General Chemistry II Jasperse
Acid-Base Chemistry. Extra Practice Problems

General Types/Groups of problems:

Conceptual Questions. Acids, Bases, and Conjugates, Miscellaneous

1. In the Brønsted–Lowry definition of acids and bases, an acid _____

   a. is a proton donor.
   b. is a proton acceptor.
   c. forms stable hydrogen bonds.
   d. breaks stable hydrogen bonds.
   e. corrodes metals.

2. In the Brønsted–Lowry definition of acids and bases, a base _____

   a. is a proton donor.
   b. is a proton acceptor.
   c. forms stable hydrogen bonds.
   d. breaks stable hydrogen bonds.
   e. corrodes metals.

3. In the following reaction in aqueous solution, the acid reactant is _____ and its conjugate base product is _____.

   a. CH_3COOH; CH_3COO^-
   b. CH_3COOH; NH_4^+
   c. NH_3; CH_3COO^-
   d. NH_3; NH_4^+
   e. CH_3COOH; H_3O^+

4. In the following reaction in aqueous solution, the acid reactant is _____, and its conjugate base product is _____.

   a. CH_3NH_2; $CH_3NH_3^+$
   b. CH_3NH_2; SO_4^{2-}
   c. HSO_4^-; $CH_3NH_3^+$
   d. HSO_4^-; SO_4^{2-}
   e. HSO_4^-; H_3O+

5. Which of the following is the conjugate acid of the hydrogen phosphate ion, HPO_4^{2-}?

   a. H_3PO_4
   b. $H_2PO_4^-$
   c. HPO_4^{2-}
   d. PO_4^{3-}
   e. H_3O^+

6. Which one of the following is *not* a conjugate acid–base pair?

a. NH_3 and NH_4^+
b. H_3O^+ and OH^-
c. $H_2PO_4^-$ and HPO_4^{2-}
d. HS^- and H_2S
e. NH_3 and NH_2^-

7. Which one of the following is a conjugate acid–base pair?

a. NH_3 and NH_4^+
b. H_3O^+ and OH^-
c. NH_2^- and NH_4^+
d. H_2O and O^{2-}
e. NaF and F^-

8. Which one of the following is a conjugate acid–base pair?

a. NaF and F^-
b. HNO_3 and HNO_2
c. HI and I^-
d. NH_4^+ and NH_2^-
e. H_2O and H_2O_2

9. Which one of the following is *not* a conjugate acid–base pair?

a. NH_3 and NH_2^-
b. HNO_3 and HNO_2
c. HI and I^-
d. $H_2PO_4^-$ and HPO_4^{2-}
e. H_2O and OH^-

10. The stronger the acid, _____

a. the stronger its conjugate base.
b. the weaker its conjugate base.
c. the more concentrated the acid.
d. the less concentrated the conjugate base.
e. the more concentrated the conjugate base.

11. Ammonia (NH_3) acts as a weak base in aqueous solution. What is the acid that reacts with this base when ammonia is dissolved in water?

a. none, there are no acids in pure water
b. H_2O
c. NH_4^+
d. trick question, because no acids are present, ammonia cannot act as a base
e. oxygen that always is dissolved in water

12. The base ionization constant K_b describes which of the following reactions for a weak base, B, in aqueous solution? (Note: often the base will be anionic rather than neutral, but "B" here is meant to represent anionic or neutral bases, which will gain one H and become one charge unit more positive whether starting neutral or anionic.)

a. $B + H^+ \rightleftharpoons BH^+$
b. $B + H_3O^+ \rightleftharpoons BH^+ + H_2O$
c. $B + H_2O \rightleftharpoons BH^+ + OH^-$
d. $B + OH^- \rightleftharpoons BH^- + O^{2-}$
e. $BH^+ + OH^- \rightleftharpoons B + H_2O$

Recognizing Strong versus Weak Acids; Recognizing Basic versus Nonbasic

13. Which of the following **is** a **strong acid**?

a. HNO_3
b. H_2S
c. HNO_2
d. HCO_3^-
e. HOCl

14. Which one of the following **is a strong acid**?

a. nitrous acid, HNO_2
b. sulfurous acid, H_2SO_3
c. carbonic acid, H_2CO_3
d. hydrofluoric acid, HF
e. perchloric acid, $HClO_4$

