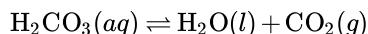


## 11.14: Lewis Acids and Bases

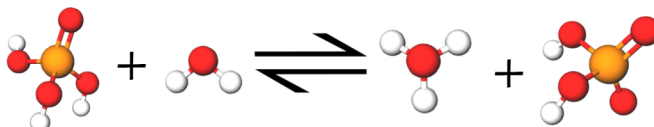
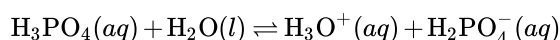
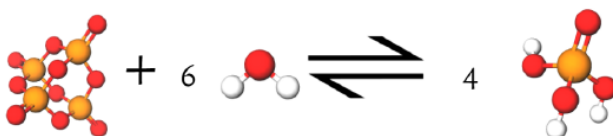
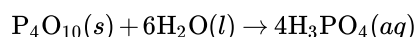
Many oxyacids are rather unstable and cannot be isolated in pure form. An example is carbonic acid,  $\text{H}_2\text{CO}_3$ , which decomposes to water and carbon dioxide:



This decomposition process is familiar to us, as it is responsible for the fizzy nature of soda. When the  $\text{CO}_2$  is dissolved in the soda, it becomes  $\text{H}_2\text{CO}_3$ , but when the soda is released from high pressure, the decomposition process occurs rapidly, forming bubbles of  $\text{CO}_2$  and water.



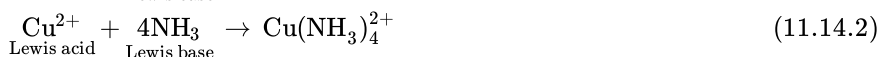
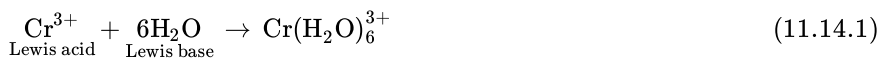
Since it can be made by removing  $\text{H}_2\text{O}$  from  $\text{H}_2\text{CO}_3$ ,  $\text{CO}_2$  is called the **acid anhydride** of  $\text{H}_2\text{CO}_3$ . (The term anhydride is derived from anhydrous, meaning “not containing water.”) Acid anhydrides are usually oxides of nonmetallic elements. Some common examples and their corresponding oxyacids are  $\text{SO}_2\text{—H}_2\text{SO}_3$ ;  $\text{SO}_3\text{—H}_2\text{SO}_4$ ;  $\text{P}_4\text{O}_{10}\text{—H}_3\text{PO}_4$ ;  $\text{N}_2\text{O}_5\text{—HNO}_3$ . Any of these anhydrides increases the hydronium-ion concentration when dissolved in water; for example,



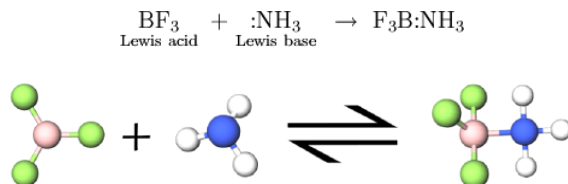
In the Arrhenius sense, then, acid anhydrides are acids, but according to the Brønsted-Lowry definition, they are not acids because they contain no hydrogen.

In 1923, at the same time that the Brønsted-Lowry definition was proposed, [G. N. Lewis](#) suggested another definition which includes the acid anhydrides and a number of other substances as acids. According to the **Lewis definition**, an acid is any species which can accept a lone pair of electrons, and a base is any species which can donate a lone pair of electrons. An acid-base reaction in the Lewis sense involves formation of a **coordinate covalent bond** (where one atom provides both shared electrons).

The Lewis definition has little effect on the types of molecules we expect to be basic. All the Brønsted-Lowry bases, for example,  $\text{NH}_3$ ,  $\text{O}^{2-}$ ,  $\text{H}^-$ , contain at least one lone pair. Lewis' idea does expand the number of acids, though. The proton is not the only species which can form a coordinate covalent bond with a lone pair. Cations of the transition metals, which are strongly hydrated, do the same thing:



So can electron deficient compounds such as boron trifluoride:



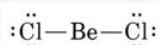
Many Lewis acid-base reactions occur in media other than aqueous solution. The Brønsted-Lowry theory accounts for almost all aqueous acid-base chemistry. Therefore the Brønsted-Lowry concept is most often intended when the words acid or base are used. The Lewis definition is useful when discussing transition-metal ions, however, and is discussed again in the sections on [Metals](#).

### ✓ Example 11.14.1 : Lewis Acids and Bases

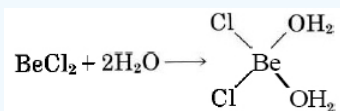
Identify the Lewis acids and bases in the following list. Write an equation for the combination of each acid with the Lewis base  $\text{H}_2\text{O}$ . (a)  $\text{BeCl}_2(g)$ ; (b)  $\text{CH}_3\text{OH}$ ; (c)  $\text{SO}_2$ ; (d)  $\text{CF}_4$ .

#### Solution

a) The Lewis diagram

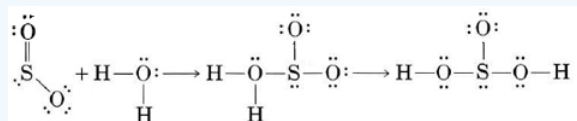


shows that Be is electron deficient. Therefore  $\text{BeCl}_2(g)$  is a Lewis acid. Because of the lone pairs on the Cl atoms,  $\text{BeCl}_2$  can also act as a Lewis base, but Cl is rather electronegative and reluctant to donate electrons, so the Lewis base strength of  $\text{BeCl}_2$  is less than the Lewis acid strength.



b) There are lone pairs on O in  $\text{CH}_3\text{OH}$ , and so it can serve as a Lewis base.

c) The S atom in  $\text{SO}_2$  can accept an extra pair of electrons, and so  $\text{SO}_2$  is a Lewis acid. The O atoms have lone pairs but are only weakly basic for the same reason as the Cl atoms in part (a).



d) Although there are lone pairs on the F atoms, the high electronegativity of F prevents them from being donated to form coordinate covalent bonds. Consequently  $\text{CF}_4$  has essentially no Lewis-base character.

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