Chapter 5 - Answer Key

Page 265, Practice Problems

1. a) H_2SO_4 acid
   b) XeF_6 molecular
   c) CH_3COOH acid
   d) $NaCH_3COO$ salt
   e) KOH base
   f) NH_3 molecular (but also a base)

2. a) $CH_3COOH + LiOH \rightarrow LiCH_3COO + H_2O$
   salt
   b) $2HI + Ca(OH)_2 \rightarrow 2H_2O + CaI_2$
   salt
   c) $3Mg(OH)_2 + 2H_3PO_4 \rightarrow 6H_2O + Mg_3(PO_4)_2$
   salt

3.	**Parent Acid**	**Parent Base**
a) KNO_2	HNO_2	KOH
b) NH_4Cl	HCl	NH_4OH (or NH_3)
c) CuC_2O_4	$H_2C_2O_4$	$Cu(OH)_2$
d) $NaCH_3COO$	CH_3COOH	NaOH

Page 268, Practice Problems

1. a) $HIO_3 + NO_2^- \leftarrow\ > HNO_2 + IO_3^-$
   acid base acid base
   b) $HF + HC_2O_4^- \leftarrow> H_2C_2O_4 + F^-$
   acid base acid base
   c) $Al(H_2O)_6^{3+} + SO_3^{2-} \leftarrow> HSO_3^- + Al(H_2O)_5OH^{2+}$
   acid base acid base

2.

Conjugate acid	**Conjugate base**
H_2O_2	HO_2^-
H_3BO_3	$H_2BO_3^-$
HCOOH	$HCOO^-$
$HC_6H_5O_7^{2-}$	$C_6H_5O_7^{3-}$

3. a) $HNO_2 + NH_3 \leftarrow> NO_2^- + NH_4^+$
   acid base base acid
   conjugate pairs: HNO_2/ NO_2^- and NH_3/NH_4^+

b) $H_3C_6H_5O_7 + CN^- \leftarrow> H_2C_6H_5O_7^- + HCN$
   acid base base acid
   conjugate pairs: $H_3C_6H_5O_7$/ $H_2C_6H_5O_7^-$ and CN^-/ HCN

c) $PO_4^{3-} + H_2S \leftarrow> HPO_4^{2-} + HS^-$
   base acid acid base
   conjugate pairs: HPO_4^{2-}/ PO_4^{3-} and H_2S / HS^-

Page 268, Quick Check

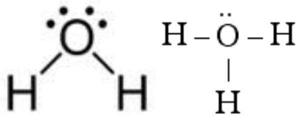
1. $HCO_3^- + CN^- \leftarrow> CO_3^{2-} + HCN$
2. $HCO_3^- + H_2O \leftarrow> H_2CO_3 + OH^-$
3. b) and e) are amphiprotic

Page 270, 5.1 Review Questions

1. Both Arrhenius and Bronsted Lowry acids contain H^+ ions. Definitions of a base differ. Arrhenius base contains OH^- ions. Bronsted Lowry base accepts H^+ ion.

2. A Hydrogen atom contains 1 proton and 1 electron. When a H^+ ion is formed, the electron is given away, leaving a single proton.

3.



One of the lone pairs of electrons on the oxygen atom of water will attract the H^+ ion from an acid.

4.

a) $NH_3 + H_3PO_4 \leftarrow> NH_4^+ + H_2PO_4^-$
   base acid acid base

b) $H_2PO_4^- + SO_3^{2-} \leftarrow> HSO_3^- + HPO_4^{2-}$
   acid base acid base

c) $CH_3NH_2 + CH_3COOH \leftarrow> CH_3COO^- + CH_3NH_3^+$
   base acid base acid

5.

$HCOOH + H_2O \leftarrow> HCOO^- + H_3O^+$

Acid base base acid

6.

$C_5H_5N + H_2O \leftarrow> C_5H_5NH^+ + OH^-$

Base acid acid base

7.

