CHAPTER 16 PRACTICE QUIZ Name_____

MULTIPLE CHOICE – NO CALCULATOR ALLOWED

1. Which of the following choices represents a Brønsted–Lowry acid that is paired with its conjugate base?

	Acid	Conjugate Base
(A)	HPO_4^{2-}	$H_2PO_4^-$
(B)	H_2SO_3	SO_3^{2-}
(C)	$C_6H_5NH_3^+$	$C_6H_5NH_2$
(D)	H_3O^+	OH^-

$$HSO_4^-(aq) + CO_3^{2-}(aq) \rightleftharpoons SO_4^{2-}(aq) + HCO_3^-(aq)$$

2. The reaction represented above is observed to proceed spontaneously to the right in aqueous solution. Which of the following statements is true?

   (A) CO_3^{2-} is the strongest base in this system because the value of *K* for the reaction is less than 1.

   (B) CO_3^{2-} is the strongest base in this system because the value of *K* for the reaction is greater than 1.

   (C) SO_4^{2-} is the strongest base in this system because the value of *K* for the reaction is less than 1.

   (D) SO_4^{2-} is the strongest base in this system because the value of *K* for the reaction is greater than 1.

$$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^- \qquad K_{a1} = 7.2 \times 10^{-3}$$

$$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-} \qquad K_{a2} = 6.3 \times 10^{-8}$$

$$HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-} \qquad K_{a3} = 4.5 \times 10^{-13}$$

3. A solution is prepared by mixing 50 mL of 1 *M* NaH_2PO_4 with 50 mL of 1 *M* Na_2HPO_4. On the basis of the information above, which of the following species is present in the solution at the <u>lowest</u> concentration?

   (A) Na^+

   (B) HPO_4^{2-}

   (C) $H_2PO_4^-$

   (D) PO_4^{3-}

Questions 4 – 7 refer to the following.

Concentration (*M*)	pH of Acid 1	pH of Acid 2	pH of Acid 3	pH of Acid 4
0.010	3.44	2.00	2.92	2.20
0.050	3.09	1.30	2.58	1.73
0.10	2.94	1.00	2.42	1.55
0.50	2.69	0.30	2.08	1.16
1.00	2.44	0.00	1.92	0.98

The pH of solutions of four acids prepared at various concentrations were measured and recorded in the table above. The four acids are, in no particular order, chlorous, hydrochloric, lactic, and propanoic.

4. For which acid is the value of the acid-dissociation constant, K_a, the smallest?

   (A) Acid 1 (B) Acid 2 (C) Acid 3 (D) Acid 4

5. Which of the four acids listed in the table is hydrochloric acid?

   (A) Acid 1 (B) Acid 2 (C) Acid 3 (D) Acid 4

6. Suppose that the formula of Acid 1 is written as HX. Which of the following species has the greatest concentration in a 1.0 *M* solution of Acid 1 at equilibrium?

   (A) H_3O^+

   (B) OH^-

   (C) HX

   (D) X^-

7. Equal volumes of the four acids at a concentration of 0.50 *M* are each titrated with 0.50 *M* NaOH. Which acid, if any, will require the greatest volume of titrant to reach the equivalence point?

   (A) Acid 1

   (B) Acid 2

   (C) Acid 3

   (D) All four acids will require the same volume of base to reach the equivalence point.

8. Which of the following solutions has the highest pH?

(A) 0.1 *M* sodium nitrite, $NaNO_2$

(B) 0.1 *M* potassium bromide, KBr

(C) 0.1 *M* lithium chlorate, $LiClO_3$

(D) 0.1 *M* iron(III) nitrate, $Fe(NO_3)_3$

9. Which of the following gives the approximate pH of a 1.0 *M* solution of ammonium chloride and the correct net-ionic equation that justifies this value?

	Approximate pH of 1.0 *M* ammonium chloride	Net-Ionic Equation that Justifies the pH of the Solution
(A)	5	$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$
(B)	5	$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$
(C)	9	$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$
(D)	9	$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

10. A 0.10 *M* solution of a weak monoprotic acid has a pH of 4.0. The ionization constant, K_a, of the acid is

(A) 1×10^{-3}

(B) 1×10^{-4}

(C) 1×10^{-7}

(D) 1×10^{-8}

11. Nitrous acid, HNO_2, has a K_a value of 4×10^{-4}. The pH of 0.01 *M* $HNO_2(aq)$ is in which of the following ranges?

