

ent adds some hydrochloric acid,  $\text{HCl}_{(\text{aq})}$ , to water and finds the resulting solution to be a pH of 3.50. What is the hydroxide ion concentration  $[\text{OH}^{-}_{(\text{aq})}]$  of this solution?

$$14 - 3.5 = 10.5$$

$$[\text{H}^{+}] = 10^{-10.5} = 3.16 \times 10^{-11}$$

- ☒ A)  $3.16 \times 10^{-11} \text{ mol/L}$   
 B)  $2.86 \times 10^{-15} \text{ mol/L}$

- C)  $10.5 \text{ mol/L}$   
 D)  $3.16 \times 10^{-4} \text{ mol/L}$

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Acid-base reaction,  $\text{HNO}_{2(\text{aq})} + \text{HCO}_3^{-1}{}_{(\text{aq})} \leftrightarrow \text{NO}_2^{-1}{}_{(\text{aq})} + \text{H}_2\text{CO}_{3(\text{aq})}$

Given that the equilibrium favors the formation of products, which of the following statements is true?

- A)  $\text{HCO}_3^{-1}$  is a stronger acid than  $\text{H}_2\text{CO}_3$ .  
 B)  $\text{HCO}_3^{-1}$  is a stronger acid than  $\text{HNO}_2$ .

- C)  $\text{H}_2\text{CO}_3$  is a stronger acid than  $\text{HNO}_2$ .  
☒ D)  $\text{HNO}_2$  is a stronger acid than  $\text{H}_2\text{CO}_3$ .

3

Acid	$K_a$
Carbonic acid, $\text{H}_2\text{CO}_3$	$4.4 \times 10^{-7}$
Hydroselenic acid, $\text{H}_2\text{Se}$	$1.7 \times 10^{-4}$
Acetic acid, $\text{CH}_3\text{COOH}$	$1.8 \times 10^{-5}$
Nitrous acid, $\text{HNO}_2$	$5.1 \times 10^{-4}$

Which is the strongest acid?

- A)  $\text{H}_2\text{CO}_3$       B)  $\text{H}_2\text{Se}$       C)  $\text{CH}_3\text{COOH}$       ☒ D)  $\text{HNO}_2$

4

Which of the following are TRUE characteristics of a strong acidic solution?

- The  $K_a$  value is very large. ✓
- It does not conduct electricity. ✗
- $[\text{H}^{+}] > [\text{OH}^{-}]$ . ✓
- $\text{pH} > 7$ . ✗
- The  $K_a$  value is very small. ✗

☒ A) 1 & 3

B) 1 & 4

C) 2 & 5

D) 3, 4 & 5

5

The ionization constant for water at  $25^\circ\text{C}$  is  $1.0 \times 10^{-14}$  & at  $100^\circ\text{C}$  it is  $5.13 \times 10^{-13}$ . What is the pH of water at  $100^\circ\text{C}$ ?

- A)  $1.00 \times 10^{-7}$       B)  $7.16 \times 10^{-7}$       ☒ C) 6.14      D) 7.00

$$5.13 \times 10^{-13} = [\text{H}^{+}][\text{OH}^{-}]$$

$$= x^2$$

$$\sqrt{5.13 \times 10^{-13}} = x$$

$$7.16 \times 10^{-7} = x = [\text{H}^{+}]$$

$$-\log(7.16 \times 10^{-7}) = 6.14$$

Q	A
1.	A
2.	D
3.	D
4.	A
5.	C

/10

1

A student adds some hydrochloric acid,  $\text{HCl}_{(\text{aq})}$ , to water and finds the resulting solution to have a pH of 3.50. What is the hydroxide ion concentration  $[\text{OH}^{-}_{(\text{aq})}]$  of this solution?

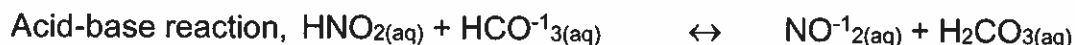
A)  $3.16 \times 10^{-4} \text{ mol/L}$

B)  $2.86 \times 10^{-15} \text{ mol/L}$

C)  $10.5 \text{ mol/L}$

D)  $3.16 \times 10^{-11} \text{ mol/L}$

2



Given that the equilibrium favors the formation of products, which of the following statements is true?

