

Problem Set #15

CHEM101A: General College Chemistry

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23 Topic G Problem 23

The concentration of H^+ ions in a solution is 0.315 M.

- a) Calculate the concentration of OH^- ions in this solution.
- b) Where did these OH^- ions come from?
- c) What is the pH of this solution?

23.1 Solution (a)

The concentration of hydrogen ions times the number of hydroxide ions is equal to a constant $K_w = 10^{-14}$. We can use that to find the concentration of hydroxide ions.

$$K_w = [\text{H}^+][\text{OH}^-] \quad (1)$$

$$[\text{OH}^-] = \frac{K_w}{[\text{H}^+]} = \frac{10^{-14}}{0.315} = 3.17 \times 10^{-14} \text{ M} = \boxed{3.2 \times 10^{-14} \text{ M}} \quad (2)$$

23.2 Solution (b)

The OH^- ions come from the surrounding water.

23.3 Solution (c)

Use the logarithm.

$$\text{pH} = -\log_{10}([\text{H}^+]) = -\log_{10}(0.315) = \boxed{0.50} \quad (3)$$

24 Topic G Problem 24

The pH of an HCl solution is 2.88.

- a) What is the concentration of H^+ ions in this solution?
- b) What is the concentration of OH^- ions in this solution?
- c) What is the concentration of Cl^- ions in this solution?

24.1 Solution (a)

Use the exponential.

$$[\text{H}^+] = 10^{-\text{pH}} = 10^{-2.88} = \boxed{0.0013 \text{ M}} \quad (4)$$

24.2 Solution (b)

The OH^- and H^+ concentrations are related.

$$K_w = [\text{H}^+][\text{OH}^-] \quad (5)$$

$$[\text{OH}^-] = \frac{K_w}{[\text{H}^+]} = \frac{10^{-14}}{0.0013} = 7.586 \times 10^{-12} \text{ M} = \boxed{7.6 \times 10^{-12} \text{ M}} \quad (6)$$

24.3 Solution (c)

There is much less OH^- than there is H^+ . Even if some of the created OH^- balanced out the H^+ , it would have been little. This means the Cl^- would be equivalent to the amount of H^+ . $\boxed{0.0013 \text{ M}}$

25 Topic G Problem 25

Calculate the pH of a 7.4×10^{-4} M solution of $\text{Ba}(\text{OH})_2$.

25.1 Solution

Start by calculating the concentration of the OH^- . It would be twice the concentration of the $\text{Ba}(\text{OH})_2$ because it is soluble in water.

$$[\text{OH}^-] = 2 * 7.4 \times 10^{-4} \text{ M} = 1.48 \times 10^{-3} \text{ M} \quad (7)$$

This leads into a calculation of the concentration of the H^+ . We can use that to find the pH.

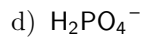
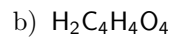
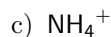
$$K_w = [\text{H}^+][\text{OH}^-] \quad (8)$$

$$[\text{H}^+] = \frac{K_w}{[\text{OH}^-]} = \frac{10^{-14}}{1.48 \times 10^{-3} \text{ M}} = 6.757 \times 10^{-12} \text{ M} \quad (9)$$

$$\text{pH} = -\log_{10}[\text{H}^+] = -\log_{10}(6.757 \times 10^{-12}) = \boxed{11.17} \quad (10)$$

26 Topic G Problem 26

Write the K_a expression and the corresponding chemical equation for each of the following weak acids.



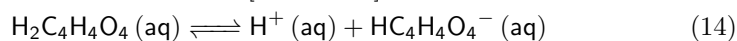
26.1 Solution (a)

$$K_a = \frac{[\text{H}^+][\text{ClO}^-]}{[\text{HClO}]} \quad (11)$$



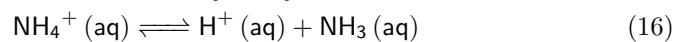
26.2 Solution (b)

$$K_a = \frac{[\text{H}^+][\text{HC}_4\text{H}_4\text{O}_4^-]}{[\text{H}_2\text{C}_4\text{H}_4\text{O}_4]} \quad (13)$$



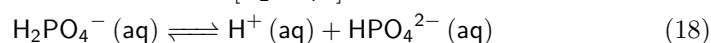
26.3 Solution (c)

$$K_a = \frac{[\text{H}^+][\text{NH}_3]}{[\text{NH}_4^+]} \quad (15)$$



26.4 Solution (d)

$$K_a = \frac{[\text{H}^+][\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]} \quad (17)$$



27 Topic G Problem 27

The pH of a 0.464 M solution of phosphorous acid (H_3PO_3) is 1.11. Using this information, calculate the K_a of phosphorous acid. (You may assume that only one hydrogen ion dissociates from phosphorous acid.)

