Acids, Bases, and Properties - HW

PSI AP Chemistry Name_____

Earlier definitions, conjugate acid/base, strong and weak acids and bases, Ka and Kb relation to the strength of the acid or base, pH, pOH, [OH-], [H+] , percent ionization of weak acid /base

1) According to the Arrhenius concept, an acid is a substance that _____.
A) is capable of donating one or more H^+
B) causes an increase in the concentration of H^+ in aqueous solutions
C) can accept a pair of electrons to form a coordinate covalent bond
D) reacts with the solvent to form the cation formed by autoionization of that solvent
E) tastes bitter

2) A Brϕnsted-Lowry base is defined as a substance that _____.
A) increases $[H^+]$ when placed in H_2O
B) decreases $[H^+]$ when placed in H_2O
C) increases $[OH^-]$ when placed in H_2O
D) acts as a proton acceptor
E) acts as a proton donor

3) A Brϕnsted-Lowry acid is defined as a substance that _____.
A) increases K_a when placed in H_2O
B) decreases $[H^+]$ when placed in H_2O
C) increases $[OH^-]$ when placed in H_2O
D) acts as a proton acceptor
E) acts as a proton donor

4) A substance that is capable of acting as both an acid and as a base is _____.
A) autosomal
B) conjugated
C) amphoteric
D) saturated
E) miscible

5) The molar concentration of hydronium ion in pure water at 25 °C is _____.
A) 0.00
B) 1.0×10^{-7}
C) 1.0×10^{-14}
D) 1.00
E) 7.00

6) The molar concentration of hydroxide ion in pure water at 25 °C is _____.
A) 1.00
B) 0.00
C) 1.0×10^{-14}
D) 1.0×10^{-7}
E) 7.00

7) The magnitude of K_w indicates that _____.
A) water autoionizes very slowly
B) water autoionizes very quickly
C) water autoionizes only to a very small extent
D) the autoionization of water is exothermic

8) In basic solution, _____.
A) $[H_3O^+] = [OH^-]$
B) $[H_3O^+] > [OH^-]$
C) $[H_3O^+] < [OH^-]$
D) $[H_3O^+] = 0$ M
E) $[OH^-] > 7.00$

9) Which solution below has the highest concentration of hydroxide ions?
A) pH = 3.21
B) pH = 12.6
C) pH = 7.93
D) pH = 9.82
E) pH = 7.00

10) Which one of the following statements regarding K_w is false?
A) pK_w is 14.00 at 25 °C
B) The value of K_w is 1.0×10^{-14}
C) K_w changes with temperature.
D) The value of K_w shows that water is a weak acid.
E) K_w is known as the ion product of water.

11) The hydride ion, H^-, is a stronger base than the hydroxide ion, OH^-. The product(s) of the reaction of hydride ion with water is/ are _____.
A) H_3O^+ (aq)
B) OH^- (aq) + H_2(aq)
C) OH^- (aq) + $2H^+$(aq)
D) no reaction occurs
E) H_2O_2 (aq)

12) An aqueous solution contains 0.10 M NaOH. The solution is _____.
A) very dilute
B) highly colored
C) basic
D) neutral
E) acidic

13) Nitric acid is a strong acid. This means that _____.
A) aqueous solutions of HNO_3 contain equal concentrations of H^+ (aq) and OH^- (aq)
B) HNO_3 does not dissociate at all when it is dissolved in water
C) HNO_3 dissociates completely to H^+ (aq and NO_3^- (aq) when it dissolves in water
D) HNO_3 produces a gaseous product when it is neutralized

E) HNO_3 cannot be neutralized by a weak base

14) Of the following acids, _____ is <u>not</u> a strong acid.
A) HNO_2
B) H_2SO_4
C) HNO_3
D) $HClO_4$
E) HCl

15) Of the following, _____ is a weak acid.
A) HF
B) HCl
C) HBr
D) HNO_3
E) $HClO_4$

16) Which one of the following is the weakest acid?

A) HF ($K_a = 6.8 \times 10^{-4}$)
B) HClO ($K_a = 3.0 \times 10^{-8}$)
C) HNO_2 ($K_a = 4.5 \times 10^{-4}$)
D) HCN ($K_a = 4.9 \times 10^{-10}$)
E) Acetic acid ($K_a = 1.8 \times 10^{-5}$)

17) Of the acids in the table below, _____ is the strongest acid.

Acid	K_a
HOAc	1.8×10^{-5}
$HCHO_2$	1.8×10^{-4}
HClO	3.0×10^{-8}
HF	6.8×10^{-4}

A) HOAc
B) $HCHO_2$
C) HClO
D) HF
E) HOAc and $HCHO_2$

18) The K_a of hypochlorous acid (HClO) is 3.0×10^{-8} at 25.0 ° C. What is the % ionization of hypochlorous acid in a 0.015 M aqueous solution of HClO at 25.0 ° C? (may use calculator)
A) 4.5×10^{-8}
B) 14
C) 2.1×10^{-5}
D) 0.14
E) 1.4×10^{-3}

19) In which of the following aqueous solutions does the weak acid exhibit the highest percentage ionization?
A) 0.01 M $HC_2H_3O_2$ ($K_a = 1.8 \times 10^{-5}$)

B) 0.01 M HNO_2 ($K_a = 4.5 \times 10^{-4}$)
C) 0.01 M HF ($K_a = 6.8 \times 10^{-4}$)
D) 0.01 M HClO ($K_a = 3.0 \times 10^{-8}$)
E) These will all exhibit the same percentage ionization.