$ClO^- + NH_4^+ \leftarrow> HClO + NH_3$

Base acid acid base

b) HClO

8. a) Add a H^+ ion. Example: CN^- becomes HCN
   b) Remove a H^+ ion. Example: HNO_2 becomes NO_2^-

9. a) HO_2^-
   b) $N_2H_5^+$
   c) $OC_6H_5^-$
   d) $C_6H_5NH_3^+$

10. A substance that is able act as both an acid or a base depending on the other substance present. Examples: HSO_3^-, $H_2PO_4^-$, HPO_4^{2-}, H_2O

11. a) As an acid: $HCO_3^- + H_2O \leftarrow> CO_3^{2-} + H_3O^+$; As a base: $HCO_3^- + H_2O \leftarrow> H_2CO_3 + OH^-$ Use litmus paper to test the solution. If it is acidic, the litmus will turn red. If it is basic, the litmus will turn blue.
b) As a base. H_2O and CO_2 can be written as H_2CO_3.

12.

$H_2O + H_2O \leftarrow> H_3O^+ + OH^-$

Acid base acid base

Page 275, Quick Check

1. Concentrated acids have a high molarity (ex. 6M acid) whereas a strong acid is one that ionizes completely (ex. HCl). You can have a concentrated weak acid – such as 6 M HF.
2. HNO_3 is a strong acid so ionizes completely:
   $HNO_3(aq) + H_2O(l) \rightarrow H_3O^+(aq) + NO_3^-(aq)$
   1.0 M 1.0 M

$CH_3COOH(aq) + H_2O(l) <\rightarrow H_3O^+(aq) + CH_3COO^-(aq)$
1.0 M very few very few

   Because both acids are the same concentration, but HNO_3 is strong and CH_3COOH is weak, the HNO_3 will have more ions in solution.
3. In 0.1 M NaOH: a bright light In 0.1 M NH_3: very dim light or no light visible
   $NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$ $NH_3(aq) + H_2O(l) \leftarrow> NH_4^+(aq) + OH^-(aq)$
4. No, Cl^- will not accept an H^+ ion. HCl is a strong acid and completely ionizes.

Page 276, Quick Check

1. $HF(aq) + H_2O(l) <\rightarrow H_3O^+(aq) + F^-(aq)$ $K_a = [H_3O^+][F^-] / [HF]$
2. NaOH is a strong base, which means that it ionizes completely. There is no equilibrium present, so no K_b.
3. $CH_3CH_2NH_2(aq) + H_2O(l) <\rightarrow OH^-(aq) + CH_3CH_2NH_3^+(aq)$
   $K_b = [OH^-][CH_3CH_2NH_3^+] / [CH_3CH_2NH_2]$
4. Acid: $HC_2O_4^-(aq) + H_2O(l) <\rightarrow H_3O^+(aq) + C_2O_4^{2-}(aq)$
   $K_a = [H_3O^+][C_2O_4^{2-}] / [HC_2O_4^-]$
   Base: $HC_2O_4^-(aq) + H_2O(l) <\rightarrow OH^-(aq) + H_2C_2O_4(aq)$
   $K_b = [OH^-][H_2C_2O_4] / [HC_2O_4^-]$

Page 278, Quick Check

1 a) strong acid
   b) strong base
   c) weak base
   d) weak acid
   e) weak base
   f) weak acid

2. c) weak base: $NH_3(aq) + H_2O(l) \leftarrow> NH_4^+(aq) + OH^-(aq)$
   $K_b = [NH_4^+][OH^-] / [NH_3]$
   d) weak acid: $C_6H_5COOH(aq) + H_2O(l) <\rightarrow H_3O^+(aq) + C_6H_5COO^-(aq)$
   $K_a = [H_3O^+][C_6H_5COO^-] / [C_6H_5COOH]$
   e) weak base: $CN^-(aq) + H_2O(l) \leftarrow> HCN(aq) + OH^-(aq)$
   $K_b = [HCN][OH^-] / [CN^-]$
   f) weak acid: $HNO_2(aq) + H_2O(l) <\rightarrow H_3O^+(aq) + NO_2^-(aq)$
   $K_a = [H_3O^+][NO_2^-] / [HNO_2]$

