First stage

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Chapter 6:
Percentage, Ratio Strength, and Other Expressions of Concentration

Objectives

•Define the expressions percent weight-in-volume, percent volume-in-volume, and percent weight-weight.

• Define the expression ratio strength.

• Convert percent strength to ratio strength and ratio strength to percent strength.

• Calculate the percentage strength and ratio strength of a pharmaceutical preparation.

• Apply percent strength and ratio strength to calculate the quantity of an ingredient present in pharmaceutical preparation.

• Apply percent strength and ratio strength to calculate the quantity of an ingredient to use in compounding a pharmaceutical preparation.

Percentages

In compounding a pharmaceutical preparation. The term ***percent*** and its corresponding sign (%) mean ‘‘by the hundred’’ or ‘‘in a hundred,’’ and ***percentage***; *50 percent* (or 50%) and *a percentage of 50* are equivalent expressions.

For computation, presents are usually changed to equivalent decimal fractions. This change is made by dropping the percent sign (%) and dividing the expressed numerator by 100.

Thus, 12.5%, 12.5/100, or 0.125; and 0.05%, 0.05 /100, or 0.0005. We must not forget that in the reverse process (changing a decimal to a percent), the decimal is multiplied by 100 and the percent sign (%) is affixed.

The percentage is an essential part of pharmaceutical calculations. The pharmacist encounters it frequently and uses it to express the concentration of active or inactive material in pharmaceutical preparation.

Percentage Preparations

The percentage concentrations of active and inactive constituents in various types of pharmaceutical preparations are defined as follows by the *United States Pharmacopeia: (***USP sets quality, purity, strength, and identity standards for, 'medicine, food ingredients, and dietary supplements. We achieve this through the publication of documentary standards (also known as monographs) in our primary reference text, the *USP-NF*, and by developing USP Reference Standards (also known as physical standards)—used by manufacturers to test their products against our standards to ensure they meet published specifications. The United States Pharmacopeia – National Formulary (USP-NF) includes over 5000 quality standards for medicines, both chemical and biological; active pharmaceutical ingredients (APIs); and excipients (inactive ingredients).**

Percent weight-in-volume (w/v) expresses the number of *grams* of a constituent in *100 mL* of solution or liquid preparation and is used regardless of whether water or another liquid is the solvent or vehicle. Expressed as: *% w/v*.

Percent volume-in-volume (v/v) expresses the number of *milliliters* of a constituent in *100 mL* of solution or liquid preparation. Expressed as: *% v/v*.

Percent weight-in-weight (w/w) expresses the number of *grams* of a constituent in *100 g* of solution or preparation. Expressed as: % *w/w*.

The term *percent*, or the symbol %, when used *without qualification* means:

• for solutions or suspensions of solids in liquids, *percent weight-in-volume*;

• for solutions of liquids in liquids, *percent volume-in-volume*;

• for mixtures of solids or semisolids, *percent weight-in-weight*; and

• for solutions of gases in liquids, *percent weight-in-volume*.

Special Consideration in Percentage Calculation

The nature of the ingredients in a pharmaceutical preparation determines the basis of the calculation. That is, a powdered substance dissolved or suspended in a liquid vehicle would generally be calculated on a ***weight-in-volume*** basis, and a powdered substance mixed with a solid or semisolid, such as an ointment base, would generally be calculated on **a *weight-weight*** basis; and, a liquid component in a liquid preparation would be calculated on a ***volume in-volume*** basis. *Based on these considerations, if the designation of the term of a calculation (e.g., w/v, w/w, or v/v) is not included in a problem, the appropriate assumption must be made.*

Table 6.1 presents examples of the usual basis for calculations of concentration for some dosage forms.

Table 6.1 Examples of Pharmaceutical Dosage Forms in Which the Active Ingredient Is Often Calculated and Expressed on A Percentage Basis

Percentage Basis	Examples
Weight-in-volume	**Solutions (e.g., ophthalmic, nasal, otic, topical, large-volume parenteral), and lotions**
volume-in-volume	**Aromatic waters, topical solutions, and emulsions**
Weight-in-weight	**Ointments, creams, and gels**

The use of percentage concentrations in the manufacture and labeling of pharmaceutical preparations is restricted to instances in which the dose of the active therapeutic ingredient (ATI) is not specific. For example, the ATIs in ointments, lotions, external solutions, and similar products may commonly be expressed in percent strength (e.g., a 1% hydrocortisone ointment).

