# Module 1: Glassware, Reagents, & Solutions

## Learning OutcomesAn image of 3 beakers, a glass funnel, and a plastic transfer pipet.

Figure 1: Image courtesy of Creative Commons

At the completion of this module, students will be able to

* Choose the correct glassware to accurately measure volumes
* Use the correct glassware to prepare a solution
* Calculate the correct amount of solute for the preparation of a solution
* Prepare a concentrated stock solution
* Use a spectrophotometer to create a calibration curve

## 

## Supplies

|  |  |  |
| --- | --- | --- |
| Glassware  * 250 mL beaker * 100 mL volumetric flask * 25 mL volumetric pipet * 100 mL Graduated cylinder * 100 or 50 mL Buret * 250 mL Erlenmeyer flask * 100 mL volumetric pipet * 1 mL graduated pipet | Equipment  * Thermometer (a single thermometer to measure the temperature in the room) * Spectrophotometer * Cuvettes * Balance to two decimal points * Test tubes | Reagents  * NaCl * Distilled water * CuSO4 |

## Instructor Notes

This module may be adapted to the equipment, glassware, and reagents that you have available at your institution. This is a lengthy module and instructors may choose to deliver the module in whatever manner is most convenient for the instructor and students.

## Exercises

### Part I: Choosing the right tool for the job

### Pre-Procedure question:

Discuss with your partner/team.

Which of the following would you use to measure 100.00 mL of water?

* 1. 250 mL beaker
  2. 100 mL volumetric flask
  3. 25 mL volumetric pipet
  4. 100 mL Graduated cylinder
  5. 100 mL Buret
  6. 250 mL Erlenmeyer flask

### Procedure

1. Measure 100.00 mL of distilled water into each piece of glassware using the markings on the glassware to determine the correct volume.
   1. 250 mL beaker
   2. 100 mL volumetric flask
   3. 25 mL volumetric pipet
   4. 100 mL Graduated cylinder
   5. 100 mL Buret
   6. 250 mL Erlenmeyer flask
2. Use a balance to weigh each 100 mL aliquot and record the mass
3. Measure the temperature of the room
4. Use the attached table to determine the density of water at that temperature
5. Calculate the actual volume of water measured by using the equation for density

### Data Analysis

* Which piece of glassware would you choose to measure a volume of 100.00 mL?
* How does this compare to your prediction prior to doing the experiment?
* Place the glassware in order from most accurate to least accurate.

Reflection

Reflect on the characteristics of the glassware that help determine the accuracy of the measurement.

Activity for Practical

Choose the best piece of glassware to measure 125.0 mL of water. Support your decision by weighing a 125 mL sample of water by using that piece of glassware and calculating its volume by using the density of water.

Instructor Notes (Part I)

Students may work individually on this if there is enough time available to complete this entire module, or you may choose to have the students work in teams where each member of the team chooses one piece of glassware. This might also be an opportunity to chat with students about team contributions to solving a problem or about how error could be introduced and how that error could be minimized.

### Part II: Concentrating on Solutions

### Pre-Procedure questions

1. How would you prepare 100.00 mL of a 0.345 M NaCl solution?
2. Which piece of glassware would you choose to measure a volume of 100.00 mL?
3. Now, let’s change the order of magnitude, how would you prepare 100.00 mL of a 3.45 x 10-4 M NaCl solution?
4. What limitations might be present in making the 3.45 x 10-4 M solution that are not present in the 0.345 M solution?

### Procedure

#### Solutions

1. Calculate the mass of NaCl needed to prepare the 0.345 M solution. Double check the mass with another student or your lab partner.
2. Measure the amount of NaCl needed.
3. Add the NaCl to a 100.00 mL volumetric flask.
4. Add distilled water to the line on the flask.
5. Stopper the flask and invert 5-7 times.

#### Dilutions

1. Calculate the mass of NaCl needed to prepare the 3.45 x 10-4 M solution.
2. Are you able to measure this mass?
3. Instead of preparing the solution as we did in Part I, you will need to dilute the more concentrated solution prepared in Part I.
4. What volume of the 0.345 M solution should be diluted to 100.00 mL to prepare the 3.45 x 10-4 M solution?
5. Measure the appropriate volume of 0.345 M solution into a 100.00 mL volumetric flask.
6. Add distilled water to the mark, stopper, and invert 5-7 times.

### Reflection

* Describe how you would you make 10.0 mL of solution that is 10-6 M NaCl.
* What concentration and what volume of stock solution would you need to prepare?

Activity for Practical

Prepare a 100.00 mL of NaCl stock solution that can be used to make BOTH of the following solutions:

* 50.0 mL solution at a concentration of 10-4 M NaCl
* 50.0 mL solution at a concentration of 10-5 M NaCl

Instructor Notes

This is a good place in the module to introduce the concept of micromolar solutions. You could also use the reflection exercise as the practical. And, as with all of these exercises, please adapt to your students, and the equipment and reagents available.

### Part III: Standard (or Calibration) Curves

#### Pre-Procedure question

1. How might you determine the concentration of an unknown solution given a series of solutions with known concentrations?

