THE DEPARTMENT OF THE AMERICAN ASSOCIATION OF COLLEGES OF PHARMACY

C. B. JORDAN—CHAIRMAN OF EXECUTIVE COMMITTEE, A. A. C. P., EDITOR OF THIS DEPARTMENT.

WHAT IS A TEN PER CENT SOLUTION?

BY JOSEPH B. BURT.

The question selected as the title of this paper appears, at first glance, to be so trivial as to scarcely merit discussion. However, upon referring to the textbook literature on the subject, it is found that a number of answers are possible, and in most cases it becomes necessary to qualify our answers. We find that our answer will be governed by such considerations as (1) the nature of the solute (whether solid, liquid or gaseous); (2) the solvent (whether aqueous or non-aqueous); (3) the character and intended use of the resulting solution and (4) more particularly the choice of our textbook, or should we say, the personal views of the author of our textbook? In spite of the fact that a lack of harmony in the treatment of percentage solutions has long been recognized by teachers of pharmacy, the wide disagreement disclosed upon examining a number of the commonly used textbooks is somewhat surprising.

It is not my purpose to solve this problem, but rather to briefly outline the situation, and make certain suggestions in the hope of stimulating discussion which may have some influence in clarifying this question.

Before taking up the confusion existing in the textbook literature, it might be well to set forth the facts, as I see them, on percentage solutions. On page 3, United States Pharmacopœia, Tenth revision, under the heading of "General Notices," this statement is found: "Percentages—Unless otherwise stated, percentage figures in this Pharmacopœia are understood to mean by weight." However, three kinds of percentage have been introduced into the Pharmacopœia, although two of them are not expressed as percentage, but in terms of grams per 100 cc. and cc. per 1000 cc. The three kinds of percentage are Weight to Weight, also known as "absolute percentage," "true percentage," and the "exact method," the so-called Weight to Volume percentage, also known as "Weight-Volume," "Percentage concentration," and the "drug-store method," and Volume to Volume percentage.

As an example of the first class, Weight to Weight percentage, **Liquor Ferri Tersulphatis** may be cited. This preparation is defined by the Pharmacopœia as "an aqueous solution containing normal ferric sulphate ($Fe_2(SO_4)_3$) corresponding to not less than 9.5 per cent and not more than 10.5 per cent of Fe."

Liquor Potassii Hydroxidi serves as an example of Weight to Volume percentage. The purity rubric for this preparation reads as follows: "Solution of potassium hydroxide contains in each 100 cc. not less than 4.5 and not more than 5.5 Gm. of KOH." Thus, we might speak of this preparation as a W/V percentage solution, varying from 4.5% to 5.5%.

The official **Spiritus Cinnamomi** serves as an example of the third class, Volume to Volume percentage. There is no purity rubric stated for this preparation, but the formula requires 100 cc. of oil of cinnamon, dissolved in enough alcohol to make 1000 cc., hence this is a 10% V/V solution.

In order to see what pharmacy students are being taught concerning percentage solutions, a brief survey has been made of a number of textbooks which were found conveniently at hand. Those chosen for the purpose were:

"Remington's Practice of Pharmacy," 7th Edition (1926).
"Arny's Principles of Pharmacy," 3rd Edition (1926).
"Caspari's Treatise on Pharmacy" (1906).
"Ruddiman's Pharmacy, Theoretical and Practical," 2nd Edition (1926).
"Coblentz's Hand Book of Pharmacy," 2nd Edition (1899).
"Wall's The Prescription," 4th Edition (1917).
"Scoville's Art of Compounding," 4th Edition (1914).
"Stevens' Arithmetic of Pharmacy" (1920).
"Snow's The Arithmetic of Pharmacy" (1925).

In considering these sources, the examination was restricted to the treatment of solutions of solid solutes, since the general practice for liquid solutes required in extemporaneous solutions seems to be to use V/V percentage.

Of the nine sources, eight advocate the W/W method of calculation, but only four actually give directions which will result in the preparation of a solution having the total volume required. The other four give directions for the preparation of solutions, in which it is erroneously assumed that a given weight of solute will occupy the same space, when dissolved, as an equal weight of water. The ninth source does not recognize W/W percentage at all, but recommends W/V percentage for all solutions of solids.

Three authors endorse true W/V percentage, while three others mention a calculation which cannot be classified as belonging to group, since the weight of a fluidounce of water is taken at some value other than its true value, such as 437.5 grs. or 480 grs. The W/V method is strongly endorsed by one author, while two others approve of its use only when the percentage strength is small. Others condemn the method as being inaccurate, and one author states that this method is not "percentage" and infers that it should not be used.

