Today's Lecture

- ✓Announcements
- ✓Quiz
- ✓Concentrations of Solutions
  - ✓Section 4.5
- ✓Solution Stoichiometry and Chemical Analysis
  - ✓Section 4.6

Announcements

- Office hours
  - Mon, Wed, 11:30-12:30 am
  - Sun,Tue,Thu 11:30-12:30 pm
- Reading
  - Chapter 4, Sections **(4.5)** and **(4.6)**
- Suggested Problems
  ,4.61,4.63,4.67,4.69,4.71,4.73,4.75,4.77,4.79, 4.81, 4.85,4.87, 4.89, 4-103 and 105

Which will have the highest concentration of Na^+?

- 0.35 *M* Na_2SO_4
- 0.40 *M* Na_3PO_4
- 0.50 *M* $NaNO_3$
- 0.80 *M* NaOH
- 1.00 *M* NaCl

Concentrations of Solutions

Molarity

- Two solutions can contain the same compounds but be quite different because the proportions of those compounds are different.
- Molarity is one way to measure the concentration of a solution.

$$\text{Molarity } (M) = \frac{\text{moles of solute}}{\text{volume of solution in liters}}$$

Sample Exercise 4.11 Calculating Molarity

Calculate the molarity of a solution made by dissolving 23.4 g of sodium sulfate (Na_2SO_4) in enough water to form 125 mL of solution.

Check: Because the numerator is only slightly larger than the denominator, it is reasonable for the answer to be a little over 1 *M*. The units (mol/L) are appropriate for molarity, and three significant figures are appropriate for the answer because each of the initial pieces of data had three significant figures.

Practice Exercise

Calculate the molarity of a solution made by dissolving 5.00 g of glucose ($C_6H_{12}O_6$) in sufficient water to form exactly 100 mL of solution.

Exercise 4.12 Calculating Molar Concentrations of Ions

What are the molar concentrations of each of the ions present in a 0.025 *M* aqueous solution of calcium nitrate?

Practice Exercise

What is the molar concentration of K^+ ions in a 0.015 *M* solution of potassium carbonate?

Exercise 4.13 Using Molarity to Calculate Grams of Solute

How many grams of Na_2SO_4 are required to make 0.350 L of 0.500 *M* Na_2SO_4?

Practice Exercise

(a) How many grams of Na_2SO_4 are there in 15 mL of 0.50 *M* Na_2SO_4? **(b)** How many milliliters of 0.50 *M* Na_2SO_4 solution are needed to provide 0.038 mol of this salt?

Matter And Measurement

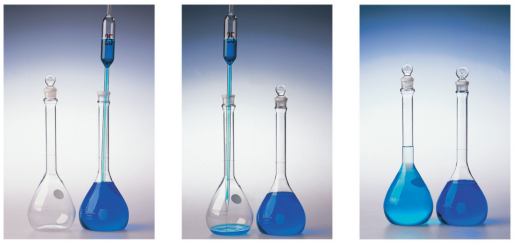
Mixing a Solution

- To create a solution of a known molarity, one weighs out a known mass (and, therefore, number of moles) of the solute.
- The solute is added to a volumetric flask, and solvent is added to the line on the neck of the flask.

Matter And Measurement

Dilution

- One can also dilute a more concentrated solution by
  - Using a pipet to deliver a volume of the solution to a new volumetric flask, and
  - Adding solvent to the line on the neck of the new flask.



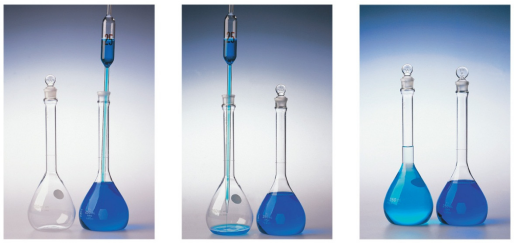
Matter And Measurement

Dilution

The molarity of the new solution can be determined from the equation

$$M_c \times V_c = M_d \times V_d,$$

where M_c and M_d are the molarity of the concentrated and dilute solutions, respectively, and V_c and V_d are the volumes of the two solutions.



Matter And Measurement

Sample Exercise 4.14 Preparing A solution by Dilution

How many milliliters of 3.0 *M* H_2SO_4 are needed to make 450 mL of 0.10 *M* H_2SO_4?