### Procedure

#### Solutions

1. Make 100.00 mL of a 0.200 M CuSO4 stock solution.
2. Determine the volume needed to make 10.0 mL of the following solutions:
   1. 0.040 M CuSO4
   2. 0.080 M CuSO4
   3. 0.120 M CuSO4
   4. 0.160 M CuSO4
   5. 0.200 M CuSO4
3. Prepare the series of solutions using 10.00 mL volumetric flasks.
4. Using a spectrophotometer,measure the absorption of each solution at 635 nm
5. Record the absorbance of each solution. Prepare a calibration curve as instructed in the prelab presentation.
6. Obtain a sample of CuSO4 solution from the instructor. Measure the absorbance of the unknown at 635 nm.
7. Determine the concentration of the unknown solution.

### Data Table

|  |  |  |
| --- | --- | --- |
| Sample | Concentration (M) | Absorbance at 635 nm |
| Blank | 0.000 M |  |
| 1 | 0.040 M |  |
| 2 | 0.080 M |  |
| 3 | 0.120 M |  |
| 4 | 0.160 M |  |
| 5 | 0.200 M |  |
| Unknown |  |  |

### Reflection

* Reflect on ways that a calibration curve could be used in biochemistry or forensic chemistry.

Activity for Practical

Your instructor will provide a sample of CuSO4 with an unknown concentration. Given the calibration curve you developed in the module, determine the concentration of the unknown.

Instructor Notes

The calibration curve part of this module may be eliminated if time is critical OR if students have already had the experience of making a calibration curve. You may also choose to use a different reagent.

# Instructor Notes - Concepts

Part I:

* Discussion of error and how the use of the wrong glassware can affect the error in a measurement.
* Significant figures and how they translate to the glassware chosen and the markings available on the glassware.
* Volumetric vs. graduated pipets

Part II: Concentrating on Solutions

**Background information for students**

Discussion of concentration and the methods for calculating the concentration of a solution. This module focuses on molarity but a discussion of molality or percent by weight may also be included (or noted as other ways to measure concentration).

Discuss why dilution of a stock solution may be preferential to preparing the solution by measuring the solute. Introduce the calculations for determining the volume of stock solution needed to prepare the dilute solution.

* Calculating the concentration (molarity, M), also described as “moles per liter.”

* Calculating moles of solute

* Dilution calculations

M1V1 = M2V2

Where M1 = the concentration of the stock solution

V1 = the volume removed from the stock solution to be diluted

M2 = the concentration of the desired solution

V2 = the final volume of the desired solution

**Example dilution problem.**

Prepare 30.0 mL of a 0.00361 M solution given a stock solution of 0.216 M.

Here

M1 = 0.216 M

M2 = 0.00361 M

V2 = 30.0 mL (0.030 L)

To make the solution, pipette 0.50 mL from the stock solution, transfer it to a 30.0 mL volumetric flask and then add water to the 30.0 mL mark. Stopper the flask, invert 5-7 times.

Part III: Calibration or Standard Curves

Topics for Discussion

* Why standard curves are important
  + Perhaps include a real-world example (DNA assays, Bradford Assays, etc.)
* Beer’s Law may be introduced here.
  + Discuss how plotting A vs. concentration is related to Beer’s Law.
* Should you include the origin when plotting a calibration curve?
* Fitting the best line (why is this a linear plot?).
* For real fun you could introduce interpolation as a method for determining the concentration of the unknown (but this is super nerdy!).

# Materials

### Instructions for Stockroom (assuming 24 students per lab)

### Module Prep

#### **Part I**

Have a set of the following glassware available for each team/student (note that the instructor can adapt the list of glassware to what is available in the department stockroom)

|  |  |
| --- | --- |
| 250 mL beaker  100 mL volumetric flask  25 mL volumetric pipet  25 mL graduated pipet  100 mL Graduated cylinder  100 mL Buret  250 mL Erlenmeyer flask | Thermometer (to measure the temperature in the room)  Additional handout for the density of water as a function of temperature  Balances |

#### **Part II**

**NaCl**

Each student or pair will need 2.10 g to prepare the 0.345 M solution. This will also act as the stock solution for the dilution part of the exercise.

**Glassware**

Each student or pair will need two 100.00 mL volumetric flasks

Graduated or volumetric pipet capable of measuring 100 uL.

#### **Part III**

**Copper (II) sulfate**

Each student or pair will need 3.19 g to prepare the stock solution.

Prepare an unknown solution of CuSO4 solution with a concentration between 0.060 - 0.150 M.

Individual unknowns of differing concentrations may be prepared or the instructor may opt for a single unknown.

**Glassware**

Each student or pair will need 1-100 mL volumetric flask plus 4-10 mL volumetric flasks

10 mL graduated pipet and bulb

Various small (<25 mL) beakers

Pasteur pipettes for transferring solutions

**Instrumentation**

UV-Vis spectrophotometer

Cuvette appropriate for the UV-Vis spectrophotometer available in the lab

# Acknowledgements

Thanks to the following authors and reviewers for the modules:

Dr. Michelle M. Brooks, American Chemical Society

Dr. Felicia Fullilove, American Chemical Society

Dr. Natalia Martin, American Chemical Society

Dr. Lily Raines, American Chemical Society

Dr. Jennifer Barber, Westlake High School

Dr. Michelle Boucher, Utica College

Dr. Bonnie Dixon, University of Maryland – College Park

Dr. Elizabeth Jenson, Aquinas College

Dr. Shanina Johnson, Spelman College