20) Which one of the following is a Brϕnsted-Lowry acid?
A)$(CH_3)_3NH^+$
B) CH_3COOH
C) HF
D) HNO_2
E) all of the above

21) Classify the following compounds as weak acids (W) or strong acids (S):
benzoic acid nitric acid acetic acid
A) Weak Weak Weak
B) Strong Strong Strong
C) Strong Weak Weak
D) Weak Strong Strong
E) Weak Strong Weak

22) Classify the following compounds as weak acids (W) or strong acids (S):
hydrocyanic acid hydrofluroic acid phenol
A) Weak Weak Weak
B) Strong Strong Strong
C) Strong Weak Weak
D) Weak Strong Strong
E) Weak Strong Weak

23) Classify the following compounds as weak acids (W) or strong acids (S):
nitrous acid hydrochloric acid hydrofluoric acid
A) Weak Weak Weak
B) Strong Strong Strong
C) Strong Weak Weak
D) Weak Strong Strong
E) Weak Strong Weak

24) Classify the following compounds as weak acids (W) or strong acids (S):
hypochlorous acid perchloric acid chloric acid
A) Weak Strong Strong
B) Strong Strong Strong
C) Strong Weak Weak
D) Weak Weak Weak
E) Weak Strong Weak

25) Ammonia is a _____.
A) weak acid
B) strong base
C) weak base
D) strong acid

E) salt

26) Using the data in the table, which of the conjugate acids below is the weakest acid?

Base	K_b
ClO^-	3.3×10^{-7}
CO_3^{-2}	1.8×10^{-4}
HS^-	1.8×10^{-7}
NH_2CH_3	4.4×10^{-4}

A) HClO
B) HCO_3^-
C) H_2S
D) $NH_3CH_3^+$
E) H_2S and HClO

27) Using the data in the table, which of the conjugate acids below is the strongest acid?

Base	K_b
NH_3	1.8×10^{-5}
C_5H_5N	1.7×10^{-9}
H_2NOH	1.1×10^{-8}
NH_2CH_3	4.4×10^{-4}

A) NH_4^+
B) $C_5H_5NH^+$
C) H_3NOH^+
D) $NH_3CH_3^+$
E) NH_4^+ and $NH_3CH_3^+$

28) Using the data in the table, which of the conjugate acids below is the weakest acid?

Base	K_b
NH_3	1.8×10^{-5}
C_5H_5N	1.7×10^{-9}
H_2NOH	1.1×10^{-8}
NH_2CH_3	4.4×10^{-4}

A) NH_4^+
B) $C_5H_5NH^+$
C) H_3NOH^+
D) $NH_3CH_3^+$
E) NH_4^+ and $NH_3CH_3^+$

29) Which of the following ions will act as a weak base in water?

A) OH^-
B) Cl^-
C) NO_3^-
D) ClO^-
E) None of the above will act as a weak base in water.

30) Which of the following ions will act as a weak base in water?
A) HS^-
B) F^-
C) NO_2^-
D) ClO^-
E) All of the above will act as a weak base in water.

31) Which of the following aqueous solutions has the highest $[OH^-]$?
A) a solution with a pH of 3.0
B) a 1 X 10^{-4} solution of HNO_3
C) a solution with a pOH of 12.0
D) pure water
E) a 1 X 10^{-3} solution of NH_4Cl

32) Which of the following aqueous solutions has the lowest $[OH^-]$?
A) a solution with a pH of 3.0
B) a 1 X 10^{-4} solution of HNO_3
C) a solution with a pOH of 12.0
D) pure water
E) a 1 X 10^{-3} solution of NH_4Cl

33) An aqueous solution of a particular compound has pH = 2.46. The compound is _____.
A) a weak base
B) a weak acid
C) a strong acid
D) a strong base
E) a salt

34) Complete the following table for each aqueous solution at 25^0C

$[H_3O^+]$	$[OH^-]$	pH	pOH	Acidic or basic
2.0 x10^{-5}				
		6.25		
	5.6x 10^{-2}			
			9.20	
8.7x 10^{-10}				

35) What is the $[H^+]$ when $[OH^-] = 8.1 \times 10^{-5}$?
A) 8.1 x 10^{-5} M B) 1.0 x 10^{-7} M C) 1.2 x 10^{-10} M D)3.6 x 10^{-6} M
E) 8.1 x 10^{-5} M

36) What is the $[H^+]$ when $[OH^-] = 3.3 \times 10^{-9}$?

A) 3.0×10^{-6} M B) 1.0×10^{-7} M C) 3.3×10^{-5} M D) 6.6×10^{-5} M
E) 3.3×10^{-9} M

37) What is the $[H^+]$ in a 0.0025 M HCl solution?
A) 1.0×10^{-7} M B) 4.0×10^{-12} M C) 2.5×10^{-3} M D) 3.6×10^{-5} M
E) need more info

38) What is the $[OH^-]$ in a 0.0050 M HCl solution?
A) 5.0×10^{-3} M B) 1.0 M C) 1.0×10^{-7} M D) 6.6×10^{-5}
E) 2.0×10^{-12} M

39) A solution in which $[H^+] = 10^{-8}$ has a pH of ___ and is _____.
A) 8, acidic B) 6, basic C) -6, basic D) -8, neutral
E) 8, basic

40) What is the pH of a 0.00030 M HNO_3 solution?
A) 8.11 B) 2.22 C) 3.52 D) 4.48
E) none of these

41) What is the pH of a 0.0060 M KOH solution?
A) 5.12 B) 2.22 C) 11.72 D) 8.88
E) 7.00

42) A sample of lemon juice is found to have a pH of 2.55. What is the $[H^+]$ concentration of the juice?
A) 0.0035 M B) 0.0028 M C) 11.6 M D) 0.0080 M
E) 355 M

43) A sample of milk is found to have a pH of 6.60. What is the OH^- concentration of the milk?
A) 2.5×10^{-21} M B) 1.0×10^{-7} M C) 5.0×10^{-7} M D) 4.0×10^{-8} M E) 2.5×10^{-7} M

