

Aqueous Solutions: Solving the Mystery of the Unknowns

Prelab

In order to complete the laboratory and characterize the unknown aqueous solutions you must first develop a plan (Use a flow chart). As we discussed in lecture, chemicals have unique properties and reactions which allow you to characterize them. The same is true for aqueous solutions of ions (Chapter 4). Using these distinct characteristics such as color, solubility, acid/base, emission spectra, and many others we can deduce chemical composition of a series of unknowns. In lab you will be given a series of unknown samples composed of **sulfuric acid, barium nitrate, sodium bicarbonate, potassium thiocyanate, sodium hydroxide, iron (III) nitrate, ammonium hydroxide, copper (II) nitrate**. Use the tests below to identify each sample. You will be given litmus paper, nichrome wire (with concentrated acid for cleaning), Bunsen burner, transfer pipettes, and test tubes for mixing samples.

Precipitation reactions: (Book section 4.2) A precipitate (insoluble solid) is formed by a reaction in solution. Precipitation reactions occur when two oppositely charged ions are attracted so strongly that they form an insoluble ionic solid. If you follow *Table 4.1: Solubility Guidelines for Common Ionic Compounds in Water (experimental section below)* you can predict the formation of a solid in a precipitation reaction.

Flame test: The flame test is used to visually determine the identity of an unknown metal or metalloid ion based on the characteristic color the salt turns the flame of a Bunsen burner. The heat of the flame excites the metals ions, causing them to emit visible light. The characteristic emission spectra can be used to differentiate between some elements.

pH test (Litmus paper): Section 4.3 Acids are substances which ionize in aqueous solutions to form hydrogen ions (H^+), there by increasing the concentration of H^+ in solution. (ex. From previous lab ($HCl \rightarrow H^+$ and Cl^- in solution.) Bases are substances which accept or react with H^+ ions, typically ionic hydroxide compounds, which dissolve in water to introduce OH^- ions into solution. Using an indicator paper called litmus paper, we can measure the pH of a solution and determine if it is acidic or basic. Blue litmus paper turns red under acidic conditions and red litmus paper turns blue under basic conditions.

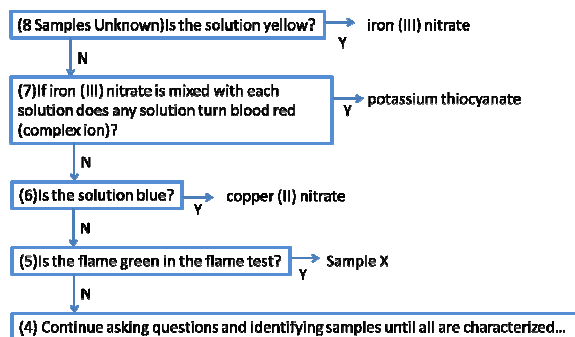
Metal Ion	Flame Color
Barium ion	
Potassium ion	
Sodium ion	
Copper ion	
Iron ion	

Color and smell: Some Ions will form a distinct color in solution, others smell will be a strong indication of compositions (i.e. Cu^{2+} (blue solution due to formation of complex ions $[Cu(H_2O)_4]^{2+}$) and NH_3^+ (strong pungent smell))

Helpful Hints: (1) If SCN^- is added to a solution containing iron (III) ions (Fe^{3+}), a blood red solution is formed due to the formation of $[Fe(NCS)(H_2O)_5]^{2+}$, another example of a complex ion. (2) Think about the previous lab with sodium bicarbonate. If an acid is added to a solution of sodium bicarbonate what will the products be? Think bubbles.

Prelab: (In your lab notebook)

- Describe the lab purpose, as usual.
- Write the chemical formula for each compound you will receive in lab.
- Transfer and fill the chart flame color for each type of ion.
- Create an initial flow chart describing how you will determine the identify of each solution. (This is your procedure; it is all up to you.)



PURPOSE

The purpose of this lab activity is to use properties of aqueous solutions and ions such as those described in Chapter 4 to determine unknown solutions composition.

INTRODUCTION

You will be given dropper bottles of **sulfuric acid (1M), barium nitrate, sodium bicarbonate (10%), potassium thiocyanate, sodium hydroxide, iron (III) nitrate, ammonium hydroxide, copper (II) nitrate.** (All solutions are 0.25 M) Solutions will be delivered as unknowns. Your task is to determine the contents of the unknown bottles. Chapter 4 and the prelab discuss properties of aqueous solutions which can be used to complete your task. Topics which may help in your endeavor are solubility, pH, and flame test.

EXPERIMENTAL

Determine the composition of the unknowns you are given. Follow the flow chart you developed in the prelab. Compare flow charts with your partner and come up with a way to positively determine the composition of each solution. Record which set of unknowns you are given in your lab notebook. Use the precipitation reactions, complex ion, pH test, and flame test to characterize the ionic solutions. Note: Do NOT cross contaminate samples. This will lead to issues in accurately determining the sample composition.

