Name: _____
Hour: ____ Date: _____

Chemistry: *Lab – Ions in Aqueous Solution*

Introduction:

Many ionic solids dissolve in water to form clear, aqueous solutions that conduct electricity. It is the ions that conduct the electric current. These solutions contain both positive ions (cations) and negative ions (anoins) in such a ratio that the net electric charge of the solution is zero.

$NaCl(s)$ dissolved in $H_2O \rightarrow Na^{1+}(aq) + Cl^{1-}(aq)$
$CaCl_2(s)$ dissolved in $H_2O \rightarrow Ca^{2+}(aq) + 2\ Cl^{1-}(aq)$

In this experiment, you will mix various ionic solutions, two at a time, and will determine which new combinations of ions will form **precipitates** (solids that do not dissolve). By knowing the ions present, and by knowing how to read a **solubility chart**, you will be able to deduce which ions are responsible for the precipitate. You will also be writing **overall reaction equations** and **net ionic equations**.

Precautions:

Observe normal lab precautions. Wear goggles. Do NOT touch your mouth, eyes, or face with your hands, and be sure to wash your hands when you have cleaned up your lab area.

Materials:

One piece of poly film with grid markings; one set of 8 different solutions in eye droppers.

Theory / Example:

Suppose you have two aqueous solutions. One was mixed using $Pb(NO_3)_2(s)$, and the other was mixed using $NaCl(s)$. Both solids dissolve in water, and the solutions contain no visible solids; they are clear. The ions in each solution are:

$Pb(NO_3)_2(s)$ dissolved in $H_2O \rightarrow Pb^{2+}(aq) + 2\ NO_3^{1-}(aq)$
$NaCl(s)$ dissolved in $H_2O \rightarrow Na^{1+}(aq) + Cl^{1-}(aq)$

When the solutions are mixed, a precipitate is observed to form. Two of the four ions have combined to form a precipitate. The original combinations (that is, $Pb^{2+}(aq) + 2\ NO_3^{1-}(aq)$ AND $Na^{1+}(aq) + Cl^{1-}(aq)$) are NOT responsible for the precipitate because, when together, they dissolve in water. The new possible combinations of ions are:

$$Pb^{2+}(aq) + Cl^{1-}(aq) \qquad \text{and} \qquad Na^{1+}(aq) + NO_3^{1-}(aq)$$

Of these, we can see from the solubility chart that the combination $Pb^{2+}(aq) + Cl^{1-}(aq)$ will form a precipitate, while $Na^{1+}(aq) + NO_3^{1-}(aq)$ will remain as invisible ions in the solution.

It is necessary now to write an **overall reaction equation** showing what happened in this reaction. Remember, both atoms and charges must be conserved when writing a chemical reaction. The overall reaction equation is:

$$Pb^{2+}(aq) + 2\ Cl^{1-}(aq) + 2\ Na^{1+}(aq) + 2\ NO_3^{1-}(aq) \rightarrow PbCl_2(s) + 2\ Na^{1+}(aq) + 2\ NO_3^{1-}(aq)$$

After writing this overall reaction equation, however, it is easy to see that the $Na^{1+}(aq)$ and $NO_3^{1-}(aq)$ ions did not react, but merely stayed in solution. Such ions are called **spectator ions**. In a **net ionic equation**, the spectator ions are left out.

$$Pb^{2+}(aq) + 2\ Cl^{1-}(aq) \rightarrow PbCl_2(s)$$

Pre-lab:

1. What ions are present in the following solutions?

   $NaCl(aq)$ → _____ $AgNO_3(aq)$ → _____

2. When these solutions are mixed together, a precipitate is seen. What are the new combinations of ions that could have formed the precipitate?

   _____ and _____

3. Using the solubility table, which new combination will form a precipitate? _____

4. Which new combination will remain in solution? _____

5. Write the overall reaction equation for this reaction. Be sure to indicate the correct phase (reaction condition) for each reactant and each product.

