

Practice - Equilibrium Constants

1.) What are the concentrations of hydronium and hydroxide in pure water?

Answer - $K_w = [H_3O^+][OH^-]$ $K_w = [x][x]$ $1.00 \times 10^{-14} = x^2$
 $x = 1.00 \times 10^{-7} M$ $[OH^-] = 1.00 \times 10^{-7} M$ $[H_3O^+] = 1.00 \times 10^{-7} M$

2.) When water is heated;

a.) What happens to the $[H_3O^+]$?



b.) Is this hot water acidic, basic, or neutral?

Answer - neutral. Both the $[H_3O^+]$ and $[OH^-]$ increase equally keeping water neutral.

c.) What happens to the K_w when the water is heated?

Answer - increases.

3.) Determine what the $[H_3O^+]$ and $[OH^-]$ in the following solutions.

a.) 4.0 M HCl

$$K_w = [H_3O^+][OH^-] \quad 1.00 \times 10^{-14} = [4.0][x]$$

$$x = 2.5 \times 10^{-15} M$$

$$[OH^-] = 2.5 \times 10^{-15} M \quad [H_3O^+] = 4.0 M$$

c.) 0.0050 M H_2SO_4

$$K_w = [H_3O^+][OH^-] \quad 1.00 \times 10^{-14} = [0.0050][x]$$

$$x = 2.0 \times 10^{-12} M$$

$$[OH^-] = 2.0 \times 10^{-12} M \quad [H_3O^+] = 5.0 \times 10^{-3} M$$

b.) 8.0 M $Mg(OH)_2$

$$K_w = [H_3O^+][OH^-] \quad 1.00 \times 10^{-14} = [x][8.0]$$

$$x = 1.25 \times 10^{-15} M$$

$$[OH^-] = 8.0 M \quad [H_3O^+] = 1.25 \times 10^{-15} M$$

d.) 0.15 M NaOH

$$K_w = [H_3O^+][OH^-] \quad 1.00 \times 10^{-14} = [x][0.15]$$

$$x = 2.5 \times 10^{-15} M$$

$$[OH^-] = 0.15 M \quad [H_3O^+] = 6.7 \times 10^{-14} M$$

4.) Write the acid ionization constant expression for the below reactions when the chemical is acting as an acid with water.

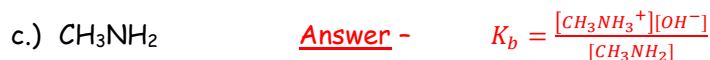
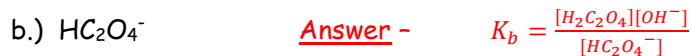
a.) HF Answer - $K_a = \frac{[F^-][H_3O^+]}{[HF]}$

b.) HPO_4^{2-} Answer - $K_a = \frac{[PO_4^{3-}][H_3O^+]}{[HPO_4^{2-}]}$

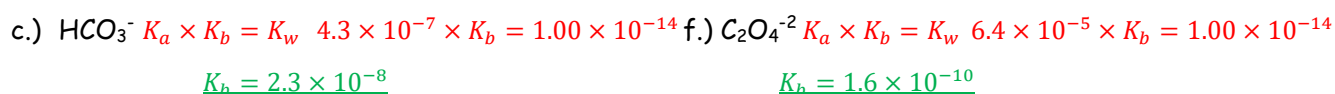
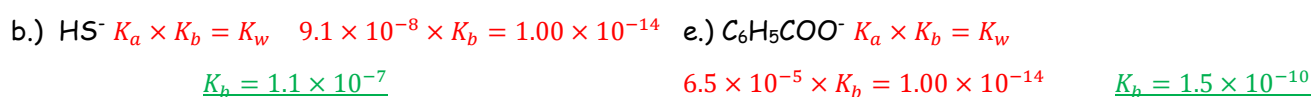
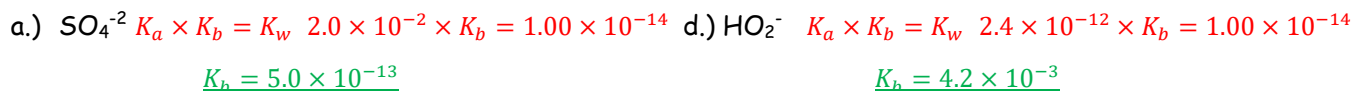
c.) HIO_3 Answer - $K_a = \frac{[IO_3^-][H_3O^+]}{[HIO_3]}$

5.) Write the base ionization constant expression for the below reactions when the chemical is acting as a base with water.

a.) CN^- Answer - $K_b = \frac{[HCN][OH^-]}{[CN^-]}$



6.) Calculate the K_b for the following bases.