3. Methanoic acid > carbonic acid > boric acid > phenol
   $HCOOH > H_2CO_3 > H_3BO_3 > C_6H_5OH$

Page 281, Quick Check

1. There are more oxygen atoms (which are highly electronegative) attached to the central nitrogen atom - therefore, the O-H bond in Acid 1 is more polarized than in Acid 2 (as 3 oxygen atoms pull electrons away from hydrogen to a greater extent than 2 oxygen atoms do) and hydrogen will be donated more easily in Acid 1. As a result, Acid 1 is stronger than Acid 2.
2. Since the presence of more hydrogen atoms bound to the central atom strengthens the bond between hydrogen and that atom, HBr, HCl, HI > H_2Se, H_2S, H_2O > CH_4 in terms of acid strength.
   I > Br > Cl in terms of size. And as the halogen atoms' size increases, the bond length between the halogen atom and hydrogen increases, so the bond strength decreases, allowing H to be donated more easily and making the acid stronger. Therefore, HI > HBr > HCl in terms of acid strength.
   For the same reason, Se > S > O in terms of size and $H_2Se > H_2S > H_2O$ in terms of acidity. Therefore, $HI > HBr > HCl > H_2Se > H_2S > H_2O > CH_4$ in terms of acid strength.
3. The more oxygen atoms are attached to the central atom, the more polarized the O-H bond is. Therefore, H_2SO_4, $HClO_4$ > $HClO_3$, $HBrO_3$, H_2SO_3 in terms of acid strength.
   Between H_2SO_4 and $HClO_4$, since Cl is more electronegative than H_2SO_4 and pulls electrons away from H more than S does, hydrogen in $HClO_4$ is donated more easily than in H_2SO_4. Therefore, $HClO_4 > H_2SO_4$ in terms of acid strength.
   For similar reasons, H_2SO_3 is weaker than $HClO_3$ and $HBrO_3$ (since Cl and Br are both electronegative halogens while S is not). Finally, since Br is less electronegative than Cl, the O-H bond is more polarized in chloric acid than in bromic. This allows hydrogen to be donated more easily. Therefore, $HBrO_3 > HClO_3 > H_2SO_3$.
   Therefore overall, $HClO_4 > H_2SO_4 > HBrO_3 > HClO_3 > H_2SO_3$.
4. Methanoic acid and benzoic acid have main carbon chain lengths of 1 while ethanoic acid has a carbon chain of length 2. Therefore, ethanoic acid's O-H bond is the least polarizable. Furthermore, benzoic acid has a huge group of carbon atoms - a benzene ring (phenyl group) - attached to the 1 carbon chain that allows any charge to disperse between the many carbon & hydrogen atoms in the benzene group, so its O-H bond is the less polarizable than that of methanoic acid.
   Therefore, methanoic acid > benzoic acid > ethanoic acid in terms of polarity of O-H bond and consequently strength.

Page 283, Practice Problems

1a) $H_2O_2 + HSO_3^- \leftarrow \quad > H_2SO_3 + HO_2^-$; reactants favored

b) $H_3C_6H_5O_7 + NH_3 \leftarrow \quad > H_2C_6H_5O_7^- + NH_4^+$; products favored
c) $HCO_3^- + H_2PO_4^- \leftarrow \quad > H_2CO_3 + HPO_4^{2-;}$; reactants favored

2. $H_3AsO_4 + SO_4^{2-} \leftarrow \quad > H_2AsO_4^- + HSO_4^-$; $HSO_4^-$is stronger
3. $SO_3^{2-} + Cr(H_2O)_6^{3+} \leftarrow \quad > HSO_3^- + Cr(H_2O)_5OH^{2+}$ products favored so $K_{eq} > 1$

Page 283, 5.2 Review Questions

1. a) strong base
   b) weak acid
   c) Strong acid
   d) weak base
2. $H_3BO_3 + H_2O \leftarrow> H_2BO_3^- + H_3O^+$ $K_a = [H_2BO_3^-][H_3O^+] / [H_3BO_3]$
   $PO_4^{3-} + H_2O \leftarrow> HPO_4^{2-} + OH^-$ $K_b = [HPO_4^{2-}][OH^-] / [PO_4^{3-}]$

3. Both acids have the same concentration. Oxalic acid is a weak acid and hydriodic acid is strong. Conductivity depends on ions in solution. Since hydriodic acid is a strong aci, it will ionize completely. Oxalic acid is weak, so it ionizes to a lesser extent, forming fewer ions in solution.

4. HNO_3 is a strong acid so ionizes completely: $HNO_3(aq) + H_2O(l) \rightarrow H_3O^+(aq) + NO_3^-(aq)$ 2.0 M 2.0 M total [ion] = 4.0 M HNO_2 is a weak acid, so does ionize completely.

