Experiment 4
Which Solution Is Which?

OUTCOMES

After completing this experiment, the student should be able to:

- determine if a chemical reaction has occurred when two solutions are combined.
- use logic to determine the identity of eight numbered solutions.

DISCUSSION

Scientists are often confronted with situations that require them to identify unknown substances. Tests are performed to reduce the size of a long list of possible substances. Logic usually plays an important role in narrowing the identity to a single substance.

In this experiment, logic will be used in order to deduce the identity of eight numbered solutions. First, eight solutions of known composition will be tested by combining two solutions together at a time until all possible combinations have been made. Observations of all occurring chemical reactions will be noted. You will then be given the same eight solutions in numbered bottles, except it will be unknown which solution is which. These solutions will then be combined together, two at a time, until all possible combinations have been made.

Your goal will be to identify each of the eight numbered solutions by looking for numbered solutions that have reactions similar to the known solutions. The hardest part will be to identify the first. If no mistakes have been made, identification of the remainder of the solutions should follow easily using a little logic. Some groups may choose to use the process of elimination, while others may look right away for similarities. Most groups will use some combination of each — its only logical that you will.

When a chemical reaction occurs in solution, one of the following observations is usually made:

1. *A precipitate forms*. A precipitate is an insoluble solid which remains suspended in the solution or sinks to the bottom. The word precipitate means literally to "fall out". When a precipitate forms as a result of a reaction, the reaction mixture appears cloudy. A precipitate may be colored.

2. *A gas is evolved*. The gas appears as bubbles that effervesce from the solution. The gases may have a noticeable odor. The correct procedure for smelling a chemical is to waft the fumes towards your nose by waving your hand over the substance. Sniffing at close range may cause undesirable results.

3. *Heat is evolved or absorbed*. This will be indicated by a change in temperature of the reaction mixture. The change is often enough to be detected by touching alone. Other changes may detected by using a thermometer.

4. *There is a change in color*. What else can be said? This one should be obvious.

PROCEDURE

⚠ ***Wear safety glasses or goggles at all times for this experiment.***

⚠ ***Avoid skin contact with the chemicals in this experiment.*** *Silver nitrate causes black stains on skin and clothing that are very difficult to remove.*

1. Locate solutions of the following aqueous solutions: sodium carbonate (Na_2CO_3), calcium chloride ($CaCl_2$), hydrochloric acid (HCl), silver nitrate ($AgNO_3$), magnesium sulfate ($MgSO_4$), potassium iodide (KI), sodium sulfate (Na_2SO_4), and zinc nitrate $Zn(NO_3)_2$.

2. Combine equal amounts (2 or 3 drops) of two solutions together at a time onto a transparent plastic sheet or spot plate, noting whether a chemical reaction takes place. This works best against a black background, since many of the precipitates are light-colored. If a precipitate is formed, note its color and any other obvious characteristics — is it a fine precipitate or is it chunky? Some precipitates appear as crystals which may take several minutes to fully form. The letters ppt are often used to abbreviate the word precipitate. You must watch closely to observe the formation of gas bubbles. When gas bubbles are formed, they often disappear immediately. Watch for bubbles at the instant solutions come in contact with each other. If no reaction occurs, write NR. Magnifying glasses are available for you to examine your combinations more closely.

3. Continue to combine two solutions together at a time until all possible combinations have been made. Allow each combination to sit for two to three minutes, as some precipitates may not form immediately. Record all observations.

4. Locate the eight unknown solutions in numbered bottles. The bottles will be numbered from 1 - 8. They will also be labeled with a letter. Be sure that the *same* letter appears on each bottle. Otherwise, you will have a big problem with your logic when it comes time to identify them! As before, combine the solutions together, two at a time, using equal amounts of each, until all possible combinations have been made. Record your observations.

⚠ ***Dispose of all chemicals in the proper waste container.***

Name_____ Lab Section_____

PRELAB QUESTIONS

1. Six solutions were combined two at a time until all possible combinations were made. The solutions used were K_2CO_3, $Pb(NO_3)_2$, NaI, HNO_3, $MgSO_4$, NH_4Cl. The following observations were made when they were combined:

K_2CO_3 →	wht ppt	NR	gas evolved	wht ppt	NR
	↑ $Pb(NO_3)_2$ →	yel ppt	NR	wht ppt	wht ppt
		↑ NaI →	NR	NR	NR
			↑ HNO_3 →	NR	NR
				↑ $MgSO_4$ →	NR
					↑ NH_4Cl

The same six solutions were placed in bottles numbered from 1-6. They were combined two at a time until all possible combinations were made, yielding the following results:

#1 →	yel ppt	NR	NR	NR	NR
	↑ #2 →	NR	wht ppt	wht ppt	wht ppt
		↑ #3 →	gas evolved	NR	NR
			↑ #4 →	NR	wht ppt
				↑ #5 →	NR
					↑ #6

Which substances were in each of the numbered bottles?

