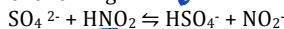




D 9. Consider the following:



Equilibrium would favour:

- A. the products since  $\text{HSO}_4^-$  is a weaker acid than  $\text{HNO}_2$ .  
 B. the reactants since  $\text{HSO}_4^-$  is a weaker acid than  $\text{HNO}_2$ .  
 C. the products since  $\text{HSO}_4^-$  is a stronger acid than  $\text{HNO}_2$ .  
 D. the reactants since  $\text{HSO}_4^-$  is a stronger acid than  $\text{HNO}_2$ .

B 10. The concentration,  $K_a$  and pH values of four acids are given in the following table:

Acid	Concentration	$K_a$	pH
HA	3.0 M	$2.0 \times 10^{-5}$	2.1
HB	0.7 M	$4.0 \times 10^{-5}$	2.3
HC	4.0 M	$1.0 \times 10^{-5}$	2.2
HD	1.5 M	$1.3 \times 10^{-5}$	2.4

Based on this data, the **strongest** acid is:

- A. HA  
 B. HB  
 C. HC  
 D. HD
- highest  $K_a$

A 11. Which of the following  $K_a$  values represents the acid with the strongest conjugate base?

- A.  $4.2 \times 10^{-12}$   
 B.  $9.5 \times 10^{-9}$   
 C.  $2.0 \times 10^{-5}$   
 D.  $7.8 \times 10^{-3}$

12. Briefly explain your answer to the question above:

Strongest conjugate base  
 = highest  $K_b$   
 = lowest  $K_a$

A 13. The  $K_b$  for the dihydrogen phosphate ion  $\text{H}_2\text{PO}_4^-$  is:

- A.  $1.3 \times 10^{-12}$   
 B.  $6.3 \times 10^{-8}$   
 C.  $1.6 \times 10^{-7}$   
 D.  $7.1 \times 10^{-3}$

$$K_b = \frac{K_w}{K_a(\text{H}_3\text{PO}_4)} = \frac{1.0 \times 10^{-14}}{7.5 \times 10^{-3}}$$

D 14. Calculate the pH of 0.01 M NaOH.

- A.  $1.0 \times 10^{-12}$   
 B.  $1.0 \times 10^{-2}$   
 C. 2.0  
 D. 12.0

$$\text{pOH} = -\log(0.01) = 2.0$$

$$\text{pH} = 12.0$$

A 15. Consider the following data:

Chemical species	$K_a$ Value
$\text{H}_3\text{AsO}_4$	$5.0 \times 10^{-5}$
$\text{H}_2\text{AsO}_4^-$	$8.0 \times 10^{-8}$
$\text{HASO}_4^{2-}$	$6.0 \times 10^{-10}$

The  $K_b$  value for  $\text{H}_2\text{AsO}_4^-$  is:

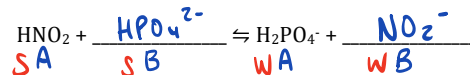
- A.  $2.0 \times 10^{-10}$   
 B.  $8.0 \times 10^{-8}$   
 C.  $1.2 \times 10^{-7}$   
 D.  $1.7 \times 10^{-5}$

16. Explain your answer to the question above:

$$K_b = \frac{K_w}{K_a(\text{H}_3\text{AsO}_4)} = \frac{1.0 \times 10^{-14}}{5.0 \times 10^{-5}}$$

17. Consider a Bronsted-Lowry acid-base equation where  $\text{HNO}_2$  is a reactant and  $\text{H}_2\text{PO}_4^-$  is a product.

a) Complete the following equation:



b) Identify the weaker base in equilibrium in the above equation.



## II. Problems:

1. Define the term amphiprotic. List 2 amphiprotic substances and write a chemical equation describing how it behaves in water.

