified order of accuracy.

We have heard it put forward as a criticism of scientific training that the child is not being taught to aim at the ideal; that no matter what may be the utility of a particular measurement in obtaining the final result, every reading should be made with the utmost possible care, and to the highest possible order of accuracy; that it is not what we are going to do with the measurement that is important, but the making of the measurement.

We are in complete agreement with the necessity for teaching the child to perform some of his experiments to produce a result as accurate as is possible with his equipment. That is a very important part of his training; but he must not then be misled by mere figures.

Suppose, for example, he weighs out 198·47 grms. of sodium carbonate; the extent of his optimism as to the absolute mass should be known to him, so that he can appreciate whether the "7" has any significance; and then he should be aware of the error introduced by the uncertain composition of the material he is employing. Then we may see, after his attempt to obtain a mass to one part in twenty thousand, that to estimate the mass of sodium present he takes round numbers for the atomic weights; admittedly in the case of the sodium carbonate the error thus introduced would only be of the order of one part in five thousand, but it would not have been noticed by him if it were one part in fifty, unless he had had his attention directed to an elementary consideration of order of accuracy.

We are not attaining the ideal if we are merely deceiving ourselves; one of the benefits of a training in a quantitative science is that it teaches commonsense. Knowing the practical limitations of the accuracy of our solution of a problem does not prevent, but rather assists us in finding a more accurate method, should that be a sensible procedure.

It is not necessary to teach the young scientist the elements of the theory of probabilities; but he must be taught to estimate an order of accuracy of a measurement and of a mean of a set of measurements; and to know the effect of using several different measurements, possibly with different orders of accuracy, in a calculation.