However, in most dosage forms, such as tablets, capsules, injections, oral solutions, and syrups, among others, the amounts of ATIs are expressed in definitive units of measure, such as milligrams per capsule, milligrams per milliliter, or other terms.

On the other hand, in many pharmaceutical formulations, *pharmaceutical components* such as flavoring agents, solvents, excipients, preservatives, and so on, may be expressed in terms of their percentage concentration.

Specific gravity may be a factor in several calculations involving percentage concentration. Many formulations are presented based on weight, even though some of the ingredients are liquids. Depending on the desired method of measurement, it may be necessary to convert weight to liquid or, in some instances, vice versa. Thus, the student should recall the equations:

g= mL x sp. gr

mL =g/sp. gr

Percentage Weight in Volume

Ex1: How many grams of dextrose are required to prepare 4000 mL of a 5% solution?

4000 mL represents 4000 g of solution

5%= 0.05, 4000 g x 0.05 =200 g.

Or, solving by dimensional analysis

5 g/100 mL x 4000 mL =200g

Ex: How many grams of potassium permanganate should compound the following prescription?

Potassium Permanganate	0.02%
Purified Water ad	250 mL

Sig. as directed.

250 mL represents 250 g of solution

0.02%= 0.0002,

250 g x 0.0002 =0.05 g

Calculating the volume of a solution or liquid preparation, given its percentage strength weight-in-volume and the weight of the solute or constituent involves the following

Ex3: How many milliliters of a 3% solution can be made from 27 g of ephedrine sulfate?

$$\frac{3}{100} = \frac{27(g)}{x(g)}$$

x = 900 g, the weight of the solution if it were

water. Volume (in mL) = 900 mL.

percentage Volume in Volume

liquids are usually measured by volume, and the percentage strength indicates the number of parts by volume of an ingredient contained in the total volume of the solution or liquid preparation considered as 100 parts by volume.

Ex1: How many milliliters of liquefied phenol should compound the following prescription?

Liquefied Phenol	2.5%
Calamine Lotion ad	240 mL

Sig. For external use.

milliliters of active ingredient= Volume (mL) x % (expressed as a decimal)

240 mL x 0.025= 6 ml

Ex2: What is the percentage strength v/v of a solution of 800 g of a liquid with a specific gravity of 0.800 in enough water to make 4000 mL?

800 g of water measures 800 mL

800 mL/ 0.800= 1000 mL of active ingredient

x =25%

Ex3: If a veterinary liniment contains 30% v/v of dimethyl sulfoxide, how many milliliters of the liniment can be prepared from 1 lb. of dimethyl sulfoxide (sp gr 1.10)?

1 lb= 454 g

454 g of water measures 454 mL

mL of dimethyl sulfoxide

30 (%)/100 (%) =412.7 (mL)/x (mL)

x =1375.7 or 1376 mL.

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Percentage of Weight-in-Weight

Percentage weight-in-weight (*true percentage* or *percentage by weight*) indicates the number of parts by weight of active ingredient contained in the total weight of the solution or mixture considered 100 parts by weight.

Examples of Weight-in-Weight Calculations

Ex1: How many grams of phenol should be used to prepare 240 g of a 5% (w/w) solution in water?

g of solute =Weight of solution (g) % (expressed as a decimal)

240 g x 0.05= 12 g.

Ex2: How many grams of a drug substance are required to make 120 mL of a 20% (w/w) solution having a specific gravity of 1.15?

120 mL of water weighs 120 g

120 g x 1.15= 138 g, the weight of 120 mL of solution

138 g x 0.20 =27.6 g plus enough water to make 120 mL

Sometimes in a weight-in-weight calculation, the weight of one component is known but *not* the total weight of the intended preparation. This type of calculation is performed as demonstrated by the following example.

ex 3: How many grams of a drug substance should be added to 240 mL of water to make a 4% (w/w) solution?