Considerable variation is noted in the value chosen to represent the weight of one fluidounce of water. Since the standard working temperature of the Pharmacopœia is 25° C., this weight should be 454.6 grs., as shown in the table of weight and volume relations, page 551. Instead the values run from 437.5 grs. to 480 grs., and include 455.7 grs., 455.19 grs., and 456.25 grs.

The following statements taken from these sources, bearing upon the use of W/V percentage, are of interest:

(1) "The method universally adopted"—for such solutions as a 3% solution of silver nitrate.

(2) "Many physicians in prescribing solutions understand percentage by measure, *i. e.*, grains of a solid to the fluidrachm or fluidounce, or mgm. to the cc. This is weight for volume and not percentage."

(3) "A less accurate method (W/V) is sometimes used."

(4) "These formulas are compounded by weight." "It would be better to prescribe all such solutions by weight rather than by measure."

(5) "When a per cent is given, it is generally understood to be by weight, whether the substance is a solid, liquid or a gas, unless otherwise specified, except in the case of alcohol."

"In many cases it is much more convenient that percentage should mean parts by weight of the solid in parts by volume of the solution."

(6) "Unfortunately, however, percentage solutions are not always made by weight. It is much easier for the physician in certain cases to calculate the dose if in making the solution the solids are weighed and the liquids are measured." "The object of the dispenser should always be to supply what the physician desires, but physicians differ in their objects in writing for percentage solution, sometimes desiring them to be made by weight and sometimes by volume, and it is not always possible to tell from the reading of the prescription which the physician desires."

(7) "Another and less accurate method, very largely employed, is by taking 5% of 480 minims, or 24 grs. dissolving this in water to make a fluidounce. This, while by no means as accurate as the former process (W/W) is more convenient, and can safely be employed in preparing solutions in small percentages."

(8) This text recommends the W/V method, saying that under 5% the error is so negligible that this method may be safely used.

(9) "For solids and gases, percentage solutions are always prepared by weight." (This author does not mention W/V percentage.)

This lack of uniformity in our textbooks is deplorable, and gives rise to much needless confusion. Moreover, in the case of percentage solutions which are administered internally, it is highly important that the method of preparation be standardized, in order to avoid variation in dosage, and the administration of dangerous doses.

While it may seem quite elementary, it may be worth while, for the sake of clearness, to see just how each of the three kinds of percentage are calculated and prepared, for the existing confusion may be traced directly to the two factors (1) the method of calculation, and (2) the choice of the method to be applied in a given case.

Consider first the W/W percentage solution. Suppose one fluidounce of a 10% aqueous solution of potassium iodide is required. Any method which results in the production of less than a fluidounce of solution fails to satisfy the requirement. Hence this calculation should be made as follows:

One fluidounce of water at 25° C. weighs 454.6 grs.

In order to be certain of having one fluidounce of solution, we must use that volume of solvent. Since the solute represents 10 per cent of the total weight of the solution, then the solvent must represent 100—10 or 90 per cent.

Then $\frac{454.6 \times 10}{90} = 50.51$ grs.

This weight of potassium iodide must then be dissolved in one fluidounce (454.6 grs.) of water. Any excess beyond one fluidounce may be discarded. Obviously, if the solvent be a liquid other than water, a correction must be introduced into the calculations for any difference in specific gravities.

The calculation for preparing the same solution by W/V percentage is as follows:

$$454.6 \times 0.10 = 45.46 \text{ gr.}$$

This weight of potassium iodide is to be dissolved in enough water to make one fluidounce of finished solution. It should be noted that this calculation remains the same, regardless of the solvent used.

For the third case, V/V percentage, we must deal with a liquid solute. Suppose one fluidounce of a 10 per cent V/V solution of oil of peppermint in alcohol is required. One fluidounce contains 480 minims. $480 \times 0.10 = 48$ minims. This volume of the oil is to be measured out and dissolved in enough alcohol to make one fluidounce of solution. This calculation is always the same, regardless of the specific gravities of the liquids involved.

In contrasting the characteristics of the W/W and W/V solutions, we may note the following points: In W/W percentage, the ration W/W represents the ratio

$$\frac{\text{weight of solute}}{\text{weight of the finished solution.}}$$

This means that this method always results in the production of a definite weight of solution, but its volume cannot be predicted.

In the Weight to Volume percentage, the expression W/V is not the true expression of the ratio employed in the calculation. It is impossible to apply a factor expressing percentage to a quantity expressing volume and obtain a product expressing weight units. Rather the calculation is based upon the ratio:

$$\frac{\text{the weight of solute}}{\text{the weight of water having the same volume as that required for the finished solution.}}$$

This means that we neglect the specific gravity of the finished solution, or rather arbitrarily assume that the specific gravities of all solutions prepared by this method are equal to that of water. It should be noted that this method results in the production of exactly the required volume of solution, but the actual weight of the solution is unknown.