#1 is _____,#2 is _____,#3 is _____,#4 is _____,#5 is _____,#6 is _____.

2. Which safety precautions, if any, must be observed during this experiment?

(*more on back)*

3. Look at the solubility tables (also called Solubility Rules) in your Chem 1020 text. Consider the following reactions that produced a precipitate in your prelab. Based on the solubility tables from your text, indicate which product is most likely the solid that was formed for each of the following reactions. Use the appropriate phase labels. Also balance the following reactions by placing coefficients in front of the reactants and products.

a. ___$Pb(NO_3)_2$ (*aq*) + ___K_2CO_3 (*aq*) → ____$PbCO_3$ ( ) + ___KNO_3 ( )

b. ___$MgSO_4$ (*aq*) + ___K_2CO_3 (*aq*) → ____K_2SO_4 ( ) + ___ $MgCO_3$ ( )

c. ___$Pb(NO_3)_2$ (*aq*) + ___NaI (*aq*) → ____PbI_2 ( ) + ___$NaNO_3$ ( )

d. ___$Pb(NO_3)_2$ (*aq*) + ___$MgSO_4$ (*aq*) → ____$PbSO_4$ ( ) + ___$Mg(NO_3)_2$ ( )

e. ___$Pb(NO_3)_2$ (*aq*) + ___NH_4Cl (*aq*) → ____$PbCl_2$ ( ) + ___NH_4NO_3 ( )

4. As a review, practice naming the following compounds that are used in the prelab exercises. Don't forget that variable-charge metals require a Roman numeral to indicate the + charge.