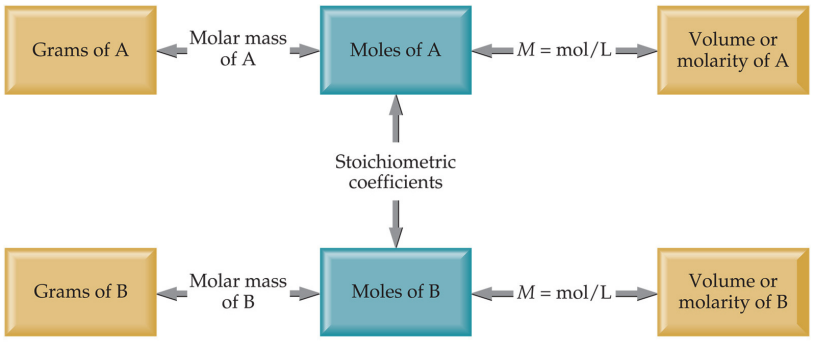
Practice Exercise

(a) What volume of 2.50 *M* lead(II) nitrate solution contains 0.0500 mol of Pb^{2+}?
(b) How many milliliters of 5.0 *M* $K_2Cr_2O_7$ solution must be diluted to prepare 250 mL of 0.10 *M* solution?
(c) If 10.0 mL of a 10.0 *M* stock solution of NaOH is diluted to 250 mL, what is the concentration of the resulting stock solution?

Solution Stoichiometry and Chemical Analysis

Matter And Measurement

Using Molarities in Stoichiometric Calculations



Matter And Measurement

Exercise 4.15 Using Mass Relations In a Neutralization Reaction

How many grams of $Ca(OH)_2$ are needed to neutralize 25.0 mL of 0.100 *M* HNO_3?

Practice Exercise

(a) How many grams of NaOH are needed to neutralize 20.0 mL of 0.150 *M* H_2SO_4 solution? **(b)** How many liters of 0.500 *M* HCl(*aq*) are needed to react completely with 0.100 mol of $Pb(NO_3)_2(aq)$, forming a precipitate of $PbCl_2(s)$?

Titration

Titration is an analytical technique in which one can calculate the concentration of a solute in a solution.

Matter And Measurement

Exercise 4.16 Determining the Quality of Solute by Titration

$$Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$$

The quantity of Cl– in a municipal water supply is determined by titrating the sample with Ag+. The reaction taking place during the titration is shown above

The end point in this type of titration is marked by a change in color of a special type of indicator. **(a)** How many grams of chloride ion are in a sample of the water if 20.2 mL of 0.100 *M* Ag^+ is needed to react with all the chloride in the sample? **(b)** If the sample has a mass of 10.0 g, what percent Cl^- does it contain?

Matter And Measurement

Practice Exercise

$$MnO_4^-(aq) + 5\,Fe^{2+}(aq) + 8\,H^+(aq) \longrightarrow Mn^{2+}(aq) + 5\,Fe^{3+}(aq) + 4\,H_2O(l)$$

A sample of an iron ore is dissolved in acid, and the iron is converted to Fe2+. The sample is then titrated with 47.20 mL of 0.02240 *M* MnO_4^- solution. The oxidation-reduction reaction that occurs during titration is as follows:
(a) How many moles of MnO_4^- were added to the solution? **(b)** How many moles of Fe^{2+} were in the sample? **(c)** How many grams of iron were in the sample? **(d)** If the sample had a mass of 0.8890 g, what is the percentage of iron in the sample?

Exercise 4.17 Determining Solution Concentration Via an Acid-Base Titration

One commercial method used to peel potatoes is to soak them in a solution of NaOH for a short time, remove them from the NaOH, and spray off the peel. The concentration of NaOH is normally in the range of 3 to 6 *M*. The NaOH is analyzed periodically. In one such analysis, 45.7 mL of 0.500 *M* H_2SO_4 is required to neutralize a 20.0-mL sample of NaOH solution. What is the concentration of the NaOH solution?

Practice Exercise

What is the molarity of an NaOH solution if 48.0 mL is needed to neutralize 35.0 mL of 0.144 *M* H_2SO_4?

Sample Integrative Exercise

Note: Integrative exercises require skills from earlier chapters as well as ones from the present chapter.

A sample of 70.5 mg of potassium phosphate is added to 15.0 mL of 0.050 *M* silver nitrate, resulting in the formation of a precipitate. **(a)** Write the molecular equation for the reaction. **(b)** What is the limiting reactant in the reaction? **(c)** Calculate the theoretical yield, in grams, of the precipitate that forms.

Next Lecture

- Basic Concepts of Chemical Bonding
  - Chapter 8
    - focus on Sections 8.1, 8.2, 8.3 and 8.4