27.1 Solution

First find the molarity of the H^+ by using the pH.

$$[\text{H}^+] = 10^{-\text{pH}} = 10^{-1.11} = 0.0776247 \quad (19)$$

That would in turn be the molarity of the H_2PO_3^- . Without having to use an ICE table, we can figure out that the equilibrium molarity of the H_3PO_3 will be the initial molarity minus the molarity of the H^+ .

$$[\text{H}_3\text{PO}_3]_f = [\text{H}_3\text{PO}_3]_i - [\text{H}^+] = 0.464 - 0.078 = 0.386 \quad (20)$$

Use these and the molarity of the H_3PO_3 to find the K_a .

$$K_a = \frac{[\text{H}^+][\text{H}_2\text{PO}_3^-]}{[\text{H}_3\text{PO}_3]} = \frac{0.0776247^2}{0.386} = \boxed{0.016} \quad (21)$$

28 Topic G Problem 28

Calculate the pH of a 0.27 M solution of HCO_2H (formic acid, $K_a = 1.8 \times 10^{-4}$).

28.1 Solution

Use an ICE table to find the molarity of the H^+ .

M	HCO_2H	\rightleftharpoons	H^+	+	CO_2H^-
I	0.27		0		0
C	$-x$		$+x$		$+x$
E	$0.27 - x$		x		x

Use this with the K_a . Solve for x .

$$K_a = \frac{[\text{H}^+][\text{CO}_2\text{H}^-]}{[\text{HCO}_2\text{H}]} = \frac{x^2}{0.27 - x} = 1.8 \times 10^{-4} \quad (22)$$

$$x^2 = 4.86 \times 10^{-5} - 1.8 \times 10^{-4}x \quad (23)$$

$$0 = x^2 + 1.8 \times 10^{-4}x - 4.86 \times 10^{-5} \quad (24)$$

$$x = 0.00688195 \text{ or } \cancel{-0.00706195} \quad (25)$$

This value of x is the concentration of the H^+ . Use this to find the pH.

$$\text{pH} = -\log_{10}[\text{H}^+] = -\log_{10} x = -\log_{10} 0.00688195 = \boxed{2.16} \quad (26)$$

29 Topic G Problem 29

Determine which solution from each of the following pairs has the higher pH. You may need to refer to the K_a values in Table 12.4.2 of your textbook.

- a) 0.1 M HCl or 0.1 M HNO_2
- b) 0.1 M HF or 0.1 M HClO
- c) 0.1 M HCN or 0.1 M NaCN

29.1 Solution (a)

The HCl is a strong acid, so practically all the HCl will dissociate. We will resultantly have a low pH. That means that the higher pH goes to the $\boxed{\text{HNO}_2}$.

29.2 Solution (b)

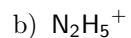
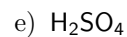
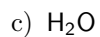
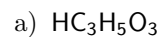
HF has $K_a = 3.5 \times 10^{-4}$. HClO has $K_a = 3.5 \times 10^{-8}$. HClO has the lower K_a , which means it will have a higher pH. The answer is $\boxed{\text{HClO}}$.

29.3 Solution (c)

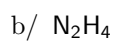
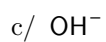
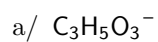
HCN has $K_a = 6.2 \times 10^{-10}$. The HCN will increase the concentration of the H^+ . NaCN has no K_a because it has no Hydrogen. However, the entirety of the NaCN will dissociate because of the Na^+ present. The CN^- will then bond with the H^+ and lower the molarity of the H^+ . The HCN will result in a higher concentration of H^+ , while the NaCN will lower the concentration of the H^+ . Since pH is inversely (logarithmically) proportional to concentration, this means the $\boxed{\text{NaCN}}$ will have the higher pH.

30 Topic G Problem 30

Each of the following species can function as an acid. Write the formula of its conjugate base.

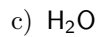


30.1 Solution

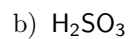
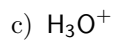
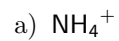


31 Topic G Problem 31

Each of the following species can function as a base. Write the formula of its conjugate acid.

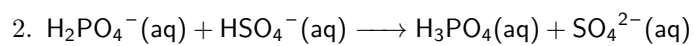
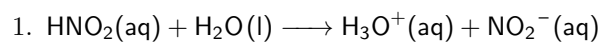


31.1 Solution



32 Topic G Problem 32

Identify the acid and the base in each of the following reactions.



32.1 Solution (a)

Acid: HNO_2

Base: H_2O

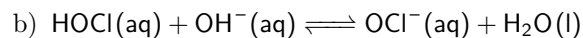
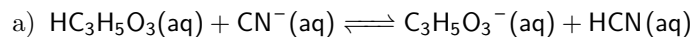
32.2 Solution (b)

Acid: HSO_4^-

Base: H_2PO_4^-

33 Topic G Problem 33

For each of the following reactions, tell whether the equilibrium will favor the reactants or the products. Use the K_a values in Table 12.4.2 of your textbook.



33.1 Solution (a)

K_a for $\text{HC}_3\text{H}_5\text{O}_3$ is 1.4×10^{-4} . K_a for HCN is 6.2×10^{-10} . The K_a for $\text{HC}_3\text{H}_5\text{O}_3$ is greater, so the equilibrium will favor the products.

33.2 Solution (b)

K_a for HOCl is 3.5×10^{-8} . K_a for H_2O is 1.0×10^{-14} . The K_a for HOCl is greater, so the equilibrium will favor the products.

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