

Qualitative Inorganic Analysis-Identification of Six Solutions

Introduction

This experiment will give you a chance to be a sort of chemical Sherlock Holmes—you will be given six bottles of UNKNOWN solutions, labeled only with a letter or number code, and you will IDENTIFY the solutions by their REACTIONS WITH EACH OTHER.

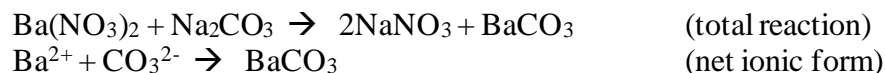
EVIDENCE for reaction when two solutions are mixed is based on observation of the following phenomena:

- (1) A precipitate (solid substance) is formed.
- (2) A gas is evolved from the solutions.
- (3) A color change is observed.
- (4) A characteristic odor is produced.

Each of these phenomena will be discussed briefly, with examples:

- (1) A precipitate is formed.

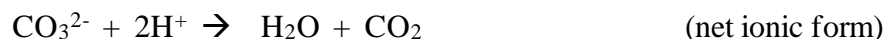
Very often, when solutions of IONIC SOLUTES are mixed, one of the four possible COMBINATIONS of the ions involved will have a very SMALL SOLUBILITY in water, and a PRECIPITATE of that substance will form (imparting a CLOUDINESS to the solution until the substance settles out completely). For example, if 0.1 M solutions of BARIUM NITRATE and SODIUM CARBONATE are mixed (each of these substances is fairly water SOLUBLE), a PRECIPITATE instantly forms, since one of the four possible combinations of ions, BARIUM CARBONATE, is of very LOW SOLUBILITY.



You can PREDICT which combinations of ions are likely to produce precipitates by consulting the “Solubility Rules” listed in your textbook in Chapter 4.

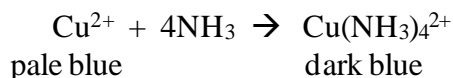
- (2) A gas is evolved from the solutions.

Certain ions, such as CARBONATE and BICARBONATE, produce GASES when reacted with other ions (HYDROGEN ion, for example). Sometimes, the gas evolved can be IDENTIFIED by a characteristic odor [see also (4) below]; in other cases, the gas may have to be identified by other means.



- (3) A color change is observed.

The presence of certain ions can be confirmed by the addition of reagents that produce a **COLOR CHANGE**, which is **CHARACTERISTIC** of the ion under study; for example, **AMMONIA**, when added to a solution of **COPPER(II) ION**, produces a coordination complex of characteristic **INTENSE BLUE** color.



(4) A characteristic odor is produced.

Certain ions, especially when acidified, produce gases with **CHARACTERISTIC ODORS** (the solution may have to be heated to release the dissolved gas). As you will see in the experiment synthesizing sodium thiosulfate pentahydrate, when the thiosulfate ion is acidified and the solution heated, **SULFUR DIOXIDE** gas, with its characteristic choking odor, is released.



In this experiment, you will know **WHAT** the six solutions are, but you won't know **WHICH BOTTLE** contains which solution. Observations such as those described above for reactions **AMONG** the six solutions you are given can be related to the known chemistry of the given ions. Small portions (approx. 0.5 mL) of the six solutions are mixed, pairwise, and observations recorded and **COMPARED** to **KNOWN** reactions of the solutions involved. The six solutions provided to you are listed in the following table (see Table I); **BEFORE COMING TO LAB, COMPLETE THE TABLE** by writing in each box the expected product of the reaction. Indicate whether the products are solids, liquids, or gases (based on what was said above). If **NO** reaction is to be expected based on the substances to be mixed, write "N.R." in the box. You should also write net ionic reactions for the reactions in making your predictions

Summary

The identity of six solutions of ionized inorganic solutes is established by observing reactions between pairs of the solutions.

Supplies

0.5 M sodium carbonate; 0.1 M calcium chloride; 0.1 M barium nitrate; 0.05 M silver nitrate; 1.0 M hydrochloric acid; 1.0 M nitric acid (the solutions will be coded with letters); six small test tubes; six Pasteur pipets; pipet bulbs, 24 hole well plate.

CHEMICALS

Silver nitrate, AgNO_3 —toxic and corrosive, may stain skin
Hydrochloric acid, HCl —toxic and corrosive, can cause skin burns
Nitric acid, HNO_3 —corrosive and toxic
Barium nitrate, $\text{Ba}(\text{NO}_3)_2$ —toxic by ingestion
Calcium chloride, CaCl_2 —no major health risks
Sodium carbonate, Na_2CO_3 —no major health risks

Procedure

CAUTION! WEAR SAFETY GLASSES AT ALL TIMES!!

Obtain a 24 hole well plate. Rinse it several times with distilled water to make sure it is clean.

Obtain about 2 mL (1/2 inch high) of each solution in its appropriate test tube.

Place a pipet in each test tube, and be careful not to switch pipets between solutions (thus contaminating them) during the following procedure.

Also obtain some rubber bulbs from the table in your lab (there may not be enough for each student to take six; if this is the case, move the bulb from pipet to pipet as needed).

Add about eight drops of the first solution to an empty well. Then add about eight drops of a second solution to this well. Observe what happens. Record your observations in your lab notebook. If no reaction occurs, swirl your well plate gently to mix the solutions. If still nothing has happened, write NR in your lab notebook for this combination.

Repeat this process until all possible combinations have been mixed.

A total of only 15 such tests is needed. (Note that mixing, e.g., solution A with solution B, is the same as mixing solution B with solution A.) You only need to complete Table II either above or below the diagonal; you can then complete the other half of the table by referring to the first half.