15. Which one of the following is ***not*** a **strong acid**?

a. nitric acid, HNO_3
b. sulfuric acid, H_2SO_4
c. carbonic acid, H_2CO_3
d. hydrochloric acid, HCl
e. perchloric acid, $HClO_4$

16. Which of the following compounds **cannot** be a Brønsted–Lowry **base**?

a. OH^-
b. H_2O
c. NH_3
d. NH_4^+
e. SH^-

17. Each of the following pairs contains one strong acid and one weak acid **EXCEPT**:

a. H_2SO_4 and H_2CO_3
b. HNO_3 and HNO_2
c. HBr and H_3PO_2
d. HSO_4^- and HCN
e. HCl and H_2S

18. Which **one** of the following is NOT **basic**?

a. OH^-
b. NO_3^-
c. NH_3
d. SO_4^{2-}
e. HPO_4^{2-}

19. Which **one** of the following **is basic**?

a. Cl^-
b. NO_3^-
c. ClO_4^-
d. HSO_4^-
e. SO_4^{2-}

pH Calculations; Relationships between pH and pOH

20. If the pH of a solution increases by 2 units (e.g., from 1 to 3), then the ratio of the new to the original hydronium ion concentration is _____

a. 2/1
b. 100/1
c. 1/2
d. 1/100.
e. 1/1, unchanged

21. When $[H^+] = 1.0 \times 10^{-7}$ *M* in water at 25°C, then _____

a. pH = 1.
b. pH = 10^{-7}.
c. $[OH^-] = 1.0 \times 10^{-7}$ *M*.
d. $[OH^-] = 1.0 \times 10^{7}$ *M*.
e. $[OH^-] = 0$ *M*.

22. When $[H^+] = 4.0 \times 10^{-9}$ M in water at 25°C, then _____

a. pH = 9.40.
b. pH = 7.00.
c. pH = –8.40.
d. pH = 8.40.
e. pH = –9.40

23. A solution with pH of 9.50 has a pOH of _____

a. 9.50.
b. 0.50.
c. 4.50.
d. 23.5.
e. 19.0.

24. A solution with an $[OH^-]$ concentration of 1.20×10^{-7} *M* has a pOH and pH of _____

a. 6.92 and 7.08
b. 1.00 and 13.00
c. 5.35 and 8.75
d. 7.08 and 6.92
e. 5.94 and 8.06

25. A solution with a pOH of 4.3 has a $[H^+]$ of _____

a. 6.8×10^{-9} *M*.
b. 3.2×10^{-4} *M*.
c. 4.8×10^{-5} *M*.
d. 2.0×10^{-10} *M*.
e. 4.3 *M*.

26. Which statement, A–D, is not correct? If all are correct, respond E. Pure water at 25°C has _____

a. $K_w = 1.0 \times 10^{-14}$.
b. pOH = 7.
c. $[H_3O^+] = [OH^-]$.
d. pH = 7.
e. A–D are all correct.

K_a: Sense + Calculations. Using K_a or pK_a to Calculate $[H^+]$ and/or pH; using pH to calculate K_a or pK_a

27. Solutions of each of the hypothetical acids in the following table are prepared with an initial concentration of 0.100 *M*. Which of the four solutions will have the lowest pH and be most acidic?

Acid	pK_a
HA	4.00
HB	7.00
HC	10.00
HD	11.00

a. HA
b. HB
c. HC
d. HD
e. All will have the same pH because the concentrations are the same.

28. What is the hydronium ion concentration of a 0.010 M solution of acetic acid? K_a for acetic acid is 1.8×10^{-5}

a. 1.8×10^{-3}
b. 1.8×10^{-5}
c. 1.0×10^{-2}
d. 1.8×10^{-7}
e. 4.2×10^{-4}

29. What is the pH of a 0.010 M solution of acetic acid? K_a for acetic acid is 1.8×10^{-5}

a. 2.74
b. 4.74
c. 2.00
d. 3.37
e. 6.74

30. When values of K_a are small (e.g., 1×10^{-5}) and concentrations of weak acids [HA] are relatively large (e.g., 0.10 *M*), and assuming there is no other source of anion A^-, the hydronium ion concentration of the solution can be calculated using which expression?

