Amphoteric & Polyprotic Substances

- A **polyprotic substance** is a chemical that has the ability to lose/gain more than one proton/hydrogen ion (H^+)
- After the acid ionizes the first time and donates its first hydrogen ion, the acid must contain another hydrogen atom that could be donated for a second time
- Consider the example of carbonic acid. Carbonic acid is *diprotic*, meaning it has two protons that can be donated

1st ionization: $H_2CO_{3(aq)} + H_2O_{(\ell)} \rightleftharpoons HCO_3^-{}_{(aq)} + H_3O^+_{(aq)}$

2nd ionization: $HCO_3^-{}_{(aq)} + H_2O_{(\ell)} \rightleftharpoons CO_3^{2-}{}_{(aq)} + H_3O^+_{(aq)}$

- Some organic acids can have several hydrogen atoms in the molecule, but not all of the hydrogen atoms will be *acidic hydrogen ions*. *Acidic hydrogen ions* are simply the hydrogen ions that can be lost in an acid-base reaction. In an organic acid, the acidic hydrogen ions are the ones attached in the –COOH group and are usually found at the ends of the molecule (not the hydrogen atoms contained in the middle of the molecule).
  - Example:

Polyprotic

$H_2C_6H_6O_6$ ← 2 acidic hydrogens

OR

$C_3H_5O(COOH)_3$ ← 3 acidic hydrogens

Not Polyprotic

C_2H_5COOH ← only 1 acidic hydrogen

- *Polyprotic bases* usually have a negative charge that is less than -1and can gain more than one hydrogen ion.
  - Example :

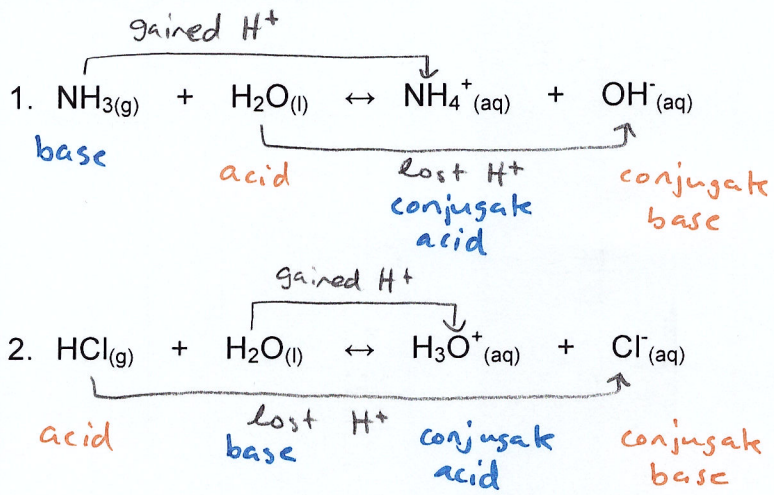
can check table pg. 8-9 of data book!

$SO_3^{2-}{}_{(aq)} + H_2O_{(\ell)} \rightleftharpoons HSO_3^-{}_{(aq)} + OH^-{}_{(aq)}$

and then

$HSO_3^-{}_{(aq)} + H_2O_{(\ell)} \rightleftharpoons H_2SO_{3(aq)} + OH^-{}_{(aq)}$

- Consider the following two reactions:



  - What observations can you make between any similarities and differences?

in rxn #1, $H_2O_{(l)}$ acts as an acid & in rxn #2, $H_2O_{(l)}$ acts as a base

✶ • A substance that can act as a base in one reaction and act as an acid in another reaction is called an **amphoteric substance** or **amphiprotic**

- Here is another example:

Review

$HSO_4^-{}_{(aq)} + HCl_{(aq)} \rightleftharpoons H_2SO_{4(aq)} + Cl^-{}_{(aq)}$ (favours products)

base acid

vs.

$HSO_4^-{}_{(aq)} + CN^-{}_{(aq)} \rightleftharpoons SO_4^{2-}{}_{(aq)} + HCN_{(aq)}$ (favours products)

acid base

✶ • Most amphoteric substances are a negatively charged ion that contains at least one *acidic hydrogen* (ie. $HSO_4^-{}_{(aq)}$, $HCO_3^-{}_{(aq)}$, $H_2PO_4^-{}_{(aq)}$)

  - However, not all amphoteric substances fall into this category. An example includes water (H_2O), which can act as an acid and form $OH^-{}_{(aq)}$ or water can act as a base and form $H_3O^+{}_{(aq)}$. Another example is NH_3, which can act as a base and form NH_4^+ or NH_3 can act as an acid and form NH_2^-.
  - Check by looking on pg. 8-9 of data book to see if the chemical is found on both sides of the table

*****Now try pg. 688 # 5-7 & pg. 690 #3*****

Section 17.2 Review Answers

Student Textbook page 690

3. $H_3BO_3(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + H_2BO_3^-(aq)$

$H_2BO_3^-(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + HBO_3^{2-}(aq)$

$HBO_3^{2-}(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + BO_3^{3-}(aq)$