Chemistry 12

Acid-Base Equilibrium I

Name:
Date:
Block:

1. **Properties of Acids & Bases**
2. **Definitions of Acids and Bases**
3. **Conjugate Acid-Base Pairs**
4. **Amphiprotic Substances**

Properties of Acids and Bases

Acids	Bases
1.	1.
2.	2.
3.	3.
4.	4.

Definitions of Acids and Bases

Arrhenius Theory of Acid and Bases

- Arrhenius acids _____ H^+ ions
- Arrhenius bases _____ OH^- ions.

Typically…

Acid	+	Base	→	Salt	+	Water
$HCl_{(aq)}$	+	$NaOH_{(aq)}$	→	$NaCl_{(aq)}$	+	$H_2O_{(l)}$

Brønsted-Lowry Acids and Bases

A broader definition

- Brønsted-Lowry acids _____ H^+ ion.
- Brønsted-Lowry bases _____ H^+ ion.

Example 1:

$$HCl_{(aq)} + H_2O_{(l)} \rightarrow Cl^-_{(aq)} + H_3O^+_{(aq)}$$

_____ _____

HCl _____ a proton, H^+, to the water molecule – HCl is acting as a _____.

H_2O _____ a proton, H^+, from HCl – water is acting as a _____.

Example 2:

$$NH_{3\,(aq)} + H_2O_{\,(l)} \leftrightharpoons NH_4^{+}{}_{\,(aq)} + OH^{-}{}_{\,(aq)}$$

_____ _____ _____ _____

NH_3 _____ a proton, H^+. NH_3 is acting as a _____.

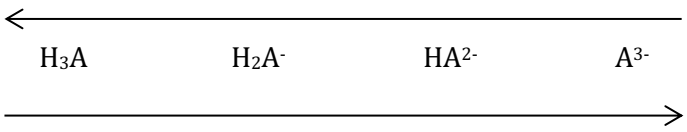
H_2O _____ a proton, H^+. water is acting as a _____.

In the reverse reaction….

NH_4^+ _____ a proton, H^+ and is acting as a _____.

OH^- _____ a proton, H^+. and is acting as a _____.

Gain or lose?



Rewrite the following compounds in order of decreasing number of protons:

a) HPO_4^{2-} | H_3PO_4 | $H_2PO_4^-$ | PO_4^{3-}

b) H_2O | H_3O^+ | OH^-

c) $SO_4^{\,2-}$ | H_2SO_4 | HSO_4^-

d) NH_3 | NH_2^- | NH_4^+

e) H_2SO_3 | SO_3^{2-} | HSO_3^-

Practice! Identify the following as an acid or base

$HClO_4 + H_2O \rightarrow ClO_4^- + H_3O^+$

$HI + H_2O \rightarrow I^- + H_3O^+$

$HBr + H_2O \rightarrow Br^- + H_3O^+$

$HCl + H_2O \rightarrow Cl^- + H_3O^+$

$HIO_3 + H_2O \leftrightharpoons IO_3^- + H_3O^+$

$HCOOH + H_2O \leftrightharpoons COOH^- + H_3O^+$

$HIO_3 + OH^- \leftrightharpoons IO_3^- + H_2O$

$H_3PO_4 + OH^- \leftrightharpoons H_2PO_4^- + H_3O^+$

$HC_2O_4^- + H_3O^+ \leftrightharpoons H_2C_2O_4 + H_2O$

$SO_3^{2-} + H_3O^+ \leftrightharpoons HSO_3^- + H_2O$

Hebden Workbook Pg. 117 #11, 12
Brønsted-Lowry Acid-Base Worksheet #1-8

Conjugate Acid-Base Pairs

Example 3 – Identify the Brønsted-Lowry acid and base in the following reaction:

$$HF_{(aq)} + CN^-_{(aq)} \leftrightharpoons HCN_{(aq)} + F^-_{(aq)}$$

_____ _____ _____ _____

Two substances that differ by one H^+ ion are called a conjugate acid-base pair.

Let's practice!

$HNO_3 + Cl^- \Leftrightarrow HCl + NO_3^-$

$PO_3^{-3} + H_2O \Leftrightarrow HPO_3^{-2} + OH^-$

$CN^- + H_3O^+ \Leftrightarrow HCN + H_2O$

$BO_2^{-3} + HC_2O_4^- \Leftrightarrow HBO_2^{-2} + C_2O_4^{-2}$

$NO_2^- + PH_3 \Leftrightarrow PH_2^- + HNO_2$

$HCO_2^- + NH_4^+ \Leftrightarrow HCOOH + NH_3$

Complete the following table:

Conjugate Acid (donates a proton)	**Conjugate Base** (accepts a proton)
$H_2C_2O_4$	
	SO_3^{2-}
HCO_3^-	
H_2O_2	
	$H_2BO_3^-$
HCOOH	
	$C_6H_5O_7^{2-}$
	H_2O
H_2O	

<u>Hebden Workbook pg. 119 #13</u>

13. Identify each species in the following equations as being an acid or base.

a) $HF + SO_3^{2-} \rightleftharpoons F^- + HSO_3^-$

b) $H_2O + HCO_3^- \rightleftharpoons H_3O^+ + CO_3^{2-}$

c) $NO_2^- + H_2O \rightleftharpoons OH^- + HNO_2$

d) $H_2PO_4^- + S^{2-} \rightleftharpoons HS^- + HPO_4^{2-}$

e) $N_2H_5^+ + SO_4^{2-} \rightleftharpoons N_2H_4 + HSO_4^-$

Amphiprotic Substances

Consider the two reactions below:

$$NH_{3\,(aq)} + H_2O_{\,(l)} \leftrightharpoons NH_4^{+}{}_{(aq)} + OH^{-}{}_{(aq)}$$

$$HF_{\,(aq)} + H_2O_{\,(l)} \leftrightharpoons H_3O^{+}{}_{(aq)} + F^{-}{}_{(aq)}$$

In the first reaction, water acts as a BL-acid. In the second reaction, water acts as a BL-base.

An amphiprotic substance has the ability to act as an acid or a base, depending on what it is reacting with.

1. Which of the following would be expected to exhibit amphiprotic behavior. Circle those that apply.

Se^{2-} HSe^{-} H_2Se H_3PO_4 HPO_4^{2-} HSO_3^{-}

2. Of the species that were circled in the above question, write two equations: (1) behaving as an acid with water (2) behaving as a base with water

<u>Complete Brønsted-Lowry Acid-Base Worksheet #9-13</u>