

Molarity

Why?

When a substance (solute) is dissolved in a solvent, a solution is formed. A chemist often needs to know how much solute is present in a given volume of solution. In this activity you will learn how to determine the amount of solute that is dissolved in a given quantity of solvent by calculating the concentration of a solution.

Learning Objectives

- Solve problems involving the molarity of a solution.

Success Criteria

- Student can manipulate the relationship between moles of solute and volume of solution by using the definition of molarity.

Prerequisites

- Moles
- Solute
- Solution
- Solvent
- Volume
- Gram formula mass
- Stoichiometry

Vocabulary

- Concentration
- Concentrated
- Molarity
- Dilution
- Dilute

Model I: What does concentration mean?

Demo: You will observe two 1.0 liter volumetric flasks, each filled with a different concentration of CuSO_4 (aq). With your class or group, discuss the concept of concentration using the terms dilute and concentrated as they relate to the two solutions.

Key Questions

1. Which solution has the darker color?
2. What might be responsible for the darker color in one of the solutions?
3. Based on your observations of the solutions, which solution probably contains more solute per unit volume? Explain your answer.

4. What is meant by the term *concentration*?

5. What factors should be considered when determining the concentration of a solution?

6. When a solution is diluted, additional solvent is added to the more concentrated solution. How does the amount of *solute* in the initial solution compare to the amount of solute in the final solution?

Information

The most common measure of concentration used by chemists is molarity (M). Molarity is defined as the number of moles of solute (mol) divided by the total volume (V) of the solution in liters (L).

$$\text{Molarity} = \text{moles of solute per liter of solution (M = mol / L)}.$$

Molarity also is called molar concentration. When the symbol *M* is accompanied by a numerical value, it is read as “molar.” For example, a solution labeled 3.0*M* NaCl is read as “three molar sodium chloride solution”.

Exercises

1. In a problem a student is given the amount of solute in grams and the volume of the solution in milliliters. What must be done with the information before the molarity can be calculated?
2. Calculate the molarity of a solution in which 0.50 moles of MgCl_2 are dissolved to produce 1.5 liters of solution.
3. Intravenous (IV) saline solutions are often administered to patients in the hospital. Normal saline solution contains 0.90g NaCl in exactly 100. ml of solution. Calculate the molarity of this solution.

4. Calculate the molarity of the following solutions.
- 1.0 mole of NaNO_3 in 500. ml of H_2O
 - 85.0 g of NaNO_3 in 250. ml of H_2O
(NaNO_3 gram formula mass = 85. grams/ mole)
 - Which of the solutions, 4a or 4b, is more concentrated? Explain your answer.

Model II

Part I- Demonstration and discussion:

When preparing one liter of a 1.0 molar solution one should pour some solvent (water) into a 1.0 liter volumetric flask. The measured amount of solute (1.0 mole) is added to the volumetric flask. The flask is stirred to dissolve the solute, and then additional solvent is added to bring the volume to the 1.0 liter mark.

Part II – Demonstration and discussion:

Fill a 1.0 liter volumetric flask with water up to the 1.0 liter mark and then add measured amount of solute (1.0 mole).

Key Questions

- In demonstration 1, why is the solute added to some of the solvent and dissolved before more solvent is added to bring the volume to the 1.0 liter mark on the volumetric flask?
- Which of the solutions prepared in Model II contains one liter of solvent? Explain.

3. Which of the solutions prepared in this demonstration contains a 1.0 M solution? Explain your answer.

Problems

1. What volume of 0.25 M solution can be prepared using 0.50 mole of KCl?
2. What volume of 0.10 M solution can be prepared using 11.6 g of NaCl?

Extension Activity

Mini-lab:

1. Determine the mass of four 100 mL volumetric flasks.
2. In each flask prepare one of the following sucrose solutions: 0.0625 M, 0.125 M, 0.250 M, and 0.500 M.
3. Determine the mass of each solution then calculate the density of each solution.
4. Prepare a graph of density versus concentration for sucrose. Include the density of pure water on the graph, using the value 1.00 g/ml.

Question: What is the relationship (direct, inverse, etc.) between concentration and density? Explain your answer.