May use the calculator for the following problems:

44) What is the conjugate acid of NH_3?
A) NH_3 B) NH_2^+ C) NH_3^+ D) NH_4^+ E) NH_4OH

45) The conjugate base of HSO_4^- is _____.
A) OH^- B) H_2SO_4 C) SO_4^{2-} D) HSO_4^+ E) H_3SO4^+

46) The conjugate acid of HSO_4^- is _____.
A) SO_4^{2-} B) H_2SO_4 C) HSO_4^+ D) H^+ E) HSO_3^+

47) What is the conjugate base of OH^-?
A) O_2 B) O^- C) H_2O D) O^{2-} E) H_3O^+

48) What is the pH of an aqueous solution at 25.0 °C in which $[H^+]$ is 0.0025 M?
A) 3.40 B) 2.60 C) -2.60 D) -3.40 E) 2.25

49) What is the pH of an aqueous solution at 25.0 °C in which $[OH^-]$ is 0.0025 M?
A) +2.60 B) -2.60 C) +11.4 D) -11.4 E) -2.25

50) What is the pH of an aqueous solution at 25.0 °C that contains 3.98×10^{-9} hydronium ion?
A) 8.400 B) 5.600 C) 9.000 D) 3.980 E) 7.000

51) What is the pH of an aqueous solution at 25.0 °C that contains 3.98×10^{-9} hydroxide ion?
A) 8.40 B) 5.60 C) 9.00 D) 3.98 E) 7.00

52) What is the concentration (in M) of hydronium ions in a solution at 25.0 °C with pH = 4.282?
A) 4.28 B) 9.71 C) 1.92×10^{-10} D) 5.22×10^{-5} E) 1.66×10^4

53) What is the concentration (in M) of hydroxide ions in a solution at 25.0 °C with pH = 4.282?
A) 4.28 B) 9.72 C) 1.91×10^{-10} D) 5.22×10^{-5} E) 1.66×10^4

54) Calculate the pOH of a solution at 25.0 °C that contains 1.94×10^{-10} hydronium ions.
A) 1.94 B) 4.29 C) 7.00 D) 14.0 E) 9.71

55) Calculate the concentration (in M) of hydronium ions in a solution at 25.0 °C with a pOH of 4.223.
A) 5.98×10^{-5} B) 1.67×10^{-10} C) 1.67×10^4 D) 5.99×10^{-19} E) 1.00×10^{-7}

56) What is the pH of a 0.015 M aqueous solution of barium hydroxide?
A) 12.48 B) 12.25 C) 1.82 D) 10.41 E) 1.52

57) What is the pOH of a 0.0150 M solution of barium hydroxide?
A) 12.2 B) 12.5 C) 1.52 D) 1.82 E) 10.4

58) An aqueous solution contains 0.100 M NaOH at 25.0 °C. The pH of the solution is _____.
A) 0.100 B) 1.00 C) 13.00 D) 7.00 E) -1.00

Dissociation of Weak acids and Bases, poly-protic acid dissociation, hydrolysis of salts, oxy-acids

59) HZ is a weak acid. An aqueous solution of HZ is prepared by dissolving 0.020 mol of HZ in sufficient water to yield 1.0 L of solution. The pH of the solution was 4.93 at 25.0 °C. The K_a of HZ is _____.
A) 1.2×10^{-5} B) 6.9×10^{-9} C) 1.4×10^{-10} D) 9.9×10^{-2} E) 2.8×10^{-12}

60) The pH of a 0.55 M aqueous solution of hypobromous acid, HOBr, at 25.0 °C is 4.48. What is the value of K_a for HOBr?
A) 2.0×10^{-9} B) 1.1×10^{-9} C) 6.0×10^{-5} D) 3.3×10^{-5} E) 3.0×10^{4}

61) A 0.15 M aqueous solution of the weak acid HA at 25.0 °C has a pH of 5.35. The value of K_a for HA is _____.
A) 3.0×10^{-5} B) 1.8 X 10-5 C) 7.1×10^{-9} D) 1.3×10^{-10} E) 3.3×10^{-4}

62) The K_a of hypochlorous acid (HOCl) is 3.0×10^{-8} at 25.0 °C. Calculate the pH of a 0.0385 M hypochlorous acid solution.
A) 1.41 B) 8.94 C) 4.47 D) 7.52 E) -1.41

63) The K_a of hypochlorous acid (HOCl) is 3.0×10^{-8}. What is the pH at 25.0 °C of an aqueous solution that is 0.0200 M in HOCl?
A) +2.45 B) -2.45 C) -9.22 D) +9.22 E) +4.61

64) The K_a of hydrofluoric acid (HF) at 25.0 °C is 6.8×10^{-4}. What is the pH of a 0.35 M aqueous solution of HF?
A) 3.25 B) 1.81 C) 3.64 D) 0.46 E) 1.22

65) The K_a of hydrazoic acid (HN_3) is 1.9×10^{-5} at 25.0 °C. What is the pH of a 0.35 M aqueous solution of HN_3?
A) 1.14 B) 2.41 C) 5.23 D) 2.59 E) -2.46

66) The acid-dissociation constants of sulfurous acid (H_2SO_3) are $K_{a1} = 1.7 \times 10^{-2}$ and $K_{a2} = 6.4 \times 10^{-8}$ at 25.0 °C. Calculate the pH of a 0.163 M aqueous solution of sulfurous acid.
A) 4.53 B) 1.30 C) 1.86 D) 6.21 E) 1.93

67) The acid-dissociation constants of phosphoric acid (H_3PO_4) are $K_{a1} = 7.5 \times 10^{-3}$, $K_{a2} = 6.2 \times 10^{-8}$ and $K_{a3} = 4.2 \times 10^{-13}$ at 25.0 °C. What is the pH of a 2.5 M aqueous solution of phosphoric acid?
A) 1.82 B) 0.40 C) 2.51 D) 0.88 E) 0.13