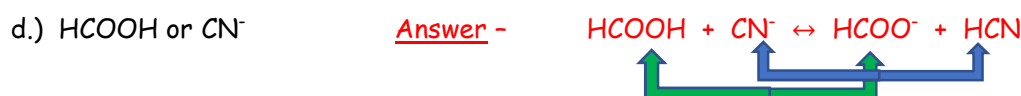
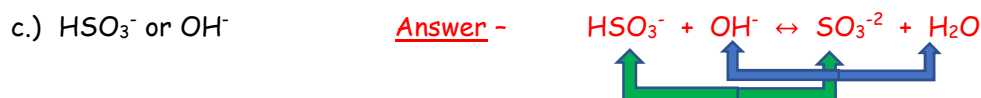
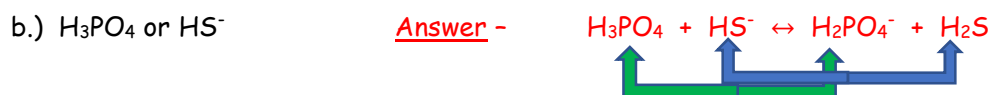
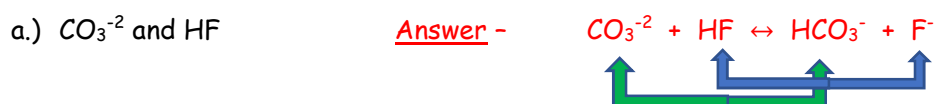
7.) If $K_b = 1.7 \times 10^{-6}$ for N_2H_4 , what is the K_a for N_2H_5^+ ?



8.) If a substance has a $K_b = 2.0 \times 10^{-10}$, is the substance a weak acid, weak base, strong acid, or a strong base? Explain.

Answer - Weak base. Strong acids and bases completely ionize and have no K_a/K_b value and since the K_b is given it must act as a base.

9.) Write the acid/base equilibrium that would occur for the following pairs, including labels for the acid/base conjugate pairs.



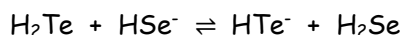
10.) Are reactants or products favoured in the following equilibrium equations?



11.) Write the equilibrium reactions when the following are put into water, and predict if reactants or products are favoured.

- a.) HSO_4^- and NO_2^- Answer - $\text{HSO}_4^- + \text{NO}_2^- \leftrightarrow \text{SO}_4^{2-} + \text{HNO}_2$ products
- b.) H_3PO_4 and HPO_4^{2-} Answer - $\text{H}_3\text{PO}_4 + \text{HPO}_4^{2-} \leftrightarrow \text{H}_2\text{PO}_4^- + \text{H}_2\text{PO}_4^-$ products
- c.) HCO_3^- and HSO_3^- Answer - $\text{HCO}_3^- + \text{HSO}_3^- \leftrightarrow \text{SO}_3^{2-} + \text{H}_2\text{CO}_3$ reactants
- d.) HSO_3^- and HC_2O_4^- Answer - $\text{HSO}_3^- + \text{HC}_2\text{O}_4^- \leftrightarrow \text{C}_2\text{O}_4^{2-} + \text{H}_2\text{SO}_3$ reactants
- e.) $(\text{NH}_4)_2\text{CO}_3$ Answer - $(\text{NH}_4)_2\text{CO}_3 \rightarrow 2 \text{NH}_4^+ + \text{CO}_3^{2-}$ (salts)
- $\text{NH}_4^+ + \text{CO}_3^{2-} \leftrightarrow \text{NH}_3 + \text{HCO}_3^-$ products

12.) $K_{eq} = 14$ at equilibrium.



- a.) Which acid is stronger? Answer - H_2Te
- b.) Which base is stronger? Answer - HSe^-
- c.) From your previous answers, fill in the blanks below with the following terms: Stronger acid, weaker acid, Stronger base, weaker base.



- 13.) $\text{HOI} + \text{H}_2\text{GeO}_4^- \rightleftharpoons \text{OI}^- + \text{H}_3\text{GeO}_4$; $K_{eq} = 8.8 \times 10^{-3}$ $\text{HOI} < \text{H}_3\text{GeO}_4$
- $\text{HOCl} + \text{OBr}^- \rightleftharpoons \text{OCl}^- + \text{HOBr}$; $K_{eq} = 14$ $\text{HOCl} > \text{HOBr}$
- $\text{HOBr} + \text{H}_2\text{GeO}_4^- \rightleftharpoons \text{OBr}^- + \text{H}_3\text{GeO}_4$; $K_{eq} = 7.9 \times 10^2$ $\text{HOBr} > \text{H}_3\text{GeO}_4$

Arrange the four acids from strongest to weakest.



14.) Three different acids are: H_2SO_3 , H_3PO_4 , and HCOOH . Which would form an equilibrium with F^- in which the reactants are favoured? Explain.

- Answer - $\text{H}_2\text{SO}_3 + \text{F}^- \leftrightarrow \text{HSO}_3^- + \text{HF}$
- $\text{H}_3\text{PO}_4 + \text{F}^- \leftrightarrow \text{H}_2\text{PO}_4^- + \text{HF}$
- $\text{HCOOH} + \text{F}^- \leftrightarrow \text{HCOO}^- + \text{HF}$ HF is a stronger acid than $\text{HCOOH} \therefore$ so favours reactants!