Some Reactions of Oxo Anions

The principles developed to predict the extent of hydrolysis of cations are most useful with metallic elements when they are in not too high an oxidation state. Nonmetals and metals in high oxidation states do not exist in solution as cations. The best approach to systematizing the chemistry of nonmetals in aqueous solution with positive oxidation numbers is to study their oxo anions. Carry out the following test tube experiments analogously to those in the "cation" experiment.

Procedure

1. Check the pH of distilled water. Measure and compare the pHs of $NaClO$ and $NaClO_4$ and Na_2SO_3 and Na_2SO_4. For each pair of compounds, indicate which component of the oxo anion, general formula MO_x^{y-}, is being varied and the effect this has on the pH.

Compound	pH	Component Varied/pH Effect
$NaClO$		
$NaClO_4$		
Na_2SO_3		
Na_2SO_4		

Predict whether $NaNO_2$ or $NaNO_3$ will have the higher pH. Test your hypothesis by measuring and comparing the pH values.

Compound	pH	Component Varied
$NaNO_2$		
$NaNO_3$		

2. Write an equation that would produce the pHs observed using the most active oxo anion tested.

3. Design an experiment to determine the effect of the charge (–y) of an oxo anion on its basicity and carry out the experiment. In addition to the salts from step 1, the following are available:

$$Na_3PO_4,\ Na_4SiO_4,\ NaIO_3$$

Indicate the relationship between charge and basicity observed.

4. Predict the trend in pHs of the following series of solutions (two of these are too intensely colored to be tested with pH paper.

$$K_3VO_4,\ K_2CrO_4,\ KMnO_4$$

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highest pH lowest pH

5. Consider the following list of the oxo anions of the later p-block elements in their highest oxidation states. Notice that the number of oxo groups (oxygen atoms) changes as you proceed down a periodic table family.

CO_3^{2-}	NO_3^{-}			
SiO_4^{4-}	PO_4^{3-}	SO_4^{2-}	ClO_4^{-}	
GeO_4^{4-}	AsO_4^{3-}	SeO_4^{2-}	BrO_4^{-}	
SnO_6^{8-}	SbO_6^{7-}	TeO_6^{6-}	IO_6^{5-}	XeO_6^{4-}

How could you explain the fact that the oxo group number does not remain constant?

6. Notice that the charge on the oxo anion also changes down a family. Considering your previous conclusions, would you expect these simultaneous changes in structure of oxo groups to have the same effects on basicity (i.e., reinforce each other's effects)? If so, describe the basicity trend for oxo anions down a periodic family. If the effects are not reinforcing, determine which effect is dominant. To do this, compile the pH values of all the oxo anions in the list from step 5 for which you have data and additionally test Na_2CO_3. What is the observed basicity trend for oxo anions down a group of the periodic table?

7. Looking at all of your trends, identify the oxo anion in step 5 that would most strongly undergo the chemical reaction you wrote in step 2.