

Acid - Base Systems: Ionic Equilibria: Ions as Bronsted-Lowry Acids and Bases

Svante Arrhenius (1859-1927) developed a theory in 1887 that provided the first useful theoretical definition of acids and bases. He described acids as substances that ionize in aqueous solution to form hydrogen ions, and bases to form hydroxide ions in solution. This theory explained the process of neutralization by assuming that $\text{H}^+_{(\text{aq})}$ and $\text{OH}^-_{(\text{aq})}$ combine to form $\text{H}_2\text{O}_{(\text{l})}$. The various strengths of acids and bases were explained in terms of degree (percentage) of ionization, but Arrhenius's theory is limited to aqueous solutions and cannot explain the properties of many common substances.

Bronsted-Lowry Theory (1879 - 1947): developed a theory in 1923, that focused on the role of acids and bases in a reaction rather than on the properties of their aqueous solutions. They defined acids as substances that are proton, (H^+), donors, and a base is a proton acceptor in chemical reactions. In the Bronsted-Lowry concept, a substance can only be defined as an acid or a base for a specific reaction.

An acid-base neutralization reaction involves the transfer of one proton from the strongest acid to the strongest base present.

An amphiprotic substance is one that appears to act as a Bronsted-Lowry acid in some reactions and as a Bronsted-Lowry base in other reactions; i.e. an entity that can gain or lose a proton. Ions such as hydrogen carbonate, $\text{HCO}_3^-_{(\text{aq})}$, or hydrogen sulphite, $\text{HSO}_3^-_{(\text{aq})}$, $\text{H}_2\text{PO}_4^-_{(\text{aq})}$, or $\text{HPO}_4^{2-}_{(\text{aq})}$ can act as acids in one reaction and as bases in another.

A conjugate acid-base pair consists of two substances that differ only by one proton.

Use the Bronsted-Lowry Theory and predict the products of the following reactions in aqueous solutions, and then perform the following experiments to confirm the predicted products and prove the Bronsted and Lowry's Theory of acid-base reactions.

Experiment

1. Add 5 cm^3 of 6 mol dm^{-3} HCl to 5 cm^3 of saturated CH_3COONa in a test tube. Cautiously smell the contents of the test tube. If no odour is detected, gently warm the contents and identify the odour of the gas being evolved.
2. Add 5 cm^3 of 6 mol dm^{-3} NaOH to 5 cm^3 of saturated NH_4Cl in a test tube. Cautiously smell the contents of the test tube. If no odour is detected, gently warm the contents and identify the odour of the gas being evolved.
3. Add 5 cm^3 of saturated CH_3COONa to 5 cm^3 of saturated NH_4Cl in a test tube. Cautiously smell the contents of the test tube. If no odour is detected, gently warm the contents and identify the odour of the gas being evolved.
4. Add 5 cm^3 of NaHCO_3 to 5 cm^3 of NaHSO_4 to in a test tube, stopper and shake the test tube. Release the stopper and record your observations.
5. Add 5 cm^3 of NaHCO_3 to 5 cm^3 of NaHSO_3 in a test tube, stopper and shake the test tube. Release the stopper and record your observations.

Record all your observations in a suitable data table. Write net ionic equations for the reactions observed and label the conjugate acid-base pairs.