68) The pH of a 0.10 M solution of a weak base is 9.82. What is the K_b for this base?
A) 2.1×10^{-4} B) 4.4×10^{-8} C) 8.8×10^{-8} D) 6.6×10^{-4} E) 2.0×10^{-5}

69) Calculate the pH of a 0.500 M aqueous solution of NH_3. The K_b of NH_3 is 1.77×10^{-5} is
A) 8.95 B) 11.47 C) 2.52 D) 5.05 E) 3.01

70) Determine the pH of a 0.35 M aqueous solution of CH_3NH_2 (methylamine). The K_b of methylamine is 4.4×10^{-4}
A) 10.00 B) 3.86 C) 12.09 D) 1.96 E) 13.24

71) An aqueous solution contains 0.050 M of methylamine. The concentration of hydroxide ion in this solution is _____ M. K_b for methylamine is 4.4×10^{-4}

A) 0.050 B) 2.2×10^{-5} C) 2.9×10^{-3} D) 4.5×10^{-3} E) 4.7×10^{-3}

72) The acid-dissociation constant, K_a, for gallic acid is 4.57×10^{-3}. What is the base-dissociation constant, K_b, for the gallate ion?

A) 4.5×10^{-3} B) 2.19×10^{-12} C) 5.43×10^{-5} D) 7.81×10^{-6} E) 2.91×10^{-2}

73) The base-dissociation constant, K_b, for pyridine, C_5H_5N, is 1.4×10^{-9}. The acid-dissociation constant, K_b, for the pyridinium ion, $C_5H_5NH^+$ is _____.

A) 1.0×10^{-7} B) 1.4×10^{-23} C) 7.1×10^{-4} D) 1.4×10^{-5} E) 7.1×10^{-6}

74) The K_a for HCN is 4.9×10^{-10}. What is the value of K_b for CN^-?

A) 2.0×10^{-5} B) 4.0×10^{-6} C) 4.9×10^{4} D) 4.9×10^{-24} E) 2.0×10^{9}

75) K_a for HF is 7.0×10^{-4}. K_b for the fluoride ion is _____.

A) 2.0×10^{-8} B) 1.4×10^{-11} C) 7.0×10^{-18} D) 7.0×10^{-4} E) 1.4×10^{3}

76) Calculate the pOH of a 0.0827 M aqueous sodium cyanide solution at 25.0 °C. K_b for CN^- is 4.49×10^{-10}.

A) 9.33 B) 10.00 C) 5.20 D) 1.17 E) 8.89

77) Determine the pH of a 0.15 M aqueous solution of KF. For hydrofluoric acid, $K_a = 7.0 \times 10^{-4}$.

A) 12.01 B) 5.85 C) 8.17 D) 2.32 E) 6.68

78) Calculate the pH of 0.726 M anilinium hydrochloride ($C_6H_5NH_3Cl$) solution in water, given that K_b for aniline is 3.83×10^{-4}.

A) 1.77 B) 12.2 C) 5.36 D) 8.64 E) 12.4

79) K_b for NH_3 is 1.8×10^{-5}. What is the pH of a 0.35 M aqueous solution of NH_4Cl at 25.0 °C?

A) 9.76 B) 4.35 C) 9.11 D) 4.86 E) 11.23

80) The K_a for formic acid (HCO_2H) is 1.8×10^{-4}. What is the pH of a 0.35 M aqueous solution of sodium formate ($NaHCO_2$)?

A) 11.64 B) 5.42 C) 3.39 D) 8.64 E) 4.26

81) K_a for HCN is 4.9×10^{-10}. What is the pH of a 0.068 M aqueous solution of sodium cyanide?

A) 0.74 B) 2.96 C) 11.07 D) 13.24 E) 7.00

82) K_a for HX is 7.5×10^{-12}. What is the pH of a 0.15 M aqueous solution of NaX?

A) 7.97 B) 1.96 C) 6.00 D) 8.04 E) 12.10

83) The pH of a 0.15 M aqueous solution of NaZ (the sodium salt of HZ) is 10.7. What is the K_a for HZ?

A) 1.6×10^{-6} B) 6.0×10^{-9} C) 8.9×10^{-4} D) 1.3×10^{-12} E) 3.3×10^{-8}

84) What is the concentration of OCl^- in a 0.60 M solution of HOCl? $K_a = 3.1 \times 10^{-8}$.

A) 1.8×10^{-4} M B) 7.1×10^{-11} M C) 0.40 M D) 1.4×10^{-4} M E) 1.1×10^{-4} M

85) What is the pH of a 0.50 M solution of $NaNO_2$? For HNO_2, $K_a = 4.5 \times 10^{-4}$.

A) 12.18 B) 5.48 C) 1.82 D) 8.52 E) 7.00

86) What is the pH of a 1.0 M solution of NaOCl? For HOCl, $K_a = 3.1 \times 10^{-8}$.

A) 10.75 B) 3.25 C) 3.75 D) 10.25 E)7.00

87) What is the pH of a 1.0×10^{-2} molar solution of HCN? (For HCN, Ka = 4.0×10^{-10})

A) 10
B) Between 7 and 10
C) 7
D) Between 4 and 7
E) 4

88) What is the pH of a 0.020 M solution of hydrosulfuric acid, a diprotic acid?
$K_{a1} = 1.1 \times 10^{-7}$ $K_{a2} = 1.0 \times 10^{-14}$

A) 7.00 B) 9.67 C) 7.84 D) 4.33 E) 3.05

89) What is the concentration of CO_3^{2-} in a 0.010 M solution of carbonic acid? The relevant equilbria are,

$H_2CO_3 \leftrightarrow H^+ + HCO_3^-$ $K_{a1} = 4.3 \times 10^{-7}$

$HCO_3^- \leftrightarrow H^+ + CO_3^{2-}$ $K_{a2} = 5.6 \times 10^{-11}$

A) 6.6×10^{-5} M B) 5.6×10^{-11} M C) 6.7×10^{-11} M D) 7.5×10^{-7} M
E) 7.9×10^{-7} M

90) What is the S^{2-} concentration in a saturated solution (0.10 M) of H_2S, in which the pH has been adjusted to 6.00 by the addition of HCl? For H_2S, $K_{a1} = 1.1 \times 10^{-7}$ and $K_{a2} = 1.0 \times 10^{-14}$.

