

Introduction to lab math

(Self-Guided)

The information and exercises provided here are intended to refresh your memory of these concepts. If they are entirely new to you or if you are struggling with the practice problems, please ask for extra help. It is absolutely essential that you are comfortable with the information presented here.

Part 1: Metric system

This is the numerical language of science. Base units that you will most often use in this class are meters, grams, liters, and moles. These units will be appended with prefixes to modify the unit by a power of ten.

$10^3 = 1000$	$= 1000/1$	$= 10^3/1$	kilo (k-)
$10^0 = 1$	$= 1/1$	$= 10^0/1$	base unit (-g, -l, -mole...)
$10^{-3} = 0.001$	$= 1/1000$	$= 1/10^3$	milli (m-)
$10^{-6} = 0.000001$	$= 1/1000000$	$= 1/10^6$	micro (μ -)

Practice problems:

1. The distance between two cells is 800 μm . How many mm is that?
2. The amount of sorbitol you want to weigh is 1.9 g. How many mg is that?
3. The volume you want to measure is 100 ml. How many liters is that?
4. Your reaction generates 0.1 μmoles of product. How many mmoles is that?

Scientific notation expresses numbers so there is one digit to the left of the decimal point and that number is multiplied by a power of ten. 2334 becomes 2.334×10^3 and 0.0041 becomes 4.1×10^{-3} . Computations are easier with numbers in scientific notation and some numbers that are easier to write (602,214,199,000,000,000,000 versus 6.02×10^{23}).

Practice problems: Convert the following to scientific notation

1. 1000
2. 2
3. 0.0023
4. 0.000000467

The metric system and scientific notation go hand in hand, making unit conversions straightforward. For example 100 μl can be converted to ml by writing the starting volume in scientific notation ($1.00 \times 10^2 \mu\text{l}$) and multiplying by the power of ten that separates the units ($1 \text{ ml} = 1 \times 10^3 \mu\text{l}$). Set up every equation so the units will cancel properly when you multiply through.

Practice problems: Be sure you can express your answers in scientific notation.

1. How many ml is 100 μ l?
2. How many mg is .023 g?
3. How many mmoles is 250 μ moles?

Part 2: Concentrations

Molarity (moles/liter) is a common expression of concentration. When making a solution of a particular molarity, you need to know three things: the desired molarity, the desired volume and the formula weight of the compound to be dissolved. The best place to find the formula weight (grams/mole) is on the chemical's bottle. Calculations are performed by setting up an equation so that the units cancel, leaving grams in the numerator and volume in the denominator.

Another common expression of concentration is percent. Percent solutions are always based on 100 ml. For powdered substances, percent solutions reflect the weight in a 100 ml volume ("w/v"). For example a 10% solution of NaCl is 10 grams in 100 ml of water. In fact a 10% solution of any powdery substance is 10 grams in 100 ml. For liquids, percent solutions reflect the volume in a 100 ml final volume ("v/v"). For example a 70% ethanol solution is 70 ml of 100% ethanol and 30 ml of water. Remembering that 1 ml of water weighs 1 gram may help you remember the w/v and v/v expressions.

Practice problems:

1. You want to make 100 ml of a 0.5M sorbitol solution. The formula weight of the substance you want to dissolve is 182. How many grams will you measure?
2. You want to make 10 ml of a 0.01% (w/v) solution of XC. How many grams will you dissolve?
3. How would you make 100 ml of a solution that is 5% (v/v) acetic acid and 5% methanol?

Part 3: Dilutions

Many solutions are made by diluting concentrated stock solutions. Dilution factors of 1:2, 1:5, 1:10 and 1:100 are common. These dilutions are made by diluting one "part" stock with 1, 4, 9 or 99 "parts" water. For example, you could make 100 ml of a 0.5M sorbitol solution by mixing 10 ml of a 5M stock solution with 90 ml of water. This is a 1:10 dilution of the stock. The dilution factor can be converted to a fraction to determine the solution's final concentration ($5M \times 1/10 = 0.5M$).

When the dilution factor is less obvious, the formula $C_1V_1 = C_2V_2$ can be used, where C_1 is the starting concentration of the stock solution, C_2 is the desired concentration, V_1 is the volume of stock you'll need (usually this is your unknown) and V_2 is the final volume you want to make. For example, to make 1000 ml of a 0.2M Tris from a 1.5M stock you would multiply $1.5M (V_1) = 0.2M (1000)$ to find that you will need 133 ml of the stock.

To determine how much water to add you would subtract $V_2 - V_1$, in this case $1000 \text{ ml} - 133 \text{ ml} = 867 \text{ ml}$ of water.

When solutions must be diluted several orders of magnitude, then serial dilutions are made. The concentrated stock is progressively diluted, for example using a 1:100 dilution as the new “stock” in another 1:100 dilution. Such a serial dilution produces a solution that is 10,000 times less concentrated than the starting material. One benefit to serial dilutions is that small volumes of each dilution can be made accurately. A drawback is that any pipetting or calculation error is propagated through every dilution.

Practice Problems

1. How would you make 50 ml of a 1:5 dilution?
2. Give the volume of stock and the volume of water necessary to make 50 ml of a 0.25 M solution starting with a 2M solution.
3. A concentrated culture of bacteria has approximately 1×10^8 cells/ml. What is the concentration of bacteria after it has been diluted 1:100? What is the concentration of bacteria if a 1:2 dilution was made of the 1:100?