By comparing your results in Table II with the predictions made in Table I, you should be able to unambiguously identify each substance. Note in Table I that each substance reacts IN A UNIQUE WAY with the other five substances. (For example, sodium carbonate forms THREE PRECIPITATES and evolves GAS TWICE with the other reagents, and is the ONLY substance of the six to do this.)

REMEMBER TO TURN IN THE YELLOW COPY OF YOUR LAB NOTEBOOK TO YOUR TA.

DISPOSAL

Discard the contents of your well plate and test tubes in the beaker labeled WASTE SOLUTIONS. Rinse your well plate and test tubes twice with a small amount of water and discard into the WASTE SOLUTIONS beaker.

Dispose of the Pasteur pipets in the red plastic sharps-biohazard container. Return the pipet bulbs to the bag that they came from.

TABLE I (To be completed before coming to lab)

	Na_2CO_3	CaCl_2	$\text{Ba}(\text{NO}_3)_2$	AgNO_3	HCl	HNO_3
Na_2CO_3	XXXXX XXXXX					
CaCl_2		XXXXX XXXXX				
$\text{Ba}(\text{NO}_3)_2$			XXXXX XXXXX			
AgNO_3				XXXXX XXXXX		
HCl					XXXXX XXXXX	
HNO_3						XXXXX XXXXX

Copy the results onto the pre-lab page.

Experiment 11

Qualitative Inorganic Analysis

Identification of Six Solutions Report Sheet (40 Points)

Name _____ Lab Day _____

Lab Instructor _____ Date _____

TABLE II (To be completed during lab period)

Solution Letters						
	XXXXX XXXXX					
		XXXXX XXXXX				
			XXXXX XXXXX			
				XXXXX XXXXX		
					XXXXX XXXXX	
						XXXXX XXXXX

Write NET IONIC EQUATIONS (there are seven) for all REACTIONS (precipitate formation and gas evolution) you have listed in Table I.

1.

2.

3.

4.

5.

6.

7.

Identification of Solutes

Code	Formula	Code	Formula
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

EXPERIMENT 11
Qualitative Inorganic Analysis—Identification of Six Solutions
Post-Lab Questions (30 Points)

Name _____

Date _____

Lab Instructor _____

Lab Day _____

1. One aspect of qualitative inorganic analysis involves the study of reactions between ions in solution. Evidence for reactions when two solutions are mixed is based on observations. Name two observations one might observe to indicate that a reaction has occurred when two solutions are mixed.

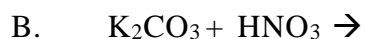
2. What are spectator ions?

3. What ions are formed when the following substances are dissolved in water?
 - A. Na_2SO_4

 - B. CoCl_2

 - C. Lithium carbonate

4. Complete the following reactions and then write the net ionic equation for each reaction.
 - A. $\text{Ba}(\text{NO}_3)_2 + \text{K}_2\text{SO}_4 \rightarrow$



5. An aqueous sample is known to contain Pb^{2+} , Cu^{2+} , or Na^+ ions. Treatment of the sample with both NaOH and LiCl solution produces a precipitate.
- A. Which of the metal cations does the solution contain? Explain your reasoning.

- B. Write all net ionic equations that could occur to justify your reasoning.

EXPERIMENT 11
Qualitative Inorganic Analysis—Identification of Six Solutions
Preliminary Questions (10 Points)

Name _____

Date _____

Lab Instructor _____

Lab Day _____

1. Fill in the following table with either the chemicals formed or no reaction upon mixing each pair of chemicals. (Copy over Table I below)

	Na ₂ CO ₃	CaCl ₂	Ba(NO ₃) ₂	AgNO ₃	HCl	HNO ₃
Na ₂ CO ₃	XXXXX					
CaCl ₂		XXXXX				
Ba(NO ₃) ₂			XXXXX			
AgNO ₃				XXXXX		
HCl					XXXXX	
HNO ₃						XXXXX

2. What is the proper disposal of all chemicals in this reaction?
3. Briefly explain any hazards associated with barium nitrate and silver nitrate.
4. A student is given the following labeled solutions: NaCl, AgNO₃, FeCl₂, HCl, and K₂CO₃. The data was collected and summarized in the following table. The student then receives the 5 test tubes labeled A, B, C, D, and E, which contain the five solution above. Data collected after mixing these solutions are given in the second table below.

Solution	K ₂ CO ₃	AgNO ₃	NaCl	FeCl ₂	HCl
K ₂ CO ₃	XXXXX XXXXX	Precipitate forms	No reaction	Precipitate forms	Gas forms

AgNO ₃	Precipitate forms	XXXXXX XXXXXX	Precipitate forms	Precipitate forms	Precipitate forms
NaCl	No reaction	Precipitate forms	XXXXXX XXXXXX	No Reaction	No reaction
FeCl ₂	Precipitate forms	Precipitate forms	No reaction	XXXXXX XXXXXX	No reaction
HCl	Gas forms	Precipitate forms	No reaction	No reaction	XXXXXX XXXXXX

Solution	A	B	C	D	E
A	XXXXXX XXXXXX	No reaction	Precipitate forms	Precipitate forms	No reaction
B	No reaction	XXXXXX XXXXXX	Gas forms	Precipitate forms	No reaction
C	Precipitate forms	Gas forms	XXXXXX XXXXXX	Precipitate forms	No reaction
D	Precipitate forms	Precipitate forms	Precipitate forms	XXXXXX XXXXXX	Precipitate forms
E	No reaction	No reaction	No reaction	Precipitate forms	XXXXXX XXXXXX

Using this data, identify each of the five solutions.

Solution A _____

Solution B _____

Solution C _____

Solution D _____

Solution E _____