How to Solve More Complicated Problems. The problems which have been given so far are easy and you could probably solve them without resorting to the "units method." But sometimes several conversion factors must be used, and then it is not as easy. To solve a problem of this kind, you first write down the number which is not a conversion factor. Then you multiply this number by as many conversion ratios as are necessary to get the answer which is desired. To illustrate this procedure, suppose you want to find the weight in grams of one sheet of paper, 25″ x 38″, if you know that a ream of such paper weighs 60 lb. This problem is not only more complicated than the preceding ones but it involves the use of conversion factors which are a little different than, say, the conversion factor between inches and feet. Anything which converts from one thing to another can be considered to be a conversion factor. To work this problem we must use the conversion factors:

500 sheets = 1 ream   and   1 ream = 60 lb.

The problem is set up as follows:

$$(1\ \text{sheet})\ \frac{1\ \text{ream}}{500\ \text{sheets}}\ \frac{60\ \text{lb.}}{1\ \text{ream}}\ \frac{453.6\ \text{gm.}}{1\ \text{lb.}} = 54.43\ \text{gm.}$$

In this problem, you are trying to convert "one sheet" into "grams." To do this you must proceed one step at a time, using the conversion ratios which you know or can find in a table. First you convert "sheets" into "reams," knowing that 500 sheets equal one ream. Then you convert "reams" into "lb.," knowing that 1 ream equals 60 lb. Finally, you convert "lb." into "gm."

Other Kinds of Conversion Factors. Any of the conversion factors listed in the Appendix can be used in the working of problems by the "units method." With this table you can convert from ounces to pounds, from grams to kilograms, or from kilograms to pounds. There are also conversion factors involving volume such as fluid ounces or cubic centimeters. Then there are conversion factors involving length such as inches, feet, centimeters, and meters.

Besides these there are several other kinds of conversion factors which can be used. Some of these are:

1. Density of a solution or a solid. The density of a solution is a conversion factor which converts from the weight of that solution to the volume which it occupies. This will be discussed in the next section.

2. Conversion factors involving money such as $0.40 per sq. ft., $2.50 per lb., or $1.80 per gal.

3. Rate factors such as 200 cu.ft. of air per minute, 6000 sheets per hour, or web speeds of 600 feet per minute.
4. Ink mileage, such as 100,000 sq. in. per lb. of ink.
5. Paint coverage, such as 300 sq. ft. per gal. of paint.
6. Chemical conversion factors. By the use of such chemical conversion factors you can, for example, convert from a given weight of magnesium carbonate to the weight of nitric acid which is needed to react with it. This will be discussed in more detail later in this chapter.
7. Percentage. If an ink contains 20% by weight of pigment, this figure is really a conversion factor between the weight of the pigment and the weight of the ink containing this pigment. The conversion of a percentage figure into a conversion ratio useful in the working of a problem will be discussed later.

The above conversion factors are typical of the more unusual kinds which can be used in the solving of certain types of problems. As we said before, anything which converts from one thing to another can be considered to be a conversion factor.

In the list above the term "per" is used several times. This term always means *one*. The expression $2.50 per lb. can be written $2.50 = 1 lb. and then expressed as the conversion ratio $\frac{\$2.50}{1\ \text{lb.}}$.

Density as a Conversion Factor. If you know the density of a material you can convert from any given weight of it to the volume which it occupies, or the reverse. There are no fixed units for density, so you must be careful when you use a density number. It may be expressed as so many gm. per cc., gm. per ml., lb. per cu. ft., or lb. per gal. The density of water is 1 gm. per ml., or it can be expressed as 8.33 lb. per gal.

Let's solve this problem: what is the weight in pounds of 10 gallons of a solvent which has a density of 0.8 gram per milliliter? We must start with "10 gal." which is a volume and we must end with "lb." which is a weight. So somewhere along the line we must convert from volume to weight and this is where the density number must be used. But the density is in "ml." and not in gal. So the general procedure is to convert "gal." to "ml.," then use the density factor to convert "ml." to "gm." and finally convert the "gm." to "lb." The problem is set up as follows:

$$(10\ \text{gal.})\left(\frac{3{,}785\ \text{ml.}}{1\ \text{gal.}}\right)\left(\frac{0.8\ \text{gm.}}{1\ \text{ml.}}\right)\left(\frac{1\ \text{lb.}}{453.6\ \text{gm.}}\right) = 66.7\ \text{lb.}$$

Relation of Density and Specific Gravity. Specific gravity is a little different than density. To put it simply, the specific gravity