Chapter 7 Acid-Base

1. The conjugate acid of HPO_4^{2-} is
   a. H_2PO_4
   b. H_3PO_4
   c. PO_4^{3-}
   d. PO_4^{2-}
   * e. $H_2PO_4^-$

HPO_4^{2-} is base (accept H^+) $HPO_4^{2-} + H^+ \rightarrow H_2PO_4^-$

2. The conjugate base of $H_2AsO_4^-$ is
   a. H_2AsO_4
   b. H_3AsO_4
   c. $HAsO_4^-$
   * d. $HAsO_4^{2-}$
   e. AsO_4^{3-}

$H_2AsO_4^-$ is acid (donate H^+) $H_2AsO_4^- \rightarrow H^+ + HAsO_4^{2-}$

3. In the reaction, $HClO_3 + N_2H_4 \rightleftharpoons ClO_3^- + N_2H_5^+$, which species are an acid-base pair? **Acid Base conj base conj acid**

   a. $HClO_3$, N_2H_4
   b. N_2H_4, ClO_3^-
   c. $HClO_3$, $N_2H_5^+$
   * d. N_2H_4, $N_2H_5^+$
   e. ClO_3^-, $N_2H_5^+$

4. In the reaction, **$HClO_3 + N_2H_4 \rightleftharpoons ClO_3^- + N_2H_5^+$,** which two species are both bases? **Acid Base conj base conj acid**

   a. $HClO_3$, N_2H_4
   b. $HClO_3$, ClO_3^-
   c. $HClO_3$, $N_2H_5^+$
   d. N_2H_4, $N_2H_5^+$
   * e. ClO_3^-, N_2H_4

5. In the reaction, $HSO_4^- + HS^- \rightleftharpoons H_2S + SO_4^{2-}$, which two species are both acids?
Acid Base conj base conj acid

   a. HSO_4^-, HS^-
   * b. HSO_4^-, H_2S
   c. HS^-, H_2S
   d. HS^-, SO_4^{2-}
   e. H_2S, SO_4^{2-}

6. For the system

$$NH_2OH + CH_3NH_3^+ \rightleftharpoons CH_3NH_2 + NH_3OH_2^+$$

Base Acid conj base conj acid

the position of the equilibrium lies to the left. Which is the strongest acid in the system?

a. NH_2OH
b. $CH_3NH_3^+$
c. CH_3NH_2
* d. $NH_3OH_2^+$
e. NH_2OH and $CH_3NH_3^+$ are equal in acid strength, and are the strongest acids in the system

Direction always from Strong → weak

Equilibrium lies to the left, this mean weak on left or strong on wright

7. If the OH^- ion concentration in an aqueous solution at 25.0 °C is measured as 3.4×10^{-3} M, what is the pH?

a. 2.47
b. 7.22
c. 8.24
* d. 11.53
e. 16.47

$[OH^-]=3.4 \times 10^{-3}$
$[H^+]= 1 \times 10^{-14} / [OH^-] = 1 \times 10^{-14} / 3.4 \times 10^{-3} = 2.94 \times 10^{-12}$
$pH = -\log [H^+] = -\log 2.94 \times 10^{-12} = 11.53$

8. The pH of a solution is measured to be 10.4. What are the values of $[H_3O^+]$ and $[OH^-]$ for this solution?

a. $[H_3O^+] = 4.0 \times 10^{-11}$, $[OH^-] = 4.0 \times 10^{3}$
b. $[H_3O^+] = 2.5 \times 10^{-4}$, $[OH^-] = 4.0 \times 10^{-11}$
c. $[H_3O^+] = 1.0 \times 10^{-10}$, $[OH^-] = 3.6 \times 10^{-4}$
* d. $[H_3O^+] = 4.0 \times 10^{-11}$, $[OH^-] = 2.5 \times 10^{-4}$
e. $[H_3O^+] = 9.6 \times 10^{-2}$, $[OH^-] = 2.8 \times 10^{-1}$

pH=10.4
$[H^+]= 10^{-pH} = 10^{-10.4}$ (OR Shift log -10.4) $= 4.0 \times 10^{-11}$
$[OH^-] 1 \times 10^{-14} / 4.0 \times 10^{-11} = 2.5 \times 10^{-4}$

9. If the OH^- ion concentration in an aqueous solution at 25.0 °C is 6.6×10^{-4} M, what is the molarity of the H^+ ion?

a. 1.5×10^{-1} M
b. 1.5×10^{-4} M
c. 6.6×10^{-10} M
* d. 1.5×10^{-11} M

e. 6.6×10^{-11} M

$[OH^-] = 6.6 \times 10^{-4}$

$[H^+] = 1 \times 10^{-14} / [OH^-] = 1 \times 10^{-14} / 6.6 \times 10^{-4} = 1.5 \times 10^{-11}$

10. If the H^+ ion concentration in an aqueous solution at 25.0 °C has a value of 0.100 M, what is the pOH of the solution?

