

## Some Reactions of Cations

You are about to observe what happens when elements in a positive oxidation state are dissolved in water. Most of the elements will be in the form of the chloride salt because the chloride anion is essentially unreactive under the conditions of the experiment.

### Procedure

1. Place 2-3 mL of water into each of five test tubes. One of the tubes will serve as a distilled water blank. Note the temperature of the water by touching the tubes. Measure the pH of the distilled water.
2. Using a spatula tip of solid, make an aqueous solution of LiCl. Stir until all the solid is dissolved, not whether there is any detectable temperature change and measure the pH of the solution. Repeat the procedure with ZnCl<sub>2</sub> and AlCl<sub>3</sub>.
3. In the hood, carefully pour the contents of a micro test tube of TiCl<sub>4</sub> into the fifth test tube of distilled water. Measure the pH of the solution and (using moistened pH paper) measure the pH of the gas being evolved from the tube. Note any temperature change.

Solute	Cation Radius (pm)	EN	Cation Charge	pH	Observations
H <sub>2</sub> O					
LiCl	90	0.98			
ZnCl <sub>2</sub>	88	1.65			
AlCl <sub>3</sub>	67	1.61			
TiCl <sub>4</sub>	74	1.54			

4. Write plausible chemical equations that would account for the observed phenomenon.
5. (a) Which of the three periodic properties listed varies most significantly in this series of four compounds?
- (b) How does the tendency of a cation to undergo the hydrolysis reaction depend on this periodic property?
- (c) Skywriting involves spraying  $\text{TiCl}_4$  from an airplane into the air. Explain the chemistry of skywriting.
- (d) How would you have to handle compounds like  $\text{TiCl}_4$  to prevent this reaction from happening?

6. In the hood carry out an analogous experiment, adding spatula-tip amounts or drops of the following compounds to 2-3 mL of distilled water.

Solute	Cation Radius (pm)	EN	Cation Charge	pH	Observations
BiCl <sub>3</sub>	117	2.19			
SbCl <sub>3</sub>	90	2.05			
PCl <sub>3</sub>	66	2.02			

- (a) What is the significant periodic variable in this series of compounds?
- (b) Write a conclusion relating the reaction tendency in this series of compounds to this variable.
7. Design and carry out an experiment to determine whether the Pauling electronegativity of the cation has any effect on the reaction tendency. The following chlorides are available for your experiment.
- CaCl<sub>2</sub>, SrCl<sub>2</sub>, MnCl<sub>2</sub>, FeCl<sub>2</sub>, ZnCl<sub>2</sub>, SnCl<sub>2</sub>, (estimated cation radius of 126 pm), Pb(NO<sub>3</sub>)<sub>2</sub>, BiCl<sub>3</sub>.
- Rather than starting by testing all of the chlorides, consider the periodic properties of the cations first and pick out only the set or sets of compounds to test that will give you the comparison that you want.

8. Check your conclusion in step 6 using  $\text{SnCl}_4$  and  $\text{CCl}_4$ . First use your principles to predict what will happen, then do the test. Explain any discrepancy between theory and observation.
  
9. Often people who make up solution of metal salts such as  $\text{SnCl}_2$ ,  $\text{Hg}(\text{NO}_3)_2$  and  $\text{BiCl}_3$  get a cloudy solution and assume that their compound was contaminated. They then throw out the solution and try again with the same result. Looking at your equations from step 4, suggest what must be done to get clear solutions of these metal ions. Test your answer by trying it with one of the salts.