

PBI '93: Adhesives
Preparation of Mixtures/Solutions:
General Concepts and Calculations

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General Concepts

Percentage or %: The percentage of a mixture of two materials refers to the number of parts of the dissolved or mixed compound per 100 parts of the final mixture. To find the percentage or concentration of a material in a mixture, you need to know both the amount of the material (weight or volume) and the total weight or volume of the final mixture. The percent is then arrived at by dividing the amount of the dissolved material by the total amount of the final mixture.

Example: If 3 ounces of sugar are dissolved in enough water to make a total solution of 8 ounces, the parts of sugar in the total parts of the solution is determined by dividing 3 by 8 = .375. To determine the percentage, multiply this number by 100: $.375 \times 100\% = 37.5\%$ sugar solution.

Weight/Weight: Used primarily for dry materials, weight/weight ratios are often expressed as w/w. This abbreviation describes a mixture which has been made by the following actions:

- a. weigh out one component (usually the smaller one),
- b. mix all of a. in enough of the other component to bring the weight up to the desired total, usually 10g, 100g, or 1000g (= 1 kilogram).

Example: Dissolving or mixing 10g (g = grams) of A into a mixture which has a total weight of 100g is expressed as a 10% solution or mixture of A in A+B, w/w (10g/100g). However, if you incorrectly dissolve or mix 10g of A in 100g of B, the % of the solution or mixture is 9% A in A+B, w/w (10g/110g).

Weight/Volume: Used primarily when a dry material is mixed with a liquid, weight/volume ratios are often expressed as w/v. This abbreviation describes a solution which has been made by the following actions:

- a. weigh out one component, then
- b. dissolve or mix all of a. in a small amount of the other component in a graduated container, then
- c. add enough of the other component to bring the total solution or mixture up to the the volume required, usually 10ml, 100ml or 1000 milliliters (= 1 liter).

Example: Dissolve 10g of A in about 50ml of B and bring the volume of the solution up to 100ml. This solution or mixture is expressed as a 10% solution of A in A+B, w/v (10g/100ml). However, if you incorrectly dissolve 10g of A in 100ml of B, the % of the solution could be closer to 9% A in A+B, w/v (10g/110ml).

Volume/Volume: Used primarily for two liquids, volume/volume ratios are often expressed as v/v. This abbreviation describes a solution or mixture which has been made by the following actions:

- a. measure out the volume of one component (usually the smaller one),
- b. add enough volume of the other component to bring the total volume up to the amount required, usually 10ml, 100ml or 1000 milliliters (= 1 liter).

Example: Measure out 10ml of solvent A and add enough of solvent B to make a total solution of 100ml will yield a 10% solution of A in A+B, v/v (10ml/100ml). However, if you incorrectly mix 10ml of solvent A with 100ml of solvent B, the % of the solution is 9% A in A+B, v/v (10ml/110ml).

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Ratios or Parts: Sometimes it is easier to calculate, measure, or dilute solutions or mixtures by using ratios or parts. In fact, the method by which the percentage of resulting solutions can be easily determined if you use this method. One part of Material A compared to two parts of Material B is really a 33.3% solution, either w/w or v/v. This is arrived at by using the ratio 1 part:2 parts. First add the parts on both sides of the colon together to arrive at the total number of parts, and then divide the number to the left of the colon by the total number of the parts, $1/3 = .333$ or 33.3%.

Example: A recipe for wheat starch paste calls for 1 part of wheat starch to 3 parts of water, v/v. This means that 1 part of the starch is measured out using a volume utensil - a beaker, a teacup, a tablespoon, etc. - to some mark or known volume on the utensil. That same utensil is then used to measure out the water to the same mark or volume. But because 3 parts of water are called for, 3 times the volume is used for the water. The resulting concentration then of the paste is 25% wheat starch in water. 1 part of starch/4 parts of starch + water ($1 + 3$) = $1/4$ or .25 or 25%. The paste might also be described as 25% solids.