A) 1.1×10^{-16} M B) 1.1×10^{-10} M C) 1.0×10^{-2} M D) 3.2×10^{-8} M
E) 3.2×10^{-6} M

91) Of the following substances an aqueous solution of ____ will form basic solution.

NH_4Cl $Cu(NO_3)_2$ K_2CO_3 NaF

A. NH_4Cl, $Cu(NO_3)_2$
B. K_2CO_3, NH_4Cl
C. NaF only
D. NaF, K_2CO_3
E. NH_4Cl only

92) A 0.1M aqueous solution of _____ will have a pH of 7.0 at 25C.

A. NaOCl
B. KCl
C. NH_4Cl
D. $Ca(OAc)_2$
E. None of these

93) A 0.1M solution of ___ has a pH of 7.0

A. Na_2S
B. KF
C. $NaNO_3$
D. NH_4Cl
E. NaF

94) An Aqueous solution of _____will produce a basic solution.

A. NH_4ClO_4
B. KBr
C. NaCl
D. Na_2CO_3
E. $NaHCO_3$

95) Which of the following salts will result in a basic solution when it is dissolved in water?

A) KCl
B) NH_4I
C) NaCN
D) $MgBr_2$
E) none of these

96) Of the following which is the strongest acid?

A) HIO
B) HIO_4
C) HIO_2
D) HIO_3
E) all nearly the same

97) of the following which is the strongest acid?

A) CH_3COOH
B) $ClCH_2COOH$
C) $Cl_2CHCOOH$
D) Cl_3CCOOH
E) $BrCH_2COOH$

98) which of the following is the strongest?

A) H_2SO_4
B) HSO_4^-
C) H_2SO_3
D) H_2SeO_4
E) HSO_3^-

99) Which of the following is the strongest?

A) HClO

B) HF
C) HBr
D) HI
E) HCl

Conceptual Questions: No calculator

1) Write the name and formula for the conjugate bases of the following.
A) HNO_2
B) H_2SO_4
C) $H_2PO_4^-$
D) HF
E) CH_3COOH

2) For each of the following predict whether an aqueous solution would be acidic, basic or neutral?
A) Sodium nitrate $NaNO_3$
B) Ammonium iodide NH_4I
C) Sodium bicarbonate $NaHCO_3$
D) Ammonium cyanide NH_4CN
E) Sodium hypochlorite NaOCl
F) Potassium acetate KCH_3CO_2

3) Complete the Brϕnsted-Lowry equilibria, label the components acid or base and pair up the conjugate acid base pairs.
A) $HSO_4^- + H_2O \rightarrow$
B) $NH_3 + H_2O \rightarrow$
C) $CN^- + H_2O \rightarrow$
D) $H^- + H_2O \rightarrow$
E) $HClO_4 + H_2O \rightarrow$

4) In the laboratory, H_2 (g) can be produced by adding which of the following to 1M HCl(aq)?
I. 1M NH_3 II. Zn(s) III. $NaHCO_3$(s)

A) I only
B) II only
C) III only
D) I and II only
E) I, II and III

5) $2NH_3 \leftrightarrow NH_4^+ + NH_2^-$ In liquid ammonia, the reaction represented above occurs. In the reaction, NH_4^+ acts as
A) a catalyst
B) both an acid and base
C) the conjugate acid of NH_3
D) the reducing agent
E) the oxidizing agent

6) At 25^0C, aqueous solution with a pH of 8 have a hydroxide ion concentration , $[OH^{-1}]$, of
   A) $1x10^{-14}$ M
   B) $1x10^{-8}$ M
   C) $1x10^{-6}$ M
   D) 1 M
   E) 8 M

7) How can 100 ml sodium hydroxide solution with a pH of 13 be converted to a sodium hydroxide solution of pH 12?
   A) By diluting the solution with distilled water to a total volume of 108 ml
   B) by diluting the solution with distilled water to a total volume of 200mL
   C) by diluting to a total volume of 1.00L
   D) By adding 100mL of 0.10M HCl
   E) By adding 100mL of 0.01M NaOH

8) The pH of a solution prepared by the addition of 10 mL of 0.002M KOH (aq) to 10mL of distilled water is close to
   A) 12
   B) 11
   C) 10
   D) 4
   E) 3

9) In solution, which of the following has the greatest $[H_3O^+]$?
   A) HCN
   B) HNO_3
   C) H_2O
   D) OH^-
   E) CH_3OH

10) Which of the following is not true for a solution at 25ºC that has a hydroxide concentration of 1.0×10^{-6} M?
   A) $Kw = 1 x10^{-14}$
   B) the solution is acidic
   C) The solution is basic
   D) $[H^+] = 1x10^{-8}$M
   E) the pOH is 6.0

11) Equal volumes of two solutions of pH 3 and pH 4 are mixed. The pH of the resulting solution will be
   A) 7
   B) 3.5
   C) 2.96
   D) 3.26
   E) 3.5

12) The pH of 1.0 x10^{-8} M solution of HCL in water is

A) 8
B) -8
C) between 7 and 8
D) between 6 and 7
E) between 8 and 9

13) Which of the following will occur if a 0.1M solution of a weak acid is diluted to 0.01 M at constant temperature?