100% - 4% =96% (by weight) of water

240 mL of water weighs 240 g

$$\frac{96\ (\%)}{4\ (\%)} = \frac{240\ (g)}{x\ (g)}$$

X=10g

It is usually impossible to prepare a specified *volume* of a solution or liquid preparation of a given weight-in-weight percentage strength because the volume displaced by the active ingredient cannot be known in advance. If an excess is acceptable, we may make a volume somewhat more than that specified by taking the given volume to refer to the solvent or vehicle and from this quantity calculating the weight of the solvent or vehicle (the specific gravity of the solvent or vehicle must be known). Using this weight, we may follow the method just described to calculate the corresponding weight of the active ingredient needed.

ex4: How should you prepare 100 mL of a 2% (w/w) solution of a drug substance in a solvent having a specific gravity of 1.25?

100 mL of water weighs 100 g

100 g x 1.25 =125 g, the weight of 100 mL of solvent

100% - 2% =98% (by weight) of solvent

$$\frac{98\ (\%)}{2\ (\%)} = \frac{125\ (g)}{x\ (g)}$$

x= 2.55 g

Therefore, dissolve 2.55 g of drug substance in 125 g (or 100 mL) of solvent

Calculating Percentage Strength Weight-in-Weight

If the weight of the finished solution or liquid preparation is not given when calculating its percentage strength, other data must be supplied from which it may be calculated: the weights of both ingredients, for instance, or the volume and specific gravity of the solution or liquid preparation.

Ex1: If 1500 g of a solution contains 75 g of a drug substance, what is the percentage strength (w/w) of the solution?

1500 (g)/75 (g) =100 (%)/x (%)

x =5%.

Or, solving by dimensional analysis:

75 g/1500 g x 100% =5%.

Ex2: If 5 g of boric acid is added to 100 mL of water, what is the solution's percentage strength (w/w)?

100 mL of water weighs 100 g

100 g +5 g =105 g, weight of solution

$$\frac{105\ (g)}{5\ (g)} = \frac{100\ (\%)}{x\ (\%)}$$

X= 4.76%.

Ex3: If 1000 mL of syrup with a specific gravity of 1.313 contains 850 g of sucrose, what is its percentage strength (w/w)?

1000 mL of water weighs 1000 g

1000 g x 1.313= 1313 g, weight of 1000 mL of syrup

1313 (g)/850 (g) =100 (%)/x (%)

x= 64.7%.

Weight-in-Weight Calculations in Compounding

Weight-in-weight calculations are used in the following types of manufacturing and compounding problems.

Ex1: What weight of a 5% (w/w) solution can be prepared from 2 g of active ingredient?

$$\frac{\mathbf{5}(\%)}{100(\%)} = \frac{2(g)}{x(g)}$$

x= 40 g.

Ex2: How many milligrams of hydrocortisone should compound thefollowing prescription?

Hydrocortisone	1/8%
Hydrophilic Ointment	10g

10 g x 0.00125 =0.0125 g or 12.5 mg.

Ex3: How many grams of benzocaine should be used in compounding the following prescription?

Benzocaine	2%
Polyethylene Glycol Base ad	2

Make 24 such suppositories

Sig. Insert one as directed

2 g x 24= 48 g, total weight of mixture

48 g x 0.02= 0.96 g..

Or, solving by dimensional analysis:

24 supp. x2 g/1 supp. =2%/100%= 0.96 g.

Use of Percent in Compendial Standards

Percent is used in the *United States Pharmacopeia* to express the degree of tolerance permitted in the purity of single-chemical entities and in the labeled quantities of ingredients in dosage forms. For instance, according to the United

States Pharmacopeia,2 ‘‘Aspirin contains not less than 99.5% and not more than 100.5% of $C_9H_8O_4$ (pure chemical aspirin) calculated on the dried basis.’’ Further, ‘‘Aspirin Tablets contain not less than 90.0% and not more than 110.0% of the labeled amount of $C_9H_8O_4$.’’ Although dosage forms are formulated with the intent to provide 100% of the quantity of each ingredient declared on the label, some tolerance is permitted to allow for analytic error, unavoidable variations in manufacturing and compounding, and deterioration to an extent considered insignificant under practical conditions.

The following problem demonstrates calculations involving percent in compendial standards.

Ex1; If ibuprofen tablets are permitted to contain not less than 90% and not more than 110% of the labeled amount of ibuprofen, what would be the permissible range in content of the drug, expressed in milligrams, for ibuprofen tablets labeled 200 mg each?