a. $[H^+] = K_a$
b. $[H^+] = K_a[HA]$
c. $[H^+] = (K_a[HA])^{1/2}$
d. $[H^+] = K_aK_b[HA]$
e. $[H^+] = K_a[HA]^2/[A^-]$

31. The first disinfectant used by Joseph Lister was called carbolic acid. This substance now is known as phenol, C_6H_5OH ($pK_a = 10.0$). What is the pH of a 0.10 *M* solution of phenol?

a. 3.5
b. 10.0
c. 6.5
d. 5.5
e. 4.5

32. The pH of a popular soft drink is 3.4; what is its hydronium ion concentration?

a. 5.0×10^{-4} *M*
b. 4.0×10^{-4} *M*
c. 2.5×10^{3} *M*
d. 1.0×10^{-7} *M*
e. 5.0×10^{-5} *M*

33. The concentration of acetic acid ($pK_a = 4.75$) in vinegar is about 1.0 *M*. With this information, what do you predict the pH of vinegar to be?

a. 4.75
b. 2.4
c. 4.0×10^{-3}
d. 7.0
e. 5.35

34. Boric acid frequently is used as an eyewash to treat eye infections. The pH of a 0.050 M solution of boric acid is 5.28. What is the value of the boric acid ionization constant, Ka?

a. 5.25×10^{-6}
b. 5.51×10^{-10}
c. 5.43×10^{-8}
d. 5.79×10^{-4}
e. 5.33×10^{-12}

35. A 0.100 *M* solution of a monoprotic weak acid has a pH of 3.00. What is the pK_a of this acid?

a. 5.00
b. 0.999
c. 3.00
d. 9.99
e. 6.00

36. The acidic ingredient in vinegar is acetic acid. The pH of vinegar is around 2.4, and the molar concentration of acetic acid in vinegar is around 0.85 *M*. Based on this information, determine the value of the acid ionization constant, K_a, for acetic acid.

a. 2.5×10^{-5}
b. 5.0×10^{-5}
c. 4.7×10^{-3}
d. 1.9×10^{-5}
e. 7.4×10^{-3}

37. Three acids found in foods are lactic acid (in milk products), oxalic acid (in rhubarb), and malic acid (in apples). The pK_a values are **LA = 3.88, OA = 1.23, and MA = 3.40**. Which list has these acids in order of decreasing acid strength?

a. LA > OA > MA
b. LA > MA > OA
c. OA > MA > LA
d. OA > LA > MA
e. MA > LA > OA

38. Use the following acid ionization constants to identify the correct decreasing order of base strengths.

HF	$K_a = 7.2 \times 10^{-4}$
HNO_2	$K_a = 4.5 \times 10^{-4}$
HCN	$K_a = 6.2 \times 10^{-10}$

a. $CN^- > NO_2^- > F^-$
b. $NO_2^- > F^- > CN^-$
c. $F^- > CN^- > NO_2^-$
d. $F^- > NO_2^- > CN^-$
e. $NO_2^- > CN^- > F^-$

K_b and pK_b, Base Strength, and using K_b or pK_b to Calculate $[OH^-]$, pOH, pH, and/or $[H^+]$

39. A cup of coffee has a hydroxide ion concentration of 1.0×10^{-10} *M*. What is the pH of this coffee?

a. 1.0×10^{-4}
b. 4
c. 10
d. 7
e. –10

40. What is the concentration of $[OH^-]$ in a 0.20 *M* solution of ammonia? The K_b value for ammonia is 1.8×10^{-5}.

a. 3.6×10^{-6} *M*
b. 1.8×10^{-5} *M*
c. 0.20 *M*
d. 1.9×10^{-3} *M*
e. 4.2×10^{-4} *M*

41. What is the pOH of a 0.20 *M* solution of ammonia? The K_b value for ammonia is 1.8×10^{-5}

a. 4.44
b. 4.74
c. 0.70
d. 2.72
e. 3.38

42. What is the pH of a 0.20 *M* solution of ammonia? The K_b value for ammonia is 1.8×10^{-5}

a. 9.56
b. 9.26
c. 4.74
d. 11.28
e. 2.72

43. What is the hydronium ion concentration of a 0.20 *M* solution of ammonia? The K_b value for ammonia is 1.8×10^{-5}

a. 2.8×10^{-10}
b. 5.5×10^{-10}
c. 1.8×10^{-5}
d. 5.2×10^{-12}
e. 1.9×10^{-3}

44. What is the pH of a 0.500 M solution of trimethylamine ($pK_b = 4.13$)?

a. 2.22
b. 11.8
c. 0.00609
d. 4.42
e. 5.91

Miscellaneous problems involving Weak Bases and perhaps their Conjugates.

