

Exercise 10.4

Aqua Complexes of Metal Cations as Acids

1. When AlCl_3 is exposed to water, it reacts with it rapidly and vigorously. The Al^{3+} cations and Cl^- anions are both solvated by water molecules giving $[\text{Al}(\text{OH}_2)_6]^{3+}(\text{aq})$ for every three $\text{Cl}^-(\text{aq})$.
 - (a) Draw a reaction equation showing the Lewis acid-base reaction of one water molecule with one Al^{3+} cation. Use curly arrows to show the movement of electrons.
Include all non-zero formal charges on the appropriate atoms.

 - (b) Compare the hydrogen atoms on the neutral water molecule with the hydrogen atoms on the Lewis acid-base adduct shown in your answer to part (a). Which are more acidic? Why?

 - (c) Draw the $[\text{Al}(\text{OH}_2)_6]^{3+}$ complex. This time, you do not need to show formal charges. Instead, the convention is to surround the complex in square brackets and just show the overall charge. *The answer to part (b) still applies even if the formal charges aren't shown.*

 - (d) The pK_a of $[\text{Al}(\text{OH}_2)_6]^{3+}$ is approximately 5. That makes it about as acidic as acetic acid. Compare the strength of this complex as an acid to that of water.
Your answer should involve a number.

- (e) Draw a reaction equation showing the reaction of one $[\text{Al}(\text{OH}_2)_6]^{3+}$ complex with one hydroxide anion. Use curly arrows to show the movement of electrons.

To do this, you have to draw the molecules. Arrows are meaningless if you use chemical formulas and we can't tell which atoms they start/finish at.

- (f) As the pH of solution increases, more hydroxide anions are available to react with the $[\text{Al}(\text{OH}_2)_6]^{3+}$ complex. How many hydroxide anions need to react with this complex to give a neutral compound that precipitates out of solution?

- (g) To your answer to part (e), add steps showing reaction of each product with one more hydroxide anion until you reach this neutral product.

When you get to this product, the water molecules attached to the central Al atom will "fall off".

- (h) What does this tell us about the solubility of Al salts in aqueous solutions with different pH values?