

LAB **11.2** LABORATORY MANUAL

Mole Ratios

Use with
Section 11.4

The mole ratio of cations to anions in an ionic compound consists of small, whole numbers. For example, the mole ratio of Mg^{2+} ions to Br^- ions in MgBr_2 is 1:2. For every 1 mol of Mg^{2+} ions present, there are 2 mol of Br^- ions. The mole ratio of ions in KBr is 1:1. In water solution, one mole of KBr will produce 1 mol Br^- ions, but 1 mol MgBr_2 will produce 2 mol Br^- ions.

Suppose you have different compounds that contain Cl^- ions. How could you determine the mole ratios in these compounds? Most chloride compounds dissolve in water, but some do not. Reacting dissolved chloride ions with a cation that forms an insoluble chloride compound can be used to determine the amount of chloride ions present. One such cation is silver. Reacting a chloride-containing solution with sufficient silver nitrate (AgNO_3) solution will precipitate any dissolved chloride ions. A solution of KCl will react with a certain amount of AgNO_3 . The same volume of BaCl_2 solution of the same concentration will require twice as much AgNO_3 to precipitate all the Cl^- ions.

Problem

What is the ratio of cations to anions in an ionic compound? How can this ratio be determined?

Objectives

- **Measure** the reacting ratios of silver nitrate solution with solutions of various chloride compounds.
- **Calculate** the ratio of positive ion to chloride ion in four chloride compounds.
- **Determine** the ratio of positive ion to chloride ion in an unknown compound.

Materials

0.10M silver nitrate (AgNO_3)	0.10M aluminum chloride (AlCl_3)
0.10M potassium chloride (KCl)	dichlorofluorescein test tubes (10)
0.10M sodium chloride (NaCl)	10-mL graduated cylinder
0.10M barium chloride (BaCl_2)	dropper

Safety Precautions

- Always wear safety goggles, a lab apron, and gloves.
- Silver nitrate is corrosive and will stain skin and clothing.
- Silver nitrate and barium chloride are toxic. Potassium chloride and aluminum chloride are slightly toxic.

Pre-Lab

1. What is meant by the term *mole*?
2. What do you need to know to calculate the number of moles of a substance?
3. Read the entire laboratory activity. Form a hypothesis about the expected ratios of reacting volumes. Form a second hypothesis about how these ratios can be used to determine the cation to anion ratio in an unknown substance. Record your hypotheses in the next column.
4. Summarize the procedures you will follow to test your hypotheses.
5. What is the net ionic equation for the reaction between $\text{AgNO}_3(\text{aq})$ and $\text{KCl}(\text{aq})$?

Procedure**Part A: Testing known solutions**

1. Pour 1.00 mL of the KCl solution into a clean, dry test tube.
2. Add 2 drops of dichlorofluoroscein indicator solution to the test tube.
3. Add silver nitrate drop by drop to the solution until the dichlorofluoroscein turns from white to pink. Hold the dropper vertically as you add the drops. Carefully shake the tube from side to side as the drops are being added. Do not spill any solution.
4. Count and record in **Data Table 1** the number of drops needed to turn the solution from white to pink.

5. Repeat the procedure for a second 1-mL sample of KCl.
6. Repeat steps 1–5, using solutions of NaCl, BaCl_2 , and AlCl_3 , in turn, instead of KCl.

Part B: Testing a solution of unknown concentration

7. Obtain an unknown sample from your teacher. Record the number of the sample.
8. Repeat steps 1–5, using the unknown solution instead of KCl.

Hypotheses

Cleanup and Disposal

1. Pour any materials containing silver into a container provided by your teacher.
2. Return all lab equipment to its proper place.
3. Report any broken or damaged equipment.
4. Wash your hands thoroughly before leaving the lab.

Data and Observations

Data Table 1				
Sample	Trial 1 drops of AgNO_3	Trial 2 drops of AgNO_3	Average drops of AgNO_3	Cation/anion ratio
KCl				
NaCl				
BaCl_2				
AlCl_3				
Unknown				

Analyze and Conclude

- Using Numbers** Calculate the average number of drops of AgNO_3 used for each solution. Record these numbers in **Data Table 1**.

- Using Numbers** Assume that the cation-anion ratio is 1:1 for KCl. All the solutions are the same concentration, which means that they all contain the same number of moles of ionic compound per liter of solution. Using this information and your results, calculate the cation to anion ratio for each of the known solutions. Record these ratios in **Data Table 1**.

- Comparing** How do your answers in question 2 compare with the ratios you predicted in your hypothesis using the formulas for the compounds?

- Inferring** Why must all the solutions being tested be the same concentration?

- Making Predictions** Assume you did not know the concentration of the silver nitrate solution. How would this unknown concentration compare with the concentration of the KCl solution if half as much AgNO_3 solution as KCl solution was used?

- Drawing Conclusions** Summarize how the results of this laboratory activity relate to the formulas of the compounds tested.

- Error Analysis** What could you have done to improve the precision of the measurements?

Real-World Chemistry

- Body fluids are often tested in medical facilities to determine the concentrations of certain substances. How could the techniques used in this lab activity be applied to such testing?
- Silver is a valuable metal. Explain how you could separate any dissolved Ag^+ ions from the solutions you disposed of in the discard beaker.

