

Formula of an Ionic Compound - Balancing Charges on Ions

Introduction:

Atoms of different elements combine with one another to form compounds. The formula of an ionic compound indicates the kinds of atoms that are present in the compound as well as the relative number (ratio) of each kind of atom. This lab investigates how the formula of an ionic compound can be determined experimentally.

Background:

Some ions consist of a charged group of covalently bonded atoms. Such ions are called *polyatomic ions*. An example is the nitrate ion (NO_3^-), which contains one nitrogen atom and three oxygen atoms and has an overall charge of -1. In calcium nitrate, calcium (Ca^{2+}) ions combine with nitrate ions in a 1:2 ratio in order to balance the positive and negative charges. The formula for calcium nitrate is $\text{Ca}(\text{NO}_3)_2$. Parentheses are used around the nitrate ion to show that the subscript "2" pertains to the nitrate ion as a whole. The overall charge on ionic compounds is always zero.

Experiment Overview:

The purpose of this experiment is to determine the formula of an unknown ionic compound. Two solutions containing equal amounts (concentrations) of two reactant ions will be combined in a series of reactions. In each reaction, the total volume of the two solutions will be held constant while the volume ratio of the reactants is varied. The amount of precipitate obtained in each reaction will be measured and plotted against the volume ratio to find the formula of the product.

Procedure:

1. Record the color of the 0.1 M copper (II) chloride solution in the data table.
2. Carefully add the appropriate number of drops of copper (II) chloride solution to each test tube #1-7, as shown in Table-1. **Note:** Exact volumes are very important.
3. Record the color of the 0.1 M sodium phosphate solution in the data table.
4. Carefully add the appropriate number of drops of sodium phosphate solution to each test tube, as shown in Table-1
5. Use a clean stirring rod to stir each reaction mixture in test tubes #1-7. Let the tubes sit undisturbed for 10-15 minutes to allow the precipitate to settle.
6. During this time, determine the volume (drop) ratio of copper (II) chloride and sodium phosphate solutions in each test tube. Write this ratio in the data table. *Example:* In test tube #1, 3 drops of CuCl_2 and 27 drops of Na_3PO_4 correspond to a 1:9 ratio of $\text{CuCl}_2:\text{Na}_3\text{PO}_4$.
7. After the precipitates have settled, observe the appearance of the products (both the solid and the solution). Record the observations in the data table in the space provided. Be as detailed as possible.
8. Use a metric ruler to measure the height of the precipitate in millimeters in each test tube. Read from the top of the solid material to the bottom center of the test tube. Record each height in mm in the data table.

Table 1.

Test Tube	1	2	3	4	5	6	7
CuCl_2 , 0.1 M (drops)	3	6	12	15	18	24	27
Na_3PO_4 , 0.1 M (drops)	27	24	18	15	12	6	3

Chemistry Lab
Ionic Compounds

Name _____
Date _____ Per ____

Data Table:

Color of copper (II) chloride solution: _____

Color of sodium phosphate solution: _____

Color of precipitate (solid): _____

Precipitation Reactions							
Test Tube	1	2	3	4	5	6	7
Volume Ratio* (drops CuCl_2 :drops Na_3PO_4)	1:9						
Height of Precipitate (mm)							

*reduce the volume ratio to the simplest whole-number ratio.

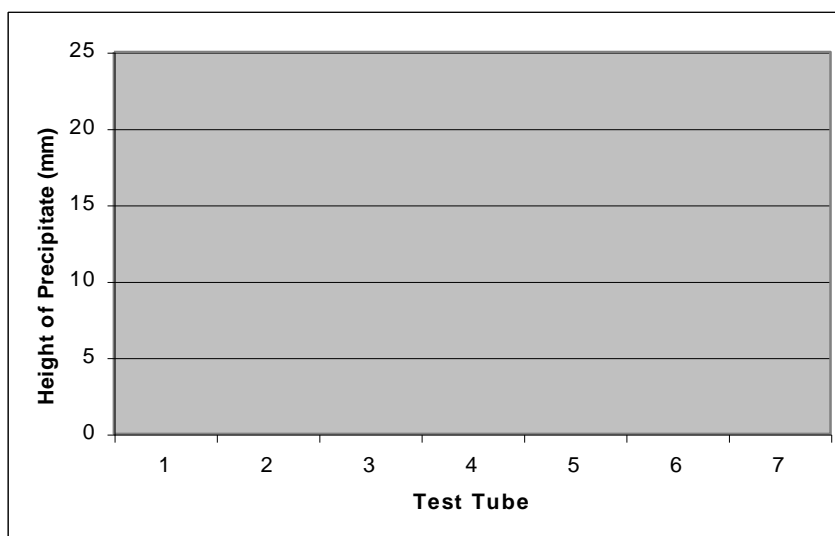
Questions:

1. The two possible solids are copper (II) phosphate and sodium chloride. Write the formulas of the products. (hint: Use the charges on the ions to balance the compound.)

copper (II) phosphate: _____ sodium chloride: _____

2. a) Based on common knowledge, which product is likely to be soluble in water?
b) The other product must be insoluble in water and therefore precipitate from solution. Which product formed the precipitate?

3. Complete the following bar graph to show the height of the precipitate in each test tube.



4. Which test tube had the greatest amount of precipitate? Does this result agree with the prediction made in Question #1 concerning the formula of the product? **EXPLAIN.**