

# Calculations involving $K_a$ , $K_b$ & Hydrolysis Review

Name: \_\_\_\_\_

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## Calculating $[HA]_{\text{initial}}$ , given $K_a$ and pH

1. Citric acid is one of the acids responsible for the sour taste of lemons. What concentration of citric acid would be required to produce a solution with a pH of 2.50?

$[H_3C_6H_5O_7] =$  \_\_\_\_\_

2. Rhubarb's sour taste is due in part to the presence of oxalic acid. A solution of oxalic acid has had the label removed. What concentration should appear on the label if the pH of the solution is found to be 0.55?

$[H_2C_2O_4] =$  \_\_\_\_\_

3. Nitrous acid is one of the components of acid rain. An aqueous solution of nitrous acid is found to have a pH of 1.85. Calculate the concentration of the acid.

$[HNO_2] =$  \_\_\_\_\_

## Calculating $K_a$ , given $[HA]_{\text{initial}}$ and pH

4. One form of vitamin C is ascorbic acid,  $H_2C_6H_6O_6$ . The name originates from the fact that ascorbic acid prevents scurvy — a fact first discovered in 1747 by British surgeon John Lind. This subsequently resulted in citrus juice (from limes and lemons) being supplied to sailors in the Royal Navy. A 0.100 M solution of ascorbic acid is found to have a pH of 3.00. Calculate the  $K_a$  for ascorbic acid.

$K_a =$  \_\_\_\_\_

5. Lactic acid ( $C_3H_6O_3$ ) is a weak acid produced in muscle tissue during anaerobic respiration and is the acid present in sour milk. It's also responsible for the sour taste of sauerkraut. A 0.025 M solution of lactic acid is found to have a pH of 2.75. Calculate the  $K_a$  for lactic acid.

$K_a =$  \_\_\_\_\_

**Calculating  $[OH^-]$  and pH using  $K_b$  and  $[B]_{initial}$**

6. Hydrazine,  $N_2H_4$  is used in rocket fuel, in producing polymer foams, and in the production of air bags. The  $K_b$  for hydrazine is  $1.7 \times 10^{-6}$ . Calculate the pH of the solution prepared by dissolving 12.0 g of hydrazine in 500.0 mL of solution.

pH= \_\_\_\_\_

7. Calculate the  $[OH^-]$ ,  $[H^+]$ , pOH, and pH of a 0.60 M solution of  $HCOO^-$ .

$[OH^-] =$  \_\_\_\_\_  $pOH =$  \_\_\_\_\_  $[H_3O^+] =$  \_\_\_\_\_  $pH =$  \_\_\_\_\_

### Calculating $[B]_{\text{initial}}$ given $K_b$ and pH (or pOH)

8. Ethylamine ( $C_2H_5NH_2$ ) is a pungent colourless gas used extensively in organic synthesis reactions. It is also a weak base with  $K_b = 5.6 \times 10^{-4}$ . What mass of ethylamine is dissolved in 250.0 mL of a solution having a pH of 11.80?

mass = \_\_\_\_\_

9. What concentration of  $CN^-$  would produce a solution with a pH of 11.50?

$[CN^-] =$  \_\_\_\_\_

10. Using the  $K_b$  provided above for hydrazine, calculate the  $[N_2H_4]$  required to produce a solution with a  $[H_3O^+] = 1.0 \times 10^{-10}$  M.

$[N_2H_4] =$  \_\_\_\_\_

### Calculating $K_b$ , given $[B]_{\text{initial}}$ and pH (or pOH)

11. A 0.400 M solution of the weak base methylamine,  $\text{CH}_3\text{NH}_2$ , is found to have a pH of 12.90. Calculate the  $K_b$  of methylamine and the percentage ionization. Compare your calculation of this  $K_b$  value with the sample problem above involving methylamine. What might this indicate about the temperature of this solution?

$K_b =$  \_\_\_\_\_      % ionization = \_\_\_\_\_

12. One of the most effective substances at relieving intense pain is morphine. First developed in about 1810, the compound is also a weak base. In a 0.010 M solution of morphine, the pOH is determined to be 3.90. Calculate the  $K_b$  and  $pK_b$  for morphine. (Let "Mor" and "HMor<sup>+</sup>" represent the conjugate pair in your equilibrium reaction.)