90% of 200 mg=180mg

110%of 200mg =220mg

Range =180-220mg

CALCULATIONS CAPSULE

Percentage Concentration

The amounts of therapeutically active and/or inactive ingredients in certain types of pharmaceutical preparations are expressed in terms of their percentage concentrations.

Unless otherwise indicated:

(a) Liquid components in liquid preparations have *volume-in-volume* relationships with calculations following the equation:

mL of preparation × % concentration[a] = mL of component

(b) Solid components in liquid preparations have *weight-in-volume* relationships with calculations following the equation:

mL of preparation × % concentration[a] = g of component

The terms of this equation are valid due to the assumption that the specific gravity of the preparation is 1, as if it were water, and thus each milliliter represents the weight of one gram.

(c) Solid or semisolid components in solid or semisolid preparations have *weight-in-weight* relationships with calculations following the equation:

g of preparation × % concentration[a] = g of component

[a] In these equations, "% concentration" is expressed decimally (e.g., 0.05, *not* 5%).

Ratio Strength

The concentrations of weak solutions are frequently expressed in terms of ratio strength. Because all percentages are a ratio of parts per hundred, ratio strength is merely another way of describing the percentage strength of solutions or liquid preparations (and, less frequently, of mixtures of solids). For example, *5%* means *5 parts per 100* or *5/100.* Although *5 parts per 100* designates a ratio strength, it is customary to translate this designation into a ratio, the first figure of which is *1;* thus, 5:100 equals 1:20.

When a ratio strength, for example, *1:1000*, is used to designate a concentration, it is to be interpreted as follows:

• *For solids in liquids 1 g* of solute or constituent in *1000 mL* of solution or liquid preparation.

• *For liquids in liquids 1 mL* of constituent in *1000 mL* of solution or liquid preparation.

• *For solids in solids 1 g* of constituent in *1000 g* of mixture. The ratio and percentage strengths of any solution or mixture of solids are proportional, and either is easily converted to the other by the use of proportion.

Example Calculations Using Ratio Strength

Express 0.02% as a ratio strength.

$$\frac{\mathbf{0.02}(\%)}{100(\%)} = \frac{1(part)}{x(parts)}$$

X= 5000

Ratio strength= 1:5000

Note: To change ratio strength to percentage strength, it is sometimes convenient to ''convert'' the last two zeros in a ratio strength to a percent sign (%) and change the remaining ratio first to a common fraction and then to a decimal fraction in expressing percent:

1:100 = 1/1% =1%

1:200 =1/2% =0.5%

3:500 =3/5% =0.6%

1:2500= 1/25% =0.04%

1:10,000 =1/100% =0.01%

Calculating the ratio strength of a solution or liquid preparation, given the weight of solute or constituent in a specified volume of solution or liquid preparation involves the following.

A certain injectable contains 2 mg of a drug per milliliter of solution. What is the ratio strength (w/v) of the solution?

2 mg =0.002 g

$$\frac{\mathbf{0.002(g)}}{1(\mathrm{g})} = \frac{1\mathrm{ml}}{\mathrm{x(ml)}}$$

x= 500 mL

Ratio strength =1:500

In solving problems in which the calculations are based on ratio strength, it is sometimes convenient to translate the problem into one based on percentage strength and to solve it according to the rules and methods discussed under percentage preparations.

How many grams of potassium permanganate should be used in preparing 500 mL of a 1:2500 solution?

1:2500 =0.04%

500(g) x0.0004=0.2g

How many milligrams of hexachlorophene should be used in compounding the following prescription?

Hexachlorophene 1:400

Hydrophilic Ointment ad 10 g

Sig. Apply.

1:400= 0.25%

10 (g) x 0.0025= 0.025 g or 25 mg.

Or,

$$\frac{400(g)}{10(g)} = \frac{\mathbf{1(g)}}{x(g)}$$

1:400 means 1 g in 400 g of ointment

x= 0.025 g or 25 mg.

Simple Conversions of Concentration to ‘‘mg/mL’’

Occasionally, pharmacists, particularly those practicing in patient care settings, need to convert rapidly product concentrations expressed as percentage strength, ratio strength, or as grams per liter (as in IV infusions) to milligrams per milliliter (mg/mL). These conversions may be made quickly by using simple techniques. Some suggestions follow.

CALCULATIONS CAPSULE

Ratio Strength

The concentrations of very weak pharmaceutical preparations (usually weight-in-volume solutions) often are expressed in terms of their ratio strengths.