45. Phosphoric acid is a triprotic acid, ionizing in the following sequential steps:

$H_3PO_4 + H_2O \rightleftharpoons H_2PO_4^- + H_3O^+$ $\quad K_a$
$H_2PO_4^- + H_2O \rightleftharpoons HPO_4^{2-} + H_3O^+$ $\quad K_a$
$HPO_4^{2-} + H_2O \rightleftharpoons PO_4^{3-} + H_3O^+$ $\quad K_a$

Write the K_b expression for the base, sodium phosphate (Na_3PO_4)?

46. Phosphoric acid is a triprotic acid, ionizing in the following sequential steps:

$H_3PO_4 + H_2O \rightleftharpoons H_2PO_4^- + H_3O^+$

$H_2PO_4^- + H_2O \rightleftharpoons HPO_4^{2-} + H_3O^+$

$HPO_4^{2-} + H_2O \rightleftharpoons PO_4^{3-} + H_3O^+$

Write the K_b expression for the base, sodium dihydrogen phosphate (NaH_2PO_4)?

47. Use the following acid ionization constants to identify the correct decreasing order of base strengths.

HF	$K_a = 7.2 \times 10^{-4}$
HNO_2	$K_a = 4.5 \times 10^{-4}$
HCN	$K_a = 6.2 \times 10^{-10}$

a. $CN^- > NO_2^- > F^-$
b. $NO_2^- > F^- > CN^-$
c. $F^- > CN^- > NO_2^-$
d. $F^- > NO_2^- > CN^-$
e. $NO_2^- > CN^- > F^-$

48. Three acids found in foods are lactic acid (in milk products), oxalic acid (in rhubarb), and malic acid (in apples). The pK_a values are LA = 3.88, OA = 1.23, and MA = 3.40. Which list has the conjugate bases of these acids in order of decreasing strength?

a. lactate > oxalate > malate
b. oxalate > malate > lactate
c. lactate > malate > oxalate
d. oxalate > lactate > malate
e. malate > lactate > oxalate

49. What is the pH of a 0.20 *M* solution of cubaramine? The K_b value for jaspersamine is 2.5×10^{-6}.

50. What is the pH of a 0.10 M solution of trimethylamine (pK_b = 4.13)?

51. How would you calculate K_b for the formate ion, given that the K_a for formic acid is 1.8×10^{-4}? ($K_w = 1.0 \times 10^{-14}$)

a. $K_b = K_a \times K_w$
b. $K_b = K_w / K_a$
c. $K_b = K_a / K_w$
d. $K_b = K_w + K_a$
e. $K_b = K_w - K_a$

52. What is the pH of a 0.20 *M* solution of jaspersamine? The pK_b value for jaspersamine 4.40.

53. What is the pH of a 0.15 *M* solution of weak acid ammonium bromide? The K_b value for ammonia is 1.8×10^{-5}.

a. 11.22
b. 7.00
c. 2.78
d. 5.04
e. 10.08

54. Phosphoric acid is a triprotic acid, ionizing in the following sequential steps:

$$H_3PO_4 + H_2O \rightleftharpoons H_2PO_4^- + H_3O^+$$
$$H_2PO_4^- + H_2O \rightleftharpoons HPO_4^{2-} + H_3O^+$$
$$HPO_4^{2-} + H_2O \rightleftharpoons PO_4^{3-} + H_3O^+$$

Which equilibrium is most important in determining the pH of a solution of sodium phosphate?

a. $HPO_4^{2-} + H_2O \rightleftharpoons PO_4^{3-} + H_3O^+$
b. $H_3PO_4 + H_2O \rightleftharpoons H_2PO_4^- + H_3O^+$
c. $PO_4^{3-} + H_2O \rightleftharpoons HPO_4^{2-} + OH^-$
d. $H_2PO_4^- + H_2O \rightleftharpoons H_3PO_4 + OH^-$
e. $2H_2O \rightleftharpoons H_3O^+ + OH^-$

55. Solutions of sodium salts of the acids in the following table are prepared with an initial concentration of 0.500 *M*. Which solution will have the highest pH and be the most basic?

