# #26 Preparation of Solutions

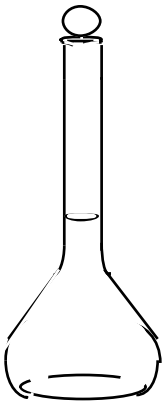
**Purpose**: This experiment provides practical experience in preparing solutions using the concentration units of molarity and molality.

**Introduction**

Preparing solutions is one of the most fundamental tasks performed in the laboratory.

*Molarity:* By far, the most common concentration unit used by chemists is molarity. Molarity (M) is the number of moles (n) of solute dissolved in exactly one liter of solution.

$$Molarity(m) = \frac{n(solute)}{L(solution)}$$



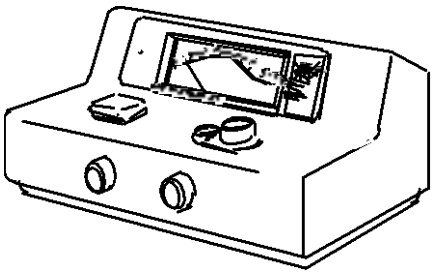
Using the *volumetric flask* shown, a measured amount of solute needed for a particular concentration is placed in the flask and solvent is added up to the mark on its neck. It is not necessary to use 1-L volumetric flasks ; other common sizes available are 10 mL, 25 mL, 50 mL, 100 mL, 250 mL, 500 mL, and 2000 mL.

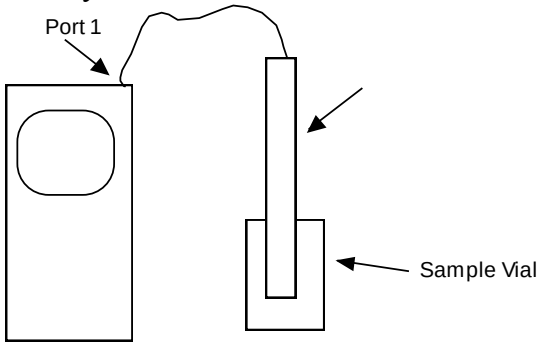
*Molality:* Molality units are used in calculating changes in boiling point and freezing point that a solvent undergoes when solute is added. Molality (m) is the number of moles of solute dissolved in exactly one kilogram (1000 g) of solvent.

$$Molality(m) = \frac{n(solute)}{kg(solvent)}$$

**Apparatus**

Electronic balances, volumetric flasks, and Erlenmeyer flasks will be used for preparing the solutions. A spectrometer (left) and a conductivity probe interfaced with LabQuest (right) will be used in testing to see if the concentrations of your solutions are correct.






**Safety and Waste disposal**

Wear gloves throughout this experiment. Copper sulfate stains the skin. A waste bottle will be provided for copper sulfate solution.

**Procedure**

Calculate the amount of solid solute needed for a solution of given volume and concentration. Prepare the solution and test to see if your concentration is correct. For help with the calculations, refer to the Data and Results sheet.

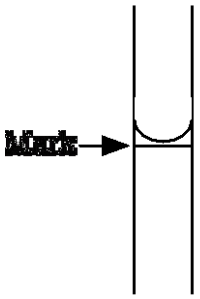
Part A: Preparation/Testing of 0.10 M Copper sulfate pentahydrate

**1**. Find the number of moles needed to make 50 mL (0.050 L) of 0.10 M solution using a 50-mL volumetric flask. Record.

**2**. From the molar mass of copper sulfate pentahydrate, $CuSO_4 \cdot 5H_2O$ and the number of moles from Step 1, find the mass in grams of solute needed. Record.

**3**. Weigh the mass of solute calculated from Step 2 and carefully transfer the blue solid to a clean 50-mL volumetric flask.

**4**. Add about half the volume of distilled water needed and swirl the flask. When most of the solid has dissolved add the rest of the water stopping below the mark on the flask. To add the remaining water use the water wash bottle. Insert the stopper and invert the flask a few times for uniform mixing. Note: The *bottom* of the curved water surface, the "meniscus", should touch the mark on the neck.




**5**. Test to see if the concentration of your blue copper sulfate solution is correct by measuring its absorbance at a given wavelength. Fill a cuvette with your solution and place in the spectrometer which is set to a wavelength of 700 nm. Record the absorbance, (A), which is directly related to concentration.

**6**. Find the % error. See Data and Results sheet

Part B: Preparation/Testing of 0.20 m Sodium Chloride

**1**. Find the number of moles of NaCl that must be mixed with 100 g water to make a 0.20 m solution. See Data and Results sheet. Record.

**2**. From the molar mass of NaCl and the number of moles from Step 1, find the number of grams of sodium chloride needed . Record.

**3**. Weigh the amount of NaCl from Step 2 and transfer to a 250 mL Erlenmeyer flask. Measure 100 mL $H_2O$ (100 g) in a graduate and pour into the Erlenmeyer. Swirl to dissolve.

**4**. Test the solution by measuring its conductance using the probe interfaced to LabQuest. Insert the probe in the solution so that the electrode surfaces are completely submerged in the liquid. Gently swirl the probe and wait about 5 to 10 seconds for a reading to appear. Record. A 0.20 m NaCl solution has a conductance of 18,500 μ S.
Note: The unit for conductance, is the *siemen*, S, a very large unit. Conductance of aqueous solutions is measured in microsiemens, μS (micro is 1 millionth, $10^{-6}$).

