

An Ionic Compound Logic Puzzle

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A number of puzzles have been published in this *Journal* in a variety of formats including sudoku puzzles, logic puzzles, and others in an effort to introduce or reinforce concepts discussed in chemistry courses (1–4). These puzzles add a variety of activities to a course. Additionally they may be used to emphasize that chemistry is not focused on memorizing facts, but instead on applying knowledge and logic to solve problems.

The logic puzzle presented here requires students to apply the concepts of ionic compound empirical formulas, ions present in aqueous solutions, the formation of precipitates, and polyatomic ions. Several terms are also reinforced by their application in solving the puzzle. This puzzle is appropriate for general chemistry students of all levels and may aid in integrating these concepts in the students' minds. This activity is suitable for individual or group work.

Puzzle Instructions

Five students (Alexander, Benjamin, Cierra, Drew, and Erin) are given unknown aqueous solutions, each containing a different ionic compound. The ionic compounds contain ammonium, calcium, nickel, potassium, or zinc as the cation and bromide, fluoride, hydroxide, nitrate, or sulfate as the anion. No single ion is repeated. Using the clues below, determine the ionic compound contained in each student's solution and its molar mass.

1. Benjamin's compound has a molar mass greater than that of the one containing the hydroxide ion, but smaller than the one containing the ammonium ion. The compound with the largest molar mass has a cation:anion ratio of 1:2.
2. Cierra's compound formed a precipitate when aqueous sodium carbonate was added. The compound with the middle value for molar mass did not contain a divalent cation. The compound with the second smallest molar mass formed a precipitate with aqueous barium iodide.
3. The molar mass of Drew's compound is between 50 and 100 grams per mole greater than the compound containing nickel. One compound had a cation:anion ratio of 2:1.
4. Alexander's compound contains all polyatomic ions. Erin has the compound with the smallest molar mass.
5. Benjamin's compound contains a transition metal. The compound containing zinc had the largest molar mass. The compound with the second largest molar mass formed a precipitate when aqueous lithium sulfate was added.
6. A precipitate was formed when a solution of iron(II) chloride was added to the solution containing the compound with the smallest molar mass. The largest molar mass of a compound is over 200 grams per mole.

Table 1. Solubility Chart for Combinations of Ions

Ions	Ammonium	Barium	Calcium	Iron(II)	Lead(II)	Lithium	Nickel(II)	Potassium	Sodium	Zinc
Acetate	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq
Bromide	aq	aq	aq	aq	s	aq	aq	aq	aq	aq
Carbonate	aq	s	s	s	s	aq	s	aq	aq	s
Chloride	aq	aq	aq	aq	s	aq	aq	aq	aq	aq
Fluoride	aq	s	s	s	s	aq	aq	aq	aq	aq
Hydroxide	aq	aq	s	s	s	aq	s	aq	aq	s
Iodide	aq	aq	aq	aq	s	aq	aq	aq	aq	aq
Nitrate	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq
Phosphate	aq	s	s	s	s	s	s	aq	aq	s
Sulfate	aq	s	s	aq	s	aq	aq	aq	aq	aq

Table 2. Logic Puzzle Solving Grid

		Cation					Molar Mass			Anion						
		ammonium	calcium	nickel(II)	potassium	zinc(II)	(low)			(high)	bromide	fluoride	hydroxide	nitrate	sulfate	
Student	Alexander															
	Benjamin															
	Cierra															
	Drew															
	Erin															
Anion	bromide															
	fluoride															
	hydroxide															
	nitrate															
	sulfate															
Molar Mass	(low)															
	(high)															