Dougherty Valley • AP Chemistry Name_____

Acid Base Reactions

Period _____ Date _____

UNIT TEST – PRACTICE

Part 1 – Multiple Choice

You should allocate 15 minutes to finish this portion of the test. No calculator should be used. A periodic table and data table will be provided. Select the answer that best responds to each question.

1. A 1.0 L solution is prepared by combining 0.020 mol HNO_2 and 0.016 mol KOH. Which of these correctly shows relationship of the concentrations of species in the solution after the reaction has occurred?
   (A) $HNO_2 > K^+ = OH^- > NO_2^-$
   (B) $K^+ = OH^- > HNO_2 > NO_2^-$
   (C) $K^+ > HNO_2 > NO_2^- > OH^-$
   (D) $K^+ > NO_2^- > HNO_2 > OH^-$

2. A 3.0 L solution contains 0.800 mol of a weak acid, HA. Which of the following species is in the greatest concentration after 0.800 mol of NaOH is added to it?
   (A) A^-
   (B) H^+
   (C) HA
   (D) OH^-

3. Solution A contains 100 mL of HCl, and solution B contains 100 mL of HNO_2. The pH for both solutions was found to be 4.0. Which solution requires more moles of KOH to reach their equivalence point?
   (A) Solution A because there are more moles of H^+ to neutralize.
   (B) Solution B because it has undissociated HNO_2 molecules that can be neutralized.
   (C) Both will require the same amount because the same volume of the acids are being neutralized.
   (D) Both will require the same amount because they initially have the same $[H^+]$.

4. When 0.050 mol of NaOH is added to 0.100 mol of an unknown weak acid, the pH was found to be 4.2. Which of the following can be the acid?
   (A) Chlorous acid $K_a = 1 \times 10^{-2}$
   (B) Nitrous acid $K_a = 4 \times 10^{-4}$
   (C) Benzoic acid $K_a = 6 \times 10^{-5}$
   (D) Hypochlorous acid $K_a = 4 \times 10^{-8}$

5. A 5.00 mL sample of a 0.100 M HCl solution was obtained. How many mL of a 0.250 M NaOH solution is needed to prepare a solution with pH 7.0?
   (A) 0.0800 mL
   (B) 2.00 mL
   (C) 12.5 mL
   (D) 200. mL

6. A 10.0 mL sample of $HC_2H_3O_2$ was obtained in an Erlenmeyer flask. After adding 15.0 mL of distilled water, it was titrated to its endpoint with a solution of KOH in a buret. The following data was obtained:
   Concentration of KOH: 0.10 M
   Initial buret reading: 5.0 mL
   Final buret reading: 45.0 mL
   What is the concentration of the original $HC_2H_3O_2$ solution?
   (A) 0.025 M
   (B) 0.063 M
   (C) 0.16 M
   (D) 0.40 M

7. Consider the amino acid, aspartic acid ($HC_4H_6NO_4$). Its protonated and deprotonated forms can be represented by the following equilibrium:

$HC_4H_6NO_4 \leftrightarrows C_4H_6NO_4^- + H^+ \quad pK_a = 3.65$

In a particular aqueous environment has pH = 5.00. How do the concentrations between the two forms compare in this environment?

(A) $[HC_4H_6NO_4] > [C_4H_6NO_4^-]$

(B) $[HC_4H_6NO_4] = [C_4H_6NO_4^-]$

(C) $[HC_4H_6NO_4] < [C_4H_6NO_4^-]$

(D) Both forms can exist in any concentration in this environment.

8. The pK_a of weak acid HA is 3.50. Which of the following can prepare a buffer solution with pH = 4.50?

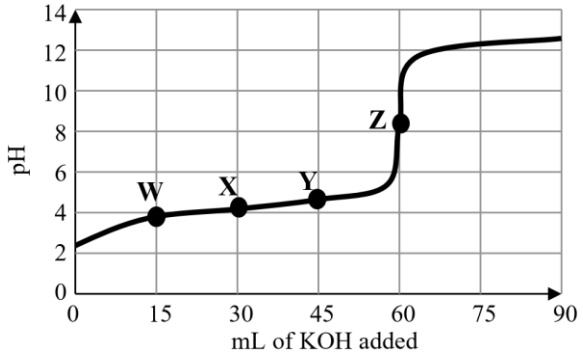
(A) [HA] = 0.010 M, $[A^-]$ = 0.010 M

(B) [HA] = 0.010 M, $[A^-]$ = 0.100 M

(C) [HA] = 0.100 M, $[A^-]$ = 0.010 M

(D) [HA] = 0.100 M, $[A^-]$ = 0.100 M

9. A 5.00 mL sample of a 0.20 M solution of weak acid HA was titrated with KOH, and the pH curve below was obtained.



Which of the following would be changed if a 50.00 mL sample of the acid were used instead?

(A) It would require a greater volume of KOH to change from the pH at point W to that at point Y.

(B) It would require a smaller volume of KOH to reach the equivalence point, Z.

(C) The pH at the equivalence point, Z, would be higher.

(D) The pH at the halfway point, X, would be higher.

10. Sulfurous acid, H_2SO_3, has a K_1 of 1×10^{-2} and K_2 of 1×10^{-7}. What is true of this solution at pH = 7?

(A) The concentrations of H_2SO_3 and HSO_3^- are approximately equal.