**5**. Find the % error. See Data and Results sheet.

**Data and Results** (Solutions)

*Name(s)*_____ *Date* _____

Part A: Preparation/Testing of 0.10 M Copper sulfate pentahydrate
Mass (g) of $CuSO_4 \cdot 5H_2O$ needed to prepare 50 mL 0.10 M solution:

| Calculation | Result |
|---|---|
| 1. Moles needed = 0.050 L x 0.10 mol/L | mol |
| 2. Molar mass of $CuSO_4 \cdot 5H_2O$ | 250 g/mol |
| 3. Mass in grams needed (1 x 2) = moles x molar mass | g |

**% Error**
Absorbance at 700 nm, 0.10 M $CuSO_4 \cdot 5H_2O$, known: __0.77___

Absorbance at 700 nm, 0.10 M $CuSO_4 \cdot 5H_2O$, measured: _____

% Error = $((A_{measured} - A_{known})/A_{known}) \times 100\%$

Part B: Preparation/Testing of 0.20 m Sodium chloride
Mass (g) of NaCl needed to mix with 100 g water to prepare a 0.20 m solution:

| Calculation | Result |
|---|---|
| 1. Moles needed = 100 g x 0.20 mol/1000g | mol |
| 2. Molar mass of NaCl | 58.5 g/mol |
| 3. Mass in grams needed (1 x 2) = moles x molar mass | g |

**% Error**
Conductance 0.20 m NaCl, known: __18,500 μ S _

Conductance 0.20 m NaCl, measured: _____

% Error = $((C_{measured} - C_{known})/C_{known}) \times 100\%$

**Questions**
**1**. Explain how you would prepare 100 mL 0.10 M NaOH.
**2**. Explain how you would prepare 0.20 m NaOH using 100 g water.

# Instructor's Guide
## (#26 *Solutions*)

**Data and Results** (Solutions)

Part A: Preparation/Testing of 0.10 M Copper sulfate pentahydrate
Calculating the mass (g) of $CuSO_4 \cdot 5H_2O$ needed to prepare 50 mL 0.10 M solution:

| Calculation | Result |
|---|---|
| 1. Moles needed = 0.050 L x 0.10 mol/L | *0.0050* mol |
| 2. Molar mass of $CuSO_4 \cdot 5H_2O$ | 250 g/mol |
| 3. Mass in grams needed (1 x 2) = moles x molar mass | *1.25* g |

**% Error**
Absorbance at 700 nm, $CuSO_4 \cdot 5H_2O$, known: 0.77

Absorbance at 700 nm, $CuSO_4 \cdot 5H_2O$, measured: _____

% Error = $((A_{measured} - A_{known})/A_{known}) \times 100\%$

Part B: Preparation/Testing of 0.20 m Sodium chloride
Calculating the mass (g) of NaCl to mix with 100 g water to prepare a 0.20 m solution:

| Calculation | Result |
|---|---|
| 1. Moles needed = 100 g x 0.20 mol/1000g | *0.020* mol |
| 2. Molar mass of NaCl | 58.5 g/mol |
| 3. Mass in grams needed (1 x 2) = moles x molar mass | *1.17* g |

**% Error**
Conductance 0.20 m NaCl, known: 18,500 m S

Conductance 0.20 m NaCl, measured: _____

% Error = $((C_{measured} - C_{known})/C_{known}) \times 100\%$

**Answers to Questions**
**1**. Explain how you would prepare 100 mL 0.10 M NaOH.

The molar mass of NaOH is 40 g/mol.
Mol NaOH needed: 0.10 mol/L x 0.1 L = 0.010 mol
g NaOH needed: 0.010 mol x 40 g/mol = 0.40 g
Place 0.40 g in a 100-mL volumetric and dilute to the mark.

**2**. Explain how you would prepare 0.20 m NaOH using 100 g water.

Mol NaOH needed: 0.20 mol NaOH/1000 g $H_2O$ x 100 g $H_2O$ = 0.020 mol

g NaOH needed: 0.020 mol x 40 g/mol = 0.80 g
Mix 0.80 g NaOH with 100 g $H_2O$.

**Time:**

**Equipment and Materials** per group

| Items | Amount | Comment |
|---|---|---|
| Distilled water wash bottle | 1 | |
| 250 mL Erlenmeyer | 1 | For molality |
| 100 mL graduate | 1 | To measure water vol/mass (molality) |
| 50-mL volumetric | 1 | For molarity |
| Electronic balances | 2/class | |
| Sodium chloride | 1 box/class | uniodized table salt. |
| Copper sulfate pentahydrate | 100 g per class | Enough for 2 trials. Crush if needed. |
| Spatulas | 2 | One for each compound used |
| Weighing boats | 2 | |
| cuvettes | 2 | To test copper sulfate solution |
| Spectronic-20 | 1 /class | |
| Conductivity setup (Vernier) | 1/class | LabQuest, conductivity probe |
| Safety glasses | 1 per student | |
| Rubber gloves | 1 box per class | |

**Ideas/ Information**
**1.** Copper sulfate is root killer.

**Variations**
1. Students can be assigned different concentrations.
2. Instead of the Spectronic-20, a color comparator can be used in which a set of vials with different concentrations are compared to the test sample. The closest color match is the concentration