Ratio strength is another way of expressing percentage strength. For example, a 1% w/v solution and a ratio strength of 1:100 w/v are equivalent.

The preferable style of a ratio strength is to have the numeric value of the solute as 1. This is accomplished when calculating a ratio strength, by setting up a proportion from the data as:

$$\frac{g\ (\textit{given solute})}{mL\ (\textit{given solution})} = \frac{1}{x};\ \text{then, } 1\!:\!\textit{value of x, answer.}$$

In using a ratio strength in a calculations problem, there are two options: (a) convert it to a percentage strength and perform calculations in the usual manner, or (2) use the ratio strength directly in a problem-solving proportion.

(a) To convert a ratio strength to a percentage strength; for example, 1:10,000 w/v:

$$\frac{1\ \text{g}}{10{,}000\ \text{mL}} = \frac{x\ (\text{g})}{100\ \text{mL}}$$

Solving for x yields percent, by definition (parts per hundred).

(b) Problem-solving proportion, for example:

$$\frac{1\ \text{g}}{10{,}000\ \text{mL}} = \frac{x\ \text{g}}{(\text{given quality, mL})};\ x = \text{g in given mL}$$

To convert product percentage strengths to mg/mL, multiply the percentage strength, expressed as a whole number, by 10.

Example: Convert 4% (w/v) to mg/mL

4x10=40mg/ml

Proof or alternate method :4%(w/v) =4g/100ml

=4000mg/100ml

=40mg/ml

To convert product ratio strengths to mg/mL, divide the ratio strength by 1000.

Example:

Convert 1:10,000 (w/v) to mg/ml.

10000 /100=1mg/10ml

Proof alternate method 1:10000=1g/10000ml

1:10000(w/v) =1000mg/10000ml

=1mg/10ml

Milligrams Percent

The term *milligrams percent* (mg%) expresses the number of milligrams of substance in 100 mL of liquid. It is used frequently to denote the concentration of a drug or natural substance in a biological fluid, as in the blood. Thus, the statement that the concentration of nonprotein nitrogen in the blood is 30 mg% means that each 100 mL of blood contains 30 mg of nonprotein nitrogen, also, quantities of substances present in biological fluids also commonly are stated in terms of milligrams per deciliter (mg/dL) of fluid.

Parts per Million (PPM) and Parts per Billion (PPB)

The strengths of very dilute solutions are commonly expressed in terms of *parts per million (ppm)* or *parts per billion (ppb)*, i.e., the number of parts of the agent per 1 million or 1 billion parts of the whole. For example, we are all familiar with fluoridated drinking water in which fluoride has been added at levels of between 1 to 4 parts per million (1:1,000,000 to 4:1,000,000) to reduce dental caries.

We also are aware of and concerned with the presence of trace amounts of *contaminants* in our drinking water and food which can pose a risk to our health and safety. Many persons have food allergies, immune system disorders, and other conditions that render them more at risk than the general population. Potential contaminants include micro-organisms, inorganic and organic chemical contaminants (some arising from the careless disposal of prescribed and over-the-counter medications, e.g., flushing), pesticides and herbicides, and radioactive compounds.

The Environmental Protection Agency (EPA). has established ***maximum contaminant levels*** **(MCLs)** which quantify the highest level of a contaminant that is allowed in drinking water below which there is no known or expected risk to a person's health or safety. Such levels are established for copper, lead, fluoride, chlorine, total organic compounds, and other trace constituents. These levels generally are expressed either in parts per million or parts per billion.

Example Calculations of Parts per Million and Parts per Billion

Express 5 ppm of iron in water in percentage strength and ratio strength.

5 ppm =5 parts in 1,000,000 parts =1:200,000, ratio strength,

And 0.0005%, percentage strength

The concentration of a drug additive in an animal feed is 12.5 ppm. How many milligrams of the drug should be used in preparing 5.2 kg of feed?

12.5 ppm =12.5 g (drug) in 1,000,000 g (feed)

Thus,

$$\frac{1{,}000{,}000\ \text{g}}{12.5\ \text{g}} = \frac{5{,}200\ \text{g}}{x\ \text{g}}$$

$$x = 0.065\ \text{g} = 65\ \text{mg},\ \textit{answer.}$$