of a liquid is a figure which tells you how much heavier or lighter it is than water. If the specific gravity of a liquid is 1.43 it means that the liquid is 1.43 times as heavy as water. If the specific gravity is 0.85 it means that the liquid is only 0.85 as heavy as water. To put it more precisely the specific gravity of a liquid is the ratio between the weight of any volume of that liquid to the weight of an equal volume of water. To be really accurate, the liquid and the water should both be at some specified temperature, which is usually, though not always, the same temperature. The specific gravity of a liquid is a figure which does not have any "units." However, for most problems which do not require the ultimate in accuracy, you can use the units of "gm. per ml." or "gm. per cc." This means that the specific gravity of a liquid is very nearly the same as the density of that liquid providing the density is expressed as gm. per ml. or gm. per cc.

Use of the "Units Method" in the Solving of Chemical Problems. Suppose we want to calculate how many grams of pure nitric acid will be required to react with 500 grams of magnesium carbonate. And as a result of this chemical reaction, suppose we want to calculate how many grams of magnesium nitrate will be formed. Problems of this kind are quite simple if you use the "units method."

First, you must know what the chemical reaction is between two substances, and then write the chemical equation for this reaction and balance it. How to do this has already been explained in Chapter I. You had better review the sections called "Molecular Weights; Gram Molecular Weights" and "Rules for the Balancing of Chemical Equations."

Consider the balanced chemical equation:

$$\underset{84.3\text{ gm.}}{MgCO_3} + \underset{126\text{ gm.}}{2HNO_3} = \underset{148.3\text{ gm.}}{Mg(NO_3)_2} + \underset{18\text{ gm.}}{H_2O} + \underset{44\text{ gm.}}{CO_2}$$

This equation tells us that if you weigh out 84.3 gm. of pure $MgCO_3$ it will require 126 gm. of pure HNO_3 to react with it. When the reaction is over, 148.3 gm. of magnesium nitrate will be formed. There will also be 18 gm. of water formed, but it will not be noticed since it will be mixed with the rest of the water in which the reaction has taken place. When this reaction is carried out, the nitric acid is usually diluted with water, so the reaction will not be too violent. There will also be 44 gm. of CO_2 formed, most of which will be lost into the air since CO_2 is a gas.

These gram molecular weights can be used to set up the required chemical conversion ratio. We can say that 84.3 gm. $MgCO_3$ *equals* 126 gm. HNO_3. By this we mean that they are chemically

equivalent to each other. So, to "convert" any given weight of $MgCO_3$ into the weight of HNO_3 which is needed to react with it, we set up the chemical conversion ratio $\frac{126\text{ gm. } HNO_3}{84.3\text{ gm. } MgCO_3}$. From here on, the solving of our first problem is just as easy as converting inches into feet. The problem is set up as follows:

$$(500\ \text{gm. } MgCO_3)\left(\frac{126\text{ gm. } HNO_3}{84.3\text{ gm. } MgCO_3}\right) = 747.3\text{ gm. } HNO_3$$

Note that you must write the formula of the materials, as well as the units of "gm." It is not merely 500 gm.; it is 500 gm. $MgCO_3$. The conversion ratio has been set up properly so that "gm. $MgCO_3$" will cancel out, leaving "gm. HNO_3" which then becomes the units of the answer.

To solve the second part of the problem, we make use of the chemical conversion ratio $\frac{148.3\text{ gm. Mg. } (NO_3)_2}{84.3\text{ gm. } MgCO_3}$.

To find out how many grams of magnesium nitrate will be produced by the reaction of nitric acid with 500 grams of magnesium carbonate the problem is set up as follows:

$$(500\ \text{gm. } MgCO_3)\left(\frac{148.3\text{ gm. } Mg(NO_3)_2}{84.3\text{ gm. } MgCO_3}\right) = 879.6\text{ gm. } Mg(NO_3)_2$$

If the last problem had read "How many pounds of magnesium nitrate can be produced if you start with 500 pounds of magnesium carbonate?" the method of calculation would be almost the same. The units of the chemical conversion ratio can be expressed in pounds, as long as both parts of the ratio are in pounds. Thus the problem would be:

$$(500\ \text{lb. } MgCO_3)\left(\frac{148.3\text{ lb. } Mg(NO_3)_2}{84.3\text{ lb. } MgCO_3}\right) = 879.6\text{ lb. } Mg(NO_3)_2$$

Percentage as a Conversion Factor. Percentage is merely a special kind of conversion factor. Percentage is based on 100, always. Unfortunately, there are different kinds of "percentages," particularly of solutions. A 5% salt solution may mean:

1. Five grams of salt in 100 grams of *solution* (salt plus water). This is what one *should* mean when he speaks of a 5% solution *by weight.*
2. Five grams of salt in 100 cc. of water.
3. Five grams of salt in 100 cc. of *solution.* Nos. 2 and 3 are not quite the same. When 5 grams of salt are dissolved in 100 cc. of water, the volume of the solution will be a little more than 100 cc.

From this discussion, it is clear that you should be careful to state what you mean when you talk about a "5% solution" of some