In the V/V percentage calculation, the expression V/V represents the ratio:

$$\frac{\text{volume of the solute}}{\text{volume of the finished solution.}}$$

This method likewise results in exactly the required volume of finished solution.

In reference especially to percentage solutions of solid solutes, and the choice between the methods of W/W and W/V, the question of accuracy depends entirely upon the point of view. Certainly all W/V percentage solutions are "inaccurate" when compared with W/W percentage as the standard, but it is also true that all W/W percentage solutions are equally "inaccurate" when measured with the W/V yard stick. Weight to Volume percentage is widely used, and cannot be discarded by simply branding it as an inaccurate method. In certain respects it has distinct advantages over the W/W method. It should be noted that it is possible to calculate accurately the dosage of the solute in any desired unit of volume of the W/V solution, and liquid preparations are always administered in volume units rather than by weight. On the other hand, this calculation cannot be made for the W/W solution, unless the specific gravity of the solution be known. Moreover, the W/W method is a wasteful method, since it is impossible to prepare exactly the required quantity of solution without having a surplus.

In order to simplify the choice of methods, and at the same time gain uniformity in the application of the three methods, the following recommendations covering the treatment of the subject of percentage solutions are offered.

(1) The complete abandonment of W/W percentage for all extemporaneous solutions, but its retention for all percentage solutions recognized by the United

States Pharmacopœia and the National Formulary, for which the specific gravity of the finished solution is given.

(2) The adoption of W/V percentage for exclusive use in preparing all types of extemporaneous percentage solutions of solid solutes.

(3) The adoption of V/V percentage for all extemporaneous percentage solutions of liquid solutes. (In the case of U. S. P. and N. F. solutions or preparations falling into this class, these solutions should be prepared by W/W percentage, provided the specific gravity is included in the official description of the preparation.)

UNIVERSITY OF NEBRASKA,
COLLEGE OF PHARMACY.

COMMITTEE REPORTS

THE PHARMACEUTICAL SYLLABUS COMMITTEE.

BULLETIN I—NOVEMBER 25, 1927.

This begins a new series of bulletins of the Committee, on the preparation of a fourth edition of the *Syllabus.*

Last spring, the Chairman made a sincere effort to give up the position and to have someone else selected in his place, as described in Bulletin XLI, old series, but no encouragement was offered by anyone. In fact, several members of the Committee and others, who wrote about the matter, strongly urged the Chairman to continue in the place and advanced reasons why he should do so. This correspondence made pleasant reading for the Chairman, but it did not help him to accomplish his wish to give up the place. However, he cannot refuse to go on with the work, without knowing that it will be carried on by someone else, and there the matter rests for the present.

Other pressing duties, in addition to his regular work, have prevented the Chairman from working on the *Syllabus* during the past summer and fall, but this extra work is completed, and it is expected that some work on the *Syllabus* can be accomplished each week and reported to the Committee in the bulletins.

The present membership of the Committee is as follows:

Terms expire.	FROM THE AMERICAN PHARMACEUTICAL ASSOCIATION.
1928	E. F. Kelly, 10 West Chase Street, Baltimore, Md.
1929	G. M. Beringer, 501 Federal Street, Camden, N. J.
1930	H. H. Rusby, 115 West 68th Street, New York, N. Y.
1931	W. G. Gregory, 185 Parkside Avenue, Buffalo, N. Y.
1932	W. H. Rudder, Salem, Indiana.
1933	W. C. Anderson, 136 Herkimer Street, Brooklyn, N. Y.
1934	E. G. Eberle, 10 West Chase Street, Baltimore, Md.
	FROM THE AMERICAN ASSOCIATION OF COLLEGES OF PHARMACY.
1928	J. A. Koch, 1431 Boulevard of the Allies, Pittsburgh, Pa.
1929	T. J. Bradley, 179 Longwood Avenue, Boston, Mass.
1930	F. J. Wulling, University of Minnesota, Minneapolis, Minn.
1931	J. G. Beard, Chapel Hill, North Carolina.
1932	E. V. Lynn, University of Washington, Seattle, Wash.
1933	E. F. Cook, 145 North Tenth Street, Philadelphia, Pa.
1934	D. B. R. Johnson, 1006 Classen Boulevard, Norman, Okla.
	FROM THE NATIONAL ASSOCIATION OF BOARDS OF PHARMACY.
1928	John Culley, 2479 Washington Avenue, Ogden, Utah.
1929	George Judisch, Ames, Iowa.