WHAT IS A "FINE CHEMICAL" ?

C. A. HILL.

The term "Fine Chemicals" used to be employed very loosely, sometimes to signify synthetic organic substances, sometimes analytical reagents or research chemicals, and frequently in a sense more vague than either of these. In the early days of the war it became clear that fine chemicals were destined to fill an important position. In a paper read before the Society of Chemical Industry at its Annual Meeting, held in Edinburgh in 1916, Hill and Morson endeavoured to indicate the far-reaching importance of fine chemicals and to give the term a definite meaning. They used it in the comprehensive sense as including all fine chemicals, making laboratory chemicals one group, pharmaceutical (or medicinal) chemicals another group, and technical chemicals (chemicals used in the arts and industries) a third group. This terminology was adopted, and the classification amplified, by the Association of British Chemical Manufacturers thus:—"Fine chemicals—Analytical; Pharmaceutical; Photographic; Rare Earths; Synthetic Essences and Perfumes." This comprehensive use of the term "fine chemicals" has since been repeatedly urged and has met with general acceptance; recently it has received official recognition in the Safeguarding of Industries Act.

The operation of this Act has raised the necessity of deciding definitely whether a given chemical product is or is not a fine chemical, and has thrown into evidence the fact that it is by no means easy to give an accurate and logical definition of "Fine Chemicals."

It is clear that the term "Fine Chemicals" cannot be restricted to chemicals of the purest grade that it is possible to produce or that is known; but they must be pure enough or special enough to be so classified, for example, as of B.P. standard for a drug, and of A.R. standard for an analytical reagent. To carry this point and that of skilled labour to extremes, one may cite a specimen of metallic salt used for an atomic-weight determination; a substance of such a degree of purity would be prepared by the research chemist himself with his own hands.

It must be emphasised that percentage purity, by itself, is certainly no criterion of whether a chemical is fine or not; it may be 99.9% and crude—if the 0.1% be arsenic contaminating a medicinal chemical—or it may be about 80% and "pure," i.e., fine, if the remainder is water or some other neutral and entirely inert diluent (e.g., potassium carbonate B.P.). Often, it is really freedom from impurities which makes the chemical a fine chemical. A simple salt, such as ammonium chloride, may be practically chemically pure, and dirty—then it is not "fine"; but diamino-dihydroxy-arsenobenzene, even if dirty, would still be a fine chemical. Crude Epsom salts and magnesium sulphate puriss. B.P. do not differ greatly in percentage composition, that is, the difference is not great numerically, although it is great in importance. Barium sulphate as supplied to the paint trade might be very fairly pure, i.e., it might test well over 99% BaSO_4 , but yet be quite unsuitable for pharmaceutical use; for the latter purpose it has to be specially prepared as a fine chemical so as to be perfectly free from soluble barium salts.

It may be that a chemical is manufactured by recognised makers of heavy chemicals on a large scale and yet produced in a state of chemical purity of such a degree as to warrant, other considerations apart, its being classed as a fine chemical. Owing to the large scale on which it is manufactured, the process has become so standardised that the comparatively unskilled labour of the process worker,

under a chemist who merely supervises, suffices to run the plant; and here the conditions of manufacture are such that the chemical ceases to be "fine." Commercial sodium bicarbonate may be taken as an example.

Substances in the infancy of their utilisation may be fine chemicals, on account of the small scale on which they are manufactured, and later on may become heavy chemicals. To put it another way, when the manufacture of a particular chemical attains a scale larger than that usually associated with fine-chemical manufacture, it may on the one hand remain a fine chemical, or on the other hand it may come to be regarded as a heavy chemical; this will depend upon whether its manufacture and refinement do or do not require intensive and highly-skilled attention on the part of trained chemists. For instance, on however large a scale they are manufactured, quinine, caffeine, saccharin, and vanillin remain fine chemicals; but if nickel sulphate came to be manufactured on the same scale as copper sulphate, or maltose on the same scale as cane sugar, then they would cease to be fine chemicals.

There is no doubt about the distinction between heavy and fine chemicals in the great majority of cases, but there are bound to be some difficult border-line cases, and here, in addition to the other attributes of scale of manufacture and skilled manufacture, the crux must be: Is the chemical of a specified degree of purity to meet special purposes?

Take the case of dyes. The writer has stated elsewhere (*cf.* J., 1920, p. 425 n) that "dyes constitute a group of fine chemicals so large and important that they are generally considered as a separate branch of chemical industry; actually, however, they cannot be thus divorced from the rest of the fine chemical industry." Many dyes are produced on a large scale in a state of comparative impurity and would therefore not be classed as fine chemicals; certain dyes are, however, made on a small scale by fine chemical manufacturers in a state of purity for purposes other than that of dyeing in the ordinary sense, as, for instance, stains, indicators, and so forth; in such cases these substances, although dyes, are undoubtedly fine chemicals.