A) [H+] will decrease to 0.01M
B) pH will decrease
C) percentage ionization will increase
D) Ka will increase
E) nothing will happen

14) Which of the following ions is the strongest Lewis acid?

A) Na^+
B) Cl^-
C) CH_3COO^-
D) Mg^{2+}
E) Al^{3+}

15) Each of the following can act as both a Brönsted acid and a Brönsted base EXCEPT

A) HCO_3^-
B) $H_2PO_4^-$
C) NH_4^+
D) H2O
E) HS^-

16) Which, if any, of the following species is in the greatest concentration in a 0.100-molar solution of H_2SO_4 in water?

A) H_2SO_4 molecules
B) H_3O^+ ions
C) HSO_4^- ions
D) SO_4^{2-} ions
E) All species are in equilibrium and therefore have the same concentrations

17) HSO_4^- + H_2O <===> H_3O^+ + SO_4^{2-}
In the equilibrium represented above, the species that act as bases include which of the following?

I. HSO_4^-
II. H_2O
III. SO_4^{2-}

A) II only
B) III only
C) I and II
D) I and III
E) II and III

18) Which of the following acids can be oxidized to form a stronger acid?

A) H_3PO_4
B) HNO_3
C) H_2CO_3
D) H_3BO_3
E) H_2SO_3

19) The reaction represented below has an equilibrium constant equal to 3.7×10^4. Which of the following can be concluded from this information?

$HC_2H_3O_2(aq) + CN^-(aq)$ <===> $HCN(aq) + C_2H_3O_2^-(aq)$

A) $CN^-(aq)$ is a stronger base than $C_2H_3O_2^-(aq)$
B) $HCN(aq)$ is a stronger acid than $C_2H_3O_2^-(aq)$
C) The conjugate base of $CN^-(aq)$ is $C_2H_3O_2^-(aq)$
D) The equilibrium constant will increase with an increase in temperature.
E) The pH of a solution containing equimolar amounts of $CN^-(aq)$ and $C_2H_3O_2^-(aq)$) is 7.0.

20) When a 0.1M solutions of HF, HCl , KF and KCl are arranged in order of increasing pH which order is correct?
A) HF, HCl, KF, KCl
B) HCl, HF, KF, KCl
C) HCl, HF, KCl, KF
D) HF, HCl, K Cl, KF
E) KCl, KF, HF, HCl

21) Which is not a conjugate acid/base pair?
A) H_2CO_3 and CO_3^{2-}
B) HSO_4^- and SO_4^{2-}
C) $H_2PO_4^-$ and HPO_4^{2-}
D) H_3O^+ and H_2O
E) HNO_3 and NO_3^-

22) What is the $[OH^-]$ in an aqueous solution which has a pH =11

A) 1.0×10^{-3}
B) 1.0×10^{-4}
C) 4.0×10^{-11}
D) 1.0×10^{-2}
E) 1.0×10^{3}

Answers:

1B	9B	17D	25C	33C	41C	49C	57C	65D	73E	81C	89B	97D
2D	10D	18E	26D	34©	42B	50A	58C	66B	74A	82E	90B	98A
3E	11B	19C	27B	35C	43D	51B	59B	67D	75B	83B	91D	99D
4C	12C	20E	28D	36A	44D	52D	60A	68B	76C	84D	91B	
5BD	13C	21E	29D	37C	45C	53C	61D	69B	77C	85D	93C	
6C	14A	22A	30E	38E	46B	54B	62C	70C	78C	86A	94D	
7C	15A	23E	31D	39E	47D	55B	63E	71D	79D	87D	95C	
8C	16D	24A	32C	40C	48B	56A	64B	72B	80D	88D	96B	

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$[H_3O^+]$	$[OH^-]$	pH	pOH	acidic or basic
2.0×10^{-5}	5.0×10^{-10}	4.70	9.30	acidic
5.6×10^{-7}	1.8×10^{-8}	6.25	7.75	acidic
1.8×10^{-13}	5.6×10^{-2}	12.75	1.25	basic
1.6×10^{-5}	6.3×10^{-10}	4.80	9.20	acidic
8.7×10^{-10}	1.1×10^{-5}	9.06	4.94	basic

Explanation for some of the above answers in the table;

85)

NO_2^-	+	$H2O$	↔	HNO_2	+	OH^-
0.5				*0*		*0*
-x				*+x*		*+x*
0.5-x				*x*		*x*

$K_b = K_w/K_a = [HNO_2]\,[OH^-]/\,[NO_2]^- = x^2 / 0.5 = 2.22 \times 10^{-11}$
pH = 14 – pOH = 8.52

88) Only the first dissociation is significant so only K_{a1} is needed

89) . From the first dissociation, $[H^+] = [HCO^{3-}]$. The second dissociation does not change this much. $K_{a2} = [H^+]\,[CO_3^{2-}]\,/[HCO_3^-]$. But $[H^+] = [HCO_3^-]$ and cancel each other out.
So $K_{a2} = [CO_3^{2-}] = 5.6 \times 10^{-11}$

90) Combine the two dissociations
$H_2S \leftrightarrow H^+ + HS^-$
$HS^- \leftrightarrow H^+ + S^{2-}$

$H_2S \leftrightarrow 2H^+ + S^{2-}$

$K = K_{a1} \times K_{a2}$ $1.1 \times 10^{-21} = \frac{[H^+]^2[S^{2-}]}{[H_2S]}$

$[S^{2-}] = k[H_2S] / [H^+]^2 = 1.1 \times 10^{-10}$

Conceptual questions:

1)

A) NO_2^- nitrite
B) HSO_4^- hydrogen sulfate
C) HPO_4^{2-} hydrogen phosphate
D) F^- fluoride
E) CH_3COO^- acetate