Acid	**pK_a**
HA	4.00
HB	7.00
HC	10.00
HD	11.00

a. NaA
b. NaB
c. NaC
d. NaD
e. All will have the same pH because the concentrations are the same.

Getting Information about an Acid or Base Based on K_a or pK_a or K_b or pK_b of the conjugate.

56. What is the pH of a 0.20 *M* solution of sodium acetate? The K_a for acetic acid is 1.8×10^{-5}?

57. What is the pH of a 0.40 *M* solution of sodium nitrite, $NaNO_2$? The pK_a for nitrous acid (HNO_2) is 3.35.

58. What is the pH of a 0.20 *M* solution of weak acid jaspersammonium bromide? The K_b value for jaspersamine is 4.0×10^{-5}.

59. What is the pH of a 0.10 M solution of weak acid trimethylammonium chloride? The $pK_b = 4.13$ for it's conjugate base triethylamine

Recognizing Acid/Base Properties when Ionics are Dissolved in Water

60. Aqueous solutions of _____ are basic.

a. NaF
b. NaCl
c. NaBr
d. NaI
e. KI

61. Which one of the following salts forms aqueous solutions with pH = 7?

a. Na_2S
b. NaBr
c. $NaClO_2$
d. $NaNO_2$
e. Na_2CO_3

62. Which one of the following salts forms aqueous solutions with pH = 7?

a. NaCN
b. NH_4Br
c. $NaNO_3$
d. NaH_2PO_4
e. Na_2CO_3

63. Which one of the following salts does **not** produce a **basic** solution when dissolved in water?

a. $NaOCH_3$
b. $NaHSO_4$
c. $NaBrO_2$
d. NaNO
e. $NaHCO_3$

64. The pH of an aqueous sodium fluoride (NaF) solution is _____ because _____

a. 7; sodium fluoride is a simple salt.
b. above 7; fluoride is a weak base.
c. below 7; fluoride reacts with water to make hydrofluoric acid.
d. about 7; fluoride is a weak base, but produces hydrofluoric acid, and these two neutralize one another.
e. 0; sodium fluoride is a salt not an acid or a base.

65. Which one of the following, A–D, is correct? If all are correct, respond E.

a. K_2SO_3 is a stronger base than $KHSO_3$.
b. K_2CO_3 is a weaker base than $KHCO_3$.
c. $NaHSO_3$ is a stronger acid than $NaHSO_4$.
d. Na_2HPO_4 is a weaker base than NaH_2PO_4.
e. All of these statements are correct.

66. Which of the following groups, A–D, consist of salts that all form basic solutions in water? (Ac = acetate) If none or all satisfy this criterion, respond E.

a. $NaNO_3$, NH_4CN, NaAc, NH_4Cl
b. Na_2CO_3, KCl, $NaOOCH_3$, NH_4Cl
c. Na_2CO_3, NaF, $NaOOCH_3$, NaCN
d. $NaHCO_3$, NaF, NH_4Cl, Na_2SO_3
e. None or all of the above.

General Chemistry II Jasperse ANSWERS
Acid-Base Chemistry. Extra Practice Problems

1. A
2. B
3. A
4. D
5. B
6. B
7. A
8. C
9. B
10. B
11. B
12. C
13. A
14. E
15. C
16. D
17. D
18. B
19. E
20. D
21. C
22. D
23. C
24. A
25. D
26. E
27. A
28. E
29. D
30. C
31. D
32. B
33. B
34. B
35. A
36. D
37. C
38. A
39. B
40. D
41. D
42. D
43. D
44. B
45. $K_b=([HPO_4^{2-}][HO^-])/[PO_4^{3-}]$
46. $K_b=([H_3PO_4][HO^-])/[H_2PO_4^-]$
47. A
48. C
49. pH=10.85
50. pH=11.44
51. B
52. pH=11.45
53. D
54. C
55. D
56. pH = 9.02
57. pH = 8.48
58. pH = 5.15
59. pH = 5.44
60. A
61. B
62. C
63. B
64. B
65. A
66. C