Making a Complex Solution

Article

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ABSTRACT

Laboratory work often includes complex solutions that are used as buffers and reagents. Preparing these solutions correctly can mean the difference between an experiment going well and failing. In this article we describe how to interpret the formula of a complex solution, calculate the ammount of each component needed and prepare the solution.

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There are a variety of ways a solution can be represented. Some of the most common ways to represent the composition of a solution is as a weight- volume (w/v), volume-volume (v/v) or in terms of molarity (M). To better understand the terminology there are a few words that should be defined. The solute is typically the component present in a smaller amount in the mixture; for simple solutions the solute is often the solid that will be dissolved in the liquid. The solvent is typically the component representing the larger amount in the mixture. Again, for a simple solution, this is often the liquid, and very often it is water. The solution is the mixture of the solute with the solvent where the solute is dissolved in the solvent.

The easiest type of solution to prepare is commonly represented as a weight-volume (w/v). This describes the weight of the solute in a specific volume of solution. Generally, researchers start with the basic assumption that a 1% weight-volume solution represents 1 gram of solute for every 100ml of solution. Therefore, to make a solution represented as w/v, you would weigh out the grams of solute on a scale and add this to the desired container, then add the solvent to the desired volume. As an example, a 10% sodium dodecyl sulfate (SDS) solution is prepared by weighing 100g of SDS, and adding this to 900ml of water. This solution requires some heat to help to dissolve the SDS, and then the pH is adjusted to 7.2 using HCl. The final volume is adjusted to 1L (1,000ml) with water. This final solution represents a 10% (w/v) solution of SDS.

Another easy solution to prepare is a volume-volume solution. In this case, two solutions are already prepared ahead of time. Then the specified volume of the first solution is added to the specified volume of the second solution.

Molarity is defined as the moles of solute per liters of solution and is represented by an uppercase “M”. To prepare a solution that is defined in terms of molarity, determine the volume of the solution that needs to be prepared and then solve for the moles of solute using the following equation:

Molarity = (moles of solute)/(liters of solution)

Moles of solute is not a measurable quantity so this has to be converted into a meaningful unit that can be accurately measured in the lab. The following equation is commonly used to convert moles of solute to grams of solute:

moles of solute × molar mass of solute in grams per mole = grams of solute

The BioMath Calculators tool, Molarity Calculator, can be used to determine the number of grams of compound with a known molecular weight that will be needed to make a desired molarity. Once the grams of solute needed are calculated, this can be measured using an analytical balance and placed in the desired vessel. The solvent is added to make the final volume desired.

Many solutions will require a specific pH. In this case, you should determine if any of the components have special properties, such as the inability to dissolve at acidic, basic or neutral pH. Typically a component that requires a particular pH prior to mixing with the other components will be represented as follows: component chemical name (pH). An example of a solution that requires a particular pH prior to mixing the components is the DNA Rehydration Solution provided with the Wizard® Genomic DNA Purification Kit. This solution is composed of 10mM Tris-HCl (pH 7.4) and 1mM EDTA (pH 8.0). For this solution, the two components need to be at the specified pH before they are combined. In contrast, when the entire solution needs to be at a particular pH after it is prepared, the final pH is usually represented after the solution name or at the end of the solution recipe. For example, 1X TE buffer (pH 8.0) means that the final pH of the TE buffer solution should be 8.0.

Sometimes it will be beneficial to make a stock solution. A stock solution is usually a solution at a higher concentration that can be diluted later to make other solutions. It is often useful to make stock solutions if your laboratory uses a lot of a particular solution or buffer, as this can simplify the preparation. To make a stock solution you will need to decide on the concentration of the stock solution (e.g., a 10X solution represents a stock solution with a concentration ten times higher than what is called for in the final solution).

As an example, to make 4X stock solutions for both the Tris-HCl and the $MgCl_2$ solutions used in the BigDye® dilution buffer (250mM Tris HCl (pH 9.0) and 10mM $MgCl_2$), multiply the desired final concentration by 4. Therefore, the 4X Tris-HCl (pH 9.0) solution is prepared as 1M Tris-HCl (pH 9.0) and the 4X $MgCl_2$ solution is prepared as 40mM. Calculate the mass of Tris base required (121.1 grams), and dissolve it in approximately 800ml of water. Adjust the pH to pH 9.0, and add water to a final volume of 1L (1,000ml). The 50mM $MgCl_2$ stock solution is prepared by dissolving 3.808 grams of $MgCl_2$ in water in a final volume of 1L (1,000ml).

To use the stock solution, calculate the necessary volumes of the stock solutions using the following equation:

(Molarity of stock solution)(volume of stock solution) = (Molarity of final solution)(volume of final solution)

This equation is often represented as:

$$C_1V_1 = C_2V_2$$

It is then possible to substitute the known concentration of the stock solution, the desired final molarity and the desired final volume to determine the volume of stock solution to use. In this case one-fourth of the final volume will consist of Tris-HCl stock solution and one-fourth of the final volume will will consits of the $MgCl_2$ solution. The remainder will be water.

Conclusion

This information covers how the majority of simple and complex solutions are commonly made in the laboratory. For more detailed information about making solutions, consult a basic chemistry book. Some of the common buffer recipes are provided here: Recipes for Common Laboratory Solutions (PDF).

HOW TO CITE THIS ARTICLE

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