2)

A) Neutral
B) Acidic
C) Basic
D) Neutral
E) Basic
F) basic

3)

A) (A) HSO_4^- + (B) $H_2O \rightarrow$ (CB) SO_4^{2-} + (CA) H_3O^+
B) (B) NH_3 + (A) $H_2O \rightarrow$ (CA) NH_4^+ + (CB) OH^-
C) (B) CN^- + (A) $H_2O \rightarrow$ (CA) HCN + (CB) OH^-
D) (B) H^- + (A) $H_2O \rightarrow$ (CA) H_2 + (CB) OH^-
E) (A) $HClO_4$ + (B) $H_2O \rightarrow$ (CB) ClO_4^- + (CA) H_3O^+

4 B	9 B	14 E	19 A
5 C	10 B	15 C	20 C
6 C	11 D	16 B	21 A
7 C	12 A	17 E	22 A
8 B	13 C	18 E	

Free Response Questions:

1) The overall dissociation of oxalic acid, $H_2C_2O_4$, is represented below. The overall dissociation constant is also indicated.

$$H_2C_2O_4 \leftrightarrow 2\ H^+ + H_2C_2O_4^{2-} \qquad K = 3.78 \times 10^{-6}$$

(a) Give the equations representing the first and second dissociations of oxalic acid.

(b) Calculate the value of the first dissociation constant, K_1, for oxalic acid if the value of the second dissociation constant, K_2, is 6.40×10^{-5}.

(c) To a 0.015-molar solution of oxalic acid, a strong acid is added until the pH is 0.5. Calculate the $[C_2O_4^{2-}]$ in the resulting solution. (Assume the change in volume is negligible.)

(d) Calculate the value of the equilibrium constant, K_b, for the reaction that occurs when solid $Na_2C_2O_4$ is dissolved in water. (Do later)

2) H_3PO_2, H_3PO_3, and H_3PO_4 are monoprotic, diprotic and triprotic acids, respectively, and they are about equal strong acids.
$HClO_2$, $HClO_3$, and $HClO_4$ are all monoprotic acids, but $HClO_2$ is a weaker acid than $HClO_3$ which is weaker than $HClO_4$. Account for:

(a) The fact that the molecules of the three phosphorus acids can provide different numbers of protons.

(b) The fact that the three chlorine acids differ in strengths.

3) The value of the ionization constant, K_a, for hypochlorous acid, HOCl, is 3.1×10^{-8}.

(a) Calculate the hydronium ion concentration of a 0.050 molar solution of HOCl.

(b) Calculate the concentration of hydronium ion in a solution prepared by mixing equal volumes of 0.050 molar HOCl and 0.020 molar sodium hypochlorite, NaOCl.

(c) A solution is prepared by the disproportionate reaction below. <u>(Do later)</u>
$Cl_2 + H_2O \rightarrow HCl + HOCl$

Calculate the pH of the solution if enough chlorine is added to water to make the concentration of HOCl equal to 0.0040 molar.

4) Methylamine CH_3NH_2, is a weak base that ionizes in solution as shown by the following equation.

$$CH_3NH_2 + H_2O \leftrightarrow CH_3NH_3^+ + OH^-$$

(a) At 25ºC the percentage ionization in a 0.160 molar solution of CH_3NH_2 is 4.7%. Calculate $[OH^-]$, $[CH_3NH_3^+]$, $[CH_3NH_2]$, $[H_3O^+]$, and the pH of a 0.160 molar solution of CH_3NH_2 at 25ºC.

(b) Calculate the value for K_b, the ionization constant for CH_3NH_2, at 25ºC.

5) The acid ionization constant, K_a, for propanoic acid, C_2H_5COOH, is 1.3×10^{-5}.

(a) Calculate the hydrogen ion concentration, $[H^+]$, in a 0.20-molar solution of propanoic acid.

(b) Calculate the percentage of propanoic acid molecules that are ionized in the solution in (a).

(c) What is the ratio of the concentration of propanoate ion, $C_2H_5COO^-$, to that of propanoic acid in a buffer solution with a pH of 5.20?

6) In water, hydrazoic acid, HN_3, is a weak acid that has an equilibrium constant, K_a, equal to 2.8×10^{-5} at 25ºC. A 0.300 L sample of a 0.050M solution of the acid is prepared.

(a) Write the expression for the equilibrium constant, K_a, for hydrazoic acid.

(b) Calculate the pH of this solution at 25ºC.

7) $NH_3(aq) + H_2O(l) \leftrightarrow NH_4^+(aq) + OH^-(aq)$

$$NH_3(aq) + H_2O(l) \leftrightarrow NH_4^+(aq) + OH^-(aq)$$

In aqueous solution, ammonia reacts as represented above. In 0.0180*M* $NH_3(aq)$ at 25ºC, the hydroxide ion concentration, $[OH^-]$ is $5.60 \times 10^{-4} M$. In answering the following, assume that temperature is constant at 25ºC and that volumes are additive.

(a) Write the equilibrium-constant expression for the reaction represented above.

(b) Determine the pH of 0.0180*M* $NH_3(aq)$.

(c) Determine the value of the base ionization constant, K_b, of $NH_3(aq)$.

(d) Determine the percent ionization of NH_3 in 0.0180*M* $NH_3(aq)$.

8) $C_6H_5NH_2\ (aq) + H_2O\ (aq) \leftrightarrow C_6H_5NH_3^+\ (aq) + OH^-\ (aq)$

Aniline, a weak base, reacts with water according to the reaction represented above.

(a) Write the equilibrium constant expression, K_b, for the reaction represented above.

(b) A sample of aniline is dissolved in water to produce 25.0 mL of a 0.10*M* solution. The pH of the solution is 8.82. Calculate the equilibrium constant, K_b, for this reaction.