As the present writer has stated before (*ibid.*), in dealing with the "Present Position of the Fine Chemical Industry," the first classification of chemicals is into the Heavy and Fine. Hence, to the question: "When is a chemical a 'fine' chemical?" we may reply: "When it is not a 'heavy' chemical."

Pope, in "Science and the Nation," states:—"The products of the chemical industry as a whole may be divided roughly into two classes, heavy chemicals, which serve largely as raw materials in other branches of chemical industry, and fine chemicals, which consist mainly of finished products such as dyestuffs, drugs, photographic chemicals, and the like."

Woolcock, in a recent issue of the *Times Trade Supplement*, states:—"The most that can be said is that a 'fine' chemical is one which (1) is usually made in small quantities relatively to heavy chemicals; or/and (2) is of an exceptionally high degree of purity, or otherwise of special quality; and (3) requires skilled supervision in its manufacture." Into (2) we must read the *use* to which the chemical is to be put; and as additional, though occasional, features, (4) rarity and (5) costliness may be mentioned.

But a recital of the attributes of fine chemicals is not a definition of them. In the minds of those who have the necessary knowledge and who have studied the question, the conception of what is a fine chemical is definite though indefinable—a colloidal conception and not a crystallisable thought.

The first rule to which a definition has to conform is that it shall not contain the name of the thing defined. In stating this rule one is irresistibly reminded of the famous reply to the question, "What is an archdeacon?" "An archdeacon is a priest who exercises archidiaconal functions"! Somewhat similarly, fine chemicals are chemicals which are made by fine chemical manufacturers. This definition is not so utterly ridiculous as it would seem at first sight; because the methods of manufacture, the scale of manufacture, the plant commonly employed, the skilled labour and the highly skilled supervision necessarily employed in fine chemical manufacture are essential concomitants of fine chemicals. Makers of fine chemicals have ideas by no means vague as to what fine chemicals are.

We have to consider, then, these attributes of chemicals:—Scale of manufacture; conditions of manufacture; skilled labour; highly skilled supervision; rarity; high cost; high grade of purity; and freedom from impurities.

Each of these ideas contributes something to a general understanding of what fine chemicals are. We require, however, something more than a general understanding. Each is true of most fine chemicals, but none alone suffices for the difficult cases. The one idea which does run right through, and may be said to be crucial, is the idea that the chemical is to be put to some specific use and for that purpose must conform to some definite standard of purity.

The shortest description of a fine chemical which is in any way adequate is that it is a chemical, not produced as a "heavy" chemical, which is of specified purity for a specific purpose.

THE CLAUDE SYNTHETIC-AMMONIA PROCESS AND PLANT.*

J. H. WEST.

The Claude synthetic-ammonia process has this in common with the older Haber process, that it consists in effecting the direct combination of hydrogen with nitrogen under pressure and in presence of a catalyst to form ammonia; the predominant difference between the two processes lies in the much higher pressure used by Claude. This difference may seem at first sight rather an unimportant one, but it will presently be seen that, on the contrary, it is a most far-reaching and fundamental one, which entirely modifies the working conditions of the reaction.

In order to understand the primary considerations which led Claude to adopt pressures which had hitherto been undreamt of in industrial working, it is necessary to examine the conditions of equilibrium between nitrogen, hydrogen, and ammonia under various pressures and temperatures. Fig. 1 was prepared by Claude from his own experimental data, and shows very clearly that, for a given temperature, the proportion of nitrogen and hydrogen remaining combined under conditions of equilibrium increases rapidly with rise of pressure, and that the lower the temperature the higher is the proportion of combination.

So far, the conditions for maximum combination would appear to be high pressure and low temperature, but in practice another consideration comes in, namely, speed of reaction. The lower the temperature the longer does it take to reach equilibrium,

Fig. 1.

and in order to have apparatus of a reasonable size the reaction must not be too slow. For practical purposes a compromise has to be made as regards the working temperature so as to obtain a reasonable speed of reaction combined with a sufficiently high proportion of combination in the gases. The useful range of working temperature is found to lie between 500° and 700° C.

Fig. 2.

* Abstract of a paper read before a Joint meeting of the Chemical Engineering Group and the Institution of Mechanical Engineers, at the Institution of Electrical Engineers, London, Nov. 22, 1921.