6. Write the net ionic equation for this reaction. Again, include the phases (reaction conditions).

7. Explain why you would expect no reaction between solutions of KOH(aq) and NaOH(aq).

Experimental Procedure:

1. Place a white sheet of paper underneath the poly film in order to better see the reactions.
2. Place one drop of the each of the solutions in the proper boxes on your clean piece of poly film as shown by your teacher. DO NOT touch the tip of the dropper to the film NOR to any chemical already in the boxes. Also, keep each cap with its appropriate dropper.
3. Continue in this fashion until all combinations have been tested.
4. When done, examine your film. On your Data Table, write PPT for "precipitate" in the boxes in which a precipitate is visible. In the boxes in which no precipitate is visible, write NR, meaning "no reaction."
5. Rinse the poly film with water and put the film between 2 pieces of paper towel. Do not wipe the poly film, as this will tend to make the Data Table come off the film. Put all lab materials back in their proper places.
6. Complete Parts I and II with reference to your Data Table.

I. ***New Combinations of Ions –*** For each of the 12 PPT reactions:

(A) In the blanks on the right, write the new combinations of ions that could have formed the precipitate

(B) Balance the left side (already typed) and right side (with the 2 blanks) by adjusting coefficients where necessary.

Use phase notation when writing out the new combinations. For the 16 NR reactions, do nothing.

1. ___ $Co(NO_3)_2(aq)$ + ___ $NaNO_3(aq)$ → _____ + _____
2. ___ $Co(NO_3)_2(aq)$ + ___ $KOH(aq)$ → _____ + _____
3. ___ $Co(NO_3)_2(aq)$ + ___ $NaOH(aq)$ → _____ + _____
4. ___ $Co(NO_3)_2(aq)$ + ___ $CoCl_2(aq)$ → _____ + _____
5. ___ $Co(NO_3)_2(aq)$ + ___ $FeCl_3(aq)$ → _____ + _____
6. ___ $Co(NO_3)_2(aq)$ + ___ $Cu(NO_3)_2(aq)$ → _____ + _____
7. ___ $Co(NO_3)_2(aq)$ + ___ $Pb(NO_3)_2(aq)$ → _____ + _____
8. ___ $Pb(NO_3)_2(aq)$ + ___ $NaNO_3(aq)$ → _____ + _____
9. ___ $Pb(NO_3)_2(aq)$ + ___ $KOH(aq)$ → _____ + _____
10. ___ $Pb(NO_3)_2(aq)$ + ___ $NaOH(aq)$ → _____ + _____
11. ___ $Pb(NO_3)_2(aq)$ + ___ $CoCl_2(aq)$ → _____ + _____
12. ___ $Pb(NO_3)_2(aq)$ + ___ $FeCl_3(aq)$ → _____ + _____
13. ___ $Pb(NO_3)_2(aq)$ + ___ $Cu(NO_3)_2(aq)$ → _____ + _____
14. ___ $Cu(NO_3)_2(aq)$ + ___ $NaNO_3(aq)$ → _____ + _____
15. ___ $Cu(NO_3)_2(aq)$ + ___ $KOH(aq)$ → _____ + _____
16. ___ $Cu(NO_3)_2(aq)$ + ___ $NaOH(aq)$ → _____ + _____
17. ___ $Cu(NO_3)_2(aq)$ + ___ $CoCl_2(aq)$ → _____ + _____
18. ___ $Cu(NO_3)_2(aq)$ + ___ $FeCl_3(aq)$ → _____ + _____
19. ___ $FeCl_3(aq)$ + ___ $NaNO_3(aq)$ → _____ + _____
20. ___ $FeCl_3(aq)$ + ___ $KOH(aq)$ → _____ + _____
21. ___ $FeCl_3(aq)$ + ___ $NaOH(aq)$ → _____ + _____
22. ___ $FeCl_3(aq)$ + ___ $CoCl_2(aq)$ → _____ + _____
23. ___ $CoCl_2(aq)$ + ___ $NaNO_3(aq)$ → _____ + _____
24. ___ $CoCl_2(aq)$ + ___ $KOH(aq)$ → _____ + _____
25. ___ $CoCl_2(aq)$ + ___ $NaOH(aq)$ → _____ + _____
26. ___ $NaOH(aq)$ + ___ $NaNO_3(aq)$ → _____ + _____
27. ___ $NaOH(aq)$ + ___ $KOH(aq)$ → _____ + _____
28. ___ $KOH(aq)$ + ___ $NaNO_3(aq)$ → _____ + _____

II. ***Overall Reaction Equations and Net Ionic Equations***

For each of the 12 PPT reactions, write the overall reaction equation and the net ionic equation, being sure to use phase notation for each case.

Reaction No. _____ ** **Overall Reaction Equation:**

** **Net Ionic Equation:**

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** **Net Ionic Equation:**

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** **Net Ionic Equation:**

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** **Net Ionic Equation:**