5. a) 6 M NH_3
   b) 0.001 M HCl

6. a) water < carbonic acid < citric acid < sulphurous acid < sulphuric acid
b) carbonate > ammonia > monohydrogen phosphate > fluoride > nitrite > water

7. a) $HC_6H_5O_7^{2-} + H_2O \leftarrow> C_6H_5O_7^{3-} + H_3O^+$

$K_a = [C_6H_5O_7^{3-}][H_3O^+] / [HC_6H_5O_7^{2-}]$

b) $H_2C_6H_5O_7^- + H_2O \leftarrow> HC_6H_5O_7^{2-} + H_3O^+$

$K_a = [HC_6H_5O_7^{2-}][H_3O^+] / [H_2C_6H_5O_7^-]$

c) $Al(H_2O)_6^{3+} + H_2O \leftarrow> Al(H_2O)_5OH^{2+} + H_3O^+$

$K_a = [Al(H_2O)_5OH^{2+}][H_3O^+] / [Al(H_2O)_6^{3+}]$

d) $H_2O_2 + H_2O \leftarrow> HO_2^- + H_3O^+$

$K_a = [HO_2^-][H_3O^+] / [H_2O_2]$

8. a) $NH_3 + H_2O \leftarrow> NH_4^+ + OH^-$
$K_b = [NH_4^+][OH^-] / [NH_3]$

b) $C_6H_5COO^- + H_2O \leftarrow> C_6H_5COOH + OH^-$
$K_b = [C_6H_5COOH][OH^-] / [C_6H_5COO^-]$

c) $CH_3COO^- + H_2O \leftarrow\ > CH_3COOH + OH^-$
$K_b = [CH_3COOH][OH^-] / [CH_3COO^-]$

d) $HC_6H_5O_7^{2-} + H_2O \leftarrow\ > C_6H_5O_7^- + OH^-$
$K_b = [C_6H_5O_7^-][OH^-] / [HC_6H_5O_7^{2-}]$

e) $C_5H_5N + H_2O \leftarrow\ > C_5H_5NH^+ + OH^-$
$K_b = [C_5H_5NH^+][OH^-] / [C_5H_5N]$

9. a) $Fe(H_2O)_6^{3+}(aq) + HO_2^-(aq) \rightleftharpoons H_2O_2 + Fe(H_2O)_5OH^{2+}$ products
b) $H_2SO_3(aq) + IO_3^-(aq) \rightleftharpoons HSO_3^- + HIO_3$ reactants
c) $CN^-(aq) + H_2PO_4^-(aq) \rightleftharpoons HCN + HPO_4^{2-}$ products

10. $H_2C_2O_4 + HCO_3^- \leftarrow> H_2CO_3 + HC_2O_4^-$

11. HClO > HBrO > H_2SiO_3

12. All are strong acids so completely ionize in solution to form H_3O^+:
$HCl + H_2O \rightarrow H_3O^+ + Cl^-$
$HBr + H_2O \rightarrow H_3O^+ + Br^-$
$HI + H_2O \rightarrow H_3O^+ + I^-$

Page 290, Quick Check

1. energy + $2H_2O \leftarrow> H_3O^+ + OH^-$
If temperature increases, equilibrium shifts right and the concentrations of H_3O^+ and OH^- both increase.
$K_w = [H_3O^+][OH^-]$
Therefore, K_w will increase as well.
2. $[H_3O^+] = [OH^-]$
3. 5.4×10^{-8} M = $[H_3O^+] = [OH^-]$

Page 291, Practice Problems

1. $[H_3O^+] = 0.15$ M because $HClO_4$ is a strong acid; $[OH^-] = 6.67 \times 10^{-14}$ M
acidic because $[H_3O^+] > [OH^-]$
2. $[OH^-] = 2s = 2.2 \times 10^{-4}$ M; $[H_3O^+] = 4.5 \times 10^{-11}$ M
basic because $[H_3O^+] < [OH^-]$
3. $[OH^-] = 0.142$ M; $[H_3O^+] = 7.04 \times 10^{-14}$ M
basic because $[H_3O^+] < [OH^-]$

Page 292, Practice Problems

1. $[OH^-] = 2 \times 10^{-13}$ M
2. 2 g
3. $[OH^-] = 5.32 \times 10^{-14}$ M

Page 294, 5.3 Review Questions

1. $NH_3 + NH_3 \leftarrow> NH_4^+ + NH_2^-$
2.