a. 1.00
b. 7.00
c. 12.00
* d. 13.00
e. 11.40

$[H^+] = 0.100$

$[OH^-] = 1 \times 10^{-14} / [H^+] = 1 \times 10^{-14} / 0.100 = 1 \times 10^{-13}$

$pH = -\log [H^+] = -\log 1 \times 10^{-13} = 13$

11. If the H^+ ion concentration in an aqueous solution at 25.0 °C has a value of 0.100 M, then what is the pH of the solution?

a. -1.00
b. 0.100
* c. 1.00
d. 6.90
e. 13.00

$[H^+] = 0.100$

$pH = -\log [H^+] = -\log 0.1 = 1$

12. If the H^+ ion concentration in an aqueous solution at 25.0 °C is measured as 6.6×10^{-4} M, what is the pH?

a. 3.00
* b. 3.18
c. 6.60
d. 9.55
e. 10.82

$[H^+] = 6.6 \times 10^{-4}$

$pH = -\log [H^+] = -\log 6.6 \times 10^{-4} = 3.18$

13. Calculate the pH of a beer in which the hydrogen ion concentration is 3.9×10^{-5} M.

* a. 4.4
b. 3.9
c. 10.1
d. 5.0
e. 9.6

$[H^+] = 3.9 \times 10^{-5}$
$pH = -\log [H^+] = -\log 3.9 \times 10^{-5} = 4.4$

14. Calculate the pH of a 0.020 M solution of $Ca(OH)_2$ whose temperature is 25.0 °C.
    a. 1.40
    b. 0.040
    c. 1.69
    * d. 12.60
    e. 12.30

$[Ca(OH)_2] = 0.020$
$[OH^-] = 2 \times 0.020 = 0.04$
$[H^+] = 1 \times 10^{-14} / 0.04 = 2.5 \times 10^{-13}$
$pH = -\log [H^+] = -\log 2.5 \times 10^{-13} = 12.6$

15. Given 0.01 M solutions of each of the following bases, which solution would have the highest pH?
    a. Aniline ($C_6H_5NH_2$), $K_b = 3.9 \times 10^{-10}$ **pH= 8.3**
    * b. Dimethylamine ($(CH_3)_2NH$), $K_b = 5.1 \times 10^{-4}$ **pH= 11.35**
    c. Hydrazine (N_2H_4), $K_b = 1.3 \times 10^{-6}$ **pH= 10.05**
    d. Methylamine (CH_3NH_2), $K_b = 4.4 \times 10^{-4}$ **pH= 11.32**
    e. Pyridine (C_5H_5N), $K_b = 1.7 \times 10^{-9}$ **pH= 8.6**

All weak bases

a) $[OH^-] = \sqrt{(K_b \times C_o)} = (K_a \times C_o)^{1/2} = \sqrt{(3.9 \times 10^{-10} \times 0.01)} = 1.97 \times 10^{-6}$
$pOH = -\log 1.97 \times 10^{-6} = 5.7$
$pH = 14 - pOH = 8.3$
Repeat for all b to e
Conclusion: you can find the highest K_b is highest $[OH^-]$ and the most basic solution which is the highest pH

16. The ionization constant, K_a, for macnic acid is 5.0×10^{-5}. What is the pK_a of this acid?
    a. 2.00×10^4
    * b. 4.30
    c. 5.70
    d. 1.75×10^{-1}
    e. 10.70

$pK_a = -\log K_a = -\log 5.0 \times 10^{-5} = 4.30$

17. Formic acid, HCO_2H, has an ionization constant with the value: $K_a = 1.76 \times 10^{-4}$. Calculate the value of pK_b for the conjugate base of formic acid.
    a. 3.75
    b. 5.35
    c. 8.65

* d. 10.25
e. 12.24

$K_a \times K_b = 1 \times 10^{-14}$
$K_b = 1 \times 10^{-14} / 1.76 \times 10^{-4} = 5.68 \times 10^{-11}$
$pK_b = -\log K_b = -\log 5.68 \times 10^{-11} = 10.25$

18. A 0.100 M solution of an acid, HA, has a pH = 2.00. What is the value of the ionization constant, K_a for this acid?
    a. 1.1×10^{-2}
    * b. 1.1×10^{-3}
    c. 1.1×10^{-4}
    d. 1.0×10^{-3}
    e. 1.0×10^{-4}

pH = 2.00
$[H^+] = 10^{-pH} = 10^{-2}$
$[H^+] = \sqrt{(Ka \times C_o)} = (Ka \times C_o)^{1/2} = \sqrt{(K_a \times 0.1)}$
$[H^+]^2 = (Ka \times C_o) = (K_a \times 0.1)$
$(10^{-2})^2 = K_a \times 0.1$
$K_a = 10^{-4} / 0.1 = 1 \times 10^{-3}$

19. A 0.400 M solution of an acid, HQ, has a pH = 1.301. What is the value of the ionization constant, K_a, for this acid?

