NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

Intravenous Error Precipitates Legal Problems

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Learning Objectives

- Understand what a double displacement reaction is and why it is relevant to the field of nursing
- Correctly determine what the chemical formula of the precipitate in the IV was, and write a balanced equation to show its formation
- Practice writing chemical formulas for ionic compounds
- Learn how to write a balanced chemical equation for a double displacement reaction

Introduction

A working knowledge of *solubility* and *precipitation reactions* is very important when working with *intravenous* (IV) infusions. *Incompatibility* can result when IV components react with each other, often leading to severe complications or death. Doctors, pharmacists, and nurses must remember to apply their knowledge of chemistry to safeguard patients. In the following case study, one such woman with several metabolic deficiencies was exposed to a precipitate from incompatibility with dramatic consequences.

A middle-aged white woman was diagnosed with dehydration and pneumonia then given antibiotics and IV fluids. Preliminary laboratory results showed the following blood serum electrolyte levels compared to the normal range for a healthy adult:

Electrolyte	*Patient concentration (mEq/L)*	*Normal range (mEq/L)*
bicarbonate	25	22 – 29
chloride	82	96 – 106
potassium	2.8	3.5 – 4.5
phosphorus	1.5	3.0 – 4.5
sodium	124	136 – 146

Based on these results, the physician changed the IV solution to the following:

Chemical	*Concentration*
sodium chloride	0.9%
potassium phosphate	40 mEq/L

After 24 hours, a more in-depth laboratory analysis indicated the following electrolyte levels:

Electrolyte	*Patient concentration (mEq/L)*	*Normal range (mEq/L)*
bicarbonate	28	22 – 29
calcium	75	90 – 110
chloride	85	96 – 106
potassium	2.6	3.5 – 4.5
phosphorus	1.6	3.0 – 4.5
sodium	129	136 – 146

The physician added 100 mg of calcium chloride to the previous pharmacy order. After receiving the new IV bag from the pharmacy, the nurse noticed that it appeared to contain a white solid. She shook the bag to try to get the particles to dissolve. She began the infusion and then called the pharmacist to ask about the solid. The pharmacist told her to call the physician, which she did without stopping the infusion. The physician ordered the infusion to be terminated, but by the time the nurse was able to remove the bag the patient was in cardiopulmonary arrest. The physician arrived too late to resuscitate, and the patient was pronounced dead. The physician noted a white precipitate in both the IV bag and tubing.

The nurse testified that the patient's symptoms continued to get worse during the infusion. She felt that she was not at fault since an earlier shift nurse had clarified the order and nurses were not responsible for predicting incompatibility issues. The autopsy confirmed that the white precipitate was calcium phosphate, but the pathologist ruled that the patient died of pneumonia rather than complications due to the precipitate. A lawsuit was filed alleging that the hospital staff should have prevented the order and administration of incompatible solutions.

Questions

1. a. What do the abbreviated units mEq/L mean?

   b. Name another unit for concentration.

2. List the most common *ionic* form(s) of phosphorus *in the body*.

3. After the preliminary laboratory results, which electrolytes were not in a healthy range?

4. Describe how the compounds in the IV order below could address the deficiencies you described in Question 3.

Chemical	*Concentration*
sodium chloride	0.9%
potassium phosphate	40 mEq/L

5. After the in-depth laboratory analysis, why did the physician add calcium chloride to the IV order?

6. Why did the presence of a precipitate in the IV bag cause the physician to stop the infusion?

7. Solubility rules can be used to help determine if a precipitate will form in an IV. Look up solubility rules and use them to predict if a precipitate will form in the following combinations:
   a. Would a precipitate form if sodium phosphate were mixed with ammonium chloride?

   b. Would a precipitate form if iron (III) sulfate were mixed with potassium phosphate?

   c. Would a precipitate form if calcium chloride were mixed with sodium carbonate?

   d. Would a precipitate form if potassium iodide were mixed with calcium nitrate?

8. List the chemical formula for the following components and predict whether they are ionic or covalent.

Chemical name	*Chemical formula*	*Ionic or covalent?*
dextrose (glucose)		
sodium chloride		
potassium phosphate		
calcium chloride		
calcium phosphate		
strontium chloride		
strontium phosphate		
potassium carbonate		
calcium carbonate		

9. Chemical incompatibility can be predicted using solubility rules based on a chemical equation that describes a *double displacement* or *precipitate reaction*. Follow the steps below to write a *balanced chemical equation* for the double displacement reaction that occurred when potassium phosphate reacted with calcium chloride to produce the precipitate, calcium phosphate.
   a. Start by writing a chemical equation where the reactants calcium chloride and potassium phosphate react on the left of the reaction arrow to form one of the two products calcium phosphate on the right. Remember to use the same chemical formulas you wrote in the table above.

   b. Predict the formula for the missing product using the reactant elements that are not in calcium phosphate.

   c. To write a balanced equation, you must have the same number of elements on each side of the reaction arrow. Balance the reaction starting with the metals. On the left there is one calcium ion. There are three calcium ions on the right so a *coefficient* in front of the chemical formula calcium chloride must be used to balance the calcium ions on the reactant side. The coefficient distributes to all of the elements in that formula so there are now three calcium ions and six chloride ions on the left of the equation. Use the same method to balance the number of potassium ions.

d. After balancing the metals, balance nonmetals except hydrogen and oxygen. Balance Cl and P using coefficients. Remember that the subscript "2" by phosphate must be distributed to both the phosphorous and oxygen atoms in the polyatomic ion.

e. Next balance the hydrogen atoms (if present) followed by oxygen.

f. Finally, double check that all elements are balanced. Start with metals and work through the nonmetals to be sure all elements are balanced on the left and right of the equation.

10. According to solubility rules, many phosphate salts are insoluble in water. Write a balanced chemical equation for the double displacement reaction that would take place if strontium chloride reacted with potassium phosphate to form the precipitate strontium phosphate.

11. According to solubility rules, many carbonate salts are also insoluble in water. Write a balanced chemical equation for the double displacement that would take place if calcium chloride reacted with potassium carbonate to form the precipitate calcium carbonate.

12. What could have been done in the case study to prevent the calcium phosphate precipitate formation? *Remember that the patient needs to increase electrolyte deficiencies so not administering one or more of the compounds is not an option.*

13. If the precipitate were the cause of death, who do you think is responsible (doctor, nurse, or pharmacist) and why?