$[H_3O^+]$	$[OH^-]$	Acidic, basic or neutral ?
1.7×10^{-15}	6.0*M*	basic
3.2×10^{-4}*M*	3.1×10^{-11}	acidic
1.1×10^{-3}	9.2×10^{-12}*M*	acidic
2.5*M*	4.0×10^{-15}	acidic
2.1×10^{-10}	4.7×10^{-5} *M*	basic

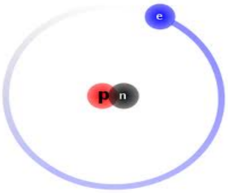
3. 57.1 kJ + $2H_2O \leftarrow> H_3O^+ + OH^-$
As temperature increases, equilibrium shifts right and $[H_3O^+]$ and $[OH^-]$ increase, so K_w increases.
4. $[OH^-] = 5.0 \times 10^{-15}$ M
5. $[OH^-] = 1.6 \times 10^{-8}$ M
acidic because $[H_3O^+] > [OH^-]$

6. Complete the table:

Temp	**K_w**	**$[H_3O^+]$**	**$[OH^-]$**
50° C	5.5×10^{-14}	2.3×10^{-7} M	2.3×10^{-7} M
100° C	5.1×10^{-13}	7.1×10^{-7} M	7.1×10^{-7} M

Both are neutral at given temperatures

7.



$K_w = 7.9 \times 10^{-15}$

8. $[OH^-] = 2s = 0.0211$ M
   $[H_3O^+] = 4.7 \times 10^{-13}$ M
9. $[OH^-] = 4.3 \times 10^{-14}$ M
10. 3.2 g

Page 298, Quick Check

1.

Solution	$[H_3O^+]$	pH
orange juice	3.2×10^{-4} *M*	3.49
milk of magnesia	2.52×10^{-11} *M*	10.598
stomach acid	0.031 *M*	1.51

2. The $[H_3O^+]$ increased because the pH decreased. A 5 unit pH decrease corresponds to a
   10^5 times increase in hydronium concentration.
3. Initial pH (prior to dilution) = 1.00
   After the dilution, the $[H_3O^+]$= 2.00

Page 299, Practice Problems

1.

$[H_3O^+]$	No. of sig. digits	pH
5.00×10^{-5} *M*	3	4.301
4.6×10^{-4} *M*	2	3.34
6.4×10^{-11} *M*	2	10.19
8.81×10^{-7} *M*	3	6.055
0.00345 *M*	3	2.462

2. Just before the equivalence point was reached: $[H_3O^+] = 4.5 \times 10^{-5}$ *M*
   Just after the equivalence point was reached:
   $[H_3O^+] = 2.2 \times 10^{-10}$ *M*
3. Because pH is defined as a negative logarithm, converting a negative pH value to a concentration involves the following:
   $[H_3O^+] = 16$ *M*
   The pH scale is not necessary to conveniently express concentrations this large.

Page 302, Practice Problems

1.

Solution	$[H_3O^+]$	$[OH^-]$	pH	pOH	Acidic/Basic/Neutral?
Orange Juice	3×10^{-4} *M*	3×10^{-11} *M*	3.5	10.5	Acidic
Tears	3.98×10^{-8} *M*	2.51×10^{-7} *M*	7.40	6.60	Basic
Blood	4.0×10^{-8} *M*	2.5×10^{-7} *M*	7.40	6.60	Basic
Milk	3.16×10^{-7} *M*	3.16×10^{-8} *M*	6.500	7.500	Acidic

2.

a) As a solution becomes more acidic, both $[H_3O^+]$ and pOH increase and both $[OH^-]$ and pH decrease.
b) A basic solution has a pOH value which is less than 7, and $[H_3O^+]$ which is greater than 10^{-7} *M*.
c) If the pH of a solution equals 14.0, the $[OH^-]$ equals 1 *M*. (1 sig. digit)
d) If the pOH of a solution decreases by 5, then the $[H_3O^+]$ has decreased by a factor of 10^5.