Amphiprotic = a chemical species that can act as an acid or a base

(Multiple possible answers)



2. Calculate the  $[\text{H}_3\text{O}^+]$  and  $[\text{OH}^-]$  in a saturated solution of magnesium hydroxide.



$$K_{sp} = 5.6 \times 10^{-12} = 4s^3$$

$$\begin{aligned} s &= \sqrt[3]{\frac{5.6 \times 10^{-12}}{4}} \\ &= 1.12 \times 10^{-4} \end{aligned}$$

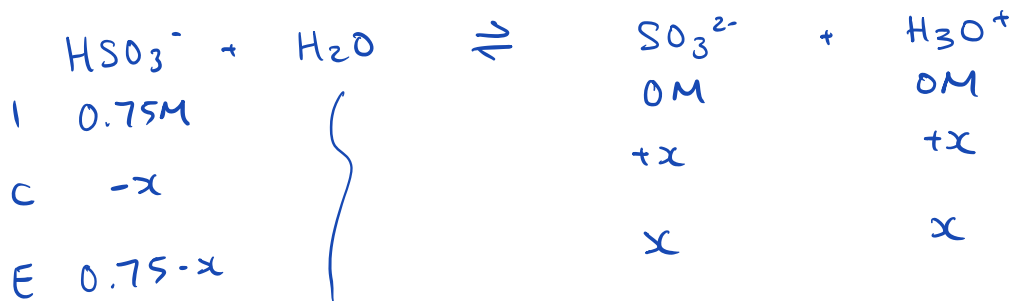
$$\begin{aligned} [\text{OH}^-] &= 2s = 2(1.12 \times 10^{-4}) \\ &= \boxed{2.24 \times 10^{-4} \text{ M}} \end{aligned}$$

$$[\text{H}_3\text{O}^+] = \frac{K_w}{[\text{OH}^-]} = \frac{1.0 \times 10^{-14}}{2.24 \times 10^{-4}} = \boxed{4.5 \times 10^{-11} \text{ M}}$$

3. Determine the pH of a 0.75M solution of  $\text{HSO}_3^-$ .

↗ Amphiprotic!

$$K_a = 1.0 \times 10^{-7} \quad K_b = \frac{K_w}{K_a(\text{H}_2\text{SO}_3)} = \frac{1.0 \times 10^{-14}}{1.5 \times 10^{-2}} = 6.7 \times 10^{-13}$$



$$K_a = 1.0 \times 10^{-7} = \frac{x^2}{0.75-x}$$

assume  $0.75-x \approx 0.75$

$$x = \sqrt{(0.75)(1.0 \times 10^{-7})} = 2.7 \times 10^{-4} \text{ M} = [\text{H}_3\text{O}^+]_i$$

$[\text{H}_3\text{O}^+]_i$  ↙

$$\text{pH} = -\log(2.7 \times 10^{-4}) = \boxed{3.56}$$

4. What mass of HCl must be dissolved in 1.50 L of a NaOH solution having a pH of 11.176 to produce a solution with a pH of 10.750? (Assume no volume change)

↳  $[\text{OH}^-]_f$

$$\text{pOH} = 14 - 10.750$$

$$[\text{OH}^-]_f = 10^{-3.25} = 5.62 \times 10^{-4} \text{ M}$$

↳  $[\text{OH}^-]_i$

$$\text{pOH} = 14 - 11.176$$

$$[\text{OH}^-]_i = 10^{-2.824} = 1.50 \times 10^{-3} \text{ M}$$

$$[\text{OH}^-]_f = [\text{OH}^-]_i - [\text{H}_3\text{O}^+]_i$$

$$[\text{H}_3\text{O}^+]_i = [\text{OH}^-]_i - [\text{OH}^-]_f$$

$$1.50 \times 10^{-3} - 5.62 \times 10^{-4} = 9.38 \times 10^{-4} \text{ M} = [\text{HCl}]$$

$$1.50 \text{ L} \times \frac{9.38 \times 10^{-4} \text{ mol}}{1 \text{ L}} \times \frac{36.5 \text{ g}}{1 \text{ mol}} = \boxed{0.0514 \text{ g}}$$