(A) Between 1 and 2

(B) Between 2 and 3

(C) Between 3 and 4

(D) Between 4 and 5

12. When 200. mL of 3.0 *M* NaOH(*aq*) is added to 700. mL of 1.0 *M* HCl(*aq*), the pH of the resulting mixture is closest to

(A) 1.0

(B) 3.0

(C) 7.0

(D) 13.0

Solution	Solute	Concentration
1	CH_3CO_2Na	0.050 *M*
2	CF_3CO_2Na	0.050 *M*

Acid	K_a
CH_3CO_2H	1.8×10^{-5}
CF_3CO_2H	1.0

13. Based on the information in the two tables above, which of the following statements is true concerning the pH of solutions 1 and 2?

(A) Solution 1 has a higher pH than solution 2 because CH_3CO_2H is the stronger acid.

(B) Solution 1 has a higher pH than solution 2 because $CH_3CO_2^-$ is the stronger base.

(C) Solution 1 has a lower pH than solution 2 because CH_3CO_2H is the stronger acid.

(D) Solution 1 has a lower pH than solution 2 because $CH_3CO_2^-$ is the stronger base.

$$2\ H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

The autoionization of water is represented by the equation above. Values of pK_w at various temperatures are listed in the table below.

Temperature (°C)	pK_w
0	14.9
10	14.5
20	14.2
30	13.8
40	13.5

14. Based on the information above, which of the following statements is true?

(A) The dissociation of water is an exothermic process.

(B) The pH of pure water is 7.00 at any temperature.

(C) As the temperature increases, the pH of pure water increases.

(D) As the temperature increases, the pH of pure water decreases.

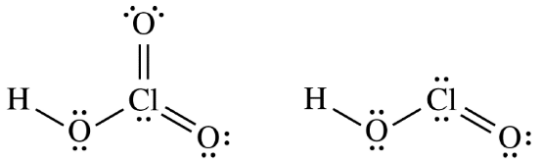
15. Which of the following most accurately describes the pH and the percent ionization for two different concentrations of acetic acid?

(A)	Concentration of Acetic Acid	pH	% Ionization
	0.0010 *M*	2.89	1.3%
	0.10 *M*	3.89	13%

(B)	Concentration of Acetic Acid	pH	% Ionization
	0.0010 *M*	2.89	13%
	0.10 *M*	3.89	1.3%

(C)	Concentration of Acetic Acid	pH	% Ionization
	0.0010 *M*	3.89	1.3%
	0.10 *M*	2.89	13%

(D)	Concentration of Acetic Acid	pH	% Ionization
	0.0010 *M*	3.89	13%
	0.10 *M*	2.89	1.3%



16. The Lewis electron-dot diagrams of the $HClO_3$ molecule and the $HClO_2$ molecule are shown above at the left and right, respectively. Which of the following statements identifies the stronger acid and correctly identifies a factor that contributes to its being the stronger acid?

(A) $HClO_3(aq)$ is the stronger acid because its molecules experience stronger London dispersion forces.

(B) $HClO_3(aq)$ is the stronger acid because the additional electronegative oxygen atom on the chlorine atom stabilizes the conjugate base.

(C) $HClO_2(aq)$ is the stronger acid because its molecules experience weaker London dispersion forces.

(D) $HClO_2(aq)$ is the stronger acid because the lone pairs of electrons on the chlorine atom stabilize the conjugate base.

CHAPTER 16 PRACTICE QUIZ Name_____

FREE RESPONSE – CALCULATOR IS ALLOWED

1. Propanoic acid is a carboxylic acid that has the molecular formula $HC_3H_5O_2$.

   (a) Propanoic acid contains the carboxylic acid group ($–CO_2H$). Write the Lewis electron-dot structure for propanoic acid ($HC_3H_5O_2$). Include all bonding electron pairs and nonbonding electron pairs.

   (b) Write the chemical formulas of the two products formed when propanoic acid reacts with water. Make sure to include the correct charges on the ions if necessary.