3. We would expect the K_w for water at 10ºC to be less than 10^{-14} because the autoionization of water is endothermic. Regardless of the temperature, pure water is always neutral and so:
   For pure water at any temperature: $[H_3O^+] = [OH^-]$ and pH = pOH
   Therefore, because pH + pOH = pK_w, when we calculate the value of pK_w, the pH (and also the pOH) must be *half the value of pK_w*.
   $pK_w = - \log (2.55 \times 10^{-15}) = 14.593$ Therefore, pH (and pOH) = $\underline{14.5934}$ = 7.297

Page 304, Practice Problems

1. 0.86
2. 0.82
3. 2.53
4. 0.0513 g HCl

Page 308, 5.4 Review Questions

1. The pH of a solution is defined as the negative logarithm of the concentration of hydronium ions.
Equation: pH = - log [H_3O^+]
The pOH of a solution is defined as the negative logarithm of the concentration of hydroxide ions.
Equation: pOH = - log [OH^-]
2. Sorenson's logarithmic pH and pOH scales are a convenient and compact way of expressing the typically very small concentrations of hydronium and hydroxide ions respectively and the extent by which they can change in aqueous solutions
3.

[H_3O^+]	pH	Acidic/Basic/Neutral
3.50×10^{-6} *M*	5.456	Acidic
3.1×10^{-12} *M*	11.51	Basic
0.00550 *M*	2.260	Acidic
1.0 *M*	0.00	Acidic
6.8×10^{-9} *M*	8.17	Basic

4.

[OH^-]	pOH	Acidic/Basic/Neutral
7.2×10^{-9} *M*	8.14	Acidic
2.8×10^{-10} *M*	9.55	Acidic
4.88×10^{-4} *M*	3.312	Basic
1.0×10^{-14} *M*	14.00	Acidic
0.000625 *M*	3.204	Basic

5.
a) As a solution's pOH value and [H_3O^+] both decrease, the solution becomes more basic.
b) As a solution's pH value and [OH^-] both decrease, the solution becomes more acidic.
c) The product of the [H_3O^+] and [OH^-] equals K_w.
d) The sum of pH and pOH equals pK_w.
6.

[H_3O^+]	pOH	Acidic/Basic/Neutral
0.0342 *M*	12.534	Acidic
2.51×10^{-6} *M*	8.400	Acidic
7.2×10^{-12} *M*	2.86	Basic
1.64×10^{-11} *M*	3.215	Basic

7. Pure water is always neutral at any temperature and so pH = pOH.
Therefore pH 6.51 (2 sig. digits)
8. pH = 13.78
9. 13.000
10. 0.81 g
11.

[H_3O^+]	[OH^-]	pOH	pH	Acidic/Basic/Neutral
5.620×10^{-5} *M*	1.779×10^{-10} *M*	9.7497	4.2503	Acidic
2.22×10^{-11} *M*	0.000450 *M*	3.347	10.653	Basic
3.2×10^{-2} *M*	3.2×10^{-13} *M*	12.50	1.50	Acidic
3×10^{-11} *M*	3×10^{-4} *M*	3.5	10.5	Basic

12. 0.79
13. 11.8

14. 12.7
15. 12.24
An alternative approach would be to calculate the total number of moles of hydronium ions from the acid solutions and then subtract that total from the moles of hydroxide ions from the basic solution. The excess moles of hydroxide ions present in the final 100.0 mL are then used to calculate final pH.
16. 0.483 g HCl
17. 0.128 g LiOH

Page 314, Quick Check

1. The amount of water that a weak acid will convert to hydronium ions is insignificant compared to the magnitude of water's concentration (55.6 *M*). The concentration of water is thus assumed to be constant and so is not included in an ICE table.
2. Because the K_a of a weak acid is normally so much greater than K_w, we can assume that the initial $[H_3O^+]$ resulting from the autoionization of water is insignificant compared to the equilibrium $[H_3O^+]$ resulting from the ionization of this weak acid.
3. The value of K_a is small enough compared to the initial concentration of the acid that the percent of the acid which actually ionizes will not significantly change that original concentration. Remember that this assumption is only valid if the percent ionization of the weak acid is ≤ 5 %.

Page 315, Practice Problems

1. 2.02
2. 2.41 (2 sig. digits)
3. 5.4 %
   The simplifying assumption would not be valid in this case because the percent ionization is greater than 5 %

Page 316, Practice Problems

1. 0.017 *M*
2. 1.6 *M*
3. 0.45 *M*

Page 317, Practice Problems

1. 1.0×10^{-5}
2. 1.4×10^{-4}
3. 6.56×10^{-5} (The acid is most likely benzoic acid)

Page 319, Quick Check

1.