    a. 5.00×10^{-2}
    b. 1.25×10^{-3}
    c. 5.56×10^{-3}
    d. 6.25×10^{-3}
    e. 7.14×10^{-3}

pH = 1.301
$[H^+] = 10^{-pH} = 10^{-1.301}$ Or (shift log -1.301) = 0.05
$[H^+] = \sqrt{(Ka \times C_o)} = (Ka \times C_o)^{1/2} = \sqrt{(K_a \times 0.1)}$
$[H^+]^2 = (Ka \times C_o) = (K_a \times 0.4)$
$(0.05)^2 = K_a \times 0.4$
$K_a = 2.5 \times 10^{-3} / 0.4 = 6.25 \times 10^{-3}$

20. A 0.200 M solution of a weak base in water has a pH = 10.40 at 25°C. Calculate the value of K_b for this base.
    a. 1.0×10^{-5}
    * b. 3.2×10^{-7}
    c. 2.2×10^{-5}
    d. 4.0×10^{-11}
    e. 5.0×10^{-5}

pH = 10.40
$[H^+] = 10^{-pH} = 10^{-10.40}$ Or (shift log - 10.40) = 3.98×10^{-11}
$[OH^-] = 1 \times 10^{-14} / [H^+] = 1 \times 10^{-14} / 3.98 \times 10^{-11} = 2.52 \times 10^{-4}$
$[OH^-]^2 = (K_b \times C_o) = (K_b \times 0.2)$
$(2.52 \times 10^{-4})^2 = K_b \times 0.2$
$K_b = 6.3 \times 10^{-8} / 0.2 = 3.2 \times 10^{-7}$

21. The ionization constant, K_a, for benzoic acid, $HC_7H_5O_2$, is 6.28×10^{-5}. What is the pH of a 0.15 molar solution of this acid?

a. 0.82
* b. 2.52
c. 4.20
d. 5.03
e. 5.79

$pH = -\log [H^+] = -\log \sqrt{K_a \times C_o} = -\log (K_a \times C_o)^{1/2} = -\log (6.28 \times 10^{-5} \times 0.15)^{1/2}$
$= -\log 3.07 \times 10^{-3} = 2.52$

Extra Exercise

22. What is the conjugate acid of NH_3?

A) NH_3^+ B) NH_4OH C) NH_2^+ D) NH_3 E) NH_4^+

23. The conjugate base of HSO_4^- is

A) HSO_4^+ B) $H_3SO_4^+$ C) OH^- D) H_2SO_4 E) SO_4^{2-}

24. The conjugate acid of HSO_4^- is

A) SO_4^{2-} B) H^+ C) HSO_4^+ D) HSO_3^+ E) H_2SO_4

25. What is the conjugate base of OH^-?

A) O^- B) H_2O C) H_3O^+ D) O^{2-} E) O_2

26. What is the pH of an aqueous solution at 25.0 °C in which $[H^+]$ is 0.00250 M?

A) -2.60 B) -3.40 C) 2.60 D) 3.40 E) 2.25

27. What is the pH of an aqueous solution at 25.0 °C in which $[OH^-]$ is 0.00250 M?

A) +2.60 B) -2.60 C) +11.4 D) -11.4 E) -2.25

28. What is the pH of an aqueous solution at 25.0 °C that contains 3.98×10^{-9} M hydronium ion $[H_3O^+]$?

A) 5.60 B) 7.00 C) 8.40 D) 9.00 E) 3.98

29. What is the pH of an aqueous solution at 25.0 °C that contains 3.98×10^{-9} M hydroxide ion $[OH^-]$?

A) 5.60 B) 9.00 C) 7.00 D) 3.98 E) 8.40

30. What is the concentration (in M) of hydronium ions in a solution at 25.0 °C with pH = 4.282?

A) 4.28 B) 5.22×10^{-5} C) 1.92×10^{-10} D) 9.71 E) 1.66×10^{4}

31. What is the concentration (in M) of hydroxide ions $[OH^-]$ in a solution at 25.0 °C with pH = 4.282?

A) 9.72 B) 1.66×10^{4} C) 5.22×10^{-5} D) 1.91×10^{-10} E) 4.28

32. Calculate the pOH of a solution at 25.0 °C that contains 1.94 × 10-10 M hydronium ions $[H_3O^+]$?.

A) 1.94 B) 7.00 C) 9.71 D) 4.29 E) 14.0

33. Calculate the concentration (in M) of hydronium ions $[H_3O^+]$ in a solution at 25.0 °C with a pOH of 4.223.

A) 5.99×10^{-19} B) 5.98×10^{-5} C) 1.00×10^{-7} D) 1.67×10^{-10} E) 1.67×10^{4}

34. What is the pH of a 0.0150 M aqueous solution of barium hydroxide $Ba(OH)_2$?

A) 10.4 B) 1.52 C) 12.2 D) 12.5 E) 1.82

35. What is the pOH of a 0.0150 M solution of barium hydroxide $Ba(OH)_2$?

A) 12.2 B) 10.4 C) 1.82 D) 12.5 E) 1.52

36. An aqueous solution contains 0.100 M NaOH at 25.0 °C. The pH of the solution is _____.

A) 1.00 B) -1.00 C) 7.00 D) 13.0 E) 0.100