

**2008
Winning Lesson Plan
from San Mateo,
California**

*Overcoming Mole
Phobia – Mastering Molar
Solution Preparation*
(adapted from *Biotechnology:
Science for the New
Millennium*, E. Daugherty,
with her permission)

by James Ikeda
San Mateo High School

Subject: Biotechnology,
Chemistry, Biotechnology

Grade Level: 9–12

Duration: 1 Week
(one 90-minute period for
learning to determine molecular
weights, 90-minute period for
the laboratory and another
50-minute period to practice
calculations and to discuss
and compare the results)

Overview and Purpose

Biotechnology courses are an opportunity to teach science in a way that more closely duplicates what real researchers and technicians do. One of the most basic lab skills is solution preparation and researchers must be able to prepare any solution in any concentration and volume.

In this lesson plan, using cupric sulfate solutions, participants learn the components of a solution (solutes and solvents) and how to calculate and diagram molar solution preparation. Students will learn how to measure solutes and solvents (using pipets, micropipettes, and balances, etc.), how to report molar concentration, and how to check their solution prep (spectrophotometry) for accuracy. The understanding of a mole is necessary to the extent that you know when you have one or part of one. By definition, a mole is equal to the amount of a compound that is equal to the compound's molecular weight, in grams. To prepare a molar solution, determine the portion of a mole desired and include it in the concentration equation as shown in the Molarity Concentration Equation:

$$\text{Volume (L)} \times \text{Concentration (mol/L)} \times \text{Molecular Weight (g/mol)} = \text{_____g}$$

Notice that if the values are given in these units, then during multiplication all the units cancel except for grams, leaving with the value of solute to be measured for the solution. Mol/L is the same as saying “molar”.

Demonstrate a calculation and preparation example such as: How much NaCl do you need for 125 mL of 0.2 M NaCl solution. Don't forget to convert to the necessary units.

$$0.125 \text{ L} \times 0.2 \text{ mol/L} \times 58.5 \text{ g/mol} = 1.4625 \text{ g, rounded to 1.46 g for our balances}$$

This means that to make 125 mL of 0.2 M NaCl solution, 1.46 g of salt are measured out and placed in a 250 mL beaker and deionized water is slowly stirred in until a final volume of 125 mL is reached.

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Innovative

This lesson plan allows students to easily master one of the hardest units in chemistry and biotechnology—molarity. By mastering molar solution preparation in this activity, students overcome their greatest fear in taking chemistry classes (abstract mathematical calculations) and are more willing to take chemistry courses. In fact, our chemistry instructors have become some of the biggest proponents of our biotech classes, since they see the way biotechnology makes students comfortable in solution preparation.

The molar solution prep activity is innovative because it is a “hands-on” way of learning that allows students to get immediate feedback on the success of their skill development. By checking their solution preparations in a spectrophotometer, students immediately know if they prepared their solution correctly. In biotech, students do the work not just the calculations (like so many chemistry classes). This activity is powerful in that it can be scaffolded with other skill development activities such as dilution, pH, and spectrophotometer labs.

Description of the larger context (unit) in which the instruction will occur along with the goals for the unit: Solution prep is a basic skill required for any student hoping to be work in a laboratory setting and is a gatekeeper for other laboratory activities in my program and in our internship placement. Student who do not successfully pass a solution preparation test are required to retrain and retest until they reach a minimum 80% competency. The only way a student will “fail” this unit is if the student “gives up”.

The molar solution preparation lab lesson is part of the Solution Preparation Unit and is taught with the other lab activities in the following order:

- Volume Measurement (pipets and micropipettes)
- Mass Measurement (tabletop and analytical balances)
- Introduction to Solutions and Concentration Measurement
- Mass/Volume Solutions
- % Mass/Volume Solutions
- Molar Solutions
- Dilutions of Solutions

Educational Standards Addressed

California science standard(s) and specific concept(s):

Chemistry: 3a-3d, 6a-6d Investigation and Experimentation 1a-1d, 1j, 1l

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Objectives

Students calculate how to prepare and then make solutions of differing molarity concentrations.
Students check their solutions using a spectrophotometer.

Materials

- Cupric Sulfate pentahydrate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$)
- water
- tabletop balance
- weigh
- paper
- tubes-15mL
- lab scoops
- gloves
- permanent marking pens
- peg racks

Procedures

- Using the Molar Solution Equation, calculate the amount of solute to use to prepare a solution of the desired molar concentration in each tube. Record the solution preparation calculations in the chart below.

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Tube #	Molar Concentration of Each Tube	Mass of CuSO ₄ (g)	Amount of dH ₂ O	Calculations and Diagram
1	5mL of 1.0 M CuSO ₄			
2	5 mL of 0.5 M CuSO ₄			
3	5 mL of 0.1 M CuSO ₄			
4	5 mL of 0.05 M CuSO ₄			
5	5 mL of 0.01 M CuSO ₄			

Show your calculations on the reaction matrix. Do the calculations and confirm them with another person's calculations before you start.

- Label all tubes with the concentration of the sample, your initials, and the date.
- Review the use of the balance and weighboats before beginning.

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Procedures (Cont'd)

2. Prepare the solutions for tubes #1–5 from the chart. Use the molar solution equation to determine the mass of CuSO_4 to be measured to give the right concentration and volume in each sample.
3. Mix up the solutions using deionized water, in labeled 15 mL capped, conical tubes.
4. Is the difference in concentration of your five tubes obvious in one tube versus another? Explain. If any volumes or colors are obviously wrong, dump them out and remake them.
5. Compare your tubes' colors and volumes to others in the class,
6. Use the spectrophotometer at a wavelength of 600 nm to compare the absorbance of the different concentrations of CuSO_4 . Collect your data into a table you create. Plot the concentration versus the absorbance of the solutions. Describe what the absorbance data tells you about the solutions' preparation. Write a paragraph discussing your success preparing the different molar solutions.

Activities Outside the Classroom

I give students review sheets of problems where students show how to prepare solutions of different molar concentrations. Other homework assignments include an internet activity where students go online and find the similarities and differences between concentrations reported in molarity (this lab), molality, and normality. Students also visit biotechnology facilities on their field trips where solution prep and media prep are entry-level jobs.