A)  $\text{HCO}_3^{-}$  is a stronger acid than  $\text{H}_2\text{CO}_3$ .B)  $\text{HCO}_3^{-}$  is a stronger acid than  $\text{HNO}_2$ .C)  $\text{HNO}_2$  is a stronger acid than  $\text{H}_2\text{CO}_3$ .D)  $\text{H}_2\text{CO}_3$  is a stronger acid than  $\text{HNO}_2$ .

3

Acid	$K_a$
Carbonic acid, $\text{H}_2\text{CO}_3$	$4.4 \times 10^{-7}$
Hydroselenic acid, $\text{H}_2\text{Se}$	$1.7 \times 10^{-4}$
Acetic acid, $\text{CH}_3\text{COOH}$	$1.8 \times 10^{-5}$
Nitrous acid, $\text{HNO}_2$	$5.1 \times 10^{-4}$

Which is the strongest acid?

A)  $\text{H}_2\text{CO}_3$ B)  $\text{H}_2\text{Se}$ C)  $\text{CH}_3\text{COOH}$ D)  $\text{HNO}_2$ 

4

Which of the following are TRUE characteristics of a strong acidic solution?

- The  $K_a$  value is very large.
- It does not conduct electricity.
- $[\text{H}^+] > [\text{OH}^-]$ .
- $\text{pH} > 7$ .
- The  $K_a$  value is very small.

A) 1 &amp; 3

B) 1 &amp; 4

C) 2 &amp; 5

D) 3, 4 &amp; 5

5

The ionization constant for water at  $25^\circ\text{C}$  is  $1.0 \times 10^{-14}$  & at  $100^\circ\text{C}$  it is  $5.13 \times 10^{-13}$ . What is the pH of water at  $100^\circ\text{C}$ ?

A)  $1.00 \times 10^{-7}$

B) 6.14

C)  $7.16 \times 10^{-7}$

D) 7.00

$$K_w = (\text{H}^+)(\text{OH}^-)$$

$$5.13 \times 10^{-13} = x^2$$

$$7.16 \times 10^{-7} = x$$

Q	A
1.	D
2.	C
3.	D
4.	A
5.	B

/10

6 Give the "Acid name" for the following compounds. (3)

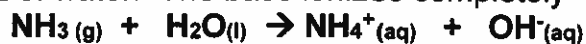
- A) hydrogen bromide (HBr) hydrobromic acid  
 B) hydrogen carbonate ( $\text{H}_2\text{CO}_3$ ) carbonic acid  
 C) hydrogen sulphite ( $\text{H}_2\text{SO}_3$ ) sulphurous acid.

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Show all you work for the following problems. Show formulae & provide units. 4 pts each

7

25.56 g of  $\text{NH}_3$  (a strong base) is dissolved into 2.00 L of water. The base ionizes completely as shown in the equation below:



Calculate the pH of this solution?

$$\frac{1 \text{ mol}}{x} = \frac{17.04 \text{ g}}{25.56} \quad x = 1.500 \text{ mol NH}_3 = 1.500 \text{ mol OH}^-$$

$$\text{pOH} = -\log[\text{OH}^-]$$

$$= -\log(0.750)$$

$$\text{pOH} = 0.125$$

$$[\text{OH}^-] = \frac{1.500 \text{ mol OH}^-}{2.00 \text{ L}} = 0.750 \text{ M}$$

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

$$\text{pH} = 14 - 0.125$$

$$\boxed{\text{pH} = 13.9}$$

8

Carbonic acid,  $\text{H}_2\text{CO}_3$ , is a weak acid.



$5.00 \times 10^{-4}$  moles of carbonic acid are placed into 500 mL of distilled water.