(B) The concentrations of HSO_3^- and SO_3^{2-} are approximately equal.

(C) The dominant species is HSO_3^-.

(D) The dominant species is SO_3^{2-}.

Part 2 – Free Response

You should allocate 20 minutes to finish this portion of the test. You may use a scientific calculator. A periodic table and data table will be provided. Respond to each part of the questions completely. Be sure to show your work clearly for questions that involve calculations.

(From AP Chemistry 2015 #3)

11. Potassium sorbate, $KC_6H_7O_2$ (molar mass 150. g/mol) is commonly added to diet soft drinks as a preservative. A stock solution of $KC_6H_7O_2$(aq) of known concentration must be prepared. A student titrates 45.00 mL of the stock solution with 1.25 M HCl(aq) using both an indicator and a pH meter. The value of K_a for sorbic acid, $HC_6H_7O_2$, is 1.7×10^{-5}.

(a) Write the net-ionic equation for the reaction between $KC_6H_7O_2$(aq) and HCl(aq).

$C_6H_7O_2^-(aq) + H^+ \rightarrow HC_6H_7O_2$

(b) A total of 29.95 mL of 1.25 M HCl is required to reach the equivalence point. Calculate $[KC_6H_7O_2]$ in the stock solution.

$$\mathbf{29.95\ mL}\left(\frac{\mathbf{1.25\ mol\ H^+}}{\mathbf{1000\ mL}}\right)\left(\frac{\mathbf{1\ mol\ C_6H_7O_2^-}}{\mathbf{1\ mol\ H^+}}\right) = \mathbf{0.0374\ mol\ C_6H_7O_2^-}$$

$$\mathbf{[KC_6H_7O_2]} = \frac{\mathbf{0.0374\ mol}}{\mathbf{0.04500\ L}} = \mathbf{0.832\ \underline{M}}$$

(c) The pH at the equivalence point of the titration is measured to be 2.54. Which of the following indicators would be the best choice for determining the end point of the titration? Justify your answer.

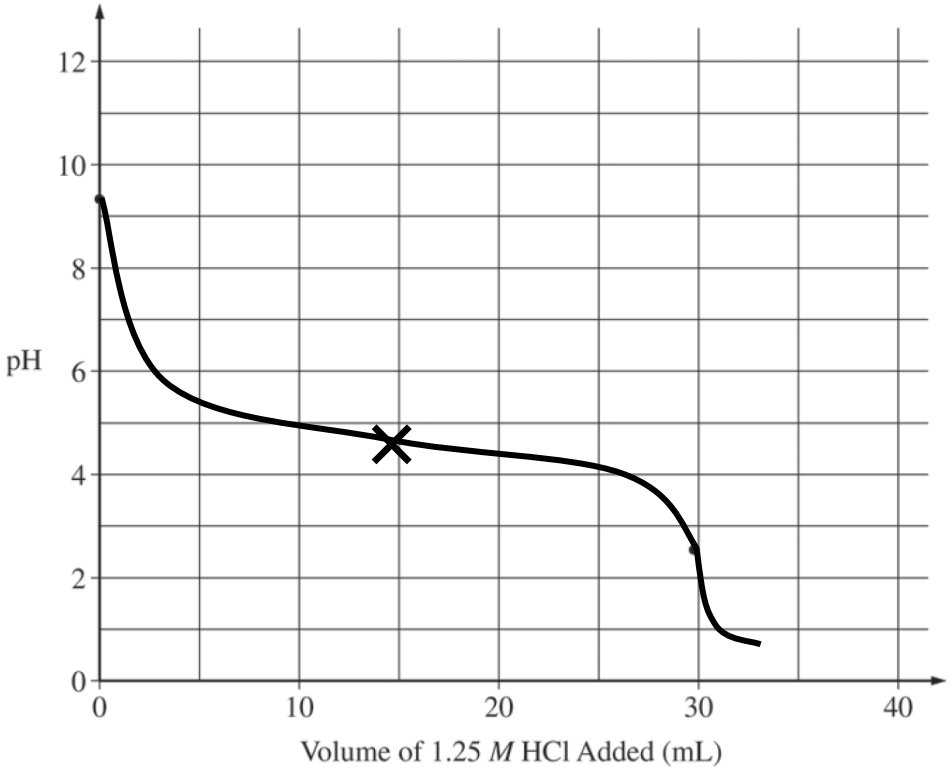
Indicator	pK_a
Phenolphthalein	9.3
Bromothymol blue	7.0
Methyl red	5.0
Thymol blue	2.0
Methyl violet	0.80

The student should use thymol blue, as this is the indicator has a pK_a and will change its color close to the pH of the equivalence point.

(d) Calculate the pH at the half-equivalence point.

At the halfway point, pH = pK_a = −log (1.7×10^{-5}) = 4.77

(e) The initial pH and the equivalence point are plotted on the graph below. Accurately sketch the titration curve on the graph below. Mark the position of the half-equivalence point on the curve with an X.



(f) The pH of the soft drink is 3.37 after the addition of the $KC_6H_7O_2(aq)$. Which species, $HC_6H_7O_2$ or $C_6H_7O_2^-$, has a higher concentration in the soft drink? Justify your answer.

Since pH of 3.37 is lower than the pK_a of 4.77, $[HC_6H_7O_2] > [C_6H_7O_2^-]$.