a. $Pb(NO_3)_2$ _____

b. K_2CO_3 _____

c. $PbCO_3$ _____

d. KNO_3 _____

e. $MgSO_4$ _____

f. $PbSO_4$ _____

g. NaI _____

h. PbI_2 _____

i. KI _____

j. NH_4Cl _____

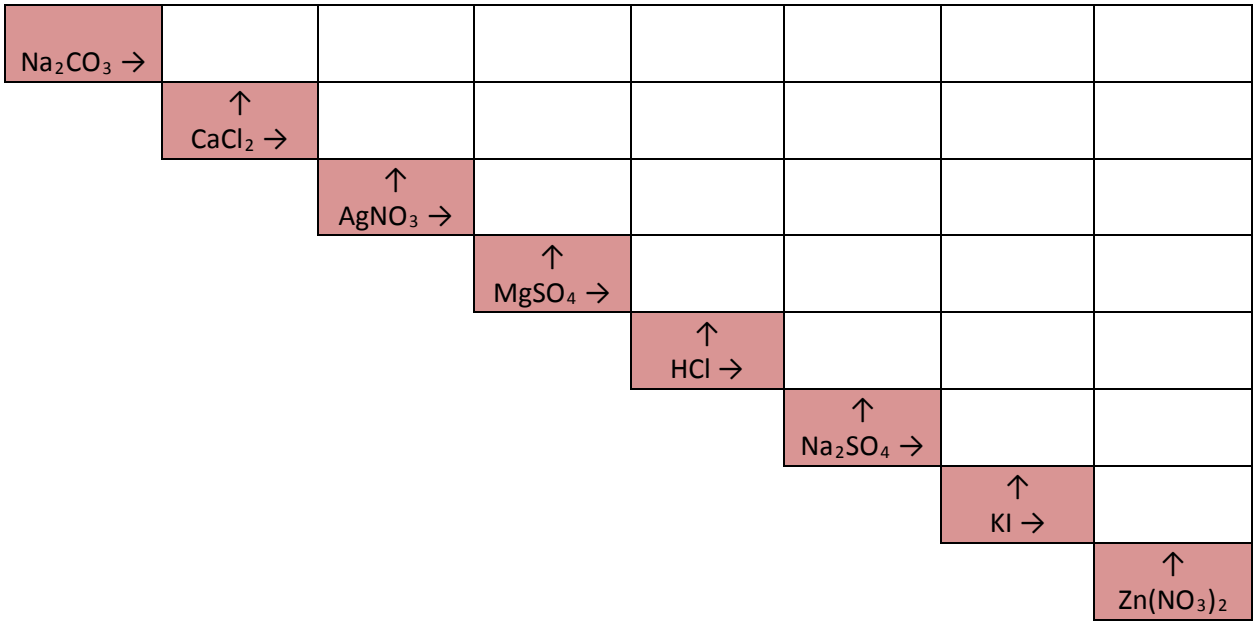
k. $PbCl_2$ _____

l. NH_4NO_3 _____

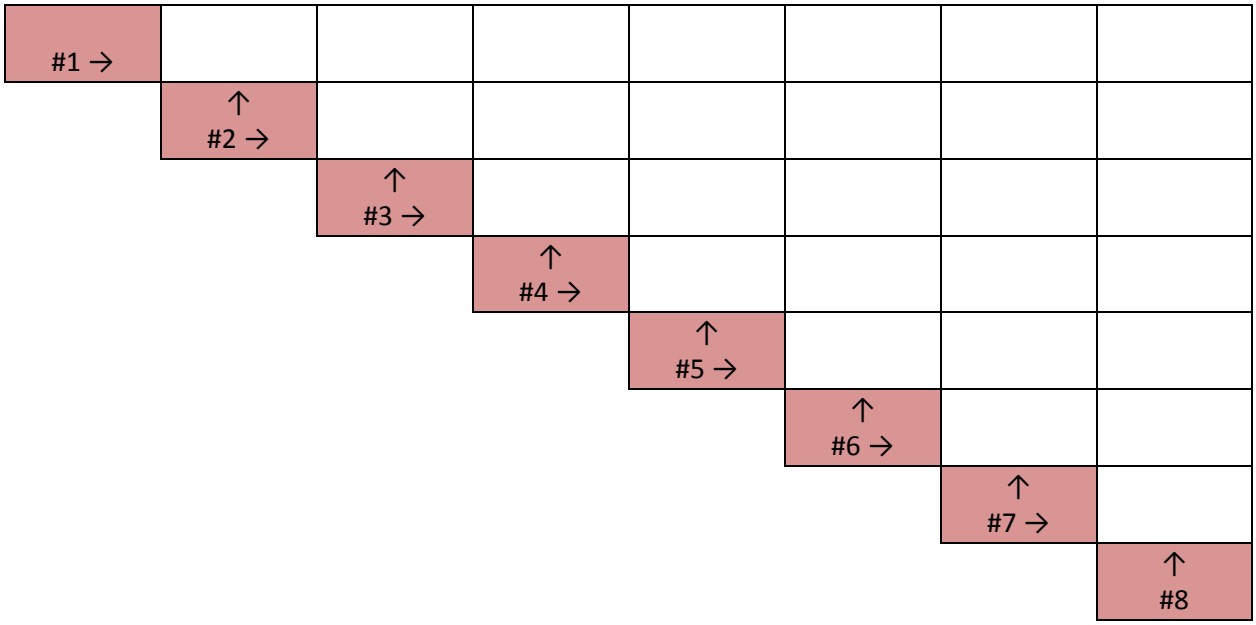
Name_____ Lab Section_____

Partner's Name_____

DATA



The letter on each of my numbered bottles is _____.



Name_____ Lab Section_____

Partner's Name_____

POSTLAB QUESTIONS

1. Which substances were in each of the numbered bottles? Give the unique logic used to arrive at each of your answers.

   The letter on each of my bottles is _____.

Bottle Number	Compound	Logic Used to Identify Compound
#1		
#2		
#3		
#4		
#5		
#6		
#7		
#8		

The following exercises may be optional, check with your instructor.

2. As a review, practice naming the following reactants or products that are used in the lab. Don't forget that variable-charge metals require a Roman numeral to indicate the + charge.

a. $AgNO_3$	_____	h. AgI	_____
b. Na_2CO_3	_____	i. KI	_____
c. $CaCl_2$	_____	j. HCl (*aq*)	_____
d. $NaNO_3$	_____	k. AgCl	_____
e. $MgSO_4$	_____	l. $Mg(NO_3)_2$	_____
f. Ag_2SO_4	_____	m. $Zn(NO_3)_2$	_____
g. NaI	_____	n. $Ca(NO_3)_2$	_____

3. Predict the possible products for the following double replacement reactions and balance the equations. Use the solubility rules from your textbook to predict the phase labels of the possible products. If no visible reaction occurs, write **NR** after the possible products.

a. ___$AgNO_3$ (*aq*) + ___Na_2CO_3 (*aq*) →

b. ___$MgSO_4$ (*aq*) + ___Na_2CO_3 (*aq*) →

c. ___$AgNO_3$ (*aq*) + ___NaI (*aq*) →

d. ___Na_2SO_4 (*aq*) + ___KNO_3 (*aq*) →

e. ___$AgNO_3$ (*aq*) + ___$MgSO_4$ (*aq*) →

f. ___$AgNO_3$ (*aq*) + ___HCl (*aq*) →

g. ___$CaCl_2$ (*aq*) + ____$AgNO_3$ (*aq*) →