CONCEPT: DIPROTIC ACIDS AND BASES CALCULATIONS

pH of Sulfuric Acid

- Sulfuric acid represents the only _____ diprotic acid.
  - □ In terms of acidity, the 1st acidic proton dissociates _____ and the 2nd acidic proton only _____.

EXAMPLE: Calculate the pH of a 0.0550 M H_2SO_4 solution. $K_{a1} = 1.0 \times 10^{3}$ and $K_{a2} = 1.2 \times 10^{-2}$.

STEP 1: Use the Bronsted-Lowry definition to predict the products formed when H_2SO_4 reacts with _____.

- □ H_2SO_4 completely dissociates initially, meaning $[H_2SO_4]$ _____ $[H_3O^+]$ and the Intermediate Form.

STEP 2: Setup an ICE Chart for the Intermediate Form created in STEP 1 and react it with _____.

ICE Chart (Intermediate Form)

	HSO_4^- (aq)	+	_____ ( )	⇌	_____ (aq)	+	_____ (aq)
I							
C							
E							

STEP 3: Using the INITIAL ROW, place the amounts from STEP 1 for the Intermediate Form and $[H_3O^+]$.

- □ Place a 0 for the basic form.

STEP 4: We _____ reactants to _____ products.

- □ Using the CHANGE ROW, place a _____ for the reactants and a _____ for the products.

STEP 5: Using the EQUILIBRIUM ROW, setup the equilibrium constant expression with Ka2 and solve for ____.

STEP 6: To solve for pH add the $[H_3O^+]$ from STEPS 1 and 5 to determine its _____ concentration.

pH Formula

$pH = -\log[\ H_3O^+\ ] = -\log[\quad\quad] =$ _____

CONCEPT: DIPROTIC ACIDS AND BASES CALCULATIONS

pH of Weak Diprotic Acids

● Utilize only _____ to calculate the pH of the acidic form of a weak diprotic acid.

EXAMPLE: Calculate the pH of a 0.115 M carbonic acid, H_2CO_3, solution. $K_{a1} = 4.3 \times 10^{-7}$ and $K_{a2} = 5.6 \times 10^{-11}$.

STEP 1: Setup an ICE Chart for the weak diprotic acid that has it reacting with _____.

□ Use the Bronsted-Lowry definition to predict the products formed.

ICE Chart (Diprotic Acid)

	$H_2CO_3(aq)$ + _____ ( ) ⇌ _____ (aq) + _____ (aq)
I	
C	
E	

STEP 2: Using the INITIAL ROW, place the amount given for the weak diprotic acid.

□ Place a ____ for any substance not given an initial amount.

STEP 3: We _____ reactants to _____ products.

□ Using the CHANGE ROW, place a _____ for the reactants and a _____ for the products.

STEP 4: Using the EQUILIBRIUM ROW, setup the equilibrium constant expression with _____ and solve for ____.

□ Check if a shortcut can be utilized to avoid the _____ formula.

ICE Chart Shortcut

500 Approximation Method	Quadratic Formula
When the ratio of $[\ ]_0$ to K is > 500 you can ignore the $-x$.	$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
$\frac{[\ ]_0}{K} = \frac{0.115\ M}{4.3 \times 10^{-7}} =$	$4.3 \times 10^{-7} = \frac{[x^2]}{[0.115 - x]}$

STEP 5: The ____ variable will equal [ ] and can be used to solve pH.

pH Formula

pH = –log[H_3O^+] = –log[ ] = _____

CONCEPT: DIPROTIC ACIDS AND BASES CALCULATIONS

Calculate Concentration of the Basic Form

- Special Case: When given the initial [H_2A] the [A^{2-}] = the _____ value.

EXAMPLE: Determine the [CO_3^{2-}] when given 0.115 M carbonic acid, H_2CO_3, solution. K_{a1} = 4.3 x 10^{-7} and K_{a2} = 5.6 x 10^{-11}.

STEP 1: Setup an ICE Chart to calculate the [HA^-] and [H_3O^+] using _____.

ICE Chart (Diprotic Acid)

	$H_2CO_3(aq)$ + _____ ( ) ⇌ _____ (aq) + _____ (aq)
I	
C	
E	

STEP 2: Setup another ICE Chart and using the INITIAL ROW, place the calculated amounts for [HA^-] and [H_3O^+].

□ Place a ____ for the [A^{2-}].

ICE Chart (Intermediate)

	$HCO_3^-(aq)$ + _____ ( ) ⇌ _____ (aq) + _____ (aq)
I	
C	
E	

STEP 3: We _____ reactants to _____ products.

□ Using the CHANGE ROW, place a _____ for the reactants and a _____ for the products.

STEP 4: Using the EQUILIBRIUM ROW, setup the equilibrium constant expression with _____ and solve for ____.

□ Check if a shortcut can be utilized to avoid the _____ formula.

ICE Chart Shortcut

500 Approximation Method

When the ratio of [ ]$_0$ to K is **>** 500 you can ignore the **+x** and **−x**.

$$\frac{[\ ]_0}{K} = \frac{2.22 \times 10^{-4}}{5.6 \times 10^{-11}} =$$

$$5.6 \times 10^{-11} = \frac{[x]\,[2.22 \times 10^{-4} + x]}{[2.22 \times 10^{-4} - x]}$$

Quadratic Formula

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

CONCEPT: DIPROTIC ACIDS AND BASES CALCULATIONS

PRACTICE: Which of the following diprotic acid would produce the most acidic solution when dissolved?

a) 0.200 M H_2SO_3 ($K_{a1} = 1.6 \times 10^{-2}$; $K_{a2} = 4.6 \times 10^{-5}$)

b) 0.200 M H_3PO_4 ($K_{a1} = 7.5 \times 10^{-3}$; $K_{a2} = 6.2 \times 10^{-8}$; $K_{a3} = 4.2 \times 10^{-13}$)

c) 0.200 M H_2CO_3 ($K_{a1} = 4.3 \times 10^{-7}$; $K_{a2} = 5.6 \times 10^{-11}$)

d) 0.200 M H_2S ($K_{a1} = 8.9 \times 10^{-8}$; $K_{a2} = 1.0 \times 10^{-19}$)

e) 0.200 M $HC_9H_7O_4$ ($K_{a1} = 3.3 \times 10^{-4}$)

PRACTICE: Determine the pH of 0.115 M Na_2S. Hydrosulfuric acid, H_2S, possesses $K_{a1} = 1.0 \times 10^{-7}$ and $K_{a2} = 9.1 \times 10^{-8}$.