Answers:

1. a) $H_2C_2O_4^- \leftrightarrow H^+ + HC_2O_4^-$ (eq. constant = K_1)

$HC_2O_4^- \leftrightarrow H^+ + C_2O_4^{2-}$ (eq. constant = K_2)

b) $H_2C_2O_4 \rightarrow H^+ + HC_2O_4^{-1}$ K_1

$HC_2O_4^{-1} \rightarrow H^+ + HC_2O_4^{-2}$ K2

$K = K_1 \times K_2$

$K_1 = K/K_2$

$= 3.78 \times 10^{-6}/6.40 \times 10^{-5} = 5.91 \times 10^{-2}$

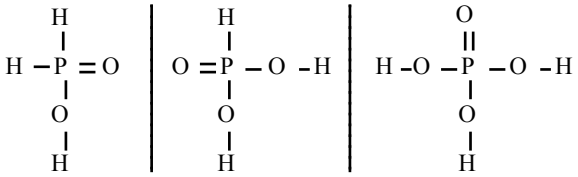
c) $K = [H^+]^2 [C2O4^{2-}]$ / $[H_2C_2O_4]$ $= 3.78 \times 10^{-6} = (0.316)^2 (x) / (0.015)$

$X = 5.68 \times 10^{-7}$ M

d) $C_2O_4^{-2} + H_2O \leftrightarrow HC_2O_4^- + OH^-$

$K_b = K_w/K_a$ $1.0 \times 10^{-14}/6.40 \times 10^{-5} = 1.56 \times 10^{-10}$

2. (a) The structure for the three acids are as follows:



The hydrogen atom*(s)* bonded directly to the phosphorus atom is/are not acidic in aqueous solution; only those hydrogen atoms bonded to the oxygen atoms can be released as protons.

(b) The acid strength is successively greater as the number of oxygen atoms increases because the very electronegative oxygen atoms are able to draw electrons away from the chlorine atom and the O-H bond. This effect is more important as the number of attached oxygen atoms increases. This means that a proton is most readily produced by the molecule with the largest number of attached oxygen atoms.

3. (a) $HOCl + H_2O \leftrightarrow H_3O^+ + OCl^-$

$3.2 \times 10^{-8} = [H_3O^+][OCl^-] / [HOCl] = X^2 / (0.050 - X)$

$X = [H_3O^+] = 4.0 \times 10^{-5}$M

(b) $HOCl + H_2O \leftrightarrow H_3O^+ + OCl^-$

$[H_3O^+][0.020 + X] / [0.020 - X] = 3.1 \times 10^{-8}$ $X << 0.010$

$X = [H_3O^+] = 8.0 \times 10^{-8}$M

(c) $Cl_2 + H_2O$ --> $HCl + HOCl$

$[HOCl] = [HCl] = 0.0040$M

HCl as principal source of H_3O^+

$pH = -\log[H_3O^+] = 2.40$

4. (a) CH_3NH_2; $0.160\text{M} \times 4.7\% = 7.5 \times 10^{-3}$ M ionizing

$(0.160\text{M} - 0.0075\text{M}) = 0.152$ M at equilibrium

$[CH_3NH_3^+] = [OH^-] = 7.5 \times 10^{-3}$ M

$[H_3O^+] = \frac{K_w}{7.5 \times 10^{-5}} = 1.3 \times 10^{-12}$ M

$pH = -\log [H_3O^+] = 11.89$

(b) $K_b = \frac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]} = \frac{(7.5 \times 10^{-3})^2}{0.152}$

$= 3.7 \times 10^{-4}$

5. (a) $K_a = \frac{[H^+][C_2H_5COO^-]}{[C_2H_5COOH]}$ $[H^+] = [C_2H_5COO^-] = X$

$[C_2H_5COOH] = 0.20\ M - X \sim 0.20$ (assume x is small)

$\frac{x^2}{0.20} = 1.3 \times 10^{-5}$; $x = 1.6 \times 10^{-3}$ M $= [H^+]$

(b) From (a), x = amount of acid that ionized, therefore

$\frac{1.6 \times 10^{-3}}{0.20} \times (100) = 0.80\%$ ionized

(c) At pH = 5.20 $[H^+] = -\log (5.20) = 6.31 \times 10^{-6}$ M

$\frac{(6.31 \times 10^{-6})[C_2H_5COO^-]}{[C_2H_5COOH]} = K_a = 1.3 \times 10^{-5}$

$\frac{[C_2H_5COO^-]}{[C_2H_5COOH]} = \frac{2.1}{1}$

6. a) $K_a = [H^+][N_3^-]/[HN_3]$

(b) $[H^+] = [N_3^-] = x$

$2.8 \times 10^{-5} = x^2/0.050$; $x = 1.2 \times 10^{-3}$ M

$pH = -\log [H^+] = 2.92$

7. (a) $K_b = [NH_4^+][OH^-]/[NH_3]$

(b) $pOH = -\log (5.6 \times 10^{-4}) = 3.252$

$pH = 14 - 3.252 = 10.748$

(c) $K_b = (5.6 \times 10^{-4})^2/(0.0180 - 5.6 \times 10^{-4}) = 1.80 \times 10^{-5}$

(d) $(5.6 \times 10^{-4}/0.0180)100 = 3.11\%$

8. (a) $K_b = \frac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]\,[H_2O]}$

(b) $pH = 8.82$

$pOH = 14 - 8.82 = 5.18$

$[OH^-] = 10^{-5.18} = 6.61 \times 10^{-6}$ $[C_6H_5NH_3^+] = [OH^-] = 6.61 \times 10^{-6}$

$K_b = [C_6H_5NH_3^+][OH^-]/[C_6H_5NH_2] = 6.61 \times 10^{-6} / 0.10$

$K_b = 4.4 \times 10^{-10}$