Color: Ions in solution are frequently a different color. Iron (III) ions in solution will appear a pale yellow and copper will be a pale blue.

Precipitation reactions: Mix roughly 1 mL of two solutions you believe will form a precipitate together. Watch for a solid to form. Use two different transfer pipets to avoid cross contamination.

Soluble Compounds	Important Exceptions
Compounds containing NO_3^-	None
$\text{C}_2\text{H}_3\text{O}_2^-$	None
Cl^-	Compounds of Ag^+ , Hg_2^{2+} , and Pb^{2+}
Br^-	Compounds of Ag^+ , Hg_2^{2+} , and Pb^{2+}
I^-	Compounds of Ag^+ , Hg_2^{2+} , and Pb^{2+}
SO_4^{2-}	Compounds of Sr^{2+} , Ba^{2+} , Hg_2^{2+} , and Pb^{2+}
Insoluble Compounds	Important Exceptions
Compounds containing S^{2-}	Compounds of NH_4^+ , the alkali metal cations, and Ca^{2+} , Sr^{2+} , and Ba^{2+}
CO_3^{2-}	Compounds of NH_4^+ and the alkali metal cations
PO_4^{3-}	Compounds of NH_4^+ and the alkali metal cations
OH^-	Compounds of the alkali metal cations, and Ca^{2+} , Sr^{2+} , and Ba^{2+}

Flame test: Use clean nichrome wire (cleaned by dipping wire in concentrated hydrochloric acid then heating it until the flame doesn't produce any color, or slight orange color). Dip wire in unknown solution and then back in flame. Depending on the ions in the solutions, each sample will emit a different color (Check your chart from prelab). Clean wire again and don't cross contaminate samples.

pH test: Place a drop of solution on the paper. Blue litmus paper turns red under acidic conditions and red litmus paper turns blue under basic conditions. Be careful not to cross contaminate samples. Always use the same dropper for each sample.

Wafting (smell): DO NOT directly sniff the sample. Hold sample at a distance and wave the sample toward your nose.

WASTE MANAGEMENT

Waste should go in the waste bottle in the hood. Ask a TA if you do not know where the bottle is located.

Name _____

Report Sheet: Aqueous Solutions: Solving the Mystery of the Unknowns

Unknown Set (letter) _____(2 pts)

1) Draw your final flow chart used in lab; include secondary verification (8 pts):

2.) Assignment of Samples (8 pts):

- | | |
|----|----|
| 1. | 2. |
| 3. | 4. |
| 5. | 6. |
| 7. | 8. |

Writing Exchange reactions and net ionic reactions (12 pts):

3) Precipitation reactions:

- a. Write the exchange **reaction** which occurs between barium nitrate and sulfuric acid.

- b. Write the complete **ionic equation** for the reaction between barium nitrate and sulfuric acid.

- c. Remove the spectator ions from the above reaction and write the **net ionic equation** for the reaction between barium nitrate and sulfuric acid.

4) Precipitation reactions:

- d. Write the exchange **reaction** which occurs between copper (II) nitrate and sodium hydroxide.

- e. Write the complete **ionic equation** for the reaction between copper (II) nitrate and sodium hydroxide.

- f. Remove the spectator ions from the above reaction and write the **net ionic equation** for the reaction between copper (II) nitrate and sodium hydroxide.

GRADING (Lab 3)

- Notebook Preparation

- lab activity entered into Table of Contents (1 pts) _____ pts
- header information on ALL pages (1 pts)..... _____ pts
- Purpose in notebook (2 pts) _____ pts

-Prelab Activity

- Chemical formulas/health hazards as requested in lab notebook (4 pts)..... _____ pts
- Flame test chart in lab notebook (2 pts)..... _____ pts
- Preliminary flow chart in lab notebook (4 pts) _____ pts

- Data collection

- Unknown set number clearly noted in lab notebook (1 pts) _____ pts
- Unknown label clearly noted in lab notebook (2 pts) _____ pts
- Flow Chart/Procedure clearly noted in lab notebook (2 pts) _____ pts

- Data Analysis

- Reporting Sheet Calculations (30 pts) _____ pts

Total point (40 pts) _____ pts

Instructor's Notes:

Lab-Lecture Demos

(aq) means aqueous...used when a substance is dissolved in water...as in HCl (aq).

- Cross contamination
- Flame test
- pH test- litmus paper
- solubility

Need for lab:

-0.25 M solutions of **potassium thiocyanate, barium nitrate, sodium hydroxide, iron (III) nitrate, and copper (II) nitrate**

-sulfuric acid (1M)

-sodium bicarbonate (10%)

-ammonium hydroxide (6M)

11 sets (numbered) of the solutions (~20 mL each) numbered 1-8 (mix then so evens and odd sets numbers are different and record them.)

-Litmus paper

-nichrome wires (for flame test)

-transfer pipets

- test tubes (extra)