Molar solutions: Although not commonly used in the preparation of adhesives, molar solutions are sometimes referred to and knowing how to make them can be important. A molar solution is one which contains the molecular weight of a compound in a solution, expressed by grams per liter. To determine the molecular weight, you need to know the chemical formula of that compound and the atomic number of each of the elements in the formula (from the Periodic Chart). The atomic number of each element is multiplied by the number of molecules for that element in the formula and all of those numbers added together are the molecular weight of the compound. This number is then expressed in grams, the compound is weighed out in grams and dissolved in about 500ml of the solvent, and then the solution is brought up to 1 liter. This would be a 1M solution. If a 5M solution is required, then 5 times the molecular weight of the compound is weighed out and dissolved in about 500ml of water, and then the solution is brought up to 1 liter.

Example: You need a 2M solution of sodium hydroxide, NaOH. The atomic weights of Na, sodium, is 23; H, hydrogen, is 1; O, oxygen, is 16. Therefore, the molecular weight of NaOH is: $23 + 1 + 16 = 40$. To make a 1M solution of NaOH we would add 40g to 500ml of water, and once dissolved bring that solution up to 1l. To make a 2M solution, we would follow the same procedure, except we would weigh out $40 \times 2 = 80$ g.

Calculations for Diluting Stock Solutions

A. To determine how much additional solvent is required to lower the concentration of a stock solution to a required percentage:

Calculations:

1). $a = bc + d$

2). $e = a - c$

a = total volume of diluted solution

b = % concentration of stock solution

c = volume of stock solution

d = % concentration of diluted solution

e = amount of additional solvent required

Example: You have a 5% w/v solution of methylcellulose, and you need to use a 4% w/v solution. As there isn't time to make up a new solution, how

much water do you add to 200ml of the 5% solution to bring the concentration down to 4%?

where: a = unknown, total volume of diluted solution
b = 5% w/v methylcellulose in water, or .05g/ml
c = 200ml
d = 4% w/v methylcellulose in water, or .04g/ml
e = unknown, amount of additional solvent required

Then, if 1). $a = bc + d$ $a = 5\% \times 200\text{ml} + 4\%$ $a = 1000\text{ml} + 4$ $a = 250\text{ml}$

and, if 2). $e = a - c$ $e = 250\text{ml} - 200\text{ml}$ $e = 50\text{ml}$

Answer: Add 50ml to 200ml of 5% stock solution to make 250ml of 4% solution

B. There is another method for determining the % of a diluted solution by using ratios or parts.

Calculation: $a = b + (c + d)$

a = % concentration of diluted solution
b = % concentration of stock solution
c = number of parts of stock solution
d = number of parts of solvent

Example: A 30% stock solution is diluted down to a working consistency by adding 2 parts of solvent to 1 part of stock. What is the % concentration of the diluted solution?

The, if: $a = b + (c + d)$ $a = 30\% + (1 + 2)$ $a = 30\% + 3$ $a = 10\%$

Answer: The working solution is a 10% solution.

If math is not your forte, you can use the following chart to either:

1). adjust the concentration of a stock solution to a known lower concentration by diluting volume part(s) of the stock with volume part(s) of solvent, or

2) by keeping track of the number of parts of solvent you add to known part(s) of the stock solution to arrive at the right consistency for your work, you can determine the actual concentration or % of the working solution.

Parts of Stock	Parts of Solvent	Starting Concentration of Stock Solution										
		40%	30%	20%	10%	8%	6%	5%	4%	3%	2%	1%
1	.25	32	24	16	8	6.4	4.8	4	3.2	2.4	1.6	.8
1	.50	26.6	20	13.3	6.7	5.3	4	3.3	2.6	2	1.3	.7
1	1	20	15	10	5	4	3	2.5	2	1.5	1	.5
1	1.5	16	12	8	4	3.2	2.4	2	1.6	1.2	.8	.4
1	2	13	10	6.6	3.3	2.7	2	1.7	1.3	1	.08	.3
1	3	10	7.5	5	2.5	2	1.5	1.25	1	.75	.5	.25
1	4	8	6	4	2	1.6	1.2	1	.8	.6	.4	.2
1	5	6.7	5	3.3	1.7	1.3	1	.83	.67	.5	.3	.17