$K_b =$  \_\_\_\_\_

13. Quinine,  $\text{C}_{20}\text{H}_{24}\text{N}_2\text{O}_2$ , is a naturally occurring white crystalline base used in the treatment of malaria. It is also present in tonic water. Calculate the  $K_b$  for this weak base if a 0.0015 M solution has a pH of 9.84. (Let "Qui" and "HQui<sup>+</sup>" represent the conjugate pair in your equilibrium reaction.)

$K_b =$  \_\_\_\_\_

# Review of Hydrolysis of Salts

**Hydrolysis** is the reaction of an ion with water to produce either the conjugate base of the ion and hydronium ions or the conjugate acid of the ion and hydroxide ions.

Consider the neutralization reactions described below.

14. (a) When equal volumes of 0.10 M  $\text{HNO}_3$  and 0.10 M  $\text{KOH}$  solutions react together, what salt solution exists in the reaction vessel following the reaction?

(b) Consider the dissociated ions of this salt. Is either of the ions located on the table of relative strengths of Brønsted-Lowry acids and bases (*consult acid base table*)? If so, where? Does this help you predict if the pH of this solution will be equal to, above, or below 7?

15. (a) When equal volumes of 0.10 M  $\text{CH}_3\text{COOH}$  and 0.10 M  $\text{NaOH}$  solutions react together, what salt solution exists in the reaction vessel following the reaction?

(b) Consider the dissociated ions of the salt. Is either of the ions located on the table of relative strengths of acids and bases? If so, where? Does this help you predict if the pH of this solution will be equal to, above, or below 7?

16. **Circle** the ions in the following list that represent cations of strong bases.

$\text{Al}^{3+}$     $\text{Rb}^{+}$     $\text{Fe}^{3+}$     $\text{Cr}^{3+}$     $\text{Ca}^{2+}$     $\text{Sn}^{4+}$     $\text{Cs}^{+}$     $\text{Ba}^{2+}$

17. **Circle** the ions in the following list that represent the **conjugate bases** of strong acids.

$\text{F}^{-}$     $\text{ClO}_2^{-}$     $\text{ClO}_4^{-}$     $\text{SO}_4^{2-}$     $\text{Cl}^{-}$     $\text{NO}_2^{-}$     $\text{CH}_3\text{COO}^{-}$     $\text{CN}^{-}$     $\text{NO}_3^{-}$

18. **Circle** the following salts whose ions will **not** hydrolyze when dissociated in water.

$\text{NH}_4\text{Cl}$     $\text{Na}_2\text{CO}_3$     $\text{RbClO}_4$     $\text{Li}_2\text{SO}_3$     $\text{BaI}_2$     $\text{NH}_4\text{HCOO}$     $\text{KIO}_3$     $\text{CsF}$     $\text{CaBr}_2$

19. **Circle** which of the following salts contain the anion of a weak acid?

$\text{NH}_4\text{Cl}$     $\text{NaClO}_4$     $\text{Fe}(\text{CH}_3\text{COO})_3$     $\text{KF}$     $\text{LiCl}$

$\text{Al}(\text{NO}_3)_3$     $\text{NH}_4\text{HSO}_4$     $\text{Pb}(\text{NO}_2)_2$     $\text{NH}_4\text{I}$     $\text{Ba}(\text{CN})_2$

20. **Circle** which of the following salts will produce a basic aqueous solution due to anionic hydrolysis?

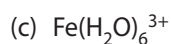
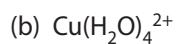
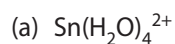


21. A sample of  $\text{Mg}(\text{CN})_2$  is dissolved in water to make a solution. Predict if the solution is acid or basic. (*show all work*)

22. **Circle** the salts below that will produce acidic aqueous solutions.



23. Write the hydrolysis reactions for the following hydrated cations:



24. **Circle** which of the following salts will dissociate into ions that will *both* react with water?



25.

a) Write out the two hydrolysis reactions that occur when a sample of  $\text{NH}_4\text{F}$  dissolves in water.

b) Which of the two hydrolysis reactions in question 2 above will occur to a greater extent? How do you know?