Calculate the pH of this solution?

$$[\text{H}_2\text{CO}_3] = \frac{5.00 \times 10^{-4}}{0.500 \text{ L}} = 1.00 \times 10^{-3} \text{ M}$$

$$K_a = \frac{[\text{H}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}$$

$$[\text{H}^+] = 2.1 \times 10^{-5}$$

$$-\log[\text{H}^+] = \text{pH}$$

$$4.3 \times 10^{-7} = \frac{(x)(x)}{0.001 - x}$$

$$\boxed{\text{pH} = 4.7}$$

$$4.3 \times 10^{-7} = \frac{x^2}{0.001}$$

$$4.3 \times 10^{-10} = x^2 \quad x = 2.1 \times 10^{-5}$$

$\text{H}_2\text{CO}_3$	$\text{H}^+$	$\text{HCO}_3^-$
0.001	0	0
-x	+x	+x
0.001-x	x	x

9

The initial concentration of an acid (HX) is 2.70 M. Calculate the dissociation constant ( $K_a$ ) for this acid if the pH is 1.3.

$$\text{pH} = 1.3$$

$$[\text{H}^+] = 10^{-1.3} = 0.05 = x$$

$$K_a = \frac{[\text{H}^+][\text{X}^-]}{[\text{HX}]}$$

$$= \frac{(x)(x)}{2.70 - x}$$

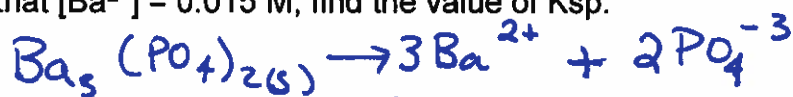
$$= \frac{(0.05)^2}{2.70 - 0.05}$$

$$K_a = \frac{0.0025}{2.65} = \boxed{9.5 \times 10^{-4}}$$

$$(\text{accept } 9.4 \times 10^{-4})$$

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10. Solid barium phosphate ( $\text{Ba}_3(\text{PO}_4)_2$ ) dissolves into its respective ions at  $25^\circ\text{C}$ . Given that  $[\text{Ba}^{2+}] = 0.015 \text{ M}$ , find the value of  $K_{sp}$ .



$$\begin{aligned} K_{sp} &= [\text{Ba}^{2+}]^3 [\text{PO}_4^{3-}]^2 \\ &= (3x)^3 (2x)^2 \\ &= (0.015)^3 (0.010)^2 \\ &= 3.375 \times 10^{-10} \end{aligned}$$

$$[\text{Ba}] = \frac{0.015}{3} = \frac{3x}{3}$$

$$0.005 = x$$

$$[\text{PO}_4^{3-}] = 2x = 0.010$$

$$K_{sp} = 3.4 \times 10^{-10}$$

11. What is the concentration of a HCl solution if it takes 180 mL of a 1.40 M solution of  $\text{Al}(\text{OH})_3$  to titrate 235 mL of HCl.



$$\frac{M_A V_A}{n_A} = \frac{M_B V_B}{n_B}$$

$$\frac{M_A (235)}{3} = \frac{(1.40)(180)}{1}$$

$$M_A = 3.22 \text{ M}$$

$$\frac{235 M_A}{235} = \frac{756}{235}$$

12. 400 mL of 1.50 M HCL was combined with 800 ml OF 0.625 M NaOH. What is the pH of the resulting solution?

$$1.50 \text{ mol/L} \times 0.400 \text{ L} = 0.600 \text{ mol } \text{H}^+$$

$$0.625 \text{ mol/L} \times 0.800 \text{ L} = 0.500 \text{ mol } \text{OH}^-$$

$$\begin{array}{r} 0.600 \text{ H}^+ \\ - 0.500 \text{ OH}^- \\ \hline \end{array}$$

$$0.100 \text{ mol } \text{H}^+ \text{ left}$$

$$[\text{H}^+] = \frac{0.100 \text{ mol } \text{H}^+}{1.200 \text{ L}} = 0.083 \text{ M}$$

$$\begin{aligned} \text{pH} &= -\log [\text{H}^+] \\ &= -\log 0.083 \end{aligned}$$

$$\text{pH} = 1.08$$

$$pH + pOH = 14$$

$$[H^+] = 10^{-pH}$$

$$pH = -\log [H^+]$$

$$[OH^-] = 10^{-pOH}$$

$$pOH = -\log [OH^-]$$

$$K_w = [H^+][OH^-]$$

$$K_w = 1 \times 10^{-14}$$

$$K_w = K_a \cdot K_b$$

$$\frac{M_A V_A}{n_A} = \frac{M_B V_B}{n_B}$$

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