   $HC_3H_5O_2(aq) + H_2O(l) \rightleftharpoons$

   (c) Write the formulas for two different Brønsted-Lowry conjugate acid-base pairs from the reaction in part (b).

Acid	Conjugate Base

Base	Conjugate Acid

   (d) Write the expression for K_a for propanoic acid.

   (e) At 25°C the pH of a 50.0 mL sample of 0.20 *M* propanoic acid is 2.79. Determine the K_a value for propanoic acid at 25°C. Show the set-up for your calculations below, and round off your answer to two significant figures.

1. (f) Calculate the % ionization in 0.20 *M* propanoic acid.

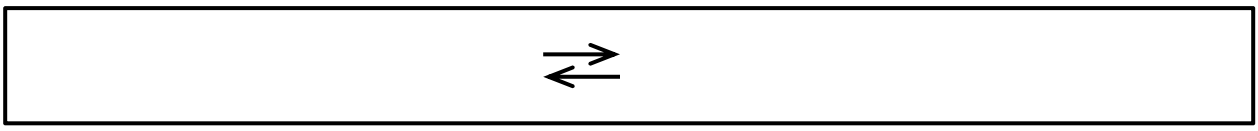
(g) Should the pH of 0.10 *M* sodium propanoate ($NaC_3H_5O_2$) be equal to 7.0, less than 7.0, or greater than 7.0? Write a chemical equation that clearly supports and justifies your answer.

(h) The pH of 0.20 *M* propanoic acid is 2.79. In the laboratory, the pH of a solution of hydrochloric acid (HCl) was recorded as 2.79.

Is the concentration of the HCl solution equal to 0.20 *M*, less than 0.20 *M*, or greater than 0.20 *M* ? Justify your answer by showing a calculation that confirms your prediction.

2. A student prepares a 0.10 *M* solution of sodium carbonate (Na_2CO_3) and measures the pH of the solution at 25°C. The pH is 11.62.

(a) Write a balanced net-ionic equation that clearly supports the fact a solution of sodium carbonate has a pH greater than 7.00.



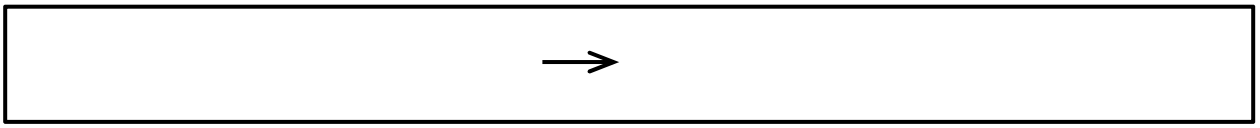
(b) Write the expression for K_b for the carbonate ion. This expression should be based on the net-ionic equation written in part (a).

(c) Calculate $[OH^-]$ in the 0.10 *M* sodium carbonate solution.

2. (d) Calculate the value of K_b for the carbonate ion. Show the set-up for your calculations below, and round off your answer to two significant figures.

(e) The conjugate acid of the carbonate ion is the hydrogen carbonate ion (also known as the bicarbonate ion.). Calculate the value of K_a for the hydrogen carbonate ion.

(f) When solutions of $Na_2CO_3(aq)$ and $HNO_3(aq)$ are mixed together, bubbles of gas are produced. Write a balanced net-ionic equation that supports this observation.



$$HC_9H_7O_4(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_9H_7O_4^-(aq)$$

3. The molecular formula of acetylsalicylic acid, also known as aspirin, is $HC_9H_7O_4$. The dissociation of $HC_9H_7O_4(aq)$ is represented by the equation above. The value of K_a for acetylsalicylic acid is equal to 3.0×10^{-4}.

(a) Calculate the pH of 0.075 *M* acetylsalicylic acid. Show the set-up for your calculations below, and round off your answer to two decimal places.

(b) A solution contains a mixture of $HC_9H_7O_4(aq)$ and $NaC_9H_7O_4(aq)$.

The ratio of $\frac{[C_9H_7O_4^-]}{[HC_9H_7O_4]}$ in this solution is equal to 1.5.

Calculate the pH of this solution. Round off your answer to two decimal places.