Weak Base	Conjugate Acid	Appropriate K_a Value	pK_a Value	Calculated K_b	pK_b Value
$HC_2O_4^-$	$H_2C_2O_4$	5.9×10^{-2}	1.23	1.7×10^{-13}	12.77
$H_2PO_4^-$	H_3PO_4	7.5×10^{-3}	2.12	1.3×10^{-12}	11.88
HPO_4^{2-}	$H_2PO_4^-$	6.2×10^{-8}	7.21	1.6×10^{-7}	6.79
NO_2^-	HNO_2	4.6×10^{-4}	3.34	2.2×10^{-11}	10.66
$HC_6H_5O_7^{2-}$	$H_2C_6H_5O_7^-$	1.7×10^{-5}	4.77	5.9×10^{-10}	9.23
HCO_3^-	H_2CO_3	4.3×10^{-7}	6.37	2.3×10^{-8}	7.63
CN^-	HCN	4.9×10^{-10}	9.31	2.0×10^{-5}	4.69

Page 321, Practice Problems

1. 11.05
2. $x = [OH^-] = 5.8 \times 10^{-6}$ *M* so $\text{pOH} = -\log(5.8 \times 10^{-6}) = 5.24$
   $\text{pH} = 14.00 - 5.24 = 8.76$ and $[H_3O^+] = 10^{-8.76} = 1.7 \times 10^{-9}$ *M*

3. (a) Methylammonium, $CH_3NH_3^+$
   $K_a = 2.3 \times 10^{-11}$
   $pK_a = 10.64$
   (b) Hydrazinium, $N_2H_5^+$
   $K_a = 5.9 \times 10^{-9}$
   $pK_a = 8.23$

Page 322, Practice Problems

1. 0.87 g $C_2H_5NH_2$
2. 0.49 *M*
3. 6.0×10^{-3} *M*

Page 324, Practice Problems

1. $K_b = 0.020$; Percent ionization = 20. %

This calculated K_b value is greater than the K_b given in the sample problem (4.4×10^{-4}). This indicates that the temperature of the solution is higher than 25° C.

2. $K_b = 2 \times 10^{-6}$ (1 sig. digits)

$pK_b = -\log(1.6 \times 10^{-6}) = 5.79$

3. 3.3×10^{-6}

Page 328, 5.5 Review Questions

1. pH = - log (0.01342) = 1.87 (2 sig. digits) $[H_3O^+] = 10^{-1.87} = 0.013$ M

pOH = 14.00 - 1.87 = 12.13 $[OH^-] = 10^{-12.13} = 7.4 \times 10^{-13}$ M

2. pH = 4.02; Percent ionization = 0.095 %
3. pH = 2.873; $K_a = 1.80 \times 10^{-5}$ (The unknown acid is acetic acid.)
4. 8.9 g HF
5. 0.16 *M* H_3PO_4
6. 0.11 g $H_2C_2O_4$
7. 2.9×10^{-8}
8. 4.9×10^{-5}
9.

Conjugate Acid	**Conjugate Base**	***K_a* for acid**	***pK_a***	***K_b* for base**	***pK_b***
HNO_2	NO_2^-	4.6×10^{-4}	3.34	2.2×10^{-11}	10.66
H_2O_2	HO_2^-	2.4×10^{-12}	11.62	4.2×10^{-3}	2.38
C_6H_5OH	$C_6H_5O^-$	1.3×10^{-10}	9.89	7.7×10^{-5}	4.11
HSO_4^-	SO_4^{2-}	1.2×10^{-2}	1.92	8.3×10^{-13}	12.08

10.

Conjugate Acid	**Conjugate Base**	***K_a* for acid**	***pK_a***	***K_b* for base**	***pK_b***
$H_2PO_4^-$	HPO_4^{2-}	6.2×10^{-8}	7.21	1.6×10^{-7}	6.79
$H_2C_6H_5O_7^-$	$HC_6H_5O_7^{2-}$	1.7×10^{-5}	4.77	5.9×10^{-10}	9.23
H_3BO_3	$H_2BO_3^-$	7.3×10^{-10}	9.14	1.4×10^{-5}	4.86
HCO_3^-	CO_3^{2-}	5.6×10^{-11}	10.25	1.8×10^{-4}	3.75

11. 11.39
12. 12.23
13. 0.10 *M*
14. 9.1 L
15. 5.7×10^{-4}